COMMENTS APPRECIATED

October 22, 2017

FIGHTING CHRONIC INFLATION WITH INTEREST RATES

Cutting a Hydra's Heads with a Swiss Army Knife?

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Abstract. Interest rates do not have a good name. They seem effective in guiding monetary variables in normal circumstances, but have failed badly under duress. For instance, high interest rates have failed to stop inflation as they seriously jeopardized public and private sectors' balance sheets. Balance-sheet issues are well known and thus will be mostly ignored here. Instead, the paper will focus on equally important issues that besiege Emerging Market economies, EMs, namely, (a) imperfect credibility, (b) price inertia, and (3) shallow domestic capital markets, in the context of Interest-Rate-Based, IRB, stabilization programs, subject to Taylor-type interest rules—which have received much less attention than non-IRB programs. This void deserves filling because several EMs that do not belong to a currency union have embraced interest rates as the instrument of choice, with the encouragement of the IMF. This paper shows that IRB plans tend to be associated *inter alia* with recession and occasional currency overvaluation, thus resembling money-based plans (even though money is endogenous!). Moreover, strictly following a Taylor rule could actually foster the existence of *anticipated* step-devaluations under perfect capital mobility (!), and give rise to multiple equilibria. This strengthens the view that IRB plans should rely on complementary nominal anchors (e.g., the exchange rate), and make sure that the private sector does not take the mix of anchors as a signal of central bankers' incompetence or irrelevance.

I. Introduction

Stopping high chronic inflation is challenging because policymakers must persuade the public that they will mend their ways, and induce the public to modify theirs. It is not just a matter of saying what you plan to do; you must make it credible. Moreover, this is a dance of a few policymakers with a group of millions. Making the 'millions' share the forecasts of policymakers and follow their advice is a herculean task, especially when the objective is to control the rate of inflation. Inflation is prices in motion and in a capitalist economy the 'millions' are the price setters. The 'millions' are at the wheel and, even if they trust policymakers, the effectiveness of a stabilization policy also depends on the 'millions' modifying their price setting practices. Many observers have highlighted, for example, the relevance of *price inertia* during the first stages of stabilization programs: the 'millions' disregarding the policymakers' dancing steps?

This has given rise to a voluminous literature about the role of credibility and other related imperfections in inflation stabilization programs (see Calvo and Végh 1999, Calvo 2016 a). Most of the literature, though, focuses on money- or exchange rate-based stabilization programs. Moreover, there is virtually no evidence in Emerging Market economies (EMs) in which interest rates were employed as central instruments to break the trend of high and persistent inflation, until inflation reached low levels (see Mishkin and Schmidt-Hebbel 2002). In developed economies the same applies, but the tide started to change with Volcker's stabilization plan at the turn of the 1980s, when the Fed (and other developed economies) raised interest rates to unprecedented levels.

Interest rates have, of course, been a standard staple in central banks' menus since their inception, but the evidence indicates that, prior to the Volcker experiment, interest rates were not considered reliable instruments for stopping chronic inflation without the support of other nominal anchors. A reason is likely to be that, until the emergence of the New Keynesian Macroeconomics (NKM), conventional theory did not provide strong support for interest rates as nominal anchors.[1, 2] The underlying intuition for this is that interest rates are tantamount to *relative,* not *nominal prices*. The same set of interest rates may be consistent with a multitude of price levels. Thus, from theory's perspective, Interest-Based (IRB) stabilization plans may turn out to be effective but only if the system exhibits other bona fide nominal anchors. This challenge was met by the NKM.[3] In a nutshell, IRB monetary policy in a typical NKM model can generate a unique price-level path by the combination of (a) rational expectations, (b) sticky staggered nominal prices, and (c) an appropriate interest-rate rule (e.g., Taylor rules). The equilibrium concept is questionable (see Calvo 2016 a, Chapter 3, Cochrane 2016, Sims 2016), but that has not prevented NKM models from being a popular staple in current central banks' technical departments.

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1 See Olivera 1970, Sargent and Wallace 1981 and, under price stickiness, Calvo 1983.

2 Volcker experiment was actually a case of "policy ahead of theory".

3 An essential reference for NKM is Woodford (2003).

Practice in EMs and the late-arrival of theoretical support for IRB stabilization are plausible explanations for the fact that most of the inflation stabilization literature applied to EMs has focused on money- or exchange rate based stabilization programs. I cannot point to a theoretical paper that squarely focuses on IRB inflation stabilization under the realistic imperfections (e.g., imperfect credibility) highlighted in the EM inflation stabilization literature (see Calvo and Végh 1999).[4] To be sure, interest rates have not been left completely out of the picture, but always accompanied by a money or exchange rate anchor (see Calvo and Végh 1990 and 1995, Lahiri and Végh 2003). This leaves a vacuum in the literature that I believe is worth filling because it is quite likely—given their current popularity—that interest rates take a central place in future EM inflation stabilization programs subject to serious initial distortions (Argentina at present is an example).

The inflation issues that I will explore in this paper are not unfamiliar, but the emphasis is different from most of the recent monetary literature. The latter has focused on inflation targeting in economies that have defeated high and chronic inflation and, if anything, are struggling to fence off stubborn *deflation*. In contrast, this paper explores the battlefield while the fight against inflation is still on, and the fight is carried out under imperfections that could be mostly ignored in normal circumstances. Thus, I believe the analysis should be kept as simple as possible. In this context, inflation stabilization is already a major shock. Thus, adding exogenous shocks, as in DSGE models, is useful for applications but might actually interfere with the objective of tracing the inevitable effects associated with inflation stabilization. Therefore, I will concentrate attention on *perfect foresight*. In addition, despite the slew of recent financial crises in EMs, I see no tendency for those economies to close their economies to capital mobility. In fact, the still tepid recovery of developed economies is an incentive for EMs to take advantage of cheap foreign saving and keep their economies wide open to capital flows. Therefore, I will focus on the case of perfect capital mobility. This is, admittedly, a strong assumption but models could easily be modified to account for capital market imperfections (see, e.g., Mendoza 2010).[5] Finally, I will stick to the assumption of a representative individual, which simplifies the analysis, and makes results easily comparable with those in the non-IRB stabilization literature, most of which rely on that assumption. The same motivation leads me to cover a set of cases that has received rigorous attention in the non-IRB stabilization literature.

- Firstly, I will focus on two examples where prices take or appear to take the lead, and give rise to what might be called *price dominance*. These are (a) a situation in which the public believes that inflation stabilization will eventually be

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[4] In contrast, inflation targeting under credibility and stable conditions has received a great deal of attention. See, for example, Llosa and Tuesta (2008), Galí and Monacelli (2005), Taylor (2001), Svensson (2000).

[5] However, a relevant extension that I will not tackle here is to assume that expectations are stochastic. Among other things, this extension would allow capturing "peso" problems (Lewis 2016). See Calvo and Drazen (1998) for an analysis of this sort.

discontinued and, as a result, raise prices much faster than if the program was fully credible, and (b) price inertia driven by, for instance, backward looking wage indexation. Price inertia received a great deal of attention from keen observers of high-inflation episodes in emerging markets (e.g., Olivera 1964, Dornbusch and Simonsen 1983, Bruno et al 1988 and 1991).

- Secondly, I will consider the case in which the policy interest rate refers to assets that also provide at least local liquidity services, e.g., bank deposits, treasury bills and bonds (see Calvo and Végh 1995, Lahiri and Végh 2003). This case is not at the center of the inflation-targeting literature, where the practice is to assume that either liquidity from those assets is absent or is invariant to policy shocks. The conventional assumption may be a good approximation in stable situations under deep financial markets, where the central bank's policy is at the fringes of the whole financial system, but the assumption is much harder to defend in inflation-stabilization episodes in emerging market economies, or when liquidity trap is at center stage (see Calvo 2016 b).

The paper is organized as follows:

- **In Section II**, I will discuss a model in which, despite sticky prices, full credibility in central bank's interest-rate rule may succeed in stopping inflation in one fell swoop. This is a useful benchmark for analyzing the impact of imperfect credibility. I will show that imperfect credibility may keep inflation high (a case of *price dominance*) and bring about socially costly distortions, e.g., capacity underutilization and real currency over-appreciation.

- **In Section III**, I will examine the impact of backward-looking price setting following Calvo and Végh (1994). Inflation targeting succeeds in the long run, but capacity underutilization holds in the transition. If the price level shows a high degree of inertia, inflation stabilization stays above inflation target (another case of *price dominance*) and the currency appreciates in real terms. On the other hand, if price setters react strongly to excess demand, the inflation battle can be won very rapidly: it drops below target on impact and stays there for the duration, while the currency depreciates in real term. This shows that inertia per se does not stand in the way of quick inflation stabilization, although the case seems especially relevant in hyperinflation episodes (see Sargent 1982).

- **In Section IV**, I will modify the basic model to account for the case in which the central bank's policy interest rate corresponds to assets that also provide *liquidity services*. A straightforward insight is that inflation in the long run cannot be stopped (yet another case of *price inertia*) if the monetary authority does not put a brake on *aggregate public sector liquid assets*. However, inflation falls in the short run, but winning that battle is not free from costs: lower inflation is accompanied by a temporary appreciation of the currency and capacity underutilization. The model is close to Lahiri and Végh (2003) but abstracts from balance-of-payments crises and sticks to the NKM basic model in which the relevant interest rate follows a Taylor rule.

- **In Section V**, I will show examples in which that IRB stabilization policy does not offer solid nominal anchoring, given that equilibrium multiplicity is always lurking in the background. In particular, the equilibrium nominal exchange rate may be highly unstable and open to self-fulfilling prophecies. These problems arise even though the analysis abstracts from fiscal constraints that are usually at the heart of high inflation, and may trigger equilibrium multiplicity (see Calvo 1988). The central lesson is that additional nominal anchors, e.g., contingent foreign exchange intervention, should be brought to bear in order to guarantee the success of IRB stabilization plans.

- **In Section VI**, I will close the paper with a summary and a brief discussion of social costs of cold-turkey anti-inflation policy if interest rates on contracts made *prior* to the stabilization program are not restructured to prevent systemic bankruptcy or unsustainable fiscal deficit, which boil down to dynamic versions of the Fisher's Debt Deflation syndrome (see Fisher 1933).

Empirical evidence shows that inflation hydra's heads pop up in all corners of the economy and for a variety of reasons. However, in this paper I will peruse the battlefield from a central bank's watchtower, whose main weapon is a policy interest rate (that may appear as a Swiss army knife given the magnitude of the battle). Fiscal and political problems are very important but I will keep them away from central stage in order to focus as sharply as possible on the monetary mechanics of IRB stabilization programs.

II. Basic Model. Imperfect Credibility

1. <u>Basic Model.</u> In line with much of the rational expectations inflation-stabilization theory in EMs (see Calvo and Végh 1999), I will assume a small open economy with a representative individual whose utility function from the perspective of "today" (time 0 here) satisfies: [6]

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

where subscript *t* denotes time, and $c, c^*$and ρ are, respectively, consumption of home and tradable goods, and the subjective rate of discount. This is an open small economy under perfect capital mobility. I will further assume that ρ also stands for the international own-rate of interest on tradables, taken as given. Moreover, utility indices *u* and *v* increase with their respective arguments and are strictly concave (and twice-continuously differentiable).

The backward-looking wealth of the representative individual is denoted by *a* and is composed of money, *m*, and a perfectly internationally tradable instant-maturity bond, *b*. All of them are expressed in terms of tradables, but the part managed by the central bank

[6] This Section supersedes and extends Section II of Calvo (2007).

is expressed in domestic currency (and, hence, its value in terms of tradable goods is affected by currency devaluation). Thus,

$$a_t = m_t + b_t. \tag{2}$$

The flow budget constraint for the representative individual satisfies:

$$\dot{a}_t = \bar{y}^* + y_t/e_t - c_t^* - c_t/e_t + \rho b_t - \varepsilon_t m_t + g_t, \tag{3}$$

where $y, \bar{y}^*$, e, ε and g, stand, respectively, for demand-determined output of home goods and exogenous endowment of tradable goods (constant over time), the real exchange rate (i.e., the relative price of tradables in terms of home goods), the rate of devaluation of domestic currency, and government lump-sum transfers. As usual in monetary theory, and to separate the effects of monetary policy from fiscal considerations and distortions, I will assume that the government rebates all seigniorage to the representative individual and that all other fiscal activities (fiscal revenue, expenditure, etc.) are nil. Without loss of generality, initial backward-looking wealth, a_0, is assumed to be nil. Moreover, the representative individual is subject to the following cash-in-advance constraint:

$$m_t \geq c_t/e_t + c_t^*. \tag{4}$$

As stated, I will assume that there is no friction in the capital market. Therefore, the domestic nominal interest rate satisfies the uncovered interest rate condition, i.e.,

$$i_t = \rho + \varepsilon_t, \tag{5}$$

where i_t stands for the domestic nominal interest rate. Equations (2)-(5) imply the following familiar overall budget constraint:

$$\int_0^\infty [\bar{y}^* + y_t/e_t - c_t^* - c_t/e_t - i_t m_t + g_t]\ \exp(-\rho t)dt = 0 \tag{6}$$

The individual maximizes utility (1) with respect to consumption paths, *c* and $c*$, subject to budget constraint (6) and cash-in-advance constraint (4). 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, except in Section V.2):

$$u'(c_t) = \frac{\lambda}{e_t}(1 + i_t), \tag{7}$$

$$v'(c_t^*) = \lambda(1 + i_t), \tag{8}$$

where λ is the Lagrange multiplier for budget constraint (2) (hence, λ is constant over time).

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

$$\dot{\pi}_t = b(\bar{y} - y_t), \tag{9}$$

where parameter $b > 0$ and $\bar{y}$ is "full employment" or "full utilization" output of home goods, assumed constant over time.

Finally, by definition, at all t where the nominal exchange rate is differentiable,[7] we have

$$\frac{\dot{e}_t}{e_t} = \varepsilon_t - \pi_t. \tag{10}$$

I will assume that the policy interest rate satisfies the following Taylor rule:

$$i_t = \rho + \theta\pi_t, \theta > 1, \tag{11}$$

which implies, without loss of generality, that target inflation = 0.[8] Thus, by equations (5) and (11), we have

$$\varepsilon_t = \theta\pi_t. \tag{12}$$

Thus, the Taylor rule is equivalent to a rate-of-devaluation rule in which the latter goes hand in hand with the rate of inflation, and an x% increase (respectively, decrease) in inflation is met by a more than x% increase (respectively, decrease in absolute value) of the rate of devaluation. It is important to note, though, that the *level* of the exchange rate is market-determined. ε rules will be discussed in Section V.2.

By equations (7) and (11), it follows that there exists some downward-sloping differentiable function C, such that

$$c_t = C\left(\frac{\lambda}{e_t}(1 + i_t)\right) = C\left(\frac{\lambda}{e_t}(1 + \rho + \theta\pi_t)\right). \tag{13}$$

Since equilibrium output of home goods is demand-determined, we have $c_t = y_t$, for all t. Hence, from equations (9) and (13), we have

[7] Differentiability can be taken for granted in all models considered here, except in Section V.2.
[8] I assume inflation target = 0 to economize on notation. All results hold true if the inflation target is a positive number.

$$\dot{\pi}_t = b\left(\bar{y} - C\left(\frac{\lambda}{e_t}(1+\rho+\theta\pi_t)\right)\right). \tag{14}$$

Moreover, by equations (10) and (12), we have

$$\frac{\dot{e}_t}{e_t} = (\theta - 1)\pi_t. \tag{15}$$

Given λ, equations (14) and (15) fully describe the equilibrium dynamics of the economy for *interior* solutions.[9] Variables π_0 and e_0 are not predetermined and, thus, following NKM methodology, local uniqueness of stable equilibrium solutions calls for system (14)-(15) to be locally unstable. This can be verified by examining the corresponding Jacobean at steady state, J, (where signs in certain cells are enough to prove instability), i.e.,

$$J = \begin{pmatrix} + & - \\ (\theta - 1)e_0 & 0 \end{pmatrix}. \tag{16}$$

Given that at an interior equilibrium $e_0 > 0$ and, by expression (11), $\theta > 1$, the Jacobean exhibits two characteristic roots with positive real parts (because both determinant and trace of $J > 0$, see Gantmacher 1956). Hence, local uniqueness is ensured, and the equilibrium path is the steady state.[10] This implies that *target inflation can be reached in one fell swoop*![11]

2. Imperfect Credibility. Let us now consider the case where, in line with the money-based and exchange-rate-based stabilization literature (see Calvo and Végh 1999), agents expect that the stabilization plan will be discontinued in $T > 0$ periods and inflation will climb to a high level, denoted by $\pi^H > 0 =$ initial inflation target.

Figure 1 depicts the dynamic system, which is qualitatively the same as under full credibility (= equations 14 and 15). However, although λ is also constant along the equilibrium path, it will not be the same as under full credibility. Fortunately, this fact does not interfere with the graphical analysis. Point IC (for "imperfect credibility") in Figure 1 would be the steady state of equations (14) and (15), if Taylor rule (11) held for all *t*. The system cannot start at steady state because at time *T* there is a change of regime

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9 I constrain equilibrium paths to be right-hand differentiable, and continuous. The latter may not hold in some situations, an issue that will be taken up in Section V.2.

10 Note that if $\theta < 1$, then system (14)-(15) displays saddle-path stability (because the determinant of the Jacobean < 0), implying the existence of a continuum of equilibrium paths that converge to the steady state. The case $\theta = 1$ cannot be characterized by local methods and will be disregarded in this paper.

11 By equation (8), it can easily be shown that at steady state equilibrium—recalling that initial wealth = 0 and endowment of tradable goods = $\bar{y}^*$, constant over time—$\lambda = v'(\bar{y}^*)/(1+\rho)$.

and variables π and e would have to jump to a different steady state, which cannot hold in interior solutions.

I will assume that at time T authorities follow a new credible Taylor rule $i = \rho + \pi^H + \theta(\pi - \pi^H)$,[12] which ensures that π^H and $\bar{y}$ are, respectively, the equilibrium inflation and consumption of home goods for all $t \geq T$. An interior equilibrium path must be continuous in the $(e/\lambda, \pi)$-plane because (a) as shown in Calvo (1983), in a perfect-foresight path π must be continuous and (b) e must also be continuous because, by assumption, the price of home goods cannot jump—and, in interior solutions, the nominal exchange rate cannot jump either (this will be relaxed in Section V.2). Therefore, the equilibrium paths must converge to the steady state that prevails from $t = T$ in a continuous fashion. This is illustrated by the arrowed solid (red) line in Figure 1, where IC+ corresponds to the steady state that prevails from time T on.[13] In Appendix to Section II, I show that IC+ lies on the right of IC, and on the left of the $\dot{\pi} = 0$ line in Figure 1—and, furthermore, that continuous equilibrium paths are unique.

As shown by the arrowed solid (red) line in Figure 1, imperfect credibility could initially push inflation near the inflation target, but it eventually creeps up away from the target and towards possibly much higher inflation, π^H. Moreover, starting at point D in Figure 1, stagflation sets in. Inflation gives no respite and, by equation (14), goes hand in hand with underutilization of capacity, which gets worse as inflation rises. Moreover, from point D to IC+ in Figure 1, currency depreciates in real terms but it is not enough to restore full employment, until the regime change that occurs at time T.

Notice that in equilibrium $c_t = y_t$ and seigniorage is rebated to the representative consumer. Therefore, equation (6) becomes:

$$\int_0^\infty [\bar{y}^* - c_t^*] \exp(-\rho t) dt = 0, \tag{6'}$$

which involves only tradable goods. Moreover, the increase in the inflation target at T (from 0 to π^H) implies a sudden fall in the nominal interest rate at T, because, recalling Figure 1,

$$\lim_{t \uparrow T} i_t = \rho + \theta \pi^H > \rho + \pi^H = i_t, t \geq T.$$

These results will come in handy for characterizing current accounts.

[12] This is the only change that takes place. Thus, system (14) and (15) hold, taking into account the new Taylor rule. This implies, by previous analysis, that the system converges instantaneously to steady state and there is full-capacity utilization in the home goods sector.

[13] The solid red line path in Fig. 1 holds if the characteristics roots are not real numbers. Otherwise, the red line will have to start somewhere above $\dot{\pi} = 0$ line in Fig. 1.

The sign of the current account is ambiguous, but an initial current account deficit cannot be discounted. One can show, for instance, that if the equilibrium path starts on point D in Figure 1, the initial current account must be negative. I will prove it by contradiction. Suppose the current account is positive. Then, by equation (8) and the arrowed solid (red) line in Figure 1, consumption of tradables falls for all $0 \leq t < T$, which implies that the current account will be positive for all $0 \leq t < T$. Given that initially the representative individual starts with zero net assets, current account surplus at time 0 implies that $c_0^* < \bar{y}^*$. Moreover, the nominal interest rate at T (= $\rho + \pi^H$) is larger than at $t = 0$ (= ρ). Hence, by equation (8) and above results, $c_t^* < \bar{y}^*$ for all $t \geq 0$, which contradicts budget constraint (6').

On the other hand, if the system starts sufficiently close to IC+, the current account must be positive. Again, I will prove it by contradiction. Let us assume that the current account at $t = 0$ is negative. Thus, for time 0 close enough to time T, $c_t^* > \bar{y}^*$, for all $0 \leq t < T$. Given the sudden fall in the nominal interest rate *i* at *T*, it follows that $c_T^* > \lim_{t \uparrow T} c_t^*$, which, in view of previous results implies that $c_t^* > \bar{y}^*$ for all $t \geq 0$. This contradicts equation (6').

Loosely speaking, these observations suggest that the initial current account for short-lived stabilization plans will be positive, but longer-lived programs may show periods of current account deficit.

These results paint a scenario in which imperfect credibility could be reinforced by the adverse phenomena with which it is associated and, in a richer model, generate self-fulfilling stagflation prophecies. Moreover, notice that at the end of the botched stabilization program, time *T*, prospects look better since, as the interest rate falls, recalling equations (7) and (8), the consumption of tradables and home goods go up, full capacity utilization is restored, the real interest rate falls—and inflation stops rising! Non-vertical Phillips' curve advocates will claim that their view has been vindicated and that, after all, inflation is a blessing—making it more difficult to get political support for future stabilization programs. A vicious circle may set in, from which empirical evidence suggests that the economy may be able to break free only after inflation reaches dangerously high levels and/or gives rise to chronic counterproductive phenomena (see, e.g., Bruno et al 1988 and 1991).[14]

[14] In the model, social welfare would be higher if inflation remained high *but credible*. This, of course, does not hold true in more realistic models, but helps to dramatize the importance of ensuring a reasonable degree of credibility before launching gung-ho stabilization plans—it should not be taken as an endorsement of high inflation.

III. Backward-Looking Inflation

I will follow Calvo and Végh (1994) and assume that backward-looking inflation takes the following form:

$$\pi_t = \omega_t + \alpha(c_t - \bar{y}), \alpha > 0 \tag{17}$$

and

$$\dot{\omega}_t = \gamma(\pi_t - \omega_t), \gamma > 0, \tag{18}$$

where ω is the backward-looking factor. Therefore, by (17) and (18),

$$\dot{\omega}_t = \gamma\alpha(c_t - \bar{y}). \tag{19}$$

By the first equality in expression (13) and equations (11) and (17), we have

$$c_t = C\left(\frac{\lambda}{e_t}(1 + i_t)\right) = C\left(\frac{\lambda}{e_t}(1 + \rho + \theta(\omega_t + \alpha(c_t - \bar{y}))\right). \tag{20}$$

Since $C' < 0$, one can solve for *c* as a function of λ/e and ω. More precisely, there exists some differentiable function ϕ such that

$$c_t = \phi(\lambda/e\,, \omega), \text{ where the partial derivatives } \phi_{\lambda/e,\omega} < 0. \tag{21}$$

Hence, by equations (15), (17) and (21),

$$\frac{\dot{e}_t}{e_t} = (\theta - 1)[\omega_t + \alpha(c_t - \bar{y})] = (\theta - 1)[\omega_t + \alpha(\phi(\lambda/e_t, \omega_t) - \bar{y})]. \tag{22}$$

Moreover, by equations (19) and (21), we have

$$\dot{\omega}_t = \gamma\alpha(\phi(\lambda/e_t, \omega_t) - \bar{y}). \tag{23}$$

Equations (22) and (23) represent the reduced form of the dynamic system in *e* and ω. In this instance, ω_0 is predetermined while e_0 is not. Thus, existence and uniqueness of local convergent equilibrium calls for the system to display saddle-path stability. This can again be established by examining the Jacobean of system (22)-(23) at steady state, denoted by J^b (*b* for backward looking). It follows that

$$J^b = (\theta - 1)\alpha\gamma\frac{\lambda}{e_\infty}\begin{pmatrix} -\alpha\phi_{\lambda/e} & 1 + \alpha\phi_\omega \\ -\phi_{\lambda/e} & \phi_\omega \end{pmatrix}. \tag{24}$$

Thus,

$$sgn\ Det\ J^b = sgn\ [(\theta - 1)\phi_{\lambda/e}]. \tag{25}$$

Recalling inequalities in expression (21), equation (25) implies that the determinant of J^b is negative under Taylor rule (11), i.e., $\theta > 1$, which ensures saddle-path stability (the Jacobean exhibits two real roots of opposite signs, see Gantmacher 1956). However, as shown in Figures 2 and 3 the slope of the saddle path depends on parameter α; moreover, as implied by equation (17), the larger is α, the faster is the adjustment of inflation to current conditions. The literature that emphasizes inflation inertia more closely corresponds to the case of slow price adjustment (i.e., 'small' α). This case has greatest interest and is depicted in Figure 2.

1. Slow Price Adjustment. I will assume that prior to the stabilization program, the economy was located at a steady state with high inflation, π^H, relative to the program's inflation target (= 0). By equation (18), at such steady state $\omega = \pi^H$, which is predetermined at the beginning of the stabilization program. Thus, equilibrium real exchange rate (relative to λ) once the (credible) program is announced, e_0/λ, is determined as depicted in Figure 2. This ensures that the resulting path converges to the new steady state. Variable ω declines monotonically towards 0, which, by equations (21) and (23), implies that the economy will exhibit excess capacity or unemployment throughout the stabilization program. Moreover, by equation (21), the fall in ω and λ/e implies that c_t increases monotonically towards steady state, $\bar{y}$.[15]

Characterizing the equilibrium real exchange rate is slightly less direct. Figure 2 shows that the real exchange rate will rise monotonically towards its steady state, denoted by e_∞/λ. What about e_0 relative to the value prevailing prior to the program, denoted by e_{-0}? Since, by Figure 2, $\dot{e} > 0$, it follows, by equation (15), that $\pi > 0$ at all times and, by equation (11), the nominal interest rate $i_t > \rho$, all *t*, and converges to ρ. Let us denote, the steady state consumption of tradables associated with the stabilization program by c_∞. Clearly, by equation (8),

$$v'(c_\infty^*) = \lambda(1+\rho) < \lambda(1+\rho+\theta\pi_t) = v'(c_t^*), \text{ all } t \geq 0. \tag{26}$$

In equilibrium, equilibrium budget constraint (6'), expression (26) and continuity of the equilibrium path, imply that there exists some $t = t_0 > 0$, such that

$$c_t^* > \bar{y}^* \text{ for all } t > t_0. \tag{27}$$

Otherwise, $c_t^* < \bar{y}^*$ for all $t \geq 0$, contradicting equilibrium budget constraint (6'). I will employ this finding to argue that $e_0 < e_{-0}$, i.e., that on impact the currency appreciates in real terms. The proof is straightforward. At the steady state that prevailed prior to the stabilization program announcement, we have, by equations (7), (8) and (27) and that $\lim_{t\to\infty} c_t = \bar{y}$,[16] $c_t \leq \bar{y}$, all t,

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[15] λ is determined taking into account the budget constraint (6') as in Appendix to Section II, equation A6, and will not be discussed here.
[16] In this case, it is more straightforward to point out that $c_t \leq \bar{y}$ for all $t \geq 0$. However, the limit condition is useful for the proof in fast-price-adjustment case

$$e_{-0} = \frac{v\prime(\bar{y}^{*})}{u\prime(\bar{y})} > \frac{v\prime(c_t^{*})}{u\prime(c_t)} = e_t \text{ for all } t > t_0. \tag{28}$$

Suppose that contrary to my conjecture $e_0 > e_{-0}$. Thus, since by Figure 2, e_t rises monotonically, it follows that $e_t > e_{-0}$ for all t, which contradicts expression (28) at all $t > t_0$.

Another implication of expression (27) is that prior to t_0 there are periods in which the current account is positive. Moreover, in the linear approximation around the inflation target (= 0), inflation converges monotonically to 0 from above, implying, by equations (8) and (11), that c_t^* is monotonically increasing. Once again, taking into account the equilibrium budget constraint (6'), it follows that the current account is positive from the start of the stabilization program, and converges to 0 as $t \to \infty$. This is interesting, because it happens despite the initial real *appreciation* of the currency.

The anti-inflation battle may suffer from additional credibility problems, given that recession holds during the entire plan. However, public support may be enhanced by the fact that capacity utilization rises, and inflation and the real interest declines over time. However, these pieces of "good news" may not suffice if price inertia is strong, because inflation will stay high, while capacity underutilization accompanied by low real exchange rates (which the layman typically associates with capacity underutilization) may show feeble signs of subsiding.

2. Fast Price Adjustment. Figure 3 shows that once again in this case variable ω falls monotonically along the equilibrium path. This implies, by equation (19), that consumption of home goods falls short of potential output. However, Figure 3 also shows that the real exchange rate e falls monotonically and thus, by equation (15), inflation is *negative* (and, hence, below target = 0) for all t! Finally, by inverting the inequalities in expressions (26), (27) and (28), one can show that the currency depreciates on impact.

This case is interesting, not so much for its realism but because it implies that—if price setters are quite sensitive to excess-demand conditions—the stabilization program pushes inflation below target on impact, and keeps it there all along the equilibrium path. This implies that the implementation of policies that discourage inflation inertia could be very effective in securing a speedy stop of inflation. And shows yet another example in which the effectiveness of a stabilization program may be highly enhanced by policies that are typically not in the hands of the central bank.

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discussed next, in which just pointing out that $c_t \leq \bar{y}$ for all $t \geq 0$ would not allow proving the inverse inequality in equation (28).

IV. Liquid Central Bank Policy Assets

In this section I will change gears, assume that there is no price inertia and price setting satisfies equation (9)—and introduce a critical new assumption, namely, that the interest rate controlled by the central bank involves assets that yield utility services. This approach is plausible in economies with shallow domestic capital markets, where assets related to monetary policy (e.g., bank deposits, treasury bills) are held primarily for their local liquidity services, but their marginal liquidity may fall noticeably with the stock of those assets (see Calvo and Végh (1995)).[17]

To simplify the analysis, I will assume that money is the only local liquid asset and that its interest rate, denoted by s, corresponds to the central bank's policy instrument. In contrast with the previous sections, nominal money supply is exogenous and will be assumed to grow at rate μ. Thus, the overall budget constraint (6) becomes

$$\int_0^\infty [\bar{y}^* + y_t/e_t - c_t^* - c_t/e_t - (i_t - s_t)m_t + g_t] \ \exp(-\rho t)dt = 0, \tag{29}$$

where s is the only new component, compared with (6).

One can show that under cash-in-advance constraints, as in previous sections, once-and-for-all changes in s or the imposition of Taylor type rules involving s have no effect on long-run inflation. This is not surprising, because in this model money supply is exogenous. More interesting is that temporary effects are totally absent, too. This helps to illustrate in a stark manner the contrast between interest-rate policy and the management of liquidity aggregates. However, a reason for the contrast is that the cash-in-advance hypothesis postulated here assumes that cash holdings per unit of planned expenditure are not sensitive to interest rates. I will, thus, drop the cash-in-advance assumption, and assume that the utility function of the representative individual satisfies:

$$\int_0^\infty [u(c_t) + v(c_t^*) + z(l_t)] \exp(-\rho t)\, dt, \tag{30}$$

where $l \equiv me$ is real monetary (or liquidity) balances expressed in terms of *home goods*. Functions u, v and z are increasing and strictly concave (and twice-continuously differentiable). The representative individual maximizes utility (30) subject to budget constraint (29), which yields the following first-order conditions for an interior optimum:

$$u'(c_t) = \lambda/e_t, \tag{31}$$

$$v'(c_t^*) = \lambda, \tag{32}$$

and

[17] I have recently argued that the approach also helps to rationalize liquidity trap in advanced economies (see Calvo 2016 b, especially Chapter 4).

$$z'(l_t) = \frac{\lambda}{e_t}(i_t - s_t), \tag{33}$$

where, as before, λ is the time-invariant Lagrange multiplier. This implies, by equation (31), that consumption of tradables is constant over time and, by budget constraint (6'), at equilibrium:[18]

$$c_t^* = \bar{y}^*, t \geq 0, \tag{34}$$

which will greatly simplify the analysis. This implies that the current account = 0 over the entire stabilization program.

Suppose that *s* satisfies the following Taylor-rule like condition:

$$s_t = \underline{s} + \kappa\pi_t, \tag{35}$$

where $\underline{s}$ and k are unrestricted parameters. The standard assumption in monetary models is $\underline{s} = \kappa = 0$, which I will assume holds prior to the inflation stabilization program.

By equations (5), (33)-(35), we have

$$z'(l_t) = \frac{v\prime(\bar{y}^*)}{e_t}\left(\rho + \varepsilon_t - \underline{s} - \kappa\pi_t\right). \tag{36}$$

Hence,

$$\varepsilon_t = e_t z'(l_t)/v'(\bar{y}^*) - \rho + \underline{s} + \kappa\pi_t. \tag{37}$$

By equations (31), (32) and (34), there exists a downward-sloping function $\mathbb{C}$, such that

$$c_t = \mathbb{C}(v'(\bar{y}^*)/e_t). \tag{38}$$

By equations (9), (37) and (38), we get

$$\frac{\dot{e}_t}{e_t} = \varepsilon_t - \pi_t = e_t z'(l_t)/v'(\bar{y}^*) - \rho + \underline{s} + (\kappa - 1)\pi_t, \tag{39}$$

$$\dot{\pi}_t = b[\bar{y} - \mathbb{C}(v'(\bar{y}^*)/e_t)], \tag{40}$$

and

$$\frac{\dot{l}_t}{l_t} = \mu - \pi_t, \tag{41}$$

[18] Notice that equilibrium budget constraint (6') holds in this case, despite (29) being different from (6). This is so, because net seigniorage is rebated through lump-sum net subsidies (variable g in equations (6) and (29)).

where μ stands for the rate of growth of nominal money supply.

One can readily show that the determinant and trace of the Jacobean associated with system (39)-(41) are negative and positive, respectively. This ensures that the system has one negative characteristic root. The other two have positive real parts. Since l is the only predetermined variable, this ensures that there exists a unique continuous equilibrium path that converges to the steady state. Interestingly, *uniqueness is totally independent of whether or not the monetary authority follows a Taylor rule on s* (for related results in a closed-economy context, see Calvo 2016 b, Chapter 3).

Clearly, by equation (41), the interest-rate rule has no effect on long-run inflation. The result is intuitive but helps to rationalize the comment often heard coming from monetarist quarters that, for instance, inflation cannot be wiped out if the central bank is committed to finance the fiscal deficit, and the latter is not adjusted in concomitance with the stabilization program.

Let us continue denoting the steady state level of a variable (associated with the stabilization program) by ∞. By equation (40), e_∞ is independent of the Taylor rule, which is another convenient simplification. Moreover, by equations (39) and (41), at the program's steady state:

$$e_\infty z'(l_\infty)/v'(\bar{y}^*) - \rho + \underline{s} + (\kappa - 1)\mu = 0. \tag{42}$$

Let us assume that prior to the stabilization program the economy was at steady state with positive inflation = $\mu > 0$. The stabilization program consists in tightening the Taylor rule by increasing $\underline{s}$ and/or κ. By equation (42), this brings about a rise in steady-state real monetary balances, l_∞, given that z is strictly concave. Thus, after the announcement of Taylor-rule tightening, the initial real monetary balances (which are predetermined because nominal money supply and home goods' prices are sticky) are smaller than at the new steady state, i.e., $l_0 < l_\infty$. Given that all variables in system (39)-(41) converge monotonically to their steady state levels, transition to the new steady state calls for a fall in the rate of inflation on impact, i.e. π_0—recall equation (41). Thus, the anti-inflationary program shows signs of success in the short run (although inflation is doomed to return to the pre-stabilization-program high level μ).

Let us now focus on the real exchange rate e. Recall the assumption that the economy starts at steady state with, presumably high, inflation $\pi = \mu > 0$, and that e_∞ is invariant across steady states. I will show that on impact equilibrium e_0 falls, i.e., the currency appreciates in real terms. I will prove this by contradiction. Suppose $e_0 \geq e_\infty$. Then, this, combined with the tightening of the Taylor rule, implies, by equation (39), that $\dot{e}_0 > 0$. As noted above, all variables converge monotonically to steady state, which further implies that $\dot{e}_t > 0$, all $t > 0$. Hence, $\lim_{t\to\infty} e_t > e_\infty$. A contradiction.

This scenario is bleaker than under price inertia. Both succeed in momentarily lowering inflation, but in the present instance the battle is bound to be lost, while in the meantime paying the cost of capacity underutilization. Moreover, credibility problems are bound to arise if the government persists in this hopeless Sisyphus-type stabilization programs.

V. Floating Exchange Rate: The Achilles Heel of IRB Stabilization?

As shown in Sections II and III, equilibrium uniqueness can be ensured in standard NKM models that satisfy Taylor rule (11), under the additional assumptions that the policy inflation index includes only home goods, and that the nominal exchange rate is continuous over time. In this Section, I will argue that removing these assumptions reveal that floating exchange rates may make Taylor rule (11) less effective to guarantee equilibrium uniqueness and, furthermore, that there are plausible situations in which anticipated future discontinuous jumps in the exchange rate can occur in perfect-foresight equilibrium paths. The Section is organized as follows:

First, I will extend the above models to the case in which the relevant inflation index includes tradable goods, and show that the larger is the weight on tradables' inflation, ε, the narrower will be the set of coefficients θ (recall equation (11)), or their equivalents, that ensure equilibrium uniqueness. In the limit in which the weight on ε equals 1, the system displays a continuum of equilibrium paths, irrespective of θ in Sections II and III models, and uniqueness calls for an anti-Taylor rule condition in Section IV model.

Second, I will show that just attaching a positive weight to ε in the inflation index, Taylor-type rules may give rise to equilibria that display *perfectly anticipated discontinuous jumps in the exchange rate* (which I will call *Maxi Revaluations*) and generate equilibrium multiplicity—even though equilibrium uniqueness would prevail if one could ensure that exchange rate paths are continuous. An important implication of this result is that, under these circumstances, effectiveness of an IRB plan would be enhanced by foreign exchange market intervention that ensures continuity of the nominal exchange rate path[19]—offering a novel rationale for "fear of floating" in IRB plans.

1. Tradables in the Policy Inflation Index. Consider the basic model in Section II and let us assume that the relevant inflation index, denoted by Π, satisfies:

$$\Pi_t = \beta\varepsilon_t + (1-\beta)\pi_t,\ \ 0 \leq \beta \leq 1, \tag{43}$$

where β is a parameter. Moreover, I will modify Taylor rule (11) such that

$$i_t = \rho + \tilde{\theta}\Pi_t. \tag{44}$$

Notice that the model in Section II assumes $\beta = 0$; and that I am not assuming $\tilde{\theta} > 1$, for reasons that will become evident momentarily.

[19] In a stochastic environment the "continuity condition" has to be modified to account for the volatility of "fundamentals." However, this issue lies outside the scope of the present paper.

By interest-rate parity condition (5) and equation (43) and (44), it follows that

$$i_t = \rho + \tilde{\theta}\frac{1-\beta}{1-\beta\tilde{\theta}}\pi_t. \tag{45}$$

Therefore, if we set

$$\theta = \tilde{\theta}\frac{1-\beta}{1-\beta\tilde{\theta}} \tag{46}$$

the model would be identical to that in Section II, where equilibrium uniqueness requires that $\theta > 1$. Clearly, by equation (46),

$$\tilde{\theta}\frac{1-\beta}{1-\beta\tilde{\theta}} > 1 \Leftrightarrow 1 < \tilde{\theta} < \frac{1}{\beta}. \tag{47}$$

Therefore, the larger is the weight of tradables β in the relevant inflation index Π, the smaller is the upper bound in Taylor rule (44) in order for $\tilde{\theta}$ to ensure uniqueness of continuous equilibrium paths.[20] Moreover, since equations (43)-(47) would also hold for the model in Section III, it is easy to show that the right-hand-side inequality in expression (47) also applies to the case of inflation inertia.

Finally, a similar result holds for the model of Section IV if the Taylor-rule like condition takes the following form:

$$s_t = \underline{s} + \tilde{\kappa}\Pi_t. \tag{48}$$

One can show that equation (39) becomes

$$\frac{\dot{e}_t}{e_t} = \varepsilon_t - \pi_t = \{e_t z'(l_t)/v'(\bar{y}^*) - \rho + \underline{s} + [\tilde{\kappa}(1-\beta) - 1]\pi_t\}/(1-\tilde{\kappa}\beta). \tag{49}$$

On the other hand, differential equations (40) and (41) for e and π are the same in the present case. Therefore, one can show that uniqueness holds if

$$\tilde{\kappa} < \frac{1}{\beta}\,. \tag{50}$$

Interestingly, if one thinks of β as akin to a pass-through coefficient, these results imply that it would be advisable for economies that are besieged by high pass-through to set $\tilde{\kappa} < 1$—an anti-Taylor rule!

The above results are somewhat counterintuitive. By assumption, tradable goods prices are perfectly flexible. Thus, one might be led to conjecture that to keep inflation on target, the policy rate of interest should react more strongly to departures from target than

[20] See Llosa and Tuesta (2008) for related results in the context of Section II model.

if tradable goods are not a component in the inflation index Π. But exactly the opposite holds true.

2. Anticipated Maxi-Revaluation. The above analysis assumes that the equilibrium exchange rate path is continuous. This is a natural assumption in the model in Section IV, where the stock of money is exogenous because, unless the demand for money were totally interest inelastic, the expectation that, for instance, a maxi-devaluation[21] will take place at a future time T, say, would lead individuals (in a continuous time context) to "dump" their money stock an "instant" before T—not at T, a contradiction. This observation is a centerpiece in Krugman's elegant balance-of-payment crisis model (see Krugman 1979). However, the models in Sections II and III (including extensions in this Section) assume that the interest rate is the only policy instrument utilized by the central bank: the stock of money and the exchange rate are endogenously determined. The private sector can change the composition of its portfolio of money and the monetary policy bond at the central bank, which is ready to exchange money for bonds at current market prices. In particular, the representative individual can get rid of her entire money holdings by selling them to the central bank in exchange for the policy bond. Recalling that such bond is assumed to be of instant maturity, individuals could wait until an "instant" before T to get rid of domestic money, without necessarily generating excess money supply and triggering an earlier devaluation. Given the cash-in-advance constraint (4), holding no money implies zero consumption, but this would have no effect on utility (1) because a point in a Riemann integral has zero weight.[22]

However, holding b would not necessarily protect individuals from maxi-devaluation and the associated instantaneous price level rise unless the bond is de facto indexed to the exchange rate (at least in points in time at which the exchange rate is discontinuous). If contrariwise, the nominal interest rate i satisfies Taylor condition (11) and does not compensate bondholders for the maxi-devaluation, the bond would be akin to money, and a maxi-devaluation could be ruled out as in Krugman (1979). However, adopting this policy is tantamount to saying that the Taylor rule applies only in periods where inflation is not "large." If so, the policy bond market vanishes because international bonds would return-wise dominate the policy bond. This could induce the representative individual to hold international bonds. If she does, managing the nominal interest rate is still possible but, in absence of a local policy bond, it will have to be done by managing the rate of devaluation ε directly, taking into account the interest rate parity condition (5). This would solve the maxi-devaluation problem but it involves a radical policy change: the central bank would control the rate of devaluation, not the nominal interest rate. However, if the central bank wants to make sure that the policy bond is as safe as international bonds, indexation to the exchange rate is mandatory. That would allow the central bank to manage the nominal interest rate i on the policy bond—which is now safe to maxi-devaluations—but, unfortunately, one cannot rule out anticipated discontinuous

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[21] For the sake of brevity, I will confine the discussion to maxi-devaluations. Moreover, maxi-devaluation episodes are much more disruptive than maxi-appreciations during inflation stabilization programs.

[22] This may not hold true if Inada conditions hold at zero consumption.

jumps in the nominal exchange rate, because if individuals expect a maxi-devaluation at T, they will switch their portfolios completely into the policy bond an "instant" before T and, then, switch back to their preferred composition after devaluation. There are no incentives for individuals to make the portfolio switch prior to T because the central bank protects investors entirely from the maxi-devaluation.[23]

To illustrate an equilibrium path that would exhibit maxi-devaluation, consider the arrowed solid (red) line in Figure 1. This path satisfies the dynamics of the economy under perfect credibility (even though Figure 1 was utilized to discuss incomplete credibility). We ruled out this path as an equilibrium path under full credibility in Section II because it does not converge to steady state *if the nominal exchange rate is constrained to be continuous over time*. However, the possibility of maxi-devaluation could make it part of a perfect-foresight equilibrium solution. Consider the section of the arrowed solid (red) path that hits point D at time $T > 0$, say. Let us consider a maxi-devaluation at T that lands the system at IC, the steady state, and stays there forever after. This is an equilibrium path because maxi-devaluation was shown to be possible in equilibrium and π is continuous, a condition that must be satisfied according to Calvo (1983). There is no room for arbitrage and all the necessary and sufficient conditions for optima are satisfied.

Furthermore, Currency Substitution—a phenomenon that is not unusual in EMs exposed to long spells of high inflation—further facilitates existence of equilibrium maxi-devaluation. Currency Substitution can be captured in the above models by modifying the cash-in-advance constraint (4) and allowing individuals to utilize foreign currency (e.g., dollar or international bonds) as a means of exchange (see Calvo 1996, Part III). Thus, Currency Substitution could help to buffer consumption against domestic currency runs.

I would like to note that maxi-revaluations of the type discussed here would subsist in a stochastic environment. This holds true under complete markets, and perfect foresight is an illustration. Moreover, under incomplete markets, the possibility of maxi-devaluations may give rise to "peso problems," even though individuals have no qualms about policymakers' stabilization commitment. Peso problems, in turn, may generate financial distress in public and private sectors, which are additional sources of multiple equilibria (see, e.g., Calvo 1988).

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[23] If the policy bond is indexed to the exchange rate, a maxi-devaluation could give rise to a large one-step rise in fiscal deficit. Remember, however, that we assumed that fiscal deficits are automatically financed by lump-sum taxes. Therefore, private-sector budget constraint, first-order conditions, and the dynamic equations are invariant with respect to maxi-devaluation (or appreciation). These assumptions help to reveal the fundamental monetary dynamics of the model, excluding distorting fiscal factors. But, of course, these factors should be taken into account in applications.

The above discussion does not question the relevance and even desirability of IRB stabilization plans under flexible exchange rates and endogenous money supply, but shows that interest rate rules may need some support from other nominal anchors and perhaps rely less on Taylor-type rules. Moreover, the discussion should alert central banks about the advisability of keeping exchange rate fluctuation within reasonable bounds to prevent self-fulfilling expectations equilibria, *even if credibility is not an issue*. In the above special models, the latter condition is equivalent to saying that the central bank should endeavor to having individuals believe that the exchange rate will not exhibit maxi-revaluation. Do policymakers do that? Empirical evidence points in that direction (although, of course, this issue would benefit from taking *fundamentals* uncertainty into account, absent here):

Exhibit 1. EM exchange rates are considerably less volatile than in advanced economies or currency unions, a phenomenon labeled *Fear of Floating* (see Calvo and Reinhart 2002).

Exhibit 2. At the height of the Great Recession episode in 2008, the Fed set up a large currency swap arrangement with the ECB to prevent the Euro/US$ exchange rate from going through the roof.

This discussion raises an interesting issue that, although not germane to this paper, is worth highlighting. It refers to the fact, noted above, that IRB stabilization is likely to require additional nominal anchors to keep the program on track. A natural anchor for a small open economy is the exchange rate. Curiously, however, despite being relatively precise about interest rates' rules, central banks seem to be reluctant to say what they will do if the exchange rate becomes excessively volatile. This lack of precision may be counterproductive. For instance, the central bank may stabilize the exchange rate but trigger capital flight if the public interprets the loss of international reserves as a balance-of-payments crisis. On the other hand, if the central bank does not intervene, non-uniqueness problems discussed above might arise. Thus, a case can be made that during inflation stabilization programs, it would be advisable to inform the public that there might be episodes in which the central bank may find it necessary to intervene in the foreign exchange market and, moreover, provide some information about the mechanics of those interventions.[24]

VI. Conclusions

This paper confirms the popular conjecture that, as in non-IRB plans, the effectiveness of IRB stabilization plans is undermined by imperfect credibility, price inertia and liquidity problems. Moreover, the paper shows that IRB resemble money-based plans in that during the entire plan recession holds or, when credibility is central, recession sets in prior to the expected phasing-out of the plan. In all cases, the currency exhibits phases of

[24] This applies to all monetary policies based on managing a nominal interest rate, but I suspect that the lack of precision with respect to the mode of using complementary anchors carries consequences that are much less worrisome under normal non-inflationary conditions.

real currency appreciation, except in an unrealistic case of low price inertia. In the case in which the central bank controls the interest rate on a liquid asset (e.g., the *Lebac* in Argentina now), the plan is successful in paring down inflation temporarily, but not in the long run—even if the plan is perfectly credible. Thus, raising interest rates would only succeed in giving temporary inflation relief.

In addition, IRB stabilization plans suffer from the 'original sin' exhibited in simple flexible prices models, in which prices and money supply have multiple equilibrium solutions. Price stickiness helps to anchor the system but Section V.2 shows that even conventional Taylor rules may not be able to erase the traces of the original sin. This is dramatically exemplified by the fact that *anticipated maxi-devaluation* cannot be ruled out unless the monetary policy bond becomes like money during a maxi-devaluation episode—in the sense that such a bond would suffer a significant capital loss if maxi-devaluation occurs. In that case, nominal anchoring would hold but it would be essentially based on *domestic nominal asset aggregates*, not the rate of interest. Interestingly, however, maxi-devaluation could be ruled out if the government manages the *rate of devaluation* in lieu of the *rate of interest*; but this amounts to openly recognizing the inefficacy of the rate of interest. In sum, the rate of interest cannot belie its original sin and needs the support of other nominal anchors. Policymakers are well aware of that problem, as shown by a wide variety of market interventions that central banks engage in to prevent wild swings in the exchange rate. It seems to me, however, that these interventions are carried out in an excessively casual manner. The exchange rate is too important a variable to hope that "constructive ambiguity" is the way to go.

In closing it is worth mentioning that the paper abstracts from private and public sector budget constraints that may cause systemic bankruptcy or early discontinuation of IRB stabilization programs. In this respect, a potentially serious practical problem is the preexistence of non-state-contingent credit contracts when the stabilization plan is implemented. If interest rates are not indexed to the rate of inflation, for example, a sharp drop in inflation could generate a large increase in the *ex post real interest rate*. This might deal a large blow on debtors who are taken by surprise or are unable to restructure their debts in line with lower inflation (see Calvo 1988, Lara Resende 2016). If public debt is denominated in terms of domestic currency, the government could eschew default by issuing domestic liquid liabilities, but at the risk of generating higher inflation (this would hold true in the model in Section IV). The latter is more difficult or impossible for the private sector. Thus, stopping inflation could trigger open private-sector default with serious systemic consequences. This may prompt the central bank to relax its monetary stance by, for instance, bailing out banks and other lending institutions with the condition that the latter restructure past contracts to soften the blow on borrowers (which, again, may put the anti-inflationary program into question marks). Interestingly, these problems could be prevented by *backward indexation* of interest rates, like the TIPS in the US where interest payments are the sum of (a) a pre-specified amount, i.e., the *real* component, and (b) an amount indexed to the realized (i.e., backward-looking) rate of inflation. However, unless backward-looking indexation is common practice, restructuring contracts ex post is likely to encounter serious legal snags. But it can be done. For instance, in1985 Argentina implemented the Austral plan that achieved similar results but was able to circumvent legal problems by creating a new currency![25]

Barring backward-looking interest rates' indexation, these financial difficulties are likely to arise no matter the monetary policy instrument utilized by the central bank, e.g., monetary aggregates, exchange rate or interest rate. Do any of these options dominate? This is a highly debatable question but I dare to conjecture that exchange-rate-based stabilization, ERBS, would be the winner, because the exchange rate is in more direct contact with prices (particularly in small-open economies) than monetary aggregates or interest rates. Moreover, floating exchange rates could enhance financial risk and further interfere with financial flows. I do not have in mind, of course, "cold turkey" ERBS policy, but rather a smooth transition from high-to-low rates of devaluation (a system resembling Argentina's "tablita" in the late 1970s, see Calvo 1986). This would give time to creditors and debtors to restructure credit contract more in line with target inflation. Needless to say, this strategy is not foolproof and would fail if gradualism were taken as a sign of policymakers' lack of determination to carry out the stabilization plan.

[25] The clever trick consisted of replacing the old *peso* with a new currency (called *austral*) and announcing that the old peso's ghost would devalue with respect to the austral as a function of the rate of inflation that prevailed prior to the austral plan (for further details, see de Pablo 2005).

Appendix to Section II

Fundamental Observation. Recall that the dynamics in Figure 1 are associated with the case in which inflation target = 0. The program is discontinued at $t = T$, but Lagrange multiplier λ remains the same across regimes, because changes are *fully anticipated*. By assumption, at T the economy lands on a steady state exhibiting full capacity utilization. Therefore, $c_t = \bar{y}$, all $t \geq T$.■

Firstly, I will show that, as depicted in Figure 1, IC+ lies to the right of IC.

By assumption, the economy is at steady state with $\pi_t = \pi^H$, all $t \geq T$, and $\varepsilon = \pi^H$. Thus,

$$i = \rho + \pi^H, \text{ all } t \geq T. \tag{A1}$$

Hence, by equation (7),

$$u'(\bar{y}) = \frac{\lambda}{e^{IC+}}(1 + \rho + \pi^H). \tag{A2}$$

On the other hand, under Taylor rule (11), we have at IC:

$$u'(\bar{y}) = \frac{\lambda}{e^{IC}}(1 + \rho). \tag{A3}$$

Consequently, $e^{IC+} > e^{IC}$. **QED**

Secondly, I will show that IC+ lies to the left of the $\dot{\pi} = 0$ line in Figure 1. I will prove it by contradiction and will, thus, assume that IC+ lies to the right of the $\dot{\pi} = 0$ line, like point A in Figure 1. Consider the following expression:

$$u'(\bar{y}) = \frac{\lambda}{e^{IC+}}(1 + \rho + \pi^H) < \frac{\lambda}{e^{IC}}(1 + \rho + \theta\pi^H) = u'(\lim_{t\uparrow T} c_t). \tag{A4}$$

The leftmost equality is, again, the steady state condition for all $t \geq T$. The inequality in (A4) follows from the above finding that $e^{IC+} > e^{IC}$ and that, by equation (11), $\theta > 1$. The rightmost equality involves the limit of home goods consumption as $t \to T$ *from the left* (denoted $\lim_{t\uparrow T} c_t$), i.e., driven by Taylor rule (11), and before the regime change at time T. If IC+ is to the right of the $\dot{\pi} = 0$ line and on the $\pi = \pi^H$ line, as point A in Figure 1, then, before the regime change, we have $\dot{\pi} < 0$ and, by equation (14), $\lim_{t\uparrow T} c_t \geq \bar{y}$. Hence, $u'(\lim_{t\uparrow T} c_t) \leq u'(\bar{y})$. A contradiction. **QED**

Thirdly, I will now show that there is only one continuous equilibrium path in the $(\pi, e/\lambda)$-plane associated with a stabilization program with inflation target = 0, satisfying all the conditions in Section II—that is discontinued in T periods and $\pi_t = \pi^H$, all $t \geq T$.

By equation A2, any equilibrium path has to hit point IC+ in Figure 1: the ratio e/λ must be the same for all equilibrium candidates. Thus, the arrowed solid (red) path in Figure 1 is the unique candidate for a continuous equilibrium path. Moreover, the farther is the initial point $(\pi_0, e_0/\lambda)$ from IC+, the longer it takes to reach it. Therefore, there exists at most one initial condition $(\pi_0, e_0/\lambda)$ that hits IC+ in T periods.

By equation (8), there exists a differentiable function C^*, such that,

$$c_t^* = C^*\big(\lambda(1 + i_t)\big). \tag{A5}$$

Therefore, by equations (13), (6'), A1, and A6, we have

$$\rho \int_0^T C^*\big(\lambda(1 + \rho + \theta\pi_t)\big) \exp(-\rho t)\, dt + C^*\big(\lambda(1 + \rho + \pi^H)\big) \exp(-\rho T) = \bar{y}^*. \tag{A6}$$

The equilibrium π path is uniquely determined because, as shown above initial condition $(\pi_0, e_0/\lambda)$ is a function of T. Thus, the only unknown in equation A6 is Lagrange multiplier λ. Moreover, the left-hand side expression in A6 is downward slopping with respect to λ. This ensures uniqueness. In addition, making the familiar Inada conditions can ensure existence. **QED**

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Figure 1. Imperfect Credibility

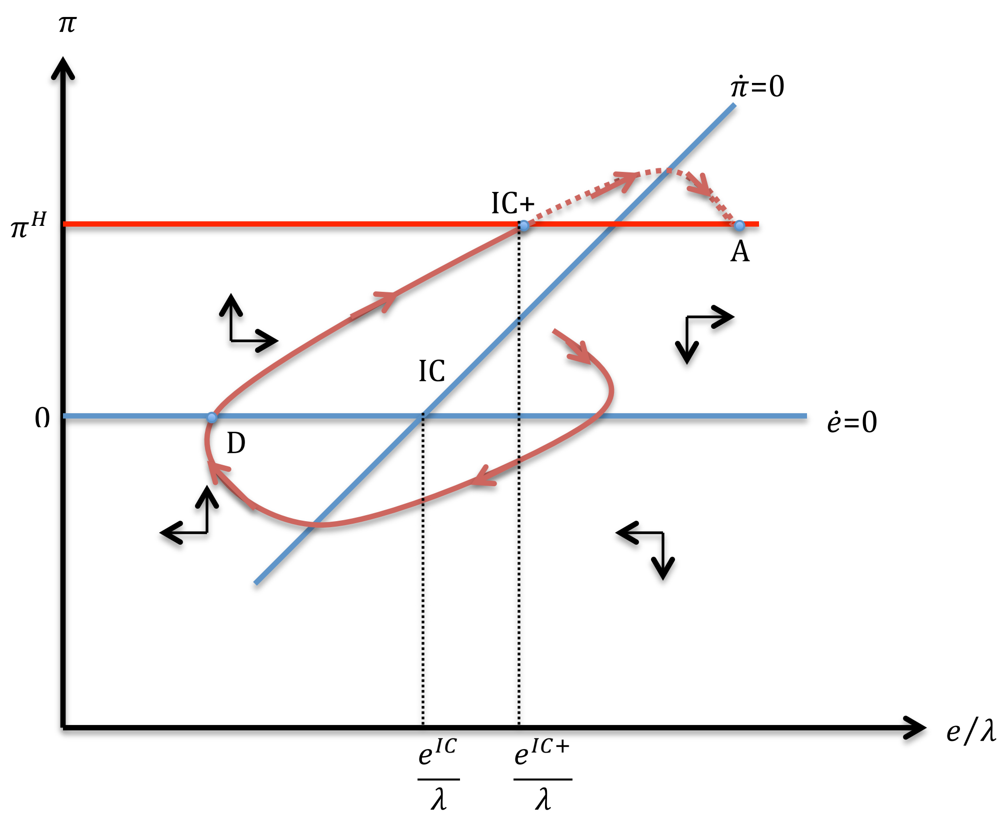

Figure 2. Backward-Looking Inflation: Slow Adjustment

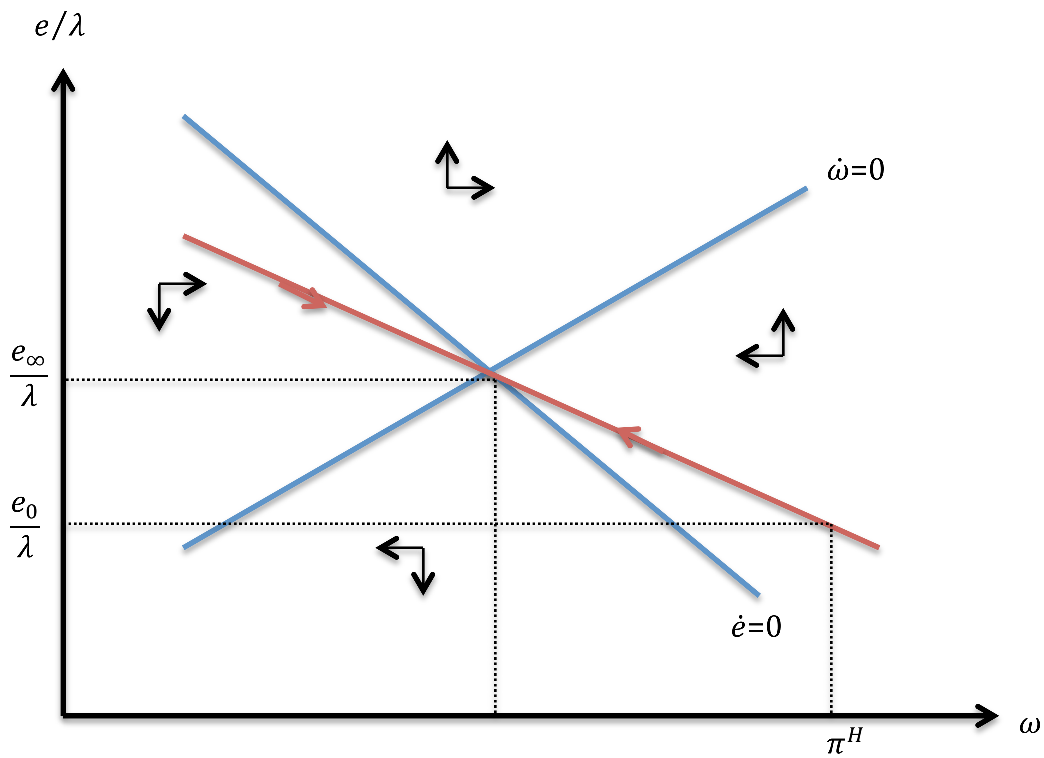

Figure 3. Backward-Looking Inflation: Fast Adjustment