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Credibility and the Dynamics of Stabilization Policy: A Basic Framework 1/

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Abstract

This paper studies price stabilization policy under both predetermined and flexible exchange rates. Under predetermined exchange rates, a non-credible stabilization program results in an initial expansion of output, followed by a later recession. The initial expansion accompanies an appreciating real exchange rate. Under flexible exchange rates, the recession occurs at the beginning of the program. The real exchange rate appreciates sharply on impact but depreciates afterwards. Lack of credibility is more costly under predetermined exchange rates because the real effects are more pronounced.

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Summary

In an open economy, a price stabilization program can be based either on fixing the rate of change of the nominal exchange rate (exchange rate-based stabilization), or on controlling the rate of growth of the money supply (money based-stabilization). Empirical evidence suggests that an exchange rate-based stabilization results in an initial expansion of output followed by a later recession. In contrast, under money-based stabilization, the recession occurs at the beginning of the program. Thus, choosing between the two nominal anchors seems to imply choosing not if but when the costs of bringing down inflation should be borne.

This paper develops a model that accounts for the main stylized facts associated with exchange rate-based stabilization and rationalizes the recession-now-versus-recession-later hypothesis. Lack of credibility in a stabilization program--in the sense that the public believes that the program will eventually be abandoned--is central to the analysis.

Under exchange rate-based stabilization, a non-credible program results in an initial expansion in the non-traded goods sector. The reason is that the temporarily lower nominal interest rate induces higher aggregate demand. As a result of the expansion, the inflation rate of non-tradable goods falls by less than the rate of devaluation --and could even increase. Hence, the real exchange rate appreciates throughout the program, which eventually results in a recession. The less credible is the program, the lower is the fall in inflation, but the more pronounced are the real effects.

Under money-based stabilization, a stabilization program always results in a recession. The higher demand for real money balances that results from a lower nominal interest rate requires a fall in output to equilibrate the money market. The real exchange rate appreciates sharply on impact but depreciates afterwards. After the initial fall, output returns gradually towards its full-employment level. The less credible is the program, the lower is the fall in inflation, but, unlike exchange rate-based stabilization, the real costs tend to vanish.

I. Introduction

The Southern-Cone stabilization programs of the late 1970's brought new challenges to economic theory. 1/ The underlying idea behind these programs was that by pegging the exchange rate to the dollar, the inflation rate would quickly come down to international levels. However --and to the surprise of policymakers--the inflation rate failed to converge quickly to the preannounced rate of devaluation, which resulted in massive real exchange rate appreciation. Moreover, real economic activity expanded despite an appreciating real exchange rate. Later in the programs--and even before the preannounced exchange rate system was abandoned--a recession set in. The eventual slump in economic activity that took place in the Southern-Cone programs gave rise to the notion of "recession now versus recession later," in comparing stabilizations based on controlling the money supply with stabilizations based on fixing the (rate of change of the) exchange rate (hereafter referred to as money-based and exchange rate-based stabilizations, respectively). The idea was that, under money-based stabilization, the costs (in terms of output losses) would be paid up-front, whereas, under exchange rate-based stabilization, the costs would be postponed until a later date. Thus, choosing between the two nominal anchors was viewed as choosing not if but when the costs of bringing down inflation should be borne. 2/

Almost half a decade later, the "heterodox" programs of Argentina, Israel, and Brazil, brought to life once again some of the same--and still mostly unresolved--issues. 3/ Real exchange rate appreciation was very much part of the picture in spite of the use of wage and price controls. More puzzling, however, was the re-emergence of the pattern of an initial boom and later recession. The Israeli recession was viewed as particularly hard to rationalize because of its occurrence in a fiscally sound and largely successful program. It then became clear that economic theory had to come to grips with the issue of an eventual recession in an exchange rate-based stabilization program.

Some observers, reminded of the old adage "the more things change, the more they remain the same," began to suspect that the similarities between the Southern-Cone and the heterodox programs were not purely coincidental. In particular, Kiguel and Liviatan (1990) dug up older

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1/ The Southern-Cone programs--which comprise the stabilization plans in Argentina, Chile, and Uruguay--have been discussed, among many others, by Harberger (1982), Corbo (1985), Fernández (1985), Hanson and de Melo (1985), Calvo (1986a), Ramos (1986), Edwards and Edwards (1987), Kiguel and Liviatan (1988), and Sjaastad (1989).

2/ See, for instance, Fernández (1985).

3/ These programs are referred to as "heterodox," because of the reliance on wage and price controls. For an account of these experiences, see, for instance, Blejer and Liviatan (1987), Bruno, di Tella, Dornbusch, and Fischer (1988), Helpman and Leiderman (1988), and Kiguel and Liviatan (1989).

programs, compared them to the programs of the late 1970's and mid-1980's, and concluded that most of the puzzling features observed in the Southern-Cone programs could be upgraded to the category of "stylized facts." 1/ Specifically, the beginning of an exchange rate-based stabilization program is characterized by a sustained real exchange rate appreciation and an overheated economy. 2/ Furthermore, later in the program, a recession takes hold. These stylized facts appear not to depend on whether the stabilization is ultimately successful or not. The scanty evidence on money-based stabilizations in chronic inflation countries also lends support to the notion that the recession takes place at the beginning of the program rather than later. Thus, the recession-now-versus-recession-later hypothesis appears to hold in practice.

Early models that attempted to explain the phenomena observed in the Southern-Cone programs (for instance, Rodriguez (1982) and Calvo (1983a)) were based on reduced-form behavioral equations. In both Rodriguez (1982) and Calvo (1983a), perfect capital mobility prevails and excess aggregate demand depends negatively on the real interest rate and positively on the real exchange rate (i.e., the relative price of tradable goods in terms of non-tradable goods). Rodriguez's (1982) key assumption is that expectations are adaptive rather than rational. Hence, a reduction in the rate of devaluation, which lowers the nominal interest rate, results in a fall in the real interest rate, because the expected rate of inflation of home goods is predetermined. The initial fall in the real interest rate causes an expansion (assuming that output of the home good is demand-determined). The real exchange rate begins to appreciate as inflation of home goods remains above the devaluation rate. Eventually, the impact of the real appreciation comes to dominate the effects of the lower real interest rate, and output falls.

In contrast to Rodriguez (1982), Calvo (1983a) assumes rational expectations and staggered price setting in the home-goods sector. A non-credible (i.e., temporary) reduction in the devaluation rate causes a reduction in the inflation rate of home goods that falls short of the decline in the rate of devaluation, thus causing the real exchange rate to appreciate. The fall in the domestic real interest rate that results from the expected real exchange rate appreciation increases excess aggregate demand on impact. 3/

1/ One notable exception appears to be the behavior of real interest rates, which declined in the Southern-Cone stabilizations but rose in the heterodox programs (see Kiguel and Liviatan (1990)).

2/ "Overheating" is defined as an expansion of the non-tradable (or home) goods sector above its full-employment level.

3/ Dornbusch (1982) also addresses the issues raised by the Southern-Cone programs in a rational expectations model. Dornbusch's key assumption is that there is inertia in the actual inflation rate, so that the inflation rate is predetermined at each point in time. The real exchange rate appreciation is thus a direct consequence of the reduction in the inflation rate of tradable goods.

An explicit comparison between money-based and exchange rate-based stabilization in a reduced-form model is carried out by Fischer (1986). In Fischer's model, prices are flexible but wages are predetermined as a result of long term nominal contracts. A money-based stabilization is recessionary, while an exchange rate-based stabilization has an ambiguous effect on output. The fall on impact of the real exchange rate, which is contractionary, could more than offset the expansionary effect of the fall in the real interest rate. 1/

A second group of models that attempts to explain the effects of exchange rate-based stabilizations derives behavioral equations from utility-maximizing consumers. These models include Obstfeld (1985), Calvo (1986b), Drazen and Helpman (1987, 1988), and Helpman and Razin (1987). Obstfeld (1985) and Drazen and Helpman (1987, 1988) include money as an argument in the utility function. Obstfeld (1985) studies a gradual reduction in the rate of devaluation, in the spirit of the Southern-Cone "tablitas." Obstfeld concludes that, if the cross-derivative between real money balances and consumption is negative, then, on impact, consumption of both tradable and home goods increase and the real exchange rate appreciates. Drazen and Helpman (1987, 1988) assume that consumption and money enter separably in the utility function and study the effects of anticipated changes in fiscal policy. If the government freezes the exchange rate and announces that it will reduce spending on tradable goods in the future, then, on impact, consumption of tradable goods increases, the current account goes into deficit, and the real exchange rate appreciates. Helpman and Razin (1987) focus on a Blanchard-type model in which Ricardian equivalence does not hold. An initial expansion in consumption may result from an exchange rate freeze, accompanied by future taxes, that generates a positive wealth effect for the current generation.

Calvo (1986b) introduces money through a cash-in-advance constraint and examines a non-credible (i.e., temporary) reduction in the rate of devaluation. The assumption of perfect capital mobility implies that the temporary reduction in the rate of devaluation translates into a temporary reduction in the nominal interest rate, and thus in the cost of consumption (since the cost of consumption includes the opportunity cost of holding money). Hence, the consumer increases the demand for current tradable goods relative to future tradable goods, which results in a current account deficit. When the policy is discontinued, consumption of tradable goods falls below its initial level. If it is assumed that the tradable good acts as the only input in the production of home goods, Calvo (1986b) shows that the real exchange falls on impact but remains constant thereafter until the policy is discontinued.

1/ Interestingly enough, Fischer (1986, p. 252) dismisses the possibility of an initial expansion, stating that "(i)ndeed, as a curiosity to be ignored henceforth, it is even possible that the real interest rate falls so much that (an initial) boom (results)."

All the models just reviewed provide valuable insights into the effects of stabilization policy. Some issues, however, remain unexplained. Specifically, a utility-maximizing model of exchange rate-based stabilization has yet to account for the following features. First, at the beginning of the program, the home-goods sector is operating above its full-employment level at the same time that the real exchange rate is appreciating. Second, the home-goods sector enters into recession (i.e., output falls below its full-employment level) either when or before the program is discontinued. Third, the inflation rate of home goods remains above the rate of devaluation for a long period of time, resulting in a sustained and cumulative real exchange rate appreciation.

A review of the literature also suggests that there exists the need to bring together the various analytical pieces and provide a unified analytical framework within which exchange rate-based and money-based stabilization policy can be analyzed. Thus, building on Calvo (1983a, 1986b), this paper develops an analytical framework which, first, accounts for the main stylized facts of exchange rate-based stabilization--including those just discussed--and, second, compares exchange rate-based stabilization with money-based stabilization.

The four key ingredients of our model are: (i) intertemporal consumption substitution; (ii) liquidity-in-advance constraint; (iii) price-staggering in the home-goods sector; and (iv) currency substitution. None of these assumptions can be relaxed in our model without loosing the capacity of explaining some of the key features of exchange rate-based or money-based stabilizations. Thus, in this sense, this paper provides a "minimal" model for rationalizing some of the puzzles associated with stabilizations.

The demand side of the model follows the Ramsey-Lucas tradition of a representative individual subject to a cash-in-advance constraint. Instead of just "cash," we assume that the individual can hold domestic and foreign currency in variable proportions--an assumption that is known as "currency substitution"--which explains the use of the term "liquidity-in-advance" constraint. This assumption is very relevant because it is well-known that in high-inflation countries foreign currencies are widely used as a store of value as well as for transactions purposes. 1/

There exist two types of goods: tradable and non-tradable (or home) goods. This distinction allows us to model and discuss the real exchange rate (i.e., the relative price of tradable goods in terms of home goods). Production of tradable goods is exogenous and subject to perfect price flexibility, while home goods exhibit staggered price setting à la Phelps-Taylor (see Phelps (1978), Taylor (1979, 1980)) with a Calvo twist (Calvo (1983b)). Output of home goods is demand-determined.

1/ For evidence on currency substitution in small open economies, see, for instance, Ortiz (1983), Ramirez-Rojas (1985), El-Erian (1988), and Canto and Nickelsburg (1989).

Under full credibility, a reduction in the rate of devaluation, and thus of the nominal interest rate, induces the consumer to substitute away from foreign currency and toward domestic currency. The resulting wealth effect--due to lower seigniorage payments on foreign currency--leads to higher consumption of tradable goods. Since, under fixed exchange rates and sticky prices, the relative price of tradable goods in terms of home goods (i.e., the real exchange rate) is given in short run, the rise in the consumption of tradable goods must be accompanied by a corresponding increase in the demand for home goods. The inflation rate of home goods falls by less than the rate of devaluation and could even increase. As a result, the domestic real interest rate falls and the real exchange rate begins to appreciate. Thus, the predictions of the model under full credibility are consistent with some of the stylized facts of exchange rate-based stabilizations--in particular, the initial expansion and real exchange rate appreciation. However, the eventual recession is left unexplained.

A fully-credible reduction in the rate of growth of the money supply also leads to higher consumption of tradable goods due to the wealth effect just discussed. However, there is a recession in the home-goods sector. The reason is that the excess demand for domestic money that results from a lower nominal interest rate necessitates a fall in consumption of home goods to equilibrate the domestic money market. The inflation rate of home goods falls by more than the nominal interest, so that the domestic real interest rate increases.

The model thus highlights key differences between the impact effects of exchange rate-based and money-based stabilization that are unrelated to credibility problems (to be discussed below). Specifically, under full credibility, an exchange rate-based stabilization (i) causes an expansion in the home-goods sector, (ii) may have little effect on the inflation rate of home goods, and (iii) reduces the domestic real interest rate. In contrast, a money-based stabilization (i) results in a recession, (ii) sharply reduces the inflation rate of home goods, and (iii) increases the domestic real interest rate.

Discontinuation of stabilization programs is the focal point of the present paper. Following Calvo (1986b), we analyze this issue in the simplest possible manner by focusing on the implications of temporary policy. 1/ By definition, a temporary policy is one that will be discontinued in the future. A temporary policy is equivalent to the case in which the authorities intend to continue the present policy but the public does not fully believe it (i.e., there exists lack of policy credibility). Thus, our analysis is capable of killing two birds with one stone: (i) it addresses the issue of policy temporariness, and (ii) it sheds some light on the implications of non-credible policies.

1/ In order to focus on the effects of lack of credibility, the analysis of temporary policy abstracts from the wealth effect discussed above.

Consider, once again, the case of predetermined exchange rates, and imagine that the public expects inflation-as-usual to be resumed after a few months. The momentary lowering of the rate of devaluation brings down the domestic nominal interest rate which, in turn, lowers the effective cost of consumption (because the latter includes the opportunity cost of holding money). Since this phenomenon is seen as transitory, it leads the public to increase the demand for present tradable goods (and, correspondingly, to decrease the demand for future tradable goods). Since the relative price of tradable goods in terms of home goods is given in the short run, the rise in the consumption of tradable goods must be accompanied by a corresponding increase in the demand for home goods. The rise in aggregate demand implies that the inflation rate of home goods falls by less than the rate of devaluation--and could even increase. Thus, a prolonged period of real exchange rate appreciation sets in, as the inflation rate of home goods remains above the devaluation rate until the policy is discontinued. Thus, an overheated economy co-exists with an appreciating real exchange rate for a prolonged period of time.

After increasing when the devaluation rate is reduced, excess aggregate demand for home goods, and hence output, fall over time as the relative price of home goods increases. At some point in time--when the policy is discontinued or even before that--output falls below its full-employment level. Therefore, a recession sets in later in the program even if the policy has yet to be discontinued.

Under flexible exchange rates, lack of credibility does not substantially alter the impact effect of a reduction in the rate of growth of the money supply. Both output and inflation (of home and tradable goods) fall on impact. Thus, under flexible exchange rates, stabilization policy is always contractionary irrespective of policy credibility. The real exchange rate falls on impact and remains below its new steady-state value during the whole adjustment process. The model thus suggests that the simultaneous occurrence of an overheated economy and a real exchange rate lower than its steady-state equilibrium is not likely to be observed in stabilization programs that rely on flexible exchange rates. 1/

Another important difference between exchange rate-based and money-based stabilization lies in the effects of lower credibility. Under flexible exchange rates, a stabilization program that enjoys very little credibility has basically no effect either on real variables or on inflation. In sharp contrast, under predetermined exchange rates, lower credibility only exacerbates intertemporal substitution effects and,

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1/ Most stabilization programs have relied on some form of predetermined exchange rates. Even in cases in which some floating is allowed--as in the 1985 stabilization plan in Bolivia--there is usually extensive government intervention in exchange markets. Hence, it may not be easy to find suitable cases to test the validity of the model's implications for flexible exchange rates.

therefore, all ensuing real effects. In this sense, therefore, substantial lack of credibility is more costly under exchange rate-based stabilization than under money-based stabilization.

The paper proceeds as follows. Section II discusses the basic model. Section III deals with exchange rate-based stabilization. Section IV addresses money-based stabilization. Section V discusses the role of nominal "anchors" in stabilization plans in light of the theoretical analysis. Some final remarks close the paper in Section VI.

II. The Model

Consider a small open economy inhabited by a large number of identical individuals. The utility function of the representative individual is

$$(1) \qquad \int_0^\infty u(c_t, c_t^*)\exp(-\beta t)dt,$$

where u(.), the instantaneous utility function, is increasing, twice-continuously differentiable, and strictly concave; c and c^* denote consumption of non-tradable (or home) and tradable goods, respectively; and β is the positive and constant subjective discount rate.

There exists currency substitution in the economy, in the sense that both domestic (M) and foreign currency (F) are used to carry out transactions. Let E denote the nominal exchange rate (in units of domestic currency per unit of foreign currency), P^* denote the (constant) foreign currency price of the tradable good, and P denote the domestic currency price of the home good. Then, real domestic money balances, m, and real foreign money balances, f, are defined as $m \equiv M/EP^*$ and $f \equiv F/P^*$. 1/ The relative price of tradable goods in terms of home goods, e, is defined as $e \equiv EP^*/P$. (To maintain the conventional terminology, e will be referred to as the "real exchange rate.") As usual, domestic and foreign money are assumed to be imperfect substitutes because of, say, legal restrictions or

1/ Except for the real exchange rate (defined below)--and unless otherwise indicated--the term "real" refers to nominal variables deflated by the price of traded goods.

different transactions patterns. 1/ Formally, the consumer is subject to a liquidity-in-advance constraint 2/

$$(2) \qquad c_t/e_t + c_t^* \le \ell(m_t, f_t), \qquad \ell_m>0,\ \ell_f>0,\ \ell_{mm}<0,\ \ell_{ff}<0,\ \ell_{mf}>0,$$

where $\ell(.)$ is a linearly homogenous, twice-continuously differentiable function, which may be interpreted as a liquidity-services production function. 3/ 4/ Equation (2) states that total real expenditure in terms of tradable goods cannot exceed liquidity services produced by domestic and foreign money.

The consumer also holds an internationally-traded bond, b, whose (constant) rate of return, in terms of tradable goods, is r. Real financial wealth is thus

$$(3) \qquad a_t = m_t + f_t + b_t.$$

The consumer's lifetime budget constraint is

$$(4) \quad a_0 + \int_0^{\infty} (y_t/e_t + y_t^* + \tau_t)\exp(-rt)dt = \int_0^{\infty} (c_t/e_t + c_t^* + i_t m_t + r f_t)\exp(-rt)dt,$$

where y and y^* denote income of home and tradable goods, respectively, τ stands for lump-sum transfers from the government, and i is the nominal interest rate.

1/ Casual evidence in chronic-inflation countries suggests that foreign currency--usually U.S. dollars--is used for large transactions while domestic currency is used for small transactions.

2/ The liquidity-in-advance constraint has been used (with interest-bearing demand deposits in lieu of foreign currency) by Walsh (1984) and Calvo and Végh (1990a,b,c). Currency substitution has usually been modeled by making both monies arguments in the utility function (see, for example, Liviatan (1981), Calvo (1985), Végh (1988), and Rogers (1990)). For alternative approaches, see Poloz (1984) and Guidotti (1989) who model currency substitution in a Baumol-Tobin context, and Végh (1989a,b) who assumes that both monies reduce "shopping" time.

3/ A subscript on a function denotes partial differentiation.

4/ The assumption $\ell_{mf}>0$ is equivalent to ruling out perfect substitutability between m and f. (Notice that if $\ell_{mf}=0$, then, by Euler's theorem, $\ell_{mm}=\ell_{ff}=0$, in which case $\ell(m,f)$ is a linear function.)

The consumer's problem consists in choosing paths of c, c^*, m, and f, to maximize (1) subject to (2), (4), and initial real financial wealth, a_0. To simplify the analysis, it will be assumed that $u(c,c^*) = \log(c)+\log(c^*)$. 1/ 2/ In addition to (2)--holding with equality--and (4), the other first-order conditions can be expressed as 3/

(5) $$1/c_t^* = \lambda[1 + i_t/\ell_m(m_t,f_t)],$$

(6) $$c_t/c_t^* = e_t$$

(7) $$\ell_m(m_t,f_t)/\ell_f(m_t,f_t) = i_t/r,$$

where λ is the (time-invariant) Lagrange multiplier associated with constraint (4). 4/ Equation (5) represents the familiar condition whereby the consumer equates the marginal utility of consumption of tradable goods to the shadow price of wealch times the "price" of tradable goods. The relevant "price" of the tradable good in this model--which will be referred to as the effective price--is given by the term in square brackets on the right-hand side (RHS) of equation (5). The effective price consists of the market price (unity) plus the cost of producing the liquidity services needed to purchase one unit of the good ($i/\ell_m(m,f)$). Intuitively, note that one additional unit of liquidity services is needed to purchase an additional unit of tradable goods. The production of a unit of liquidity services requires $1/\ell_m(m,f)$ units of m, whose cost is $i/\ell_m(m,f)$. 5/ Equation (6) indicates that, at an optimum, the marginal rate of substitution between tradable and home goods equals the relative price of tradable goods in terms of home goods (i.e, the real exchange rate).

At an optimum, the marginal rate of substitution between domestic and foreign money equals the ratio of their opportunity costs, as indicated by equation (7). Equation (7) implicitly defines the demand for f

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1/ While the logarithmic form is critical in simplifying the analysis under flexible exchange rates, it would be straightforward to conduct the analysis of predetermined exchange rates under a general, but separable, utility function.

2/ Since it will be assumed that output of home goods is always demand-determined, the consumer is not subject to any quantity constraints.

3/ Equation (2) holds with equality at an optimum because the opportunity cost of both monies will be assumed to be positive.

4/ It has been assumed that β=r to ensure the existence of a steady-state.

5/ Formally, differentiate equation (2), as an equality, and set $d(c/e)=df=0$, to obtain $dm/dc^*=1/\ell_m(m,f)$.

relative to m as a function of i/r (recall that $\ell(m,f)$ is homogenous of degree one so that $\ell_m(m,f)$ and $\ell_f(m,f)$ are homogeneous of degree zero):

$$(8) \qquad f_t/m_t = \phi(i_t/r), \qquad \phi'(i_t/r)>0.$$

An increase in the nominal interest rate induces a rise in foreign money balances relative to domestic money balances, which characterizes the phenomenon of currency substitution (also known as "dollarization"). 1/

The sum of m and f will be referred to as "real liquidity" and will be denoted by z (i.e., $z\equiv m+f$). Combining equations (2)--holding with equality--and (8) yields the demand for m, f, and z:

$$(9) \qquad m_t = (c_t/e_t+c_t^*)\Phi^m(i_t/r), \qquad \Phi^{m\prime}(i_t/r)<0,$$

$$(10) \qquad f_t = (c_t/e_t+c_t^*)\Phi^f(i_t/r), \qquad \Phi^{f\prime}(i_t/r)>0,$$

$$(11) \qquad z_t = (c_t/e_t+c_t^*)\Phi^z(i_t/r), \qquad \Phi^{z\prime}(i_t/r)>0.$$

As one would expect, the demands for m and f depend positively on real expenditure ($c/e+c^*$) and negatively on their respective opportunity costs, as equations (9) and (10) indicate. Under the assumption that $i>r$, the demand for z depends positively on i/r (equation (11)). In other words, an increase in i, for given $c+ec^*$, reduces the demand for m by less than it raises the demand for f, which results in a higher demand for z. The reason is that the marginal productivity of m is higher, at an optimum, than that of f, because the opportunity cost of m is higher than that of f (recall equation (7)). Hence, for given real expenditure, a rise in i must reduce the demand for m by less than it increases the demand for f for liquidity services (and thus real expenditure) to remain constant.

Equations (7) and (8) can be used to express the effective price of tradable goods--given by the term in square brackets on the RHS of equation (5)--as a function of i/r, which will be denoted by p(i/r):

$$(12) \qquad p(i_t/r) = 1 + r/\ell_f[1,\phi(i_t/r)], \qquad p'(i_t/r)>0.$$

1/ An asset demand function such as (8) was the key building block in early models of currency substitution (see Kouri (1976) and Calvo and Rodriguez (1977)).

A reduction in i lowers the effective price of tradable goods because it reduces the opportunity cost of one of the two monies that are used to produce liquidity services. First-order condition (6) implies that the effective price of home goods is p(i/r)/e, so that a reduction in i also lowers, for given e, the effective price of c. Changes in the effective price of consumption as a result of changes in the nominal interest rate will play a key role in the analysis.

Let us now turn to equilibrium conditions. The present discounted value of government transfers is given by:

$$(13) \quad \int_0^\infty \tau_t \exp(-rt)dt = q_0 + \int_0^\infty (\dot{m}_t + \varepsilon_t m_t)\exp(-rt)dt,$$

where q_0 denotes the government's initial stock of bonds, and $\varepsilon(=\dot{E}/E)$ denotes the instantaneous rate of devaluation (or depreciation).

Equilibrium in the home-goods market requires that

$$(14) \qquad c_t = y_t.$$

Moreover, perfect capital mobility is assumed, which implies that

$$(15) \qquad i_t = r + \varepsilon_t.$$

Combining equations (4), (13), (14), and (15) (and imposing the usual transversality condition) yields the economy's resource constraint:

$$(16) \qquad k_0 + \int_0^\infty y_t^* \exp(-rt)dt = \int_0^\infty (c_t^* + rf_t)\exp(-rt)dt,$$

where k=f+b+q denotes the economy's stock of bonds. Equation (16) states that the economy's wealth (i.e., the present discounted value of tradable resources) equals the present discounted value of consumption of tradable goods plus seigniorage on foreign money paid to the rest of the world. 1/

1/ See Fischer (1982) for estimates of the cost, in terms of seigniorage, of using a foreign currency.

To derive the current account, consider the consumer's flow constraint given by

$$(17) \qquad \dot{a}_t = y_t/e_t + y_t^* - c_t/e_t - c_t^* + rb_t - \varepsilon_t m_t + \tau_t.$$

Under predetermined exchange rates, the government's flow constraint indicates that the excess of revenues over spending results in asset (or reserve) accumulation; namely, $\dot{q}_t=\dot{m}_t+\varepsilon_t m_t+rq_t-\tau_t$. Combining the latter with equation (17) yields the current account balance:

$$(18) \qquad \dot{k}_t = rk_t + y_t^* - c_t^* - rf_t,$$

As expected, the accumulation of net foreign assets (i.e., the current account balance) equals the difference between income of tradable goods and expenditure on tradable goods. Expenditure on tradable goods comprises consumption of tradable goods plus the rental cost of foreign money holdings. 1/

Naturally, equation (18) also obtains under flexible exchange rates. To derive (18) under flexible exchange rates, note that the central bank accumulates no reserves (and the government's initial stock of bonds is taken to be zero). The growth of real money balances is given by

$$(19) \qquad \dot{m}_t/m_t = \mu_t - \varepsilon_t,$$

where $\mu(=\dot{M}/M)$ is the rate of growth of the nominal money supply. Transfers are given by $\tau_t=\mu_t m_t$. Combining the latter equation with (19) and (17) yields the current account balance (18) with $q_t=0$.

We now turn to the supply side of the model. To simplify the analysis, it will be assumed that the supply of tradable goods is exogenously given at the constant level y^* (i.e., $y_t^*=y^*$ for all t), while

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1/ The equilibrium path of reserves follows from assuming, as usual, that domestic credit expansion just compensates the consumer for the depreciation of real money balances, so that $\tau_t=rq_t+\varepsilon_t m_t$. Substituting the latter into the government's flow constraint yields, $\dot{q}_t=\dot{m}_t$. Thus, changes in reserves reflect changes in domestic real money balances.

the home-goods sector operates under staggered price setting and supply is demand-determined. 1/ Following the staggered-prices model in Calvo (1983b), it is assumed that:

$$(20) \qquad \dot{\pi}_t = -\theta D_t, \qquad \theta > 0,$$

where π is the inflation rate of home goods, and $D = y-\bar{y}$, where $\bar{y}$ could be interpreted as "full-employment" output. Thus, D is a measure of excess demand in the home-goods market. As shown in Calvo (1983b), equation (20) can be derived from a setup in which firms set prices in an asynchronous manner, taking into account the expected future path of the average price of home goods and the path of excess demand in that market. Equation (20) indicates that the rate of change in the inflation rate is a negative function of excess demand. Intuitively, the higher is excess demand at time t, the higher will be the prices set by those firms that revise their prices at time t. Therefore, the higher is excess demand at time t, the higher will be the rate of inflation of home goods at t, π_t. Furthermore, excess demand at time t is not taken into account by price setters at t', for all t'>t. Hence, the higher is excess demand at time t, the sharper will be the drop in the inflation rate after t, which is what equation (20) asserts. 2/

Substituting $D_t=y_t-\bar{y}$ into (20) and imposing home-goods market equilibrium (14) yields

$$(21) \qquad \dot{\pi}_t = \theta(\bar{y} - c_t),$$

which constitutes one of the key dynamic equations.

We now derive the equilibrium path of consumption of tradable goods. First-order condition (5) and the economy's resource constraint (16) imply that (recalling that $y_t^*=y^*$ for all t)

1/ A more symmetric, but analytically less convenient, formulation would assume that (i) output in each sector is produced by a neoclassical production function with labor as the only input, (ii) prices are flexible, and (iii) wages are set in a staggered manner.

2/ The microfoundations of the staggered-prices model are discussed in Calvo (1982) and Romer (1989).

$$(22) \qquad c_t^* = \frac{y^* + rk_0 - r\int_0^\infty rf_t \exp(-rt)dt}{p(i_t/r)r\int_0^\infty [1/p(i_t/r)]\exp(-rt)dt},$$

where the definition of the effective price of consumption of tradable goods, given by (12), has been used. The numerator in equation (22) represents permanent income. The inverse of the denominator can be interpreted as the equilibrium marginal propensity to consume (MPC) tradable goods out of permanent income (see Calvo and Végh (1990a) for details), and reflects intertemporal substitution effects. If the nominal interest rate is constant over time (and equal to $\bar{i}$), the denominator, and thus the MPC, becomes unity. The time path of the effective price is constant over time so that there are no incentives to engage in intertemporal consumption substitution. Specifically, if $i_t = \bar{i}$, for all t, consumption of tradable goods is given by (using (2), holding with equality, (6), (8), and (22))

$$(23) \qquad c_t^* = \frac{y^* + rk_0}{1 + 2r/\ell[1/\phi(\bar{i}/r),1]},$$

which implies that consumption of tradable goods is constant over time. It follows that unanticipated and permanent changes in i will affect c^* only through the wealth effect that results from using a different stock of foreign currency.

In order to isolate the substitution effects that result from temporary policy, the analysis will abstract from the wealth effect when studying temporary policy. For further reference, then, note that, if we abstract from seigniorage payments on foreign currency, equation (22) reduces to 1/

1/ Equation (24) can be derived by proceeding in the same way as before. Formally, we are implicitly assuming that seigniorage paid on foreign currency held by domestic residents is given back to the domestic economy.

(24) $$c_t^* = \frac{y^* + rk_0}{p(i_t/r)r\int_0^{\infty}[1/p(i_t/r)]\exp(-rt)dt}.$$

Since the wealth effect associated with substituting foreign for domestic currency is no longer present, unanticipated and permanent changes in i have no effect on c^* because $c_t^* = y^* + rk_0$ for <u>any</u> level of i, as long as i is constant over time.

Having introduced the analytical framework which is common to the cases of both predetermined and flexible exchange rates, we can now proceed to study stabilization policy under each regime separately.

III. Exchange Rate-Based Stabilization

This section studies stabilization plans based on lowering the (exogenously given) rate of devaluation. It will be assumed here--and throughout this section--that prior to any policy change at t=0, the rate of devaluation, ε, is fixed at ε^h and is expected to remain constant forever. The economy is thus at a steady-state given by (steady-state values are denoted by a subscript "ss"):

(25) $$i_{ss} = r + \varepsilon^h,$$

(26) $$\pi_{ss} = \varepsilon^h,$$

(27) $$c_{ss} = \bar{y},$$

(28) $$c_{ss}^* = \frac{y^* + rk_0}{1 + 2r/\ell\{1/\phi[(r+\varepsilon^h)/r],1\}},$$

(29) $$e_{ss} = \bar{y}/c_{ss}^*,$$

(30) $$r_{ss}^d = r,$$

(31) $$m_{ss} = 2c^{*}_{ss}\Phi^{m}[(r+\varepsilon^{h})/r],$$

(32) $$f_{ss} = 2c^{*}_{ss}\Phi^{f}[(r+\varepsilon^{h})/r],$$

(33) $$z_{ss} = 2c^{*}_{ss}\Phi^{z}[(r+\varepsilon^{h})/r].$$

The nominal interest rate (equation (25)) follows from the assumption of perfect capital mobility (equation (15)). For the real exchange rate to remain constant, the inflation rate of tradable goods (i.e., the rate of devaluation) and the inflation rate of home goods must be the same, as indicated by equation (26). From equation (21), it follows that consumption of home goods must equal full-employment output for inflation of home goods to remain constant, as indicated by equation (27). Consumption of tradable goods, given by (28), follows from (23) and (25) because the devaluation rate, and thus the nominal interest rate, are constant over time. The steady-state level of the real exchange rate, given by (29), follows from (6) and (27). A higher steady-state consumption of tradable goods must be accompanied by a lower real exchange rate (i.e, a lower relative price of tradable goods). Equation (30) indicates that the steady-state domestic real interest rate, r^{d} (defined as $r^{d} \equiv i - \pi$), equals r, which follows from the definition and equations (25) and (26). Equations (31)-(33) follow from (9)-(11), using (6) and (25).

1. <u>Permanent reduction in the rate of devaluation</u>

Suppose that the economy is initially at the steady-state just described. At t=0 (the "present"), policymakers announce that the rate of devaluation will be immediately and permanently reduced from ε^{h} to ε^{ℓ}. 1/ Furthermore, the announcement is fully credible, in the sense that the public <u>expects</u> that the devaluation rate will stay at ε^{ℓ} for the indefinite future.

Perfect capital mobility (see equation (15)) implies that the fall in the rate of devaluation causes the nominal interest rate to adjust immediately to its lower steady-state value, given by $r+\varepsilon^{\ell}$. The reduction in the nominal interest rate lowers the opportunity cost of domestic money relative to foreign money, which induces the consumer to reduce the ratio of foreign to domestic currency. The adjustment to the new steady-state value is instantaneous, because, from (8), the ratio f/m depends only on the nominal interest rate. The consumer increases his or her holdings of real domestic money balances by exchanging foreign currency for domestic currency at the central bank.

1/ Throughout the paper, superscripts "h" and "ℓ" stand for "high" and "low" levels, respectively, of a policy variable.

Since the lower nominal interest rate is expected to prevail forever, consumption of tradable goods is given by equation (23). The constant path of the nominal interest rate implies that there are no incentives to engage in intertemporal substitution; in other words, the path of c^* will remain flat. The substitution of domestic for foreign money results in lower seigniorage payments on foreign currency, which increases the present discounted value of tradable resources. This wealth effect causes c^* to adjust instantaneously to its higher level, as indicated by (23). 1/

We now turn to the behavior of the real exchange rate, e, and inflation of home goods, π. Substituting (6) into (21) yields

$$(34) \qquad \dot{\pi}_t = \theta(\bar{y} - e_t c_t^*).$$

Since $e \equiv EP^*/P$, it follows that (recall that P^* is constant)

$$(35) \qquad \dot{e}_t = (\varepsilon - \pi_t)e_t,$$

where ε denotes the constant rate of devaluation. The determinant associated with the linear approximation of the dynamic system (34) and (35) around the steady-state equals $-\theta\bar{y}$, which, being negative, indicates that the system exhibits saddle-path stability. Figure 1 depicts the corresponding phase diagram. The initial steady-state is at point A where $\pi_{ss}=\varepsilon^h$ and $e_{ss}=\bar{y}/c_{ss}^*$. The new steady-state is given by either B or D, depending on the magnitude of the fall in e_{ss}. The fall in e_{ss} depends, in turn, on how large is the increase in c_{ss}^*, and hence on the magnitude of the wealth effect discussed above. 2/ If the increase in c_{ss}^* is relatively small (c_{ss}^* increases to, say, $c_{ss}^{*\prime}$), then the fall in e_{ss} is small as well (e_{ss} falls to e_{ss}', where $e_{ss}'=\bar{y}/c_{ss}^{*\prime}$); the new steady-state is thus at point B, and B'B' denotes the corresponding saddle path. On impact, the inflation rate of home goods <u>falls</u> from A to C and then proceeds along the saddle path B'B' towards point B. If the increase in c_{ss}^* is relatively large (c_{ss}^* increases to, say, $c_{ss}^{*\prime\prime}$, where $c_{ss}^{*\prime\prime}>c_{ss}^{*\prime}$), then the fall in e_{ss} is large as well (e_{ss} falls to e_{ss}'', where $e_{ss}'' = \bar{y}/c_{ss}^{*\prime\prime}$); the new steady-state is thus at point D, and D'D' denotes the

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1/ The rise in c^* increases the demand for foreign currency, thus <u>partially</u> offsetting the negative effect on the demand for foreign currency of the reduction in i. To see that f necessarily decreases as a result of the fall in i, note that if i, and hence c^*, are constant over time, so is f, as follows from (2), (6), and (8). Hence, equation (22) reduces to $c^*=y^*+rk_0-rf$. The rise in c^*, which follows from (23), implies that f falls.

2/ One would conjecture that, for a given reduction in ε, the higher the elasticity of substitution between domestic and foreign money, the higher the wealth effect, and thus the larger the rise in c^*.

corresponding saddle path. In this case, the inflation rate of home goods <u>increases</u> on impact from A to E and then the system proceeds along D'D' towards point D. 1/ In both cases, the real exchange rate appreciates over time towards its lower steady-state value.

The intuition behind the result that π can either increase or fall on impact lies in the presence of two opposing forces. The first force acting on π is the reduction in the devaluation rate. In the absence of any wealth effect--because of, say, fixed proportions between domestic and foreign money--π would instantaneously adjust to its lower steady-state level (i.e. π would jump from A to F in Figure 1) because c^* would remain at its initial level. The second force acting on π is the wealth effect that results from substituting domestic for foreign currency. This effect tends to increase π because the higher c^*_{ss} necessitates a fall in the relative price of c^* (i.e., a real exchange rate appreciation). For a given rate of devaluation, this requires a rise in the inflation rate of home goods, π.

If π decreases on impact, then the average inflation rate--which is a weighted average of π (the inflation rate of home goods) and ε (the inflation rate of tradable goods)--also jumps downwards. 2/ The wealth effect could, in principle, be strong enough for the rise in π to more than offset the reduction in ε and thus cause the average inflation rate to rise. 3/

Let us now examine the behavior of consumption of home goods. It follows from equation (6) that, since e is given on impact, c must increase on impact as a result of the jump in c^*. Because c^* is time invariant (i.e., $\dot{c}^*=0$), first-order condition (6) implies that, after increasing on impact, c declines over time towards its unchanged steady-state level, $\bar{y}$, as the real exchange rate appreciates. Hence, the domestic real interest rate must fall on impact and remain below the world real interest rate throughout the adjustment path to induce consumers to choose a declining consumption path.

We have thus shown that, <u>in the presence of currency substitution, an exchange rate-based stabilization program results in an initial expansion, even if the program enjoys full credibility</u>. The inflation rate of home

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1/ As one would expect, simulations of the model suggest that a high elasticity of substitution between m and f is required for π to increase on impact.

2/ The average inflation rate is defined as the proportional change in the marginal cost of increasing utility by one unit and equals $(1/2)(\pi+\varepsilon)$, given that both goods have the same weight in the utility function.

3/ The openness of the economy--as reflected in the weight attached to the inflation of tradable goods in the average inflation rate--should also play an important role in determining the direction of the initial jump in the average inflation rate. This could be easily incorporated into the present analysis by working with a more general utility function.

goods falls by less than the devaluation rate--and could even increase--thus causing real exchange rate appreciation. These predictions of the model are consistent with the stylized facts discussed in the Introduction. However, the eventual recession is left unexplained. To account for such a feature, lack of credibility needs to be introduced into the picture. 1/

2. Temporary reduction in the rate of devaluation

Consider now a temporary reduction in the rate of devaluation. 2/ Initially (i.e, before time 0), the devaluation rate is ε^h. At t=0, it is set to a lower level; after a while, however, the devaluation rate is increased back to its original level. Formally, for some T>0,

$$(36a) \qquad \varepsilon_t = \varepsilon^\ell, \qquad 0 \le t < T,$$

$$(36b) \qquad \varepsilon_t = \varepsilon^h, \qquad t \ge T,$$

where $\varepsilon^h > \varepsilon^\ell$.

The path of the nominal interest rate under policy (36) follows from equation (15): i falls at t=0 and remains at that level up to t=T, at which time it increases back to its initial level given by (25). This path of the nominal interest rate induces the consumption path of tradable goods illustrated in Figure 2, Panel A. Since the effective price of c^*

1/ It is worth stressing that when foreign and domestic currency are held in fixed proportions, the adjustment is instantaneous. This has two important implications. First, it is the substitutability between domestic and foreign currency rather than the presence of foreign currency in itself that causes a slow adjustment. Second, sticky prices need not imply slow adjustment to the new steady-state equilibrium. Hence, our model flatly contradicts the popular view that the presence of staggered prices results in slow adjustment towards the new full-employment equilibrium.

2/ Later in the section, the temporariness of the policy will be interpreted as lack of credibility in the stabilization plan. In order to isolate the effects of policy temporariness, the ensuing analysis will abstract from the wealth effect resulting from lower seigniorage payments that was the focus of the previous case. (Note that, in the absence of the wealth effect, a permanent reduction in ε results in an instantaneous adjustment of π to its lower steady-state value.) Therefore, in what follows, equation (24) applies to consumption of tradable goods. Since, as we will see, the intertemporal substitution effects resulting from temporary policy are sufficient to generate an initial expansion, including the wealth effect would only reinforce the expansionary effects of a temporary reduction in the devaluation rate.

is lower during [0,T) than during [T,∞) (recall (12)), there is intertemporal substitution toward present consumption, which results in high consumption of tradable goods during [0,T) and low consumption afterwards. The parameter T measures the "degree of temporariness" of the policy. A lower T implies that the tradable good is cheaper for a shorter period of time, which exacerbates the intertemporal substitution effects. Hence, the smaller is T, the higher is the rise in c^* at $t=0$. Conversely, the larger is T, the smaller is the initial rise in c^*. 1/

The current-account path, illustrated in Figure 2, Panel B, follows from equation (18) (abstracting from the last term on the RHS, which reflects seigniorage payments, and recalling that $y_t^*=y^*$ for all t) and from the behavior of consumption of tradable goods just described. On impact, the current account jumps into deficit due to the upward jump in c^*. The current account then deteriorates steadily during [0,T), even though c^* remains constant, because interest payments on net foreign assets decline throughout. At t=T, the fall in c^* brings the current account into balance. In the new steady-state, net foreign assets are lower than they were initially.

We now turn to system (34) and (35) to examine the behavior of e and π. The fact that the system includes two exogenous variables (ε is a policy variable and c^* is exogenous to the system), both of which jump at t=0 and t=T, does not prevent us from using standard graphical techniques, as will become clear below. Figure 3, which depicts the same phase diagram as Figure 1, will be used to analyze temporary changes in the rate of devaluation. As in the previous case, the initial steady-state is at point A where $\pi_{ss}=\varepsilon^h$ and $e_{ss}=\bar{y}/c^*_{ss}$. The final steady-state is given by point C where π_{ss} remains unchanged at ε^h but the steady-state real exchange rate, e'_{ss}, is higher because steady-state consumption of tradables has declined to $c^{*\prime}_{ss}$. Since π is continuous at T, the system must hit C'C'--the saddle path corresponding to point C--at t=T in a continuous manner (i.e., neither π nor e are allowed to jump at T). 2/ From our previous analysis, we know that c^* rises on impact; this implies that the $\dot{\pi}=0$ schedule shifts downward at t=0 to $\dot{\pi}'=0$. At t=T, c^* falls and therefore the $\dot{\pi}'=0$ schedule shifts upward to $\dot{\pi}''=0$. During the transition (i.e., during $0\le t<T$), the system is governed by equations (34) and (35) with $c_t^*=c_0^*$. (The directional arrows depicted in Figure 3 correspond to the transition.) Therefore, the corresponding "steady-state" is point D in Figure 3, and the associated saddle path is D'D'. To find the equilibrium convergent path, we need to establish where π jumps on impact (recall that e is a non-jumping variable). It should be clear that π cannot jump to point K or to the left of K for, otherwise, the system could not hit the saddle path C'C' in a continuous fashion at t = T.

1/ Formally, the path of c^* and the effects of changes in T can be derived by substituting policy (36) into (24) (see Calvo and Végh (1990a)).

2/ The continuity of π at T follows from Calvo (1983b).

It can be shown that there exist three qualitatively different paths, which differ in the behavior of the inflation rate of home goods. If T is large, the system jumps on impact to a point such as G, hits the saddle path C'C' (point H) at t=T, and then proceeds towards point C. The path of π is illustrated in Figure 2, Panel C; π falls on impact, then decreases and, before the transition is over, begins to increase. If T is small, π may rise or fall on impact, depending on how large is the reduction in the rate of devaluation. 1/ If the fall in ε is relatively small, the system jumps on impact from A to E, travels along an unstable branch to hit the saddle path C'C' (point F) at time T, and then proceeds towards point C along the saddle path C'C'. 2/ Thus, π falls on impact but, unlike the first case, decreases throughout the transition. For large reductions in ε, the system jumps from A to I, travels along an unstable branch to hit the saddle path C'C' (point J) at time T, and then proceeds towards point C. Thus, π increases on impact and decreases throughout the transition. The initial rise in π reflects the large increase in c^* (as a result of a large reduction in ε and a small T), which requires a large real exchange rate appreciation during the transition.

It follows from Figure 3 that, qualitatively, the time path of the real exchange rate, illustrated in Figure 2, Panel D, does not depend on T. Since the inflation rate of home goods always falls by less than the rate of devaluation--and could even increase--the real exchange rate appreciates throughout the transition (i.e., during [0,T)). Furthermore, the less credible is the program (i.e., the smaller is T), the more will the real exchange rate appreciate at the beginning of the program. At t=T, when the devaluation rate returns to its original level, the real exchange rate begins to depreciate.

Figure 2, Panel E, illustrates the time path of consumption of home goods (and thus output) for a large T. The fall in i induces an increase in the consumption of c^* on impact, as indicated earlier. Since the relative price of tradable goods in terms of home goods, e, does not change on impact, consumption of home goods increases as well (see (6)). During [0,T), consumption of home goods falls over time as the relative price of home goods increases. Moreover, for a large T, consumption of

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1/ It can be shown that as $T \to 0$, $\lim[\pi_0(T)] = \varepsilon^h$; that is, in the limit π does not jump. If the reduction in ε is relatively small, then $\pi_0(T)$ is a decreasing function of T. For a relatively large reduction in ε, however, $\pi_0(T)$ may increase at first and then decrease (the existence of the latter case was established by simulating the model).

2/ As indicated earlier, a smaller T implies that the initial jump in c^* is larger, which implies that the downward displacement of the $\dot{\pi}=0$ schedule is larger. Similarly, because a smaller T implies that c_t^*, $t \geq T$, is higher, the $\dot{\pi}''=0$ schedule is closer to the $\dot{\pi}=0$ schedule. To simplify the graphical exposition, the position of the $\dot{\pi}'=0$ and $\dot{\pi}''=0$ schedules is assumed to be independent of T.

home goods falls below its full-employment level before T. 1/ Thus, the model can explain a recession in the home-goods sector (in the sense of output falling below its full-employment level), even before the program is discontinued. For a small T, consumption of home goods remains above its full-employment level up to time T, at which point c falls below $\bar{y}$ accompanying the fall in c^*.

The behavior of the domestic real interest rate is depicted in Figure 2, Panel F. Since $r^d \equiv i-\pi$, r^d falls on impact because, even if π decreases on impact, the fall in i exceeds that of π. The initial fall in the domestic real interest rate induces the consumer to increase consumption of home goods. After increasing during [0,T), r^d jumps upward at t=T, and falls over time afterwards. 2/

It is important to highlight the effects of lower credibility on an exchange rate-based stabilization. Indeed, this aspect constitutes one of the key differences between exchange rate-based and money-based stabilization programs. As suggested earlier, a smaller T (i.e., a lower degree of credibility in the program) implies that the initial upward jump in consumption of tradable goods is larger. This, in turn, implies a larger increase in consumption of non-tradable goods because the real exchange rate is predetermined. Therefore, the real effects of an exchange rate-based stabilization program get more pronounced the less credible is the program. The reason is that the nominal interest rate gets "anchored" at a low level by the reduction in the devaluation rate and the assumption of perfect capital mobility. The shorter the period of time during which the public believes the nominal interest rate will stay at that low level, the more pronounced the intertemporal substitution effects become.

We have abstracted from the wealth effect to isolate the effects of lack of credibility. In the absence of the wealth effect, the inflation rate of home goods adjusts instantaneously to its lower level if the public believes that policymakers will maintain the lower rate of devaluation forever. 3/ But if the stabilization program lacks credibility and the public believes that the stabilization attempt will be short-lived (i.e. that it will end at T), the economy will behave during (0,T) as though the authorities had announced a temporary reduction in the devaluation rate. If, when time T arrives, policymakers validate this

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1/ This follows from the fact that $\dot{\pi}$ becomes positive before T when T is large. Hence, from (21), c falls below $\bar{y}$.

2/ As indicated in the Introduction, real interest rates apparently fell at the beginning of the Southern-Cone programs, which is in accordance with the predictions of the model. In other programs reviewed by Kiguel and Liviatan (1990), however, real interest rates rose. Thus, the behavior of real interest rates during exchange rate-based stabilizations certainly deserves further attention, from both an analytical and an empirical standpoint.

3/ The same is true in the absence of currency substitution.

belief by effectively raising the devaluation rate, the economy will behave from T on as described above.

It is interesting to examine some of the alternatives that policymakers face at T. Suppose, for instance, that at time T they decided to stick to their announced policy and that, as a result, the public now <u>believed</u> that the rate of devaluation would be ε^{ℓ} from T on. Interestingly, the paths of c^* and c would not be affected. To see why, note that, as far as the public is concerned (which is what matters), there is an unanticipated and permanent reduction in the devaluation rate at t=T from ε^h to ε^{ℓ}, because the public had acted on the expectation that the devaluation rate would be ε^h from T on. Therefore, the consumption of tradable goods does not change because, in the absence of the wealth effect, a permanent change in ε has no effects on c^*. Because the real exchange rate is given at T, the sharp drop in consumption of home goods still occurs and is in fact quantitatively the same as that which would occur if the authorities were to validate the public's expectations. To see why the path of c is unaffected, notice that if ε is expected to remain constant forever, system (34)-(35) can be expressed as follows:

(34') $$\dot{v}_t = \theta(e_t c_t^* - \bar{y}),$$

(35') $$\dot{e}_t = v_t e_t,$$

where $v_t \equiv \varepsilon - \pi_t$. Thus, the equilibrium solution for e is independent of ε. Hence, by (6) and the fact that $c_t^* = c_{ss}^*$ for $t \geq T$, it follows that the path of c is entirely unaffected by the policy change. <u>1</u>/ However, the inflation path differs from what it would be if the authorities discontinued the stabilization program, i.e., if $\varepsilon_t = \varepsilon^h$ for $t \geq T$. Consider, for instance, the path AEF in Figure 3. At time T, there is a sharp drop in inflation from F to L; π undershoots its steady-state value, now given by ε^{ℓ}, and the system then travels toward point M. More precisely, by (34') and (35'), we know that, compared to the value that it would take if the authorities discontinued the stabilization program, inflation is lower by exactly $\varepsilon^h - \varepsilon^{\ell}$ for all $t \geq T$. We then conclude that, <u>if policymakers stick to their disinflationary policy, and if the public now becomes convinced that the policy is permanent, inflation is successfully brought down at no costs in addition to those that would have occurred had the public's expectations been validated</u>. This provides an interesting example in which adopting a "tough" policy stance pays off if it results in substantive credibility gains. <u>2</u>/

<u>1</u>/ We have shown that, in the absence of the wealth effect, a permanent change in ε is <u>everywhere</u> superneutral; that is, a change in ε is superneutral even when the system starts outside the steady-state.

<u>2</u>/ It should be pointed out, however, that the important question of why the program would become credible at T is left unanswered.

IV. Money-Based Stabilization

This section analyzes stabilization policy under flexible exchange rates; that is, stabilization policy based on the reduction of the rate of growth of the money supply. From an analytical standpoint, the case of flexible exchange rates is somewhat more involved than the predetermined exchange rates case. The reason is that the ratio of foreign to domestic money, f/m, is not necessarily time-invariant, because the nominal interest rate may vary over time. 1/

It proves convenient to define a new variable, x, by

$$(37) \qquad x_t \equiv z_t/(c_t/e_t+c_t^*),$$

which can be interpreted as real liquidity demand per unit of total consumption. Using (11) and (37), the demand for x can be expressed as an increasing function of the nominal interest rate:

$$(38) \qquad x_t = \Phi^z(i_t/r), \qquad \Phi^{z\prime}(i_t/r)>0.$$

As discussed in Section II, an increase in i raises the demand for f by more than it reduces the demand for m (thus increasing the demand for $z(\equiv m+f)$), because domestic money is more productive at the margin than foreign money. From (38), it follows that, in equilibrium,

$$(39) \qquad i_t = rw(x_t), \qquad w(x_t) \equiv (\Phi^z)^{-1}(x_t), \qquad w'(x_t) > 0.$$

Equation (39) implies that if the demand for x is, say, increasing, the nominal interest rate is also increasing. Furthermore, using (39), the demand for f/m (equation (8)) can be rewritten as

$$(40) \qquad f_t/m_t = \eta(x_t), \qquad \eta(x_t) \equiv \phi[w(x_t)], \qquad \eta'(x_t) > 0.$$

If x is increasing, the nominal interest rate must be increasing as well--as follows from (39)--which induces the consumer to increase the ratio of foreign to domestic money, as (40) indicates.

1/ The logarithmic utility function plays a critical role in making the case of flexible exchange rates analytically tractable, unlike the predetermined exchange rates case in which only the separability between c and c^* is important.

It can be shown (see Appendix) that x obeys the following differential equation:

$$(41) \qquad \dot{x}_t = [1/\Gamma(x_t)][rw(x_t)-\mu_t-r]x_t, \qquad \Gamma(x_t)>0.$$

As shown in the Appendix, differential equation (41) is unstable; since x is a jumping variable, this ensures a unique converging equilibrium path for x.

The laws of motion of consumption of tradable and home goods can be expressed in terms of x and the domestic real interest rate. The law of motion of c^* is (see Appendix)

$$(42) \qquad \dot{c}^*_t/c^*_t = -\gamma(x_t)\dot{x}_t/x_t, \qquad \gamma(x_t)>0.$$

Equation (42) states that if x is, say, increasing over time, consumption of tradable goods is decreasing. The reason is that, as already discussed, an increasing x is accompanied, in equilibrium, by an increasing i. In turn, a rising i implies that the effective price of consumption is increasing over time (recall equation (12)). Since consumption is getting more expensive over time, the consumer chooses a decreasing path of consumption, which is what equation (42) indicates. This effect on consumption will be referred to as "the effective price channel." 1/

The law of motion of consumption of home goods is given by 2/

$$(43) \qquad \dot{c}_t/c_t = r^d_t - r - \gamma(x_t)\dot{x}_t/x_t,$$

In addition to the effective price channel, given by the last term on the RHS of (43), the path of consumption of home goods is affected by the familiar "real interest rate channel," given by r^d-r in (43), whereby consumption increases as long as the domestic real interest rate is above the world real interest rate. 3/

1/ Under predetermined exchange rates, the path of c^* is time-invariant (i.e., $\dot{c}^*=0$) because the nominal interest rate, and thus the effective price of consumption, are time-invariant.

2/ Equation (43) follows from equation (42), using first-order condition (6) and the definition of the domestic real interest rate.

3/ Naturally, the real interest rate channel is absent from the law of motion of tradable goods (equation (42)), because the real interest rate in terms of tradable goods is constant and equal to r.

The impact effect of money-based stabilization on consumption of home goods will be dictated by equilibrium in the domestic money market. It is convenient to define domestic real money balances in terms of home goods; namely, $n=M/P$. (Note that n, unlike m, is a non-jumping variable, because both M and P are predetermined variables.) 1/ Thus,

$$(44) \qquad n_t = e_t m_t.$$

Substituting (44) into (9), using (6), yields money-market equilibrium:

$$(45) \qquad n_t = 2c_t \Phi^m(i_t/r).$$

Since n cannot jump, an incipient excess demand for real money balances that results from a reduction in the nominal interest rate necessitates a fall in consumption of home goods to equilibrate the money market.

Consider now the high-inflation initial equilibrium. Suppose that, initially (i.e., prior to t=0), $\mu_t=\mu^h$, and that μ is expected to remain at that level. The steady-state values are given by:

$$(46) \qquad \varepsilon_{ss} = \mu^h$$

$$(47) \qquad i_{ss} = r + \mu^h,$$

$$(48) \qquad \pi_{ss} = \mu^h,$$

$$(49) \qquad c_{ss} = \bar{y},$$

$$(50) \qquad c^*_{ss} = \frac{y^* + rk_0}{1 + 2r/\ell(1/\phi[(r+\mu^h)/r],1)}$$

$$(51) \qquad e_{ss} = \bar{y}/c^*_{ss},$$

$$(52) \qquad r^d_{ss} = r$$

1/ In what follows, the expression "real money balances" will refer to n.

(53) $$n_{ss} = 2\bar{y}\Phi^{m}[(r+\mu^{h})/r],$$

(54) $$f_{ss} = 2c^{*}_{ss}\Phi^{f}[(r+\mu^{h})/r],$$

(55) $$x_{ss} = \Phi^{z}[(r+\mu^{h})/r],$$

Conceptually, the initial equilibrium does not differ from that under predetermined exchange rates. 1/

1. Permanent reduction in the rate of growth of the money supply

Suppose that, at t=0, policymakers announce that the rate of growth of the money supply will be immediately and permanently reduced from μ^{h} to μ^{ℓ}. The announcement is fully credible; therefore, the public expects the lower rate of growth of the money supply to prevail for the indefinite future.

The reduction in μ lowers the steady-state nominal interest rate (equation (47)), which in turn decreases the steady-state demand for real liquidity per unit of total consumption, x_{ss} (equation (55)). Since (41) is an unstable differential equation, x must adjust instantaneously to its lower steady-state. This implies, by (39) and (40), that both the nominal interest rate and the ratio f/m adjust instantaneously to their lower steady-state values, as is the case under predetermined exchange rates.

Consider now the dynamics of n and π. The law of motion of real money balances, which follows from (19), (35) and (44) is

(56) $$\dot{n}_t = (\mu - \pi_t)n_t.$$

From (2), (6), (40), and (44), it follows that $c_t=(1/2)n_t\ell[1,\eta(x_t)]$. Substituting this expression into (21) yields

(57) $$\dot{\pi}_t = \theta\{\bar{y} - (1/2)n_t\ell[1,\eta(x_t)]\}.$$

Equations (56) and (57) constitute a dynamic system in n and π because the behavior of x is exogenously given to the system by (41). The system, illustrated in Figure 4, exhibits saddle-path stability since the

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1/ The reader is referred to the predetermined exchange rates case for the derivation of equations (46)-(52) and (54). Equations (53) and (55) follow from (38), (45), and (47).

determinant associated with the linear approximation equals $-\theta\bar{y}<0$. Point A represents the initial steady-state. When μ is reduced from μ^h to μ^ℓ, the $\dot{n}=0$ locus shifts to the left (to $\dot{n}'=0$) and the locus $\dot{\pi}=0$ shifts upward (to $\dot{\pi}'=0$) so that the new steady-state becomes point B, where real money balances are higher and inflation is lower. On impact, inflation falls from A to C and then the system travels along the saddle path B'B' towards point B. The rate of inflation must fall below the new rate of monetary growth to accommodate an increase in steady-state real money balances.

The impact effect on consumption of home goods follows from the money market equilibrium condition, given by (45). Real money balances in terms of home goods, n, are given on impact. Hence, the fall in i, which causes an incipient excess demand for domestic money, necessitates a fall in c to restore equilibrium in the money market. To induce the consumer to reduce consumption of home goods on impact, the domestic real interest *rate needs to increase.* 1/ *Therefore,* r^d *rises on impact and decreases* over time. 2/ Consumption of home goods increases after the initial fall towards its full-employment level (as follows from setting $\dot{x}_t=0$ in (43)). 3/

The absence of the effective price channel implies that $\dot{c}^*_t=0$ for all t (as follows from setting $\dot{x}_t=0$ in (42)). Although the effective price of consumption falls on impact due to the lower i, there are no incentives to engage in intertemporal consumption substitution, because the path of the effective price remains flat. It follows from (23) that c^* jumps upwards at t=0 and remains and that level thereafter. The higher consumption of tradable goods reflects the wealth effect that results from the economy's lower holdings of foreign currency. Naturally, the current account remains balanced.

Since steady-state consumption of tradable goods increases, the steady-state relative price of tradable goods (i.e., the real exchange rate) must fall. On impact, the real exchange rate appreciates by more than in the steady-state, because it needs to accommodate not only the rise in c^* but also the fall in c. During the transition, the real exchange rate depreciates, as consumption of home goods increases.

Perfect capital mobility implies that $i=r+\varepsilon$. Therefore, the rate of inflation of tradable goods (i.e., the rate of depreciation), ε, adjusts

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1/ Since the nominal interest rate adjusts instantaneously to its lower steady-state value, the effective price channel is inoperative when the change in μ is permanent.

2/ Formally, note that, by definition, $r^d \equiv i-\pi$. On impact, π falls by more than i does, so that r^d increases. Thereafter, r^d falls over time because i does not change while π increases over time.

3/ It is worth noticing that the path of c is independent of the path of c^*, which would not be the case if the utility function were not separable.

instantaneously to its lower steady-state value, μ^{ℓ}. Since the inflation rate of home goods, π, remains below μ^{ℓ} throughout the adjustment path, the average inflation rate will also be below μ^{ℓ} throughout the adjustment path.

It is important to emphasize that, unlike the predetermined exchange rates case, the presence of the wealth effect resulting from a lower stock of foreign currency plays no role in affecting the outcome of a money-based stabilization policy. Indeed, as should be clear from the analysis, the same effects on inflation and consumption of home goods would obtain if one were to abstract from this effect. The only difference would be that consumption of tradable goods would remain unchanged which would mean an unchanged steady-state value of the real exchange rate--although it would still fall on impact and increase thereafter. To understand why the wealth effect is irrelevant for the behavior of c and π, consider an unanticipated and permanent increase in y^*. In that case, c^* and e would adjust instantaneously to their higher and lower steady-state values, respectively, but no other effects would result.

In summary, a fully credible (i.e., permanent) reduction in the rate of monetary growth succeeds in bringing down inflation but only at the cost of an initial recession. The initial reduction in inflation is accompanied by a rise in the domestic real interest rate and an appreciation of the real exchange rate.

2. Temporary reduction in the rate of growth of the money supply

Consider a temporary reduction in μ. Initially (i.e.,for t<0), $\mu_t=\mu^h$. At t=0, policymakers announce the following policy:

(58a) $\mu_t = \mu^{\ell}, \qquad 0 \le t < T,$

(58b) $\mu_t = \mu^h, \qquad t \ge T,$

for some T>0, and where $\mu^h > \mu^{\ell}$. 1/ We first need to establish whether the path of x is continuous at t=T. Using equations (2), (5), (6), and (8) yields

(59) $2/\{m_t \ell[1,\eta(x_t)]\} = \lambda\{1 + r/\ell_f[1,\eta(x_t)]\}.$

1/ As in the case of exchange rate-based stabilization, the analysis will abstract from seigniorage payments when studying this case, in order to isolate the effects of temporariness. However, for the same reasons discussed above, the presence of the wealth effect would only affect the behavior of consumption of tradables and the real exchange rate.

which implies that x_t is continuous at time t=T because the left-hand side of (59) is a decreasing function of x, while the right-hand side is an increasing function of x. 1/ Therefore, c_t^* is continuous at t=T (note that, from (2), (6), and (8), $c_t^*=(1/2)m_t\ell[1,\eta(x_t)]$). Furthermore, c_t is continuous at t=T because $c_t=e_tc_t^*$ (and both e_t and c_t^* are continuous at t=T).

Having established that the paths of x, c^*, and c, are all continuous at T, we can proceed with the analysis. 2/ The instability of (41) implies that x jumps downward on impact (but falls short of the value it takes when the change in μ is permanent, x'_{ss}), and increases thereafter to reach its initial steady-state at t=T. Therefore, $\dot{x}_t>0$ for $0\leq t<T$. Equation (39) indicates that the nominal interest decreases on impact (but falls short of $r+\mu^\ell$), increases afterwards, and reaches its initial level at T. 3/ By the same token, from equation (40), f/m falls on impact, increases during the transition, and reaches its initial level at T. Intuitively, the reduction in μ lowers the nominal interest rate on impact, which induces the public to decrease its holdings of foreign money relative to domestic money. As the opportunity cost of domestic money increases, f/m increases.

The dynamics in the (π,n) plane are more involved than in the case in which the reduction in μ is permanent, because it is no longer the case that x adjusts instantaneously to its new steady-state. However, the same familiar graphical techniques may be used to characterize the equilibrium converging path. 4/ Consider an "auxiliary" system that consists of (56) and (57) but in which x_t has been "frozen" at the value it takes at t=0, x_0:

(60) $$\dot{n}_t = (\mu - \pi_t)n_t.$$

(61) $$\dot{\pi}_t = \theta\{\bar{y} - (1/2)n_t\ell[1,\eta(x_0)]\}.$$

Figure 4 illustrates the response of system (60) and (61) to policy (58). Since $x_0<x'_{ss}$, the schedule $\dot{\pi}=0$ shifts upward to $\dot{\pi}''=0$--rather than to $\dot{\pi}'=0$ as in the case in which the rise in μ is permanent--so that the laws of motion drawn in Figure 4 are those corresponding to point D. If T is large, the system jumps on impact to a point like E, hits the saddle path A'A' (point F) at t=T, and then proceeds along the saddle path

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1/ Note that $m(=M/EP^*)$ is continuous at T because E cannot jump at T. If E jumped at T, there would be unbounded arbitrage profits, which is inconsistent with equilibrium.

2/ Recall that, from Calvo (1983b), π is also continuous at T.

3/ Note, for further reference, that, as $T\rightarrow 0$, the downward jump in x, and thus in i, tend to zero.

4/ See Calvo and Végh (1990c) for a similar expository device.

towards point A. 1/ 2/ If T is small, the system would jump to a point like G and then follow the path GHA.

Let us now extend the results obtained in the "auxiliary" system to the "true" system. Inflation cannot initially jump to point I or to the left of I for, if it did, the system would follow a non-convergent path given that neither variable can jump at T. Because x increases between [0,T), the schedule $\dot{\pi}''=0$ in Figure 4 will be shifting downward during the same period. It can be readily checked that the "true" system must follow the same laws of motion as the "auxiliary" system does, because the "true" system always lies below the shifting $\dot{\pi}''=0$ schedule. The continuity of x at T implies that the $\dot{\pi}''=0$ schedule gets arbitrarily close to the $\dot{\pi}=0$ schedule as $t \to T$. It follows that, as suggested earlier, π cannot exceed μ^h during the transition because, if it did so, the system would diverge. The path of the inflation rate, which is qualitatively independent of T, is illustrated in Figure 5, Panel A. On impact, consumption of home goods must fall to equilibrate the money market, because the fall in i creates an excess demand for real domestic money balances (see equation (45)). Since π increases throughout the adjustment path, it follows from equation (21) that c is always below $\bar{y}$. Thus, <u>consumption of home goods falls on impact, and remains below the full-employment output level throughout the adjustment path</u>. Figure 5, Panel B illustrates the path of consumption of home goods. 3/

Consider now how the initial fall in consumption of home goods is affected by T (the credibility horizon). Money market equilibrium, given by (45), indicates that the magnitude of the initial fall in c depends on the size of the initial fall in the nominal interest rate. If T is small (the program has low credibility), the fall in i is small as well. Therefore, <u>the smaller is T, the smaller is the initial fall in consumption</u>. In contrast, if T is large, the initial fall in c approaches that which occurs when μ is lowered permanently.

1/ Note that, in the auxiliary system, it could happen that π overshoots μ^h before T. We will show, however, that this path is not feasible in the "true" system (i.e., when x is allowed to move over time).

2/ The position of the $\dot{\pi}''=0$ schedule depends on T: the larger is T, *the closer the $\dot{\pi}''=0$ schedule is to the $\dot{\pi}'=0$ schedule. For graphical* simplicity, Figure 4 assumes that the position of the $\dot{\pi}''=0$ schedule is independent of T.

3/ For $t \geq T$, it follows from (43) that $\dot{c}_t>0$, because $\dot{x}_t=0$ for $t \geq T$ and, as discussed below, $r_t^d>r$ for $t \geq T$. The direction in which c moves during [0,T) depends on the magnitude of T, which determines the relative strength of the real interest rate and effective price channels emphasized in equation (43). For large T, it can be shown that the real interest rate channel prevails at t=0, so that $\dot{c}_0>0$. For small T, the change in r^d is small, so that the effective price channel dominates at t=0, and $\dot{c}_0<0$. The monotonicity of the path of c during [0,T) remains an open issue.

The behavior of consumption of tradable goods, illustrated in Figure 5, Panel C, follows from equation (42). Equation (42), together with the path of x discussed above, imply that c^* decreases during $[0,T)$ and remains constant thereafter. Hence, it must be the case that c^* jumps upward on impact and reaches at T a value which is below its initial level for, otherwise, the economy's resource constraint (given by (16) abstracting from seigniorage payments) would be violated. Intuitively, because the effective price of consumption increases during the transition (since i increases), the consumer chooses a declining path of consumption.

The current-account path that results from the behavior of c^* is illustrated in Figure 5, Panel D. The current account jumps into deficit at $t=0$ but the deficit declines over time because the effect of a declining path of consumption of tradable goods more than offsets the reduced interest income on net foreign assets. 1/

The behavior of the real exchange rate is illustrated in Figure 5, Panel E. The steady-state real exchange rate increases due to lower steady-state consumption of tradable goods. Since, on impact, c falls while c^* increases, the relative price of tradables, e, must fall to accommodate such changes (recall equation (6)). For large T, the real exchange rate depreciates at the beginning of the adjustment path, because c is increasing and c^* is decreasing. 2/

Consider now the behavior of the domestic real interest rate. Since $r_t^d=r+\dot{e}_t/e_t$, and $\dot{e}_t>0$ at $t=0$ (for large T), it follows that the domestic real interest rate increases on impact for large T. Alternatively, recall that for large T, the fall in inflation is larger than the fall in the nominal interest rate, which implies a rise in the domestic real interest rate. For small T, the jump in r^d tends to zero because the downward jumps of both i and π tend to zero. 3/ The direction of r^d during $[0,T)$ is in principle ambiguous because i increases while π decreases. At $t=T$, r^d must lie above r because $\dot{r}_t^d=-\dot{\pi}_t<0$ for $t\geq T$ and r_t^d is continuous at $t=T$.

Finally, consider the path of the depreciation rate, illustrated in Figure 5, Panel F, which follows from (15) and the behavior of x discussed above. The depreciation rate falls on impact because of the fall in the nominal interest rate. The smaller is T, the smaller is the initial fall in ε, because the smaller is the initial fall in i. The rate of depreciation increases afterwards and reaches its unchanged steady-state level at $t=T$. Therefore, the inflation rate of tradable goods returns to its initial level at time T.

1/ The path of the current account may not be necessarily monotonic during $[0,T)$.

2/ It cannot be ruled out that the real exchange rate decreases over some range.

3/ The issue of whether r^d could fall on impact for some value of T remains open.

In summary, the presence of lack of credibility in a stabilization program under flexible exchange rates does not alter the qualitative behavior of the home-goods sector. The fall in inflation is accompanied by a fall in consumption of home goods. In contrast, the behavior of the tradable-goods sector (i.e., the current account) is dramatically altered by lack of credibility in the stabilization program. This is due to the existence of intertemporal substitution effects in consumption that are absent when the program is fully credible. Therefore, when a money-based stabilization program lacks credibility, the recession in the home-goods sector that accompanies the fall in the inflation rate co-exists with a current account deficit.

Finally, let us examine the consequences of lower degrees of credibility. Interestingly, the effects of lower credibility are dramatically different from those which obtain under predetermined exchange rates. The basic result is that as the program gets less credible (i.e., $T \rightarrow 0$), all real and monetary effects tend to vanish. As discussed earlier, as $T \rightarrow 0$, the jump in i at $t=0$ is very small (i.e., it tends to zero). This implies, in turn, that the fall in consumption of home goods which is necessary to equilibrate the money market tends to zero as well. The fall in the inflation rate of home goods, as well as the fall in the depreciation rate, are also very small. Because the fall in the nominal interest rate is small and consumption of tradables is continuous at $t=T$, the upward jump in c^* is also very small and, hence, so is the initial current account deficit. We conclude that very low credibility in the program will mean no success whatsoever in bringing down inflation. But, at the same time, the program's failure will not cause any particular hardship either. This conclusion stands in stark contrast to the effects of very low credibility under predetermined exchange rates, in which case the real effects of the program are exacerbated.

V. Anchors

As suggested in the Introduction, several attempts to stop high inflations in the 1970's and 1980's have shown once again that inflationary forces are not easily curtailed by just pulling at monetary policy strings. This phenomenon is clearly exhibited by our model. We have focused on a feature of stabilization programs that is often mentioned as an explanation for their lackluster performances; namely, imperfect policy credibility. In fact, we have shown that under imperfect credibility the dynamic response of the economy is quite different than under perfect credibility.

Imperfect credibility could arise due to a variety of factors. A stabilization policy could not be credible, for example, because the fiscal program is not in line with the inflation target. Indeed, lack of fiscal adjustment is a recurrent problem in stabilization programs, but the roots of the problem could be less obvious. For instance, a resumption of inflation could be feared because the public realizes the fiscal-revenue potential of surprise departures from preannounced policy. A case in point is when there exists a relatively large stock of non-indexed domestic debt whose real value could be quickly reduced through surprise inflation or devaluation.

Our model does not tackle the issue of how credibility is affected by policy. Therefore, it is ill-suited to evaluate the chances of success of, for example, a so-called big-bang program that eliminates all distortions and fiscal imbalances at once. However, the model sheds some light on any situation in which policy--either by fact or artifact--fails to restore full credibility.

Consider the choice between flexible and predetermined exchange rates. Independently of the credibility horizon, T, predetermined exchange rates are capable of stopping the inflation of tradable goods on its track. This is not the case for flexible exchange rates since, as shown above, inflation of tradable goods remains above μ^{ℓ}, unless the program is fully credible. In both regimes, however, the inflation rate of home goods has much of a life of its own, and its behavior is strongly influenced by credibility factors. In particular, the analysis has shown that when the credibility horizon is very small (i.e., when T tends to zero), inflation of non-tradable goods is approximately the same under the two exchange rate regimes. Consequently, if policymakers put a lot of weight on stopping, or at least dramatically decelerating, the rate of inflation--a typical situation when inflation seems out of control and about to devour the real economy, and credibility is at a low ebb--a regime of predetermined exchange rates could be highly appealing.

A drawback of predetermined exchange rates, however, is that large intertemporal substitution effects may result which, as shown in related models, could be quite costly (see Calvo (1987,1988)). Furthermore, the intertemporal substitution effects get exacerbated the less credible is the program. This contrasts sharply with the case of flexible exchange rates, in which stabilization policy has almost no real effects when the credibility horizon is small. Therefore, a clear lesson is that the choice of nominal anchors could have implications for the real sector, aside from resulting in different inflation paths.

As a way to avoid unduly high current account deficits at the beginning of the stabilization program, authorities might try to interfere with international capital flows. After all, one important avenue for the economy as a whole to carry out a significant amount of intertemporal consumption substitution is by means of accumulating or decumulating foreign assets. 1/ Consequently, the model helps to rationalize an

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1/ Another important avenue, not treated in our model, is through the accumulation or decumulation of human or physical capital.

often-found additional anchor in exchange rate-based programs, namely, controls on international capital mobility. 1/

In practice, however, policymakers would have a hard time distinguishing between "bad" capital flows (i.e., those arising from lack of credibility) and "good" capital flows (i.e., those unrelated to credibility problems), which surely reduces the appeal of capital controls. In addition, the optimal time for removing capital controls would be hard to ascertain. Too early a removal may unleash the same credibility problems that capital controls were supposed to deal with in the first place. Too late a removal may lead to a resumption of inflation if the public believed that capital controls were a fundamental component of the stabilization program.

As previously noted, neither flexible nor predetermined exchange rates can do much to put a lid on prices of non-tradable goods. Thus, the policymaker might feel inclined to meddle directly with price/wage-setting mechanisms, as in the recent "heterodox" programs. 2/ One "neutral" way to institute price controls would be to force firms to set their prices as if the program were fully credible. Thus, if the program is actually followed as initially announced, no firm (or worker, for that matter) would have any serious ground for grievance because regulations would lead them to the same actions that they would have taken themselves had they known, in advance, that the policymaker was going to honor his or her announcements in full. 3/

A possibly serious problem with the above price-controls solution is that, in practice, there are many goods whose production and consumption are subject to a myriad of sector-specific random shocks. This information is both hard to obtain and hard to process in order to calibrate the price vector along its full-credibility equilibrium path. Therefore, the price-controls scheme is, at best, relevant only during the first few months of the program. Perhaps an alternative that should be explored in the context of a stochastic model is the imposition of price/wage "ceilings" which would hopefully be non-binding for all or most goods or labor services.

Price controls face two additional problems. First, they may be simply ineffective in economies in which black markets are relatively well

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1/ Controls on capital mobility have not been studied in the previous sections. However, they can be easily introduced by, for example, assuming that the private sector is not allowed to hold foreign bonds, b, and that the central bank ensures convertibility only on current-account type transactions (i.e., exports and imports). Those conditions ensure that the private sector would not be able to finance an initial consumption binge.

2/ For a discussion of incomes policy in stabilization plans, see Dornbusch and Simonsen (1987).

3/ This idea was first exposed, in a different context, by Phelps (1978).

organized. Second, like capital controls, the optimal time to remove price controls is hard to establish.

In summary, the model highlights the basic problems that arise from lack of credibility, and thus helps to rationalize the use of additional anchors, such as capital controls and price and wage controls, in exchange rate-based stabilizations. 1/ However, in order to establish whether these additional anchors are, in some sense, optimal would require a richer model in which both the costs and benefits of the additional anchors are explicitly incorporated.

VI. Final Words

The model presented in this paper is capable of explaining some of the puzzles that have arisen in connection with several recent stabilization programs based on the exchange rate as the nominal anchor. In particular, the model accounts for the following stylized facts: first, the co-existence of an appreciating real exchange rate and an overheated economy at the beginning of the program; second, a recession late in the program; and, third, sustained and cumulative real exchange rate appreciation. A key ingredient in explaining these features of exchange rate-based stabilization is the expectation that the stabilization program will be discontinued in the future, leading to a resumption of inflation. This is the critical "credibility problem" emphasized in the paper, which results in intertemporal consumption substitution. 2/

The analytical framework developed in this paper also serves to highlight key differences between money-based and exchange rate-based stabilization. In particular, the costs, in terms of output, of bringing down inflation are borne at the beginning of the program under money-based stabilization, but only later in the program under exchange rate-based stabilization. The consequences of low credibility are dramatically different under both regimes. Under exchange rate-based stabilization, real effects get more pronounced if the program is less credible; in contrast, under money-based stabilization, real effects tend to disappear as credibility decreases.

The discussion has dealt exclusively with qualitative results. Quantitative work is, of course, highly relevant but there is still little to report that is directly connected with the above kind of model. Such an endeavor is likely to require some revisions of the basic model. For

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1/ An important issue, which we have not addressed, is the viability of predetermined exchange rates in light of potential balance-of-payments crisis.

2/ We would conjecture that the effects of the nominal interest rate on consumption discussed in this paper could also result from the introduction of liquidity constraints--rather than from intertemporal substitution in consumption--a line of research we are currently pursuing.

example, in a quantitative-oriented rendition of the model we would put a great deal of emphasis on durable goods, since we strongly believe that it is actually through the accumulation and decumulation of inventories that much of the intertemporal substitution effects take place. 1/

Furthermore, at least the credibility horizon, T, should be treated as a random variable. This is essential because otherwise one would be unable to explain credibility-generated risk premia in domestic interest rates (an important feature of stabilization programs that is not exhibited by our model due to the assumption of perfect foresight). 2/

The paper deals with the credibility issue as a completely exogenous phenomenon. We believe that this is a convenient and non-misleading analytical device, because we would expect that in any well-structured model of the public's beliefs, history should weigh heavily during the first stages of the stabilization program. This, of course, means that there will always be an element of exogeneity in the public's expectations. Thus, since stabilization programs normally start from unmanageably high inflation--and, not unusually, from a history of unsuccessful stabilization programs--our model's assumption that the public expects a future resumption of inflationary forces is likely to be a feature of any fully-structured expectations model.

Nevertheless, the above observation does not relieve us of the duty of searching for more complete credibility models. In our view, however, this field of enquiry is still in its infancy. According to a dominant paradigm, for example, the public does not know the true characteristics of the policymakers (i.e., whether they are "tough" or "soft"), while policymakers know their type and, depending on their position in the spectrum of types, may prefer to try to reveal who they are, or to disguise themselves as members of some other type. All the interesting models along these lines assume that "soft" is the dominant type (which, by assumption, is not good for making credible commitments), while the "tough" ones (who are effective stabilizers) are rare in kind (see, for example, Backus and Driffill (1985) and Barro (1986)). The theory then revolves around the issue of the optimal deception strategy for the soft ones. The soft ones try to build a reputation that they are actually tough, which results in their implementing tough policies for a while. Thus, the reduced-form type of policy implied by this paradigm is not much different from that in our model. A major reservation about this line of research, however, is that policymakers are normally subject to rather close public scrutiny, so one might argue that their types are relatively

1/ Durable goods can actually give rise to large intertemporal substitution effects even when there is perfect intertemporal complementarity of consumption, as shown in Calvo (1988).

2/ Drazen and Helpman (1988) develop an interesting model in which T is random. In their model, the nominal interest rate includes a risk premium which reflects a discrete jump in the exchange rate when the predetermined exchange rate regime is discontinued at T.

well known. Moreover, even when policymaker types may be, to some extent, unknown by the public, it requires an unparalleled no-leaks system to be able not to reveal one's type in the course of everyday policymaking, especially given that most major decisions are made by committees.

In this respect, Alesina and Drazen (1989) take a promising track by developing a model in which, in a sense, the policymaker himself is not fully aware of his type. They model this by assuming that the policymaker's decisions are dictated by a committee which operates according to majority rule. The committee members, in turn, play "attrition" games against each other. Leaving aside the specific details of their model, we believe that this is a relevant line of research because casual empiricism shows that policymakers spend a lot of time looking for their constituencies' support. This behavior will naturally give rise to stop-and-go cycles which could be incorporated in the basic structure presented above.

This appendix derives differential equation (41). Substituting (39) and (40) into (5), taking into account that $\ell(m,f)$ is homogenous of degree one, and differentiating with respect to time yields

(A.1) $\dot{c}^*_t/c^*_t = -\gamma(x_t)\dot{x}_t/x_t$,

where $\gamma(x_t) = rx_t \dfrac{w'(x_t)\ell_m - w(x_t)\ell_{mf}\eta'(x_t)}{\ell_m^2[1 + rw(x_t)/\ell_m]} > 0$,

which is equation (42) in the text. 1/ Using (2), holding with equality, (6), and (40), and differentiating with respect to time yields

(A.2) $\dot{c}^*_t/c^*_t = \dot{m}_t/m_t + \zeta(x_t)\dot{x}_t/x_t$,

where $\zeta(x_t) = \dfrac{x_t\ell_f[1,\eta(x_t)]\eta'(x_t)}{\ell[1,\eta(x_t)]} > 0$.

Combining (15), (19), (39), (A.1), and (A.2), implies that

(A.3) $\dot{x}_t = [1/\Gamma(x_t)][rw(x_t)-\mu_t-r]x_t$,

where $\Gamma(x_t) = \gamma(x_t) + \zeta(x_t) > 0$,

which is equation (41) in the text. The linear approximation of (A.3) around the steady-state is

(A.4) $\dot{x}_t = [rw'(x_{ss})x_{ss}/\Gamma(x_{ss})](x_t-x_{ss})$,

which shows that this is an unstable differential equation (recall, from (39), that $w'(x)>0$). Since x is a jumping variable, this ensures a unique converging equilibrium path for x.

1/ The arguments of ℓ_m and ℓ_{mf}, $[1,\eta(x_t)]$, have been omitted for notational simplicity.

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