ELSEVIER

Journal of Development Economics
Vol. 47 (1995) 97–133

JOURNAL OF
Development
ECONOMICS

Targeting the real exchange rate: Theory and evidence

Guillermo A. Calvo [a], Carmen M. Reinhart [b], Carlos A. Végh [b,*]

[a] University of Maryland, College Park, MD 20472, USA
[b] Research Department, International Monetary Fund, Washington, DC 20431, USA

Received 1 May 1993, final version received May 1994

Abstract

This paper presents a theoretical and empirical analysis of policies aimed at setting a more depreciated level of the real exchange rate. An intertemporal optimizing model suggests that, in the absence of changes in fiscal policy, a more depreciated level of the real exchange rate can only be attained temporarily. This can be achieved by means of higher inflation and/or higher real interest rates, depending on the degree of capital mobility. Evidence for Brazil, Chile, and Colombia supports the model's prediction that undervalued real exchange rates are associated with higher inflation.

Keywords: Real exchange rates; Inflation; Real interest rates

JEL classification: F41

1. Introduction

In an open economy, either the money supply or the nominal exchange rate can serve as a nominal anchor. Such an anchor is usually viewed as a necessary condition for macroeconomic stability since, at least in the long run, all nominal variables will converge to the pre-set rate of growth of either the money supply or

* Corresponding author.

SSDI 0304-3878(95)00006-2

the exchange rate. Assuming that appropriate fiscal and microeconomic policies are in place, the price stability brought about by a nominal anchor should ensure that the economy achieves long-run economic growth.

In practice, however, such a 'neo-classical' view of policymaking is not universally accepted. Policymakers are not always content, especially in the short run, with targeting nominal variables such as the exchange rate or the money supply. After all, the reasoning goes, if one is interested in the behavior of real variables which have a direct bearing on growth (such as the real exchange rate or real interest rates), why not bypass nominal targets and simply try to set those variables at their desired levels? Thus, in spite of dire warnings from neo-classically inclined economists about the perils of losing the nominal anchor, policymakers have time and time again pursued real targets in implementing monetary and exchange rate policy.

Being a key relative price in any open economy, the real exchange rate is probably the most popular real target in developing countries. [1] A policy of 'real exchange rate targeting' usually aims at controlling the level of the real exchange rate, either in an effort to keep it at a constant level in the face of domestic or external shocks, or achieve a different (typically more depreciated) level. Diverse circumstances lead policymakers to engage in real exchange rate targeting. One of the most common reasons is the desire to index the nominal exchange rate to the price level in an effort to avoid losses in competitiveness. Such policies are usually referred to as 'purchasing power parity (PPP) rules'.

An early example of a PPP rule is provided by Brazil, where such a policy was adopted in August 1968 (Bacha, 1979). [2] Under this rule, the exchange rate was changed by small percentages at irregular intervals of time (ten to fifty days), depending on the inflation differential between Brazil and the United States. With occasional deviations (due, for example, to changes in terms of trade and short-lived stabilization programs), Brazil has been following PPP rules ever since, even if such rules have not always been made explicit. This is illustrated (beginning in 1978) in Fig. 1, which plots the behavior of the actual nominal exchange rate alongside the nominal exchange rate that would be consistent with a PPP rule [3].

[1] It is certainly not the only real target. Chile, for instance, has also used an interest rate on an indexed bond (i.e., a real interest rate) as its main policy instrument since 1985 (see Fontaine, 1991).

[2] According to Williamson (1981a), Chile was the first country to adopt a PPP rule in 1965 (see Ffrench-Davis, 1981).

[3] The PPP exchange rate was computed as the ratio of the domestic CPI to that of the U.S., and set equal to the actual value of the exchange rate in 78.01 for Brazil, 85.07 for Chile, and 86.01 for Colombia. The U.S. inflation is used for simplicity; more comprehensive trade-based indices could be used. In the case of Brazil, the base date coincides with the beginning of the sample; in the case of Chile and Colombia, the base date marks the beginning of a period during which a PPP rule was in effect (see below).

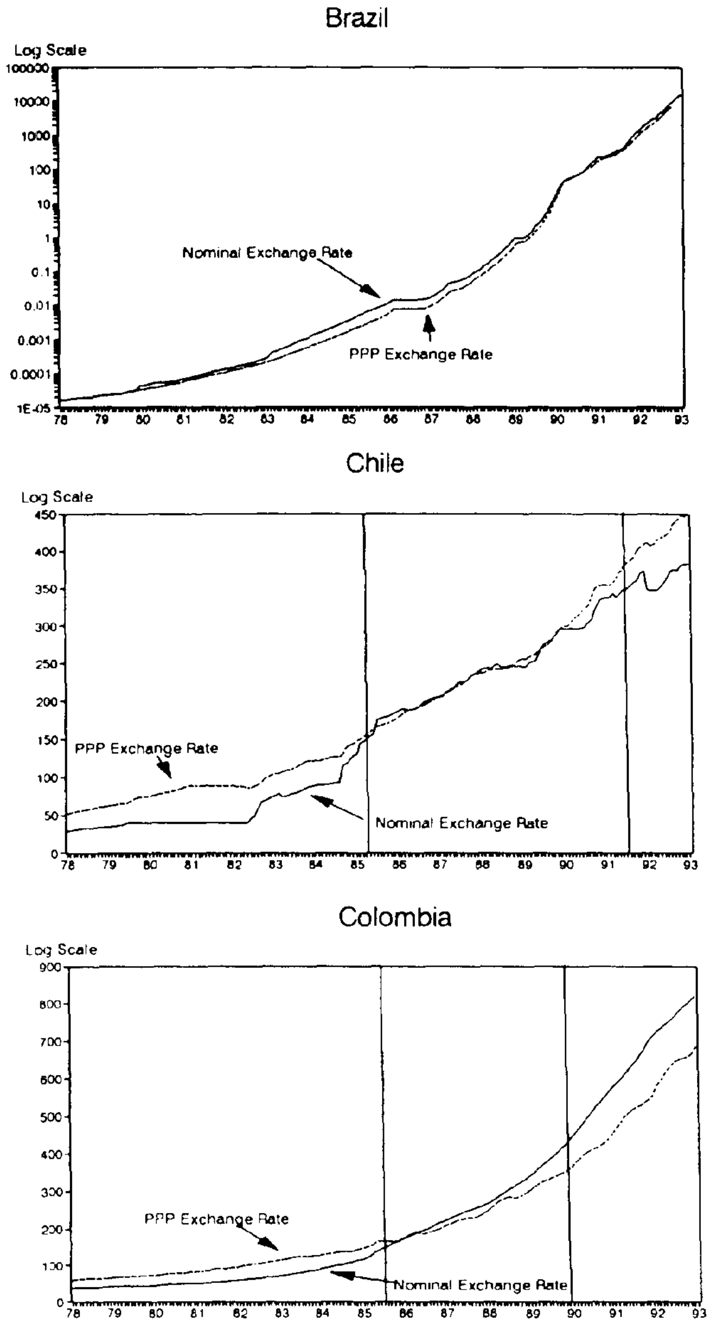

Fig. 1. Nominal and PPP exchange rates. *Sources:* International Financial Statistics (IMF) and authors' calculations. *Note:* Vertical bars indicate periods during which PPP rules were followed.

Chile arguably provides the most consummate example of a PPP rule. In July 1985, an exchange rate band was established whose central parity is adjusted at daily intervals according to a schedule based on the inflation rate during the previous month minus the estimated world inflation rate. Remarkably enough, there were no deviations from this rule until January 1992, when renewed pressures towards nominal appreciation of the peso stemming from capital inflows led to a revaluation of five percent. The Chilean PPP rule can be clearly seen in Fig. 1, starting in mid-1985. Following a sharp real devaluation during 1985, Colombia also followed a PPP rule during the period 1986–1990, as can be seen in Fig. 1.

As suggested above, real exchange rate targeting may also consist of policies designed to achieve a more depreciated level of the real exchange rate. Chile, for instance, pursued a very aggressive policy of nominal devaluation during the period June 1982–June 1985, making a point of devaluing the domestic currency by rates that far exceeded the rate of inflation in order to engineer a substantial real depreciation (Edwards, 1991). As a result, in July 1985, the real exchange rate had almost doubled with respect to its May 1982 level (Fig. 2). Similarly, during 1985 Colombia devalued the domestic currency by substantial amounts, which led to a real depreciation of around 50 percent (Fig. 2).

For all its practical and policy relevance, there is relatively little analytical work, and even less econometric work, on real exchange rate targeting. Adams and Gros (1986) were among the first to formally ask the two questions which, in our view, are key in analyzing real exchange rate targeting. [4] First, what are the inflationary consequences of giving up a nominal anchor? Second, can money provide the needed nominal anchor if capital is less than perfectly mobile? In the context of a log-linear stochastic model, Adams and Gros (1986) argue that, in the presence of PPP rules, inflation tends to be whatever it was in the past, modified by shocks to prices during the current period (i.e., inflation follows a random-walk). The intuition is simply that the exchange rate fully accommodates all price shocks and, hence, has no long-run equilibrium value. Furthermore, they show that, under no capital mobility, a sustained policy of sterilizing monetary inflows is unfeasible, as it leads to either an unstable current account or an unstable stock of foreign assets.

More recently, Lizondo (1991, 1993) and Montiel and Ostry (1991, 1992) have reexamined the same two issues in terms of a common reduced-form, deterministic model. [5] As shown in Lizondo (1991), real exchange rate targeting is also inflationary in this framework, but the mechanism is fundamentally different from

[4] Early work by Dornbusch (1982) focused on the effects of PPP rules on the trade-off between output and price-level variability. Many of the issues raised by Adams and Gros (1986) had already been discussed at length in the volume edited by Williamson (1981b), mainly in the context of Latin America.

[5] The essential mechanism presented in Lizondo (1991) remains the same in the other three papers.

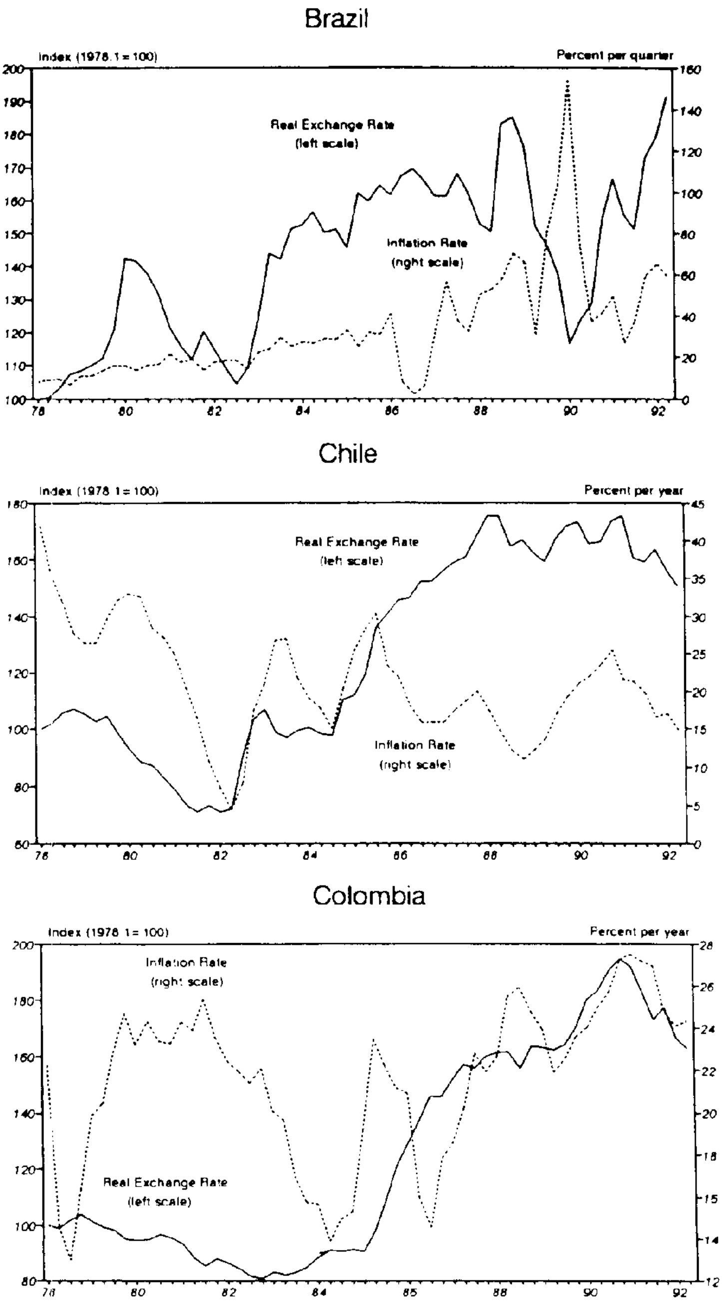

Fig. 2. Real effective exchange rate and inflation. *Sources:* International Financial Statistics (IMF) and Information Notice System (IMF). *Note:* A decrease in the real effective exchange rate index denotes an appreciation. Inflation is computed as the change in the CPI over the previous quarter for Brazil and over the previous four quarters for Chile and Colombia.

that highlighted in Adams and Gros (1986). Specifically, the demand for non-traded goods depends positively on the real exchange rate (defined as the price of traded goods relative to non-traded goods) and real private wealth. Real private wealth, in turn, depends negatively on revenues from the inflation tax. Hence, equilibrium in the non-traded goods market requires that the steady-state inflation rate be that which generates, through its impact on inflation tax revenues, a level of real private wealth which is consistent with the targeted real exchange rate. [6] Therefore, a more depreciated real exchange rate can only be achieved with higher inflation. [7] With regard to whether money can provide the needed nominal anchor with imperfect capital mobility, Montiel and Ostry (1992) conclude that such a policy is not feasible in the long run as an ever-widening spread in the parallel market would lead to a breakdown of the system.

This paper takes a new look at real exchange rate targeting, from both a theoretical and an econometric point of view. Specifically, the purpose of the paper is two-fold. First, we go back to basics and analyze the two key questions mentioned above in the context of a simple, neo-classical, optimizing model. By so doing, we highlight mechanisms which are quite different from those emphasized by either Adams and Gros (1986) or Lizondo (1991, 1993) and Montiel and Ostry (1991, 1992). Second, we test the main implication of our model for Brazil, Chile, and Colombia. Furthermore, we also provide empirical evidence on the mechanism emphasized by Lizondo (1991, 1993) and Montiel and Ostry (1991, 1992).

The analysis is based on a simple representative-consumer, cash-in-advance model with flexible prices. We first show that, in the absence of fiscal policy, *the steady-state real exchange rate is independent of (permanent) changes in the rate of devaluation*. Hence, all that policymakers can hope to do is to target the real exchange rate for a limited period of time. Under perfect capital mobility, a more depreciated level of the real exchange rate – relative to its initial equilibrium value – can be achieved by generating higher inflation today than in the future. Intuitively, in a cash-in-advance model, the nominal interest rate affects the effective price of consumption because money is required to buy goods. Hence, if inflation, and thus the nominal interest rate, are expected to be lower in the future than they are today, consumption of traded goods falls today relative to the future. Since consumption of home goods cannot change (because output of home goods is constant), the exchange rate depreciates to accommodate the lower consumption of traded goods. Hence, *targeting a more depreciated real exchange rate requires*

[6] The inflation elasticity of money demand is assumed to be below unity, so that higher inflation implies higher revenues from the inflation tax.

[7] Lizondo (1991) implicitly assumes that government expenditure on traded goods acts as the residual variable in that it accommodates the higher tax revenues.

that inflation be higher today than in the future. In this sense, therefore, real exchange rate targeting is inflationary. Numerical simulations of the model suggest that, since the intertemporal elasticity of substitution for most developing countries is relatively low (see Reinhart and Végh, 1994), the inflationary effects of real exchange rate targeting might be substantial.

The same results would obtain if one assumes that policymakers attempt to keep the real exchange rate constant in response to a shock that would tend to appreciate it. Specifically, in the context of our model, suppose that the world nominal interest rate falls temporarily. In the absence of any policy response, such a shock temporarily reduces the effective price of consumption which leads to a current account deficit and a real exchange rate appreciation. Suppose now that, in the spirit of a PPP rule, the authorities' goal is to prevent the real exchange rate from appreciating. This can be achieved by keeping the domestic nominal interest rate constant; that is, by increasing the rate of devaluation (and thus the rate of inflation) by the same amount as the world nominal interest rate falls. Such a PPP-type rule will therefore keep the real exchange rate constant but at the cost of higher inflation (relative to the equilibrium in which there is no policy response). Hence, in our model, *either targeting a more depreciated real exchange rate or preventing the real exchange rate from appreciating in response to a positive shock is inflationary.* [8]

Under no capital mobility, we show that a temporarily depreciated real exchange rate relative to its steady-state level can be generated without inflation. However, the domestic real interest rate rises above its initial value, and keeps increasing for as long as the real exchange rate remains at its more depreciated level. Again, a numerical simulation of the model suggests that the rise in the domestic real interest rate may be substantial. Therefore, even if the absence of capital mobility enables policymakers to regain full control over inflation, the effects of real exchange rate targeting take the form of high real interest rates. In sum, given that in the real world neither the assumption of perfect capital mobility nor that of perfect capital controls is likely to hold, the model suggests that *real exchange rate targeting will lead to some combination of higher inflation and higher domestic real interest rates.*

Given that the analytical framework stresses the role of temporary shocks to the real exchange rate, the empirical section of the paper first assesses the relative importance of temporary shocks to the real exchange rate for Brazil, Chile, and Colombia. To this effect, we use Cochrane's (1988) methodology, which provides a measure of the persistence of shocks in a variable by examining the variance of its long differences. In all three countries considered, it is found that temporary

[8] The welfare effects, however, differ. Targeting a more depreciated level is welfare reducing because there is no initial distortion. In contrast, keeping the real exchange rate constant is welfare improving because it offsets the distortion introduced by the temporary external shock.

shocks to the real exchange rate account for a sizable share of the variance of the real exchange rate (between 43 and 62 percent). These results suggest that our emphasis on temporary shocks to the real exchange rate is well placed.

We then proceed to test, for the same three countries, the main implication of real exchange rate targeting under perfect capital mobility; namely, there should be a positive correlation between the temporary components of inflation and the real exchange rate (defined as the relative price of traded goods in terms of home goods). In order to test the above proposition, we decompose the real exchange rate, which is non-stationary in all three countries, into its permanent and temporary components using the Beveridge–Nelson decomposition. We then compute the correlation between the temporary component of the real exchange rate and inflation, as both of these variables are stationary. In all three cases, the correlation has the expected sign and is statistically different from zero, with values ranging from 0.26 to 0.42. Hence, the evidence supports the temporary mechanism highlighted in the model.

Finally, we also provide some evidence on the long-run relationship between revenues from the inflation tax and the real exchange rate highlighted in Lizondo (1991, 1993) and Montiel and Ostry (1991, 1992). Our results suggest that there is room for an indirect link between inflation and the real exchange rate via wealth effects. The evidence, however, is not conclusive, and further research is needed which incorporates other determinants of the long-run equilibrium real exchange rate, such as government spending on non-traded goods.

The paper proceeds as follows. Section 2 presents the theoretical analysis. Section 3 discusses the numerical simulations of the model. Section 4 contains the econometric work. Section 5 concludes.

2. The model

Consider a small open economy inhabited by a large number of identical individuals blessed with perfect foresight. The representative consumer derives utility from the consumption of a traded good (whose price in terms of foreign currency is given and constant over time) and a non-traded (or home) good. Lifetime utility is given by

$$\int_0^\infty u(c_t^*, c_t) \exp(-\beta t) \, \mathrm{d}t, \tag{1}$$

where c^* and c denote consumption of traded and home goods, respectively, and $\beta(>0)$ is the subjective discount rate. The instantaneous utility function, $u(.)$, is twice-continuously differentiable (with positive partial derivatives), and strictly concave.

The country faces a constant world real interest rate, r. The domestic real interest rate (in terms of traded goods), ρ, may differ from the world real interest rate due to imperfect capital mobility. Let the domestic discount factor (in terms of traded goods) at t, D_t, be given by

$$D_t = \exp\left(- \int_0^t \rho_s \, \mathrm{d}s \right). \tag{2}$$

Therefore, the representative consumer's lifetime budget constraint is given by (see appendix) [9]

$$\int_0^\infty (y_t^* + y_t/e_t + \tau_t) D_t \, \mathrm{d}t = \int_0^\infty (c_t^* + c_t/e_t + i_t m_t) D_t \, \mathrm{d}t, \tag{3}$$

where y^* and y denote the endowments of traded and home goods, respectively; e is the real exchange rate (i.e., the relative price of traded goods in terms of home goods); τ are real lump-sum transfers from the government; and i denotes the instantaneous nominal interest rate (i.e., the real interest rate, ρ, plus the rate of devaluation) in terms of domestic currency. [10] Eq. (3) states that the present discounted value of consumption expenditure, $c^* + c/e$, and the rental cost of money, im, equals the present discounted value of disposable income, $y^* + y/e + \tau$, all evaluated in terms of traded goods, and employing the domestic discount factor, D.

Consumers must use money to purchase goods. Formally, they face a cash-in-advance constraint of the form

$$\alpha (c_t^* + c_t/e_t) \leqslant m_t, \tag{4}$$

where α is a positive constant. [11] Eq. (4) requires that the stock of real money balances not fall short of total consumption expenditure, $c^* + c/e$. Constraint (4) holds with equality at equilibrium if the rental cost of money (i.e., the nominal interest rate) is positive, which is the only case studied in the present paper. Hence, budget constraint (3) can be rewritten as

$$\int_0^\infty (y_t^* + y_t/e_t + \tau_t) D_t \, \mathrm{d}t = \int_0^\infty (c_t^* + c_t/e_t)(1 + \alpha i_t) D_t \, \mathrm{d}t. \tag{5}$$

The representative consumer's optimization problem consists of choosing the paths of c and c^* so as to maximize lifetime utility, Eq. (1), subject to the intertemporal budget constraint, Eq. (5), given the expected paths of y, y^*, τ, e,

[9] To simplify notation and without loss of generality, we assume that, aside from endowment of future output, the individual and the country have no wealth as of time 0.

[10] The real exchange rate is defined as $e = EP^* / P$, where E is the nominal exchange rate, in units of domestic currency per unit of foreign currency, P^* is the foreign currency price of traded goods, and P is the nominal price of home goods.

[11] The same results would hold if money was introduced as an argument in the utility function and the cross-derivative between money and consumption was positive.

D, and i (which, given the assumption of perfect foresight, are also the actual paths). The first-order conditions for this problem are [12]

$$u_{c^*}(c_t^*, c_t) \exp(-\beta t) = \bar{\lambda} D_t(1 + \alpha i_t), \tag{6}$$

$$\frac{u_{c^*}(c_t^*, c_t)}{u_c(c_t^*, c_t)} = e_t, \tag{7}$$

where $\bar{\lambda}$ is the (constant) Lagrange multiplier associated with budget constraint (5). Eq. (6) indicates that the marginal utility of consumption of traded goods is proportional to the effective price of consumption, $1 + \alpha i$. The effective price of consumption includes the opportunity cost of holding the real money balances needed to purchase goods. Eq. (7) equates the marginal rate of substitution between traded and home goods to their relative price, e.

Assume, for simplicity, that endowments are constant over time; that is, $y_t = y$ and $y_t^* = y^*$ for all t. Hence, assuming away government consumption, the market equilibrium conditions for this economy are [13]

$$c_t = y, \tag{8}$$

$$m_t = m_t^s, \tag{9}$$

$$\int_0^\infty c_t^* \exp(-rt)\, dt = \frac{y^*}{r}, \tag{10}$$

where m^s denotes money supply. Eqs. (8) and (9) denote the equilibrium conditions for home goods and money, respectively. Since traded goods can be freely bought and sold in the rest of the world, Eq. (10) indicates that the country is only constrained to spend 'within its budget'; namely, to make the present discounted value of its consumption of traded goods equal to the present discounted value of its endowment (where flows are discounted by the constant world real interest rate r). [14]

For the sake of concreteness, we will focus on the case in which the exchange rate path is exogenously determined by the monetary authority. Specifically, we will assume that the nominal exchange rate is devalued at a constant rate. (A particular case would be a system of fixed exchange rates.) Two polar situations will be studied: (a) perfect international capital mobility, and (b) no international capital mobility (i.e., perfect capital controls).

2.1. Perfect capital mobility

Under perfect capital mobility, the domestic real interest rate (in terms of traded goods) equals the world real interest rate (i.e., $\rho = r$). Furthermore, the supply of

[12] To ensure the existence of a steady state and eliminate inessential dynamics from the case of perfect capital mobility, it will be assumed that $\beta = r$.

[13] For the sake of simplicity, no new notation is introduced to denote equilibrium values.

[14] See the appendix for the derivation of Eq. (10).

money, m^s, is endogenous, implying that equilibrium condition (9) always holds. Therefore, under perfect capital mobility, Eqs. (6), (7) and (8) are reduced to (recall that $\beta = r$):

$$u_{c^*}(c_t^*, y) = \bar{\lambda}(1 + \alpha i_t), \tag{11}$$

$$\frac{u_{c^*}(c_t^*, y)}{u_c(c_t^*, y)} = e_t. \tag{12}$$

Consider first steady-state solutions. By Eq. (12), a constant real exchange rate is obtained if, and only if, c^* is constant over time, which implies, by Eq. (11), that the monetary authority must engineer a constant nominal interest rate. Since under perfect capital mobility $i_t = r + \epsilon_t$ (where ϵ is the rate of devaluation), a constant i implies a constant rate of devaluation. In turn, by the overall budget constraint (10), a constant c^* implies that $c^* = y^*$, which is independent of the nominal interest rate, i, and, therefore, of the rate of devaluation, ϵ. Hence, by (12),

$$e_t = \frac{u_{c^*}(y^*, y)}{u_c(y^*, y)}. \tag{13}$$

We have thus obtained the intuitively plausible implication that the *steady-state real exchange rate is independent of (permanent changes in) the rate of devaluation.* [15] In other words, the real exchange rate will be given by (13) for *any* constant level of the rate of devaluation and thus of the nominal interest rate. Furthermore, since the utility function is assumed to be strictly concave, it can be verified that a constant c^* path is a necessary and sufficient condition for a social optimum. Hence, in this economy it is socially optimal to have a constant rate of devaluation and, consequently, to generate the (unique) real exchange rate which can be kept constant over time. Any departure from this constant-real-exchange-rate path will be non-optimal, which proves, for the case of perfect capital mobility, that any attempt to depreciate the real exchange rate by monetary policy is bound to be socially costly. [16]

Suppose that the government attempts to depreciate the real exchange rate over and above the level achieved on the steady-state path. By previous considerations,

[15] This property does not hold in Lizondo (1991, 1993) or in Montiel and Ostry (1991, 1992), because in those models changes in the revenues from the inflation tax are not returned to the household in a lump-sum way, and thus affect private wealth. Hence, these models (implicitly) assume that fiscal policy changes with inflation.

[16] In more realistic examples, the real exchange rate associated with the social optimum may not be constant over time, particularly to the extent that shocks have a permanent component. However, one could prove in a wide variety of cases that any attempt to modify the real exchange rate via monetary policy (specifically, by a variable-rate-of-devaluation policy) would result in an inferior social outcome.

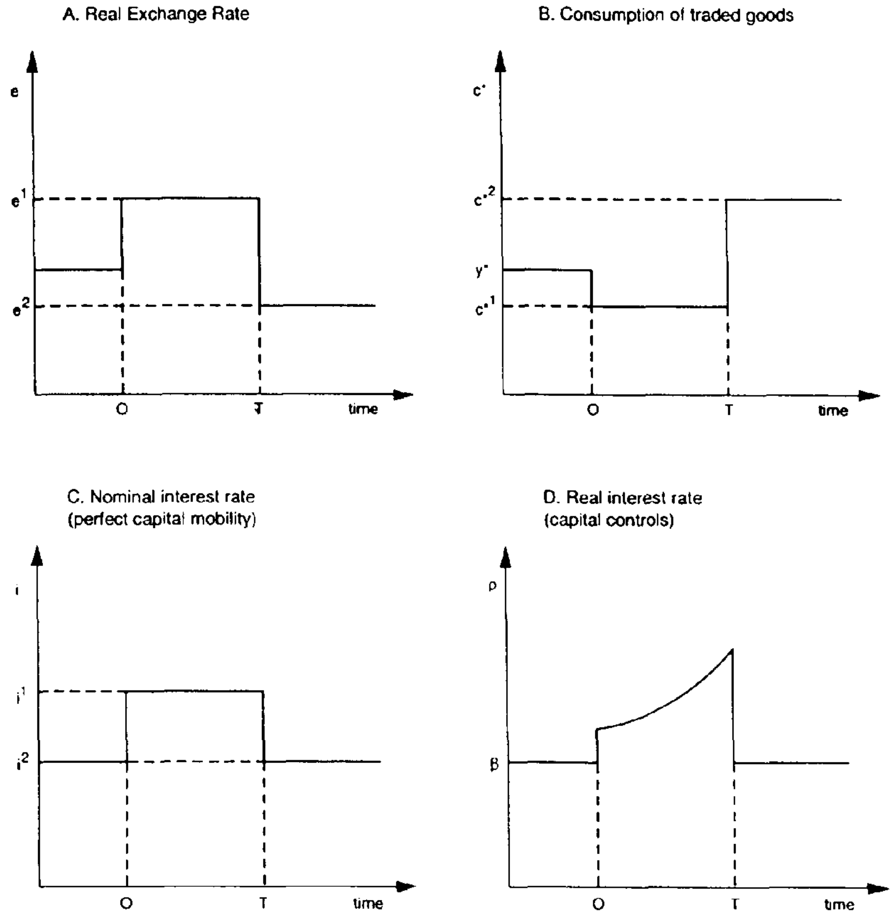

Fig. 3. Effects of real exchange rate targeting.

such a policy can only attain its objective for a limited period of time (since we have shown that the steady-state is unique). Given the strict concavity of the utility function, it follows from Eq. (12) that e rises if, and only if, c^* falls. By the resource constraint (10), the latter requires c^* to rise over its present steady-state level sometime in the future.

For the sake of clarity, consider the case in which the government sets the real exchange rate from time 0 to time T (>0) (hereafter referred to as the 'first period') at a level, e^1, which exceeds its present steady-state level (see Fig. 3, Panel A). After time T (hereafter referred to as the 'second period'), the economy settles to its new steady-state, indicated by e^2 [17]. Thus, denoting the corresponding consumption of traded goods by c^{*1} and c^{*2}, it follows, from Eq. (12), that $c^{*1} < y^*$ and, from the resource constraint (10), that $c^{*1} < y^* < c^{*2}$ (see Fig. 3, Panel B). Hence, by Eq. (12), e^2 is lower than initial e. Such a path of c^* implies, using (11), that $i^1 > i^2$ or, equivalently, that $\epsilon^1 > \epsilon^2$ (see Fig. 3, Panel C) [18]. Since within each period the relative price of traded goods in terms of home goods, e, is constant, it follows from the above analysis that the rate of inflation in period 1 exceeds that of period 2. Under perfect capital mobility, therefore, the model implies that in order to depreciate the real exchange rate over and above its current steady-state level, present inflation should be (and *expected* to be) higher than future inflation (i.e., inflation is higher in period 1 than in period 2).

Notice that the above result is not tantamount to saying that the current rate of inflation has to *increase* relative to its past level. Rather, the result says that the policy must be such that the public *expects* inflation to *fall* over time (i.e., it expects inflation in the second period to be lower than in the first period). From a theoretical point of view, therefore, it is conceivable that a (temporarily) more depreciated real exchange rate may follow from a *fall* in the inflation rate in the first period, provided that inflation in the second period is expected to fall even further. In practice, however, the public is likely to be highly skeptical of announcements of future lower inflation. Therefore, if the public cannot be persuaded that inflation in the future will be lower than initial inflation, targeting a more depreciated real exchange rate will necessarily imply a *rise* in inflation relative to its initial level.

Finally, note that the central result that real exchange rate targeting is inflationary would remain valid under a PPP-type rule whereby the real exchange rate is kept constant in the face of external shocks. Specifically, consider an initial equilibrium in which foreign inflation (π^*) is positive so that $i = i^* + \epsilon$, where $i^*(= r + \pi^*)$ denotes the world nominal interest rate. Further, suppose that there is a temporary fall in foreign inflation and, thus, in the world nominal interest rate; that is, $i^{*1} < i^{*2}$. In the absence of any policy response, this positive external shock would lead to a temporary fall in the domestic nominal interest rate (i.e., $i^1 < i^2$), which increases consumption of traded goods (i.e., $c^{*1} > y^* > c^{*2}$) and causes the real exchange rate to appreciate (i.e., e^1 falls below its initial level). The authorities can prevent this by setting ϵ^1 higher than ϵ^2 so as to exactly offset the change in the world nominal interest rate. In other words, policymakers set $i^1(= i^{*1} + \epsilon^1)$ equal to $i^2(= i^{*2} + \epsilon^2)$. By so doing, consumption of traded goods and, thus, the real exchange rate remain unchanged with respect to the

---

[17] As discussed below, for the resource constraint (10) to hold, e^2 must be below its initial steady state.

[18] Fig. 3, Panel C assumes that the nominal interest rate increases with respect to its initial level (see the discussion below).

initial pre-shock equilibrium. Hence, the policy is successful in preventing the real exchange rate from appreciating, but at the cost of higher inflation (i.e., $\epsilon^1 > \epsilon^2$) relative to the situation in which the authorities would not have responded to the external shock. [19]

Although the two types of real exchange rate targeting analyzed – setting a more depreciated level of the real exchange rate and a PPP-type rule – lead to higher inflation, the welfare effects differ. As argued above, temporarily setting a more depreciated level of the real exchange rate is welfare-reducing because there is no initial distortion. In contrast, keeping the real exchange rate constant in the face of a temporary fall in the world nominal interest rate is welfare-improving. To see this, note that such a policy rule implies that the consumption path of traded goods remains flat over time, and thus yields higher utility than the alternative, non-constant consumption path that would obtain if the monetary authority did not respond. In other words, the monetary authority fully offsets the distortion introduced by a non-constant world nominal interest rate. [20]

2.2. No capital mobility

Consider now the case in which capital controls are in place. It will be assumed that such controls can be perfectly enforced so that the stock of foreign assets in the hands of the public remains constant over time. [21] It will be shown that, unlike the case of perfect capital mobility, a temporary real exchange rate depreciation can be obtained with zero inflation and a constant devaluation rate. [22]

Unlike the case of perfect capital mobility, the domestic real interest rate (in terms of traded goods), ρ, can transitorily differ from the world real interest rate. Once again, consider the experiment of setting $e_t = e^1$ for $0 \leqslant t < T$. Since, by assumption, the nominal exchange rate is fixed (i.e., $\epsilon = 0$), $i = \rho$. Furthermore, equilibrium condition (10) still holds in this case, implying that $c_t^* = c^{*1} < y^*$ during the first period. Thus, as before, if the economy settles down to a

[19] We are assuming, of course, that private sector expectations are not altered by the policy response itself.

[20] Note that a key feature of the present model is that welfare is independent of the *level* of the nominal interest rate, as long as it is constant over time. A more comprehensive welfare analysis would also take into account the beneficial effects from a lower level of inflation, along the lines of the transactions-costs model of Reinhart and Végh (1994). In such a set-up, the PPP-type rule analyzed above would not necessarily lead to higher welfare, as the benefits of keeping a constant path of the nominal interest rate could be more than offset by the cost (in terms of higher transactions costs) of foregoing a period of lower nominal interest rates.

[21] Formally, the model becomes a dual exchange rates regime with no leakages; see, for instance, Obstfeld (1986) and, in the same cash-in-advance context, Guidotti and Végh (1992).

[22] It will be assumed, for simplicity, that the rate of devaluation is zero. The results, however, hold for any constant rate of devaluation.

steady-state after time T, we have $c_t^* = c^{*2} > y^*$, for $t \geqslant T$.[23] Moreover, by Eqs. (6) and (7), it is straightforward to show that in a steady-state with fixed exchange rates $i = \rho = \beta$. We will now show that, during the first period, the money supply can be manipulated in order to generate $e_t = e^1$ and $c_t^* = c^{*1}$ for $0 \leqslant t < T$.

By first-order condition (6), it follows that

$$u_{c^*}(c^{*1}, y) = \lambda_t(1 + \alpha i_t) \quad \text{for} \quad 0 \leqslant t < T, \tag{14}$$

$$u_{c^*}(c^{*2}, y) = \lambda_T(1 + \alpha\beta) \quad \text{for} \quad t \geqslant T, \tag{15}$$

where

$$\lambda_t = \bar{\lambda} D_t \exp(\beta t) \quad \text{for} \quad 0 \leqslant t < T, \tag{16}$$

$$\lambda_t = \lambda_T \quad \text{for} \quad t \geqslant T. \tag{17}$$

Therefore, recalling Equation (2) and that, with fixed exchange rates, $i = \rho$, we have

$$\dot{\lambda}_t = \lambda_t(\beta - i_t). \tag{18}$$

Thus, by Eqs. (14) and (18), it follows that

$$\dot{\lambda}_t = \left(\frac{1}{\alpha} + \beta\right)\lambda_t - \frac{u_{c^*}(c^{*1}, y)}{\alpha} \quad \text{for} \quad 0 \leqslant t < T. \tag{19}$$

By definition (recall Eqs. (14) and (15)), λ is continuous with respect to time. Moreover, from (15), it follows that λ must attain a well-defined level at time T. Formally, then, the equilibrium solution is associated with the continuous path of λ that satisfies dynamic equation (19) and terminal condition (15). We now have the basic elements to proceed with the substantive part of the analysis.

We first show that λ decreases over time. Suppose, to the contrary, that λ increases over time. This implies, from Eq. (19), that $(1/\alpha + \beta)\lambda_0 > u_{c^*}(c^{*1}, y)/\alpha$. Then, since $\lambda_T > \lambda_0$ and $c^{*1} < c^{*2}$, it follows, using (12), that $(1/\alpha + \beta)\lambda_T > u_{c^*}(c^{*1}, y)/\alpha > u_{c^*}(c^{*2}, y)/\alpha$, which contradicts terminal condition (15). Therefore, $(1/\alpha + \beta)\lambda_0 < u_{c^*}(c^{*1}, y)/\alpha$, which implies, by Eq. (19), that λ decreases over time.[24] Consequently, by Eq. (14), *the nominal interest rate (and hence the real interest rate) increases over time.* Moreover, by Eq. (14) and the above finding that $(1/\alpha + \beta)\lambda_0 < u_{c^*}(c^{*1}, y)/\alpha$, it follows that

$$u_{c^*}(c^{*1}, y) = \lambda_0(1 + \alpha i_0) > \lambda_0(1 + \alpha\beta), \tag{20}$$

[23] Notice that we can choose the same values of c^{*1} and c^{*2} as in the case of perfect capital mobility, because the economy as a whole faces the same overall resource constraint (10), independently of the degree of international capital mobility.

[24] Note that it cannot be the case that $(1/\alpha + \beta)\lambda_0 = u_{c^*}(c^{*1}, y)/\alpha$. If that were the case, $\lambda_t = \lambda_0$ for $0 \leqslant t < T$, and terminal condition (15) would be violated.

implying that $i_0(=\rho_0)>\beta$. Therefore, if before the attempt to raise the real exchange rate the economy was in a steady-state equilibrium, *an overdepreciated real exchange rate can be sustained by a jump in the nominal / real interest rate, followed by further increases until the policy is abandoned at time T* (and ρ goes back to its steady-state level β), as illustrated in Fig. 3, Panel D. [25]

In sum, the analysis has shown that, under no capital mobility, a temporary depreciation of the currency in real terms can be achieved without affecting the inflation rate if it is accompanied by a temporarily tight credit stance. As expected, tight credit is achieved by lowering real monetary balances. To prove it, notice that the cash-in-advance constraint (4) and equilibrium condition (8) imply

$$m_t = \alpha\left(c_t^* + \frac{y}{e_t}\right). \tag{21}$$

Hence, m falls at time 0 (since e rises and c^* falls) and remains constant in each of the periods. Consider the domestic credit policy that supports such a path of the money supply. At time 0, domestic credit is reduced to engineer the drop in the money supply. Thereafter, and for the rest of the first period, the monetary authorities fully sterilize the reserve inflow that results from the current account surplus, so as to keep the money supply constant. At time T, domestic credit is increased to support the higher consumption of traded goods and lower real exchange rate. The above result testifies to the much greater power that monetary policy has under imperfect capital mobility. In our example, the real exchange rate can be changed by manipulating the supply of money but, remarkably enough, without having to change the rate of inflation. It should be pointed out, however, that even in the extreme case of no international capital mobility, temporary changes in the real exchange rate are socially costly. Actually, our example dramatizes this point since the associated social costs of temporary changes in the real exchange rate are identical to those borne under perfect capital mobility. [26]

The power of monetary policy is undermined also in this case if government policy is not fully credible. Consider, for example, the case in which the public expects high inflation in the future, irrespective of government announcements. Under those conditions, the expected future interest rate is largely independent of present announcements. Hence, in order to provoke a temporary depreciation of the real exchange rate, the government will be forced to increase current interest rates even further than it would under perfect credibility. In a more realistic model in which there is a positive stock of short-term government debt, higher interest

[25] A PPP-type rule would lead to similar results, as discussed above for the perfect capital mobility case. Hence, keeping the real exchange rate constant in the face of a temporary external shock that would tend to appreciate it would entail high and rising real interest rates relative to the situation in which there is no policy response.

[26] This point should be obvious as the path of c^* is the same in both cases.

rates would worsen the fiscal balance, possibly generating the high inflation expected by the public.

3. Simulation of the model

The previous section presented a simple example in which the government is able to temporarily set the real exchange rate at a more depreciated level than in the steady-state by either raising inflation in the present relative to the future (under perfect capital mobility) or increasing real interest rates (under no capital mobility). This section discusses a numerical illustration of the model to get a sense of the orders of magnitudes involved. [27] Specifically, we are interested in assessing how much inflation and real interest rates must rise to generate a given depreciation of the real exchange rate. [28]

For the purposes of simulating the model, we need to specify preferences. Assume that the instantaneous utility function exhibits constant relative risk aversion:

$$u(c_t^*, c_t) = \frac{z_t^{1-1/\eta} - 1}{1 - 1/\eta}, \tag{22}$$

where $\eta(>0)$ is the intertemporal elasticity of substitution, and z, an index of total consumption takes the Cobb–Douglas functional form

$$z_t = c_t^{*q} c_t^{1-q}, \tag{23}$$

where q denotes the share of traded-goods consumption in total consumption. We now have all the elements needed to simulate the model under both perfect capital mobility and capital controls.

3.1. Perfect capital mobility

Taking into account Eqs. (22) and (23), first-order conditions (11) and (12) become:

$$qz_t^{-1/\eta}\left(\frac{y}{c_t^*}\right)^{1-q} = \bar{\lambda}(1 + \alpha i_t), \tag{24}$$

$$\frac{qy}{(1-q)c_t^*} = e_t. \tag{25}$$

[27] See Reinhart and Végh (1994) for a similar numerical exercise under perfect capital mobility aimed at assessing the quantitative importance of imperfect credibility in exchange rate-based stabilization programs.

[28] For the sake of concreteness, we will assume that the nominal interest rate does not change across steady states and is equal to r (i.e., steady-state inflation is zero). Hence, in the first period the nominal interest rate is *higher* than in the initial steady state.

Using (24), (25), and resource constraint (10), a closed-form solution for c^* can be derived:

$$c_t^* = y^* \frac{p_t^{-\eta^*}}{r\int_0^\infty p_t^{-\eta^*} \exp(-rt)\,\mathrm{d}t}, \tag{26}$$

where

$$p_t \equiv 1 + \alpha i_t, \tag{27}$$

$$\eta^* \equiv \frac{\eta}{q + (1-q)\eta}. \tag{28}$$

To simplify notation, Eq. (27) defines the effective price of consumption, while Eq. (28) defines the intertemporal elasticity of substitution relevant for traded goods. [29]. Note that if i, and thus p, are constant over time, then the term that multiplies y^* on the right-hand side of Eq. (26) is unity, which implies that $c_t^* = y^*$ for all t. If i, and thus p, vary over time, then c^* will also vary over time. In this case, the parameter η^* plays a key role in determining the response of c^*. Specifically, if p is higher in the present than in the future, then today's consumption of traded goods is lower than in the future. The higher is η^*, the smaller will be today's consumption relative to future consumption.

To make Eq. (26) operational, we need to make explicit the path of i and thus p. Following the theoretical example, suppose that $i_t = i^1$ for $0 \leqslant t < T$ and $i_t = i^2$ for $t \geqslant T$, where $i^1 > i^2$. Then, denoting by p^1 and p^2 the respective effective prices (i.e., $p^1 = 1 + \alpha i^1$ and $p^2 = 1 + \alpha i^2$, where $p^1 > p^2$), Eq. (26) reduces to

$$c_t^* = y^* \left(1 - \exp(-rT) + \left(\frac{p^2}{p^1}\right)^{-\eta^*} \exp(-rT)\right)^{-1} \quad \text{for} \quad 0 \leqslant t < T. \tag{29}$$

where p and η^* are defined in Eqs. (27) and (28), respectively. (An analogous expression holds for $t \geqslant T$.)

Using Eqs. (25), (27), (28) and (29), we can compute the nominal interest rate which is needed to generate a given depreciation of the exchange rate. [30] Assuming that $i^2 = r = 0.03$, Table 1 shows the nominal interest rate (in monthly

---

[29] It should be noted that, when $q = 1$, Eq. (26) reduces to the closed-form solution that would hold in a one-good model (see Reinhart and Végh, 1994). Thus, this two-good setting makes clear that the intertemporal elasticity of substitution relevant for traded-goods consumption, η^*, may differ from the elasticity of substitution of aggregate consumption, η. Note that if $q = 1$, then $\eta^* = \eta$. In a two-good setting, however (i.e, when $q < 1$), if $\eta < 1$ (the relevant case in practice, see below), then $\eta^* > \eta$.

[30] Specifically, we take i^2 as given and vary i^1 so as to generate through Eq. (29) the value of c^{*1} that implies, by Eq. (25), the desired depreciation of the real exchange rate.

Table 1
Perfect capital mobility: Nominal interest rate needed to generate a given real depreciation (in percent per month)

	Intertemporal elasticity of substitution	Depreciation of real exchange rate		
		5 percent	10 percent	15 percent
$T = 0.5$	0.15	10.57	23.35	39.26
	0.4	4.97	10.07	15.55
	0.8	3.43	6.73	10.15
$T = 1$	0.15	10.75	23.78	40.06
	0.4	5.05	10.22	15.81
	0.8	3.48	6.83	10.31
$T = 2$	0.15	11.10	24.67	41.74
	0.4	5.20	10.55	16.34
	0.8	3.58	7.05	10.63

Source: Authors' calculations.

effective terms) which generates during period 1 a real depreciation of 5, 10, and 15 percent for different values of η and T (expressed in years). [31,32] For example, if $\eta = 0.4$ and $T = 1/2$ (half a year), then the nominal interest rate needs to be 4.97 percent per month (or 79.0 percent per year) for the real exchange rate to depreciate by 5 percent.

Four observations follow from the figures reported in Table 1:

(i) The inflationary consequences of engineering a temporary depreciation of the real exchange rate are likely to be substantial. Even though these figures should be viewed as an upper bound – given that in practice capital mobility is less than perfect – the order of magnitude is large enough to suggest that the inflationary effects would still be large under less than perfect capital mobility.

(ii) The real exchange rate target has a substantial effect on the inflation upsurge. In other words, for a given value of the intertemporal elasticity of substitution (say, 0.4), targeting a real depreciation of 15 percent during one year (i.e., $T = 1$) results in considerably more inflation (a nominal interest rate of 15.81

[31] Note that i is an interest rate which is capitalized instantaneously. Hence, if i is 3 percent, the corresponding yearly effective rate is 3.05 percent and the monthly rate is 0.25 percent. In what follows, and unless otherwise noticed, all interest rates are expressed in effective terms.

[32] The following parameter values were used: $\alpha = 0.15$, $q = 0.4$, $r = 0.03$. Without loss of generality (since we are only concerned with percentage changes), y^* and e were normalized to one. The values of α and q were chosen based on actual data. Specifically, the ratio of M1 to private consumption was 11.4 for Brazil in 1991, 10.7 for Chile in 1991, and 16.7 for Colombia in 1988 (data from IFS). The value of q, based on the average share of traded-goods consumption during the period 1978–1986, was 0.47 for Brazil and 0.32 for Colombia (see Ostry and Reinhart, 1992).

percent per month) than targeting a real depreciation of 5 percent (a nominal interest rate of 5.05 percent per month).

(iii) The intertemporal elasticity of substitution plays a key role. Since the real exchange rate depreciation is effected through intertemporal consumption substitution, it is not surprising that the magnitude of this parameter critically affects the inflationary consequences of real exchange rate targeting. For instance, for $T = 1$ and a real exchange rate depreciation of 10 percent, the nominal interest rate varies from 23.78 to 6.83 percent per month as η varies from 0.15 to 0.8. As reported in Reinhart and Végh (1993), intertemporal elasticities of substitution for several developing countries, which include Brazil and Chile, are clustered around 0.20. [33]. Hence, these low values of η are likely to exacerbate the inflationary consequences of real exchange rate targeting.

(iv) The time period during which policymakers seek to maintain a more depreciated real exchange rate is relatively unimportant. As Table 1 shows, the values of the parameter T make little difference to the inflationary effects. For instance, for a real depreciation of 5 percent and $\eta = 0.15$, the nominal interest rate varies only from 10.57 to 11.10 percent per month as T varies from half a year to two years. Hence, what matters is not so much the time period during which the more depreciated real exchange rate is maintained, but rather the desired target *level* of the real exchange rate.

3.2. No capital mobility

In spite of having intrinsic dynamics, the model with capital controls is simple enough to lend itself to an easy numerical solution. Our objective is to compute the initial and final values of the real interest rate path (i.e., ρ_0 and ρ_{T^-}), depicted in Fig. 3, Panel D, that generate a temporarily depreciated real exchange rate. [34,35]. The values of c^{*1} and c^{*2} are the ones that follow from the perfect capital mobility case since, by construction, the policy under capital controls studied in Section 2 supports such a path.

Since no additional insights are derived from solving the model, we will only indicate how the model is solved without reporting the solution itself. The linear differential equation (19) can be solved to obtain λ_0 as a function of λ_T and c^{*1}. Since we know both λ_T (which follows from Eq. (15) using Eqs. (22) and (23))

[33] Reinhart and Végh (1993) use for estimation purposes a monetary model very similar to the present cash-in-advance model, but which allows for variable velocity. Depending on the parameters of the money demand, estimates for η lie in the range 0.04–0.80 and are statistically significant. In a real model, using panel data for five Latin American countries (including Brazil and Colombia), Ostry and Reinhart (1992) estimate the intertemporal elasticity of substitution to be around 0.4.

[34] T^- denotes the left-hand limit.

[35] Recall that since the rate of inflation is zero, the real interest rate is also the nominal interest rate.

Table 2
No capital mobility: Real interest rate needed to generate a given real depreciation (in percent per month)

	Intertemporal elasticity of substitution	Depreciation of real exchange rate		
		5 percent	10 percent	15 percent
$T = 0.5$	0.15	0.55–10.57	0.79–23.35	0.99–39.26
	0.4	0.40– 4.97	0.53–10.07	0.65–15.55
	0.8	0.35– 3.43	0.45– 6.73	0.53–10.15
$T = 1$	0.15	0.26–10.75	0.27–23.78	0.27–40.06
	0.4	0.26– 5.05	0.26–10.22	0.26–15.81
	0.8	0.25– 3.48	0.26– 6.83	0.26–10.31
$T = 2$	0.15	0.25–11.10	0.25–24.67	0.25–41.74
	0.4	0.25– 5.20	0.25–10.55	0.25–16.34
	0.8	0.25– 3.58	0.25– 7.05	0.25–10.63

Source: Authors' calculations.

and c^{*2}, λ_0 can be computed. Given λ_0 and c^{*1}, $i_0(=\rho_0)$ can be computed from Eq. (14), using Eqs. (22) and (23). The value of i_{T^-} can be computed in the same way by recalling that λ is continuous at $t = T$.

The results of the simulation are reported in Table 2. Each entry reports two values of the real interest rate path depicted in Fig. 3, Panel D: the first is the value of the real interest rate at time 0, while the second is the value at time T^- (i.e, just before the real interest rate falls). In general, the initial increase in real interest rates is rather small. [36] However, the real interest rate eventually reaches high, and in some cases exorbitant, levels. Note that the final value taken by the real interest rate (or the nominal interest rate) coincides with the value that the nominal interest rate takes in the perfect capital mobility case, as a comparison of Tables 1 and 2 reveals. This should not come as a surprise since terminal condition (15) also holds under perfect capital mobility, which implies that $\lambda_T = \bar{\lambda}$. Hence, since consumption is the same in both cases, ρ_{T^-} (under no capital mobility) equals i^1 (under perfect capital mobility).

The same observations made for the case of perfect capital mobility apply here. In particular, the key parameters are the intertemporal elasticity of substitution and the target level of the real exchange rate. The time frame during which the more depreciated real exchange rate is in effect plays a minor role.

In conclusion, it should be borne in mind that Tables 1 and 2 represent two extreme situations – perfect capital mobility and perfect capital immobility – neither of which is likely to hold in practice. In the real world, the applicable

[36] The steady-state value of the real interest rate is 0.25 percent per month. In all the entries of Table 2, the value of the real interest rate at time 0 is higher than the steady-state value, although in some cases this is not evident from the table as figures have been rounded to two decimals.

scenario will be somewhere in between, even when it has been moving towards the perfect capital mobility case during the last 20 years. Therefore, in practice, targeting an over-depreciated real exchange rate for a limited period of time is bound to result in both higher inflation and higher real interest rates. Under this interpretation, Tables 1 and 2 suggest *upper* bounds for the order of magnitudes involved.

4. Empirical implications

The model outlined in Section 2 implies that the steady-state real exchange rate is independent of (permanent changes) in monetary policy. Since there is no direct steady-state link between inflation and the real exchange rate, monetary authorities' impact on the real exchange rate is, at best, transitory. This section examines some of the main empirical implications of the theoretical framework. Given that the model emphasizes temporary changes in the real exchange rate, we first assess the relative importance of temporary shocks in explaining the total variability of the real exchange rate for Brazil, Chile, and Colombia, three countries which have followed a PPP rule. [37] We then examine empirically the main implication of the model: if there is some measure of capital mobility, inflation will accelerate during episodes in which the real exchange rate is depreciated relative to its permanent, 'steady-state' level. To this end, we compute the correlation between inflation and the 'cyclical' component of the real exchange rate, as the latter captures transitory deviations from its steady-state level.

Quarterly data for the real exchange rate and consumer prices for the period January 1978 to December 1992 are employed. The empirical analysis that follows requires that the individual time series properties of the variables of interest be known beforehand. Hence, we apply a battery of unit root tests, which are reported in Table 3. The augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests indicate that the real exchange rate and the price *level* have one unit root (i.e., they are difference stationary). Inflation is a stationary variable. [38] The unit root tests indicate that the variables in question have a permanent component but do not provide information on the relative importance of this component.

4.1. Temporary shocks to the real exchange rate

To determine how important a role temporary shocks play in explaining real exchange rate variability, we employ Cochrane's (1988) methodology, which

[37] Of course, other policy actions not discussed in this paper, such as changes in government spending on nontraded goods will have *permanent* effects on the real exchange rate (see, for example, Edwards (1989)).

[38] When the test results give conflicting results (for instance, inflation in Colombia), a higher weight is attached to the PP tests, which allow for more general forms of heteroskedasticity.

Table 3
Unit root tests: 1979:II–1992:II [a]

Regression: $\Delta y_t = \mu + \beta t + \alpha y_{t-1} + \Sigma_{i=1}^{k} \delta_i \Delta y_{t-i} + e_t$

Series	k	t-statistic on α (A.D.F. statistic)	Phillips–Perron statistic
Real exchange rate			
Brazil	1	−2.9837	−2.1865
Chile	3	−2.3568	−1.9772
Colombia	1	−1.8625	−1.5359
Inflation			
Brazil	1	−4.249 ***	−3.850 **
Chile	4	−3.598 **	−4.932 ***
Colombia	3	−1.884	−6.472 ***
Critical values	1%	5%	10%
50 observations[b]	−4.18	−3.51	−3.18

[a] The real exchange rate is expressed in logs while inflation is measured as the first difference of the log of the price level. The actual number of observations is 52. A '***' and '**' denote significance at the one and five percent levels, respectively.
[b] The critical values are taken from Guilkey and Schmidt (1989).

provides a measure of the persistence of shocks to a variable by examining the variance of its long differences. Specifically, suppose that the variable x has the following representation:

$$x_t = \delta x_{t-1} + u_t, \quad \text{where} \quad u_t \sim \mathrm{N}(0, \sigma_u^2). \tag{30}$$

Then, if $\delta = 1$, x follows a pure random walk and the variance of its k-differences grows linearly with the difference

$$\operatorname{var}(x_t - x_{t-k}) = k\sigma_u^2. \tag{31}$$

If $\delta < 1$ and x is a stationary process, the variance of its k-differences is given by

$$\operatorname{var}(x_t - x_{t-k}) = \sigma_u^2(1 - \delta^{2k})/(1 - \delta^2). \tag{32}$$

Therefore, the ratio $(1/k)\operatorname{var}(x_t - x_{t-k})/\operatorname{var}(x_t - x_{t-1})$ is equal to one if x follows a random walk process and converges to zero if x is stationary. If x has both permanent (random walk) and temporary (stationary) components, the ratio will converge to the ratio of the variance of the permanent shock to the total variance of x. Thus, the closer that ratio is to unity, the lower is the relative importance of temporary shocks.

Table 4 summarizes the main results. The values of k range between one and ten years. In all three countries considered, temporary shocks account for a sizable share of the variance of the real exchange rate. Temporary shocks are most important for Chile (62 percent of the variance) and least important for Brazil (43 percent of the variance). Colombia falls in the middle of the range with temporary

Table 4
Temporary and random walk components of the real exchange rate [a]

$(1/k)\sigma_k^2/\sigma_1^2$ for various k (quarters)				
8	16	24	32	40
Brazil				
1.072	0.640	0.752	0.575	
(0.015)	(0.021)	(0.028)	(0.030)	
Chile				
1.041	0.863	0.704	0.513	0.376
(0.017)	(0.027)	(0.031)	(0.031)	(0.012)
Colombia				
1.494	1.217	0.953	0.687	0.465
(0.017)	(0.027)	(0.031)	(0.031)	(0.012)

[a] Quarterly data were used. The real exchange rate indices are from the Information Notice System (IMF). Standard errors are in parentheses. The standard errors were tabulated from Monte Carlo simulations (600 replications) for $n = 62$ and $k = 32$ and $k = 40$, under the null hypothesis of a random walk. The variance ratio converges at a lower k for the case of Brazil, indicating that temporary shocks are relative less persistent than in Chile and Colombia.

shocks accounting for about 54 percent of the variance of the real exchange rate. On balance, these results would seem to indicate that, for these countries, temporary shocks play an important role in the behavior of real exchange rates. Hence, at least in this respect, the theoretical framework outlined in Section 2 is not devoid of empirical content.

Our results contrast with those of Edwards (1989), who suggests that temporary shocks play a relatively small role in determining the behavior of real exchange rates. Edwards' (1989) conclusion, however, is based on the results of a regression which has the level of the real exchange rate as the dependent variable, and includes as explanatory variables both permanent and temporary components of the terms of trade, government spending, and other 'real' variables (see Edwards, 1989). The main problem with that approach is that not all variables appearing in the regression are integrated of the same order, which will bias the results towards finding no role for temporary shocks. Note that both the real exchange rate and, by construction, the 'permanent component' of all the explanatory variables are non-stationary. [39] However, also by construction, the 'temporary component' of all explanatory variables is stationary. Hence, regression methods, such as OLS, will attach zero coefficients to all the stationary variables appearing in the right-hand side, since asymptotically there can be no relationship between a nonstationary and a stationary variable. However, such lack of statistical signifi-

[39] The Beveridge–Nelson (1981) trend–cycle decomposition was used by Edwards (1989).

cance of the temporary components was taken as evidence that temporary shocks were not an important factor in real exchange rate behavior.

The methodology outlined here is more direct and does not require any estimation. It is important to note, however, that this methodology does not discriminate among 'types' of temporary shocks. In other words, it does not distinguish between a 'temporary policy shock', such as the one considered in the previous exercise from, say, a temporary terms-of-trade shock, which underlies Edwards' (1989) exercise.

4.2. *Inflation and the real exchange rate*

The theoretical model suggests that inflation will accelerate when the authorities attempt to depreciate the real exchange rate beyond its equilibrium level. To examine this proposition we follow a two-step approach. First, employing the Beveridge–Nelson technique (Beveridge and Nelson, 1981) as modified by Miller (1988), we decompose the exchange rate into its 'permanent' (or steady-state) component and 'temporary' (or cyclical component). As discussed above, the identifying criteria for this technique is that the former captures the nonstationary component of the variable, while the latter captures its stationary element. [40] Second, we examine the pairwise correlations between the cyclical component of the real exchange rate and inflation (which was also shown to be a stationary variable).

The inverse of the IMF index of the real exchange rate is used; hence, as in the theoretical model, an increase in the index denotes a real *depreciation*. [41] When the cyclical component is negative, the actual exchange rate is 'overvalued' relative to its equilibrium steady-state level. Therefore, the model suggests that we should observe a positive correlation between inflation and the cyclical or temporary component of the real exchange rate. The corresponding correlations and their standard errors are reported in Table 5. In all three cases considered, the correlation has the anticipated sign and is significant at the ten percent confidence level or higher. In all cases, the correlation is relatively low (ranging from 0.26 to 0.42), suggesting that there are also important differences in the driving forces behind these two variables. This low correlation is evident from Fig. 4, which plots inflation and the cyclical component of the real exchange rate.

By contrast, no systematic relationship is evident from the correlations of the (log) level of the real exchange rate and inflation in two of the three countries (see

[40] Table A.1, in the appendix, provides details about the ARMA processes that best described the real exchange rate for the three countries in our sample, while Appendix A.2 discusses the links between the 'economic fundamentals' and the trend and cycle.

[41] The data source is the Information Notice System (IMF).

Table 5
Pairwise correlations: 1979:IV–1992:III [a]

	Country		
	Brazil	Chile	Colombia
Inflation			
Real exchange rate [b]	0.092	0.066	0.324
	(0.148)	(0.146)	(0.135)
Cyclical component of the real exchange rate	0.257	0.293	0.333
	(0.144)	(0.139)	(0.134)
Cyclical component of inflation			
Real exchange rate	−0.224	0.415	0.196
	(0.145)	(0.133)	(0.140)
Cyclical component of the real exchange rate	0.265	0.423	0.362
	(0.144)	(0.132)	(0.133)

[a] Standard errors of the correlation coefficients are in parentheses. The real exchange rate is expressed in logs while inflation is measured as the first difference of the log of the price level. The trend–cycle decomposition of the real exchange rate was obtained using the Beveridge–Nelson technique. The ARMA processes that model the change in the permanent component are presented in Table A.1 in the Appendix. Since inflation was found to be stationary around a deterministic trend, the bottom panel of this table reports the correlations for the cyclical deviations from trend.
[b] The correlations with the real exchange rate are only meant to be illustrative. Inference-making cannot proceed as usual given that the real exchange rate is I(1) and inflation is I(0). Such problems do not arise with the correlations involving the cyclical component of the real exchange rate which, by construction, is I(0).

Table 5).[42] This lack of a systematic relationship between inflation and the real exchange rate has fueled the observation that Chile represents a case of successful real exchange rate targeting, in the sense that a policy of targeting the real exchange rate coexisted with declining inflation rates (see Edwards (1991)). The above results would suggest, however, that the lack of inflationary pressures in the case of Chile possibly stemmed from having a real exchange rate target that was, in effect, closely tracking the equilibrium real exchange rate throughout most of the sample period.[43] However, as in Brazil and Colombia, the evidence suggests that in periods when the real exchange rate was depreciated relative to its steady-state level, inflation did tend to accelerate.[44]

[42] This is not surprising; since the two variables have different orders of integration, any relationship is bound to be spurious.

[43] This issue is discussed further in Appendix A.2.

[44] In the case of Colombia, Herrera (1991) and Carrasquilla (1992) have also noted that periods of real exchange rate disequilibria (in the sense of an overdepreciated real exchange rate) have been characterized by inflationary pressures.

In sum, the empirical exercises summarized in this section yield two main observations, both of which are consistent with the theoretical model: (i) temporary shocks play an important role in explaining real exchange rate behavior, and (ii) there appears to be a systematic relationship between real exchange rate disequilibria and inflation.

4.3. Implications of other models

The theoretical model outlined in this paper has stressed the relationship between the temporary or cyclical component of the real exchange rate and inflation. However, other models (see Lizondo, 1991, 1993; Montiel and Ostry, 1991, 1992) have focused on the relationship between inflation and the steady-state real exchange rate. Specifically, the relationship between these two variables implied by these models is an indirect one (in the sense that the implied relationship is between *revenues* from the inflation tax, rather than inflation, and the real exchange rate), and comes about through wealth effects. In these models, the steady-state real exchange rate is determined by market clearing in the nontraded goods sector. Demand for the nontraded good depends on its relative price (i.e. the real exchange rate), and wealth, which, in turn, depends on the inflation tax. Changes in the inflation tax affect household wealth because it is assumed that the government does not return revenues from the inflation tax to the household via a lump-sum transfer. Rather, the government uses these revenues to, say, increase spending on traded goods. Hence, these models predict that the steady-state real exchange rate can be depreciated by permanently increasing the inflation rate. [45] An increase in inflation reduces households' wealth and decreases their demand for the nontraded good. As a result, the real exchange rate must depreciate to restore equilibrium in the market for home goods.

The empirical examination of a steady-state relationship between inflation and the real exchange rate is far from trivial because, in principle, there are a host of other variables (for instance, the terms of trade and government spending) that affect the steady-state real exchange rate, and which should be incorporated into the empirical analysis. [46] At the very least, however, and given that we have in mind the equilibrium in the home goods market, the supply of home goods must be taken into account. Hence, to explore some of the empirical implications of these models we proceed in two steps. First, we establish the time series properties of the inflation tax (i.e. πm) and GDP (which will serve as a proxy for output of the nontraded good). As is well known, a steady-state relationship can only exist among variables which are integrated of the same order. Hence, the inflation tax

[45] It is assumed that real money demand is inelastic, so that an increase in inflation raises revenues from the inflation tax.

[46] See, for instance, Edwards (1989).

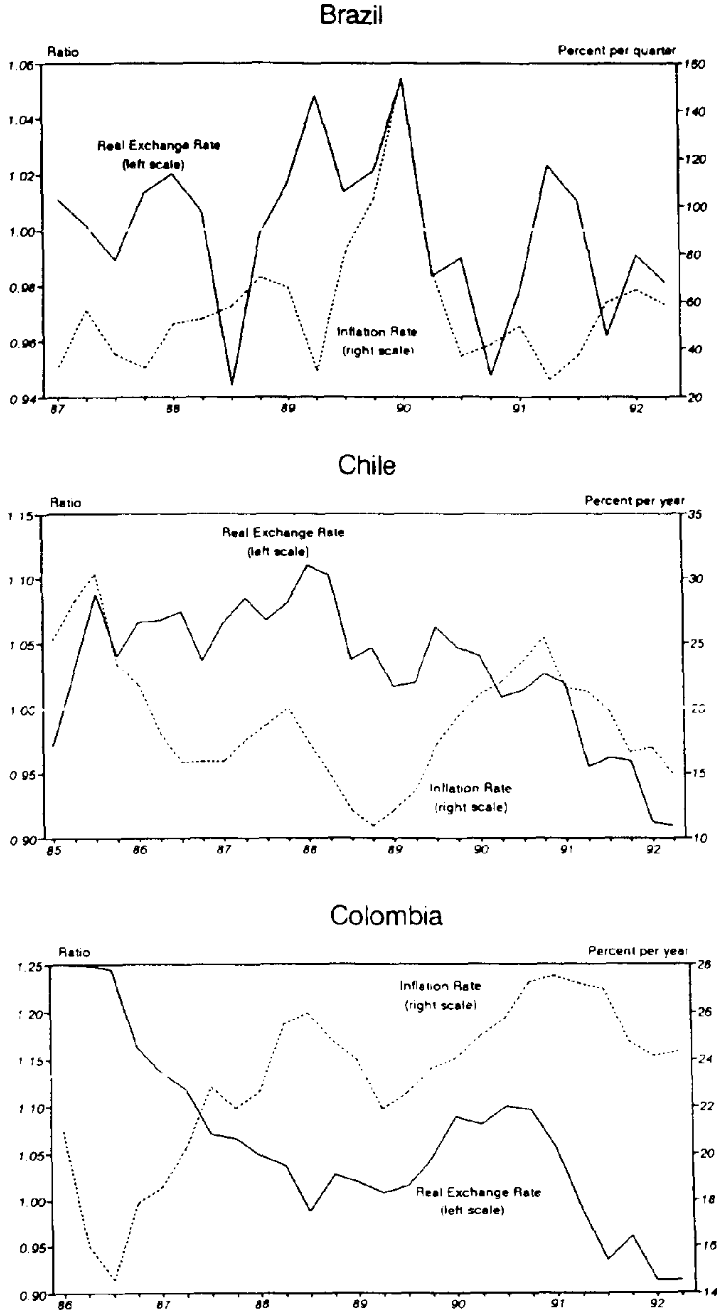

Fig. 4. Inflation and temporary component of real exchange rate. *Sources:* International Financial Statistics (IMF), Information Notice System (IMF), and authors' calculations. *Note:* A decrease in the real effective exchange rate index denotes an appreciation. The temporary component of the real exchange rate is expressed as the ratio of actual to permanent so, for example, a ratio of less than one indicates an overvaluation. Inflation is computed as the change in the CPI over the previous quarter for Brazil and over the previous four quarters for Chile and Colombia.

and real GDP must be difference stationary (like the real exchange rate) if the steady state relationship postulated by these models is to have empirical content. Second, for the cases where the all the variables are integrated of the same order, we proceed to examine via cointegration tests if a steady-state relationship among them can be identified.

Applying the same battery of tests as before, in all three countries considered, GDP per capita and the inflation tax (also on a per capita basis) were found to be nonstationary (however, the inflation tax as a percent of GDP is *stationary*). [47] Hence, based on the individual unit root tests there is no a priori basis for ruling out the steady-state relationship postulated by Lizondo (1991, 1993) and Montiel and Ostry (1991, 1992).

To examine whether output and the inflation tax are sufficient to pin down the steady-state behavior of the real exchange rate, we perform the cointegration tests of Johansen (1988, 1991). The results summarized in Table 6 report the λ-max and trace statistics, as well as their respective critical values. In addition, Table 6 reports the estimated parameters for the cointegrating vectors (when they exist). Cointegration among the real exchange rate, real GDP per capita, and the inflation tax per capita was detected only for Colombia. [48] If the assumption of a single traded good is relaxed, and a distinction is made between importables and exportables, the equilibrium real exchange rate also depends on the terms of trade (see for example, Edwards (1989)). Including the terms of trade in the vector of variables was particularly important for Chile. Once the terms of trade are included, cointegration obtains (see Table 6 and critical values for $n = 4$). Hence any meaningful inference will be limited to those two cases. The Stock–Watson (1989) estimates of coefficients of the cointegrating vectors, which deal with the biases introduced in the cointegrating regressions by simultaneity and serial correlation in the errors, indicate that the variables enter significantly and with the anticipated signs. Hence, an expansion in output depreciates the real exchange rate, implying a positive coefficient; similarly, an increase in the inflation tax depreciates the equilibrium real exchange rate. An improvement in the terms of trade, other things equal, tends to appreciate the equilibrium real exchange rate (implying a negative coefficient). For the case of Brazil, little inference is possible as cointegration did not obtain. [49] The persistent lack of cointegration for Brazil suggests a misspecification problem, possibly due to omitted variables or perhaps to the linearity imposed in the cointegration tests (given that the relationship

[47] These results are not reported but are available upon request.

[48] For the system that includes the real exchange rate, real per capita GDP, and the inflation tax, the relevant critical values are those for $n = 3$ in Table 6. For the extended system, which also includes the terms of trade, the critical values are those for $n = 4$.

[49] Although the variables appear with the anticipated signs, no conclusions are possible since these parameter estimates are neither unbiased nor consistent.

Table 6
Cointegration tests for the real exchange rate, the inflation tax, and real GDP [a]

	Country		
	Brazil	Chile	Colombia
λ-max	11.530	36.410 **	30.068 **
Trace	15.904	60.769 *	43.917 **
Coefficient estimates:			
Inflation tax		0.102	0.130
		(0.034)	(0.024)
Real GDP		0.747	2.445
		(0.223)	(0.426)
Terms of trade		−0.312	
		(0.040)	

	$n=3$	$n=4$
Critical values for λ-max:		
at 95% confidence level	25.54	31.46
at 90% confidence level	23.11	29.12
Critical values for trace:		
at 95% confidence level	42.44	62.99
at 90% confidence level	39.06	59.14

[a] Coefficients are only reported when cointegration obtains. Standard errors are in parentheses. The number of lags in the vector autoregression is three. The critical values are those under the null hypothesis of no cointegration. The source of the critical values is Osterwald-Lenum (1992). For the specification that includes the terms of trade, the λ-max and trace statistics for Brazil are 25.08 and 50.44, respectively. A '**' and '*' denote for the cointegration tests significance at the 95% and 90% level, respectively.

among the real exchange rate and the explanatory variables implied by these models may be nonlinear). A leading candidate in the list of potentially omitted variables is public expenditure on nontraded goods. [50]

In sum, our results suggest that there is potential for quantitatively important indirect links between inflation and the equilibrium real exchange rate. The evidence, however, is not conclusive, which suggests that a more comprehensive model of equilibrium real exchange rate determination may be needed to be able to quantify the steady-state relationship between the real exchange rate and the inflation tax.

[50] See Roldos (1990) for some empirical evidence on the effects of government spending and other exogenous variables on the real exchange rate.

5. Final remarks

Developing countries often engage in real exchange rate targeting with a view to either maintaining or enhancing international competitiveness. The simple optimizing model developed in this paper offers sharp predictions about the feasibility and macroeconomic consequences of such policies. First, this framework suggests that the monetary authorities can only have a transitory impact on the real exchange rate. The model thus stresses the role of 'temporary shocks', which have been largely ignored in the literature on the subject. Second, when there is perfect capital mobility, a policy that aims at depreciating the real exchange rate results in a temporary rise in inflation; when there is no capital mobility, the impact of the policy rule is reflected in higher real interest rates. Since neither extreme adequately depicts reality, the implication is that an attempt to depreciate the real exchange rate beyond its equilibrium level is likely to be accompanied by a mix of higher inflation and rising real interest rates.

Simulations of the model based on available parameter estimates revealed that this tradeoff is likely to be steep. For instance, an attempt by the monetary authorities to depreciate the real exchange rate five percent over its equilibrium level may require an increase in the inflation rate of about five percent per month. Furthermore, the lower the degree of intertemporal substitution, the higher is the required increase in the inflation rate. Since available empirical evidence suggests that intertemporal elasticities of substitution in developing countries are relatively low, the tradeoff between a more depreciated real exchange rate and lower inflation is likely to be substantial.

This paper also attempts to fill a gap in the literature on real exchange rate targeting by providing empirical evidence of some of the key implications of the existing models. Three main stylized facts emerge from the experiences of Brazil, Chile, and Colombia. First, temporary shocks, including (but not necessarily limited to) the type of policy shock outlined in the theoretical framework play an important role in determining real exchange rate behavior. Second, partial correlations between the inflation rate and the cyclical or temporary component of the real exchange rate indicate that, as suggested by the model, inflation increases when the real exchange rate is depreciated relative to its steady-state level. Third, our results suggest that there is room for an indirect link between inflation and the real exchange rate via wealth effects. However, the evidence for the latter is not conclusive, and further research is required which incorporates other determinants of the long-run equilibrium real exchange rate, such as government spending on non-traded goods.

Since our empirical conclusions are based on the experience of three countries that have had one or more episodes of policies aimed at targeting the real exchange rate, a fruitful line for future research would broaden the coverage to include a more diverse group of countries that have had similar policies in place. Only by studying a more comprehensive sample of countries are the main empirical regularities associated with real exchange rate targeting likely to emerge. In addition, this paper has focused almost exclusively on the direct and indirect links between inflation and real exchange rate targeting. A more exhaustive evaluation of the macroeconomic consequences of these policies would also have to examine the behavior of other key variables, such as exports, the current account, and growth.

Acknowledgment

The authors are grateful to Miguel Kiguel, Saul Lizondo, Peter Montiel, Jonathan Ostry, Jorge Roldos, Andrés Velasco, Sweder van Wijnbergen, an anonymous referee, and seminar participants at the Sixth InterAmerican Seminar on Economics (Caracas, May 1993), the University of Montreal, the International Monetary Fund, the 1993 Meetings of the Latin American Econometric Society (Tucuman, Argentina), and the 1994 meetings of the American Economic Association (Boston) for helpful comments and suggestions. The views expressed in the paper are those of the authors and do not necessarily represent those of the International Monetary fund.

Appendix

A.1. Derivation of some expressions in the text

Under capital controls (modeled as a dual exchange rates regime), the consumer's flow constraint is given by (see Guidotti and Végh, 1992)

$$\dot{a}_t = \frac{y_t}{e_t} + y_t^* - \frac{c_t}{e_t} - c_t^* + \rho_t s_t b_t - \epsilon_t m_t + \tau_t, \tag{A.1}$$

where b is the real net stock of bonds; s is the domestic price of real bonds; $a(=m+sb)$ denotes real financial assets; and τ are real transfers from the government. Eq. (3) in the text follows from multiplying Eq. (A.1) by D_t, integrating forward, imposing the standard transversality condition, and assuming that $a_0 = 0$ (note that $i = \rho + \epsilon$).

In order to derive the resource constraint (10), consider the government's flow constraint

$$\dot{h}_t = \dot{m}_t + \epsilon_t m_t + r h_t - \tau_t, \tag{A.2}$$

where h denotes the government's net stock of bonds. Combining (A.1) and (A.2), and imposing equilibrium condition (8), it follows that

$$\dot{h}_t + s_t \dot{b}_t = y_t^* - c_t^* + r(h_t + b_t). \tag{A.3}$$

Table A.1
ARMA process used in modelling the change in the permanent component of the real exchange rate (quarterly: 1978:I–1992: III) [a]

Country:	Brazil	Chile	Colombia
ARMA(p,q)	ARMA(1,0)	ARMA(4,3)	ARMA(5,1)
Constant	−0.002	−0.003	0.001
	(0.012)	(0.392)	(0.015)
AR(1)	0.234	1.688	−0.303
	(0.103)	(0.336)	(0.286)
AR(2)	–	−1.714	0.454
		(0.311)	(0.187)
AR(3)	–	1.644	0.122
		(0.359)	(0.170)
AR(4)	–	−0.630	−0.024
		(0.282)	(0.159)
AR(5)	–	–	0.206
			(0.062)
MA(1)	–	−1.265	0.742
		(0.416)	(0.284)
MA(2)	–	1.101	–
		(0.362)	
MA(3)	–	−1.051	–
		(0.421)	
R^2	0.164	0.304	0.333
Q statistic	20.571	17.304	12.447
Significance level	(0.485)	(0.693)	(0.927)

[a] Standard errors are in parentheses. The models were estimated using log-differences. All series were allowed to have a break in their rates of change in 1985:I. The Q-statistic tests whether the regression residuals are white noise. The significance level is the probability that the actual Q-statistic value will be observed under the null hypothesis that the residuals are white noise.

Under perfect capital mobility, $s \equiv 1$; under capital controls, $b_t = b_0$ for all t so that $\dot{b}_t = 0$. In either case, Eq. (10) in the text follows from integrating forward Eq. (A.3), imposing the appropriate transversality condition, and assuming that $y_t^* = y^*$ for all t and that $h_0 + b_0 = 0$.

A.2. Trend–cycle decomposition and 'economic fundamentals'

The Beveridge–Nelson approach to decomposing a time series into its permanent and cyclical components relies exclusively on the univariate behavior of the series in question and, hence, does not offer much insights into how trend and cycle interact with other economic variables. The purpose of this appendix is to briefly examine whether the constructed trends and cycles of the real exchange rate are linked to economic fundamentals. We first focus on the cycle and then consider the behavior of the 'equilibrium' permanent component.

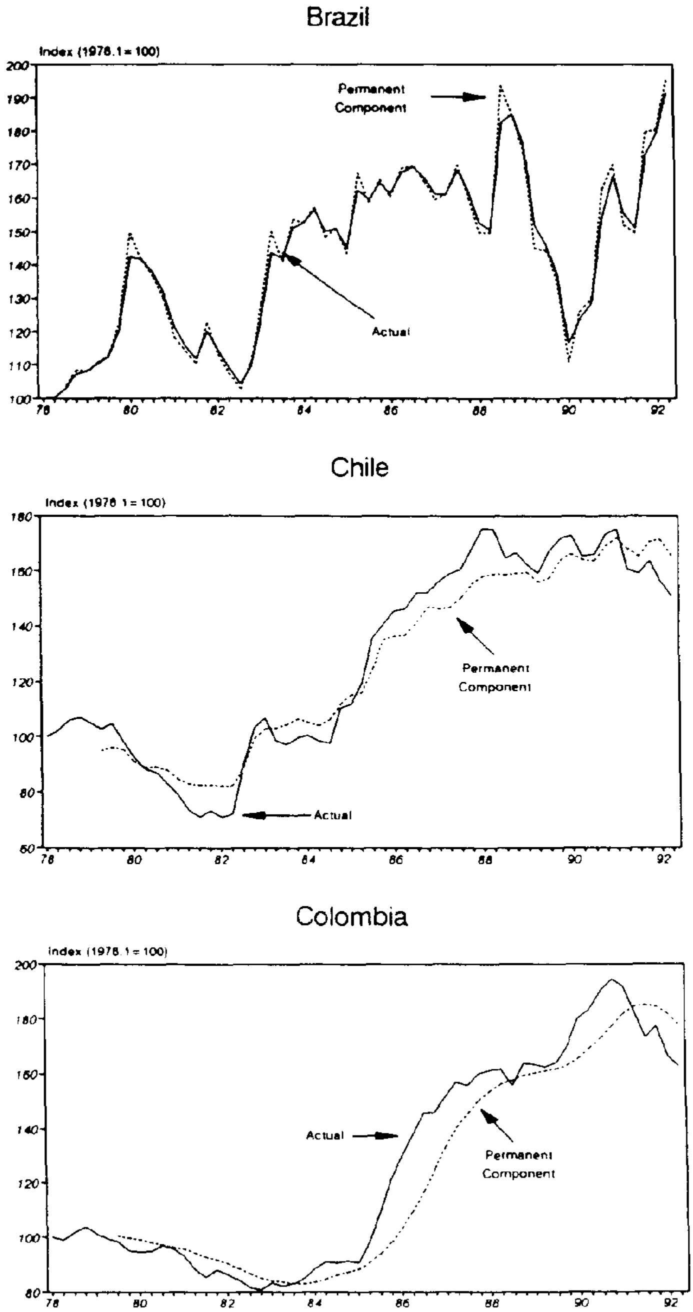

Fig. A.1. Real exchange rate: Actual and permanent component. *Sources:* International Financial Statistics (IMF), Information Notice System (IMF), and authors' calculations. *Note:* A decrease in the real effective exchange rate index denotes an appreciation.

As noted in the text, the cyclical component of the real exchange rate is correlated with inflation in the way predicted by the theory. In addition, the constructed cycle appears to be consistent with consumption-smoothing behavior, at least in the cases of Chile and Colombia. Fig. A.1 plots the actual real exchange rate alongside the permanent component. When the actual series is below the permanent component, the real exchange rate is 'temporarily overvalued'. This was the case for Chile during 1980–85 and again from 1991 on. A similar, although less marked, pattern can be found in Colombia, with evidence of some overvaluation during 1981–1983 and after 1991. Consumption-smoothing suggests that temporary overvaluations would be associated with wider current account deficits and increased capital inflows. In effect, these characteristics describe the periods mentioned fairly well. For Chile, during 1980–82 (the period with the largest suggested overvaluation), the current account deficit as a share of GDP averaged 10.4 percent. This was financed by capital *inflows* of similar orders of magnitude (see also Edwards (1985)). By contrast, the 1986–1990 period recorded a current account deficit of 3.4 percent and capital *outflows* of 3.1 percent. During 1991–93, the current account deficit continued to shrink, but the balance on the capital account swung markedly, with recorded *inflows* amounting to 5.7 percent of GDP. The pattern for Colombia is similar, although the swings are less pronounced. Capital inflows amounted to 6 percent of GDP during 1980–82, fell to 0.7 percent during 1985–90, and accelerate in recent years, averaging 1.2 percent in 1991–93. [51]

With regard to the macroeconomic determinants of the permanent component of the real exchange rate, we proceed, as before, to examine if a cointegrating relationship can be detected among the 'permanent' component and real GDP per capita (a proxy for output of nontraded goods), the inflation tax per capita, and the terms of trade. The results (not reported) mimic those reported in Table 6 for the actual exchange rate in that cointegration was obtained only for Chile and Colombia and in these two cases the coefficients have the same signs. Interestingly, in the case of Chile where the terms of trade are a crucial variable, the relationship among the real exchange rate and the terms of trade appears to be between the permanent components but not between the cycles (which, according to our tests, are uncorrelated). These findings would suggest that much of the sustained real depreciation in the post-1985 period can be traced to deteriorating terms of trade and not to the real exchange rate target itself.

[51] It is important to note that the figures for Colombia understate the recent surge in capital inflows, since some of the capital inflows were being recorded as transfers in the current account.

References

Adams, C. and D. Gros, 1986, The consequences of real exchange rate rules for inflation: Some illustrative examples, IMF Staff Papers 33, 439–476.

Bacha, E.L., 1979, Notes on the Brazilian experience with minidevaluations, 1968–1976, Journal of Development Economics 6, 463–481.

Beveridge, S. and C. Nelson, 1981, A new approach to decomposition of economic time series into permanent and transitory components with particular attention to the measurement of the business cycle, Journal of Monetary Economics 7, 151–174.

Carrasquilla, A., 1992, Estabilización macroeconómica y tasas de interés en Colombia: Se agotó otro modelo?, Mimeo. (Banco de la República, Bogota).

Cochrane, J., 1988, How big is the random walk in GNP?, Journal of Political Economy 96, 893–920.

Dornbusch, R., 1982, PPP exchange rate rules and macroeconomic stability, Journal of Political Economy 90, 158–165.

Edwards, S., 1985, Stabilization with liberalization: An evaluation of ten years of Chile's experiment with free market policies, 1973–1983, Economic Development and Cultural Change 33, 223–254.

Edwards, S., 1989, Real exchange rates, devaluation, and adjustment (MIT Press, Cambridge, MA).

Edwards, S. 1991, Comment, in: M. Bruno, S. Fischer, E. Helpman, and N. Liviatan, eds., Lessons of economic stabilization and its aftermath (MIT Press, Cambridge, MA) 92–98.

Ffrench-Davis, R., 1981, Exchange rate policies in Chile: The experience with the crawling-peg, in: J. Williamson, ed., Exchange rate rules (St. Martin's Press, New York) 152–174.

Fontaine, J.A., 1991, La administración de la política monetaria en Chile, 1985–1989, Cuadernos de Economía 28 (Chile) 109–129.

Guidotti, P.A. and C.A. Végh, 1992, Macroeconomic interdependence under capital controls: A two-country model of dual exchange rates, Journal of International Economics 32, 342–367.

Guilkey, D.K. and P. Schmidt, 1989, Extended tabulations for Dickey–Fuller tests, Economics Letters 31, 355–357.

Herrera, S., 1991, Qué tan grande es el desequilibrio cambiario en Colombia?, Ensayos sobre política económica 20 (Banco de la República, Bogota) 145–174.

Johansen, S., 1988, Statistical analysis of cointegrating vectors, Journal of Economic Dynamics and Control 12, 231–254.

Johansen, S., 1991, Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, Econometrica 59, 1551–1580.

Lizondo, J.S., 1991, Real exchange rate targets, nominal exchange rate policies, and inflation, Revista de Análisis Económico 6, 5–22.

Lizondo, J.S., 1993, Real exchange rate targeting under imperfect asset substitutability, IMF Staff Papers 40, 829–851.

Miller, S., 1988, The Beveridge–Nelson decomposition of economic time series: Another economical computational method, Journal of Monetary Economics 21, 141–142.

Montiel, P.J. and J. Ostry, 1991, Macroeconomic implications of real exchange rate targeting in developing countries, IMF Staff Papers 38, 872–900.

Montiel, P.J. and J. Ostry, 1992, Real exchange rate targeting under capital controls: Can money provide a nominal anchor?, IMF Staff Papers 39, 58–78.

Obstfeld, M., 1986, Capital controls, the dual exchange rate and devaluation, Journal of International Economics 20, 1–20.

Osterwald-Lenum, M., 1992, A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistic, Oxford Bulletin of Economics and Statistics 54, 461–469.

Ostry, J. and C.M. Reinhart, 1992, Private saving and terms of trade shocks: Evidence from developing countries, IMF Staff Papers 39, 495–517.

Reinhart, C.M. and C.A. Végh, 1993, Intertemporal consumption substitution and inflation stabilization: An empirical investigation, Mimeo. (IMF, Washington, DC).

Reinhart, C.M. and C.A. Végh, 1994, Nominal interest rates, consumption booms, and lack of credibility: A quantitative examination, Journal of Development Economics, forthcoming.

Roldos, J.E., 1990, The terms of trade and the real exchange rate: Theory and evidence, Mimeo. (University of Rochester, Rochester, NY).

Stock J., and M. Watson, 1989, A simple MLE of cointegrating vectors in higher order integrated systems, Technical working paper 83 (NBER, Cambridge, MA).

Williamson, J., 1981a, The crawling peg in historical perspective, in: J. Williamson, ed., Exchange rate rules (St. Martin's Press, New York) 3–30.

Williamson, J., ed., 1981b, Exchange rate rules (St. Martin's Press, New York).