IMF WORKING PAPER

WP/94/84

INTERNATIONAL MONETARY FUND

Research Department

Supply-Side Effects of Disinflation Programs

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July 1994

Abstract

This paper focuses on the short-run and long-run supply-side effects of disinflation programs in a two-sector economy. Fixing the exchange rate reduces the wedge between the return on foreign assets and that on domestic capital, leading to an increase in the latter. After an initial real exchange rate appreciation and increase in the production of nontradables --due to a consumption boom--the new capital is gradually installed in the tradable sector. During this transitional period, further real appreciation takes place--as the expansion of the tradable sector pulls labor away from the nontradable sector--together with investment-driven deficits in the current account. We conclude that when appreciation and deficits are due to supply-side rigidities, rather than to credibility and/or price stickiness, no further policies (i.e., capital controls, incomes policies) are advisable.

JEL classification:

F41

1/ I wish to thank Donald J. Mathieson, Pierre-Richard Agénor, José De Gregorio, Gian Maria Milesi-Ferretti and Carlos Végh for useful discussions and suggestions. The views expressed in this paper do not necessarily reflect those of the International Monetary Fund.

Contents

		Page
Summary		iii
I.	Introduction	1
II.	The Model	4
	1. Supply	4
	2. Demand	6
	3. Equilibrium	8
III.	Steady State and Dynamics	9
IV.	Effects of a Permanent and Credible Disinflation	13
	1. The long run	13
	2. Short run and transitional dynamics	14
V.	Discussion, Extensions and Policy Implications	16
	1. Related literature	16
	2. The production and accumulation structures	17
	3. Variable labor supply	18
	4. Policy implications	19
Table 1		2
Figures:		
1.	Dynamics of K and B	12a
2a.	Permanent Stabilization	14a
2b.	Permanent Stabilization	14b
Appendix		20
References		23

Summary

This paper focuses on the supply-side effects of disinflation programs, an aspect of these programs that has been largely neglected in the literature. Although the results are based on some Latin American countries' programs, the introduction of supply-side factors is useful in understanding stabilization programs in Eastern Europe and the former Soviet Union where high inflation and structural changes are likely to coexist.

The paper considers an economy where a tradable good is produced using reproducible capital and labor, and a nontradable good is produced using land (that is, nonreproducible capital) and labor. This asymmetry in the reproducibility of the specific factors captures the slower medium-run response of the supply of nontradables. The tradable sector responds more flexibly through the importation of machinery and equipment compared to a nontradable sector that requires relatively more investment in infrastructure.

In this framework, inflation generates a wedge between the real return of foreign assets and that of domestic assets--money, capital, and land--owing to the cash-in-advance constraint. An exchange rate-based stabilization program reduces this wedge and leads to a higher desired capital stock. In the short run the capital stock is fixed, but an increase in aggregate demand causes a real exchange rate appreciation, an expansion in the production of nontradables, and a boom in land prices. As the new capital is installed it draws labor away from the nontradable sector, leading to further real exchange rate appreciation. The consumption and investment booms lead to a deficit in the current account of the balance of payments, which is gradually reduced as the production of tradables grows over time. It is worth noting that over the medium run the economy experiences a persistent real exchange rate appreciation together with an improvement in the trade balance. This suggests that commonly held notions of competitiveness and sustainability of external deficits may be misleading, especially when the stabilization program has achieved a reasonable degree of credibility.

Some evidence on these supply-side effects from the Argentine and Mexican stabilization programs is presented. In particular, both countries show a remarkable (at least fourfold) increase in imports of capital goods, the driving force of the model under study. This confirms existing evidence of the negative effect that inflation has on capital formation, which has consequences not only for the long run but also for the transitional periods that are the subject of the paper. There is also some evidence of an increase in labor force participation and hence in labor supply.

I. Introduction

This paper focuses on the supply-side effects of disinflation programs, an aspect of these programs that has been largely neglected in the literature. The dynamic effects on several macro-variables, generated by a disinflation program that permanently--and credibly--reduces the rate of devaluation, are studied in the context of a two-sector economy. Fixing the nominal exchange rate would be a particular case of our analysis, one of special interest given the renewed attention on currency boards as a stabilization instrument. Although we motivate our results with reference to some Latin American countries' programs, the introduction of supply-side factors "is bound to be particularly useful in understanding stabilization programs in Eastern Europe and the former Soviet Union where high inflation and structural changes are likely to coexist" (Vegh, 1992, p.669).

The main "stylized facts" from disinflation programs in chronic inflation countries are sustained real appreciations of the domestic currency and cumulative current account deficits (Vegh, 1992). Most explanations for these facts have relied upon the existence of backward-looking price-setting behavior (Rodriguez 1982, Dornbusch 1982, Calvo and Vegh 1992), credibility problems (Calvo 1986, Calvo and Vegh 1990) or gradual reductions in the rate of devaluation (Obstfeld 1985, Roldos 1993). Furthermore, with the exception of Roldos (1993), output in those papers is demand-determined. In this paper, we show that those stylized facts can be obtained in a framework with market clearing, rational expectations, no credibility problems and without the extrinsic dynamics of gradual programs. Our analysis shares some of the features of the models simulated by Rebelo (1993) and Uribe-Echevarria (1993) but, unlike these papers, the results are obtained analytically and using different production and accumulation structures.

Some evidence on these supply-side effects from the Argentine and Mexican stabilization programs is presented in Table 1. Both programs seem to have achieved a reasonable degree of credibility and fiscal consolidation fairly soon after their inception. The first two columns display the above mentioned stylized facts of real exchange rate appreciation and current account deficits. The third column, shows a remarkable (at least four-fold) increase in imports of capital goods, the driving force of those stylized facts in the model that we study. In a recent and comprehensive study, Fischer (1993) presents evidence of the negative effect that inflation has on growth and, in particular, on capital formation. By exploiting both cross-section and time-series data, the study suggests that this negative effect of inflation is not restricted to the long run, but that it also applies to the transitional periods that are the subject of our paper. The final column of Table 1, indicates a steady increase in labor force participation and hence in labor supply. Broader evidence on this issue is mixed: Cooley and Hansen (1989) find a negative correlation between the employment ratio and inflation for a sample of 23 countries during 1976-85, but De Gregorio (1993) finds a negative but statistically insignificant effect for twelve Latin American countries between 1950 and 1985.

Table 1

Year	Real Exchange Rate[1] (Index: 1980-100)	Current Account[2] (Mill. of US$)	Imports of Capital Goods[3] (Mill. of US$)	Labor Force Participation[4] (Percentage)
		Argentina		
1987	40.9	-4,235	973	39.2
1988	37.4	-1,572	847	39.1
1989	32.7	-1,305	717	39.8
1990	48.7	1,903	618	39.1
1991	66.3	-2,810	1,637	39.5
1992	75.4	-8,381	3,888	40.0
1993*	82.5	-8,850	4,625	41.5
		Mexico		
1987	55.6	3,968	2,631	-
1988	68.7	-2,443	4,027	51.6
1989	73.8	-3,958	4,769	51.8
1990	75.4	-7,117	6,789	51.8
1991	83.6	-13,785	8,588	53.3
1992	89.8	-22,811	11,556	53.9
1993*	96.5	-21,700	11,259	55.1

*Estimated.
Sources: 1.INS, 2.IFS, 3.INEC, INFGI.

This paper studies the short-run and transitional dynamics of a dependent-economy model in which inflation affects negatively the capital stock in the long run. When money is required to buy consumption as well as capital goods, Stockman (1981) has shown that, contrary to the Mundell-Tobin effect, inflation reduces the steady-state level of the capital stock. In two-sector versions of that cash-in-advance model, it has been shown that inflation can have long-run effects on the pattern of trade as well as on the distribution of income (see Stockman (1985) and Roldos (1992)). Those papers, however, study only the long-run effects of inflation and do not allow for trade in foreign assets, precluding the analysis of the transitional dynamics of the real exchange rate and the current account. It is well known that the dynamics of the one-sector closed economy version of that model are fairly involved (Abel 1985). To overcome this problem, which is compounded by the two-sector nature of our model, the continuous-time cash-in-advance constraint popularized by Feenstra (1985) and Calvo (1986) is extended to include purchases of capital goods.

We consider an economy that produces and consumes a tradable and a nontradable good. The tradable good is produced using reproducible capital and labor, whereas the nontradable uses land (i.e., nonreproducible capital) and labor. This asymmetry in the reproducibility of the specific factors is introduced not only for tractability reasons but also to reflect the slower medium-run response of the supply of nontradables. Indeed, the supply of nontradables increases right after the fixing of the exchange rate, due to a shift in labor supply towards that sector. However, in the medium run the tradable sector responds more flexibly through the importation of machinery and equipment relative to a nontradable sector that requires relatively more investment in infrastructure. 1/

In this framework, inflation generates a wedge between the real return of foreign assets and that of domestic assets--money, capital and land--due to the cash-in-advance constraint. Fixing the nominal exchange rate reduces this wedge and leads to a higher desired capital stock. On impact the capital stock is fixed, but an increase in aggregate demand causes a real exchange rate appreciation, an expansion in the production of nontradables and a boom in land prices. 2/ As the new capital is installed it draws labor away from the nontradable sector leading to further real exchange rate appreciation. The consumption and investment booms lead to a deficit in the current account of the balance of payments, which is gradually reduced as the production of tradables grows over time. It is worth noting that over

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1/ One can think about the response of, for instance, the housing and retail sectors, public utilities and services like health and education.

2/ Calvo (1983) presents a portfolio-balance model where demand and supply functions are not derived from first principles. In his model, it is the increase in the price of land, due to a portfolio shift, that leads to an increase in the demand for nontradables and a real appreciation. In our model, the increase in the demand for nontradables causes the real appreciation and this in turn leads to an increase in the price of land.

the medium run the economy experiences a persistent real exchange rate appreciation together with an improvement in the trade balance. This suggests that commonly held notions of competitiveness and sustainability of external deficits may be misleading.

The impact of the disinflation program on real wages and labor supply is also discussed. Though real wages are likely to fall during the early stages of the disinflation program, they increase in the transition to the new steady state. In contrast with the persistent increase in labor supply that one would observe in a gradual disinflation experiment (Roldos, 1993), the response here is ambiguous. On the one hand, the reduction in the monetary wedge leads to an increase in labor supply (as originally shown in Aschauer and Greenwood 1982) as the income generated from work effort is no longer subject to the inflation tax. On the other hand, the wealth and intertemporal substitution effects (wages are higher in the future) tend to reduce labor supply. Despite the fact that there seems to be some evidence of a positive response of labor supply, it is unlikely that it would be strong enough to outweigh the effects due to capital formation.

When the real exchange rate appreciation and current account deficits are due to credibility problems or price stickiness, capital controls and/or incomes policies may be used to attenuate those effects. Our analysis shows that when the rigidities come from the supply-side, rather than from prices and/or expectations, those policy recommendations are unwarranted.

The paper proceeds as follows. Section II presents the model and solves for the equilibrium values of the main variables. Section III determines the steady state as well as the transition path that leads to it. The short-run, long-run and transitional effects of a permanent and credible disinflation program are examined in Section IV. In the final section, we discuss our results and possible extensions, as well as the policy implications that we derive from them.

II. The Model

Consider a small open economy that produces and consumes tradable and nontradable goods. After the derivation of demand and supply functions from the optimizing behavior of consumers and firms, relative prices are determined from the equilibrium of goods, assets and factor markets.

1. Supply

Consider a two-sector specific-factors model where the tradable good T is produced using capital K and labor L^T, while the nontradable good uses land N and labor L^N, according to the constant returns to scale production functions

$$y^T = G(L^T, K) = K^{\beta} L^{T(1-\beta)} \tag{1}$$

$$y^N = F(L^N, N) = N^{\gamma} L^{N(1-\gamma)} \tag{2}$$

The tradable good is also a capital good, but in order to invest it, installation or adjustment costs have to be incurred (as in Abel and Blanchard (1983)). Without loss of generality, we assume the simplest quadratic adjustment cost technology, i.e., that to invest I units of the tradable good one has to spend J units, where

$$J = I\left[1 + \frac{\phi}{2}\frac{I}{K}\right] \tag{3}$$

The relative price of the nontradable good in terms of the tradable good is defined as $p = p^N/p^T$. To maximize profits, firms hire labor up to the point where the value of the marginal product equals the wage rate w:

$$G_L(L^T, K) = w(K, p) = pF_L(L^N, N) \tag{4}$$

which is a function of the capital stock and the relative price of nontradables, as are the rental on capital r^K and on land r^N:

$$r^K(K, p) = G_K(L^T, K) \tag{5}$$

$$r^N(K, p) = pF_N(L^N, N) \tag{6}$$

From this optimal behavior, the supply functions for the representative firm in each sector follow:

$$y_t^T = \delta_T K_t [w(K_t, p_t)]^{\frac{(\beta-1)}{\beta}} \; ; \qquad y_t^N = \delta_N N [p_t/w(K_t, p_t)]^{\frac{(1-\gamma)}{\gamma}} \tag{7}$$

where δ_T and δ_N are constants. Features of these supply functions will be important for the dynamics of the real exchange rate and the current account.

2. Demand

The representative household in this economy derives utility from the flow of consumption of both tradable (c^T) and nontradable (c^N) goods over an infinite horizon. The instantaneous utility function is assumed to be Cobb-Douglas to simplify the dynamics of consumption and concentrate on that of investment and the capital stock. Aggregate welfare is then given by

$$U = \int_0^{\infty} [\nu \log c^T + (1-\nu) \log c^N] e^{-\rho t} dt \tag{8}$$

The household is assumed to own both the tradable and nontradable firms. In order to purchase both consumption and capital the household has to hold sufficient cash in advance of those purchases, i.e., it is subject to the liquidity constraint: 1/

$$M_t \geq \alpha E_t (c_t^T + p_t c_t^N + J_t) \tag{9}$$

where E_t is the nominal exchange rate. In this dynamic set-up, capital and land are not only factors of production but also assets. In addition to those assets and money, individuals in this economy have access to an internationally-traded bond whose rate of return in terms of the tradable good is r. Interest rate parity ensures that its nominal rate of return is $R = r + \pi$, where π equals the rate of devaluation. Hence, the budget constraint

$$\dot{B}_t = rB_t + y_t^T + p_t y_t^N + \tau_t - c_t^T - p_t c_t^N - J_t - R_t m_t \tag{10}$$

shows the change in net foreign assets B as the difference between income--which includes government transfers τ, and absorption--including the opportunity cost of real cash balances m. The household maximizes utility (8) subject to the cash-in-advance constraint (9) the budget constraint (10) and the accumulation constraint

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1/ This is a straightforward extension of the cash-in-advance constraint in Stockman (1981) to continuous time; for a rationalization along the lines of Feenstra (1985) see Roldos (1988).

$$\dot{K}_t = I_t \tag{11}$$

as well as the initial conditions $B_o = B(0)$ and $K_o = K(0)$. For simplicity, no depreciation is assumed.

The details of the solution of the optimization problem are discussed in the Appendix. We assume that the rate of time preference ρ equals the world interest rate r. This implies that the shadow value of foreign assets λ will always be at its steady state value, allowing us to concentrate on the dynamics of investment. From that solution we derive consumption functions for tradables and nontradables:

$$c^T(\lambda;\pi) = \frac{\nu}{\lambda(1+\alpha R)} \tag{12}$$

$$c^N(\lambda,p_t;\pi) = \frac{(1-\nu)}{\lambda(1+\alpha R)p_t} \tag{13}$$

where the rate of devaluation π enters through the nominal interest rate of the monetary wedge $(1+\alpha R)$. They also satisfy the usual efficiency conditions, i.e., that the marginal rate of substitution in consumption and the marginal rate of transformation in production equal the relative price:

$$\frac{(1-\nu)c^T}{\nu c^N} = p_t = \frac{G_L(L^T,K)}{F_L(L^N,N)} \tag{14}$$

The investment function is derived from the condition that equates the marginal cost of investing to its marginal benefit. Investment is hence a function of Tobin's q

$$I(K_t,q_t) = \frac{K}{\phi}(q_t-1) \tag{15}$$

and of the capital stock. The parameter ϕ is an important determinant of the concavity of the technology of the tradable sector (see Roldos (1991), Serven (1993)). It determines the degree of intertemporal substitution in production, i.e., what is the response of investment to a given increase in the shadow value of capital. The latter is given by

$$q_s = \int_s^{\infty} [(1+\alpha R)^{-1} G_K(L_t^T, K_t) - \frac{\phi}{2}(I/K)^2]\, e^{-r(t-s)} ds \tag{16}$$

where we can see how the rate of devaluation reduces the net marginal product of capital and leads to a lower capital stock (as in Stockman (1981, 1985) and Roldos (1988, 1992)). In those studies, however, the analysis is concerned only with steady-state comparative statics, as the dynamics are very complex for the discrete-time cash-in-advance constraint (see Abel (1985)). Our continuous-time version will allow us to study not only the steady-state impact of reductions in the rate of devaluation but also the dynamic evolution of the system.

3. Equilibrium

We have derived consumption and investment functions which take as given the relative prices p_t and q_t. In a perfect foresight equilibrium, these prices have to be consistent with equilibrium in goods and factor markets.

Equilibrium in the labor market yields the usual expression for changes in the wage rate derived from the static specific factors model (Jones 1971, Mussa 1974):

$$\hat{w} = \xi_p \hat{p} + \xi_k \hat{K}; \qquad \xi_p = \frac{\lambda_N \eta_N}{\lambda_N \eta_N + \lambda_T \eta_T}, \quad \xi_k = \frac{\lambda_T}{\lambda_N \eta_N + \lambda_T \eta_T} \tag{17}$$

where λ_i stands for the fraction of the labor force employed in sector i=T,N, η_i for the respective elasticity of labor demand, and a "^" over a variable denotes its rate of change. In our dynamic framework, however, the changes in p and K are endogenously determined.

Equilibrium in the nontradable sector requires

$$c^N(\lambda, p_t; \pi) = y^N(p_t, K_t) \tag{18}$$

Totally differentiating this expression, it follows that changes in the real exchange rate are directly related to those in the capital stock:

$$\hat{p} = \left[\frac{(1-\gamma)\xi_k}{\gamma-(1-\xi_p)(1-\gamma)}\right]\hat{K} = \Omega\,\hat{K} \tag{19}$$

In the Appendix we show that the constant Ω is positive for reasonable parameter values.

To concentrate on the dynamics of stabilization we assume that the government increases domestic credit at the same rate as the devaluation rate and that it redistributes back to consumers the proceeds of the inflation tax together with the interest from reserves h_t:

$$\tau_t = \pi_t m_t + r h_t \tag{20}$$

The assumption of a smooth path for reserves ensures that the government does not violate its intertemporal budget constraint and that the monetary terms cancel out in the aggregate budget constraint (see Obstfeld 1985). Substituting these results and (20) into (10) we get a simpler expression for the current account:

$$\dot{B}_t = rB_t + y^T(p_t,K_t) - c^T(\lambda;\pi) - J(q_t,K_t) \tag{21}$$

which will be determined by the evolution of the capital stock and the relative prices p and q.

III. Steady State and Dynamics

The economy we study presents a very rich menu of assets (capital, land, money and foreign bonds), which would suggest a complex dynamic behavior. It is straightforward to see, however, that the dynamics of the system are governed by the evolution of the capital stock and its shadow value. Equations (19) and (21) show that, once the general equilibrium features of the model are spelled out, the dynamics of the real exchange rate and the current account follow recursively from the dynamics of Tobin's q and the capital stock. The latter are given by the system

$$\dot{K}_t = \frac{K_t}{\phi}(q_t - 1) \tag{22}$$

$$\dot{q}_t = rq_t - [r^K(K_t, p_t) + \frac{\phi}{2}(I_t/K_t)^2] \tag{23}$$

which can be linearized around the steady state values ($\bar{K}$, $\bar{q}$) and put in matrix form:

$$\begin{bmatrix} \dot{K} \\ \dot{q} \end{bmatrix} = \begin{bmatrix} 0 & \frac{K}{\phi} \\ \frac{-r_K^K(K,p)}{(1+\alpha R)} & r \end{bmatrix} \begin{bmatrix} K - \bar{K} \\ q - \bar{q} \end{bmatrix} \tag{24}$$

The determinant of this differential equation system is $D = (K/\phi)[\partial r^K/\partial K + \partial r^K/\partial p \; \partial p/\partial K]$, which is negative thereby ensuring that the equilibrium is a saddlepoint. Given the initial value of the capital stock and no anticipated disturbances, the convergent trajectories of K and q are

$$K_t - \bar{K} = (K_o - \bar{K})e^{\mu t} \tag{25}$$

$$q_t - \bar{q} = (\mu\phi/K)(K_o - \bar{K})e^{\mu t} \tag{26}$$

where μ is the (stable) negative root of the transition matrix. Using these results into (19) we obtain the transitional equation for the real exchange rate

$$p_t - \bar{p} = \Omega(\bar{p}/\bar{K})(K_o - \bar{K})e^{\mu t} \tag{27}$$

The price of nontradables moves in the same direction as the capital stock along the convergent path to the steady state. 1/ When the economy starts from a low level of capital, the expansion of the capital stock pulls labor away from the nontradable sector, leading to an increase in real wages together with a real exchange rate appreciation.

The dynamics of net foreign assets can be obtained by linearizing the expression for the current account: 2/

$$\dot{B}_t = r(B_t - \bar{B}) + (y_K^T - J_K)(K_t - \bar{K}) - J_q(q_t - \bar{q}) \tag{28}$$

Using previous results we finally get the following differential equation

$$\dot{B}_t = r(B_t - \bar{B}) + \Gamma(K_0 - \bar{K})e^{\mu t} \tag{29}$$

where $\Gamma = (y_K^T - J_K - \mu)$ summarizes the impact of the evolution of K and p on the production of the tradable, net of investment spending; in the Appendix we show that Γ is positive for reasonable parameter values. The solution of (29) relates the evolution of net foreign assets to that of the capital stock:

$$B_t - \bar{B} = -\Gamma(r - \mu)^{-1}(K_0 - \bar{K})e^{\mu t} \tag{30}$$

The increase in the capital stock is financed by a reduction in the level of net foreign assets, i.e., by increases in external debt. The sustainability of the latter is guaranteed by the imposition of the usual transversality condition.

A graphical description of the model is given in Figure 1. The upper diagram shows the usual $\dot{q} = 0$ schedule, where the negative slope reflects the decline in the return to capital, due not only to the increase in K but also to the appreciation of the real exchange rate. The stable adjustment

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1/ Serven (1993) obtains the opposite relationship between capital accumulation and the real exchange rate. This is due to the existence of only one domestic good that faces a downward-sloping demand in world markets. Capital accumulation leads to an increase in its supply that can only be absorbed with a fall in its relative price.

2/ See Sen and Turnovsky (1989) and Serven (1993) for a similar strategy in one-sector models; the latter imposes also balanced private trade. Roldos (1991) solves for the path of net foreign assets in a two-sector model without linearizing the dynamic system.

path (SS), described by equation (26), has a negative slope determined largely by the adjustment cost parameter ϕ. The larger that parameter, the steeper the path, reflecting a lower degree of intertemporal substitution on the production side as well as a slower speed of adjustment towards the steady-state--summarized by the negative root μ. The lower diagram describes the path of net foreign assets (FF) as a function of the capital stock (equation (30)), where the degree of concavity of the technology plays a similar role on the slope of the adjustment path.

In the steady state there are neither capital gains nor losses (i.e., $\dot{q} = 0$) and the stocks of capital and net foreign assets are constant (i.e., $\dot{K} = \dot{B} = 0$). This implies that the capital/labor ratio in the tradable sector is determined by the rate of devaluation and the rate of return on foreign assets:

$$G_K(L^T,\bar{K}) = r^K(\bar{p},\bar{K}) = r(1+\alpha R) \tag{31}$$

where we have used the fact that Tobin's q equals 1 in the steady-state. From (10) and (21), we have that total spending in the steady state has to equal interest earnings on their wealth

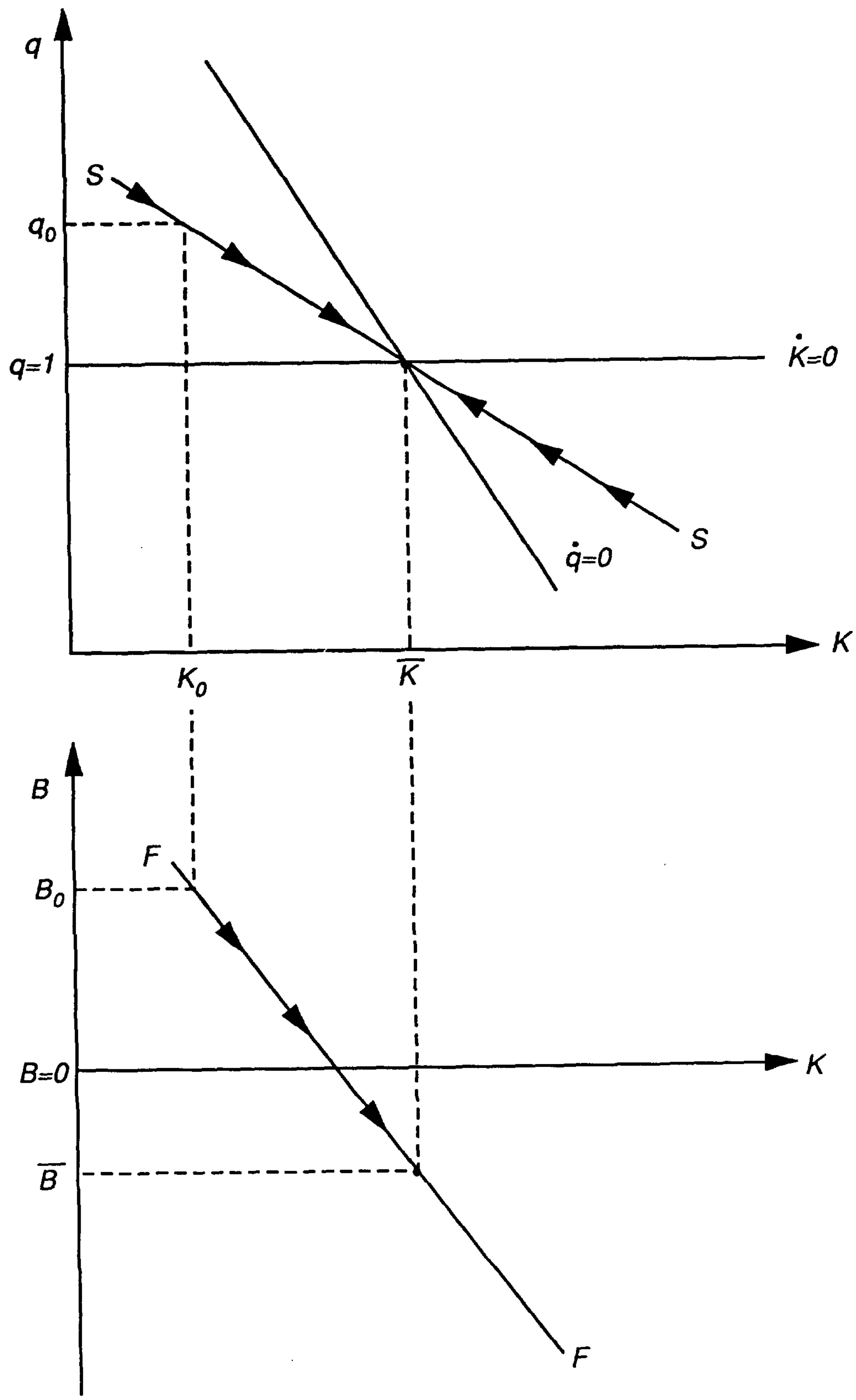
$$\begin{aligned} c^T(\lambda;\pi) + \bar{p}c^N(\bar{p},\lambda;\pi) &= r\bar{B} + y^T(\bar{p},\bar{K}) + \bar{p}y^N(\bar{p},\bar{K}) \\ &= r\bar{B} + r^K(\bar{p},\bar{K})\bar{K} + r^N(\bar{p},\bar{K})\bar{N} + \bar{w}(\bar{p},\bar{K})L \end{aligned} \tag{32}$$

where the last two terms summarize the rentals from capital and land as well as wage income. As is well known (see Giavazzi and Wyplosz (1983)), the models that equate the rate of time preference to the world interest rate have the feature that the steady state--as well as the path that leads to it--depends on the dynamic characteristics of the model and the initial conditions. In particular, the rate at which capital is accumulated has permanent effects on the real exchange rate and the level of net foreign assets, as can be seen from (27) and (29). Using the initial condition for net foreign assets into (30), we can obtain (see Sen and Turnovsky (1989) and Serven (1993)) the steady-state level of net foreign assets

$$\bar{B} = B_o + \Gamma(r-\mu)(K_o - \bar{K}) \tag{33}$$

as a function of the steady-state level of the capital stock. Substituting this result, together with the equilibrium condition in the nontradable good market and the efficiency conditions in (14) into (32), we obtain a simplified expression of the budget constraint

Figure 1
Dynamics of K and B



$$r\bar{B}(\bar{K}) + y^T(\bar{p},\bar{K}) = \gamma(1-\gamma)^{-1}\bar{p}\,y^N(\bar{p},\bar{K}) \tag{34}$$

This expression and (31) are sufficient to pin down the steady-state levels of the capital stock and the real exchange rate.

IV. Effects of a Permanent and Credible Disinflation

Most stabilization programs involve a reduction in the rate of devaluation, sometimes a fixing of the nominal exchange rate. The ensuing real exchange rate appreciation and trade deficits have been attributed to lack of credibility or backward-looking indexation (see Vegh 1992). In this section, we show how these stylized facts may appear as an equilibrium phenomenon, due to the interaction of monetary and supply-side factors.

We study first the effects that a permanent and credible reduction in the rate of devaluation has on the steady-state or long-run values of the main variables. Secondly, we analyze the short-run effects as well as the transition towards the new steady state.

1. The long run

As was mentioned above, inflation acts as a tax on the return to domestic capital relative to foreign assets. A reduction in the rate of devaluation leads then to an increase in the capital-labor ratio in the tradable sector. Such an increase could result from either a rise in the capital stock or a shift in the allocation of labor towards the nontradable sector--which is likely, given the increase in the relative price of that good. We show in the Appendix that under fairly general conditions, both the capital stock and the relative price of nontradables increase in the long run. The results are given by:

$$\frac{d\log K}{d\log(1+\alpha R)} = \left(\frac{-\Delta_L}{\Delta_K + \Delta_L}\right)\left(\frac{1+\beta}{1-\beta}\right) < 0 \tag{35}$$

$$\frac{d\log p}{d\log(1+\alpha R)} = -\left(\frac{\beta}{1-\beta}\right) - \gamma\left(\frac{\lambda_T}{\lambda_N}\right)\frac{(s-1)[\beta + \Gamma(r-\mu)^{-1}]}{(1-\beta)(\Delta_K + \Delta_L)} < 0 \tag{36}$$

$$\frac{d\log L^T}{d\log(1+\alpha R)} = \frac{(s-1)[\beta + \Gamma(r-\mu)^{-1}]}{(1-\beta)(\Delta_K + \Delta_L)} > 0 \tag{37}$$

where

$$s = \frac{y^T}{y^T + rB} \quad ; \quad \Delta_K = s\beta + (s-1)\Gamma(r-\mu)^{-1}$$

$$\Delta_L = s(1-\beta) + \left(\frac{\lambda_T}{\lambda_N}\right)$$

The parameter s is the ratio of the domestic production of tradables to the total supply of those goods. Since most chronic-inflation countries hold large external debts--so that B is negative and large--that ratio is greater than one, as assumed in equations (35)-(37). This is a sufficient condition to obtain an increase in the capital stock and in the relative price of nontradable goods--i.e., a real exchange rate appreciation. 1/ The intuition for the importance of this parameter is related to the dual role of capital as an asset and as a factor of production. Inflation biases the portfolio of domestic residents away from domestic assets (money, capital and land) and towards foreign assets. The smaller the share of the latter in the total portfolio, the larger the share of labor in the tradable sector (i.e., the supply of tradables comes more from domestic production than from the interest on net foreign assets). Under this circumstances, a given increase in the capital stock leads to a strong increase in wages and a large real exchange rate appreciation.

If the country is neither a net creditor nor a net debtor (so that s=1), the sectoral allocation of labor would remain the same as before the stabilization program was launched. The increase in labor demand in the nontradable sector--linked to the real appreciation--is exactly compensated by the increase in labor demand in the tradable sector--linked to capital formation. However, if the country was originally a net debtor, labor employed in the tradable sector falls (see equation (37)) which means that output of the nontradable increases. Production of tradables also increases, despite the fall in employment, due to the higher capital stock. This is required to ensure the sustainability of the trade deficits incurred during the initial stages of the stabilization--see the discussion in the next section and Figure 2 below. From equation (32) one can infer that a higher level of consumption in the new steady state, together with a lower income from net foreign assets, requires more production of tradables.

2. Short run and transitional dynamics

The short run effects and the transitional dynamics to the new steady-state can be read from Figure 2. On the one hand, neither the capital stock nor foreign assets can jump when the stabilization begins. On the other hand, both the shadow value of capital and that of foreign assets jump on

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1/ Similar results were found in Roldos (1988). In that paper, however, there was no dynamic adjustment as the absence of adjustment costs implied an instantaneous exchange of foreign assets for capital.

Figure 2-a
Permanent Stabilization

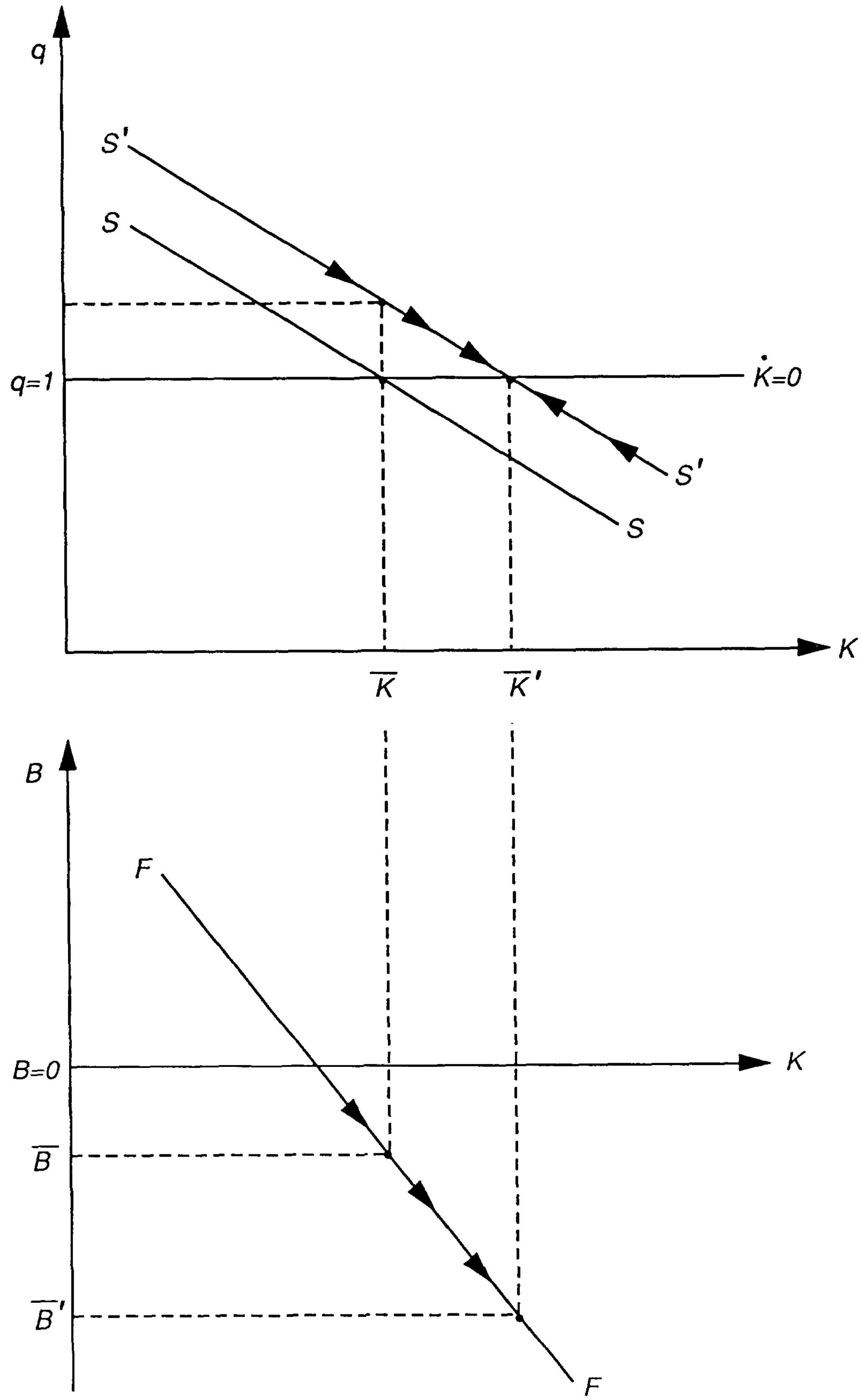
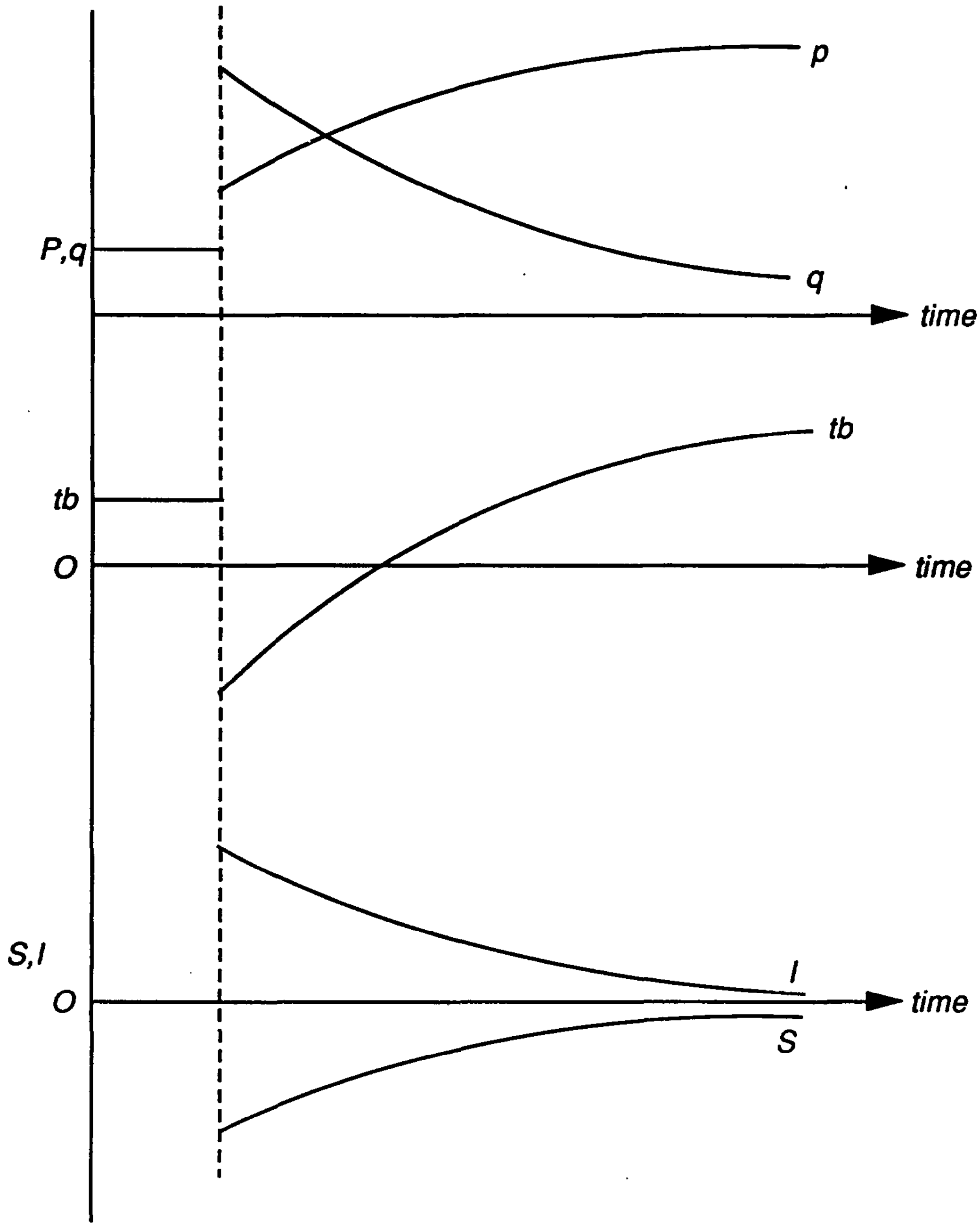


Figure 2-b



impact, discounting all the effects of the reduction in the rate of devaluation.

The increase in the capital stock from $\bar{K}$ to $\bar{K}'$ guarantees that the $\dot{q} = 0$ schedule shifts up. A higher value of Tobin's q leads to an increase in investment, which is smoothed over time according to the value of the adjustment cost parameter ϕ (see equation (15)). This surge in investment is partially responsible for the deficit in the current account that is typical of the early stages of stabilization.

In order to derive the impact on savings, we have to determine the response of the shadow value of foreign assets λ to the reduction in π. Even though the change in λ is ambiguous (see the Appendix), we can show that $\lambda(1+\alpha R)$ falls causing an increase in consumption of both goods (see (12) and (13)). The ensuing real exchange rate appreciation draws labor away from the tradable sector, whose output falls until the new capital is gradually installed. This fall in savings reinforces the increase in investment, leading to a further deficit in the current account. Both the increase in p and that of L^N cause land rents (see equation (6)) and the price of land to jump up.

During the transition to the new steady state, the new capital is gradually installed and the production of tradables recovers at the same pace as the capital stock expands. In the process, labor is now being drawn away from the nontradable sector, leading to further real exchange rate appreciation--as summarized in equation (27). It is worth noting that during this transition we observe an expansion of net exports in spite of the sustained real exchange rate appreciation (see Figure 2-b for the time path of the trade balance, tb, and other variables). The features of the production and accumulation structure that contribute to this result are further discussed in Section V.

We can also derive the model's implications for real wages. On impact we get the result from the traditional static specific-factors-model (Jones 1971, Mussa 1974), summarized in equation (16) for $\hat{K} = 0$. Wages increase in terms of tradables--the numeraire--but they decrease in terms of nontradables. The higher share of consumption of nontradables suggest the possibility of an initial fall in real wages (see Ruffin and Jones (1977)). However, once we allow for the endogenous increases in capital and in the relative price of nontradables, those results change. If we substitute (19) into (16), we can see that the evolution of wages is now:

$$\hat{w} = \left(\xi_p + \frac{\gamma}{1-\gamma}\right)\hat{p} \qquad (38)$$

The term in brackets may or may not be greater than one, but the former holds for a set of reasonable parameter values discussed in the Appendix. In that case, real wages increase unambiguously during the transition to the new steady state.

V. Discussion, Extensions and Policy Implications

In this section, we compare our results to those found in related literature, suggest some extensions and derive policy implications.

1. Related literature

Calvo (1986) and Calvo and Vegh (1991) study temporary reductions in the rate of devaluation as a modelling strategy for the lack of credibility that is usually present in the early stages of stabilization attempts in chronic-inflation countries. The temporary fall in prices vis-a-vis the future induces an intertemporal substitution in consumption towards the present period that leads to a real exchange rate appreciation and current account deficit. Both results are reversed when the stabilization is abandoned, with the real exchange rate depreciating even beyond its pre-stabilization level. Despite this being an attractive approach to study failed stabilizations, the quantitative relevance of the "temporariness" hypothesis has been questioned by Reinhart and Vegh (1994). Given the relatively low elasticity of intertemporal substitution in consumption, nominal interest rates would have to fall substantially more than what has been observed to account for a sizable fraction of the consumption boom experienced in several stabilization attempts.

Permanent and hence credible reductions in the rate of devaluation can lead to real exchange rate appreciation and current account deficits due to the existence of backward-looking behavior (Rodriguez (1982), Calvo and Vegh (1992)) or due to wealth effects (Helpman and Razin (1987), Calvo and Vegh (1990), De Gregorio, Guidotti and Vegh (1993) and Roldos (1993)). Calvo and Vegh (1992) call into question that the initial expansion in aggregate demand may be due to backward-looking price behavior, since this would require an intertemporal elasticity of substitution in consumption larger than the one observed in most countries. Furthermore, they show that the result in Rodriguez (1982) is not due to the absence of rational expectations but to the lack of optimizing behavior.

The results in our model are also driven by a wealth effect, but one generated by a channel different from the ones emphasized in the existing literature. In Helpman and Razin (1987), freezing the exchange rate means that the current generation receives an intergenerational redistribution of wealth, as they get the benefits of an inflation tax cut. In Calvo and Vegh (1990), the reduction in the rate of devaluation reduces the amount of seigniorage paid abroad due to currency substitution. In our model, the reduction of the monetary wedge that disinflation generates, leads to a higher net-of-inflation return on domestic assets. This leads to more capital formation and hence to a supply response that is not available in the above mentioned literature.

2. The production and accumulation structures

The model presented has two strong asymmetric assumptions. First, that capital is used only in the tradable sector, and second that only the tradable good can be accumulated. In this section we show that the assumptions on the production structure are not crucial for the results whereas those on the accumulation side appear to be more critical--but have indeed a plausible economic rationale.

Jones and Easton (1983) study a more general model that allows for the three factors to be mobile across both sectors. They reach the conclusion that (p.98): "the results of the sector-specific model lie in the "neutral" range of possibilities evident in the more general model, despite the strong asymmetric assumptions that extreme factors are used only in one industry...". Furthermore, the departures from this neutral case are only a few and can be ruled out for standard assumptions on factor intensities across sectors. In particular, the conclusions of our model could be reversed if increases in the capital stock lead to a fall in output of the tradable sector, which using Samuelson's reciprocity condition implies that a real exchange rate appreciation leads to an increase in the return to capital:

$$\frac{\partial y^T}{\partial K} = \frac{\partial r^K}{\partial(1/p)} < 0 \tag{39}$$

This can be avoided by the fairly general intensity assumptions (θ_{ij} stands for the share of factor i in good j):

$$\frac{\theta_{KT}}{\theta_{KN}} > \frac{\theta_{LT}}{\theta_{LN}} > \frac{\theta_{NT}}{\theta_{NN}} \tag{40}$$

and/or

$$\frac{\theta_{KT}}{\theta_{KN}} > \frac{\theta_{NT}}{\theta_{NN}} > \frac{\theta_{LT}}{\theta_{LN}} \tag{41}$$

as well as with less intuitive factor substitutability assumptions (see Jones and Easton 1983). It is reassuring that for (39) to hold when capital and land are good substitutes, it is also required that the share of labor in the tradable sector be larger than in the nontradable sector; international evidence seem to reject the latter requirement (see Kravis, Heston and Summers (1983)).

When there are tradable and nontradable capital goods (see Brock and Turnovsky (1993), Serven (1993)), an exercise like the one we perform in this paper would yield a real exchange rate appreciation on impact, to be followed by a depreciation thereafter (contrary to the persistent appreciations observed in the stabilization experiences). Uribe-Echevarria (1993) simulates a real-business-cycle model where investment goods are non-tradable--though produced with a tradable component--and gets that same pattern for the real exchange rate. He provides persistence to the initial real appreciation by adding gestation lags ("time-to-build") to the investment process. It is not clear whether both features belong in an investment technology, as they appear to be competing rather than complementary stories (see Kydland and Prescott, 1982). Furthermore, in the simulations investment in the tradable sector does not recover to its initial level until after the real exchange rate begins to depreciate.

What is done in this paper amounts to assuming a differential supply response in the tradable sector vis-a-vis the nontradable sector. The former uses capital goods (say, machines and equipment) that can be easily obtained through trade, though the supply response is somewhat slowed down by the adjustment costs. 1/ The nontradable sector uses capital goods (say, structures) that are more difficult to reproduce and hence its medium-run supply response is much slower than that of the tradable sector. Our assumption of nonreproducible capital in the nontradable sector is an extreme case of a model where adjustment costs are larger than in the tradable sector. Finally, it would be straightforward to allow for the installation costs of the capital stock to be nontradable (as is done in Brock (1988) and Murphy (1989)) and our results would still go through. 2/

3. Variable labor supply

So far we have assumed that capital is the only factor of production that increases as a result of the reduction in inflation. However, it is well-known (see Aschauer and Greenwood (1983), Stockman (1985)) that labor supply would also be augmented as a result of disinflation. If we include leisure $\underline{x}$ as a third argument in the utility function, i.e., $u = u(c^T, c^N, x)$, and we use subindices for the respective partial derivatives we would obtain:

$$u_1(\,.\,) = \lambda(1+\alpha R) = (1+\alpha R)\,\frac{u_3(\,.\,)}{w} \qquad (42)$$

1/ We are thinking here of the supply response of manufactures or non-traditional-exports. As we discuss below, we interpret land broadly as capital that is slow to reproduce, i.e., probably including also infrastructure. Otherwise, the ranking of eq. (40) would not be valid for natural-resource exporters.

2/ Brock (1988) and Murphy (1989), however, make the strong assumption that there is no consumption of nontradables, and they discuss only fiscal policy issues.

We know from our previous discussion that the three terms have to fall, but that the net effect on λ is ambiguous. Assuming that λ doesn't change as a benchmark, we have that the last equality would imply that the ratio of the marginal utility of leisure to the wage would have to be constant. As wages increase on impact and during the transition to the new steady state (see equation (17)), leisure has to fall, i.e., labor supply has to increase. These results hold for a separable utility function. Contrary to the case of a gradual reduction in the rate of devaluation (see Roldos (1993)), a high degree of intertemporal substitution tends to work against that direct increase in labor supply in the early stages of the disinflation program. The increase in labor supply would be concentrated more in the later stages, when wages are higher and hence the reward to work effort is larger. It is likely, however, that the direct effect mentioned above would yield some expansion of work effort throughout the stabilization, its magnitude being an empirical issue. Even if labor supply were to expand, it is unlikely that the increase would be large enough to reverse the real exchange rate appreciation.

4. Policy implications

Whenever the lack of credibility of a disinflation program is modelled by a temporary reduction in the rate of devaluation, an intertemporal distortion is created. The imposition of capital controls is suggested in Calvo (1986) as a possible solution to that distortion, but not without caveats. Since credibility is exogenous in those models it is not clear whether capital controls would actually increase the likelihood of success of the program. Agenor (1993) and Vegh (1992) discuss alternative policies that might enhance the credibility of disinflation programs. An overly stringent fiscal stance and price and wage controls could have some impact on credibility but, again, the results are not clear-cut.

The policy prescription from our model is that no other policy would be necessary: a gradual appreciation of the domestic currency and protracted current account deficits are the equilibrium response of the economic system once the supply side is given more structure and it is allowed to respond gradually over time. It is true that a fiscal balance was assumed throughout the paper for simplicity, but similar assumptions underlie the papers reviewed at the beginning of this section.

This is not to downplay the role that credibility issues and nominal rigidities might have in the early stages of disinflation. It is to stress, however, that when chronic inflations are suddenly stopped there are factors that lead to the same "stylized facts" usually attributed to lack of credibility and price stickiness. And that when the rigidities come from the slow response of the supply side, as opposed to when they come from prices and/or expectations, no further policy measures--like capital and/or price-wage controls--need to be adopted.

In this Appendix we discuss some of the more technical derivations that underlie the equations in the text.

Optimality conditions

To solve the household's optimization problem we form the current value hamiltonian:

$$
\begin{aligned}
H(c_T, c_N, I, L_T; K_o, B_o) = {} & [\nu \log c_t^T + (1-\nu)\log c_t^N] \\
& + \lambda_t [r B_t + y_t^T + p_t y_t^N + \tau_t - (1+\alpha R)(c_t^T + p_t c_t^N + I_t + \frac{\phi}{2}\frac{I^2}{K})] \\
& + \lambda_t \theta_t I_t
\end{aligned}
\quad (A.1)
$$

and the first order conditions are:

$$\nu c^{T^{-1}} = \lambda(1+\alpha R) \quad (A.2)$$

$$(1-\nu) c^{N^{-1}} = \lambda p (1+\alpha R) \quad (A.3)$$

$$\frac{\partial y^T}{\partial L^T} - p \frac{\partial y^N}{\partial L^N} = 0 \quad (A.4)$$

$$(1+\alpha R)[1+\phi(I/K)] = \theta \quad (A.5)$$

$$-\lambda \left[\frac{\partial y^T}{\partial K} + (1+\alpha R)\frac{\phi}{2}(I/K)^2\right] + \rho\lambda\theta = (\lambda\theta) \quad (A.6)$$

$$-\lambda\rho + \lambda r = \lambda \quad (A.7)$$

to which we add the accumulation constraints (10) and (11) from the text as well as the usual transversality conditions. From (A.2)-(A.4) we derive equation (14) in the text. Equation (15) follows from (A.5) once we define $q = \theta(1+\alpha R)^{-1}$. From (A.6) we obtain the expression for Tobin's q.

1. Dynamics

The direction of the evolution of the real exchange rate as capital is accumulated is determined by the sign of Ω (see eq.19). To study the determinants of that sign we rewrite Ω as:

$$\Omega = \frac{\xi_k}{\frac{\gamma}{1-\gamma} - (1-\xi_p)} = \frac{\xi_k}{\frac{\gamma}{1-\gamma} - \frac{\lambda_T/\beta}{\lambda_N/\gamma+\lambda_T/\beta}} \tag{A.8}$$

The stylized fact that the share of labor in nontradables is larger than that in tradables (Kravis, Heston and Summers, 1983) implies that $\beta>\gamma$. Associated with the fact that the fraction of the labor force employed in the tradable sector tends to be smaller than the one employed in nontradables, it yields a strong presumption that Ω is positive for reasonable values of labor shares. In particular, if we take the average of the values calculated for Portugal by Rebelo (1992) and for Argentina by Uribe-Echevarria (1993), we obtain $\beta = 0.56$ and $\gamma = 0.32$. Combined with the value of $\lambda_N = 0.54$ presented by Rebelo (1992), 1/ we obtain a value of $\Omega = 1.3$, which implies a 13 percent increase in the relative price of nontradables for every 10 percent increase in the capital stock.

The sign of Γ is largely determined by that of $y_K{}^T$, since $J_K=0$ around the steady-state and μ is negative. A positive value of Γ implies that the increases in the capital stock are financed by borrowing abroad. A sufficient condition for this to happen is that $y_K{}^T$ be positive. This would mean that as the capital stock expands, production of the tradable grows despite the fact that the ensuing real exchange rate appreciation pulls labor towards the nontradable sector. In formal terms:

$$\begin{aligned}\frac{dy^T}{dK} &= \frac{\partial y^T}{\partial K} + \frac{\partial y^T}{\partial p}\frac{\partial p}{\partial K} = \\ &= \frac{y^T}{K}\left\{1 - \left(\frac{1-\beta}{\beta}\right)\xi_k - \left(\frac{1-\beta}{\beta}\right)\xi_p \frac{(1-\gamma)\xi_k}{\gamma-(1-\xi_p)(1-\gamma)}\right\}\end{aligned} \tag{A.9}$$

where the first term in braces shows the direct effect of capital formation on the supply of tradables, and the other two represent the less-than-proportional increase of labor due to the higher wages induced by more capital (the term in the middle) as well as by the increase in p (the last term). Simple manipulation of (A.9) yields:

1/ Uribe-Echevarria does not present data on λ_N. From the OECD intersectoral database used in De Gregorio, Giovannini and Wolf (1993), we found that a value of 0.62 for the OECD countries in the period 1980-85.

$$\frac{dy^T}{dK} = \frac{y^T}{K}\left\{1 - \left(\frac{1-\beta}{\beta}\right)\xi_k\left[1 + \frac{\xi_p}{\frac{\gamma}{1-\gamma} - (1-\xi_p)}\right]\right\} \tag{A.10}$$

where we can see in the last term how the same factors that we discussed for the sign of Ω apply for the sign of Γ. In particular, for the parameter values discussed above, Γ is positive.

2. Long-run and impact effects

The steady-state of the model can be summarized by equations (4), (31) and (34). Totally differentiating that system and using (7) and (33) we get:

$$\begin{aligned}
\hat{p} &= [\, s\beta - (1-s)\Gamma(r-\mu)^{-1}\,]\,\hat{K} + [\, s(1-\beta) + (\lambda_T/\lambda_N)(1-\gamma)\,]\,\hat{L}^T \\
\hat{p} &= -\gamma(\lambda_T/\lambda_N)\,\hat{L}^N - \left(\frac{\beta}{1-\beta}\right)(1\hat{+}\alpha R) \\
\hat{L}^T &= \hat{K} + (1-\beta)^{-1}(1\hat{+}\alpha R)
\end{aligned} \tag{A.11}$$

Combining the first two equations, we finally get a system in $\hat{K}$ and $\hat{L}^T$ that yields the results in (35)-(37).

To get the initial jump in the real exchange rate, we exploit the fact that λ takes its new steady-state value on impact and stays there forever. Hence we can differentiate (32) using (11) to get:

$$d\log\lambda(1+\alpha R) = -d\log[\, r\bar{B} + y^T(\bar{K},\bar{p})\,] = \frac{\mu[\Gamma(r-\mu)^{-1} - 1]}{r\bar{B} + y^T(\bar{K},\bar{p})} < 0 \tag{A.12}$$

where we have used the fact that $\Gamma(r-\mu)^{-1} > 1$, due to the adjustment costs (see Sen and Turnovsky (1989) and Roldos (1991)). Given that on impact K is fixed, from the condition of equilibrium in the nontradable market we get:

$$d\log\lambda(1+\alpha R) = -\,[\, 1 + (1/\gamma)(1-\gamma)(1-\xi_p)\,]\, d\log p < 0 \tag{A.13}$$

which implies that p increases from the very beginning of the disinflation program.

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