Exchange Rate Based Stabilizations Under Real Frictions: The role of endogenous labor supply

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Abstract: This paper studies exchange rate based stabilization programs in the context of a model of a small open economy where labor supply is endogenous. Agents derive utility from both consumption and leisure. In environments where consumption is subject to a cash-in-advance constraint, a cut in the rate of devaluation lowers the nominal interest rate and hence alters the optimal mix of consumption and leisure. The paper shows that in the presence of adjustment costs of investment, a perfectly credible cut in the devaluation rate causes, simultaneously, a consumption and output boom, a cumulative current deficit, a sustained real appreciation of the domestic currency and an increase in labor supply over time. It is also shown that an imperfectly credible stabilization program in this environment would have effects similar to the perfectly credible program but generate richer dynamics such as an initial boom in output followed by a recession which begins prior to the end of the program. The model has clear welfare implications in that permanent reductions in inflation are welfare enhancing while temporary reductions are welfare reducing.

JEL Classification: E2, F3, F4

Key words: Devaluation rates, inflation stabilizations, labor supply response

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Since the early 1980's a large literature has emerged on the effects of disinflation programs which use the exchange rate as a nominal anchor. The interest in this issue was generated by the experience of the Southern Cone stabilization programs in Argentina, Chile and Uruguay in the late 1970's and the heterodox programs of the mid 1980's in Argentina, Brazil, Israel and Mexico. All these programs used the exchange rate as a nominal anchor and attempted to reduce the rate of inflation through reductions in the rate of devaluation. Details of these programs can be found in Kiguel and Liviatan (1992) and Vegh (1992).

The stylized facts of these programs that have attracted the greatest attention are (a) a consumption boom and an associated cumulative current account deficit; and (b) a sustained real appreciation of the domestic currency over time. In general, these facts have been attributed to either imperfect credibility of the programs (see Calvo (1986), Calvo and Vegh (1993), and Calvo and Drazen (1994)) or to inflation rigidity due to backward looking price setting behaviour (see Rodriguez (1982) and Dornbusch (1982)). Calvo and Vegh (1994) however raise doubts about this second explanation by showing that in a utility maximizing framework with backward looking contracts, a permanent reduction in the rate of devaluation causes a consumption boom only if the intertemporal elasticity of consumption substitution exceeds the intratemporal elasticity of substitution between traded and non-traded goods. Econometric estimates of the two elasticities suggest that the opposite is true (see Ostry and Reinhart (1992)).

In almost all the papers on this issue, output is either taken to be fixed or assumed to be a function of the relative price where adjustments are instantaneous. More generally, the potentially important effects due to supply side adjustments seem to have been largely ignored in this literature. Three notable exceptions to this are Rebelo (1993), Roldos (1994) and Uribe-Echevarria (1993). While

Rebelo and Uribe-Echevarria obtain their results through simulations, Roldos analytically solves a model which shares some of the features of the other two models.

In the Roldos model consumption and capital goods are both subject to a cash-in-advance (CIA) constraint. A reduction in the rate of devaluation lowers the nominal interest rate which, in turn, lowers the spread between the returns to foreign assets and domestic capital, thus encouraging domestic capital formation. Investment is subject to a convex adjustment cost and thus capital adjusts slowly to its desired long run level. Capital accumulation in the traded goods sector draws labor away from the non traded goods sector causing a real appreciation over time while the instantaneous adjustment of tradable consumption combined with the slow adjustment of output causes a cumulative current deficit. A debatable feature of the model is the CIA constraint on capital. It is unlikely that all or most investment activity is carried out through cash payments upfront. More importantly, the absence of a CIA constraint on capital would cause the real effects of a permanent change in the nominal interest rate to disappear from the Roldos model.

In this paper, I analyze an alternative model of supply side adjustment frictions which is capable of generating the previously documented features of a cumulative current account deficit and a sustained real appreciation of the domestic currency in response to a permanent cut in the rate of devaluation of the nominal exchange rate. The key feature of the model is the existence of variable labor supply due to utility from leisure which is an idea previously investigated by, among others, Aschauer and Greenwood (1983) and Stockman (1985). In the presence of a CIA constraint on consumption, a cut in the nominal interest rate changes the marginal rate of substitution between consumption and leisure thus altering the optimal mix of the two. In particular, individuals desire more consumption and less leisure. The instantaneous adjustment of consumption to its permanent income level generates the consumption boom while the sluggish adjustment of output to its long run equilibrium level (due to a costly adjustment process) causes a cumulative current deficit. The accumulation of capital in the traded goods sector draws labor away from leisure and the non-traded goods sector leading to declining non-traded goods production and a gradual appreciation of the real exchange rate. The model is thus also able to account for some existing evidence that inflation and labor supply are negatively correlated (see Cooley and Hansen (1989)) and that labor force participation rates seem rise after most inflation stabilization episodes (see Table 1 for related evidence from Argentina and Mexico). Importantly, the above features of the model arise without any credibility or price flexibility problems.

Further, when the model is combined with a temporary cut in the devaluation rate, the paper shows that the implied dynamics are similar to the case of a permanent stabilization but are much richer. In particular, the model can then account for the business cycle dynamics typically associated with exchange rate based stabilizations with the boom giving way to a recession before the end of the program and a crash in consumption which occurs at the end of the program. Another advantage of the model is that it has clear welfare implications in that a permanent cut in the devaluation rate is unambiguously welfare enhancing since it reduces the distortion in the allocation of consumption and leisure. Further, temporary stabilizations are welfare reducing.[1]

One should note at the outset that the particular model of variable labor supply (endogenous labor-leisure choice) adopted in the paper is intended to be a stylized representation of some basic realities of life in chronic high inflation economies. It is meant to capture the fact that in these economies agents devote a disproportionate amount of time and resources towards efficient money management -

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[1]After the completion of this paper I became aware of the paper by Rebelo and Vegh (1995) who investigate, amongst other candidate channels, the labor supply channel proposed in this paper. However, their paper is a quantitative exercise while this paper is an exercise intended to provide a complete analytical description of the labor supply channel.

so on. Reductions in the rate and variability of inflation typically reduce the amount of time and resources devoted to these activities and, hence, are likely to induce an increase in effective labor supply.[2] The point being made here is that conventional measures of labor supply elasticities are likely to understate the increase in *effective* labor supply since they typically focus on aggregate labor supply movements as proxied by measures such as hours of employment. The relevant measure from the perspective of this paper is labor productivity.

Chart 1 shows the rates of growth of prices, average labor productivity and gross private investment in Mexico between 1989 and 1994. As the chart shows, inflation was falling secularly from 1990 onwards and it was accompanied by a secular rise in the rate of growth of average labor productivity in manufacturing. Gross private investment, on the other hand, shows no such secular trend.[3] Without putting too fine a point on it, it is still worth noting that the other major supply-side channel which has been proposed in the literature is a strict inverse relationship between investment and inflation due to an assumed cash-in-advance constraint for the purchase of capital goods. At least in terms of chart 1, support for that hypothesis seems a little tenuous.

In order to highlight the implication of variable labor supply, I start in section II by presenting a simple, one good, frictionless model of a small open economy where utility is derived from both consumption and leisure and where consumption is subject to a CIA constraint. In this set up it is easy to see that a one-time reduction in the rate of devaluation causes a jump up in consumption and an expansion of output due to greater labor supply which is the only factor of production. However, the

[2]An alternative but analytically more complicated method of modelling this feature would be to introduce a transactions cost technology involving money and leisure time where both inputs reduce the costs of effecting transactions. One can qualitatively reproduce all the results reported here through this approach as long as money and leisure time are substitutes in the transaction cost technology.

[3]Data for Mexico is taken from "The Mexican Economy 1995" published by Banco de Mexico.

absence of any adjustment frictions implies that the model is incapable of generating any transitional dynamics.

In section III I consider the same model as above but introduce capital as another factor of production. Further, a friction is introduced into the model by making capital accumulation subject to a convex adjustment cost. A permanent cut in the nominal interest rate now generates not only a consumption and output boom but also a cumulative current deficit. This section also shows that supply side frictions and credibility of the programs could be complementary channels of explanations since a temporary cut in the devaluation rate causes similar effects but richer dynamics. Section IV extends the model by introducing non traded goods and shows that a similar experiment as before also causes a real appreciation over time. Section V discusses the welfare implications while the last section concludes.

II. A One Good, Frictionless Model

Consider a small open economy inhabited by a representative agent who consumes and produces a single traded good. The agent derives utility from consumption and leisure. She has an endowment of one unit of time which can be used for either leisure or for labor which is used to produce the traded good. The agent can borrow or lend freely in perfectly competitive world capital markets. This trading is done in terms of bonds whose face value is one unit of the traded good and which pay a fixed r units of the traded good per unit of time as interest. The world price of the traded good is assumed fixed and normalized to unity. Thus, the domestic price of the good is given by E which is the nominal exchange rate.

The agent faces a cash-in-advance (CIA) constraint for consumption

$$m_t \geq \alpha c_t \tag{1}$$

where m_t are real balances while c_t denotes consumption at time t. As long as the nominal interest is positive, which I shall assume to be true in the rest of the paper, (1) will hold with equality. There is a government in this economy which prints money and returns the revenue from the inflation tax and interest earnings on its reserves to the private agent through lump sum transfers in terms of the traded good. Thus, the budget constraint faced by the government is given by

$$rd_t + \pi_t m_t = \tau_t \tag{2}$$

where d_t are government foreign exchange reserves, τ is the lump sum transfer, πm is the inflation tax (π denotes the rate of inflation). The domestic credit rule given by (2) implies that reserves and real balances grow at the same rate.

The representative agent maximizes the discounted value of lifetime utility given by

$$V = \int_{t=0}^{\infty} e^{-\rho t}[u(c_t)+v(l_t)]dt \tag{3}$$

where u and v are concave and twice differentiable in their respective arguments and where c denotes consumption while l denotes leisure. ρ is the subjective rate of time preference which is exogenous and constant. The agent faces a lifetime budget constraint given by

$$b_0 + \int_{t=0}^{\infty} e^{-rt} f(1-l_t)dt = \int_{t=0}^{\infty} e^{-rt}(c_t - \tau_t + \mu_t m_t)dt \tag{4}$$

where b_0 are initial private assets, f is a concave, twice differentiable, production function where the time endowment constraint ($l+L=1$) has been substituted in for L which denotes labor.[4] Time differentiation

[4]For convenience, here the household has been modelled as both a consuming and producing unit. Separating the two decision making units leaves the results unchanged.

of (4) yields the flow budget constraint for the agent

$$\dot{b} = rb + f(1-l) - c + \tau - \mu m \tag{5}$$

where time subscripts on the variables have been dropped for notational convenience. Combining (1) and (5) with $\dot{m} + \pi m = \mu m$ where μ denotes the rate of money printing, we get the equation describing the evolution of total private assets

$$\dot{a} = ra + f(1-l) - (1 + \alpha i)c + \tau \tag{6}$$

where a are total private assets (b+m) while i is the nominal interest rate which is given by $r+\pi$. This follows from the interest rate parity condition due to free capital mobility and the purchasing power parity condition P=E where P is the domestic currency price of the good. (6) shows that the effective price of consumption includes the cost of holding domestic money balances which are needed for purchasing consumption.

Among the first order conditions for the agent's problem are

$$u'(c) = (1 + \alpha i)\lambda \tag{7}$$

$$v'(l) = f'(1-l)\lambda \tag{8}$$

$$\dot{\lambda} = (\rho - r)\lambda \tag{9}$$

where λ is the costate variable associated with a. In order to ensure the existence of a steady state in this model r is assumed to be equal to ρ so that λ is constant over time. This implies that in the absence of shocks, c and l are constant over time and the model exhibits no transitional dynamics. Note that from (1), a constant c implies a constant m which, in turn, implies that d is constant due to the domestic credit rule given by (2).

Substituting (2) into (4) and noting the constancy of c and l over time, we get the consumption equation for the agent

$$c = r(b_0 + d_0) + f(1 - l) \tag{10}$$

Equations (7) and (8) can be combined to get

$$\frac{u'(c)}{v'(l)} = \frac{1 + \alpha i}{f'(1 - l)} \tag{11}$$

Using (11) and the concavity of u and v to solve for l in terms of c and i, we get

$$l = H(1 + \alpha i, c), \qquad H_1 > 0 \ , \ H_2 > 0 \tag{12}$$

where the subscript j on H denotes its partial derivative with respect to its j^{th} argument. Thus, H is increasing in both arguments.

Permanent cut in the rate of devaluation

Since the rate of inflation is given by the rate of devaluation due to the purchasing power parity condition (E=P), a cut in the rate of devaluation lowers the nominal interest rate, i. From (12) one can see that this causes equilibrium leisure to fall. Reduced leisure implies increased labor supply which in turn raises output. This adjustment is instantaneous. From (10), c jumps up one-for-one with output and, hence, there are no current account effects. Inflation jumps down immediately to the lower rate of devaluation.

Thus, even in this simplified one good, frictionless environment with endogenous labor supply, one can generate a consumption and output boom through a cut in the rate of devaluation though the simplicity of the model precludes it from replicating any of the time trends typically associated with exchange rate based stabilizations. However, one can see that if output adjusted slowly to its long run level then the current account would go into a deficit as consumption would adjust immediately to its permanent income level. In the next section I expand the model by introducing adjustment frictions in order to confirm the intuition gained above.

III. The Role of Structural Frictions

Consider the same one good model as in section II but let output be a function of capital (K), and labor (L). Further, capital accumulation is assumed to be subject to an adjustment cost. In particular, to invest in I units of capital one has to spend A ($\geq$ I)units of the good. I assume that A is a twice continuously differentiable function of I with $A_I > 0$, $A_{II} > 0$ and $A(0) = 0$.[5] The assumption that both total and marginal adjustment costs go to zero as investment goes to zero rules out issues of hysteresis. Readers interested in this issue are referred to Abel and Eberly (1994). Thus, adjustment costs are increasing and convex in investment.[6]

Under the new specification, the equation describing the evolution of the agent's total assets, a, is now given by

$$\dot{a} = ra + F(K, 1-l) - (1 + \alpha i)c + \tau - A(I) \tag{13}$$

where F(.,.) is a homogenous of degree one production function which is concave, increasing and twice continuously differentiable in each of its arguments. The homogeneity of degree one along with the strict concavity assumption implies that the cross partials are positive, i.e., $F_{KL} = F_{LK} > 0$. (13) is just the modified version of equation (6). The capital accumulation equation is given by

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[5]These conditions would be satisfied by $A = I(1 + zI/2)$ where z is a positive constant which captures the degree of convexity of the adjustment cost function.

[6]The results would remain unchanged if we made adjustment costs a function of both I and K with $A_K < 0$, $A_{KK} > 0$ and $A(0,K) = 0$. A function which will satisfy these properties is $A = I[1 + zI/2K]$ where z is a positive constant. This is the functional form used in Roldos (1994).

$$\dot{K} = I - \delta K \tag{14}$$

where δ is the rate of depreciation which is constant and positive.

The agent maximizes (3) subject to (13) and (14). The first order conditions derived in the frictionless model (equations (7), (8) and (9)) still hold except that the notation for the marginal product of labor changes due to the altered production function. Thus, (11) gets modified as

$$\frac{u'(c)}{v'(l)} = \frac{1+\alpha i}{F_L(K,1-l)} \tag{15}$$

where the subscript L on F indicates its partial derivative with respect to labor. Among the other first order conditions are

$$A_I = q \tag{16}$$

$$\dot{q} = \left(\rho + \delta - \frac{F_K}{A_I}\right)q \tag{17}$$

where q can be interpreted as Tobin's q. Note that in steady state $(\rho+\delta)A_I = F_K$.

Equation (15) along with the concavity of u and v can be used to solve for leisure (l) in terms of i,c and K

$$l = H(1+\alpha i,c,K), \qquad H_1 > 0 \, , \, H_2 > 0 \, , \, H_3 < 0 \tag{18}$$

where the subscripts denote the respective partial derivatives. Further, (16) combined with the convexity of A in I can be used to solve for equilibrium investment as a function of q

$$I = M(q), \qquad M' > 0 \tag{19}$$

Using equations (18) and (19), the two fundamental differential equations that characterize the behaviour of this economy are given by

$$\dot{q} = (\rho + \delta)q - F_K(K, 1-H(1+\alpha i, c, K)) \tag{20}$$

$$\dot{K} = M(q) - \delta K \tag{21}$$

The system defined by (20) and (21) when linearized around a steady state has one positive root and one negative root and, thus, exhibits saddle path dynamics.[7] Figure 1 shows the dynamics through a phase plane analysis of the system. The phase plane has been drawn on the assumption that the $\dot{q} = 0$ locus is downward sloping in which case the saddle path is downward sloping.[8] The only paths consistent with equilibrium lie along the convergent saddle path. All other paths are driven by the positive root and can be ruled out due to violations of the transversality condition on capital or the individual optimality conditions.

Note that from (7) and (9) we know that c is constant over time. With F being homogenous of degree one, a rise in K increases F_L. Since (15) has to hold at all times, this implies that as K rises, l falls and L rises. Thus, the process of capital accumulation is characterized by an unambiguous increase in output. Hence, if the system starts from a lower level of initial capital than the steady state level, then capital and output increase gradually to their long run steady state levels as the initial q overshoots its long run steady state level and then slowly declines to its steady state value. Consumption jumps immediately to its constant steady state level.

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[7]The saddle path dynamics are conditional on the assumption $|F_{KK}| > |F_{KL}H_K|$. This is a sufficient condition for the system to have a positive and a negative root as well as being necessary and sufficient for the $\dot{q} = 0$ locus to be downward sloping.

[8]It is worth noting that a necessary and sufficient condition for saddle path stability is $\delta(\rho+\delta) > M'(q)(F_{KK} - F_{KL}H_K)$. Thus, in the no depreciation case, i.e., $\delta=0$, the necessary and sufficient condition for saddle path stability reduces to the condition for the $\dot{q} = 0$ locus to be downward sloping.

Combining equations (2) and (5) in their modified forms yields the current account equation for this economy

$$\dot{n} = rn + F(K,1-l) - c - A(I) = f \tag{22}$$

where n=b+d. Note that the constancy of c implies that m and d are constant as well. Hence, the evolution of n is given by the evolution of private foreign assets, b. The right hand side of (22) gives the current account surplus of this economy, f. Differentiating the right hand side of (22) with respect to time yields

$$\dot{f} = rf + (F_K - F_L H_K)\dot{K} - (A_I M')\dot{q} \tag{23}$$

(23) describes the evolution of the current account over time. (22) and (23) show that the dynamic behaviour of all the relevant variables in this economy can determined from the time paths of K and q.

The coefficients on $\dot{K}$ and $\dot{q}$ in equation (23) are both positive. Also, adjustment of K and q to the steady state is monotonic and driven by the negative root. Since in steady state we must have f=0, i.e., a zero current deficit, and since K and q move in opposite directions along the saddle path, (23) implies that when K is increasing over time, f has to be negative since f is monotonically rising on such paths. If this is not true then K and q will come to rest at a point where f>0. But that cannot be a steady state point. Hence, if the economy starts off with a lower level of capital than its steady state level, then the economy would run a current deficit over time as capital and output would slowly adjust over time to their long run levels while consumption would adjust permanently at the starting point itself.

Permanent cut in the rate of devaluation

Given the preceding analysis, one can now investigate the impact of a permanent change in the rate of devaluation. Starting from a steady state, the cut in the devaluation rate lowers the nominal interest rate, i. This reduces equilibrium leisure, l, which causes the $\dot{q} = 0$ locus to shift out to the right while leaving the $\dot{K} = 0$ unchanged. As shown in figure 2, the new saddle path, SS_1, lies above the old saddle path, SS_0. The new long run equilibrium point is at point b where both K and q are higher relative to the old equilibrium. In order to attain the new steady state the system jumps to point a in figure 2 and then travels along SS_1 to asymptotically reattain steady state at point b. Along the transition path q falls while K rises. Figure 3(a) depicts the time path of K after the change.

Investment: Recalling that $I=M(q)$, $M'>0$, we know that at the initial point I jumps up since q jumps up. Thereafter, I falls as q falls till the system comes to rest at a higher I and q. The time path of I is shown in figure 3(b).

Net Output and Consumption: Net output is given by F(K,L)-A(I,K), i.e., output minus the adjustment cost. At the initial point, output jumps up since labor supply increases. However, A jumps up as well since I jumps up. Thus the net effect is ambiguous. I shall assume that at the initial point net output actually jumps up. As shown earlier, along the transition path K rises which causes L to rise as well. Thus, output rises over time. Also, as I declines and K rises the adjustment costs, A, fall causing net output to rise over time. Consumption, on the other hand, jumps up immediately to its new long run steady state level, C_1, from its old level, C_0, and remains constant at that level over time. The time paths of net output and consumption are shown in figure 3(c).

Current Account: As argued previously, the slow adjustment of output and capital to their long run steady state levels causes a current account deficit to emerge as consumption adjusts immediately to its new, higher steady state level. Under the specifications of this section, equation (10) gets modified as

$$c_1 = rn_0 + \int_{t=0}^{\infty} e^{-rt}[F(K,L) - A(I)]dt \tag{24}$$

(24) is the consumption equation for the agent after the change. Since net output increases over time, from (24) we know that C_1 exceeds $rn_0+F(K_0,L_0)-A(I_0)$. Thus, a cumulative current deficit emerges in response to a permanent cut in the devaluation rate. The trade account initially goes into a deficit but later recovers and shows a long run surplus.

The analysis above has shown that once we introduce endogenous labor supply into a model with supply side frictions, one can explain both a consumption boom and an output boom as also the emergence of a cumulative current deficit due to a permanent cut in the rate of devaluation. The model also predicts that labor supply and investment should rise on impact and across steady states. Further, the labor supply effect should be increasing over time. This would seem to be consistent with the evidence (see Roldos 1994).

Implications of imperfect credibility

The main question that this subsection addresses is whether the endogenous labor supply with adjustment costs channel of explanation proposed here is a competing or complementary channel to the imperfect credibility channel which is an alternative explanation that is popular in the literature. In order to analyze the implications of imperfect credibility of the stabilization program consider the case of a cut in the devaluation rate at time $t=0$ which is reversed at time $t=T$. Thus, instead of a permanent change we now consider a transitory change.

As before, the $\dot{q}=0$ locus shifts out and to the right on impact leaving the $\dot{K}=0$ locus unchanged. However, now it is known with certainty that at time $t=T$ the system will revert to the new saddle path, SS_2, with the associated long run steady state values of K_2 and q_2.[9] It is easy to see that at

[9]As shown below, at $t=T$ c jumps down to c_2 which is lower than the initial level of consumption, c_0. Thus, the jump down in consumption at time T is greater than the jump up in consumption at time 0. From (18) it is easy to see that since c and i move in opposite directions, the jump in consumption dampens the response of leisure to changes in i. At time T, the dampening effect is greater since the

$t=0$ q cannot jump up all the way to the transitory saddle path, SS_1. If it did then the transversality conditions on K and q would be violated since from $t=T$ the system would be on an explosive path. At $t=0$, the system has to get on a dynamic path which hits SS_2 at precisely time T. Recall that from time T onwards, SS_2 is the only path which leads to long run stability.

In terms of figure 2, at time $t=0$ the system jumps to a point such as c and travels along an unstable path which hits SS_2 at time $t=T$.[10] From T onwards, the system moves along SS_2 to asymptotically regain steady state at the new, higher (K,q) combination. Output initially increases as capital accumulates and labor supply increases to accommodate this capital accumulation. However, given the levels of K and q in the long run equilibrium, the process reverses and capital decumulation sets in before the policy ends. Commensurately, the output boom disappears and a recession sets in before the program ends. Thus, when combined with imperfect credibility, the model can generate a perfect "boom-bust" cycle for output.

Consumption initially jumps up and remains fixed for the entire duration of the program. At time T the nominal interest rate, i, rises which causes consumption to fall at that point. This can be seen from the first order condition for consumption given by $U'(c) = \lambda(1+\alpha i)$ (see equation (7)). Note that λ changes at time $t=0$ and then remains fixed forever since the future changes are known with perfect foresight. Further, (7) also implies that the new long run equilibrium consumption level must lie below the old long run consumption level. To see this, first note that i is the same in the old and new long run

consumption jump is greater. Hence, the shift of the $\dot{q} = 0$ locus is smaller at time T relative to the shift at time 0 which, in turn, causes SS_2 to lie above SS_0.

[10]The dynamic path depicted in figure 2 is one of many candidate paths. The important thing to note is that the actual path that is chosen is a function of the period of time that the policy change is expected to last. For changes which last a short time (i.e., T sufficiently close to zero), the system could jump to some point below c and reach SS_2 at time T without crossing the $\dot{K} = 0$ locus. In this event the economy would not exhibit a contraction prior to the end of the program.

equilibria. Further, the first order condition for leisure is $v'(l) = \lambda F_L(K,L)$. At time $t=0$, l falls while L rises. Since K is fixed at that time and the first order condition has to hold at all times, λ has to rise at $t=0$. This information combined with (7) implies that consumption in the new steady state must be lower than in the initial steady state.

It is also easy to see that in the new steady state, l must be lower than the old steady state. By $l=H(1+\alpha i,c,K)$ and $H_2>0$, $H_3<0$, we know that since c is lower and K is higher in the new steady state while i is the same across the two equilibria, l must be lower in the new steady state. Hence, output is higher in the new steady state as well since L and K are both greater. Figures 4(a) and 4(b) show the time paths of K and I while the time paths of c and net output are shown in figure 4(c). Note that in figure 4(c), c_0 denotes initial steady state consumption, c_1 denotes consumption during the program and c_2 denotes the consumption from time T onwards.

The current account goes into a deficit at $t=0$ which is accompanied by a trade deficit. The trade deficit narrows for a while but at some point prior the end of the program it starts widening again as net output starts contracting while consumption remains unchanged. At $t=T$ the trade account jumps into a surplus as consumption jumps down at that point while output remains above its long run equilibrium level.[11] The trade surplus persists in the long run and is used to service the interest payments on debt incurred to finance the current deficit.

Thus, when the model developed in this paper is analyzed under imperfect credibility of the stabilization programs, the implied dynamics are much richer while they retain most of the qualitative features of the perfect credibility version. In this context it is worth stressing that two interesting features

[11]Note that at time T there is no jump in output since there is no jump in labor supply at that point. This can be seen from the first order condition for leisure which is given by $v'(l) = \lambda F_L(K,L)$. Since neither K nor λ jump at time T, labor supply cannot jump at that point either.

of the model that arise only on the introduction of imperfect credibility are (a) an output boom followed by a recession which begins prior to the end of the program; and (b) a crash in consumption at the end of the program. These results suggest that supply-side frictions and imperfect program credibility are complementary rather than competing explanations for the key stylized facts of exchange rate based stabilization programs.

IV. Non-traded Goods and the Real Exchange Rate

In this section I extend the basic model by introducing non-traded goods. This facilitates a study of the behaviour of the real exchange rate over time - a variable that has been neglected till now.

I assume that the representative agent now derives utility from consumption of both traded and non-traded goods as also from leisure. Further, let instantaneous utility be separable across the three. Thus, (3) gets modified as

$$V = \int_{t=0}^{\infty} e^{-\rho t}[u_T(c_T)+u_N(c_N)+v(l)]dt \tag{25}$$

where time subscripts are suppressed for notational convenience and where c_j ($j=T,N$) denotes consumption of the j^{th} commodity and T and N denote the traded and non-traded commodity respectively. U_T, U_N and v are assumed to be standard concave, increasing utility functions.

Non-traded goods are assumed to be produced by a technology which only uses labor. The production function for non-traded goods is given by

$$Y_N = f(L_N), \qquad f' > 0, f'' < 0 \tag{26}$$

The constraint on the time endowment is $L_T+L_N+l=1$. The real exchange rate which is the relative price of traded goods in terms of non-traded goods, E/P_N, is denoted by e. It is also assumed that the adjustment cost of investment is in terms of the traded good which is also the good used as capital.

The first order conditions for the agent's problem look much like before except for the addition of two first order conditions

$$\frac{u_T'}{u_N'} = e \tag{27}$$

$$v'(l) = \lambda F_L(K,L_T) = \frac{\lambda}{e} f'(L_N) \tag{28}$$

where λ once again denotes the shadow value of wealth. (27) shows that in equilibrium the marginal rate of substitution between traded and non-traded goods should equal their relative price while (28) shows that at the optimum, the marginal utility of leisure should equal the value marginal product of labor in the two sectors. Equation (15) which is the condition $\frac{u_T'(c_T)}{v'(l)} = \frac{(1+\alpha i)}{F_L(K,L_T)}$ still holds. Importantly, (22) and (23) still characterize the dynamic behaviour of the economy.

Starting from a steady state, a permanent cut in the nominal interest rate, i, once again alters the optimal mix between C_T and l in equilibrium. But now a reduced l need not necessarily translate to an increase in labor supply to the traded goods sector since an alternative employer of labor is the non-traded goods sector. Furthermore, if L_T remains unchanged then $F_K(K,L_T)$ remains unchanged on impact which, in turn, leaves the $\dot{q} = 0$ locus unchanged. In this event there would be no effect on capital accumulation. However, this possibility can be ruled out since it leads to a contradiction of the optimality conditions.

Note that if K and L_T remain unchanged then the output of traded goods remains unchanged. This would imply that C_T would also remain unchanged if the solvency constraint for the agent is to be satisfied. Now, a fall in leisure which is fully accommodated by L_N implies that $f(L_N)$ increases which, through the market clearing condition for non-traded goods, implies that c_N rises. By equation (27), a constant c_T and a higher c_N implies that e rises on impact. But the labor market equilibrium conditions (equation (28)) imply that the value marginal product of labor should be equalized across the traded and non-traded goods sectors. Thus, on impact the condition $F_L(K,L_T)=f'(L_N)/e$ must hold. But a rise in both e and L_N implies that the right hand side of the condition falls while the left hand side remains unchanged since K and L_T are unchanged. Hence, this cannot be an equilibrium response. Upon impact, L_T has to rise.

As documented in the model with a single good, a rise in L_T caused by a permanent reduction in the rate of devaluation shifts the $\dot{q} = 0$ locus out and to the right and all of the previous analysis carries over. Thus, capital accumulates over time. The process of capital accumulation draws labor to the traded goods sector and hence, output increases gradually over time. As before, the economy runs a cumulative current account deficit as c_T jumps up immediately to its long run equilibrium level. In effect all the time paths plotted in figure 3 still apply.

The variable of interest now is the real exchange rate. By totally differentiating the first order conditions and then applying Cramer's rule we can implicitly solve for c_N and sign its partial derivatives with respect to its arguments:

$$c_N = N(1+\alpha i,\lambda,e), \qquad N_1<0,\ N_2<0,\ N_3>0 \tag{29}$$

Substituting (29) into the market clearing condition for non-traded goods, $c_N=Y_N$, enables us to implicitly solve for e:

$$e = R(1+\alpha i,\lambda,L_N), \qquad R_1>0,\ R_2>0,\ R_3>0 \tag{30}$$

where the signs of the partial derivatives are obtained by totally differentiating the market clearing condition. Since i and λ are constant over time, (30) implies that

$$\dot{e} = R_3 \dot{L}_N \tag{31}$$

(31) shows that the real exchange rate and L_N move in the same direction. As the output of non-traded goods falls the real exchange rate appreciates while the converse occurs when the non-traded goods sector expands.

First, note that as capital grows $F_L(K,L_T)$ rises as well. Thus, for the marginal utility from leisure to equal the marginal product of labor in the traded goods sector, l has to fall and L_T has to rise (see equation (28)). If the entire rise in L_T comes through a fall in l then L_N would remain unchanged. From (28), for $v'(l) = \lambda \frac{f'(L_N)}{e}$ to hold, e would have to fall since a lower l implies a rise in v'. But by (31), e can fall only if L_N falls. Thus, as L_T, rises both L_N and l have to fall.

The above implies that along paths with growth in capital $\dot{L}_N < 0$. Hence, as capital accumulates and output of traded goods rises, (31) shows that there is a sustained real exchange rate appreciation over time which is indeed one of the key features of exchange rate based stabilizations.

Before closing this section it is worth pointing out that in the case of a transitory cut in the devaluation rate, all the results of the one good model carry over. The behaviour of the real exchange rate is interesting. Once capital starts declining both L_N and l rise over time as L_T falls. Thus, the real exchange rate initially appreciates for some time but then starts depreciating along with the recession which sets in before the program comes to an end.

V. Welfare Implications

The model analyzed here has the added advantage of having clear welfare implications. As pointed out by Aschauer and Greenwood (1983), the transactions cost of consumption built into the model through the cash-in-advance constraint creates a distortion in the consumption-leisure allocation. In this context, it is worth recalling that in the one good model analyzed in section III, the consumption-leisure allocation was determined through the first order condition given by equation (15) which is repeated here for convenience

$$\frac{u'(c)}{v'(l)} = \frac{1+\alpha i}{F_L(K,1-l)} \tag{15}$$

In a real economy with no money and where transactions could be carried out through barter transactions, (15) would get modified as

$$\frac{u'(c)}{v'(l)} = \frac{1}{F_L(K,1-l)} \tag{32}$$

Comparing (15) and (32) reveals that the cash in advance constraint on consumption creates a wedge between the marginal product of labor in the two cases. Aschauer and Greenwood point out that this occurs because the private cost of holding money in the cash-in-advance economy, $\alpha i/(1+\alpha i)$, is not equal to the social cost which is zero since money is costless to produce. It is easy to see that for the distortion to be eliminated i has to be set equal to zero. Thus, at the optimum, the rate of devaluation should equal to the negative of the real interest rate, r. But this is just the optimum quantity of money result due to Friedman (1969).

The welfare implications of the stabilization programs studied in this paper are also clear. A permanent cut in the devaluation rate lowers the distortion by lowering the nominal interest rate which moves closer to the optimum. Thus, the model suggests that stabilization programs that successfully cut the inflation rate are welfare enhancing since they reduce the distortions in domestic resource allocation. This is strikingly different from the results typically obtained in the "imperfect credibilty" literature where permanent changes in the devaluation rate have no real effects and hence, have no welfare implications whatsoever even though inflation jumps down to a lower level (e.g., see Calvo (1986)).

We also saw that in the case of a transitory cut in the devaluation rate, equilibrium consumption and leisure in the new steady state were lower than in the initial steady state. Thus, when we compare steady states, a transitory stabilization program is unambiguously welfare reducing in the model studied here. This is consistent with the results obtained in Calvo (1986).

However, the welfare effects of transitory programs become ambiguous once we account for the transitional dynamics. During the transition, consumption is higher while leisure is lower relative to the initial steady state. It is likely that the duration of the program (the magnitude of T) would be an important determinant of welfare for temporary programs. Analytically, a complete characterization of the welfare effects in the presence of capital accumulation is a non-trivial exercise. A full welfare analysis would require a calibration exercise which is beyond the scope of this paper but is the subject of ongoing research.

VI. Conclusion

This paper has proposed an alternative model to analyze exchange rate based stabilizations. It has shown that embedding endogenous labor supply into an otherwise standard model of a small open economy with a cash-in-advance constraint on consumption is enough to generate a consumption and output boom in response to a permanent cut in the rate of devaluation. Further, enriching the model with an adjustment friction in the form of adjustment costs of investment generates not only the aforementioned booms but also a cumulative current account deficit and a sustained real exchange rate appreciation over time. Thus, the model is able to account for a number of features associated with exchange rate based stabilizations. Importantly, none of these features arise due to either imperfect credibility of the program or due to price rigidities - explanations which have traditionally been used to account for the above features. In addition to the above, the paper is also able to account for increases in labor supply that is also associated with credible programs.

The analysis has also shown that the "endogenous labor supply and adjustment costs" explanation offered in this paper is not necessarily a competing channel of explanation with the "imperfect credibility" explanation. In the presence of imperfect program credibility, the implied dynamics exhibited by the model developed here become much richer. In particular, the model can then explain a recession which begins *before* the program ends as also a crash in consumption at the end of the program.

We also saw that the model analyzed in this paper has clear welfare implications. A permanent cut in the inflation rate is welfare enhancing since it reduces the distortion in domestic resource allocation between consumption and leisure. Further, a temporary stabilization program is welfare reducing since it reduces long run consumption and leisure.

An issue that has not been addressed so far is the quantitative importance of the cash-in-advance setting that has been used here. This is precisely the issue that Rebelo and Vegh (1995) address. Their principal finding is that while supply-side issues are extremely important in accounting for the stylized facts, their is still a large part of the consumption and output booms left unexplained. One of the problems that Rebelo and Vegh find with the endogenous labor supply channel is the negative effect on labor supply of positive wealth shocks. However, in a fully developed quantitative study one may be better advised to proceed along the effective labor supply or labor productivity channel rather than the aggregate labor supply channel. Further, the Rebelo and Vegh study assumes perfect foresight like most of the theoretical literature. However, from a quantitative perspective, accounting for uncertainty regarding the duration of the program (along the lines of Calvo and Drazen (1994)) may be extremely important.

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Table 1

Year	Real Exchange Rate (Index: 1980=100)	Current Account (Mill. of US$)	Imports of Capital Goods (Mill. of US$)	Labor Force Participation (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	-8,310	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*	96.7	-21,700	11,259	55.1

Note: The Mexican stabilization program began in 1987 while the Argentinian convertibility plan began in 1990

*Estimated
Source: Roldos 1994

Chart 1: MEXICO - Selected Indicators 1989-1994

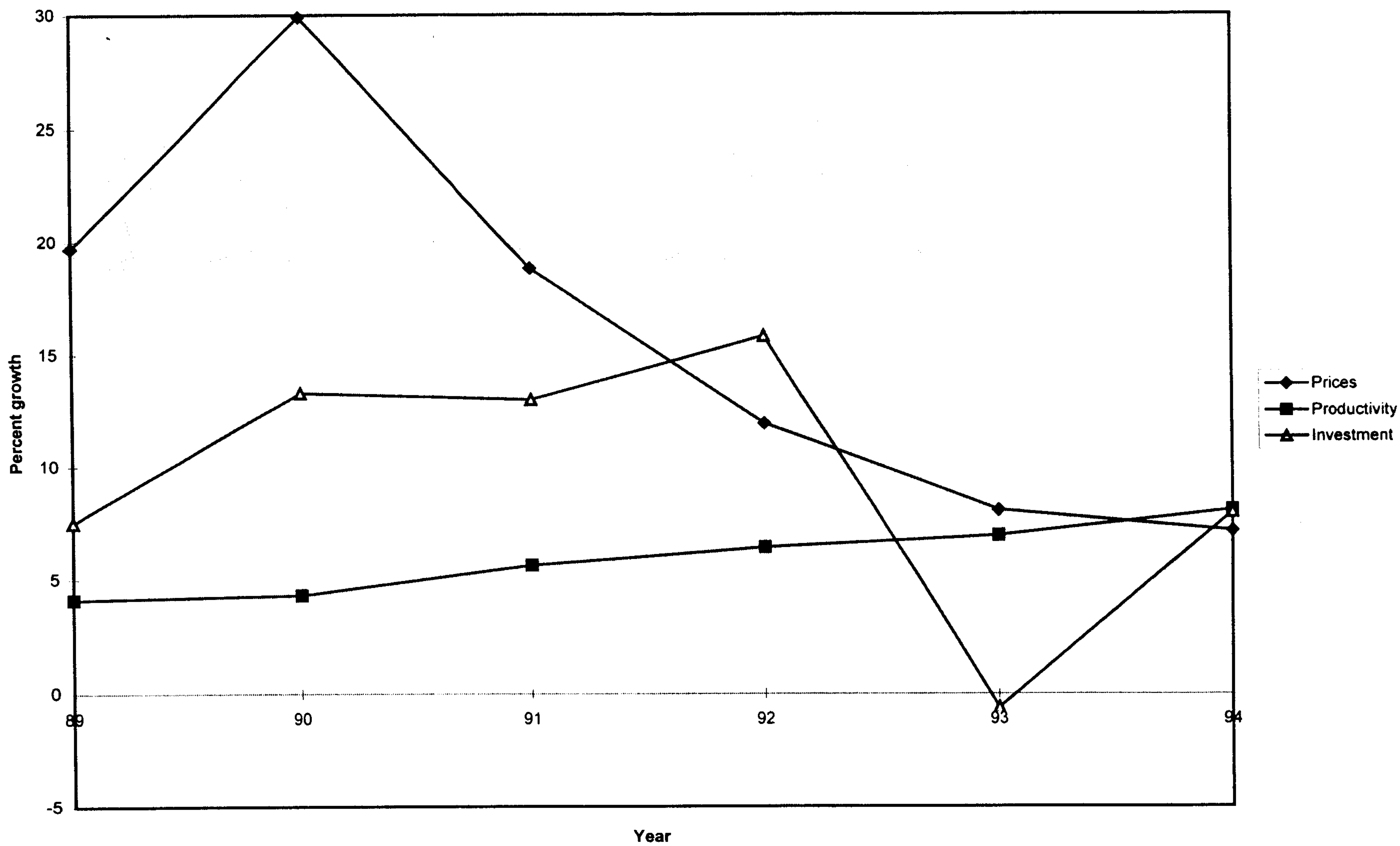


Figure 1: Dynamic System

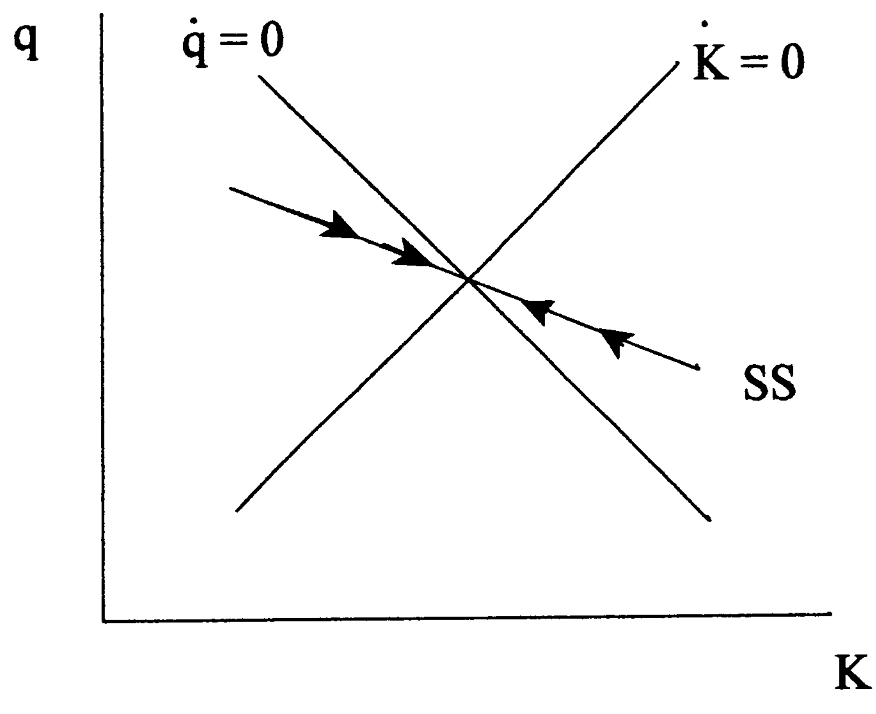


Figure 2: Devaluation rate changes

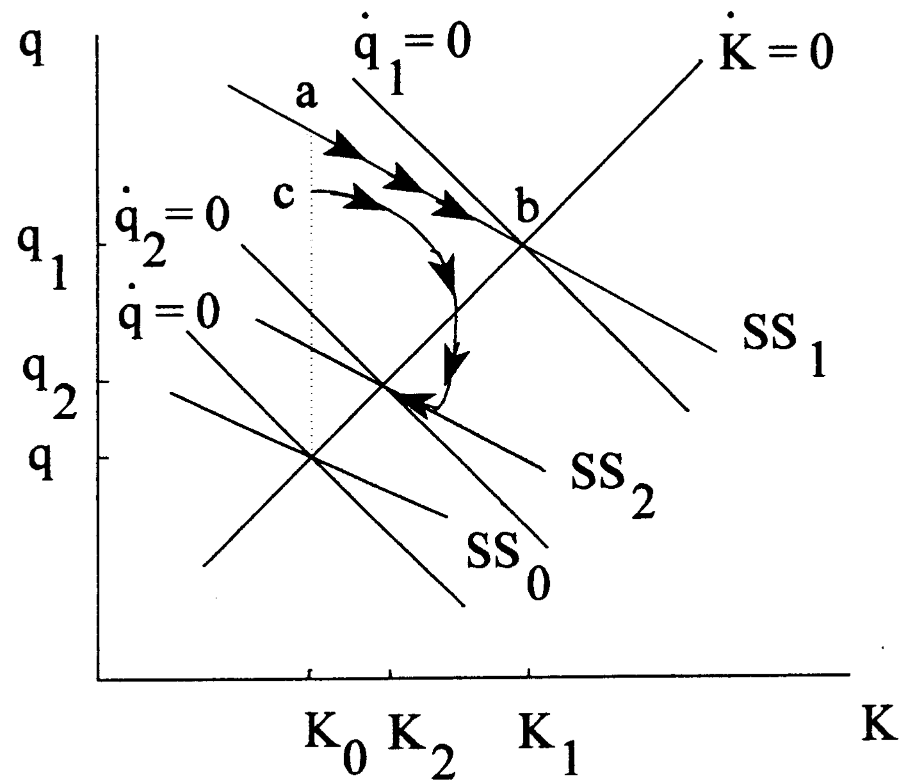
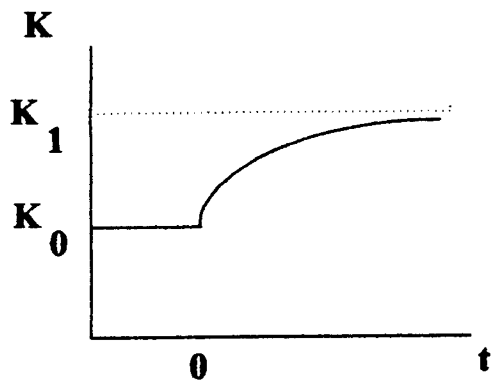
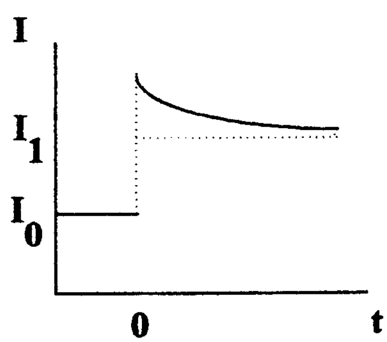


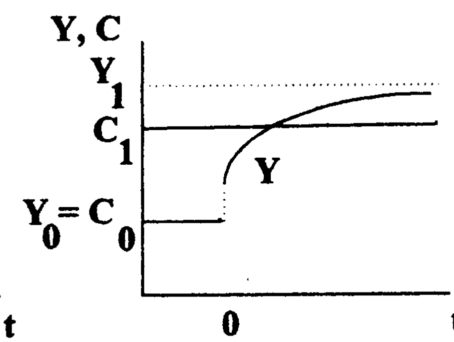
Figure 3: Permanent reduction in devaluation rate



3(a): Capital

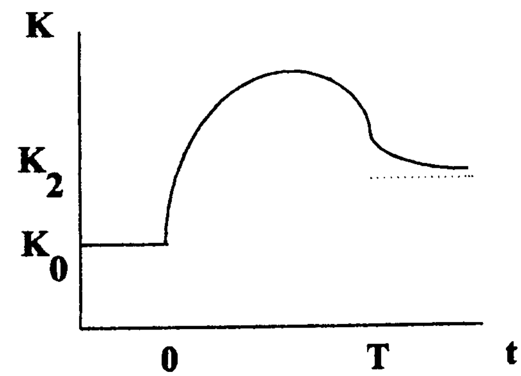


3(b): Investment

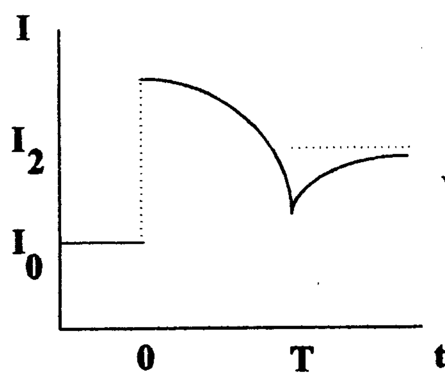


3(c): Consumption, net output

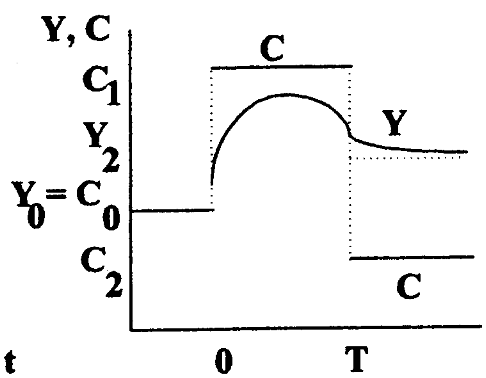
Figure 4: Temporary reduction in devaluation rate



4(a): Capital



4(b): Investment



4(c): Consumption, net output