Disinflation Programs Under Policy Uncertainty:

Insights for Exchange-Rate-Based Stabilization

Programs

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Disinflation Programs Under Policy Uncertainty: Insights for Exchange-Rate-Based Stabilization Programs*

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Abstract: This paper uses a model with endogenous labor supply to study exchange-rate-based inflation stabilization programs under uncertainty regarding the duration of the program. The paper finds that the output and consumption dynamics induced by these programs are extremely sensitive to whether the programs are perceived to have a chance of continuing permanently or whether they are expected to end in finite time. It is shown that the business cycle dynamics that are typically associated with these programs arise only when the policy is expected to collapse in finite time. The model also generates a risk premium for the nominal interest rate when agents expect the policy reversal to be accompanied by a maxi-devaluation. Arrival of "news" regarding the expected size of the exchange rate jump at the time of collapse leads to a fall in both consumption and output, and discrete losses of foreign exchange reserves. Thus, the paper is able to rationalize some of the post-December 1994 developments in Mexico.

JEL Classification: F3, F4

Keywords: Inflation stabilization, devaluation rates, policy uncertainty, supply-side effects

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1. Introduction

Since the late 1970's a large literature has emerged on exchange-rate-based inflation stabilization programs that have been implemented in a number of countries since that time. While one branch of this literature has demonstrated that the stylized facts associated with these programs contradict the conventional wisdom of large costs of disinflation, another branch has put together a number of alternative explanations for the seemingly counter-intuitive empirical regularities associated with these programs.

The cornerstone of all the stabilization packages mentioned above was the use of the exchange rate as a nominal anchor and the preannounced fixing of its time path in order to reign in chronic three digit inflation rates. Kiguel and Liviatan (1992) and Vegh (1992) have shown that four features that are common to all these episodes are: (a) an expansion in consumption, output and investment; (b) a deterioration of the current account and the trade account; (c) an appreciation of the real exchange rate; and (d) a contraction in economic activity towards the end of the stabilization programs.

The theoretical body of the literature has proposed, broadly speaking, three alternative explanations for the stylized facts. First, Dornbusch (1982) and Rodriguez (1982) have argued that in the presence of price inertia a cut in the devaluation rate causes the real interest rate to drop. This acts as the spark to real activity.[1] Second, Calvo (1986), Calvo and Vegh (1993) and Calvo and Drazen (1994) have shown that in the event of a temporary stabilization or less than perfect credibility of the stabilization program, individuals would engage in intertemporal

[1]It is worth noting that Calvo and Vegh (1994) show that in a utility maximizing framework with nominal rigidities, a permanent reduction in the devaluation rate causes a consumption boom only if the elasticity of intertemporal consumption substitution exceeds the intratemporal elasticity of substitution between traded and non-traded goods. Available econometric estimates of the two elasticities indicate that the magnitudes are more likely to run the other way (see Ostry and Reinhart (1992)).

consumption substitution towards the present in order to take advantage of the lower transactions costs in the present relative to the future. This causes a demand driven upswing in economic activity. Third, Lahiri (1995a), Roldos (1995) and Uribe (1995) argue that permanent cuts in the devaluation rate could generate the observed stylized facts due to important supply-side adjustments even without any nominal frictions or credibility problems.

Two recent papers have used different methods to evaluate the strengths of these alternative hypotheses. Lahiri (1995b) studies the different hypotheses using a model with potential supply-side effects (due to an endogenous labor-leisure choice) by relaxing the perfect capital mobility assumption. Under the alternative assumptions of no capital mobility and imperfect capital mobility, he finds that the "temporary policy" hypothesis is the most robust to realistic model respecifications. Rebelo and Vegh (1995), on the other hand, simulate a much more elaborate model to numerically compare the results with the actual data. Their principal finding is that both permanent disinflation programs and temporary programs work well in replicating the data under certain conditions. Further, they find that the supply-side effects of disinflation programs are crucial in accounting for the stylized facts.

The above raises two issues. First, it underscores the importance of credibility and supply-side issues for understanding the stabilization episodes. Second, it highlights a missing link in this literature. Most of the literature has focused on models of perfect foresight to analyze the stabilization episodes. The only exceptions are Drazen and Helpman (1987) and Calvo and Drazen (1994) who analyze reform programs of uncertain duration. However, both papers use endowment economy models and, hence, ignore all supply-side issues. The supply-side literature, on the other hand, has either completely ignored credibility issues (Roldos (1995) and Uribe (1995)), or combined it with credibility issues under the assumption of perfect foresight (Lahiri (1995a) and Rebelo and Vegh (1995)).

This paper attempts to fill this gap in the literature by analyzing exchange-rate-based stabilization programs under the realistic assumption that private agents are uncertain about how long the programs will survive. The model used is one where agents make a labor-leisure choice under the constraint that consumption is a cash good while leisure is a credit good. This induces a supply response upon disinflation.

A second innovation of the paper is that it relaxes the perfect capital mobility assumption which is standard in most of the literature. Imperfect capital mobility is introduced into the model through the assumption that the interest rate at which international capital markets are willing to lend increases with the stock of outstanding country debt. It is also shown that the dynamic implications of this type of market imperfection are, qualitatively, identical to the effects under capital controls imposed by the government through a "Tobin" tax on the international flow of private capital as long as the government uses the tax to target the stock of country assets.

The principal findings of the paper are: (a) the dynamics induced by an exchange-rate-based inflation stabilization program are extremely sensitive to whether individuals expect the program to end in finite time or whether they assign positive probability to the event of no program collapse ever in finite time; (b) a program which has a positive probability of permanent survival over all finite time intervals induces dynamics which are the exact opposite of the dynamics induced by a program which is expected to end at a known date with perfect foresight; (c) a program whose end date is uncertain but which has a finite and known last date by which time the program must end induces dynamics which are a mix of those described in (b) above. In particular, the dynamics initially resemble those under a positive probability of permanent survival but later change to qualitatively resemble those under certain reversal with perfect foresight; and (d) during the life of a program any "news" which induces expectations of a jump devaluation at the end of the program or an increase in the size of the expected jump causes contractions in economic activity and discrete losses of foreign exchange reserves. The model is, thus, able to rationalize some of the developments in Mexico in December 1994.

It is worth stressing at the outset that the endogenous labor supply set up used here is a convenient modeling strategy and is intended to capture the fact that in high inflation economies agents spend a large portion of their labor time and resources in activities related to money management (coordinating transactions, predicting price changes, reducing average daily cash holdings etc.).[2] A lowering of the inflation rate should thus free up some of this time for effective labor supply.

The next section lays out the model while section 3 analyzes disinflation programs under certainty. Section 4 studies the model under uncertainty regarding the duration of the reform and compares the results with those obtained under certainty. Section 5 of the paper analyzes the economic implications of the arrival of "news" and uses the model and its insights to analyze the Mexican developments of December 1994. The last section concludes.

2. The Model

Consider a small open economy consuming and producing a single traded good. The world price of the good is assumed to be constant and, for convenience, is normalized to unity. Thus, purchasing power parity ensures that the domestic currency price of the good is given by the nominal exchange rate, E, which is the price of the foreign currency in terms of the domestic

[2] An alternative but more complicated modeling strategy would be to introduce a transactions cost technology which uses money balances and leisure time as inputs. All the results reported here can be reproduced under this alternative as long as money and leisure time are substitutes in the transactions cost technology.

currency. The economy is inhabited by infinitely lived, identical agents who derive utility from consumption and leisure. Thus, the representative agent maximizes

$$V = \int_{t=0}^{\infty} e^{-\rho t}[u(c_t) + v(l_t)]dt \tag{1}$$

where u and v are concave and twice differentiable in their respective arguments, c and l denote consumption and leisure respectively, and ρ is the subjective rate of time preference which is assumed to be constant. The agent has an endowment of one unit of time which can be allocated to labor or leisure. The labor constraint is given by

$$l + L = 1 \tag{2}$$

where L denotes labor. The good is produced using only labor and a concave, twice differentiable production function which is increasing in labor:

$$y = f(L), f' > 0, f'' < 0 \tag{3}$$

Agents have access to world capital markets in which they can trade in bonds denominated in terms of the traded good. Since the world price of the good is equal to unity the face value of the bond is also unity. The bonds pay r units of the traded good per unit of time as interest which is taken as given by private agents. By interest rate parity we have $i_t = r_t + \varepsilon_t + RP_t$ where i denotes the nominal interest rate, ε denotes the domestic inflation rate which is also the devaluation rate in this one good model while RP denotes the risk premium. The exact form of the risk premium will be formalized later at which point we shall have more to say about it.

The representative agent's flow budget constraint is given by

$$\dot{b} = rb + c + \mu m - \tau - f(L) \tag{4}$$

where μ is the rate of money printing, m are real money balances, τ denotes lump sum transfers from the government to the private agent, and b denotes private foreign debt. In equation (4) and the rest of the paper, time subscripts are suppressed for notational convenience wherever possible and a dot over a variable is used to indicate its time derivative The agent also faces a cash-in-advance (CIA) constraint on consumption which is given by

$$m = \alpha c \tag{5}$$

Using the CIA constraint[3] and the fact that $\mu m = \dot{m} + \pi m$, we can rewrite (4) as

$$\dot{a} = ra + (1 + \alpha(r + \varepsilon))c - \tau - f(L) \tag{6}$$

where a (= b - m) denotes the net debt of private agents. Integrating equation (6) subject to the No-Ponzi-Game (NPG) constraint, $\lim_{T \to \infty} e^{-\int_{v=0}^{T} r_v dv} a_T \leq 0$, we have

$$a_0 = \int_{t=0}^{\infty} e^{-\int_{v=0}^{t} r_v dv} [f(L) + \tau - c(1 + \alpha(r + \varepsilon))]dt \tag{7}$$

Equation (7) gives the lifetime budget constraint of the agent in terms of net debt. The government in this economy does not issue debt. It earns revenues through interest earnings on its foreign exchange reserves and through money printing. It is assumed that all government revenues are rebated to the public through lump sum transfers, τ. Thus, the budget constraint of the government is given by

$$\tau = rd + \varepsilon m \tag{8}$$

where d denotes government holdings of foreign exchange reserves. The domestic credit rule given by (8) implies that the government increases domestic credit at the same rate as the rate of inflation.[4] Hence reserves and domestic real money balances, m, grow at the same rate.

The assumption of the primary experiment in this paper is that at time t=0 the government announces a new exchange rate policy which exogenously reduces the rate of

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[3] The strict equality in the cash-in-advance constraint given by (5) implicitly assumes positive nominal interest rates at all points in time.

[4] Details and discussions regarding this specification can be found in Obstfeld (1985). Intuitively, the specification here ensures that the domestic credit policy is consistent with the announced exchange rate policy.

devaluation from the prevailing rate, $\bar{\varepsilon}$, to a lower rate, $\underline{\varepsilon}$, permanently. The public, however, does not consider the announced policy to be fully credible. It expects the policy to collapse at some time T (> 0) and expects the devaluation rate to jump back up to $\bar{\varepsilon}$ at that time. However, private agents are uncertain about the precise time of policy collapse, i.e., they are uncertain about time T. This is the only source of uncertainty in the model. It is assumed that the public has a subjective probability distribution on T with its distribution function being given by H(T) with H(0) = 0 and $H(T_m) = 1$. It is assumed that the function H(.) is common knowledge and that once the policy collapses all uncertainty is resolved and the economy locks into the higher rate of devaluation, $\bar{\varepsilon}$, forever.

This is, essentially, a two stage problem. Stage 1 is from time t = 0 to time T when agents face the uncertainty regarding program reversal. Stage 2 is from time T onwards when all uncertainty has been resolved and agents optimize under perfect foresight. Let $V^+(.)$ denote the present discounted value of lifetime utility from time T (the date of policy collapse) onward. V^+ is a function of the individual's asset holdings at time T.[5] The expected present discounted value of lifetime utility from time t = 0 is thus given by

$$\int_{T=0}^{\infty}\left[\int_{t=0}^{T} e^{-\rho t}[u(c_t)+v(l_t)]dt + e^{-\rho T}V^+(a_T)\right]dH(T) \tag{9}$$

where a_T denotes financial assets at time T. Financial assets at time T are given by

$$a_T = a_0 e^{\int_{v=0}^{T} r_v dv} + \int_{t=0}^{T} e^{\int_{v=t}^{T} r_v dv}[f(L_t)+\tau_t - c_t(1+\alpha(r_t+\varepsilon))]dt \tag{10}$$

[5] It is assumed that the post-policy-collapse devaluation rate is constant and independent of time. Thus, V^+ is independent of T.

The representative agent maximizes (9) by choosing sequences of consumption and leisure subject to (10) and the time endowment constraint (equation (2)). The first order conditions for this problem are given by:

$$e^{-\rho t}\frac{u'(c_t)}{1+\alpha(r_t+\varepsilon)} = \int_t^{\infty} e^{-\rho T+\int_{v=t}^{T} r_v dv} V_a^+ \frac{dH(T)}{1-\mathrm{H}(t)} \tag{11}$$

$$e^{-\rho t}\frac{v'(l_t)}{f'(L_t)} = \int_t^{\infty} e^{-\rho T+\int_{v=t}^{T} r_v dv} V_a^+ \frac{dH(T)}{1-\mathrm{H}(t)} \tag{12}$$

where the subscript on the function V indicates its derivative with respect to financial assets while the superscript + denotes post policy reversal values. Let

$$\lambda = \frac{u'(c)}{1+\alpha(r+\varepsilon)} \tag{13}$$

Using the notational convention given by (13), λ^+ will denote the effective marginal utility of consumption at time t conditional on a policy reversal having taken place at that time. Using equation (13) and combining (11) with (12) implies that (12) can be rewritten as

$$\frac{v'(l)}{f'(L)} = \lambda \tag{14}$$

where the time subscripts have again been suppressed for convenience. We can differentiate (11) with respect to t and use equation (13) to get

$$\dot{\lambda} = [\rho+\theta_t - r_t]\lambda - \theta_t\lambda^+ \tag{15}$$

where $\theta_t = \dfrac{h(t)}{1-H(t)}$ denotes the probability of a policy collapse at time t conditional on no collapse till t. Equations (13) and (14) can be used to solve for consumption and leisure as functions of λ and $r + \varepsilon$:

$$c = \psi(\lambda, 1+\alpha(r+\varepsilon)), \quad \psi_1 < 0, \psi_2 < 0 \tag{16}$$

$$l = G(\lambda), G' < 0 \tag{17}$$

where the subscript j on a function indicates its partial derivative with respect to the jth argument. Equation (16) shows that increases in wealth cause consumption to rise while increases in the devaluation rate, which are a component of the effective price of consumption due to the CIA constraint, cause consumption to fall. Likewise, (17) shows that leisure increases with increases in wealth.

Recalling that the domestic credit rule given by (8) implies that foreign exchange reserves and real balances move together, i.e., $\dot{m} = \dot{d}$, we can substitute (8) into (6) to get

$$\dot{n} = rn + c - f(L) \tag{18}$$

where n (= b - d) denotes net country debt and the right hand side of (18) gives the current account deficit of the economy.

As stated above, the interest rate, r, is taken as given by atomistic agents who are individually too small to influence the market. However, world capital markets are not perfect. It is assumed that the world capital markets link the interest rate to the net indebtedness of the country. In other words, the net indebtedness of the country is taken to be a proxy for the creditworthiness of the country by international creditors. It is assumed that

$$r_t = r^* + t(n_t), \quad t' > 0 \tag{19}$$

where r* can be interpreted as the risk free rate.[6,7] Substituting equations (16), (17) and (19) into (15) and (18) we get

$$\dot{\lambda} = [\rho + \theta - r^* - t(n_t)]\lambda - \theta\lambda^+(n_t; \bar{\varepsilon}) \tag{20}$$

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[6] An alternative specification for the interest rate function would be to let R(n) = rn where $R' > 0$, $R'' > 0$ and $R \geq (<) 0$ as $n \geq (<) 0$. For an application using this approach see Pitchford (1991).

[7] This interest rate schedule would emerge as an equilibrium outcome in a situation where international creditors assign a positive probability at each point in time to default by sovereign debtors and consider the default probability to be increasing in the size of country debt.

$$\dot{n} = [r^* + t(n)]n + \psi(\lambda, 1 + \alpha(r + \varepsilon)) - M(\lambda) \tag{21}$$

where M = f(1-G(.)) and $M' > 0$ and where time subscripts have been suppressed for convenience. Equations (20) and (21) describe the dynamic behavior of the economy. Note that in (20) we take the post policy reversal dynamics to be driven by the saddle path, λ^+, that prevails in the certainty environment under the higher devaluation rate. In the next section we shall show that the dynamics of the system under certainty are indeed driven by a saddle path.

It is worth noting that one could relax the imperfect capital markets assumption and, instead, assume that capital markets are perfect but that the government exercises some control on the international flow of private capital through taxes on such flows (a Tobin tax). Lahiri (1995b) shows that, qualitatively, the results remain unchanged as long as the government uses the tax to target the stock of country assets/debt. I outline the argument briefly in the next paragraph. Readers interested in the details are referred to Lahiri (1995b) where the issue is analyzed at greater depth.

A tax p per unit of foreign bond holdings implies that the the flow budget constraint of the agent is given by $\dot{a} = (r - t)a + [1 + \alpha(r - t + \varepsilon)]c - \tau - f(L)$ where r is now the fixed world interest rate. Assume that the tax revenues from the capital tax are rebated back to the public through lump sum transfers and that the government uses the tax to target the stock of country debt, n, such that $t' < 0$. This implies that the tax rises when country debt (assets) falls (rise). Thus, the effective interest rate falls as assets rise due to the higher tax. But this is exactly what the assumed market imperfection does to the real interest rate. Under the foregoing assumption, the two fundamental equations driving the economy are given by

$$\dot{\lambda} = [\rho + \theta - r^* + t(n)]\lambda - \theta\lambda^+(n; \bar{\varepsilon})$$

$$\dot{n} = r^* n + \psi(\lambda, 1 + \alpha(r - t(n) + \varepsilon)) - M(\lambda)$$

The dynamics of this sytem are qualitatively identical to those given by (20) and (21) even though there are significant quantitative differences.

Before proceeding to the actual analysis, we need an equation that describes the evolution of the nominal interest rate for this economy. Risk neutral investors would be indifferent between holding nominal bonds denominated in terms of the domestic currency and real bonds denominated in terms of the traded good invested during the periods 0 to t as long as the following condition holds:

$$\int_{(T=0)}^{t} \frac{1}{E_t^+} e^{\int_{s=0}^{T} i_s ds \int_{s=T}^{t} i_s ds} dH(T) + [1 - H(t)] \frac{1}{E_t} e^{\int_{s=0}^{t} i_s ds} = \frac{1}{E_0} e^{\int_{s=0}^{t} r_s ds} \qquad (22)$$

Since all uncertainty is resolved at time T, time differentiation of the counterpart of equation (22) for all s ≥ T implies that

$$i_s = r_s + \bar{\varepsilon} \quad \text{for all } s \geq T \qquad (23)$$

Noting that $E_t^+ = E_T^+ e^{\bar{\varepsilon}(t-T)}$ and using (23), we can differentiate (22) with respect to time t to get

$$i_t = r_t + \underline{\varepsilon} + \frac{\theta_t}{E_t}\left(1 - \frac{E_t}{E_t^+}\right) \quad \text{for all } t \leq T \qquad (24)$$

Equation (24) describes the nominal interest rate while the uncertainty about the policy reversal or collapse exists. It shows that if investors expect the policy collapse to be accompanied by a jump devaluation of the domestic currency, $E_t^+ > E_t$, they would require to be compensated for the expected capital loss on their domestic money holdings through a positive risk premium. In the absence of an expected jump devaluation at the end of the program, the nominal interest rate would be given by the standard interest rate parity condition under perfect foresight. Thus, uncertainty about program duration is, by itself, insufficient to generate a positive risk premium.[8]

We are now in a position to analyze the dynamics associated with an exchange-rate-based stabilization. We shall start by first outlining the effects under complete certainty which will set the stage for the results under uncertainty about program duration.

3. The Certainty Case

The economy is not subject to any uncertainty during two phases: (a) prior to the implementation of the stabilization program; and (b) after the program collapse at time T. In this section we shall detail the behavior of the economy during these two phases and, in the process, also analyze the implications of a stabilization program whose longevity is known with perfect foresight.

The first thing to note is that all the optimality conditions derived in the previous section for the uncertainty case continue to apply for the certainty case where the probability distribution of the collapse date has a mass point at a single T, i.e., $\theta_t = 0$ for all $t < T$. Given this observation, the dynamic system that describes the economy under certainty is given by equation (21) and a modified version of equation (20):

$$\dot{\lambda} = [\rho - r^* \text{-} t(n_t)]\lambda \tag{25}$$

It is easy to check that the system given by (21) and (25) is saddle path stable in a local neighborhood around a steady state. Figure 1 depicts the dynamics of the system.[9] The saddle

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[8] This result is the same as that obtained by Calvo and Drazen (1994) and, in a different model, by Drazen and Helpman (1987).

[9] Figure 1 has been drawn under the assumption that the $\dot{n} = 0$ locus is upward sloping. This is conditional on the assumption $\rho + nt' > \alpha t' \psi_2$, i.e., the positive revaluation effect on debt service due to increases in debt outweigh the negative effect of a drop in consumption that is

path associated with this system is upward sloping while the $\dot{\lambda} = 0$ locus is vertical and independent of λ.

As described in the introduction, exchange-rate-based disinflation programs rely on lowering the devaluation rate in order to cut inflation. In terms of figure 1, a cut in the devaluation rate causes the $\dot{n} = 0$ locus to shift up to the $\dot{n}_1 = 0$ locus. If the policy change is permanent the system jumps up from point 'e' to point 'b' and locks into its long run equilibrium position instantaneously. There are no effects on the current account and trade account. However, both consumption and output jump up to higher equilibrium levels.

A temporary cut in the devaluation rate, on the other hand, implies that after the policy collapse at time T (which is known with perfect foresight), the system will be driven by the original saddle path, SS_0. Thus, the dynamic behavior of the economy during the life of the stabilization program ($0 \leq t < T$) will be driven by the requirement that the economy has to be on the saddle path SS_0 at precisely time T. Hence, on impact, the system jumps up to a point such as 'a' and then travels along an explosive path to reach point 'c' at time T. From then on the system travels back along SS_0 to reattain its original long run equilibrium position at point 'e'.

As can be seen from figure 1, the economy runs a current account deficit during the life of the program which gives way to a long run current surplus from time T that is eliminated asymptotically. Output jumps up on impact due to increased labor supply but thereafter goes into a secular decline. Consumption behavior is ambiguous during the stabilization phase since the nominal interest rate, which is the effective price of consumption, and the wealth parameter, λ, move in opposite directions. However, the impact current deficit implies that at time 0 consumption jumps up and increases more than the impact increase in output. At time T

induced by the rise in the nominal interest rate due to the increase in n. Note however that the saddle path dynamics are ***not contingent*** on the slope of the $\dot{n} = 0$ locus.

consumption jumps down due to the rise in the nominal interest rate which is caused by the rise in the devaluation rate at that time. From time T onward consumption rises back towards its long run equilibrium level.[10]

The dynamics documented above raise a couple of issues. First, permanent disinflation programs and their associated supply-side responses due to labor supply effects are, by themselves, insufficient to generate the current deficits and widening trade deficits that were observed in most of these programs. To qualitatively fit the facts we also need frictions in the adjustment process for output as in Lahiri (1995a) among others. As shown by Rebelo and Vegh (1995), these frictions also have to be fairly strong in order to replicate the actual observed magnitudes.

Second, supply-side models without adjustment frictions when combined with temporary stabilization programs or programs with imperfect credibility are capable of replicating the current deficits, and the consumption and output booms that typically emerge on impact in these programs. However, they are unable to account for the observed sustained expansions in real activity during the initial stages of the programs which are typically followed by a collapse which often begins ***prior*** to the end of the program.

As shown by Lahiri (1995a) and Rebelo and Vegh (1995), these business cycle dynamics can be generated under perfect foresight through the combination of adjustment frictions with temporary stabilization programs. The next section will show that these dynamics can also be generated under uncertainty regarding program duration even ***without*** adjustment frictions.

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[10] In the case where the $\dot{n} = 0$ locus is downward sloping, the saddle path continues to be upward sloping. However, a cut in the devaluation rate causes the $\dot{n} = 0$ locus to shift down. In the event of a temporary change in policy, this causes a current account surplus to emerge which is accompanied by a fall in output and consumption. These dynamics, however, are completely counterfactual.

4. Uncertainty of Program Duration

As shown in section 2, equations (20) and (21) describe the dynamics of the system when agents are uncertain about the duration of the stabilization program. The two equations are repeated here for convenience:

$$\dot{\lambda} = [\rho + \theta(t) - r^* - t(n_t)]\lambda - \theta(t)\lambda^+(n_t;\bar{\varepsilon}) \tag{20}$$

$$\dot{n} = [r^* + t(n)]n + \psi(\lambda, 1 + \alpha i) - M(\lambda) \tag{21}$$

Noting that λ^+ pertains to the system that pertains to the certainty phase that prevails after the policy collapses, we use our results from the previous section to identify SS_0 in figure 2 as the stable branch for the post-policy-collapse phase. The equation for SS_0 is

$$\lambda^+ = \lambda^+(n;\bar{\varepsilon}), \lambda_1^+ > 0 \tag{26}$$

As stated in the introduction, there are two different cases to be analyzed: (a) the case where it is possible for the policy to remain in place for all finite time intervals; (b) the case where the policy has to revert in finite time.

(a) $T_m = \infty$

Under this case we have $H(\infty) = 1$ and, as before, $H(0) = 0$. This corresponds to the case where the event of no-policy-reversal in finite time has a positive probability weight. To focus the discussion, it is further assumed that the date of policy reversal follows a Poisson distribution: $h(T) = \theta e^{-\theta T}$. This distribution implies that the expected time until policy collapse is $1/\theta$ which is unchanging over time. This is due to the constant probability of policy reversal in any finite time interval. Note that under this distribution for T we have $h(t)/1-H(t) = \theta$ for all t, i.e., the probability of a policy reversal at any time t conditional on no policy reversal till then is constant for all t. This is admittedly an extreme and, possibly, slightly unrealistic assumption about the evolution of policy credibility but is adopted here for analytical convenience.[11]

The system given by equations (20) and (21) exhibits saddle path stability in the neighborhood of a steady state as long as the $\dot{n} = 0$ locus is flatter than the $\dot{\lambda} = 0$ locus.[12] Since we continue to assume that the $\dot{n} = 0$ locus is upward sloping, i.e., the intertemporal price effect of an increase in n dominates the temporal price effect through the nominal interest rate, the saddle path stability condition implies that we restrict attention to only n such that $n < n^*$ where n^* is defined by the condition $t(n^*) = \rho + \theta - r^*$. Figure 2 shows the dynamics of the system.

At the outset one should note a few things about the dynamic system depicted in figure 2. First, the original and post-policy-collapse certainty phases are driven by the $\dot{n} = 0$ and $\dot{\lambda} = 0$ loci along with their associated saddle path, SS_0. This is the same system that was depicted in figure 1 for the certainty case. The system given by the $\dot{n}_1 = 0$ and $\dot{\lambda}_1 = 0$ loci and their associated saddle path, SS_1, drives the economy during the uncertainty phase which prevails during the life of the stabilization program. Second, the $\dot{\lambda}_1 = 0$ locus has to pass through the original steady state point, e_0. This can be seen from equation (20) and the fact that for $\dot{\lambda}_1 = 0$ when $n = n_0$, we must have $\lambda = \lambda^+(n_0)$. Hence, $\dot{\lambda}_1 = 0$ has to go through the

[11] This assumption essentially makes the hazard rate, θ, time autonomous and thus enables us to tie down the steady state values of λ and n.

[12] The precise condition for saddle path stability is $\frac{\rho + nt'(n) + \alpha\psi_2 t'(n)}{M_1 - \psi_1} < \frac{\lambda t'(n) + \theta\lambda_1^+}{\rho + \theta - r^* - t(n)}$. The left hand side of the inequality gives the slope of the $\dot{n} = 0$ locus while the right hand side gives the slope of the $\dot{\lambda} = 0$ locus.

original steady state point. Third, the $\dot{\lambda}_1 = 0$ locus asymptotes the line $t(n^*) = \rho + \theta - r^*$ since as n approaches n*, the slope of the $\dot{\lambda}_1 = 0$ locus becomes arbitrarily large.

The implications of a cut in the devaluation rate are now easy to analyze in terms of figure 2. For now the analysis presumes that the exchange rate path is expected to be continuous so that the risk premium in the nominal interest rate is zero. The implications of relaxing this assumption will be discussed later.[13] As before, starting from a steady state at point 'e_0', a cut in the devaluation rate shifts the $\dot{n} = 0$ locus upwards to the new $\dot{n}_1 = 0$ locus. Concurrently, the $\dot{\lambda} = 0$ locus shifts to the new $\dot{\lambda}_1 = 0$ locus which, as explained above, passes through the old steady state point. The new saddle path, SS_1, lies above the old saddle path.

The system jumps up to point 'a' on SS_1 at time 0 and then travels along SS_1 towards e_1 which is its asymptotic steady state point conditional on no policy reversal. Once the policy reverses the system jumps down vertically to SS_0 and then travels back along it to asymptotically regain steady state. This jump is consistent with optimality since the policy reversal is always a surprise shock due to its less than perfect anticipation.

It is worth noting that if the system does not get on SS_1 at time 0 then the dynamics will lead to either zero consumption in finite time or a violation of the transversality condition. Since the policy may not collapse in finite time, these paths can never be optimal. The only path that is consistent with asymptotic stability in the event of no policy collapse lies along SS_1. One should note that even though the optimal path lies along SS_1, ***ex post*** some other paths may well be

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[13] The existence of a risk premium creates a secondary complication in the dynamic adjustment path of the economy. If the anticipated jump in the level of the exchange rate is high enough then it could cause the nominal interest rate to actually rise upon the announcement of the cut in the devaluation rate. This, in turn, would cause the $\dot{n} = 0$ locus to shift down upon impact and, hence, reverse all the dynamics described below.

optimal. However, the absence of perfect foresight about the time of policy reversal is sufficient to prevent such paths from being optimal ***ex ante***.

The time paths of consumption, output and the current account associated with the adjustment dynamics described above are easy to derive. Output jumps up on impact and continues rising over time. On impact, a current account deficit emerges which is eliminated asymptotically. Consumption jumps up on impact, overshooting its long run equilibrium level in the process, and then falls over time. At the time of policy reversal both consumption and output jump down. Thereafter, consumption rises and output declines. The current deficit gives way to a current surplus which is eliminated asymptotically.

The intuition behind the declining time path of consumption during the life of the program is fairly simple. As in Calvo and Drazen (1994), at each point in time the agent assigns positive probability to the event of a policy reversal at the next instant with its consequent rise in the nominal interest rate. This induces an intertemporal consumption substitution from tomorrow to today in order to take advantage of the lower consumption price in the present. At the next instant the news of no program collapse implies that the agent has overconsumed in the past and, hence, needs to adjust her consumption downward. The downward adjustment of consumption is complemented by the rising nominal interest rate over time due to the increasing levels of country debt, n. The overconsumption at each point in time caused by the uncertainty regarding program duration, in turn, generates a cumulative current deficit.

The output and consumption dynamics described above stand in stark contrast to those derived under certainty regarding program duration. As seen in section 3, a devaluation rate cut which is certain to revert at a known time T causes output to ***fall*** over time after the initial jump up in contrast to the secular ***rise*** obtained here. Further, the consumption response over time was seen to be ambiguous in the certainty case as opposed to the unambiguous rise obtained here.

The reason for these sharply contrasting dynamics is easy to see. Letting the upper support of the distribution for T go to infinity implies giving a positive probability weight to the event of no policy reversal ever. This causes economic effects which are very different from those when no policy reversal in finite time is a zero probability event.

(b) $T_m = T^* < \infty$

The preceding analysis brings us naturally to the case of a finite T_m. The assumption of a finite T_m implies that the policy reversal takes place in finite time with probability one. However, the uncertainty regarding the precise time of policy reversal still remains. As before, a cut in the devaluation rate lowers the nominal interest rate which causes the $\dot{n} = 0$ locus to shift up to the $\dot{n}_1 = 0$ locus while the $\dot{\lambda} = 0$ locus shifts to the new $\dot{\lambda}_1 = 0$ locus. The dynamic system is depicted in figure 3.[14]

The dynamic path that the system jumps to in this case is crucially dependent on the first point in time at which all uncertainty about the policy reversal resolves itself. Given our assumption about the distribution for T, at time t = T* the policy collapses with certainty, i.e., with probability 1. Hence, at T* the agent faces a perfect foresight problem where she knows that from T* onward the policy will revert to the original high inflation regime with the dynamics of the system being driven by the original saddle path, SS_0. For the consumption path to be optimal there can be no perfectly anticipated jumps in it. Thus, the optimal path should be on SS_0 at precisely time T* in order to attain long run equilibrium. This enables us to tie down the dynamic trajectory that the system needs to follow from time 0.

As shown in figure 3, starting from steady state, at time 0 the cut in the devaluation rate induces the system to jump to a point such 'b' and then travel along a dynamic path which reaches SS_0 at exactly time T* . If a policy reversal occurs prior to T* the system jumps down

[14] For the rest of this subsection it shall be assumed that $\theta(t) > 0$ for all $t \leq T^*$.

vertically to SS_0 at that time and from then on travels back along SS_0 to asymptotically regain steady state. The precise dynamic trajectory followed by the system depends on the value of T* but the qualitative characteristics of the path remain the same for all ***finite*** values.

The dynamics of consumption, output and the current account are easily derived from the dynamic behavior of n and λ. The output dynamics mimic the behavior of λ. It jumps up on impact, proceeds to rise for a while and then starts declining thus reproducing the familiar business cycle dynamics associated with exchange-rate-based stabilization programs. Note that these dynamics are very different from both the certainty case and the previous case of $T_m = \infty$. Recall that in the certainty case output went into a secular decline after the initial jump up while with $T_m = \infty$ it rose continuously after the initial jump up.

Consumption jumps up on impact at time 0. Thereafter, consumption falls unambiguously as long as output is rising. Once output starts falling the consumption dynamics become ambiguous. The rising path of the real interest rate induces a rising path for consumption while the rise in the nominal interest rate has a negative effect. Assuming that the intertemporal effect dominates, consumption starts growing after a while. At the time of policy reversal consumption jumps down and rises unambiguously thereafter. The current account dynamics associated with this case are similar to the previous cases. A current deficit emerges upon impact which persists till the policy reverts. In the long run the economy runs a current surplus which is eliminated asymptotically.

The consumption dynamics are best understood by rewriting equation (20) as:

$$\frac{\dot{\lambda}}{\lambda} = [\rho - r^* - \dot{t}(n_t)] + \theta(t)\left(1 - \frac{\lambda^+}{\lambda}\right) \tag{27}$$

Note that since $\lambda^+ < \lambda$ the second term on the right hand side of (27) is always positive. At time 0 the initial level of country debt, n, is equal to n_0 since we start from steady state. Thus the first term is zero while the second term is positive since $\theta > 0$. Note that the second term represents the expected capital loss due to a jump in marginal utility in the event of a policy reversal. Hence λ starts rising initially. However, the rise in n implies that the first term becomes progressively more negative inducing a dampening of the consumption decline. This is the intertemporal price effect through the real interest rate. After the economy crosses point 'd', the positive effect on λ coming from the second term becomes insufficient to counter the negative effect and, thus, λ starts falling. Consumption starts rising once the intertemporal price effect starts dominating the combined negative effects due to the rising nominal interest rate and the capital loss. Note that the capital loss component becomes progressively smaller over time.

The unambiguous output dynamics essentially reflects the effects of the intertemporal wealth variable, λ, on leisure. The intuition for the time path of leisure is symmetric to that for consumption. In contrast to the consumption dynamics, the unambiguity of the predicted time paths of leisure and labor supply derives from the fact that unlike consumption, leisure is a credit good. Hence the devaluation rate does not factor into its effective price.

The preceding result sharply contrasts with the result obtained by Calvo and Drazen (1994) for a similar experiment in the context of an endowment economy model. They found that consumption falls unambiguously during the course of the stabilization program as long as the inflation tax revenues are fully rebated to the private agents. The reason for the difference in the results is that they assumed an exogenously fixed real interest rate which was set equal to the rate of time preference. In terms of equation (27), the first term on the right hand side would drop out and, hence, λ would be rising throughout due to the positive second term. Thus, consumption would decline for the entire duration of the program.

Lastly, as T_m becomes larger the dynamic path followed by the economy would exhibit longer stretches of a rising time path of λ. In terms of figure 3, the dynamic path would take a longer time to cross the $\dot{\lambda}_1 = 0$ locus. At the limit as T_m tends to infinity, the dynamic path would resemble the saddle path, SS_1, in figure 2. This reflects the turnpike property of the dynamic adjustment path. Note that the above implies that the downturn in output is delayed by a higher T_m. Intuitively, the more we postpone the first point in time at which the policy collapse occurs with probability 1, the more sustained is the positive effect on output.

5. Maxi-Devaluations and "News": An application to Mexico

The model developed above can also be used to analyze the impact of the arrival of "news" regarding the post-policy-collapse exchange rate policy. In particular, it is worth investigating the impact of a change in the expected level of the nominal exchange rate at the time of the policy reversal. This is of particular interest since a number of exchange-rate-based stabilization programs ended with the program abandonment being accompanied by maxi-devaluations.

Before doing so however, we need to modify the model such that the nominal risk premium factors into optimal private decisions. Recall that with real bonds the effective price of consumption was given by $1+\alpha(r+\varepsilon)$. Thus the nominal risk premium did not enter the picture at all. We now introduce nominal bonds into the model. Let B denote nominal debt holdings of private agents. Defining $A \equiv B - M$, we can derive the equation of motion for this net nominal debt in real terms:

$$\dot{a} = (r + RP)a + (1 + \alpha i)c - \tau - f(L) - z \tag{28}$$

where RP is the risk premium while z are lump sum transfers received from the rest of the world. One can see that the existence of a risk premium causes a windfall loss to the domestic agent at every point in time that the program remains in place. To abstract away from income effects I assume that the rest of the world transfers back to domestic agents the entire windfall gain that they make. Thus, both z and the RP term in (28) drop out. We thus have

$$\dot{a} = ra + (1+\alpha i)c - \tau - f(L) \tag{29}$$

Equation (29) is a standard equation of motion. We can apply the same techniques as before to study the dynamic equilibrium path of this economy. Everything derived above carries through except for the nominal interest rate replacing r+ε in all the equations. Thus the dynamic path looks very similar to the ones we analyzed above.

An increase in the expected jump up in the level of the nominal exchange rate at the time of policy collapse translates into an increase in the nominal interest rate due to the increased risk premium. Letting $1 - \frac{E_t}{E_t^+} = \omega_t$, we can rewrite equation (24) as

$$i_t = r_t + \underline{\varepsilon} + \frac{\theta_t}{E_t}\omega_t \tag{30}$$

$100\omega_t$ is the percent devaluation of the domestic currency at time t expected by private agents. For the purposes of our experiment, at time 0 let ω be expected to be a constant, i.e., $\omega_t = \omega_0$ for all $t \leq T^*$. Now suppose ω_0 increases to $\omega_1 > \omega_0$ at some time s ($0 < s < T^*$). Thus, there is a jump up in the nominal interest rate at time s. In terms of both figures 2 and 3, the $\dot{n}_1 = 0$ locus shifts down leaving the $\dot{\lambda}_1 = 0$ locus unchanged. Consequently, in both the cases ($T_m = \infty$ and $T_m = T^*$) analyzed above in this section, the dynamic path shifts down upon impact. In other words, upon arrival of the "news' regarding the maxi-devaluation the system jumps down vertically to the new dynamic path and thereafter travels towards its new long run steady state position.[15]

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[15] Note that the long run steady state position of the system need not necessarily change. It changes only in the case of $T_m = \infty$ since the saddle path which drives the system towards its long run steady state position itself shifts down. If T_m is finite, the system starts traveling

The impact effect of the "news" on consumption and output is interesting to analyze. Both consumption and output fall on impact. The consumption fall is associated with a fall in real money balances due to the binding cash-in-advance constraint on consumption. The decline in real money balances is intermediated through the central bank. Private agents turn in their domestic money balances to the central bank for foreign exchange and use those to acquire foreign bonds or to retire some of the outstanding foreign debt. The changes in private foreign debt and central bank reserves exactly offset each other leaving the outstanding stock of country debt unchanged.

The model is thus able to account for episodes such as those in Mexico in December 1994. As has been documented by a number of authors, the political uncertainty in Mexico caused by the Chiapas uprising and the assassinations of the Revolutionary Institutional Party (PRI) presidential candidate Donaldo Colosio and its secretary general, Francisco Ruiz Massieu very quickly undermined the economic confidence generated by the exchange-rate-based stabilization program started in March 1988. Calvo and Mendoza (1995) provide a detailed review and exposition of the Mexican crisis.

The political uncertainty combined with a current account deficit close to 8% of GDP induced intense speculation about the sustainability of the exchange rate policy and the prospect of a devaluation of the peso. Calvo and Mendoza (1995) note that perceptions of a systemic political crisis caused two runs on foreign exchange reserves in 1994 prior to the December episode - the first early in 1994 and the second in November. On both occasions the central bank responded by sterilizing the effect on the monetary base by expanding domestic credit. The third run caused the ultimate collapse and the maxi-devaluation of the peso.

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towards SS_0 along the new dynamic path which is tied down by the requirement that the system reaches SS_0 at precisely time T*.

In terms of the model developed in this paper, speculation and expectations of an impending maxi-devaluation would cause a discrete fall in money demand which would be intermediated through a run on foreign exchange reserves of the central bank. Importantly, this would occur without any change in the underlying fundamentals. Furthermore, the run would be accompanied by a discrete drop in both consumption and output - features which are corroborated by the post-collapse Mexican developments.

This channel of explanation is complementary to the channel emphasized in Calvo (1995) who stresses the role of herding behavior by international creditors and their sensitivity to the arrival of "news".[16] In a diversified world capital market where information is costly to acquire, investors might find it optimal to diversify enough to minimize their overall risk and thereafter remain rationally ignorant about individual markets due to the high information costs. In this environment investors are likely to be extremely sensitive to even "small news" and display herding behavior.

6. Conclusion

This paper has attempted to analyze ***both*** supply and demand implications of policy uncertainty for exchange-rate-based inflation stabilization programs. Most of the existing work on the subject has proceeded under the assumption of perfect foresight of private agents. The few attempts at analyzing the implications of policy uncertainty have used endowment economy models thereby ruling out the study of all supply-side issues.

[16] Atkeson and Rios-Rull (1995) provide an alternative explanation for the run. They emphasize borrowing constraints imposed by international creditors on Mexico which implied that once the borrowing ceiling is reached the economy would gradually run down its foreign exchange reserves in order to finance higher consumption. The higher consumption, in turn is generated by increases in permanent income caused by the economic reforms. This channel however leads to the counterfactual prediction that the run on reserves and the end of the program would coincide with a boom in consumption and output.

We have seen that it is possible to generate a "boom-bust" cycle for real economic activity when supply-side issues are combined with uncertainty about the duration of the exchange-rate-based stabilization. We have also seen that it is crucial to distinguish between programs which are perceived to have a chance of continuing permanently and those which are expected to definitely end in finite time, i.e., between the case where the upper support of the distribution for the date of policy reversal is infinite and where it is finite. The economic implications of the two are very different for the stabilization programs. The "boom-bust" cycle emerges only in the case where policy reversal is expected to occur in finite time. This finding when combined with the stylized fact of a business cycle that is typically associated with these programs would tend to suggest that these programs were indeed expected to be temporary by the public.

The presence of exchange rate uncertainty also enabled the model to generate a risk premium on the nominal interest rate. We saw that a risk premium emerged only when agents expected the policy reversal to be accompanied by a jump devaluation of the domestic currency. The model was used to analyze the implications of these expected maxi-devaluations at the end of the program and the arrival of "news" regarding the size of the jump in the nominal exchange rate at the end. We saw that any "news" which increased the size of the expected exchange rate jump would cause an impact fall in consumption and output, and would induce a discrete loss of foreign exchange reserves of the central bank. These predictions square well with the experience of Mexico in December 1994.

The analysis, however, remains incomplete in a number of respects. Most stabilization and reform programs are characterized by a number of different measures, the exchange rate policy being only one of them. One possible extension of the model would be to analyze the supply-side implications of fiscal reform. Calvo and Drazen (1994) study this issue in the context of an endowment economy model by analyzing the implications of a policy which exogenously changes the size of the endowment. By introducing physical capital into the model developed here, one could endogenously generate output movements induced by capital tax reforms of uncertain duration.

Another issue that has been ignored is the quantitative implication of policy uncertainty for the time series of consumption, output, and the current account along the lines of Rebelo and Vegh (1995) and Reinhart and Vegh (1994). Future work intends to address both these issues in the framework of a more elaborate two good model. That would also enable us to study the evolution of the real exchange rate which is hard to get a handle on in the one good model of this paper.

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FIGURE 1

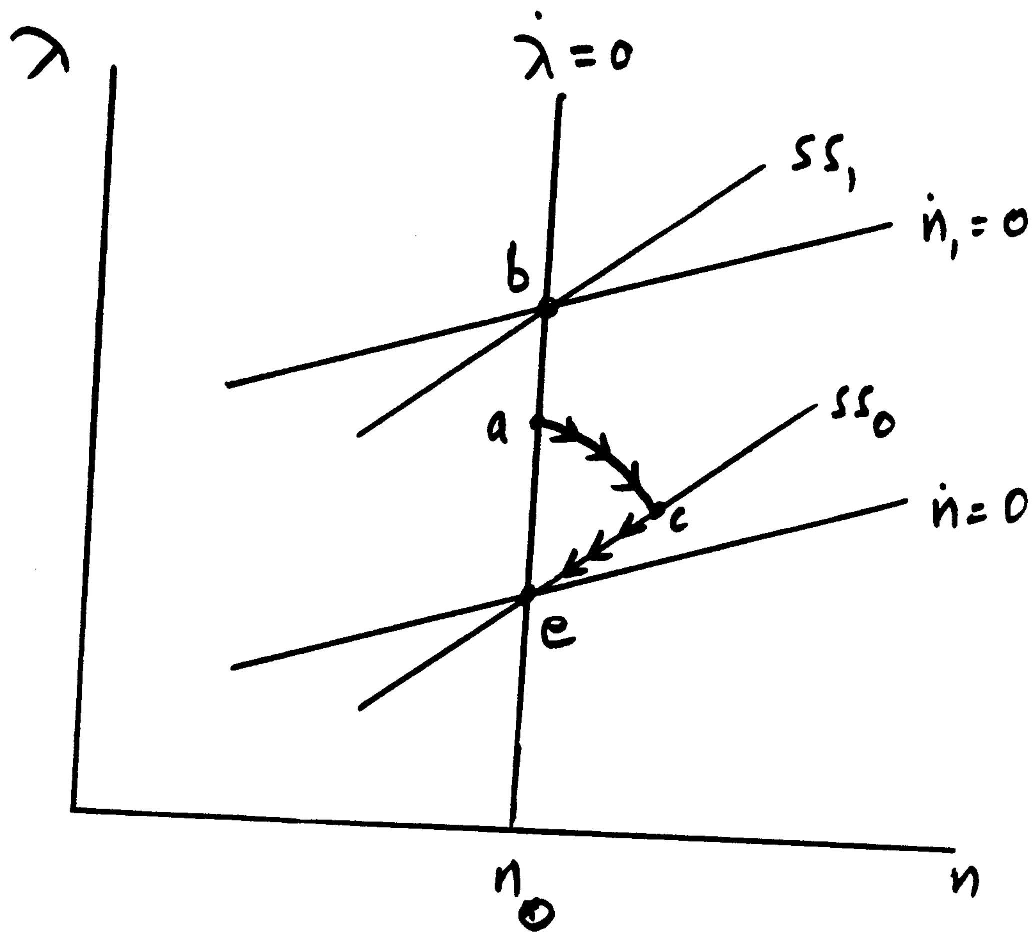
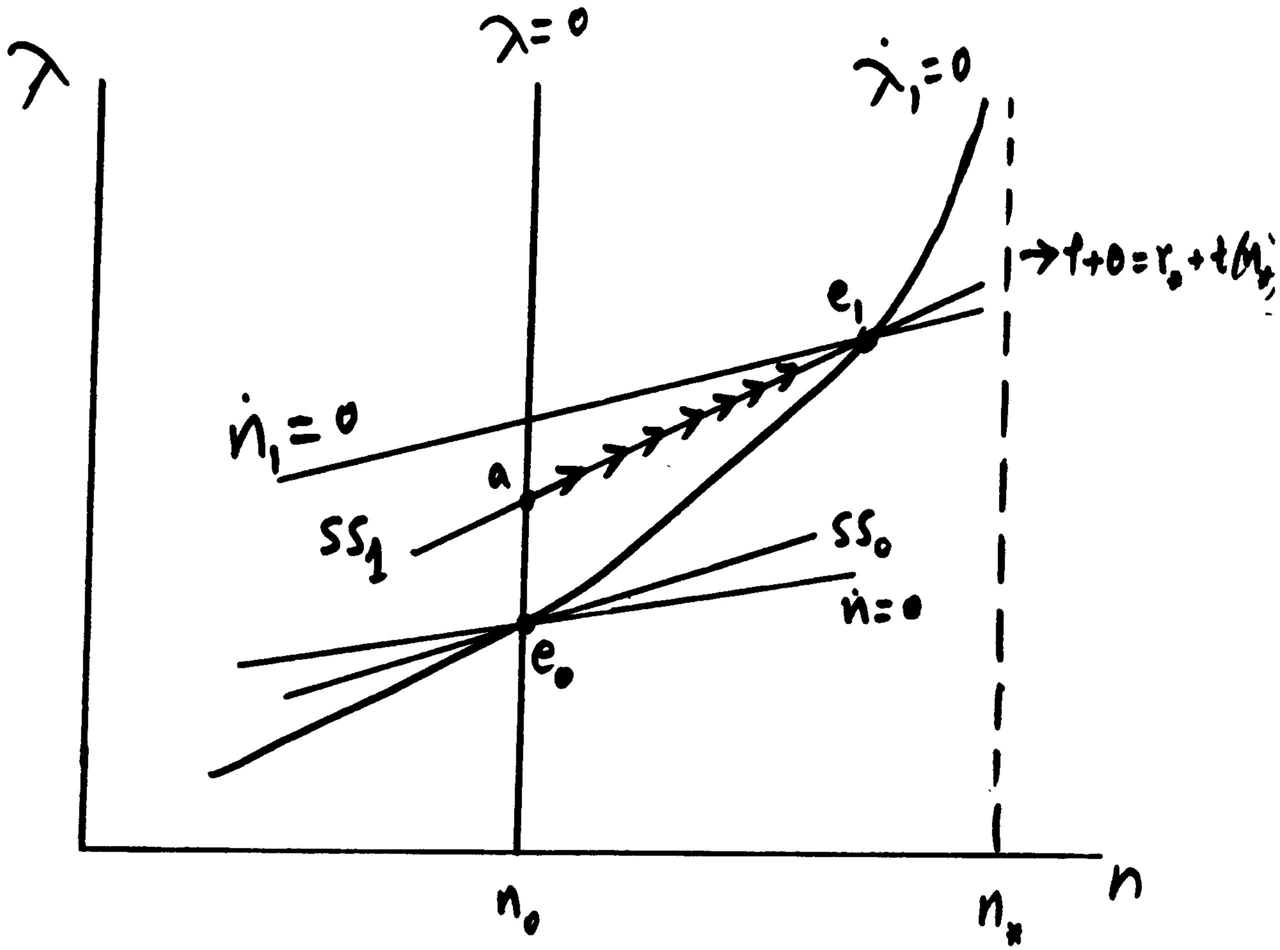
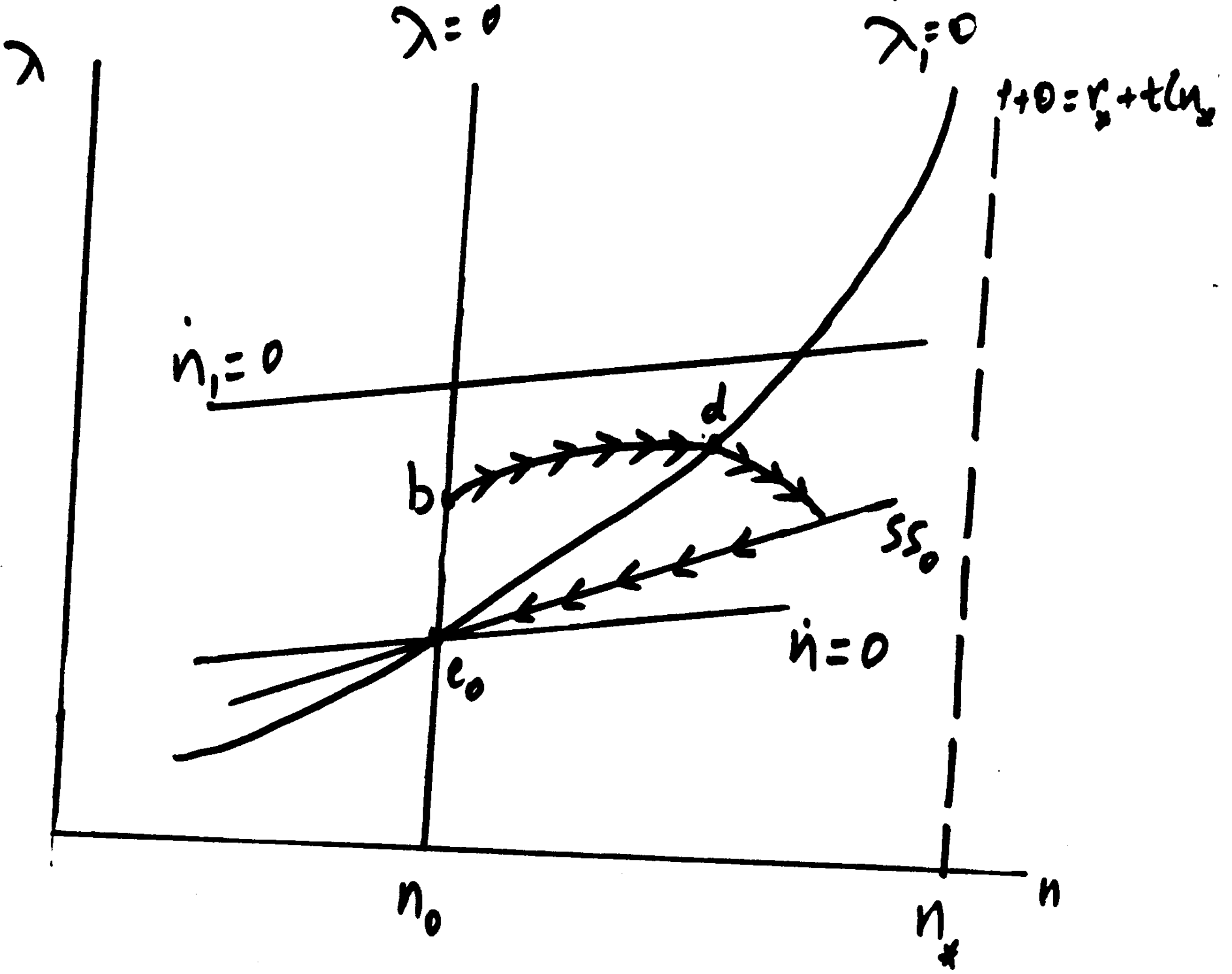


FIGURE 2



λ
$\dot{\lambda} = 0$
$\dot{\lambda}_1 = 0$
$\to f + \theta = r_0 + t(n_*)$
e_1
$\dot{n}_1 = 0$
a
SS_1
SS_0
$\dot{n} = 0$
e_0
n_0
n_*
n

FIGURE 3



λ
$\dot{\lambda}=0$
$\dot{\lambda}_1=0$
$f+\theta=r_*+t(n_*$
$\dot{n}_1=0$
d
b
SS_0
$\dot{n}=0$
e_0
n_0
n_*
n