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The Syndrome of Exchange-Rate-Based Stabilizations and the Uncertain Duration of Currency Pegs

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ABSTRACT

This paper shows that some key stylized facts of exchange-rate-based stabilization plans can be explained by the uncertain duration of the plans themselves. Uncertain duration is modeled to reflect evidence showing that devaluation probabilities are higher when the plans are introduced and abandoned than in the period in between. If contingent-claims markets are incomplete, this uncertain duration distortion introduces temporary fiscal cuts with large wealth effects. Investment and employment are also distorted, and the resulting supply-side effects play a critical role. Stabilizations of uncertain duration entail large welfare costs, but they are preferred to persistent high inflation. México's experience is examined in the light of these predictions.

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1. Introduction

The chronic economic crises and currency collapses that affect developing economies, dramatically exemplified by the Mexican crisis of 1994-95, are one of the most widely studied issues in international macroeconomics. A key question that research in this area has aimed to answer is: why do disinflation programs based on fixed exchange rates trigger a perverse dynamic process that often leads to the breakdown of the programs themselves? In Mexico, for example, a stabilization plan that practically fixed the peso-dollar exchange rate, and successfully tightened economic policies, had been in place for seven years before the collapse. During this period, the real exchange rate appreciated sharply, the economy boomed, external imbalances widened markedly, and the velocity of circulation of money plummeted. These stylized facts define the syndrome of exchange-rate-based stabilizations (ERBS) identified by Helpman and Razin (1987), Kiguel and Liviatan (1992) and Végh (1992).

Several explanations of the syndrome have been proposed in the literature. Dornbusch (1982) and Rodriguez (1982) explain it as a consequence of inflationary inertia in models with adaptive expectations and sticky prices. The fixed exchange rate causes an economic boom because it lowers the real interest rate, as interest parity forces the nominal interest rate to fall and inflationary expectations adjust slowly. Persistent inflation and the currency peg produce the real appreciation. Helpman and Razin (1987) and Drazen and Helpman (1988) provide a second explanation using dynamic equilibrium models to examine the consistency between fiscal and exchange-rate policies. In these models the syndrome is driven by wealth effects resulting from the timing of expected cuts in the inflation tax and government expenditures. Obstfeld (1985), Roldós (1995), Uribe (1995), and Kehoe (1997) offer a third approach arguing that the syndrome can be a feature of the transitional dynamics of successful stabilization or structural reform.

The empirical relevance of these three views has been examined in various studies (see, for example, Helpman and Razin (1987), Edwards (1993), Fernandez (1985), Kehoe (1997), Mendoza (1995), and Milesi-Ferretti and Razin (1996)). However, the three views are challenged by the experiences of México and Argentina in 1994-95, where deep economic recessions emerged despite the dismantling of indexation mechanisms, large fiscal cuts, and radical and sustained structural reforms.

A fourth competing theory of the syndrome that may help explain the recent Argentine and Mexican experiences is the perfect-foresight credibility framework proposed by Calvo (1986). This framework attributes the syndrome to the government's lack of credibility, which originates in the chronic failures of stabilization plans and the rational incentives of policy-makers to alter policy (i.e. "time inconsistency"). Calvo studied an endowment-economy model in which agents anticipate a devaluation with full certainty at a known future date. This acts like a tax on savings, which, via intertemporal substitution, leads consumption to jump to a higher constant level for the duration of the plan, before collapsing in another discrete jump to a lower constant level when the plan fails. Calvo's work originated a large literature in which several extensions of the credibility framework were developed (see Chapters 15-18 in Calvo (1996)).

The credibility approach seems a promising explanation of ERBS syndrome, but it shares with the other three approaches two drawbacks. First, existing models of the syndrome cannot explain the price-consumption puzzle of ERBS programs. As identified by Uribe (1997), this puzzle refers to the fact that, while a positive correlation between the real exchange rate and consumption is a robust feature of ERBS programs worldwide, a large class of models proposed in the literature predicts the opposite. Models in this class include all perfect-foresight models of small open economies with free access to a perfectly competitive world capital market, assuming a real interest rate equal to the rate of time preference, and with standard time-separable utility functions (defined in terms of a linearly homogeneous, concave aggregator of traded and nontraded goods). These models satisfy two conditions: (a) the real exchange rate (i.e. the relative price of nontradable goods in terms of tradable goods) is increasing in the ratio of consumption of tradables to consumption of nontradables, and (b) the marginal utility of consumption of tradables equals the marginal utility of wealth times the monetary distortion. Since perfect foresight and interest parity imply that the marginal utility of wealth and the monetary distortion are constant during currency pegs, conditions (a) and (b) imply that aggregate consumption is a negative function of the ratio of tradables to nontradables consumption. Thus, after a stabilization plan begins consumption can only boom if the real exchange rate depreciates. This prediction is grossly counterfactual, as Figure 1 illustrates for the Mexican case.

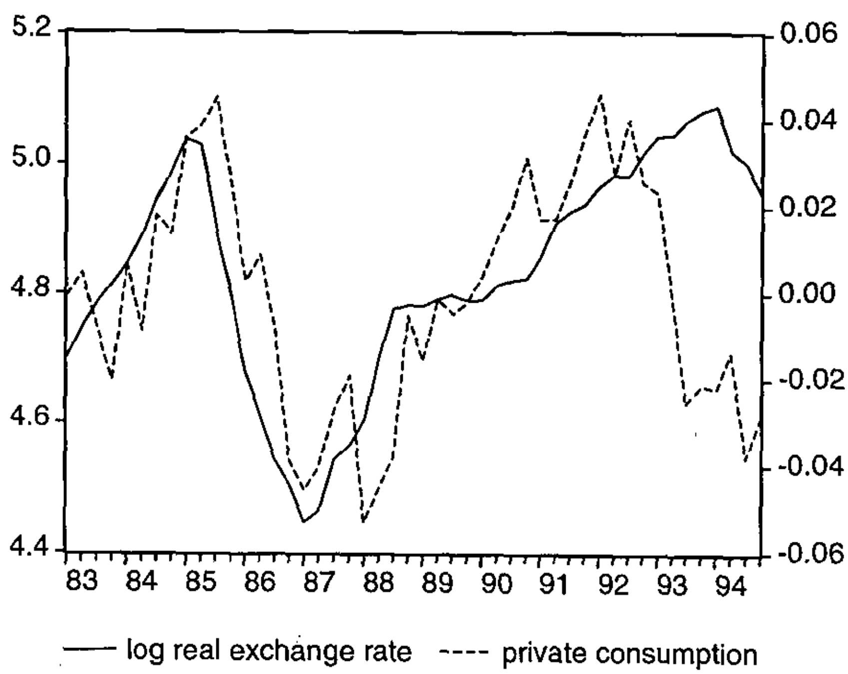

FIGURE 1. MEXICO: PRIVATE CONSUMPTION AND THE EFFECTIVE REAL EXCHANGE RATE[2]

Existing theories of the syndrome also face other empirical challenges. The data show in many ERBS episodes periods of stable real exchange rates in between large appreciations and recessions that follow large, gradual booms and often predate currency collapses. This is sharply at odds with the models' predictions. For instance, in most credibility models consumption and the real exchange rate remain constant in between the sudden jumps that occur when

[2]The logarithm of the real exchange rate is plotted in the left axis, and the deviation from a quadratic trend in private consumption is plotted in the right axis. See Section 4 for a discussion of detrending issues.

stabilizations begin and end. Also, as Rebelo and Végh (1995) showed, the intertemporal substitution effect driving these models generates negligible booms and real appreciations.[3]

The second drawback of existing theories is that they abstract from uncertainty and risk aversion. Recent research by Calvo and Drazen (1993) shows that adding these features alters the predictions of existing models radically. The stochastic credibility models examined by these authors, known as uncertain duration models, deal explicitly with the fact that agents do not know the date in which a stabilization plan will be abandoned -- they can only attach some probability to that event. In these models, consumption can exhibit gradual booms or recessions depending on the structure of financial markets and on whether wealth effects of policy distortions are neutralized or not. In particular, if insurance markets are incomplete, the wealth effect triggered by the temporary fiscal cuts typical of stabilization plans can lead to a gradual boom for the duration of the plan. Moreover, since wealth under incomplete markets becomes state-contingent, this framework can also help resolve the price-consumption puzzle.

To date the theory of uncertain duration has focused on examining qualitative predictions of partial equilibrium models of consumer demand. Calvo and Drazen (1993) showed that these models produce consumption dynamics that are either nonincreasing or nondecreasing, regardless of the time path of the probability of policy reversal. Thus, these models cannot explain recessions predating currency collapses, or stable real exchange rates in between sharp appreciations. In this context, the analysis of the quantitative predictions of a general equilibrium extension of the uncertain duration framework seems an interesting task.

This paper aims to complete this task by inquiring whether the syndrome of exchange-rate-based stabilizations can be rationalized as a feature of the dynamics of a stochastic general equilibrium model in which agents are uncertain of the government's ability to maintain an exchange-rate-based stabilization plan. The model represents a two-sector small open economy

[3]These authors also showed that lager booms and real appreciations can be obtained by introducing exogenous inflation stickiness and eliminating the wealth effect on leisure. However, the price-consumption puzzle still prevails.

with incomplete contingent-claims markets in which economic fluctuations are driven by a stochastic process describing time-variant, conditional devaluation probabilities. The goal is to answer the following question: if devaluation probabilities are set to estimates derived from the data, are the model's equilibrium allocations consistent with the observed stylized facts?

To compute equilibrium allocations, we introduce a time-recursive numerical solution method designed to solve incomplete-markets models in which uncertainty follows absorbent Markovian processes. In the benchmark case, the probabilities of devaluation are calibrated to the estimates produced for Mexico by Blanco and Garber (1986). These authors identified J-shaped devaluation probabilities according to which the Mexican currency pegs that collapsed in 1976 and 1982 had a higher devaluation probability near the dates of their introduction and abandonment than in the periods in between. The cross-country analysis of Klein and Marion (1997) provides further evidence in favor of the J-shaped evolution of devaluation probabilities.

Simulation results, compared to the Mexican experience, show that uncertain duration explains key features of the syndrome. In particular, the model resolves the price-consumption puzzle, generates recessions that pre-date currency crises, and produces periods of real-exchange-rate stability in between sharp appreciations. This is done under the assumptions that prices are fully flexible and fiscal policy is tightened sharply for the duration of the plan, in contrast with traditional explanations of the syndrome. The simulations also show that welfare costs of uncertain duration largely exceed the negligible costs of lack of credibility obtained in perfect-foresight studies (see Calvo (1988)). Also in contrast with those studies, stabilizations of uncertain duration are welfare-improving relative to the high-inflation status quo. Uncertain duration is still very costly when compared to credible disinflations.

The rest of the paper is organized as follows. Section 2 describes the model and the solution method. Section 3 presents the quantitative analysis and examines welfare and policy implications. Section 4 compares the model's predictions with the Mexican post-war experience. Section 5 concludes.

2. A Model of Uncertain Duration of a Currency Peg in a Small Open Economy

Preferences, Technology, and Financial Markets

Households are infinitely-lived and maximize the following expected utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{\left[\left[\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}\right]^{-\frac{1}{\mu}} (1-L_t^N-L^T)^{\rho}\right]^{1-\sigma}}{1-\sigma} \tag{1}$$

$$C(C_t^T, C_t^N) = \left[\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}\right]^{-\frac{1}{\mu}} \tag{2}$$

Households consume a traded good (C_t^T) and a nontraded good (C_t^N). They supply labor inelastically to the industry that produces traded goods, in the amount L^T, and trade off the remaining "time supply" between providing labor to the nontraded goods industry (L_t^N) or enjoying leisure (ℓ_t). The time constraint is $\ell_t = 1 - L_t^N - L^T$. The expectations operator E_o applies to the probability of duration of a currency peg, as defined below. Preferences between C^T and C^N are represented by a constant-elasticity-of-substitution (CES) function, where $1/1+\mu$ is the elasticity of substitution between traded and nontraded goods, and ω is the share of C^T in consumption of C, as defined by the CES aggregator in equation (2). Leisure enters in multiplicative form in the utility function, with ρ governing the substitutability between consumption and leisure. Utility from C and ℓ is represented also by an isoelastic function, where $1/\sigma$ is the intertemporal elasticity of substitution in consumption. β is the discount factor.

Households maximize (1) subject to these two constraints:

$$\begin{aligned} &B_{t+1} - (1+r^*)B_t + \left(C_t^T + p_t^N C_t^N\right) + I_t = \\ &A_t^T (K_t^T)^{1-\alpha T} (L^T)^{\alpha T} + p_t^N A_t^N (K^N)^{1-\alpha N} (L_t^N)^{\alpha N} - \frac{\phi}{2}(K_{t+1}^T - K_t^T)^2 - m_t V_t S(V_t) + \frac{m_{t-1}}{1+e_t} - m_t + T_t \end{aligned} \tag{3}$$

$$I_t = K_{t+1}^T - (1-\delta)K_t^T \tag{4}$$

The budget constraint (3) embodies the model's financial markets, which are assumed to be incomplete. In particular, world asset trading is limited to one-period bonds B paying the timeinvariant rate r^* in units of the traded good. Uses of household income in the left-hand-side of (3) include private absorption (i.e. purchases of traded and nontraded goods for consumption and investment, with p^N defining the relative price of nontradables or the real exchange rate) and changes in bond holdings net of interest. Sources of household income in the right-hand-side of (3) include factor incomes from industries producing traded and nontraded goods, net of capital-adjustment costs, transaction costs, changes in real money balances, and net government transfers. Production functions are Cobb-Douglas, with capital inelastically supplied to the nontraded sector in the amount K^N and a zero depreciation rate.[4] The stock of capital in the traded sector, K^T, is a traded good. All markets are competitive, so production is exhausted in paying factor incomes. Capital-adjustment costs distinguish financial from physical assets to prevent excessive investment variability (see Mendoza (1995)).

Real money balances m enter the model as a means to economize transaction costs. Following Greenwood (1983,1984) and Kimbrough (1986), transactions costs per unit of private absorption are given by S, which is a convex function of expenditure velocity $V=(C^T+p^NC^N+I)/m$. Real money balances are eroded by inflation at the rate e. PPP in tradable goods holds and foreign prices are constant, so e represents both the inflation rate of tradables and the depreciation rate.

T is a lump-sum transfer from the government. The government issues money and uses T to rebate to households fractions η_m and η_S of seignorage and transaction costs. When $\eta_m = \eta_S = 0$, government revenue finances only unproductive expenditures G. The government budget constraints are:

$$G_t + T_t = m_t - \frac{m_{t-1}}{1+e_t} + m_t V_t\, S(V_t) \tag{5}$$

$$T_t = \eta_m \left(m_t - \frac{m_{t-1}}{1+e_t} \right) + \eta_S \left(m_t V_t S(V_t) \right), \qquad 0 \leq \eta_m\, , \eta_S \leq 1 \tag{6}$$

[4]Mendoza (1995) and Rebelo and Végh (1995) assume similar production environments in which labor (capital) is inelastically supplied in the traded (nontraded) sector.

The assumptions that transaction costs are government revenue and investment enters in the relevant measure of V enable the model to induce a sharp tightening of fiscal policy following the implementation of an exchange-rate-based stabilization plan. This will occur because, as shown later, the fixed exchange rate, and the decline in velocity that accompanies it, lead to a decline in revenue from both seignorage and transaction costs. If $\eta_m = \eta_S = 0$, the revenue shortfall must be offset with a corresponding decline in G. This basic approach to model the large fiscal cuts that accompanied recent stabilization plans avoids complicating the model by adding income or consumption taxes, which would make difficult to isolate the effects of uncertain duration.

The policy experiment referred to as a currency peg of uncertain duration is the following. At $t=0$ the government announces and implements the policy $e_o=0$. Agents attach a time-dependent, conditional probability $z_t=Pr[e_{t+1}>0|e_t=0]$, defined by the hazard rate function $Z(t)$, to the abandonment of the peg. As in Calvo and Drazen (1993), we assume that the devaluation is an absorbent state, so $Pr[e_{t+1}>0|e_t>0]=1$, and that at some future date J policy uncertainty is resolved, so at J the stabilization plan fails permanently with probability Π.

Equilibrium and Numerical Solutions

The first-order conditions of the households' optimization problem are the following:

$$\lambda_t = \frac{\omega}{1+S(V_t)+V_tS'(V_t)}\left(\frac{C_t^T}{C_t}\right)^{-(1+\mu)} C_t^{-\sigma}\left(1-L_t^N-L^T\right)^{\rho(1-\sigma)} \tag{7}$$

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{C_t^N}{C_t^T}\right)^{-(1+\mu)} \tag{8}$$

$$C_t^{1-\sigma}\rho(1-L_t^N-L^T)^{(\rho(1-\sigma)-1)} = \lambda_t\alpha N\, A_t^N\left(\frac{K^N}{L_t^N}\right)^{1-\alpha N} p_t^N \tag{9}$$

$$\lambda_t = \beta E_t\, \lambda_{t+1}(1+r*) \tag{10}$$

$$\lambda_t\left[1 - S'(V_t)V_t^2\right] = \beta E_t\, \frac{\lambda_{t+1}}{1+e_{t+1}} \tag{11}$$

$$\lambda_t\left[1 + S(V_t) + V_t S'(V_t) + \phi(K_{t+1}^T - K_t^T)\right] =$$
$$\beta E_t\, \lambda_{t+1}\left[(1-\alpha T)A_{t+1}^T\left(\frac{K_{t+1}^T}{L_{t+1}^T}\right)^{-\alpha T} + (1-\delta)\left(1 + S(V_{t+1}) + V_{t+1}S'(V_{t+1})\right) + \phi(K_{t+2}^T - K_{t+1}^T)\right] \tag{12}$$

Equation (7) is the marginal utility of wealth, using C^T as the numeraire. Equation (8) equates the marginal rate of substitution between C^T and C^N to the corresponding relative price. Equation (9) equates the marginal disutility of labor in the nontradables sector to its marginal product. As (8) and (9) show, the assumed frictions in the sectoral allocation of labor imply that the equilibrium real exchange rate is driven by supply and demand. This is in contrast with the Balassa-Samuelson model, in which perfect sectoral labor mobility implies that p^n is supply-determined by the ratio of sectoral labor productivities. Equations (10)-(12) are Euler equations for the accumulation of foreign assets, real balances, and physical capital respectively.

Equation (11) can be re-written as follows to explain the effects of uncertain duration:

$$\lambda_t^L\left[1-S'(V_t^L)(V_t^L)^2\right] = \beta\left[z_t\frac{\lambda_{t+1}^H}{1+e_{t+1}} + (1-z_t)\lambda_{t+1}^L\right] \tag{13}$$

λ^H and λ^L represent the marginal utility of C^T for state-contingent allocations under high and low inflation respectively. The equation assumes that at t the stabilization plan continues, so agents observe λ_t^L. Equation (13) shows that e_{t+1} is a tax on real balances that operates exactly as in a perfect-foresight credibility model. The probability of devaluation z_t plays a similar role. A higher z_t increases the tax on real balances by attaching a higher probability to the devaluation scenario. Thus, the uncertain duration model is similar to a deterministic credibility model, but with the key differences that uncertain duration can be interpreted as a case of random taxation, and that the credibility of the policy (i.e. the probability of policy reversal z_t) is time-variant and different from the policy instrument itself (e_{t+1}).

Through the transaction costs technology, the distortions induced by uncertain duration on real balances are transmitted into the real sector of the economy. If seignorage and transaction costs are fully rebated, the distortions are limited to intertemporal substitution effects. For as long as it lasts, a currency peg represents a sequence of favorable relative price shocks. At each date t in the fixed-exchange-rate period, agents attach a certain probability to the scenario that prices at $t+1$ will rise with a devaluation, and hence have an incentive to over-consume. As $t+1$ arrives they realize they overconsumed and aim to adjust consumption accordingly. In contrast, if government revenue is used to finance unproductive expenditures, the intertemporal substitution effect can be offset by a wealth effect. Each period that the currency peg survives, permanent income rises by the amount of fiscal adjustment corresponding to the foregone unproductive expenditures that seignorage and transaction costs would have financed under high inflation. If the elasticity of intertemporal substitution is sufficiently low, the wealth effect dominates and consumption can rise over time, as Calvo and Drazen (1993) demonstrated.

In addition to distorting consumption, equation (12) shows that uncertain duration also distorts investment and labor. The model features a direct distortion on investment induced by the transaction costs technology that exists even under perfect foresight (see Uribe (1995)). This distortion includes both transitional and long-run effects, as a permanent disinflation cuts transaction costs permanently, thereby releasing resources to finance a permanently higher capital stock. Uncertain duration adds indirect investment distortions because the marginal utility of wealth is state-contingent, and because the probability of devaluation acts as a random tax on capital income at the rate z_t. The labor market is distorted because the distortions on consumption and wealth shift the supply of labor. The resulting effects of all these distortions affect factor payments and allocations, and hence the household's wealth.

In equilibrium, conditions (7)-(12) hold jointly with these market-clearing conditions:

$$C_t^T + G_t + I_t + B_{t+1} - B_t(1+r*) = A_t^T(K_t^T)^{1-\alpha T}(L^T)^{\alpha T} - \frac{\Phi}{2}(K_{t+1}^T - K_t^T)^2 \tag{14}$$

$$C_t^N = A_t^N(K^N)^{1-\alpha N}(L_t^N)^{\alpha N} \tag{15}$$

The equilibrium stochastic processes of the model are given by sequences of state-contingent allocations and prices such that (7)-(12) and (14)-(15) hold for $t=0,\ldots\infty$. We assume for simplicity that at any date $t>0$ there are only two possible realizations of e: $e_t=0$ or $e_t=e>0$. Thus, when there is a devaluation the exchange rate regime switches to a floating rate with a constant rate of depreciation. Since the state $e_t>0$ is absorbent, in each date macroeconomic aggregates can either: (a) follow the optimal path corresponding to the state in which $e_t=0$ at t, with z_t governing the probability that $e_{t+1}=e$, or (b) if $e_t=e$ at t they switch to the dynamic path corresponding to that constant rate of devaluation under perfect-foresight. The model is solved by specifying a time-dependent function Z to determine z_t for $t=0,..,J-2$. This, jointly with the values of J and Π, provides well-defined state-transition probabilities and terminal conditions, so that paths (a) and (b) can be solved by backward-recursion following the intuition from the two-period analysis of Calvo and Mendoza (1994). The state-contingent evolution of wealth in our model is, however, significantly more difficult to calculate (see the Appendix for details on the solution method).

Calibration

The model is calibrated to Mexican data at a quarterly frequency as follows.

a) Financial Sector: The transaction costs technology adopts the form $S(V_t)=AV_t^{\gamma}$, so that conditions (11)-(12) imply an implicit money demand function $V_t=(i_t/1+i_t)^{1/(1+\gamma)}(\gamma A)^{-1/(1+\gamma)}$, where i is the nominal interest rate. This function is calibrated to M2 money demand in México, given strong empirical evidence in favor of a log-linear relationship between m and $i/1+i$.[5] The coefficient $1/1+\gamma$ is the interest elasticity of money demand estimated at -0.15, so $\gamma=5.66$. A is set so that the high-inflation, pre-stabilization steady state mimics Mexico's M2/GDP ratio (31.8 percent on an annual basis) and nominal interest rate (177 percent annually) at end-1987, when the last ERBS program started. M2/GDP rose gradually to 35.5 percent in 1994, and collapsed in 1995. The steady-state money demand equation is then solved for A ($A=0.19$).

b) Preferences and Technology: The risk aversion coefficient is set at $\sigma=5$, in line with the

[5]See Calvo and Mendoza (1996) and Kamin and Rogers (1996).

median of the estimates produced by the econometric literature applied to developing economies, which range between 1.25 and 10 (see Reinhart and Vegh (1995)). $\sigma=5$ is also the lower-bound of the GMM estimates obtained for Mexico by Reinhart and Vegh (1994) using quarterly data for the period 1981-1991. Other preference and technology parameters are set as follows: $\rho=0.786$, $\omega=0.5$, $\mu=-0.218$ $\alpha T=0.42$, $\alpha N=0.34$ and $\delta=0.1$. These are taken from the developing country model calibrated in Mendoza (1995). $\phi=0.06$ is set to mimic the standard deviation of Mexican investment using that model. Also, we assume $\beta=(1+r^*)^{-1}$ with r^* set at 6.5 percent per annum.

c) Fiscal Policy: The rebates parameters η_m and η_S are set to zero so as to induce maximum fiscal adjustment for the duration of the stabilization plan. In Mexico, the overall public sector balance as a share of GDP switched from a deficit of 16 percent in 1987 to a surplus of about 1 percent in 1993. This sharp adjustment included a reduction of 5 percentage points of GDP in current public expenditures (excluding debt service) and a large program of divestiture of public enterprises. Through this program, over 450 public enterprises were closed and several others were sold, yielding 1/5 of total government revenue during 1991-93. By the time of the 1994 devaluation the overall fiscal balance reverted to a deficit equivalent to 4.5 percent of GDP.

c) Hazard rate function: The hazard rate takes a J-shaped form consistent with Blanco and Garber's (1986) estimates of one-step-ahead, conditional devaluation probabilities for the Mexican peso in the six years before the devaluations of 1976 and 1982. Their estimates are derived from a Krugman-style model of balance-of-payment crises and an econometric model of Mexican money demand. These authors estimated a probability of collapse of 0.2 early in 1977, declining to near zero in about a year, rising slowly in 1978-79, and rising rapidly to about 0.3 before the collapse. These results are qualitatively consistent with the findings of Goldberg (1994) and Klein and Marion (1997). Goldberg extended the Blanco-Garber analysis to the 1980-86 period, although in 1982-87 Mexico allowed the exchange rate to float. She found that probabilities of collapse oscillate between low and high and that before the 1982 collapse the probability of devaluation was roughly 1. Klein and Marion used logit analysis to identify factors that influence the duration of currency pegs in a panel of monthly data for 17 countries over the 1957-91 period. They found strong evidence showing that sharp real appreciations predate devaluations and that devaluation probabilities are J-shaped. Probabilities of collapse one month before a devaluation are as high as 0.89, with 1/10 of the estimates higher than 0.55.[6] In light of this evidence, we adopt a J-shaped hazard rate set below 0.5 when the program begins, falling to zero, and rising to about 0.8 prior to the collapse. We also set $J=24$ quarters, in line with the six-year duration of Mexican currency pegs observed since 1970 (see Section 4), and assume $\Pi=1$.

3. Quantitative Implications of Uncertain Duration in General Equilibrium

This section examines the quantitative implications of the model. Figure 2 plots state-contingent equilibrium dynamics as percent deviations from the pre-stabilization steady state and the hazard rate function. The continuous lines represent the dynamic equilibrium paths under the assumption that the ERBS program continues. The dotted lines indicate the allocations to which the variables shift on impact when a devaluation occurs.

The main quantitative features of the model are that it produces convex dynamics in velocity and net exports, concave dynamics in GDP, consumption, investment, and labor supply, and real exchange rate dynamics that shift from concave, in the first 10 quarters of the program, to convex, from the 10th quarter until the collapse. These dynamics are consistent with key features of the syndrome:

(1) The model recreates boom-recession cycles in GDP, consumption, and investment (with recessions pre-dating devaluations). The booms in GDP and consumption are consistent with empirical evidence, but the investment boom seems excessive.

(2) Consumption and the real exchange rate increase together during the earlier stages of the stabilization plan, suggesting that the model can also explain the price-consumption puzzle.

(3) The model mimics the pattern of a stable real exchange rate in between periods of sharp

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[6] The Klein-Marion estimates use all within-sample information to generate ex-post probabilities of devaluation, whereas the Blanco-Garber and Goldberg estimates compare a period-ahead forecast of the exchange rate to the prevailing peg.

appreciation. There is a sharp appreciation of about 10 percent in the first two years of the program. The real exchange rate then stabilizes for two years, after which the upward trend re-emerges leading to an appreciation of almost 15 percent before the devaluation. These real-exchange-rate dynamics are determined by the interaction of demand and supply features, particularly the elasticity of substitution in consumption between traded and nontraded goods and the supply response in the nontraded sector. C^T and C^N are gross substitutes ($(1/1+\mu)$=1.28), which implies that a given change in the C^T/C^N ratio results in a less than proportional change in the real exchange rate. C^T rises faster than C^N during the boom, and declines more slowly during the recession, causing the sustained rise in p^N. The boom (recession) in C^N requires a reduction (increase) in leisure, so L^N rises (falls) in tandem with the consumption boom (recession).
(4) The trade balance worsens markedly on impact, from 5 percent of GDP to -3 percent of GDP, and then it follows a J-curve pattern reaching almost -10 percent of GDP by the 8th quarter after the plan starts. After the 8th quarter the trade deficit begins to narrow gradually.
(5) The velocity of circulation of money falls sharply in a sudden jump when the program begins, and then continues to fall gradually for the first 10 quarters of the program. This fall in velocity reflects the observation that liquidity grows much faster than output in the early stages of ERBS syndrome. The accelerated monetary growth has in turn been linked to banking fragility, and both banking fragility and the collapse of money demand that occurs at J play a key role in models of balance-of-payments crises (see Calvo and Mendoza (1996)).

The model's ability to produce these five results primarily as an implication of the lack of credibility expressed in the devaluation probabilities is a striking feature that sets it apart from existing models of the syndrome -- further details on model comparisons are provided below.

Our analysis also has interesting implications for the theory of uncertain duration. In particular, our results show that cyclical dynamics can be a feature of uncertain duration models in general equilibrium. This is because the shape of expenditure dynamics depends on the characteristics of the hazard rate function, contrary to the findings of Calvo and Drazen (1993).

These authors found that under incomplete markets, no rebates, and $\sigma>1$, a tariff cut of uncertain duration leads to an increase in consumption on impact, followed by a gradual boom. Consumption is strictly-increasing for the duration of the tariff cut, regardless of the shape of the hazard rate function. This result follows from the fact that for any date t $(0<t<J)$ in which the tariff cut continues, the addition to permanent income implied by the foregone tariff revenue always dominates the intertemporal substitution effect, implied by the fact that the expected tariff for $t+1$ is always higher than the current tariff. In a one-good, endowment economy, this implies from the consumption Euler equation that $C_t<C_{t+1}$, regardless of the time path of the probability of abandonment of the trade reform. In contrast, in our general equilibrium analysis a J-shaped hazard rate induces downward adjustments in investment and labor as the probability of devaluation raises in the later stages of the stabilization plan, leading households to choose declining paths for consumption of traded and nontraded goods.

Sensitivity Analysis

Figure 3 provides charts summarizing the results of sensitivity analysis. Plots for dynamics of the real exchange rate, the trade balance-output ratio, aggregate consumption, and investment are presented for 10 alternative model specifications. The first one recreates the benchmark model and the rest are for the following experiments: (1) flat, linear hazard rate, set at 28 percent for all $0\leq t<J$ to reflect the same unconditional expectations of devaluation as the J-shaped hazard rate, (2) perfect-foresight ($z_t=0$ for $0\leq t<J$ and $z_t=1$ for $J=24$), (3) no fiscal adjustment (full rebates of seignorage and transaction costs, $\eta_S=\eta_m=1$), (4) zero substitutability between consumption and leisure ($\rho=0$), (5) unitary elasticity of substitution between traded and nontraded goods ($\mu=0$), (6) near-unitary intertemporal elasticity of substitution ($\sigma=1$), (7) extended time horizon ($J=36$), (8) money demand calibrated to M1 velocity, and (9) non-zero long-run probabilities of success of the stabilization program ($\Pi= 1/10$ *and* $1/2$). Each simulation produces a different terminal condition on foreign assets, but all simulations are based on the same initial foreign asset position.

The comparison between the benchmark case and the flat-hazard-rate case shows that the J-shaped hazard rate is a key determinant of the model's dynamics. The flat, linear hazard rate produces quasi-linear dynamics, so it cannot explain the observed cyclical dynamics and the nonlinearities of real appreciations. Further analysis of the role played by the J-shaped hazard rate shows that the strict convexity of this hazard rate function is more important than its actual values. In principle, given (13) and $\beta=(1+r^*)^{-1}$, one would be inclined to argue that $z_t=0$ at some date t would be required to induce concave consumption dynamics, because on that date the marginal utilities of C_t^T and C_{t+1}^T are equalized. However, we found that $z_t>0$ for all $0<t<J$ still yields concave dynamics, as long as the hazard rate function is strictly convex. $z_t=0$ is not required because of the model's supply-side effects. We also found in the experiments that follow, however, that a strictly convex hazard rate is *necessary* but not *sufficient* to ensure concave expenditure dynamics.

The perfect-foresight simulation confirms that, in the absence of uncertain duration, the model behaves as the typical deterministic credibility model, despite capital adjustment costs and the non-neutralities of money implied by the specification of the transaction costs technology. Consumption, investment, and the real exchange rate jump on impact to higher constant levels as the program begins, and collapse when the program ends.

The model without fiscal adjustment (or full rebates) produces expenditure dynamics qualitatively similar to those of the benchmark model. Thus, the model's prediction regarding the key role of J-shaped devaluation probabilities in explaining observed concave expenditure dynamics holds whether government revenue is rebated or not. Ruling out fiscal adjustment, however, has two important implications. First, the dynamics of the real exchange rate are grossly counterfactual -- there is a modest real depreciation of about 1 percent. Second, the model without fiscal adjustment produces smaller consumption booms and an excessively large widening of the trade deficit. This occurs because full revenue rebates limit the effects of the tax-like distortion of uncertain duration to intertemporal substitution effects, eliminating the wealth effect. Thus, the comparison of the benchmark and full-rebates cases shows that wealth effects allowed by market incompleteness and temporary fiscal cuts are critical for enabling the model to produce large boom-recession cycles and large real appreciations.

The preference parameters σ and ρ also play a crucial role. The sensitivity experiments involving these parameters differ critically in the consumption and real-exchange-rate dynamics they yield. With $\rho=0$, which effectively makes labor supply inelastic, the model still produces a period of real-exchange-rate stability in between rapid appreciations, but consumption dynamics are unrealistic because they become nondecreasing. The initial consumption boom is followed by a period of stability and then a continuation of the boom. In contrast, when $\sigma=1$, consumption displays the observed recession prior to the devaluation, but real-exchange-rate dynamics are now unrealistic because there is a continuous depreciation for 3 years before the collapse. These two experiments thus show that while the strict convexity of the hazard rate function plays a key role, it is not sufficient to yield realistic consumption and exchange-rate dynamics. The right combination of preference parameters is also important for the favorable performance of the model.

The non-decreasing consumption dynamics of the case with $\rho=0$ result from the elimination of the supply response in the nontradables sector and the J-shaped hazard rate. Consumption continues to increase after the mid-program plateau because the consumption of tradables rises as the devaluation is expected with increasing probability, and there are no offsetting influences in aggregate consumption resulting from falling consumption of nontradables or falling leisure. The real exchange rate begins to appreciate again because tradables consumption is increasing while consumption and production of nontradables are fixed.

When $\sigma=1$, consumption of both goods declines in the late stages of the peg, as in the benchmark case, but consumption of nontraded goods falls more rapidly than that of traded goods, resulting in the real depreciation that occurs between the 10th quarter and the end of the stabilization plan. Aggregate consumption falls from the peak of the boom at 20 percent above the pre-stabilization equilibrium to about 5 percent before the collapse. This consumption boom is larger than the one observed in the benchmark case, with $\sigma=5$, which peaks at 13 percent above the high-inflation equilibrium. Note that these results, and the comparison with the $\rho=0$ case, reflect the fact that changes in σ affect both the intertemporal elasticity of substitution in consumption ($1/\sigma$) and the intertemporal elasticity of leisure ($1/[1-\rho(1-\sigma)]$), while changes in ρ affect the latter but not the former.

In contrast to σ and ρ, μ and J do not alter the outcome of the simulations significantly -- except for the fact that $J=36$ produces a larger real appreciation and a larger consumption boom than the benchmark case. The move to $(1/1+\mu)=1$ is not a radical departure from the 1.28 elasticity in the benchmark. However, this elasticity has the potential for affecting significantly sectoral consumption allocations and the behavior of the real exchange rate if it varies more widely, as evident from equilibrium condition (10).

The model calibrated to M1, rather than M2, is intended to control for the fact that while M2 is a good proxy for money balances used in transactions, it includes interest-bearing deposits on which seignorage is collected at a rate smaller than the rate of inflation (or devaluation). Thus, the M2 specification approximates well transaction costs, but exaggerates seignorage, while the M1 specification is better at measuring seignorage but underestimates transaction costs. The results show that the wealth effects implicit in non-rebated transaction costs affects the model's ability to explain the magnitude of booms and real appreciations, but is not critical for the cyclical expenditure dynamics and the non-linear dynamics of the real exchange rate.

The assumption that the program fails with probability 1 after 6 years is not crucial for the model's key results. If the eventual probability of currency collapse after 6 years is 1, 0.9, or 0.5, expenditure dynamics before the 20th quarter are nearly identical in all three experiments, although after that date they differ markedly. This result shows that some of the symptoms of ERBS syndrome occur regardless of the long-run probability of success of the program, and is in essence a reflection of the state-contingent nature of wealth under incomplete markets. However, the normative predictions of the model can be significantly affected by the large differences in macroeconomic dynamics after the 20th quarter. Moreover, the size of the real appreciation that re-emerges after the period of stability depends critically on the long-run probability of success of the plan. The higher this probability, the less likely the final outcome of a devaluation becomes, and the weaker the incentives for the consumption and labor dynamics that lead to continued real appreciation before the devaluation.

The wide differences in equilibrium dynamics for alternative parameterizations within the range of reasonable parameter values shown in Figure 3 is indicative of the richness of dynamics embodied in the general equilibrium, uncertain duration model. Investment and net exports seem to vary widely only in the magnitude of their fluctuations, but consumption and the real exchange rate vary both in the size of booms and recessions and in their dynamic patterns. The real exchange rate can follow linear, concave, convex, or a mix of concave and convex dynamics. These results thus challenge the notion that a continuing real appreciation is a required feature of unsustainable exchange-rate-based disinflations.

One additional element worth considering is the fact that the probability of devaluation may depend on the state of the economy, and not just reflect an arbitrary function of time. In particular, the real appreciation and widening trade deficits associated with ERBS syndrome are likely to influence agents' expectations on the sustainability of the currency peg, leading agents to grow more pessimistic about its prospects as the stabilization program progresses. Indeed, Klein and Marion (1997) show that real appreciations provide useful information to anticipate currency crashes. Thus, we consider modelling the hazard rate as the outcome of a rational expectations equilibrium in which the dynamics of the real exchange rate influence the probability of devaluation.[7] We explored an approach that postulates a rule by which devaluation probabilities

[7]The solution of the model now requires computing a sequence of the real exchange rate yielding a hazard rate function that supports the same real exchange rate dynamics. This requires extending the algorithm to add iterations over hazard rate functions. We begin with a guess for this function, and solve equilibrium dynamics as before using the resulting path of the real exchange rate to update the hazard rate.

are a weighted sum of "reputation" and real appreciation. Reputation is measured as the number of quarters that the currency peg has lasted, and it contributes to reduce the probability of devaluation tomorrow given a fixed exchange rate today. Real appreciation is measured relative to the date of adoption of the currency peg and it increases the probability of devaluation as the appreciation grows larger. We identified weights of this ad-hoc rule that support the J-shaped hazard rate of the benchmark simulation as an endogenous outcome of the model.

We conclude the sensitivity analysis by comparing our results with those obtained in perfect-foresight studies. Consider first the simulations performed by Reinhart and Végh (1995) based on Calvo's (1986) endowment-economy model. These authors simulated consumption booms given observations on temporary declines in nominal interest rates, duration of stabilization plans, and econometric estimates of σ. They found that for the model to predict realistic consumption booms, the fall in interest rates needs to be substantial (in excess of 1500 basis points). Moreover, as noted earlier, consumption jumps on impact as the stabilization begins, and remains constant until it collapses when the program is abandoned, so the price-consumption puzzle cannot be accounted for.

Rebelo and Végh (1995) simulated a two-sector, general-equilibrium model and also found that the magnitude of actual consumption booms and real appreciations is largely underestimated. The real exchange rate appreciates by about 5 percent at a constant rate, consumption of tradables (nontradables) rises on impact also by about 5 percent and then rises (falls) gradually until it collapses when devaluation arrives. The jumps in consumption typical of deterministic credibility models do not emerge because of the combination of (a) capital adjustment costs, (b) the introduction of investment in the transaction costs technology, (c) perfect substitutability of labor across sectors with Cobb-Douglas technologies, and (d) the use of the utility function proposed by Greenwood, Hercowitz and Huffman (1988), which eliminates the wealth effect on labor supply.[8] However, investment and real balances still display sudden jumps, and without features (c) and (d) the discrete jumps re-emerge (as shown in our perfect-foresight example). Moreover, the gradual real appreciation is driven by a counterfactual supply contraction in the non-tradables sector that begins immediately after the announcement of the plan, and the price-consumption puzzle remains unresolved.[9]

The fact that the 15 percent real appreciation in our model is more than 3 times larger than those produced by perfect-foresight models is critically related to market incompleteness and temporary fiscal adjustment. In the above-cited perfect-foresight studies, government revenue is fully rebated to the public, so there is no temporary cut in government expenditures during the ERBS plan. In contrast, our benchmark case assumes that tax revenue finances unproductive government purchases and hence that these purchases fall in tandem with the decline in inflation tax revenue. This assumption seems more consistent with the stance of fiscal policy in Mexico during 1987-94 reviewed earlier.

Welfare and Policy Implications

If uncertain duration causes ERBS syndrome, policy-makers face a serious challenge. On the one hand, the initial high-inflation steady state embodies long-run distortions on money balances with costly spillovers into consumption, investment, and output, which make disinflation policy desirable. On the other hand, a stabilization program that is less than fully credible introduces new distortions, which make disinflation policy undesirable. In the perfect-foresight example of Calvo (1988), lack of credibility is always costly because it is identical to a temporary, constant tax on savings with the proceedings fully rebated to households. But in models like the one studied here, uncertain duration adds time-varying distortions on different margins, with potentially large wealth effects resulting from non-rebated revenue, and thus

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[8]Rebelo and Végh (1995) found that labor supply exhibited a counter-factual decline using an isoelastic utility function like the one we adopted. Note also that in their model government rebates seignorage but not transaction costs.
[9]Erceg and Levin (1996) provide detailed evidence of sustained booms in nontradables production and consumption for most of the duration of ERBS programs.

welfare assessments are more complex. Hence we need to provide a quantitative assessment of the welfare implications of different strategies (no stabilization, credible and incredible disinflations) in order to determine whether exchange-rate-based stabilization plans of uncertain duration are worth pursuing.

We computed welfare effects as follows. A policy-maker at date *t=0*, at the beginning of a stabilization plan, ponders the benefits of stabilization by comparing the familiar compensating variations in consumption (see Lucas (1987)) that capture the change in expected lifetime utility that renders agents indifferent between the allocations implied by an ERBS of uncertain duration and the continuation of the high-inflation status quo. These calculations take into account the state-contingent allocations of consumption and leisure, and their associated probabilities. The resulting welfare effects are reported in Table 1.

TABLE 1. WELFARE GAINS OF EXCHANGE-RATE-BASED STABILIZATION PROGRAMS

Hazard rate	Benchmark model		Inelastic labor supply	
function	No Rebates	Rebates	No Rebates	Rebates
J-shaped	1.5016	0.0940	1.4002	0.0690
Flat	1.1358	0.0713	1.0596	0.0519
Perfect foresight	7.2853	0.4068	6.7231	0.3140
Credible program	23.7218	1.8771	22.8840	1.2053

Note: Welfare gains are measured as the negative of the percentage change in consumption constant across dates and states of nature under an ERBS program that produces the same expected utility as the high-inflation stationary equilibrium.

The first important feature of this welfare analysis is the fact that temporary programs produce a welfare gain.[10] This deviates from Calvo's (1988) result in which lack of credibility is always welfare-reducing. We measured the welfare *cost* of a Calvo-style perfect-foresight incredible trade reform, assuming an endowment economy with tariff revenue rebates, at 0.14 percent of the trend level of consumption per capita. This compares to a welfare *gain* of 0.41

[10] Uribe (1996) obtains a similar result in the presence of currency substitution.

percent in the perfect-foresight, general-equilibrium model of ERBS programs also with rebates. Thus, it follows that temporary currency pegs are better than continued high inflation because of the supply-side effects introduced by investment and labor supply, even in the absence of uncertainty. The labor supply effect seems less important than that the investment effect because the gains in a model with inelastic labor are similar to those of the benchmark model. The welfare gain, assuming a convex hazard rate, is 0.07 (1.4) percent with inelastic labor and with (without) rebates, compared to gains of 0.09 (1.5) percent in the benchmark model.

The second key welfare result is that *uncertain duration embodies much larger welfare costs than the standard perfect-foresight credibility problem.* The larger welfare costs of uncertain duration are reflected in the fact that the welfare gains in the benchmark case are smaller than those produced under perfect foresight by a factor of about 1/5, with or without rebates and regardless of labor supply elasticity. Thus, while temporary programs can be beneficial relative to continued high-inflation, uncertain duration induces costly distortions.

The wealth effects due to temporary fiscal adjustment (i.e. no rebates) and incomplete markets also have significant welfare implications. The welfare gains of temporary stabilizations range between 0.05 and 0.41 percent under full rebates, and thus are much smaller than those obtained in the absence of rebates, which range from 1.1 to 7.3 percent. Note, however, that the proportion by which welfare gains under perfect foresight exceed those of uncertain duration is similar with and without rebates.

Following Calvo and Mendoza (1994), it is also important to note that once one breaks away from the basic credibility model, comparing welfare under a temporary program with welfare under a fully-credible program becomes important. This comparison is trivial in Calvo's (1988) model because the allocations under the status quo and a fully-credible policy reform are identical. In our benchmark model, in contrast, the welfare effect of uncertain duration is equivalent to a 1.5 percent gain in permanent consumption relative to the pre-stabilization equilibrium, but that welfare gain is 22 percentage points smaller than the 23.7 percent gain produced by a fully-credible stabilization. Thus, credible disinflation programs are still significantly more desirable than temporary programs.

4. Mexico's Post-War Experience with ERBS Syndrome

This section examines the empirical regularities that characterize ERBS syndrome in México from the perspective of the uncertain duration model. This analysis adds interesting evidence to the cross-country studies by Helpman and Razin (1987), Kiguel and Liviatan (1992) and Végh (1992) for two reasons. First, until 1994 México's currency collapses co-existed with a solid political structure, in contrast with the political crises that often accompany economic crises in other developing countries. Thus, in México lack of credibility did not reflect uncertainty about the duration of political institutions, but mainly uncertainty about economic policies. Second, México's ERBS episodes highlight the varying speed of economic expansion and real appreciation on which the uncertain duration framework sheds some light. Note, however, that our objective is not to obtain the best match to Mexican data, as that requires adding other key sources of business cycles that would make it impossible to isolate uncertain-duration effects.

The empirical analysis examines the period 1945-95 using annual data, and the last ERBS episode (1988-94) using quarterly data. The analysis of the latter episode is useful because reforms implemented in this period brought México closer to the environment of openness to global markets and flexible prices assumed in the model. Data on prices and exchange rates were obtained from the IMF's *International Financial Statistics*, and national accounts data were retrieved from *Indicadores Economicos* of Banco de México. The real exchange rate (RER) in the 1945-95 sample is a bilateral CPI-based index with 1970=100 defined as P/EP*. P and P* are average Mexican and U.S. CPIs respectively, and E is the average nominal exchange rate in terms of pesos per U.S. dollar. RER in the quarterly sample is the IMF's measure of the trade-weighted, CPI-based real effective exchange rate.

Figure 4 plots the evolution of annual exchange rates. The logarithm of the nominal exchange rate is in the left scale, and the RER index is in the right scale. Figure 4 shows sharp real appreciations during fixed-exchange-rate regimes, typical of ERBS syndrome, prior to large real depreciations that coincided with the collapses of the currency in 1949, 1954, 1976, 1982, and 1994.[11] The real appreciations occurred rapidly, over 2 to 4 years, and in two instances periods of real-exchange-rate stability existed in between sharp appreciations: in the 1960's era of the so-called "stabilizing development" and in 1989-90.

Consider next the cyclical behavior of GDP per capita and its expenditure components. Figure 5 plots the logarithm of real per-capita GDP and two estimates of its long-run trend; the cubic time trend (T^3) and the random-walk (RW) trend. Both trends show a large break after 1980 that raises important long-run growth issues beyond the scope of this study. We also identified the same structural break using the Hodrick-Prescott (HP) filter and the Baxter-King band-pass (BP) filter. The BP filter is designed here to isolate information contained in frequencies between 2 and 8 years. Both BP and RW filters track more closely the structural break than the T^3 and HP filters, and hence produce smaller cycles.[12] The cyclical components of the four filters are stationary.[13] Thus, these filters provide alternative measures of Mexico's business cycles at a low-frequency (T^3 and HP filters), mid-frequency (BP filter), or high-frequency (RW filter), while maintaining the condition that cyclical components are stationary.

Figure 6 plots business cycles and Table 2 reports statistical moments for cyclical co-movements. The qualitative features of México's cycles are similar to those observed in other developing countries (see Mendoza (1995)). Fixed investment (I) and the net exports-GDP ratio (NX/Y) are significantly more volatile than GDP, while private consumption (C) is only slightly more volatile than output.[14] C and I are procyclical and NX/Y is countercyclical, and all four

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[11] 1987 is an exception in which the peso collapse was not preceded by exchange-rate-based stabilization.
[12] The T^3 filter and the HP filter with the smoothing parameter set at 100 produce highly correlated cyclical components for GDP, C, and I. The correlations exceed 0.91 in all cases.
[13] The BP and HP filters exclude unit roots by design, and for the RW and T^3 filters ADF tests rejected unit roots at the 1-percent confidence level with 3 lags.
[14] C includes durables, which often results in larger consumption fluctuations relative to GDP.

variables (GDP, C, I, and NX/Y) exhibit positive persistence[15] Business cycle volatility, measured in terms of percent standard deviations, is higher the lower the frequency of the filter used. However, the standard deviations of C and I *relative* to GDP are similar for the BP, HP, and T^3 filters, while for the RW filter the relative variability of C is larger and that of I is smaller than with the other filters. Thus, as a first approximation, the lower-frequency filters produce larger and more correlated business cycles, but the differences across filters are not substantial.

Table 2 also shows that the variability of RER is much larger than that of the other variables. Moreover, real appreciations and output booms are uncorrelated, but the trade deficit is strongly correlated with the real exchange rate. Thus, real appreciations coincide on average with a widening trade imbalance relative to GDP, reflecting a strong positive correlation between real appreciation and domestic absorption.

TABLE 2. MEXICO: BUSINESS CYCLE INDICATORS

Variable	Standard deviation T3	HP	BP	RW	GDP correlation T3	HP	BP	RW
GDP	3.78	2.76	1.87	1.35	1.000	1.000	1.000	1.000
Consumption	4.39	3.37	2.22	1.75	0.910	0.883	0.860	0.838
	1.16	*1.22*	*1.19*	*1.30*				
Investment	13.82	9.91	6.91	3.21	0.870	0.840	0.851	0.773
	3.66	*3.60*	*3.70*	*2.38*				
Net exports / GDP 2/	2.95	2.05	2.95	2.12	-0.651	-0.647	-0.463	-0.443
	0.78	*0.74*	*1.58*	*1.57*				
Real exchange rate 2/,3/	27.70	18.47	27.70	22.82	0.176	0.262	0.169	0.109
	14.81	*6.69*	*7.32*	*16.90*				

1/ HP is the Hodrick-Prescott filter, BP is the band-pass filter, T3 is the cubic time trend and RW is the random walk (first-difference) filter. Numbers in italics are standard deviations relative to the standard deviation of GDP.
2/ Stationary in levels, not filtered in BP and T3 columns.
3/ Correlations between the real exchange rate and the next exports-GDP ratio are: -0.682 (T3), -0.612 (HP), -0.761 (BP), and -0.449 (RW)

[15]ADF tests rejected the hypotheses that NX/Y and RER contain unit roots in levels, and hence it is unclear whether they should be filtered. Co-movements for NX/Y and RER in the BP and T^3 columns of Table 2 were computed in levels, while NX/Y and RER were filtered in the HP and RW columns. The Table shows that cyclical indicators are not too dependent on whether these variables are filtered or not.

The data show that México generally goes through the complete expansionary phase of the business cycle during each fixed-exchange-rate regime (except in the long-lasting currency peg of 1955-76). Thus, the size of the booms and real appreciations associated with ERBS episodes can be identified by examining visually Figures 4 and 6. A typical example is the 1976-82 episode. Between 1976 and 1981, RER appreciated by 38 percent, deviations from trend in I widened by 30 percentage points and those for C and GDP widened by 8 percentage points (using the BP filter), and NX/Y changed from virtual balance to an 8 percent deficit.

Figure 7 plots cyclical components of macroeconomic aggregates based on quarterly data for the period 1983:1-1994:4. The plot shows that, after a sharp initial appreciation in the first semester of 1988, following the beginning of the currency peg in February, RER remained almost constant until 1990:4. In 1991:1 the real appreciation started again, so that by the December, 1994 devaluation the real exchange rate appreciated by 35.4 percent relative to 1988:1. By end-1993 the real appreciation reached 46.8 percent, so RER fell by about 10 percentage points in the year before to the devaluation. Deviations from trend in I, GDP, and C widened considerably during 1988-92, but in 1993 all three fell below trend.[16] Interestingly, the size of the booms and real appreciation are similar to those observed in the annual data for 1976-82.

In comparing the model's predictions to the Mexican data, we acknowledge that Mexico's business cycles are caused by several factors in addition to lack of credibility, such as the collapse of oil prices and the rise in world interest rates after 1982. Thus, we are interested in measuring what fraction of the Mexican business cycle can be explained by lack of credibility, and in exploring whether the model can account for that fraction. Favorable results both directions would not render unimportant other sources of business cycles. On the other hand, if only a negligible share of observed fluctuations can be explained by uncertain duration, one should conclude that credibility is of little relevance.

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[16]Since the period examined here excludes the sharp structural break in GDP noted earlier, a quadratic trend produces stationary cyclical components. ADF tests show that these components do not include unit roots.

We gauge the contribution of lack of credibility to explain the data by isolating the potential contribution of credibility effects from the effects of other sources of business cycles using VAR methods (as in Schmitt-Grohe (1995)). Borrowing from Calvo and Mendoza (1996), we computed variance decompositions of a parsimonious VAR system that uses the interest-rate spread between Mexican and U.S. treasury bills as a measure of the probability of devaluation and default. GDP, NX/Y, RER, and real M2 enter as endogenous and the terms of trade are exogenous. Two lags of all variables are used in the estimation following the Akaike Information Criterion. The results show that the credibility measure explains about 40 percent of the variability of RER, GDP, NX/Y, and real M2 over 24 quarters.[17]

In general, the dynamics of the uncertain duration model calibrated to Mexico 1987 are consistent with several of the time-series features identified in the data. Given the overall size of ERBS booms and real appreciations, and the estimate of the credibility component provided by the VAR, we conclude that an ideal simulation should produce an 18 percent real appreciation, consumption and GDP booms in excess of 2 percent, and investment booms in excess of 5 percent. The 15 percent real appreciation produced by the model is less than 1/2 the full real appreciation observed in México during 1988-94, or 1976-82, but is close to the 18 percent appreciation measured using the VAR. As already noted, the model also mimics key features of the data in that there is a phase of stable real exchange rate in the middle of the program and in that consumption and the real exchange rate are positively correlated. Fluctuations in GDP and the trade deficit are also consistent with Mexican data, as is the fact that recessions in GDP, consumption and investment predate the collapse of the currency. Note, however, that booms in tradables consumption and investment are larger than observed in the data. Finally, as Figure 2 shows, the uncertain duration model rationalizes stronger correlations of the real exchange rate with expenditures and the trade deficit than with GDP.

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[17]Note, however, that the interest differential is almost perfectly correlated with the Mexican interest rate, and the latter was influenced by sterilized intervention of large capital flows during 1990-94. Thus, the differential is at best a noisy measure of the "market" expectations of the sustainability of the peg.

5. Concluding Remarks

This paper shows that the uncertain duration of stabilization plans anchored on fixed exchange rates produces macroeconomic dynamics roughly consistent with the stylized facts identified in the data of countries that suffer chronically from surges of high inflation. This conclusion is derived by comparing Mexico's post-war experience, which includes five failed currency pegs, with the predictions of a dynamic, stochastic general equilibrium model of a two-sector, small open economy with incomplete contingent-claims markets. Agents in this economy are uncertain of whether the government will continue with the stabilization plan in the future, or will abandon it by devaluating the currency. Thus, economic fluctuations in the model are driven by the agents' time-dependent, conditional probabilities of devaluation. These devaluation probabilities are calibrated to existing empirical evidence, and the model's equilibrium dynamics are computed using a backward-recursion algorithm designed to solve incomplete-markets models driven by absorbent Markovian chains.

The model accounts for five key features of the data: (1) booms in output and expenditures (in the aggregate and across sectors) followed by recessions that predate devaluations, (2) strong positive co-movement between aggregate and sectoral consumption and the real exchange rate (i.e. the price-consumption puzzle), (3) periods of stability of the real exchange rate in between rapid appreciations, (4) sharp widening of the trade deficit followed by a reversal to a surplus, and (5) sharp fall in the velocity of circulation of money. The model's ability to explain these stylized facts primarily as a result of the lack of credibility of government policy sets it apart from existing theories of the syndrome. The cyclical dynamics we obtained also extend the theory of uncertain duration by showing that in general equilibrium consumption is not always non-increasing or non-decreasing, as in partial-equilibrium models.

These results depend critically on three elements of the analysis. First, the shape of the hazard rate function that governs devaluation probabilities. A strictly convex hazard rate is a necessary condition to produce realistic macroeconomic co-movements. This J-shaped hazard rate is consistent with a large body of empirical evidence based on models of speculative attacks and cross-country studies of determinants of currency collapses. Second, wealth effects introduced by the incompleteness of financial markets under the assumption that temporary fiscal adjustment accompanies exchange-rate-based disinflations. Third, supply-side effects that operate because uncertain duration acts like a random tax on savings that affects labor markets and investment plans. Wealth and supply-side effects play an important role in enabling the model to produce large booms and real appreciations. The model produces booms and appreciations that are 3 to 4 times larger than those obtained in other studies, although it explains about 1/2 of the magnitude of observed real appreciations. VAR analysis suggests, however, that only roughly 40 percent of the observed real appreciations and economic fluctuations in Mexico could be attributed to lack of policy credibility, which is in line with the model's predictions.

Our findings suggest that uncertain duration may be particularly helpful for explaining the recent experience of countries where currency pegs failed, or came under severe pressure, despite successful efforts to diminish price inertia and reduce fiscal deficits sharply, as in Argentina and México in 1994-95. Moreover, the model differs sharply from other explanations of the syndrome of exchange-rate-based stabilizations because it explains key features of the data without making use of price rigidities or borrowing constraints, and without assuming that the government fails to tighten fiscal policy for the duration of the stabilization plan.

The analysis of the model's welfare implications shows that uncertain duration entails much larger welfare costs than the negligible costs of credibility estimated under perfect foresight. Despite these larger costs, the model's strong supply-side effects imply that stabilizations of uncertain duration can be welfare-improving relative to a high-inflation equilibrium. Fully-credible stabilizations still yield the best outcome, and hence policies aimed at enhancing the credibility of currency pegs, or at lessening the impact of uncertain-duration distortions are desirable. For example, if tax policy is credible, a well-designed consumption tax can be useful in controlling credibility-induced business cycles. In practice, however, the design of this tax is difficult because it requires information on how incredible the stabilization policy is (i.e. an estimate of z_t) and what fraction of the business cycle is due to lack of credibility relative to other sources of business cycles (see Calvo and Mendoza (1994)).

We end with an important policy implication of the analysis. Our results show that, regardless of whether stabilization plans fail or not in the long run, and even in an environment of perfect capital mobility, flexible prices, and fiscal discipline, those plans go through difficult early stages in which the exchange rate is highly overvalued and the trade deficit is large simply because agents doubt the government's intentions. Policy lessons must then be drawn carefully. Devaluation by itself is never a practical solution for real overvaluation and large trade deficits, as is often suggested.

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Appendix: Solution Method

Computing equilibrium dynamics for models of incomplete markets is a complex task in general because of difficulties involved in tracing the optimal state-contingent evolution of wealth. In the case of small open economy models, with perfect capital mobility and conventional utility functions, this problem is compounded by the fact that stationary equilibria, when they exist, are determined by initial conditions. In light of these difficulties, we developed an algorithm that obtains a near-exact solution for equilibrium dynamics.

The equilibrium stochastic processes that characterize macroeconomic dynamics are computed by backward recursion on the general equilibrium system defined by equations (5)-(12) and (14)-(15). The method exploits the assumptions that (a) the date of collapse of the program is a random variable with finite support ($[1, J]$) and (b) that the collapse of the program is an absorbent state. Thus, there is a distant future date in which policy uncertainty is resolved. This imposes well-defined terminal conditions on consumption, leisure and money velocity, all of which jump to their corresponding high-inflation stationary equilibria on the date of the collapse. The current account and investment take some time to reach their steady state equilibria because of the inertia induced by capital adjustment costs, but their post-collapse dynamics are easily determined by solving a linearized version of the Euler equation for capital accumulation.

The algorithm begins by guessing period-J values for the state variables (capital and bonds) and uses intertemporal Euler equations and the budget constraint to compute the values taken by these variables in periods $t = J-1, J-2, \ldots 0$. Solutions for the control and co-state variables are provided by atemporal optimality and market-clearing conditions. A shooting algorithm is then introduced to ensure that the period-J guess is consistent with the initial conditions for the capital stock and bond holdings.

Notation: let x_t^H denote the value assumed by x_t if $e_t = e^H$ and $e_{t-1} = e^L$, and x_t^L the value assumed by x_t if $e_t = e^L$. The exception to this notation is the capital stock, K_{t+1}^T. K_{t+1}^{TH} denotes the value assumed by K_{t+1}^T if $e_t = e^H$ and $e_{t-1} = e^L$, and K_{t+1}^L the value assumed by K_{t+1}^T if $e_t = e^L$.

Initial conditions are given for the capital stock, K_0^T, the stock of real financial wealth, $B_{-1} + m_{-1}/(1+e_0)$. Since $e_t = e^H$ is an absorbent state, it follows from the equilibrium conditions that in this event consumption and money velocity are constant. In particular money velocity solves $1 - S'(V^H){V^H}^2 = \beta/(1+e^H)$ (see equation (11)). Given this value for money velocity, it follows from (12) that K_{t+j}^T, $j \geq 1$ follows a second order differential equation with a unique steady state, K^T, given by $(1-\alpha_T)(K^T/L^T)^{-\alpha_T} = (r+\delta)(1+S(V^H)+S'(V^H)V^H)$.

Equilibrium dynamics are computed in the following way. Start with an initial guess for K_{J-1}^{TL}, C_{J-1}^{TL} and $\{m_{t-1}^L\}_{t=0}^{J-1}$ — this last guess is necessary only if the government does not fully rebate seignorage income ($\eta_m < 1$).

(1) Period $J-1$: In this period all variables except K^T reach their steady state, since the exchange rate uncertainty is removed.

(1.1) Given C_{J-1}^{TL}, find C_{J-1}^{NL}, p_{J-1}^{NL}, L_{J-1}^{NL} and λ_{J-1}^L by solving the intra-temporal Euler conditions (7)-(9) and the market clearing condition (13).

(1.2) Compute an approximate solution for K_{J-1+j}^T, $j > 1$ by solving a linearized version of (12).

(1.3) Find B^L_{J-2} by solving (14) forward, using m^L_{J-2} and (5)-(6) to eliminate G_{J-1} and T_{J-1}.

(1.4) Use B^L_{J-2} and m^L_{J-2} to solve equations (5)-(9) and (13)-(14) for C^{TH}_{J-1}, C^{NH}_{J-1}, p^{NH}_{J-1}, L^{NH}_{J-1} λ^H_{J-1}, G^H_{J-1} and T^H_{J-1}.

(2) Periods $t = J-2, ...0$

(2.1) Given V^i_{t+1}, λ^i_{t+1}, $i = L, H$, K^{TL}_{t+j}, $j = 1,2$, and K^{TH}_{t+2}, solve the intertemporal Euler equations (10)-(12) for V^L_t, λ^L_t, and K^{TL}_t.

(2.2) Given V^L_t and λ^L_t, solve (7)-(9) and (13) for C^{TL}_t, C^{NL}_t, p^{NL}_t, and L^{NL}_t.

(2.3) Use B^L_t, m^L_{t-1} and the values obtained in (2.2) to solve (5)-(6) and (14) for B^L_{t-1}, G^L_t and T^L_t.

(2.4) B^L_{t-1} and m^L_{t-1} can then be used to solve (7)-(9), (13) and (14) (forward) for λ^H_t, C^{TH}_t, C^{NH}_t, p^{NH}_t, and L^{NH}_t.

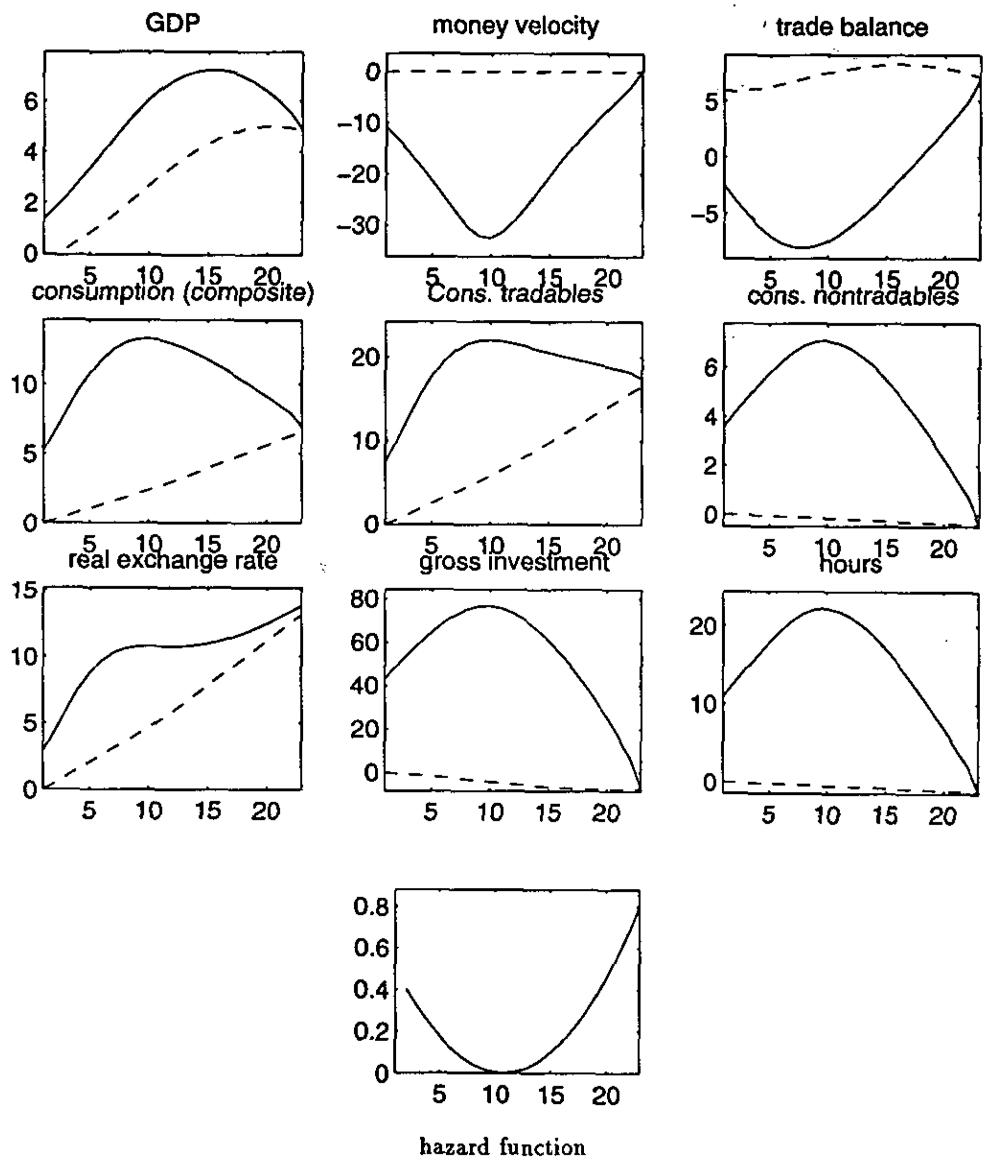
(2.5) Use a linearized version of (12) to solve for K^{TH}_{t+1}.

(3) Steps (1)-(2) yield a new vector of real balances $\{m^L_{t-1}\}^{J-1}_{t=0} = \{(C^{TL}_{t-1} + p^{NL}_{t-1}C^{NL}_{t-1})V^L_{t-1}\}^{J-1}_{t=0}$. If this vector differs from the one guessed, use it as the new guess and repeat steps (1)-(2).

(4) If K^T_0 differs from the desired initial condition for the capital stock, change the guess for K^{TL}_{J-1} and repeat steps (1)-(3). (K^T_0 is increasing in K^{TL}_{J-1}.)

(5) If $B_{-1} + m_{-1}/(1+e_0)$ differs from the desired initial condition for the stock of financial wealth, change the guess for C^{TL}_{J-1} and repeat steps (1)-(4). ($B_{-1} + m_{-1}/(1+e_0)$ is increasing in C^{TL}_{J-1}.)

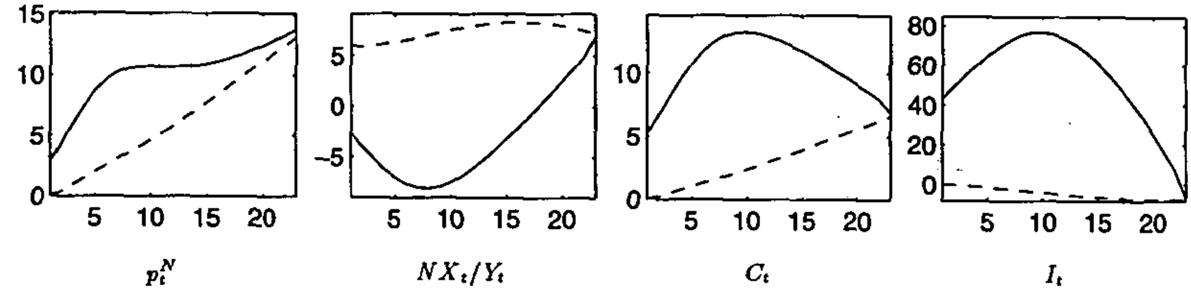
Figure 2: MACROECONOMIC DYNAMICS OF AN EXCHANGE-RATE-BASED STABILIZATION OF UNCERTAIN DURATION*



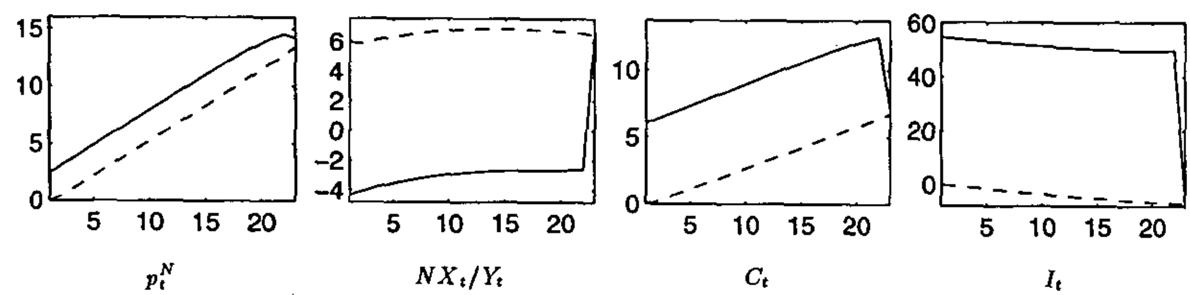
* All variables, except NX_t/Y_t, are expressed in percentage deviations from their pre-stabilization steady-state. Solid lines denote pre-collapse values and broken lines at-collapse values.

Figure 3: SENSITIVITY ANALYSIS*

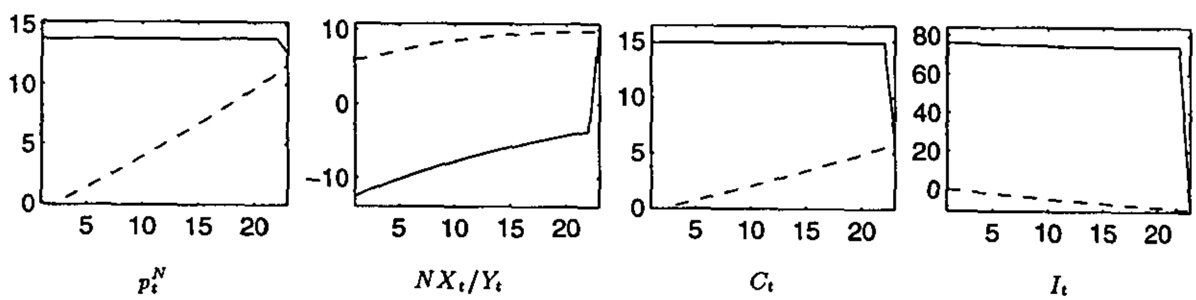
The Benchmark Model



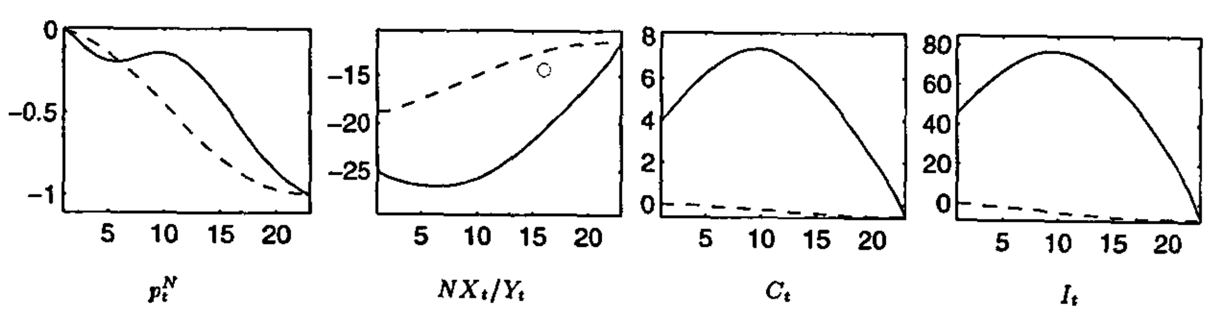
Flat Hazard Rate



Perfect Foresight



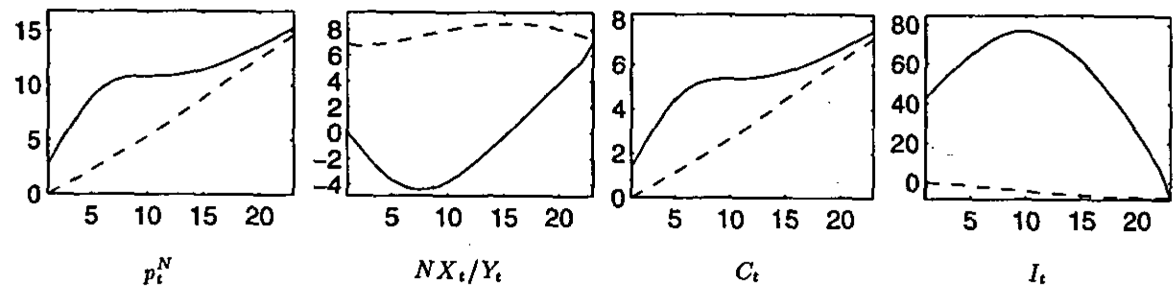
Full Rebate ($\eta_s = \eta_m = 1$)



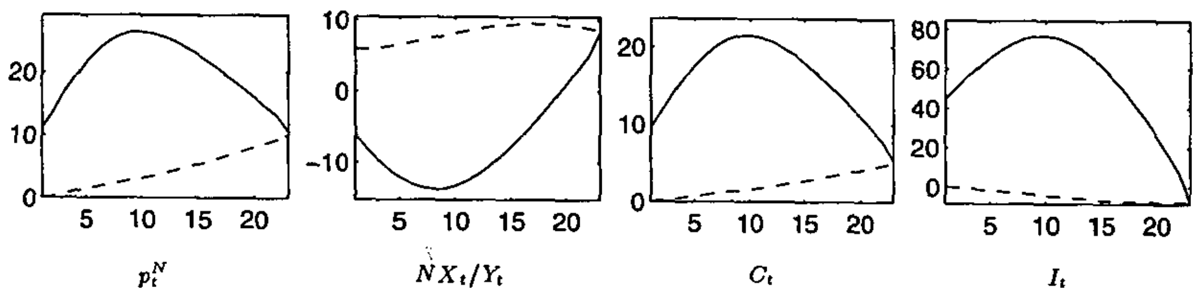
* All variables, except NX_t/Y_t, are expressed in percentage deviations from their pre-stabilization steady-state. Solid lines denote pre-collapse values and broken lines at-collapse values.

Figure 3: (continued) SENSITIVITY ANALYSIS

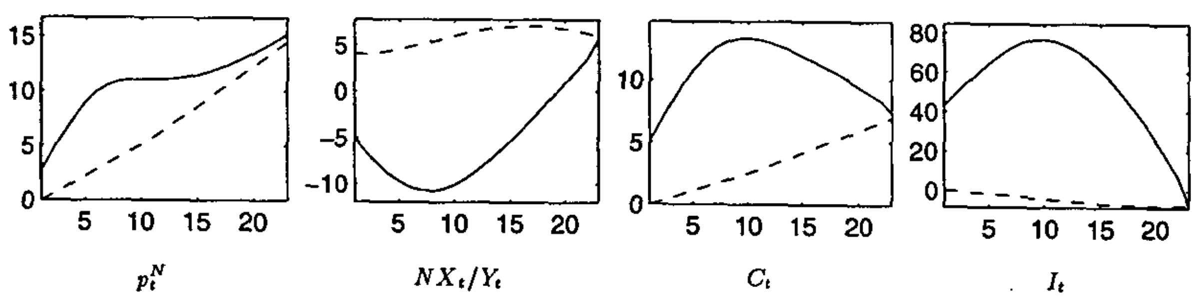
Inelastic Labor Supply ($\rho = 0$)



High Intertemporal Elasticity of Substitution ($\sigma = 1$)



Cobb-Douglas Aggregator Function ($\mu = 0$)



Extended Time Horizon ($J = 36$)

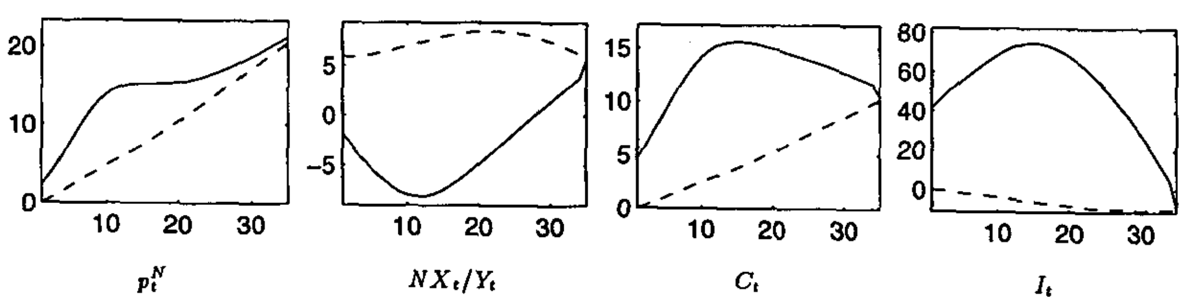
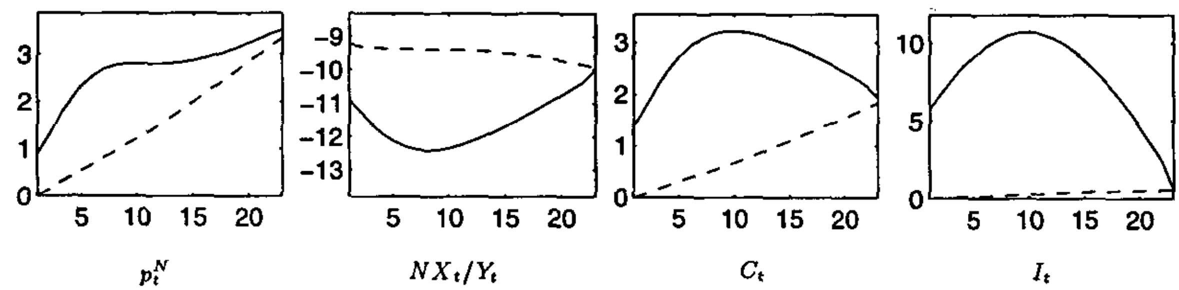


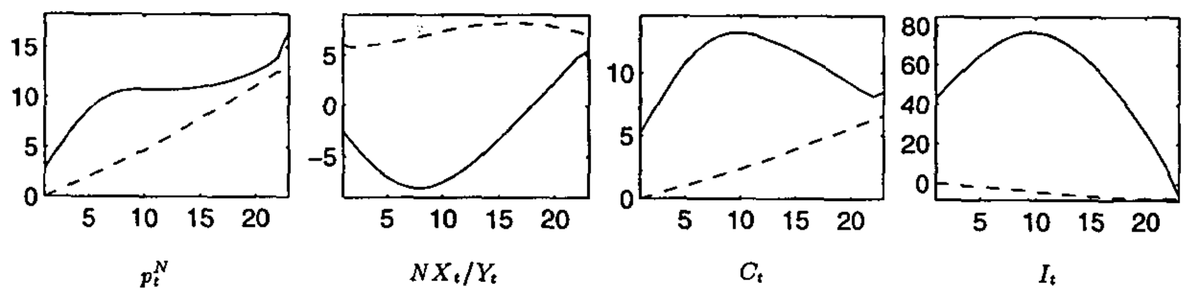
Figure 3: (continued) SENSITIVITY ANALYSIS

High Steady State Money Velocity ($V^H = 15.4$ per year)



Non-zero Probability of Long-Run Success

$Pr(e_J = e^H | e_{J-1} = e^L) = .9$ and $Pr(e_{J+j} = e^i | e_J = e^i) = 1$ for $i = H, L$ and $j > 1$



$Pr(e_J = e^H | e_{J-1} = e^L) = .5$ and $Pr(e_{J+j} = e^i | e_J = e^i) = 1$ for $i = H, L$ and $j > 1$

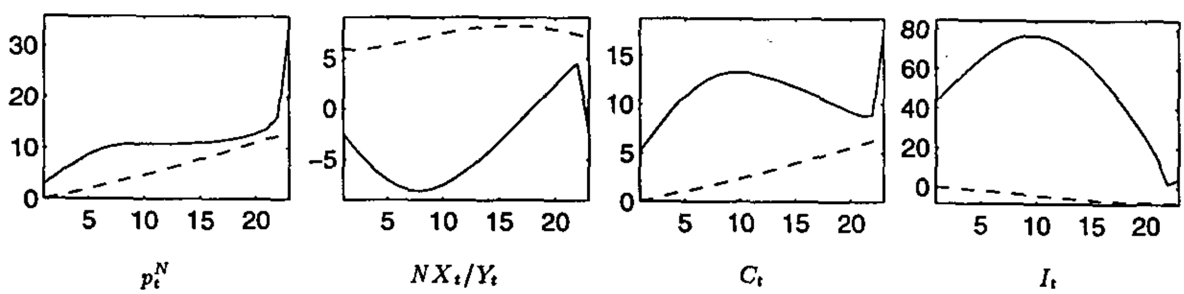
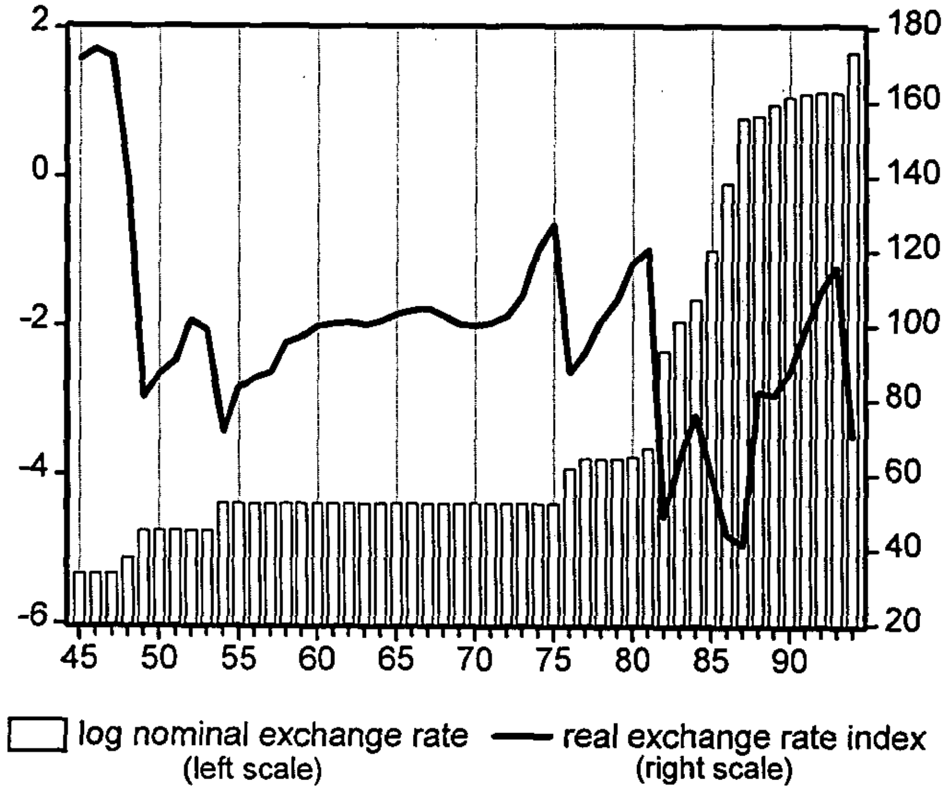


Figure 4
Mexico: Real and Nominal Exchange Rates



Note: The real exchange rate index is P/EP*, where P is the Mexican CPI, E is the nominal exchange rate in nuevos pesos per dollar, and P* is the U.S. CPI. The base of the index is 1970=100.

Figure 5
Mexico: GDP Per capita and Trend Estimates

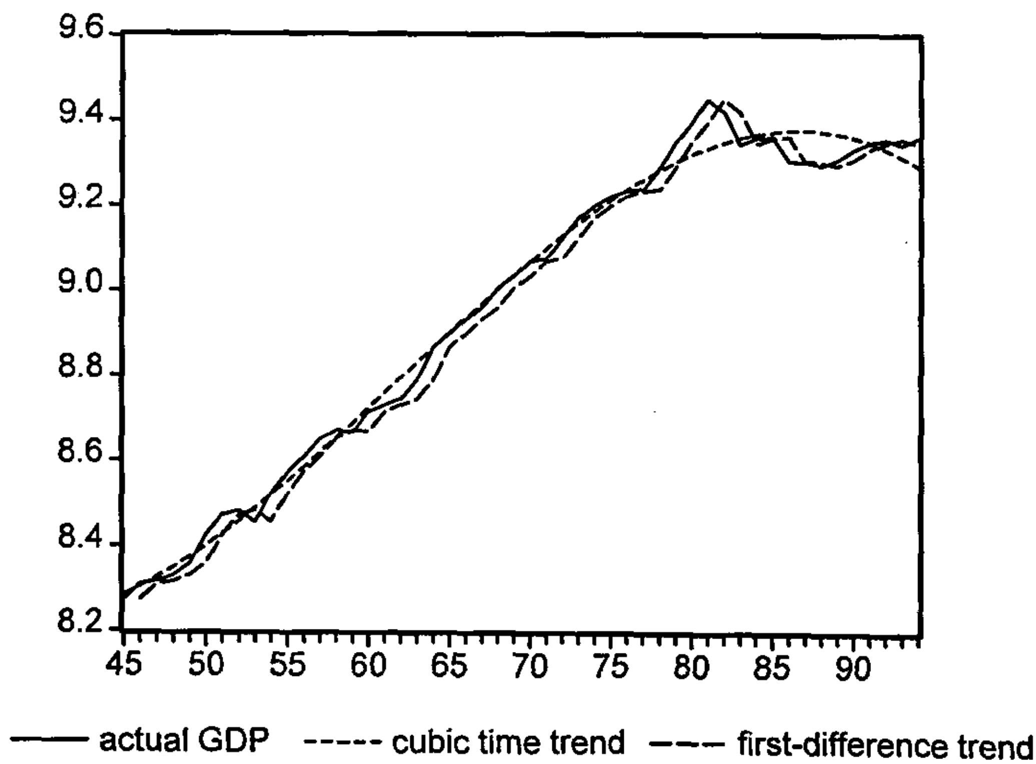


Figure 6
Post-war Mexican Business Cycles

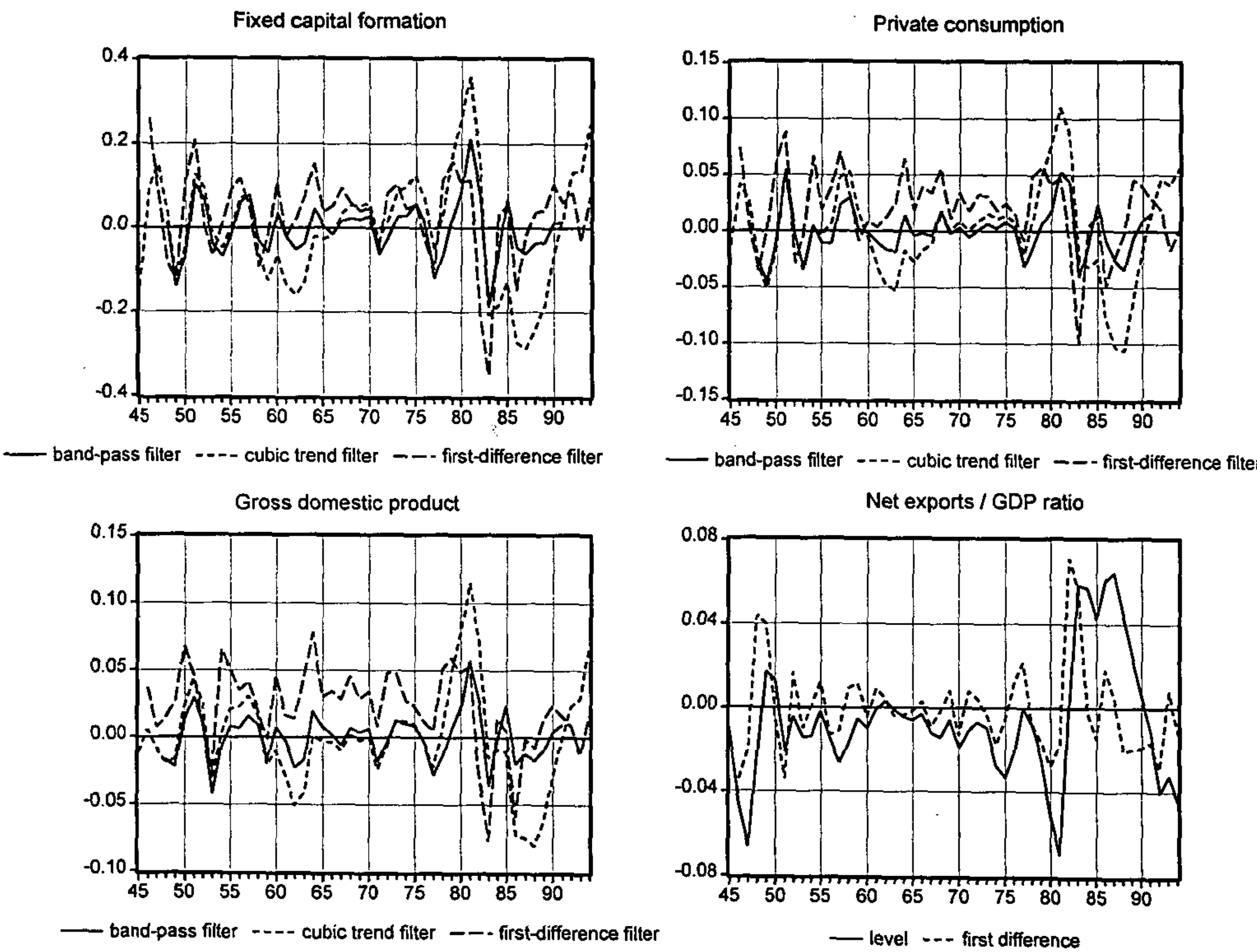


Figure 7
Mexican Business Cycles: 1983:1-1994:4
(percent deviations from quadratic trend, except RER)