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HIGH REAL INTEREST RATES IN THE AFTERMATH OF DISINFLATION: Is it a Lack of Credibility?

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Abstract

High real interest rates have been observed in many countries for several months after the adoption of disinflation programs. While they may reflect primarily a liquidity crunch, high *ex post* real interest rates can also be explained in terms of an *ex post* error in inflation expectations that reflects a lack of credibility of the low-inflation policy. The latter hypothesis is tested using data for Argentina, Israel, and Mexico during the implementation of the stabilization programs in the mid-1980s.

HIGH REAL INTEREST RATES IN THE AFTERMATH OF DISINFLATION: Is it a Lack of Credibility?

Graciela L. Kaminsky and Leonardo Leiderman[1]

I. Introduction

High real interest rates have been observed in many countries for several months after the adoption of disinflation programs. For example, six months after the start of stabilization plans in Argentina, Israel, and Mexico in the mid-eighties, real interest rates were still on the order of 40-50 percent per year (see Table 1). Much higher real interest rates have been observed in the aftermath of hyperinflations. For example, real interest rates reached about 100 percent per year six months after the Bolivian stabilization of October 1985 (see Calvo and Guidotti, 1992). Dornbusch (1986) presented similar evidence for the first year after the end of the German hyperinflation. High real interest rates, of about 5-6 percent per year, were also observed in OECD countries following reductions in the inflation rates in the early 1980s. The same phenomenon has been observed in the aftermath of several recent stabilizations in Eastern Europe, for example in Poland (see Calve, 1992).[2]

Although one possible explanation for this fact is that high real interest rates reflect primarily a shortage of liquidity induced by contractionary monetary policy (see, for example, Dornbusch, 1986), recent research has stressed another explanation, which is the focus of this paper. Specifically, high *ex post* real rates can be explained in terms of an *ex post* error in inflation expectations, which reflects a lack of credibility of the low-inflation policy. That is, despite some reductions in inflation immediately after the start of a stabilization program, nominal interest rates could remain high due to a lack of confidence in the program and hence the expectation that high inflation may return. Over time, and to the extent

[1] The authors are staff economist at the Board of Governors of the Federal Reserve System and Professor at Tel-Aviv University, respectively. The views expressed in this paper are those of the authors and should not be interpreted as reflecting those of the Federal Reserve System or other members of its staff. We have benefited from insightful discussions with G. A. Calvo on this topic. Seminar participants at Banco de México and Universidad Nacional Autónoma de México provided very helpful comments. Special thanks also go to two anonymous referees, whose careful review of an earlier draft led to substantial improvement. Work on this paper was partly done while Kaminsky was visiting the Institute for International Economic Studies, Stockholm University and the International Monetary Fund; and Leiderman was visiting the International Monetary Fund. Both authors thank these institutions for their hospitality.

[2] Notably, real interest rates fell in some orthodox exchange-rate-based stabilizations. For example, real interest rates were negative (about -10 percent per year) in the first six months of the so-called *Tablita* programs in Argentina and Uruguay in the late 1970s. We thank an anonymous referee for pointing out this evidence to us.

that the program results in disinflation, the new policy gains credibility, expectations of inflation are revised downward, and nominal (and real) interest rates exhibit a gradual decline. Throughout this process, expected inflation is likely to exceed actual inflation, and therefore *ex* ante real interest rates are smaller than rates observed *ex post*.[3]

This paper explores the empirical relevance of arguments based on lack of credibility for explaining high *ex post* real interest rates after stabilization programs were implemented in Argentina, Israel, and Mexico in the mid-1980s. These countries experienced, to different degrees, chronic inflation in the post-WWII period, and investors were witnesses to many failed stabilization attempts. Naturally, after the collapse of several anti-inflationary programs, probably investors were reluctant to believe any new announcements made by the government right away. Instead, it is likely that market participants checked month after month to see whether, for example, monetary and fiscal policies were consistent with the announced inflation target. Unexpected expansionary monetary or fiscal shocks could lead investors to doubt the commitment of the authorities to low inflation. In this regard, the model below envisions economic agents as learning gradually, using Bayesian updating, about possible changes in the inflationary regime that they face.

Our main analysis considers two main inflationary regimes: one characterized by high inflation and the other by low inflation. Regimes can differ in the mean of inflation rates, in the degree of inflation persistence, and in the variance of shocks to the inflation process. We assume that in every period investors will try to assess the likelihood of being in a low or a high inflation regime by using information on inflation and on monetary and fiscal shocks. In this way, we can use model estimates to construct time series for expected inflation, which we then use to calculate implied *ex ante* real interest rates. The analysis can then examine a key implication of credibility-based theories -namely, that high *ex post* real interest rates are not necessarily associated with high *ex ante* real rates. our results suggest that for Argentina the bulk of variation in nominal interest rates reflected movements in expected inflation. In contrast, after the stabilization program in Israel, nominal and *ex ante* real interest rates moved together. Last, the results for Mexico tell an intermediate story in which lack of credibility can explain only part of the high *ex post* real interest rates.

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3 The role of the lack of credibility in accounting for the facts after disinflation programs has been recently emphasized by Calvo and Végh (1993) and Cukierman and Liviatan (1992). Also, Lucas (1990) suggested attributing a large portion of the rise in *ex post* real interest rates in OECD countries in the early eighties to (ex *post*) wrong expectations. In particular, his view is that throughout most of the *1980s* people expected high inflation to resume (to the levels of the 1970s), but these expectations turned out to be wrong. This view is supported by the empirical findings of Evans and Lewis (1992).

The paper is organized as follows. Section H provides a chronology of the events leading to the stabilization programs and discusses the salient features of the plans. Section III provides a theoretical background and Section IV describes our methodology of estimation. Section V presents the main results and Section VI concludes.

II. Antecedents and Salient Features of the Three Stabilization Plans*

Argentina, Israel, and Mexico have all experienced chronic inflation in the postwar period and –to different degrees– also have a rich history of failed stabilization programs.[5] A study of investors' credibility (or lack of) in the stabilization plans of the 1980s requires some historical background to identify the main reasons why, typically, the private sector might view with skepticism any new attempt to bring inflation down to international levels.

Argentina's average inflation was already above 30 percent in the 1960s, and despite several major attempts, such as the 1978 *Tablita* program, the government was unsuccessful until very recently in reducing inflation to levels observed in industrialized countries. Naturally, the immediate cause of inflation was high money growth, with money printing financing chronic budget deficits. Inflation particularly accelerated in the mid-1970s with the Peronist government, when government deficits increased from about 5 percent of GDP in 1960-1975 to about 12 percent of GDP in the late 1970s (see Cavallo and Pena, 1983). At its peak, inflation reached 35 to 50 percent per month. Even with increasing fiscal deficits, inflation declined transitorily to an annual rate of less than 100 percent in the 1976-81 period in response to a decline in the rate of depreciation of the domestic currency implemented during the *Tablita* Program. This plan collapsed in 1981 after a huge overvaluation of the peso, which ultimately precipitated massive capital flight and accumulation of external debt. Fueled by military spending during the Malvinas war in 1982, by the 1981 bail-out program of the private sector financed with rediscounts of the Central Bank, and by Central Bank losses on exchange rate guarantees in the aftermath of the Martinez de Hoz overvaluation, inflation continued to increase to three-digit levels. By June 1985, the rate of inflation had

[4] The narrative in this section draws heavily from a number of sources including Buffie (1990), Dornbusch and de Pablo (1990), Rebelo and Vegh (1995), Ruge-Murcia (1995), and Végh (1992).

5 Chronic inflation, as examined by Pazos (1972) and Végh (1992) exhibits two key characteristics. First, it may last for long periods of time; it is measured in terms, not of months, but of years. Second, chronic inflation has an intermediate intensity, higher than that of moderate inflation but much lower than that of hyperinflation, which results from countries learning how to live with high and persistent inflation by creating various indexation mechanisms. Specifically, inflation does not have an inherent propensity to accelerate, or if it does, it soon reaches a new plateau.

reached 6,000 percent per year and Argentina was only one step away from economic cataclysm. Against this background, in June 1985 the Alfonsin government announced the *Austral* plan, the first stabilization program to combine income policy with an initial dose of fiscal austerity. The four key features of the plan were the following: First, the government increased public sector prices, depreciated the exchange rate, and imposed import duties, export tariffs, and a forced saving scheme. It raised some tax rates and sped up tax collection. Second, the plan imposed a wage-price freeze and adopted a fixed exchange rate against the U.S. dollar. Third, a scale of conversion to adjust outstanding contracts for the immediate and unanticipated end of inflation was put into place. Fourth, a new monetary unit, the Austral, was introduced. Although the *Austral* plan helped to avoid economic collapse, inflation did not disappear mainly because of the lack of fiscal and monetary policy discipline. On the contrary, by mid-1986, inflation had risen above 100 percent at an annual rate and high government budget deficits had returned.

In contrast to Argentina, Israel and Mexico were low-inflation countries during the 1960s. In the 1970s inflation skyrocketed and soon reached three-digit figures. The rate of inflation in Israel increased after 1977 primarily as a result of massive budget deficits and accommodating monetary policy. In the early 1980s, fiscal deficits averaged about 10 percent of GNP. The key factors in the government fiscal crisis were the government bail-out of banks in October 1983 after the collapse of bank share prices; the steep decline in tax revenues as a percentage of GDP, due in part to tax arrears, caused by the acceleration of inflation; and the government interest rate subsidies on fixed-rate loans to the private sector (see Dornbusch and Fischer, 1986). By June 1985, inflation had reached 430 percent at an annual rate. In July 1985, the government announced a new stabilization package. The plan had three main features (see Leiderman, 1993): First, the new shekel replaced the old shekel at the rate of 1:1,000, and its parity with respect to the U.S. dollar was fixed at 1.5 new shekels per dollar. Second, a Draconian fiscal plan was implemented, balancing the government budget almost overnight. Public expenditure was reduced by 10 percent. These savings were accomplished mainly through major reductions in defense expenditures and cuts in subsidies of various kinds, including subsidies on foodstuffs and government-provided goods and services. Third, the government and trade unions agreed to a social pact to break the inflationary inertia due to price and wage indexation. This pact included a 14 percent increase in general wages, followed by a freeze in nominal wages and the suspension of indexation for 3 months. With fiscal and monetary policy under control, the annual inflation rate was reduced below 20 percent ever since the adoption of the plan.

During the 1960s, Mexico experienced the same inflation rate as the United States. In the early 1970s, the fiscal deficit started to rise quite rapidly. Large increases in government spending drove the consolidated public sector deficit upward from 2.5 percent of GDP in 1971 to 10 percent in 1975. The growth in the deficit was mainly fueled by increased losses by the non-PEMEX state-owned enterprises. Fiscal deficits were financed in large measure by borrowing from the Central Bank, which in turn accelerated inflation. On August 31, 1976, the peso was devalued nearly 100 percent, and the annual rate of inflation that year reached 27 percent. Shortly after the devaluation, a letter of intent was submitted to the IMF outlining a stabilization program to be implemented in stages over the following three years. The stabilization program was fairly successful in its first year, with the government deficit decreasing from 9.9 percent to 6.7 percent of GDP. Nevertheless, inflation remained at a 2-digit levels. In 1982 inflation escalated, fueled by enormous increases in the government deficit due to large subsidies to aid firms holding dollar debt, to an emergency scheme involving fiscal relief and outright subsidies to support "productive firms," and to tax exemptions equaling 15 percent of the monthly payroll to firms that could prove they had maintained employment levels. Although fiscal austerity plans were announced, fiscal discipline was not persistently enforced, and by 1986 the overall budget deficit had reached 15 percent of GDP. To stop inflation the government announced a stabilization plan in December 1987, which included a one-year fixed exchange rate as well as a "pacto social" to reduce inflation. As in Israel, a profound fiscal reform was implemented. The tax code was reformed, major cuts were made in government spending, and many of state-owned enterprises were privatized. Although in 1987 there was already a large primary surplus, the overall deficit continued to be high for a couple of years because of the service of the public debt.

Table 1 presents summary monetary, fiscal, and inflation statistics for the three countries before and after the stabilization plans. Note that while the Israeli and Mexican plans were successful in persistently reducing inflation to levels below 20 percent per year,[6] the policies in Argentina failed and inflation resumed almost immediately to levels similar to those prevailing before the plan. The behavior of money, credit to the private sector, budget deficits, and the rate of inflation suggests two patterns in the data: Israel and Mexico show a steady contraction in real monetary aggregates and budget deficits after the plans were implemented. In contrast, Argentina does not show such. monetary contraction or long--lasting fiscal austerity. Despite these differences, all three countries show high *ex post* real

[6] The Mexican stabilization program finally collapsed in December 1994 with a devaluation of the peso on the order of 100 percent.

interest rates in the first few quarters after stabilization.

111. Monetary and Fiscal Policies and the Feasibility of the Stabilization Plan

In this section we elaborate on how agents possibly decide whetherto believe that the announced stabilization plan will actually be carried out. It is plausible to postulate that when an anti-inflationary program is implemented, investors will try to assess the viability of the plan by examining whether government policies are in fact consistent with the new announced low-inflation target. As the basic ingredient in the three stabilization plans was the fixing of the exchange rate to anchor inflation to "world" levels, we now discuss how investors assess the feasibility of the fixed-exchange-rate regime.

The plan of bringing down inflation to world levels by fixing the exchange rate is based on the idea that, at least over the long run, domestic inflation will converge to foreign inflation plus the rate of depreciation of the domestic currency:

$$\text{Apt} = \Delta p_t^* + \Delta e_t \tag{1}$$

where Ap_t is the domestic inflation rate, Δp_t^* is the foreign inflation rate, and Δe_t is the rate of depreciation of the domestic currency. If the exchange rate is fixed, Δe_t is zero, and the domestic inflation rate will converge over time to the foreign inflation rate.

The decision to fix the exchange rate, so as to anchor domestic inflation to world inflation, naturally constrains monetary and fiscal policies because the rate of growth of the money supply becomes demand-determined. For example, if domestic credit expansion financing a government deficit is higher than the world inflation rate, there will be an excess supply of money leading to continuous outflows of foreign exchange reserves. When foreign exchange reserves of the central bank are depleted, the authorities will be forced to abandon the fixed-exchange-rate regime. A viable fixed-exchange-rate regime requires the growth rate of domestic credit to be smaller than or equal to the world inflation rate. Thus, an increasing rate of expansion of domestic credit, perhaps financing a government deficit, will signal conflicts between monetary and fiscal policies and inflation targets, leading investors to expect an abandonment of the stabilization package.

Suppose that the demand for money is given by a stable Cagan money demand function

$$m_t^d - p_t = \alpha_0 - \alpha_1 i_t + \mu_t^{m^d} \tag{2}$$

where m_t^d and p_t are the natural logarithms of money demand and the price level, respectively, i_t is the domestic interest rate, α_0 is a scale variable, α_1 is the semi-elasticity of money demand with respect to the rate of interest, and $\#^d$ is a money-demand shock.

With international capital mobility, the domestic nominal interest rate is linked to the world interest rate

$$i_t = i^* + \Delta_t e_{t+1} + \rho \tag{3}$$

where i* is the world nominal interest rate and ρ is the spread between domestic and foreign interest rates reflecting imperfect substitutability between domestic and foreign bonds. In this example, we assume for simplicity that both i^* and ρ are constant. Finally, $\Delta_t e_{t+1}$ is the expected rate of depreciation of the domestic currency.

In the long run, the growth rate of money demand in a fixed-exchange-rate regime will be

$$\Delta m_t^d = \Delta p_t^* + \Delta \mu_t^{m^d} \tag{4}$$

The demand for money in (4) will restrict the growth rate of the money supply in the fixed-exchange-rate regime and impose a binding restriction on the part of the government budget deficit financed by money creation.

Since in chronic-inflation countries, the growth rate of the (domestically created) money supply has been determined primarily by the government's need to raise revenue through seigniorage to finance the budget deficit, we assume that the growth rate of the domestic component of the money supply follows the following process:

$$\Delta dc_t = \gamma_0 + \gamma_1 d_t + \mu_t^{m^s} \tag{5}$$

where Δdc_t is the rate of growth of the domestically created money supply at time t, d_t is the government's budget deficit as a percentage of GDP, γ_0 is a constant term, γ_1 measures the response of money growth to a 1 percent change in the government deficit (as a percentage of GDP), and $\mu_t^{m^s}$ is a money supply shock.

The budget deficit in every period is assumed to follow an autoregressive process

$$d_t = b_{0t} + b_1 d_{t-1} \text{ -i-p:} \tag{6}$$

where b_{0t} is a variable whose value depends on the government fiscal stance, with large b_{0t}'s before the stabilization program and smaller ones afterward if the government is genuinely committed to the austerity plan, and μ_t^d is a fiscal shock.

In the long run, for the stabilization plan to be feasible, monetary and fiscal policies have to guarantee that foreign exchange reserves of the central bank are not depleted. Naturally,

domestic inflation should also be equal to foreign inflation. With foreign exchange reserves constant and without loss of generality assumed to be zero, the growth rate of money supply will be

$$\Delta m_t^s = 70 + \gamma_1[b_{0t} + \textbf{halt-}I + \mu_t^d] + \mu_t^{m^s} \tag{7}$$

Thus, for the stabilization package to be feasible, the following condition should hold:

$$\gamma_0 + \gamma_1[b_{0t} + b_1 d_{t-1} + \mu_t^d] + \mu_t^{m^s} - \Delta\mu_t^{m^d} \leq \Delta p_t^* \tag{8}$$

The feasibility condition for the fixed-exchange-rate regime indicates that the growth rate of the domestically created money supply –corrected by changes in the demand for money due, for example, to financial innovations- cannot be higher than the world inflation rate if the equilibrium in the money market is not to entail continual outflows of reserve.

If monetary and fiscal policy are consistent with the fixed exchange rate, inflation will converge to

$$\Delta p_t = \Delta p_t^* \tag{9a}$$

If, instead, fiscal and monetary policy are inconsistent with the fixed-exchange-rate regime, the domestic currency will float with inflation equal to

$$\Delta p_t = \Delta dc_t + \gamma_1 \Delta b_{0t} \tag{9b}$$

and will be higher, by assumption, than the world inflation rate. Equation (9a) represents the stochastic process followed by inflation in the low-inflation regime and equation (9b) represents the stochastic process followed by inflation in the high-inflation regime.[7]

If we denote the low-inflation regime by R_t = O and the high-inflation regime by $R_t = 1$, the probability of success of the announced stabilization program will be

$$\text{Prob}(R_t = \text{O}) = \text{Prob}(\gamma_0 + \gamma_1[b_{0t} + b_1 d_{t-1} + \mu_t^d] + \mu_t^{m^s} - \Delta\mu_t^{m^d} \leq \Delta p_t^*) \tag{1o}$$

In (10) large money supply shocks or large positive fiscal shocks will make investors doubtful about the ability of the government to tame inflation.[8] In the next section, we will use

[7] Equation (9b) was derived under the assumption that p_t^* and b_{0t} follow a random "alk Process"

[8] Naturally, during th, transition period, when the rate of inflation starts to decrease, domestic credit can expand at a rate exceeding Δp^* without jeopardizing the long-run success of the reform because the demand for money will increase because of disinflation. Thus, in the short run, the Central Bank will not

this measure of feasibility of the announced stabilization programs to estimate the expected inflation rate and the expected real interest rate.

IV. Methodology

With a changing fiscal and monetary stance, the stochastic process followed by inflation will also change over time- To examine whether high *ex post* real interest rates reflect just a lack of credibility, we focus our attention on the changing stochastic process followed by inflation before and after the stabilization program is implemented. We first examine whether in fact the stochastic process followed by inflation changed after the stabilization program was implemented and then examine whether the low-inflation reform was credible by looking at the probabilities of being in a low-inflation regime implied by the model. These probabilities will allow us to examine whether high *ex post* real interest rates reflect a lack of credibility or a credit crunch. Moreover, the difference between the actual and the estimated inflation rates will allow us to calculate what part of the increase in *ex post* real interest rates is explained by the credibility effect.

More specifically, we model the inflation rate as following a two-state switching regime process. As in Section III the probability of being in a low-inflation regime was related to fiscal and monetary shocks, we assume in the estimation process that market participants assess the current inflationary regime using past and current information on inflation, money, and the government budget deficit. The model consists of the following equations:

$$\Delta p_t = \delta_0^i + \sum_{j=1}^{q} \delta_j^i \Delta p_{t-j} + \epsilon_t \qquad \epsilon_t \sim N(0, \sigma_i^2) \tag{11}$$

$$\Pi_t = \begin{bmatrix} (1 - \lambda_t^{10}) & \lambda_t^{01} \\ \lambda_t^{10} & (1 - \lambda_t^{01}) \end{bmatrix} \tag{12}$$

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lose foreign exchange reserves if

$$\gamma_0 + \gamma_1[b_{0t} + b_1 d_{t-1} + \mu_t^d] + \mu_t^{m'} - \Delta\mu_t^{m^d} + \Delta q_t \leq \Delta p_t^* - \alpha_1 \Delta i_t$$

where Δq_t is the change in the real exchange rate and captures possible deviations from PPP in the short run. The measure of feasibility of the stabilization plan, which takes into account the remonetization of the economy in the aftermath of stabilization, will be given by

$$\text{Prob}(R_t = 0) = \text{Prob}(\gamma_0 + \gamma_1[b_{0t} + b_1 d_{t-1} + \mu_t^d] + \mu_t^{m'} - \Delta\mu_t^{m^d} + \Delta q_t \leq \Delta p_t^* - \alpha_1 \Delta i_t)$$

(13a) $$\lambda_t^{01} = \frac{\exp(\beta_0 + \beta_m \epsilon_t^m + \beta_d \epsilon_t^d)}{1 + \exp(\beta_0 + \beta_m \epsilon_t^m + \beta_d \epsilon_t^d)}$$

(13b) $$\lambda_t^{10} = \frac{\exp(\beta_0 - \beta_m \epsilon_t^m - \beta_d \epsilon_t^d)}{1 + \exp(\beta_0 - \beta_m \epsilon_t^m - \beta_d \epsilon_t^d)}$$

(14a) $$\epsilon_t^m = m_t - p_t - \alpha_0 + \alpha_1 i_t$$

(14b) $$\epsilon_t^d = d_t - \sum_{j=1}^{q} a^j d_{t-j} - \sum_{j=0}^{q} b^j i_{t-j}$$

In (11) inflation, Δp_t, is modeled as an autoregressive process of order q with state-dependent constant, autoregressive parameters, and volatility, Since the high inflation regime is denoted by R_t = 1, one expects that $\delta_0^0 < \delta_0^1$. Since most of the stabilization packages included de-indexation schemes, one expects that inflation persistence will decrease after the stabilization program is implemented, that is $\sum_{j=1}^{q} \delta_j^0 < \sum_{j=1}^{q} \delta_j^1$. Equation (12) shows the Markov chain transition probability matrix, I_I,, where λ_t^{ij} is the period t probability of switching from Regime i to Regime j in one period.

As examined in Sections II and III, stabilization attempts in chronic-inflation countries are likely to suffer from lack of credibility. Chronic-inflation countries have learned to live with high inflation, and as a result, the incentives to eradicate inflation are less than those in hyperinflation. Furthermore, countries with chronic inflation have a rich history of many failed stabilization attempts. As a result, typically policymakers will have a hard time convincing skeptical investors that the current stabilization plan will not collapse. Doubts about how likely these plans are to succeed can also be fueled by positive shocks to money growth and the budget deficit. To account for this behavior, we have introduced in (12) time-varying transition probabilities. These transition probabilities in turn depend on the behavior of those market fundamentals that indicate consistency of the announced monetary and fiscal policies with inflation targets. In line with the analysis in Section III, equations (13a) and (13b) postulate that the probability of switching regimes will be affected by surprises in the money market, ϵ_t^m, and by surprises in the government budget deficit ϵ_t^d. Positive money and fiscal shocks will suggest that the stabilization program is in danger of collapsing, with the probabilities of being in a high-inflation regime increasing (that is, β_m and β_d are expected

to be positive).[9] If β_m and β_d are equal to zero, the model collapses to that of Hamilton (1988) with constant transition probabilities λ^{01} and λ^{10}.[10]

Equations (14*a*) and (14*b*) describe the estimation of money and fiscal shocks. The money shock, ϵ_t^m, is a composite of money supply and money demand shocks and is estimated as the difference between the supply of real money balances minus the demand for money, which is inversely related to nominal interest rates, as assumed in equation (2). According to equations (13*a*) and (14a), unexpected increases in money supply or unexpected decreases in the demand for money will increase the probabilities of switching to a high inflation regime. Forecasts of government deficits are constructed using lagged government deficits and current and lagged nominal interest rates, as described in equation (146). Naturally, if fiscal reforms are implemented, the process followed by the fiscal deficit will be changing over time, as described in equation (6). To capture the evolving fiscal policy, we introduce the nominal interest rate in the forecasting equation. Because nominal interest rates fluctuate with inflation, they provide information about the changing degree of austerity of the government and the monetization of the fiscal imbalances. [11]

To allow for lack of credibility, we assume that market participants do not observe the current regime directly nor do they know when the regime switch will take place. Investors must estimate the probabilities of being in the different regimes based on the available information. Forecasts will look biased *ex post* if regime changes occur only sporadically. For example, if Regime O persists for some time, the sample mean of the forecast errors conditioned on R_t = O will be negative even though forecasts are rational *ex ante*. As argued above, the claim that *ex ante* real interest rates are significantly different from *ex post* real interest rates is equivalent to the hypothesis of a peso problem after the stabilization program is implemented.

To estimate the model in equations (11) – (14), we use a modified Hamilton's (1988) nonlinear filter. Since there is no presumption that in fact there were changes in regime, the estimation procedure does not impose the existence of two differentiated states. Moreover, the estimation is based on the assumption that the regime is not observed directly but must be inferred based on the observation of current and past values of inflation, money, interest

[9] To obtain a more parsimonious model, we impose that monetary and fiscal shocks affect the transition probabilities in the same proportion but with opposite signs.

[10] In this case $\lambda^{01} = \exp(\beta_0)/(1 + \exp(\beta_0))$

[11] Another possibility is to estimate equation (6); however, doing so would complicate the estimation process considerably.

rates, and the fiscal deficit. The optimal forecast of this process can be thought of as the following sequence of steps: For any period t, we have a certain prior about the probability of being in state 1 or O based on past information.

$$\text{Prior}(R_t = 1) = (1 - \lambda_{t-1}^{10})\text{Post}(R_{t-1} = 1) + \lambda_{t-1}^{01}[1 - \text{Post}(R_{t-1} = 1)] \tag{15}$$

where $\text{Prior}(R_t = 1) = \text{Prob}(R_t = 1|I_{t-1})$, $I_t = \{\Delta p_t, m_t, d_t, i_t, \ldots, \Delta p_1, m_1, d_1, ii\}$, and $\text{Post}(R_t = 1) = \text{Prob}(R_t = 1|I_t)$. We then calculate the density function of Δp_t

$$f(\Delta p_t|I_{t-1}) = f(\Delta p_t|R_t = 1)\ \text{Prior}(R_t = 1) + f(\Delta p_t|R_t = 0)[1 - \text{Prior}(R_t = 1)] \tag{16}$$

Finally, we update our predictions using the Bayes formula:

$$\text{Post}(R_t = 1) = \frac{f(\Delta p_t|R_t = 1)\ \text{Prior}(R_t = 1)}{f(\Delta p_t|I_{t-1})} \tag{17}$$

We update repeatedly over the entire sample using (15) – (17).

The estimation procedure is as follows. We start at $t = 1$ with the unconditional probability, which we set equal to the limiting probability of being in Regime 1 of the Markov process in equation (15). Using (15)-(17) we construct the sample log likelihood

$$\sum_{t=1}^{T} \ln f(\Delta p_t|I_{t-1}) \tag{18}$$

which can be maximized numerically with respect to the unknown parameters $\delta_0^i, \delta_j^i, \sigma_i^2, \beta_0, \beta_m$, β_d, and the parameters in the forecasting equations (equations (14a) and (14b)).

V. Results

The model in equations (11)-(14) was estimated using monthly data for the consumer price index. money supply, interest rates, and the government budget deficit for each country.[12] For Argentina the sample period extended from September 1981 to December 1988, for Israel it stretched from December 1982 to January 1988, and for Mexico it included observations from December 1984 to December 1990.

[12] The consumer price index, money Supply, and interest rates series were obtained from *International Financial Statistics,* lines *64, 34,* and 60p, respectively. The fiscal deficit of Argentina is the primary deficit of the Treasury published by FIEL in *Indicadores Económicos*; the fiscal deficit of Israel is the total deficit of the Central Government and was obtained from the data base of the Bank of Israel; and the fiscal deficit of Mexico is the deficit of the consolidated public sector, which is reported in *Indicadores Económicos* published by Banco de México.

Table 2 reports the results of this estimation. Panel A presents the estimates of the coefficients in equations (11)-(13). Panel B presents the average monetary and fiscal shocks over different periods, as estimated from equations (14a) and (146).13 We find that the inflation process in each regime is best described by an autoregressive process of order one. Hence we report just the results imposing $q = 1$. The estimated stochastic process followed by inflation has three main features. First, the estimates capture a low-inflation and a high-inflation regime for all the countries. In all three cases, the estimated δ_0 is lower in Regime O (low inflation) than in Regime 1 (high inflation). For example, in Israel we find that δ_0 is equal to 1.3 percent per month in the low-inflation regime while it increases to 3.7 percent per month during the high-inflation regime. Second, the degree of inflation persistence is estimated to be higher under high inflation than under low inflation. This may well be the result of the tight targeting of wages, prices, and the exchange rate under the broad agreements (social pacts) underlying heterodox programs. Third, in all cases the volatility of the shocks to the inflation process also seem to be contingent on the regime: high volatility prevails under high inflation.

The estimated probabilities of switching regimes are composed of two terms, the constant part, $\lambda = \exp(\beta_0)/(1 + \exp(\beta_0))$, and a time-varyin$_g$ part, which depends on the coefficients β_m and β_d, which in turn measure the response of the probabilities to money and fiscal shocks, respectively. Interestingly, we find that money and fiscal shocks do provide additional information on the stochastic process followed by the rate of inflation. In all cases we can reject at all conventional significance levels the null hypothesis that the probabilities of switching regimes are constant as in the Hamilton (1988) model. As expected, positive money and fiscal shocks increase the probabilities of switching to a high-inflation regime. Note that in the case of Argentina and Mexico the probabilities of switching regimes depend only on the monetary indicator. For Israel, the fiscal indicator is the one that affects the probabilities of switching regimes.

As noted above, panel B provides some indication of the severity of the fiscal or monetary contractions in each country over time. We measure the depth of the anti-inflation program by the average of the shocks to monetary or fiscal policies, as estimated from equations (14a) and (146). Since the probabilities of switching regimes in Argentina and Mexico depend only on monetary shocks, the index of severity for these two countries reflects only the depth of

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13 We d. not report th$_e$ estimates of the parameters in equations (14a) and (14b) because they "' '^{ot} provide any additional information to the discussion of credibility of the stabilization plans. However, they are available from the authors upon request.

the monetary contraction. Since only fiscal shocks seem to matter in the determination of the probabilities of switching regimes in Israel, the index of severity for Israel provides only a measure of fiscal austerity. The index is set equal to 100 for the twelve months before the stabilization program is launched. A number larger than 100 indicates a more severe contraction relative to the twelve months before stabilization. Using the results in this panel, the countries can be ranked according to the depth of the reform as follows: Israel first; Mexico second; and Argentina last. For the failed *Austral* plan in Argentina, the index reflects only a transitory monetary contraction during the first six months of the program. In contrast, the following eighteen months were characterized by an expansionary monetary policy that contributed to the collapse of the stabilization attempt. In contrast, the indexes for Israel and (to a lesser extent) for Mexico reflect a more persistent and drastic reform.

From the estimation of the model in equations (11)-(14) we can obtain the implied prior probabilities of a low-inflation regime. These probabilities measure the short-run (one-month) credibility of the stabilization package. The probabilities are reported in Figure 1 together with the level of foreign exchange reserves of the central bank. Naturally, in all the countries, before the stabilization program was implemented inflation was rampant as a result of expansionary monetary policy and large government deficits. The estimated probabilities capture this situation. In general, the probabilities of being in a low-inflation regime range from 1 percent to 30 percent in the 24 months before the implementation of the stabilization packages. After the implementation of the stabilization packages, the probabilities of a low-inflation regime increase sharply. Israel shows the strongest increase in these probabilities, whose levels reach about 99 percent within nine months after the program is implemented. A sharp fiscal restrain, as measured by the index of severity of the reform in Table 2, panel B, certainly contributes to improve credibility. The increased confidence in the success of the stabilization program contributes to reduce capital flight, with foreign exchange reserves of the central bank increasing almost 50 percent in the first year of the stabilization.

Mexico also shows a large increase in the probabilities of being in a low-inflation regime after the program is announced in December 1987. While fiscal shocks do not affect the probabilities of switching regimes, monetary shocks sharply increase the odds of success of the stabilization program. During the first half of 1988, monetary shocks, as indicated by the index of severity of the reform in Table 2, suggest an increasingly tighter monetary policy. Investors' assessment of the commitment of the government to the anti-inflation program improves, with probabilities of being in a low-inflation regime increasing from 13 percent during the first month of the program to 99 percent in July 1988. However, monetary policy

becomes more expansionary in the fourth quarter of 1988, which induces investors to decrease their odds of the maintenance of low inflation: the probabilities of being in a low-inflation regime decrease to about 80 percent by the first half of 1989. Naturally, this loss of credibility has a negative effect on foreign exchange reserves of the central bank. Within a year, reserves decline by 60 percent reaching a trough in May 1989. In contrast to Argentina, monetary policy in Mexico does not get out of control. The maintenance of the "pacto social," which keeps observed inflation low, together with a somewhat conservative monetary stance restore investors' confidence a bit in the third quarter of 1989. The small improvement in credibility helps to stop the depletion of foreign exchange reserves, which increase about 30 percent in the last six months of 1989. Although not shown in Figure 1, credibility declines again in the first half of 1990 fueled by unexpected expansionary monetary shocks, with international reserves of the Bank of Mexico also decreasing (about 15 percent in those six months).

The stabilization program is far less credible in Argentina. As in Israel and Mexico, immediately after the stabilization program is introduced, the probabilities of a low-inflation regime increase sharply. The de-indexation of the economy as a result of the heterodox *Austral* plan and contractionary monetary shocks contribute to the change in expectations of investors. Although money growth during the six months after the announcement continues at rates similar to those in the pre-stabilization period, the large monetization of the economy, due to the stabilization, results in a liquidity crunch: In this period, money shocks (money supply minus money demand shocks) are three times more restrictive than in the twelve months before stabilization (see Table 2, Panel B). Monetary policy, however, becomes more expansionary in 1986. Unlike the experience in Israel and Mexico, investors' confidence in the ability of the government to maintain low inflation deteriorates rapidly reaching a trough in September 1986. In this month, the probability of continuation of the stabilization program another month is just 50 percent. In October 1986, a new attempt at stabilizing the economy is taken, with monetary policy becoming more restrictive. This attempt to save the plan improves investors' confidence only for three months. In January 1987, the probabilities of a low inflation regime are already 47 percent. On February 27, 1987, the government introduces a new wage and price freeze and a modest crawling peg to be in force until May and June. The new announcement improves credibility temporarily, but by August 1987 the odds of success of the stabilization program (one-month ahead) decrease to 30 percent (not shown in figure). The program finally collapses, with inflation in the fourth quarter of 1987 on the order of 300 percent per year and foreign exchange reserves of the central bank decreasing to the low levels observed before the implementation of the

stabilization program. [14]

In Figure 2 we compare expected and actual rates of inflation before and after the implementation of the various stabilization programs. The two series move together, with expected inflation being lower than actual inflation before the stabilization program is implemented (and inflation is increasing) and higher after the stabilization program was implemented (and inflation is falling). The figures suggest that for Argentina there were prolonged episodes of *ex post* expectations errors in which expected inflation generally exceeded actual inflation. On average, during the eighteen months following the implementation of the program the forecasting error was about 12 percent (annual rate). At variance with the above, the evidence for Israel indicates that, as a result of the sharp reduction in the probabilities of being in the high-inflation regime, which resulted in several observations for which expected inflation is lower (and not higher) than actual inflation, *ex post* and *ex ante* inflation rates are practically the same in the aftermath of the stabilization program. Consequently: *ex ante* and *ex post* inflation rates diverge substantially in Argentina, but they move together in Israel (see our credibility tests below). The results for Mexico tell an intermediate story in which credibility starts to decline somewhat six months after the implementation of the program, but is restored a bit over the medium run. In any case, the average forecasting errors during the first year of the program are on the order of 6 percent at an annual rate.

We calculate (actual and expected) real interest rates in period t for each country by subtracting the (actual and expected) inflation rate between periods t and $t + 1$. Figure 3 depicts actual and expected real interest rates. One sees that lack of credibility and the gradual learning of the new regime go a long way in accounting for observed high *ex post* real interest rates in Argentina. For example *ex ante* real rates after the *Austral* program are just 24 percent per year whereas the *ex post* real interest rates average approximately 58 percent per annum over the semester after the stabilization. Thus, the distinction between *ex post* and *ex ante* real rates has empirical content. In contrast, the movements in the *ex ante* real interest rates in Israel tell a different story, one of an apparent credit crunch that

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14 The results just described coincide with the chronology of the developments of the stabilization package in Canavese and Di Tella (1988). These authors describe four stages of the *Austral* plan aa follows: 'The first lasted ten months, from June 1985 until March 1986, and was characterized by a price freeze and fiscal austerity. The second stage, from April to September 1986, was characterized by an attempt to administer prices in an easy money environment, resulting in a re-indexing of the economy and an acceleration of inflation. In the third stage, from October 1986 to February 1987, a restrictive monetary policy to curb renewed inflationary process was tried, despite the increased fiscal deficit. And finally, in the fourth stage, from February on, a new price and wage freeze and an announcement of a devaluation path until July 1987 were made." (page 157)

lasted for more than 18 months on average. Finally, the results for Mexico suggest that lack of credibility can explain only part of the high *ex post* real interest rates.

Also, we formally tested whether expected inflation differs significantly from actual inflation. For this purpose, we estimated the model inflation mean error (and corresponding t-statistic) for different subsamples: 18 months, 12 months, and 6 months before the stabilization program and 6 months, 12 months, and 18 months after the stabilization program. The results of this test are reported in Table 3. As expected, we capture a significant difference between actual and expected inflation for Argentina and Mexico after the stabilization program is implemented. On the contrary, for Israel we fail to find any bias in inflationary expectations.

VI. **Conclusions**

This paper examines whether investors' lack of credibility in the stabilization programs implemented in Argentina, Israel, and Mexico in the mid-1980s can explain the abnormally high real interest rates in the months after the launching of the programs. The stabilization packages in these three countries included as a key factor the pegging of the exchange rate to the U.S. dollar. With fixed rates, monetary growth becomes demand-determined, and thus government deficits financed by money creation will naturally signal conflicts of fiscal and monetary targets on one hand and the exchange rate target on the other, with a foreseeable currency crisis and a collapse of the stabilization program. Naturally, investors probably use information on monetary and fiscal policies to assess the likelihood of success of the anti-inflation program. To replicate one plausible mechanism through which investors assess the viability of the program, we estimate a regime-switching model of inflation in which the probabilities of switching regimes are affected by fiscal and money shocks. The estimation of this model allows us to examine whether in fact the stochastic process followed by inflation was modified by the adoption of the program and to construct probability inferences about the inflationary regime.

We find that the heterodox stabilization programs, with social pacts and wage and price agreements, did help to break inflation inertia at the very beginning of the anti-inflation program. Low inflation, however, did not necessarily improve investors' confidence in the government plan, as the market belief in the success of the plan depends not only on realized inflation but also on the behavior of fiscal and monetary fundamentals. In some cases, inflation may be reduced temporarily through wage and price controls, but disinflation depends on the compatibility of these controls with fundamentals. In this respect, we find that the

failed *Austral* plan was basically not credible almost from the outset, in view of the lack of a persistently contractionary monetary policy. In contrast, the profound fiscal measures implemented in Israel seem to have helped the government to gain immediate credibility, The Mexican experience tells an intermediate story with transitory insufficient adjustment in monetary policy, which fostered investors doubts a year after the implementation of the program and almost depleted foreign exchange reserves of the central bank. Notwithstanding this transitory lack of credibility, *ex ante* real interest rates were on average unusually high after the stabilization plan was launched. Our results on the presence or lack of credibility are supported by the evolution of foreign exchange reserves of the central bank, with increasing doubts about the plan being accompanied by the loss of foreign exchange reserves of the central bank.

Although our findings account, at least for Argentina and to a lesser extent for Mexico, for a substantial fraction of the rise in *ex post* real interest rates after disinflation in terms of lack of full policy credibility, there is a residual that needs to be explained. As indicated in the introduction, in some cases contractionary monetary policy may have contributed to high real interest rates after stabilization. We leave it for future research to determine the extent to which this additional factor accounts for the residual evidence.

In the 1980s debtor countries such as Argentina, Israel, and Mexico did not have complete access to international capital markets. After the debt crisis, according to international market perceptions, country risk for these countries certainly increased. For example, as noted by Khor and Rojas-Suarez (1991), the risk-premium of Mexican assets oscillated between 14 and 44 in the first three years of the stabilization program.[15] In view of this evidence, another important extension would be to attempt to capture the role of a time-varying country risk premium in explaining why domestic nominal interest rates do not fall much after a stabilization plan is implemented.

The different international scenario in the 1970s from the one in the 1980s may explain, in part, why interest rates drop substantially in Argentina and Uruguay after the *Tablita* programs were implemented in the late 1970s (see footnote 1) -in the midst of the first post-WWII capital inflow period to Latin America, with basically no restrictions to capital mobility and an almost non-existent risk of default (see, for example, Calvo and Kaminsky (1990)). Notwithstanding the different international scenario, the behavior of *ex post* real interest rates in purely exchange-rate-based plans -such as the *Tablita* plans, which do not

[15] The risk premium is estimated as the difference between the return on Mexican dollar-denominated assets (PAGAFES) and the LIBOR rate.

rely on wage and price controls– may be different from their behavior in more comprehensive heterodox plans. Inflation inertia and backward-indexation may keep, in the context of the former plans, actual and expected inflation rate above the nominal interest rate that falls –at least transitorily– with the rate of devaluation. Although important, these extensions are beyond the scope of this paper.

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Table 1

Inflation. Money Growth, and Government Deficits

Year/ Quarter	Inflation Rate (b)	Nominal Interest Rate (b)	Real Interest Rate (-b)	MI Growth Rate (a)	credit 10 Private Sector Growth Rate (a)	Government Deficit (in percent of GDP)
			ARGENTINA			
1982	250.9	201.9	6.2	247.5	224.0	12.6
1983	472.6	738.9	57.1	362.1	400.8	15.7
1984	745.9	868.8	10.9	566.7	554.1	17.2
1985:1	1268.3	1266.2	-4.2	500.0	684.8	
1985:2	1945.4	3143.1	307.8	650.0	1030.6	
1985:3	58.7	139.5	81.7	950.0	676.6	
1985:4	34.6	93.1	37.7	500.0	372.1	12.3
1986	85.9	107.5	10.5	86.7	83.7	8.5
1987	213.4	242.6	21.3	150.0	196.0	10.8
1988	513.8	430.4	-0.2	357.1	3s5.7	
			ISRAEL			
1982	135.7	140.2	5.7	110.3	158.0	10.0
1983	238.9	186.2	-0.4	138.1	198.5	6.0
1984	530.1	823.0	118.6	342.1	526.9	13.0
1985: 1	249.6	499.8	17.7	392.7	469.9	
1985:2	421.1	715.3	77.5	342.2	440.3	
1985:3	624.0	599,5	349.7	396.7	358.3	
1985:4	31.2	174.2	168.1	257.2	181.1	2.8
1986	20.8	62.1	31.5	119.9	16.1	-0.7
1987	16.7	62.1	41.2	51.0	20.6	3.3
1988	16.6	46.3	23.0	11.2	22.2	8.1
			MEXICO			
1984	60.2	48.6	-6.7	60.0	51.3	6.4
1985	66.2	60.2	-2.2	49.5	69.7	8.7
1986	108.2	86.7	-8.2	67.2	101.7	14.8
1987: I	133.6	96.1	-17.4	77.9	94.3	
1987:2	]48.0	92.0	-20.4	94.0	74.8	
1987:3	142.1	90.5	-21.4	123.1	74.8	
1987:4	244.5	105.2	-48.5	118.1	104.4	15,0
1988	74.8	69.2	23.2	67,8	66.9	11.3
1989	20.1	4s.0	19.6	37.4	45.6	5.4
1990	30.8	3S.8	6.4	62.9	41.7	3.6

Sources: Banco Central de la Republica Argentina. *Boletin Estadistico*: Banco de Mexico. *Indicadores Economicos*: IMF. *International Financial Statistics*: IMF. *Government Finance Statistics;* Dornbusch and de Pablo (1990).

Notes: All rates of change and interest rates are expressed in percent per year. The real interest rate is computed using the one-month-ahead inflation rate. (a) Annual rate. (b) Annual (quarterly) average of monthly rates.
The government budget deficits of these countries are defined us follows: for Argentina the deficit series reported is the Cavallo-Pena measure. for Israel the deficit corresponds m deficit o! the central government. and for Mexico it reflects the overall public sector deficit.

Table 2

Panel A

Switching-Regime Model for Inflation

Maximum Likelihood Estimates

$$\Delta p_t = \delta_0^i + \delta_1^i \Delta p_{t-1} + \varepsilon_t, \; E_t\text{-}N(O, \sigma_i^2) \qquad \text{Prob}\,(R_t = i \mid R_{t-1} = j) = \lambda_t^{ij}$$

Variable	δ_0^0	δ_1^0	δ_0^1	δ_1^1	σ_0	σ_1	λ	β_m	β_s
				ARGENTINA					
Coefficient	*0.0365*	*0.2460*	0.0434	0.7704	0.0191	0.0310	0.0612	7.7608	0.000.5
t-Statistic	5.7583	*4.1193*	2.6051	7.5297	5.9128	9.7264	1.2334	2.2094	().5625
				ISRAEL					
Coefficient	0.01 30	0.0985	0.0370	().5963	0.0097	().0379	0.0090	0.0000	0.0200
t-Statistic	*6.4067*	*2.3611*	2.1037	4.3286	8.6682	11.0587	0.5892	0.0000	1.9987
				MEXICO					
Coefficient	0.0072	*0.5091*	0.0150	0.7791	0.0040	0.0171	0.0870	10.0000	0.0000
l-statistic	6.9553	18.3109	1.9944	6.3823	6.0815	7.6255	1.2236	1.8000	0.0000

Notes: Parameters are defined by equations (11)-(13) and were estimated solely on the basis of observations on the rate of inflation. money and fiscal shocks, and interest rates.

Panel B

Index of Seventy of the Reform

	ARGENTINA	ISRAEL	MEXICO
Before stabilization			
12-mOnth period	100	100	100
After stabilization			
6-monrh period	306	562	120
12-month	91	*474*	185
24-month	-4	125	48

Notes: The index of severity reflects the tightness of monetary policy for Argentina and Mexico and the depth of the fiscal reform for Israel. The index is constructed using the estimates of monetary and fiscal shocks (equations (14a) and (14b)). A large number indicates tight monetary or fiscal policies.

Table 3
Were the Stabilization Programs Credible'?

Country	Period	Inflation Forecasting Error ($\Delta p_t - \Delta p_t^e$) Mean	t-statistic
	1983: 12-1985:05	1.23	1.31
	1984:06-1985:05	2.26	1.95
	1984: 12-1985:05	4.31	3.44
ARGENTINA	Stabilization		
	1985:08- 1986:01	-2.00	-12.36
	1985:08-1986:07	-1.37	-4.21
	1985:08-1987:01	-0.92	-3.01
	1984: 01- 985:06	2.21	1.21
	1984:07 - 985:06	2.24	1.28
	1985:01 - 985:06	2.57	1.70
ISRAEL	Stabiliza ion		
	1985:09 - 986:02	0.01	0.01
	1985:09-1986:08	0.02	0.05
	1985:09-1988:02	0.16	0.53
	1986:07- 1987: 12	0.53	1.91
	1987:01 - 1987: 12	0.76	2.82
	1987:07-1987:12	1.06	3.24
MEXICO	Stabilization		
	1988:02-1988:07	-0.88	-1.77
	1988:02-1989:01	-0.47	-1.55
	1988:02-1989:07	-0.44	-2.10

Notes: The mean forecast error is expressed in percent per month.

Figure 1

Probability of a Low-inflation Regime and Reserves of the Central Bank

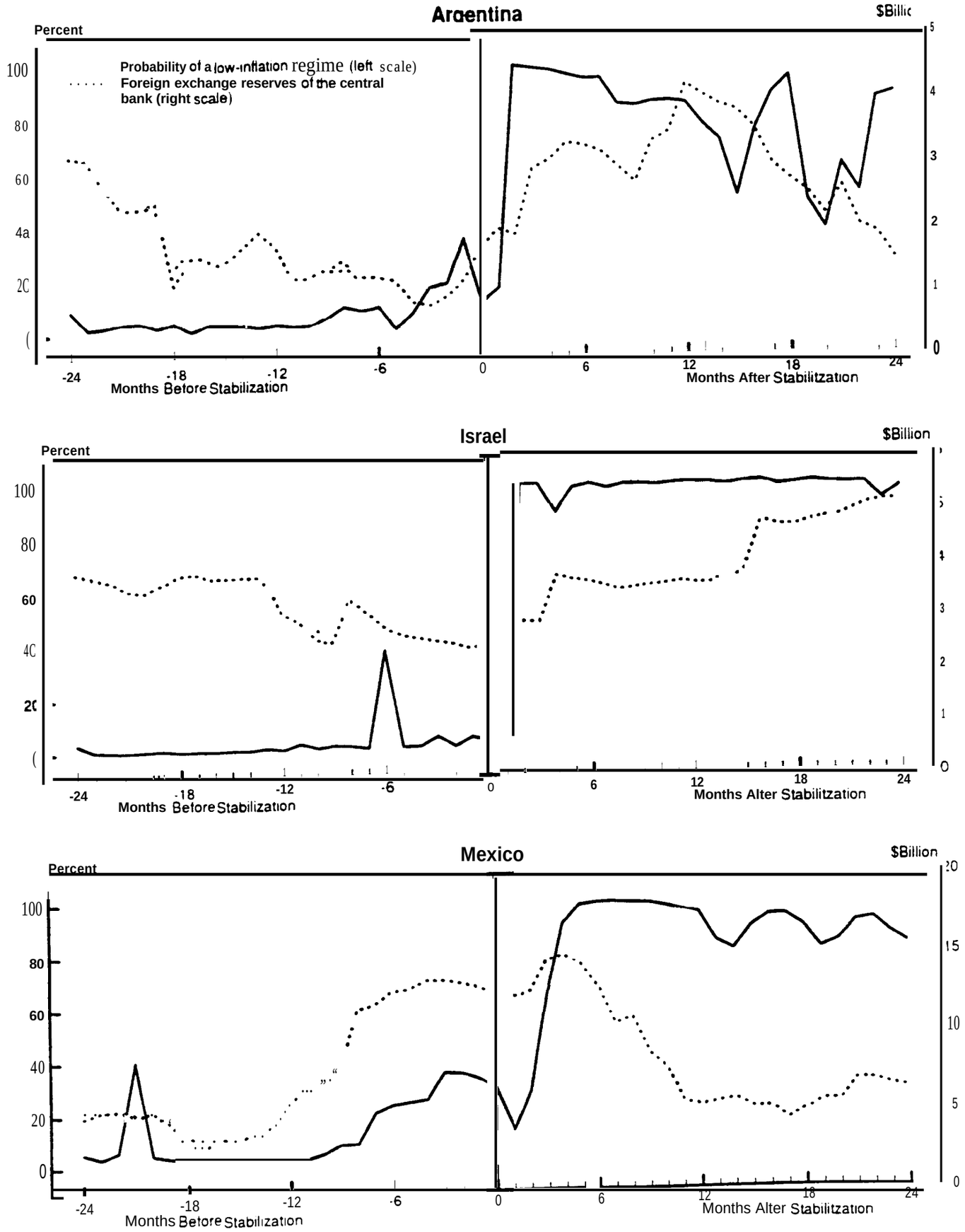
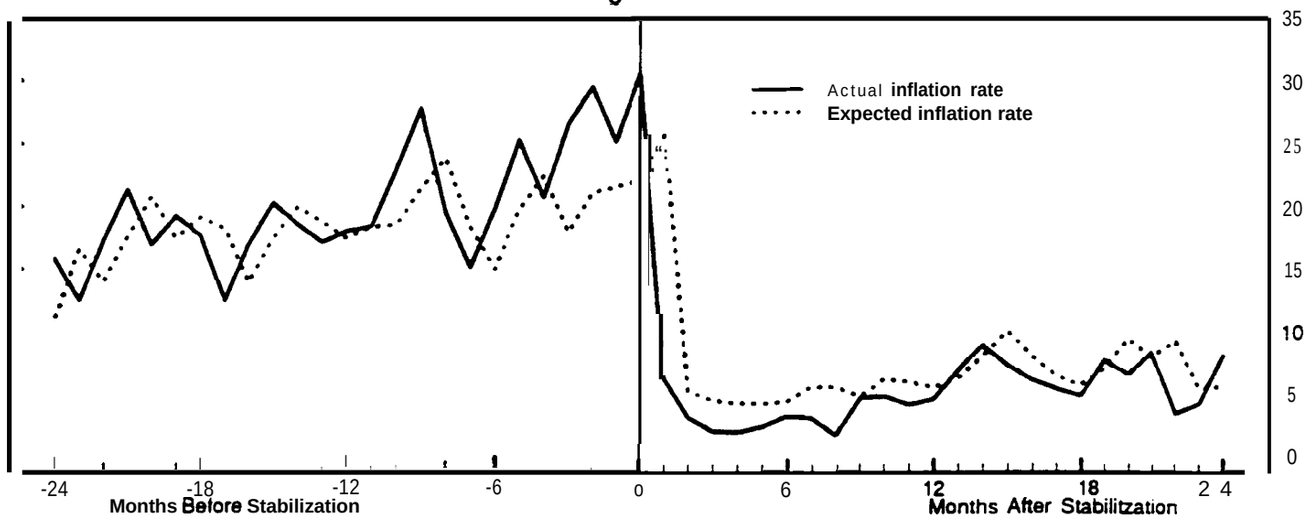


Figure 2

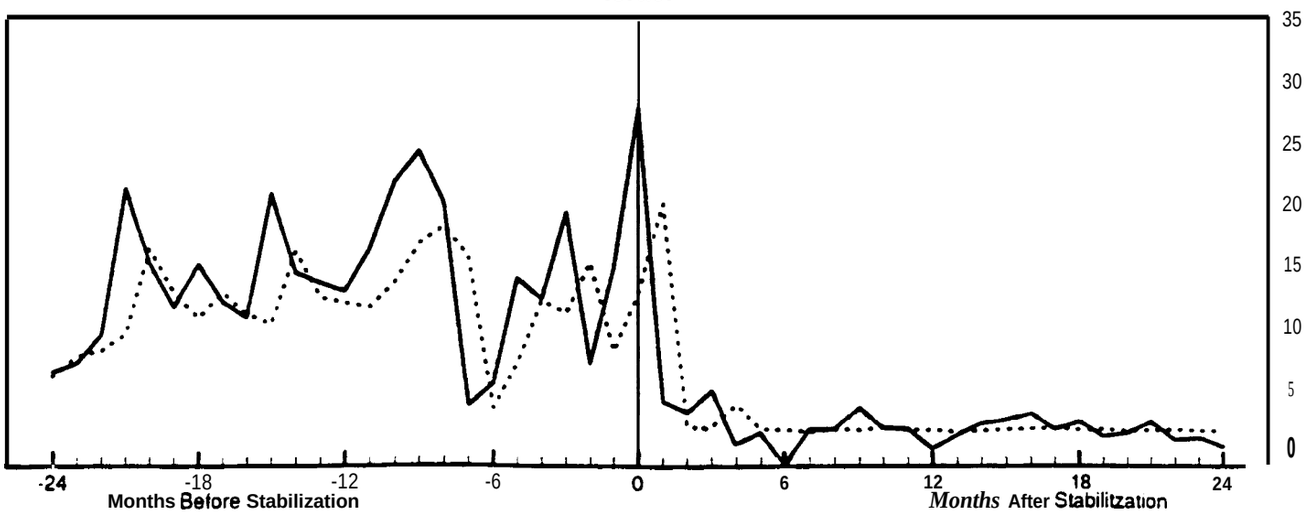
Actual and Expected Inflation Rates

(Percent per Month)

Argentina



Israel



Mexico

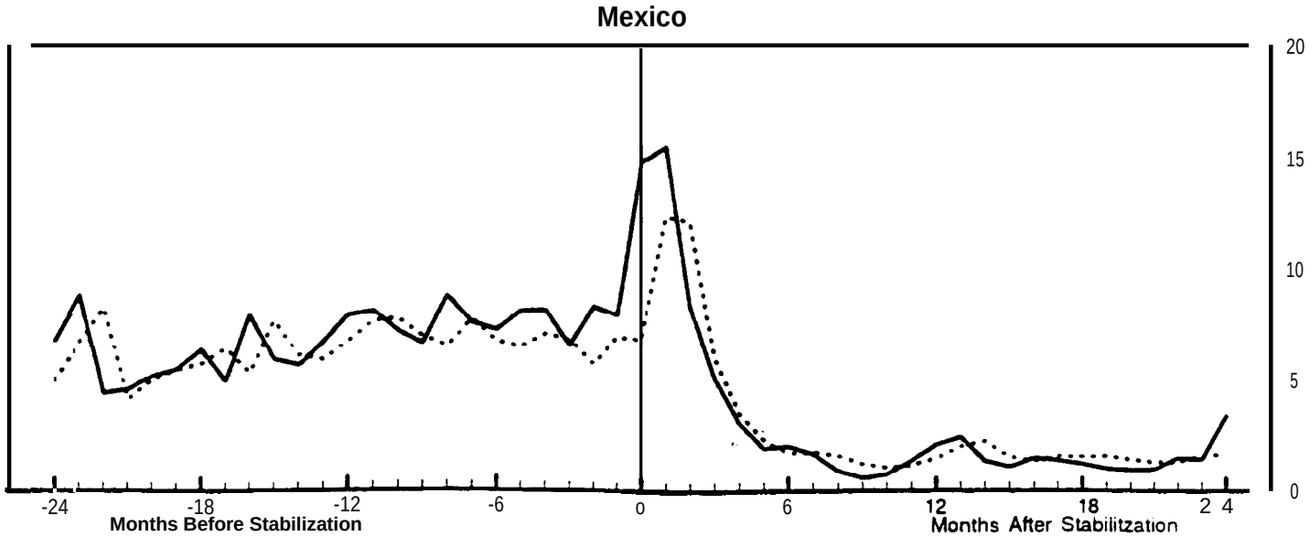
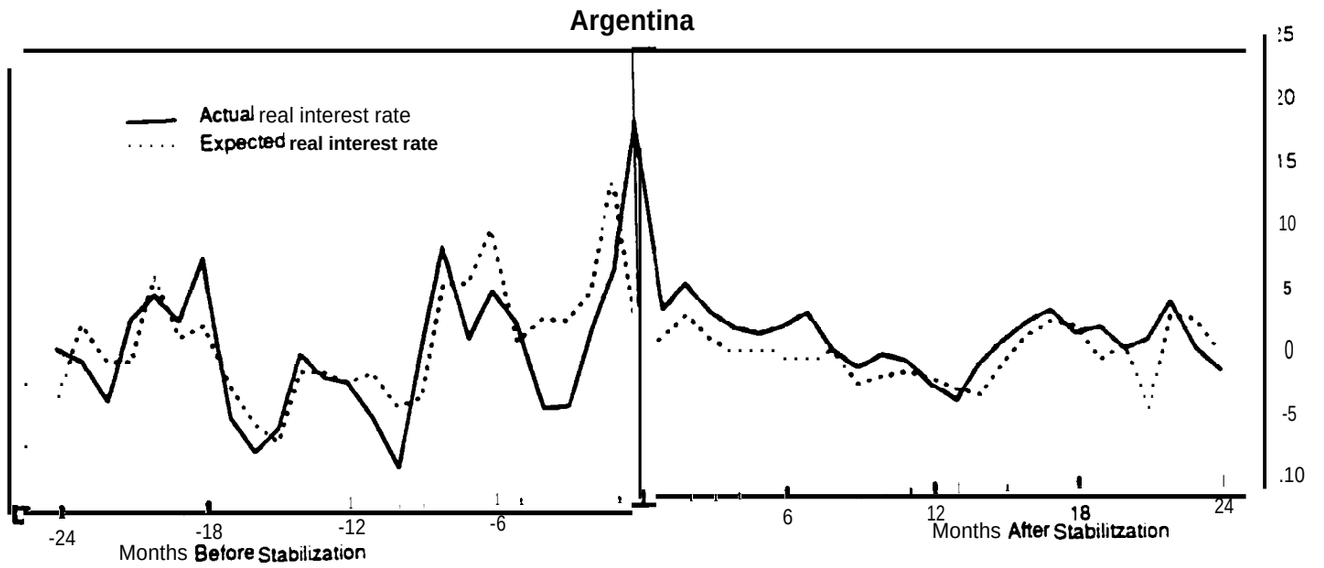
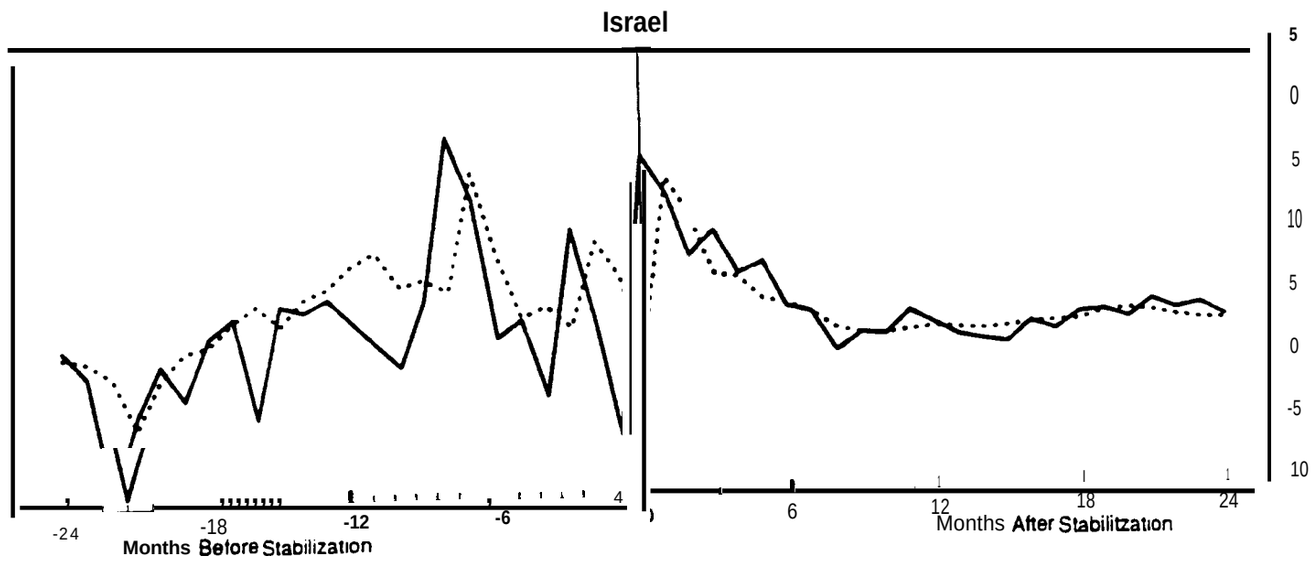


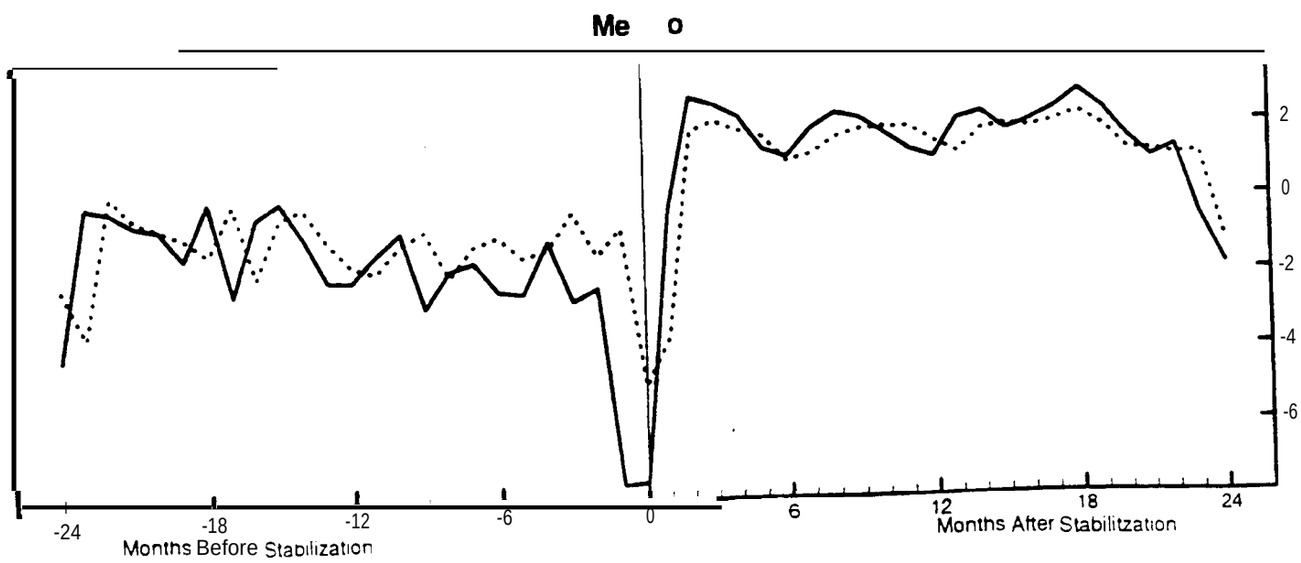
Figure 3

Actual and Expected Real Interest Rates

(Percent per Month)







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