The Mexican Peso Crisis: Overview and Analysis of Credibility Factors

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Abstract

This paper examines credibility and reputational factors in explaining the December 1994 crisis of the Mexican peso. After reviewing events leading to the crisis, a model emphasizing the inflation-competitiveness trade-off is presented to explain the formation of devaluation expectations. Estimation results indicate that investors appear to have seriously underestimated the risk of devaluation, despite early warning signals. The collapse of confidence that followed the December 20 devaluation may have been the result of a shift in the perceived commitment of the authorities to exchange rate stability.

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1 Introduction

Between the late 1980s and 1993, Mexico underwent a period of rapid economic transformation. Stabilization measures and structural reforms resulted in a sharp reduction in the fiscal deficit and a lowering of inflation to single-digit levels. However, a combination of adverse political shocks, a large and growing current account deficit, and policy shortcomings led to increasing reserve losses and growing dependence on short-term external borrowing. A devaluation on December 20, 1994, triggered a crisis of confidence that led to the subsequent collapse of the peso. As a result of the "Tequila" effect, events in Mexico led to serious pressures and increased volatility in financial and exchange markets in a number of Asian and Latin American countries. Between December 1994 and February 1995 the cumulative decline in stock market prices (measured in terms of U.S. dollars) reached 24.8 percent in Argentina and 22.6 percent in Brazil.

In part because of their systemic implications, understanding the recent events in Mexico has become a major preoccupation of academics and policymakers alike. A key issue in recent discussions has been the roles of economic "fundamentals" and "pure" speculation in causing the peso crisis. The purpose of this paper is to examine the extent to which credibility and reputational factors may help understand movements in Mexican interest rates before the crisis and the collapse of confidence that followed the devaluation of the Mexican peso.[1] As in Drazen and Masson (1994) and Masson (1995), credibility is defined as the likelihood, as perceived by private agents, that policy commitments will be carried out. More specifically, this notion of credibility is viewed as consisting of two elements: an assessment of the policymaker's "type" with respect to its commitment to a price or exchange rate target (which could be termed reputation), and (given the type of policymaker) an assessment of the probability that a policymaker subject to policy tradeoffs will actually decide to stick to announced policies—in the context considered here, maintain the exchange rate peg—in the presence of

[1]Models of speculative attacks in the Krugman-Flood-Garber tradition (see Agénor and Flood, 1994) have been used in numerous studies of exchange rate crises in developing countries. See, for instance, Cumby and van Wijnbergen's (1989) study of Argentina, and Blanco and Garber (1986), Connolly and Fernandez (1987), and Goldberg (1994) on previous crises of the Mexican peso. See also Calvo (1995) for more recent models of foreign exchange crises, emphasizing notably the role of foreign borrowing.

adverse shocks.[2]

The remainder of the paper is organized as follows. Section II provides an overview of macroeconomic developments during the period preceding the crisis.[3] Our analysis suggests, as many commentators have recently emphasized, that the peso collapse resulted from a combination of expansionary fiscal and credit policies—partly related to the electoral cycle—heavy dependence on short-term borrowing, and exogenous political shocks. A striking feature of the crisis, however, is that there was no evidence of a confidence crisis in the months preceding the decision to devalue. We argue that this pattern may have resulted either because investors perceived "fundamentals" to be essentially appropriate or improving—after several years of continued real exchange rate appreciation and growing external deficits—or because private agents (following the election of the ruling party candidate in August) had regained confidence in the policymakers' intentions—particularly regarding the exchange rate peg. Section III presents a simple model, based on the inflation-competitiveness tradeoff, through which the role of credibility and reputational considerations on the formation of devaluation expectations can be captured. Section IV provides estimates of the model over the period March 1991-November 1994 using a Kalman filter technique to account for changes in credibility over time. Section V offers some final observations on the factors underlying the collapse of confidence in the aftermath of the peso crisis.

2 The Mexican Peso Crisis: An Overview

Between 1988 and 1993, macroeconomic stabilization and economic reform in Mexico led to a sharp reduction in inflation and a significant improvement in the operational balance of the public sector (Figure 1).[4] A key factor in

[2]A recent study attempting also to distinguish the temptation to devalue from reputation along the Drazen-Masson lines is Holden and Vikøren (1996). It should be noted that the concept of credibility that underlies these studies is by no means universally accepted. Cukierman and Liviatan (1991), for instance, define credibility as the ability of the government to precommit its actions—that is, its capacity to convince private agents that it will carry out policies that may be time inconsistent.

[3]Our overview of the events leading to the peso crisis relies in part on International Monetary Fund (1995*a*, 1995*b*).

[4]See Aspe (1993) for a comprehensive overview of Mexico's reform and stabilization during that period.

bringing down inflation to single digit levels was exchange rate policy. Specifically, this involved the fixing of the Mexican peso-U.S. dollar exchange rate in December 1987 (which lasted until January 1989), followed by a preannounced narrow margin crawling peg and the adoption in November 1991 of a crawling peg with adjustable bands. The floor of the band (that is, the more appreciated limit of the band) was kept constant while the ceiling was allowed to depreciate relative to the U.S. dollar at a predetermined rate. As a result, the intervention band widened from 1 percent in November 1991 to 9 percent at the end of 1993. Between January 1990 and December 1993, the peso depreciated in nominal terms by about 17 percent.

However, nominal depreciation over the period did not prove sufficiently large to prevent growing real exchange rate appreciation. Between January 1990 and December 1993, the real effective exchange rate based on consumer prices appreciated by almost 35 percent (Figure 2). At the same time, the current account deficit widened from 3.2 percent of GDP in 1990 to 4.8 percent in 1991 and 6.6 percent in 1992-1993, averaging $24 billion in these two years (Figure 3). Despite the growing external deficit, a surge in capital inflows led to a significant increase in gross international reserves, which stood at $ 19.4 billion at the end of 1992 and $25.4 billion at the end of 1993, compared to $6.5 billion in 1989. In order to sterilize capital inflows, the authorities issued large amounts of short-term treasury bills (*Certificados de Tesoreria*, or Cetes bonds) denominated in pesos.

Large capital inflows continued during the first quarter of 1994, after the approval of the North American Free Trade Agreement (NAFTA) by the U.S. Congress in November 1993. As a result, the interest rate differential between Cetes bonds and interest rates in the United States declined significantly. Figures 4 and 5 decompose this differential into two components: the interest rate differential between Cetes and Tesobonos (short-term dollar liabilities repayable in pesos), which represents an indicator of currency risk, and the Tesobono-U.S. CD rate differential, which represents an indicator of country or default risk.[5] The figures show that both components of the Cetes-U.S. interest rate differential narrowed in early 1994. The Cetes-Tesobono differential fell from a peak of about 10 percent in early November 1993 to about 3 percent in early April 1994, whereas the Tesobono-U.S. CD

[5]Alternatively, the differential between Tesobono assets and U.S. interest rates could be calculated using the yield on U.S. Treasury bills. In practice, the choice between the two U.S. interest rate series is immaterial.

rate differential dropped from about 2 percent in December 1993 to less than half a percentage point in early March 1994.[6]

However, the macroeconomic policy stance weakened considerably in 1994. Fiscal policy became more expansionary, as the government increased expenditure financed through state-controlled development banks. Credit to the financial system expanded sharply between March and June 1994, from 15.7 to 33.5 billion pesos. It rose further by about 10 percent (to 36.5 billion pesos) in September 1994. Net credit to the public sector also expanded, from -12.5 billion pesos in March to -2.1 billion pesos and -1.6 billion pesos in June and September, respectively. Credit extended by official development banks (such as Nacional Financiera) grew at an annual rate of more than 40 percent in the first three quarters of the year. The overall expansion in credit largely offset the effect on liquidity of the fall in net foreign assets of the Bank of Mexico. The monetary base fell only slightly, from 47.1 billion pesos in March 1994 to 45.3 billion in June and 45.8 billion in September 1994. Overall, the money supply expanded in 1994 at the same rate as in 1993 (about 18 percent), but credit extended by the banking system to the private sector expanded at a rate of 32 percent.

The expansion in domestic credit and relaxation of the fiscal stance (which appear to have been related to electoral considerations) and a series of adverse political events (unrest in Chiapas in January and the assassination of presidential candidate Luis D. Colosio in March), brought the Mexican peso under severe pressure in the second quarter of 1994. The Cetes-Tesobono interest rate differential rose above 10 percentage points in April (Figure 4). The stock of international reserves fell from $26.8 billion at the end of March to $16.9 billion by the end of June 1994. To stem capital outflows, the authorities raised domestic interest rates and allowed the peso to move to the upper limit of the exchange rate band. Reserves then remained relatively stable through the period of the presidential election in August, as negotiations continued on the social-economic pact (the Pacto) into September. During that period, the exchange remained at or near the ceiling of the authorities' intervention bands (Figure 7). The authorities also substituted short-term indebtedness denominated in foreign currency for peso-denominated debt. As a result of these swap operations, the outstanding stock of Tesobonos more

[6] As shown in Figure 6, however, prices of Mexican Brady bonds–fixed-income government paper issued in exchange for restructured commercial bank debt–indicate a modest increase in the perceived degree of country risk in the early part of 1994.

than doubled between March and April 1994 from 14.0 billion to 36.4 billion pesos, reaching 47.5 billion pesos in June and 64.9 billion pesos in July. The share of Tesobonos in proportion of the total stock of Cetes and Tesobonos held by the private sector rose from less than 10 percent in January-February 1994 to more than 40 percent in April and almost 60 percent in July (Figure 8). Although the Cetes-Tesobono differential does not indicate significant increases in devaluation expectations, a direct measure of the expected rate of depreciation of the peso (shown in Figure 9) suggests that some participants in international financial markets (those covered by the monthly survey conducted by Currency Forecasters' Digest) did attach a higher probability to a devaluation–at least through September 1994.

The current account deficit continued to deteriorate in the third quarter of 1994 (reaching 7.6 percent of GDP on average for the year as a whole), heightening concerns about the sustainability of Mexico's external position. Political unrest in Chiapas intensified after the Zedillo administration took office on December 1, 1994. These developments were accompanied by increased pressure on the exchange rate and large capital outflows. Despite relative stability from end-April until August and a slight improvement between September and October (Figure 1), official reserves fell further to $10 billion in mid-December. The stock of Tesobonos continued to increase, from 78.4 billion pesos in September to 85.2 billion pesos in November. As a proportion of the privately-held stock of Cetes and Tesobonos, the share of Tesobonos reached 80 percent in that month (Figure 8). The continued accumulation of short-term dollar liabilities offset to some extent movements in reserves but exposed the authorities' debt servicing operations to greater exchange rate risk. Although currency risk and default risk indicators did not deteriorate significantly (Figures 4, 5, and 6), the Cetes-Tesobono interest rate differential remained significantly above its first quarter level–indicating that investors' devaluation expectations were somewhat higher towards the end of the year.

On December 20, the exchange rate band was widened by 15.3 percent and the Mexican authorities announced their intention to support the currency at about 4 pesos to the U.S. dollar. But the Bank of Mexico was unable to hold the exchange rate there. Widespread investor fears put further pressure on foreign exchange and financial markets (leading to a loss of reserves of $4 billion in two days) and forced the adoption of a free float regime on December 22. The peso, which had closed at 3.47 to the U.S. dollar on December 19, quickly depreciated in the ensuing days to around 5.5 to the U.S. dollar.

It recovered slightly afterwards, but between December 20 and January 3, 1995 the peso depreciated by about 30 percent from its pre-devaluation rate. Domestic interest rates rose sharply, with the 28-day Cetes rate increasing nearly three-fold to an annualized level of 45 percent by January 10, 1995.[7] At end-December 1994, the value of the outstanding stock of Tesobonos amounted to about 29 billion U.S. dollars, or approximately 156 billion pesos, at the prevailing exchange rate.

A striking feature of the peso crisis is that the perceived devaluation risk, as measured by the Cetes-Tesobono interest rate differential, did not reach very high levels in the months preceding the decision to devalue. As shown in Figure 4, although the currency risk indicator jumped upward in April 1994 (following the Colosio assassination), it followed a downward trend until early December.[8] The country risk indicator evolved in a similar manner (Figure 5). Two sets of factors may explain this pattern. First, it may be that investors perceived "fundamentals" to be essentially appropriate– despite the growing real appreciation of the exchange rate and the widening of the current account deficit.[9] Second, investors may have given the benefit of the doubt to the newly-elected president and his team, in particular concerning their commitment to the announced exchange rate policy. As noted earlier, the exchange rate anchor had been an important element of the adjustment program implemented by the previous government in the late 1980s.[10] The drop in the Cetes-Tesobono interest rate differential from an average of about 10 percent between April and July 1994 to about 7.5 percent between August and early December may indeed be viewed as re-

[7]As illustrated in Figure 6, prices of Mexican Brady bonds also fell sharply on international markets in the weeks following the peso collapse.

[8]Survey-based expectations do indicate that investors perceived a growing risk of devaluation between November 1993 and August 1994, that is, until the time of the presidential election (Figure 9). In September the perceived currency risk increased further, perhaps as a result of rumors of an impending change in exchange rate policy. However, in October devaluation expectations were sharply revised downward.

[9]The lack of relevant and timely data on some important macro- economic aggregates (such as government spending and the level of foreign reserves) may have hampered investors' assessments of Mexico's situation during 1994, and may have led to the erroneous perception that economic policies were fundamentally sound. However, it should be noted that the issue of the sustainability of the external deficit did not emerge abruptly: the appreciation of the real exchange rate started in 1988, and the current account deficit had already reached very high levels in 1991.

[10]Zedillo was a member of the team that implemented the adjustment program under President Salinas.

flecting increased confidence in the authorities, as well as reduced concern about political instability. The analysis below attempts to disentangle the effects of these two sets of factors—economic fundamentals and the authorities' perceived commitment to their exchange rate policy—in the evolution of devaluation expectations.

3 Credibility and the Inflation Competitiveness Tradeoff

To assess the role of credibility and reputational factors in the Mexican peso crisis, a simple model is developed in what follows. The model attempts to explain fluctuations in exchange rate expectations, as measured by the differential between the rate on Cetes (payable in domestic currency) and on Tesobonos (whose value is linked to the U.S. dollar).[11] It posits an objective, or loss, function guiding the actions of the authorities in the face of domestic or external shocks- -in particular, the choice of whether to devalue or not, relative to the preannounced path for the exchange rate.[12] However, financial market prices also reflect assessments about the "type" of the policymaker, as captured by the relative weights that the authorities place on each of their policy objectives, which are not known by the private sector. Such a modeling setup has become standard since the work of Backus and Driffill (1985) and Vickers (1986). Moreover, financial markets—knowing that random shocks hitting the economy will tip the balance of costs and benefits for devaluation relative to maintaining the exchange rate path—will reevaluate on the basis of observed variables the probabilities that a particular type of government will decide to devalue in the future.

The analytics of this modeling strategy are discussed more fully in Drazen and Masson (1994) and Masson (1995). Its essential features are uncertainty

[11] An alternative measure of devaluation expectations, as discussed earlier, is the survey measure produced by Currency Forecasters' Digest, which represent "consensus forecasts" of some major companies. The Cetes-Tesobono interest rate differential, however, provides a more comprehensive measure of currency expectations held by all market participants.

[12] As recognized by many commentators, Mexico's exchange rate regime was not very different from a fixed exchange rate: the exchange rate was at the ceiling of the band for most of 1994, and the ceiling itself was allowed to depreciate at a very gradual rate. For simplicity, therefore, we assume below that the nominal exchange rate is constant between devaluation episodes.

about policymakers' preferences and exogenous shocks that directly or indirectly affect the variables that enter into those preference functions. In addition, if there is persistence in the effects of policies, then a restrictive policy carried out today may make it less likely that such a policy will be continued in the future.[13]

In the setup considered here, there exists a perceived tradeoff between fighting inflation, on the one hand, and maintaining a reasonable level of competitiveness so as to maintain economic activity by preventing a deterioration of Mexico's external accounts, on the other. In this setup, shocks to domestic prices (due, for instance, to domestic credit expansion) will tend both to raise inflation and to worsen competitiveness. The higher the weight put on maintaining competitiveness versus limiting inflation, the more likely that the authorities will be led to devalue.[14] The combination of a view that policymakers put a low weight on containing inflation and unfavorable developments for competitiveness would thus, in this model, explain widening interest differentials. The expected devaluation rate is thus decomposed into two parts: *a*) the probability that the authorities do not truly put a high weight on limiting inflation, and *b*) the probability that an exogenous shock will make a devaluation the preferred policy option, given their objective function. The assessment of the authorities' type is updated using Bayesian inference, over the period that the peg was maintained, and taking into account the relative probabilities that the two types of policymaker would have chosen to do so.

The first component of (lack of) credibility, the probability that policymakers put a low weight either on inflation control or exchange rate stability, is modeled using Bayesian updating, on the assumption that there are two possible types of policymaker, each with a known set of weights on its objectives. As a shorthand, we can call these two types "weak" and "tough" policymakers. Thus, investors can calculate the likelihood ex ante of each type deciding to devalue, or alternatively maintaining the exchange regime

[13]Thus, in the Drazen-Masson framework, a restrictive monetary policy may in some circumstances harm, not help, the credibility of anti-inflation policy, if by depressing output it makes it more likely that an adverse output shock will further lower output to the extent that monetary policy will have to be eased later. However, this latter aspect is not developed here.

[14]As shown for instance by Agénor (1994), the inflation-competitiveness tradeoff leads to a devaluation bias—in a similar manner to the inflationary bias of the Barro-Gordon model. See also Andersen and Risager (1991).

of an announced crawling peg. Ex post, the absence of devaluation gives information about whether the policymaker is weak (even if the shocks cannot be observed), so that initial priors about that probability are updated on the basis of the relative likelihood that each policymaker would not have devalued, given the distribution of the unobserved shocks.

Formally, let the authorities' one-period loss function L_t be given by[15]

$$L_t = s_t^2 + \theta \Delta p_t, \quad \theta > 0 \tag{1}$$

where Δp_t is the rate of consumer price inflation, s_t the level of competitiveness, defined below and expressed in logs, as a deviation from its base period level—and the weight θ can take on one of two values θ^w and θ^T, for weak and tough governments, respectively, with $\theta^T > \theta^w$. For simplicity, the objective function is assumed to be linear in inflation (since inflation is always positive in our sample, attention to the disutility of deflation is not necessary) but quadratic in competitiveness (loss of competitiveness is associated with employment losses and balance-of-payments problems, while excessively competitive exports could lead to undesirable shifts out of nontradables into tradables and immiserizing real wages). Stickiness in wage setting, in a now-standard fashion, is modeled in terms of overlapping contracts, where a fraction of all contracts come up for renewal in each period. For those contracts, wages are set to equal expected consumer prices. In turn, domestic output prices are a fixed markup over wages. This gives an equation in which (the logarithm of) the domestic output price p_t^d is a weighted average of (the logarithm of) expected consumer prices and lagged output prices, plus an error term ε_t:

$$p_t^d = \alpha E_{t-1} p_t + (1-\alpha) p_{t-1}^d + \varepsilon_t, \tag{2}$$

where $E_{t-1} x_t$ denotes the expectation of x formed at $t-1$.

The consumer price index is defined as a weighted average of foreign prices p_t^* converted at the current nominal exchange rate e_t (with weight δ) and domestic output prices (with weight $1-\delta$):

$$p_t = (1-\delta) p_t^d + \delta (e_t + p_t^*), \quad 0 < \delta < 1 \tag{3}$$

[15] A more general multi-period formulation, along the lines of Drazen and Masson (1994), would allow considering the role of future potential gains in reputation in choosing today's policies. However, such a specification would complicate considerably the analysis, and would preclude the use of a closed-form solution for estimation.

Expected consumer prices are therefore given by

$$E_{t-1}p_t = (1-\delta)E_{t-1}p_t^d + \delta(E_{t-1}e_t + E_{t-1}p_t^*). \tag{4}$$

Substituting equation (4) in equation (2) and solving for the domestic price level gives

$$p_t^d = \alpha\delta\mu(E_{t-1}e_t + E_{t-1}p_t^*) + (1-\alpha)\mu p_{t-1}^d + \varepsilon_t, \tag{5}$$

where $\mu = 1/[1-\alpha(1-\delta)] > 0$.

Defining the level of competitiveness as $s_t = e_t + p_t^* - p_t^d$ yields, using equations (3), (4) and (5):

$$s_t = -\alpha\delta\mu E_{t-1}(\Delta e_t + \Delta p_t^*) + (\Delta e_t + \Delta p_t^*) + (1-\alpha)\mu s_{t-1} - \varepsilon_t, \tag{6}$$

$$\Delta p_t = \alpha\delta(1-\delta)\mu[E_{t-1}(\Delta e_t + \Delta p_t^*) - s_{t-1}] + \delta(\Delta e_t + \Delta p_t^*) + (1-\delta)\varepsilon_t. \tag{7}$$

Expectations of exchange rate change depend on the probabilities that policymakers are weak or tough and the ex ante probabilities that a given type will decide to devalue in the light of a shock to domestic inflation. The sequence of events is assumed to be as follows: *a*) the private sector forms its devaluation expectations and agrees to wage contracts prior to the occurrence of any shock; *b*) policymakers observe a shock to inflation; and *c*) they decide whether or not to devalue. Here, the government devalues when a shock ε to domestic prices is large enough that the costs of maintaining the peg—in terms of loss of competitiveness—exceed those of incurring higher inflation. Let L_t^F be the value of the loss function if the exchange rate is kept fixed (so that $\Delta e_t = 0$), and L_t^D the value when the exchange rate is devalued—so that $\Delta e_t = d$, where d, the devaluation size, is assumed exogenous. The government therefore devalues when $L_t^D - L_t^F < 0$.

From equations (1), (6), and (7), the difference in values of the objective function L_t^D versus L_t^F is given by

$$L_t^D - L_t^F = 2d\Delta p_t^* + d^2 - 2d[\alpha\delta\mu E_{t-1}(\Delta e_t + \Delta p_t^*) - (1-\alpha)\mu s_{t-1} + \varepsilon_t] + \theta\delta d.$$

Therefore, $L_t^D - L_t^F < 0$—implying that the authorities choose to devalue—if and only if

$$\varepsilon_t > \tilde{\varepsilon}_t \equiv \Delta p_t^* + \kappa + (1-\alpha)\mu s_{t-1} - \alpha\delta\mu E_{t-1}(\Delta e_t + \Delta p_t^*), \tag{8}$$

where $\kappa \equiv d/2 + \theta\delta/2$. $\tilde{\varepsilon}_t$ depends, through κ, on the policymaker's type, since θ can take on one of two values θ^w or θ^T.

The private sector does not observe the shock to inflation, but just its own output price and whether the government devalued or not. The private sector's assessment of the probability of devaluation ρ_t is equal to the probability of a weak government π_t times the probability that a weak government will devalue ρ_t^w, plus a corresponding term for a tough government:

$$\rho_t = \pi_t \rho_t^w + (1 - \pi_t)\rho_t^T. \tag{9}$$

The expected devaluation rate is the product of the devaluation probability ρ_t and the devaluation size d:

$$\rho_t d \equiv E_{t-1}\Delta e_t = [\pi_t \rho_t^w + (1 - \pi_t)\rho_t^T]d. \tag{10}$$

Given knowledge of the authorities' objective function and of the distribution of shocks, the private sector can calculate the probabilities ρ_t^w and ρ_t^T. A large enough shock to consumer prices will lead to a devaluation because of its adverse effect on competitiveness, but the threshold level is lower for a weak policymaker than a tough policymaker.

Now ρ_t^h, for $h = w, T$, can be written as

$$\rho_t^h = \Pr(\varepsilon_t > \tilde{\varepsilon}_t).$$

Assuming that ε_t follows a uniform distribution in the interval $[-v, v]$, with $2v > d$, yields

$$\rho_t^h = (v - \tilde{\varepsilon}_t^h)/2v. \tag{11}$$

Using equations (8) to (11), we can solve for $\rho_t d$:

$$\begin{aligned} \rho_t d \;=\; & \left\{ \frac{d(2v-d)}{4v} - \theta^T(\delta d/4v) \right\} \Omega + (d/2v)(\theta^T - \theta^w)(\delta/2)\Omega\pi_t \\ & -(d/2v)\Omega\Delta p_t^* - (1-\alpha)\mu(d/2v)\Omega s_{t-1}, \end{aligned} \tag{12}$$

where

$$\Omega = \frac{1 - \alpha(1-\delta)}{1 - \alpha[1 - \delta(1 - \frac{d}{2v})]} > 1.$$

The solution for the expected devaluation rate can thus be written as

$$E_{t-1}\Delta e_t = a_0 + a_1\pi_t + a_2\Delta p_t^* + a_3 s_{t-1} + u_{t,} \tag{13}$$

where $a_1 > 0$, $a_2 < 0$, $a_3 < 0$, and u_t is an error term. Devaluation expectations thus depend directly on the probability of a weak government, and inversely on foreign inflation and the level of competitiveness.

The updating equation for π_t is derived as follows. Starting from a prior estimate π_{t-1} of the type of government, investors observe the absence of a devaluation at time $t-1$. Bayesian updating implies revision of π_{t-1} on the basis of the relative likelihoods that the two types would have chosen not to devalue:

$$\pi_t = \frac{1-\rho_{t-1}^w}{(1-\rho_{t-1}^w)\pi_{t-1} + (1-\rho_{t-1}^T)(1-\pi_{t-1})}\pi_{t-1}. \tag{14}$$

Substitution of (11) for ρ_t^w and ρ_t^T in equation (14) gives a complicated non-linear expression, which is not written here. As in Masson (1995), it is estimated in linearized form. This equation is given by

$$\pi_t = b_1\pi_{t-1} + b_2\Delta p_{t-1}^* + b_3 s_{t-2} + z_t, \tag{15}$$

where $0 < b_1 < 1$, $b_2 > 0$, $b_3 > 0$, and z_t is an error term. It is notable that although foreign inflation and competitiveness have negative coefficients in (13), the reverse is true of their lagged values in equation (15): the willingness to accept a loss of competitiveness and lower foreign inflation without devaluing signifies that policymakers are less likely to be weak–and hence leads to a lower value of π_t.

4 Estimation Results

The model was estimated using monthly data for Mexico from March 1991 through November 1994. The time period was dictated by the availability of data, and by the fact that the Mexican authorities devalued in December 1994. The models were estimated using a Kalman filter, with a measurement equation (equation 13 above) for the Cetes-Tesobonos differential $diff_t$ and an equation for the unobserved state variable given in equation (15). The maximum likelihood procedure *MAXLIK* in Gauss 3.1 was used, starting from an initial value of equal to 0.5 (the path for the state variable was subsequently adjusted using the estimated constant term in the measurement equation, as described below). Means were removed from the variables for competitiveness and the U.S. interest rate, after taking logs in the case of

the first variable. Interest rates and inflation are at monthly rates.[16]

The state variable is calculated in each case as follows: the path for (starting from a value of 0.5) that results from estimation is adjusted using the formula $\pi'_t = \pi_t + a_0/a_1$. This essentially attributes the constant term to concerns about the type of government, so that if $\pi_t = 0$ and the other right-hand side variables were at their means (that is, were equal to zero), Cetes would pay the same rate as Tesobonos, indicating complete credibility of a "tough" government.

Results are presented in Table 1. Three variants are presented. The first includes all variables appearing in the measurement and state equations (as defined above), together with two dummy variables in the state equation: "*colosio*" and "*election*", which are temporary dummies taking values of unity in April and August, 1994, respectively, and zero otherwise.[17] The first dummy is expected to have a positive effect on π_t, and the second a negative effect. The second regression is identical to the first, but excludes the two dummy variables. The third regression drops all the least significant variables. The first two regressions include the predicted value (derived from instrumental variable estimates) of the ratio of the stock of Cetes to Tesobonos in the hands of the private sector in the measurement equation. The reason is that the increased supply of Tesobonos relative to Cetes assets—as documented in Section II—may explain why the Cetes-Tesobono interest differential did not widen in the latter part of 1994 (Werner, 1996). The results, however, do not suggest that this variable (despite having the correct sign) has a statistically significant effect on the interest rate differential. Thus, it does not appear in the third regression.

The adjusted probability series for the third regression (the restricted model) is plotted in Figure 10, together with a one-standard error band.[18] What does the model have to say about factors explaining incomplete credibility of the crawling peg regime for the Mexican peso? As pointed out in

[16] All data were taken from IMF *International Financial Statistics*, except for the Cetes-Tesobonos differential, which was calculated from data obtained from Merrill Lynch by Jeffrey Frankel, and data obtained directly from the Bank of Mexico. We used the Cetes-Tesobono differential for 91 day instruments, for March 1991 to May 1993, and the differential for 28-day instruments for June 1993 to November 1994, since no series was available for the complete period. Figure 4 shows that the two series evolve closely together during the May-June 1993 period of overlap.

[17] The *colosio* dummy also has a value of 0.25 in March, reflection the fraction of the month subsequent to the assasination.

[18] The standard error is calculated as described in Hamilton (1994, pp. 397-99).

Section II above, the Cetes-Tesobonos differential did not show a persistent increase. Although it widened significantly in April 1994 in the aftermath of the Colosio assassination, it subsequently narrowed once again, and was reasonably small in November 1994, a month before the devaluation. The first conclusion, which is apparent from Figure 10, is the absence of increasing concerns about the "toughness" of the authorities in the months leading up to the December devaluation, although there were concerns earlier. There is no evidence here that markets foresaw a shift in government policy concerning the exchange rate, for instance reflecting expectations that the Zedillo government had a different weight on price stability than its predecessor. On the contrary, there is some decrease in the likelihood that the government was "weak", which continued (despite some increase in the spring and summer) throughout the period to November 1994.

The second conclusion from the estimates, in particular the coefficients in Table 1, is that competitiveness does not seem to be a significant variable in explaining the interest differential, either directly or through the updating of π_t. This is consistent with the fact that competitiveness did not continuously deteriorate during the sample period. Indeed, although there was a worsening of competitiveness in 1991-93, this was to some extent reversed in 1994, as the peso weakened within its fluctuation band, which was allowed to crawl upward (see Figure 7).

Third, the U.S. inflation rate seems to have some effect on the Cetes-Tesobono interest rate differential indirectly through π_t. According to the model, higher U.S. inflation leads to increased concern that the Mexican authorities would put a low weight on fighting inflation (and a higher one on maintaining competitiveness). However, this effect does not seem to be very robust to changes in specification, and the coefficient seems unduly large.[19] Moreover, there is not much variation in U.S. inflation over this period, contributing to a poorly determined coefficient.

[19]It should be noted that the inflation and interest rates are on a monthly basis, and expressed as decimal fractions (rather than as percentages). The coefficients in the state equation as well as the coefficient of π_t in the $diff_t$ equation (13) reflect this.

Table 1

Mexico: Kalman Filter Estimates of Cetes-Tesobono Differential and Probability of a "Weak" Government

March 1991-November 1994

	Models					
Variables	1		2		3	
	Cetes-Tesobono interest differential					
Constant	0.0070	(5.7)	0.0071	(7.4)	0.0069	(6.7)
π_t	0.0103	(1.2)	0.0130	(2.8)	0.0183	(6.4)
Δp_t^*	0.0510	(0.4)	-0.0166	(0.1)	—	—
s_{t-1}	0.0173	(1.3)	0.0099	(1.1)	—	—
$\hat{C}_{t-1}$	0.0008	(0.4)	0.0010	(0.5)	—	—
	Probability of a "weak" government π_t					
π_{t-1}	0.8354	(11.3)	0.8061	(9.4)	0.8224	(11.3)
Δp_{t-1}^*	21.111	(0.8)	14.612	(1.0)	10.905	(1.7)
s_{t-2}	0.0326	(0.1)	-0.0034	(0.0)	—	—
colosio	0.2212	(1.0)	—	—	—	—
election	-0.2138	(0.9)	—	—	—	—
σ_z	0.1144		0.0973		0.0696	
$\ln L$	6.2296		6.1612		6.1527	

Notes: Coefficients in parentheses are absolute t-ratios. $\ln L$ is the maximized value of the log likelihood function. σ_z is the estimated standard error of equation (15). $\hat{C}_t$ is the predicted value of the Cetes-Tesobonos ratio. The instruments list used to calculate this predicted value consists of the U.S. Treasury bill rate at t, U.S. inflation at t, C_{t-1}, m_{t-1}, and the two dummy variables.

A potential problem with the above specification relates to the use of the interest differential as a measure of devaluation expectations. If Cetes and Tesobonos are not perfect substitutes, the interest differential among these two assets may also include a risk premium. In this case, a direct measure of exchange rate expectations might be preferable. However, use of the survey data discussed above and plotted in Figure 9 did not give results that differed significantly from those discussed above.

5 Concluding Observations

This paper has developed and estimated a simple model of credibility and reputation, aimed at understanding the behavior of exchange rate expectations in the lead-up to the peso crisis. In Agénor and Masson (1996) we present another model emphasizing the tradeoff between the cost of deviations of domestic interest rates from a desired value, and exchange rate stability. Domestic interest rates in that setup are determined through equilibrium in the money market, and thus depend on the behavior of official reserves—which themselves (under the assumption of imperfect substituability between domestic and foreign goods, and domestic and foreign assets) are assumed to depend on the differential between domestic and foreign interest rates (adjusted for the expected depreciation rate) and the real exchange rate. Deviations of domestic interest rates from their desired level are viewed as being associated with fluctuations in output, either directly or indirectly via the health of the banking system.[20] Estimation results were broadly similar to those reported here.

Hence, a tentative conclusion that we draw from the analysis is that there is little empirical basis for attributing expectations of peso devaluation in 1991-94 (as measured by movements over time of the interest rate differential between peso-denominated and dollar-linked assets) to economic fundamentals. On the contrary, investors appear to have seriously underestimated the risk of devaluation, despite early warning signals—such as the

[20]Both considerations were important in Mexico in 1994. Several commentators have attributed the reluctance of the Mexican authorities to raise domestic interest rates after the Colosio assassination (in order to stem capital outflows) to their concerns with the banking system, which had shown signs of weakness since early 1993. The authorities were also concerned with potentially adverse effects on economic activity—a particularly important consideration prior to a presidential election in which, for the first time in recent history, the election prospects for the ruling party's candidate appeared uncertain.

appreciation of the real exchange rate and the growing external deficit.[21]

The above analysis may, however, help explain the collapse in confidence after the ceiling of the exchange rate band was broadened by 15 percent (a de facto devaluation) on December 20, 1994. The explanation proposed by Sachs, Tornell, and Velasco (1995) is that investors, having ignored the deteriorating fundamentals prior to the devaluation, finally realized that something was wrong–and may have gone too far in their pessimism. The new information included data on the low level of official reserves, making investors aware that the authorities would be unable to defend the new exchange rate. However, it should be noted that although the devaluation had some adverse effects—in particular, it further weakened the banking system, by raising the cost of servicing foreign-currency denominated debts—it also led to a large depreciation of the real exchange rate, which could have been expected to reduce the external deficit over time and thus improve the longer-run prospects of the economy.[22]

An alternative explanation for the loss of confidence in the government's macroeconomic policy stance—and the one that we would subscribe to—is that the devaluation was viewed by investors (perhaps wrongly) as signaling the real policy preferences of the Mexican authorities. In the context of our framework, investors may have concluded that policymakers were actually not very committed to exchange rate and price stability. Figure 10 shows that just prior to the devaluation, the estimated probability π_t of a "weak"

[21]There is substantial anecdotal evidence suggesting that many private institutions involved in monitoring economic and financial developments in Mexico failed to "blow the whistle." On November 22, 1994, for instance, in a report entitled *Mexico: Zedillo reaffirms the Pacto*, analysts at Salomon Brothers concluded that "although... an eventual more rapid depreciation of the peso may become necessary, the probability of a one-off devaluation is virtually nil." On November 7, analysts at Bear, Stearns, in a report entitled *Mexican Pesos and Cetes are Attractive*, concluded that "political and technical problems have created an undervalued peso... We expect a strengthening of the peso in coming months, creating very high dollar returns on Cetes." The very morning of the devaluation, clients of the firm received a report in which the same analysts continued to discount the risk of a currency adjustment.

[22]In the case of the United Kingdom, for instance, high unemployment and the large current account deficit associated with an overvalued exchange rate led to a loss of confidence in the sustainability of the exchange rate commitment within the exchange rate mechanism (ERM) of the European Monetary System. The devaluation that followed the U.K. departure from the ERM in September 1992, however, restored competitiveness and permitted lower interest rates, suggesting improved confidence in macroeconomic policy generally (Masson, 1995).

government (in the sense of attaching a lower weight to price stability) had declined to about 0.3. The devaluation may have been seen as revealing the authorities' "true" type (as being weak), on the assumption that they could have prevented it—by, say, tightening monetary and fiscal policies well beforehand. If we let π_t rise to unity, the model would predict a widening of the Cetes-Tesobono differential by 15 percentage points at annual rates.[23] An effect of this magnitude is strikingly similar to what actually occurred immediately following the devaluation (as shown in Figure 4).

[23]These figures are calculated as follows. Using the coefficient for π_t in the third regression in Table 1, and multiplying by 12 to convert to an annual interest rate, we have $12 \cdot 0.018 \cdot (1 - 0.3) \cdot 100 = 15.4$ percent.

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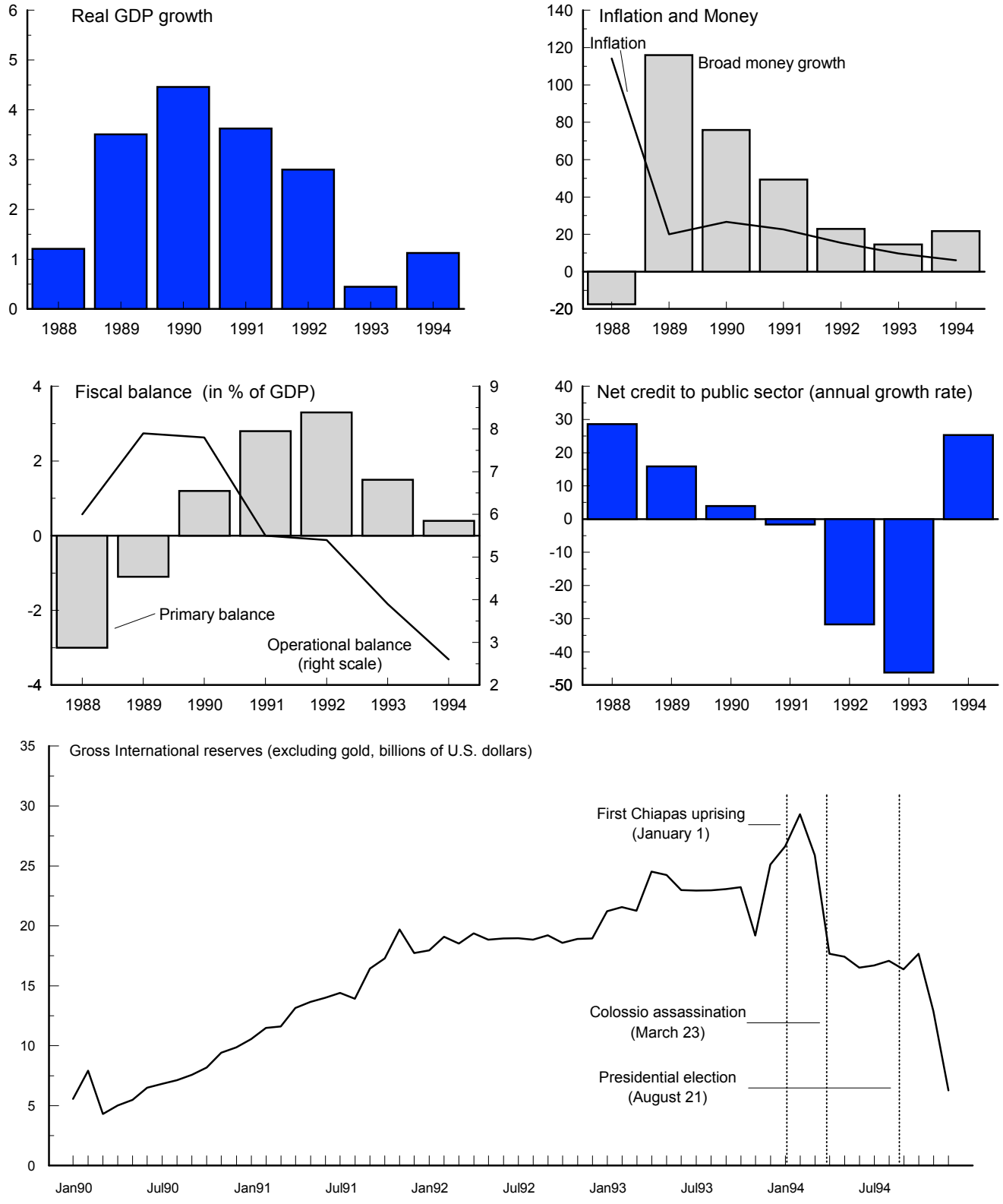
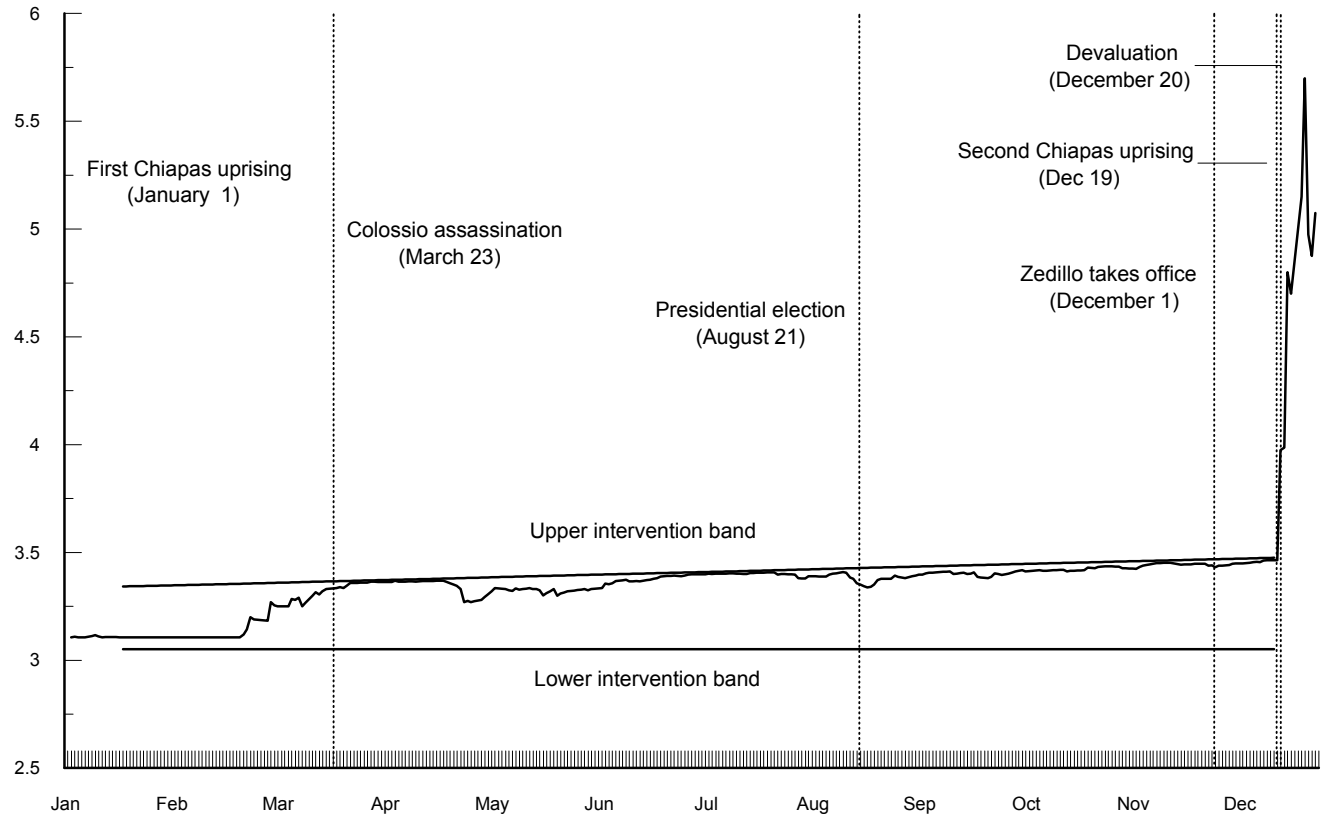
Figure 1
Mexico: Macroeconomic Indicators, 1988-94



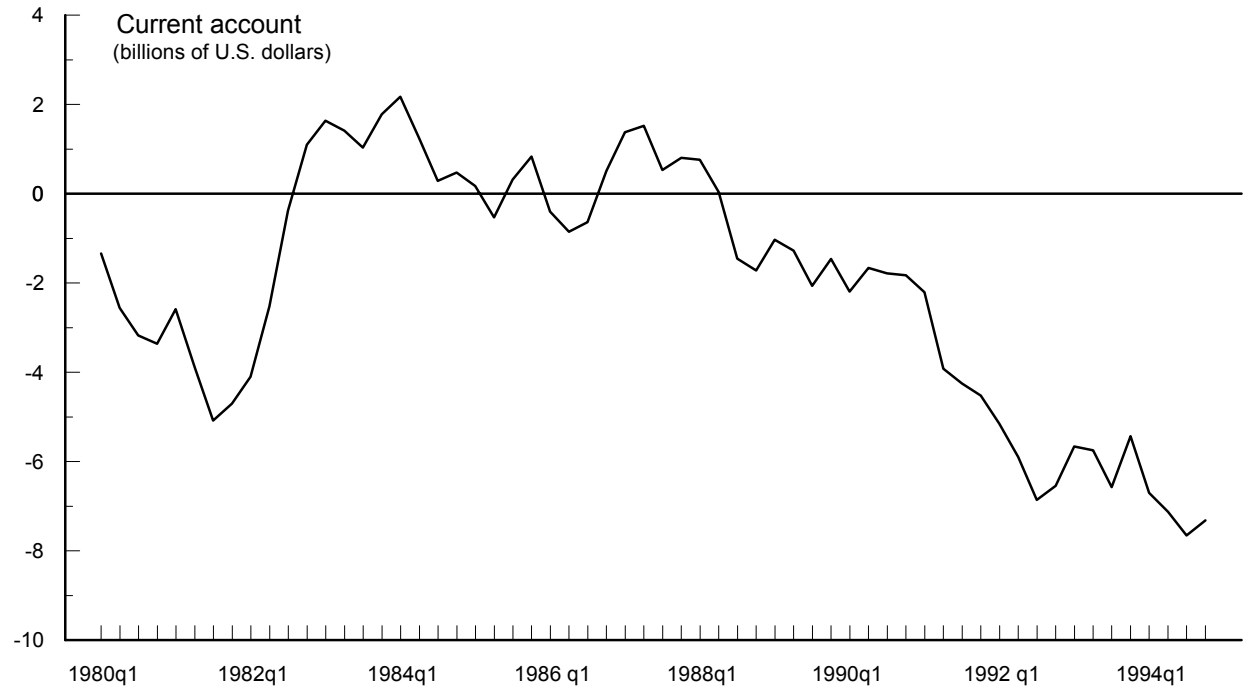
Source: International Monetary Fund.

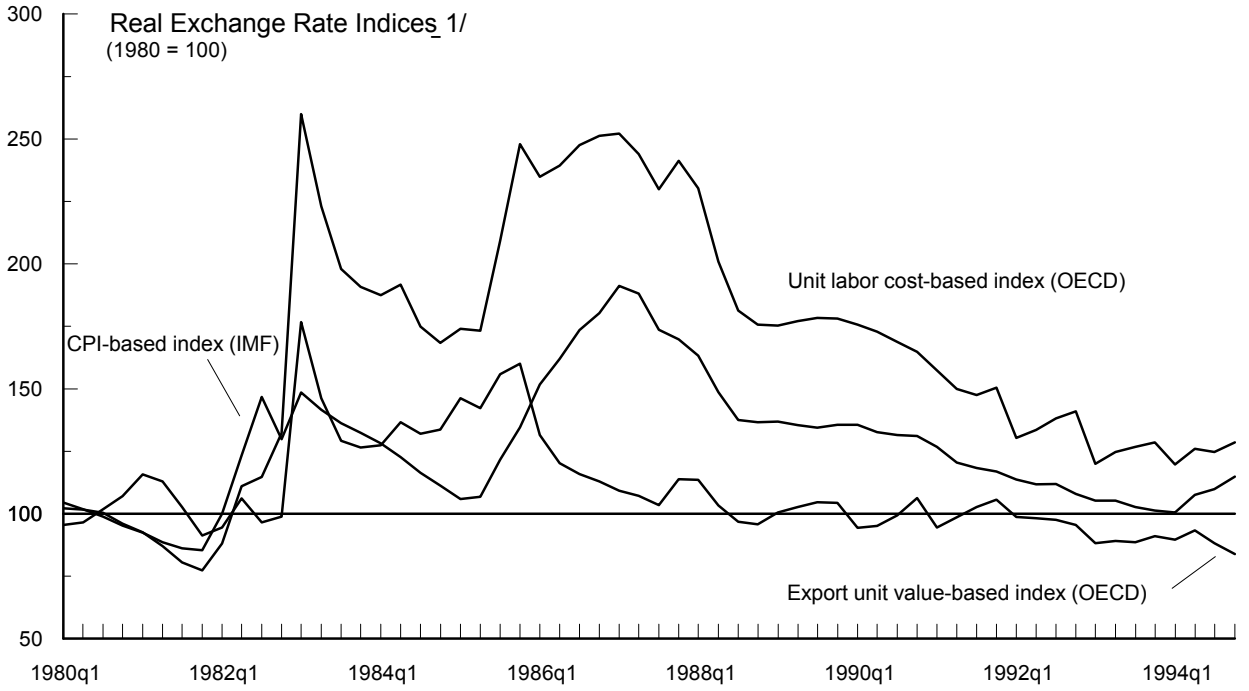
Figure 2
Mexico: Nominal Exchange Rate and Intervention Bands, 1994
(Pesos per U.S. dollar)



Source: Bank of Mexico and Bloomberg, Inc.

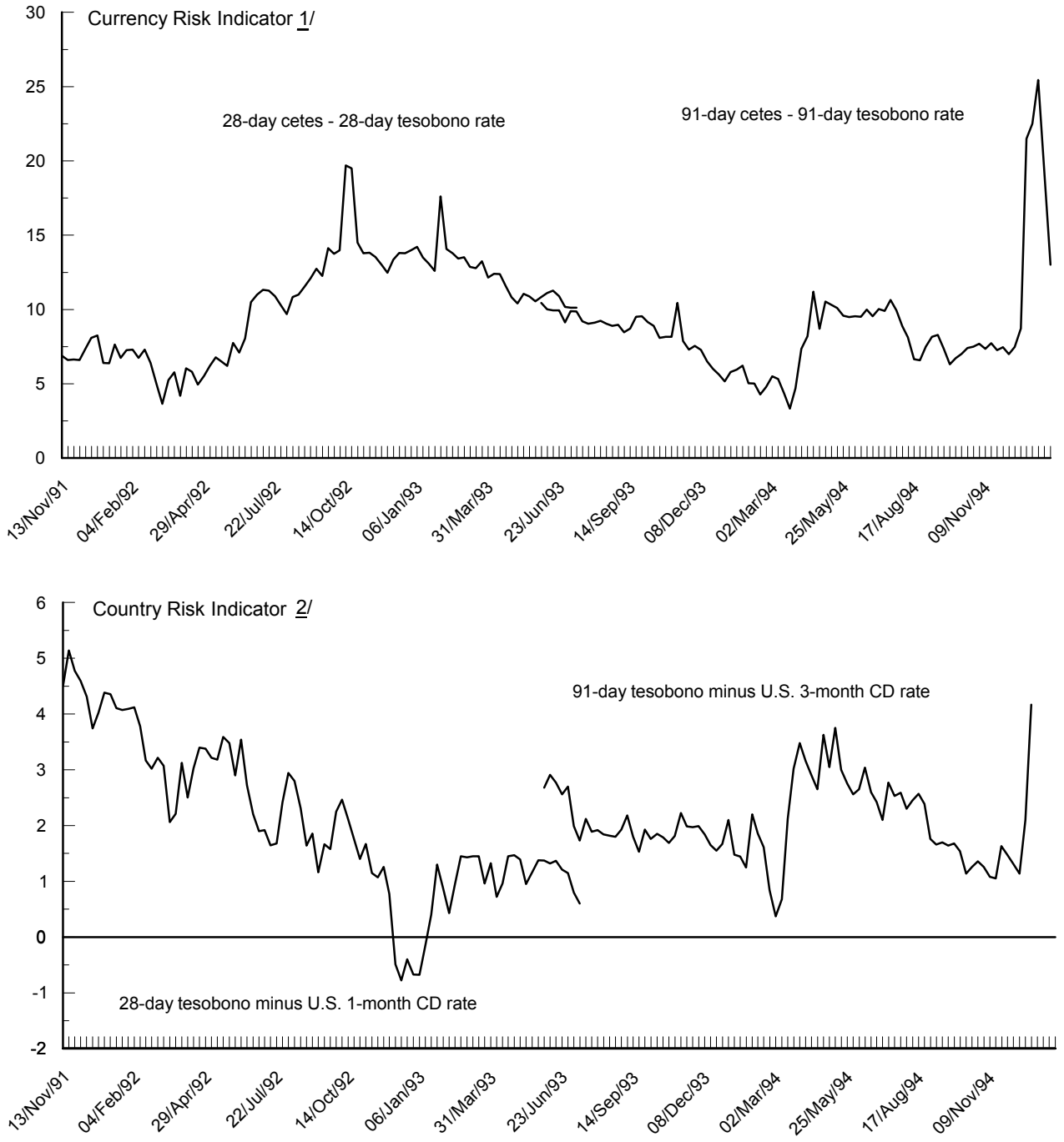
Figure 3
Mexico: Current Account and Real Exchange Rate Indices, 1980-94





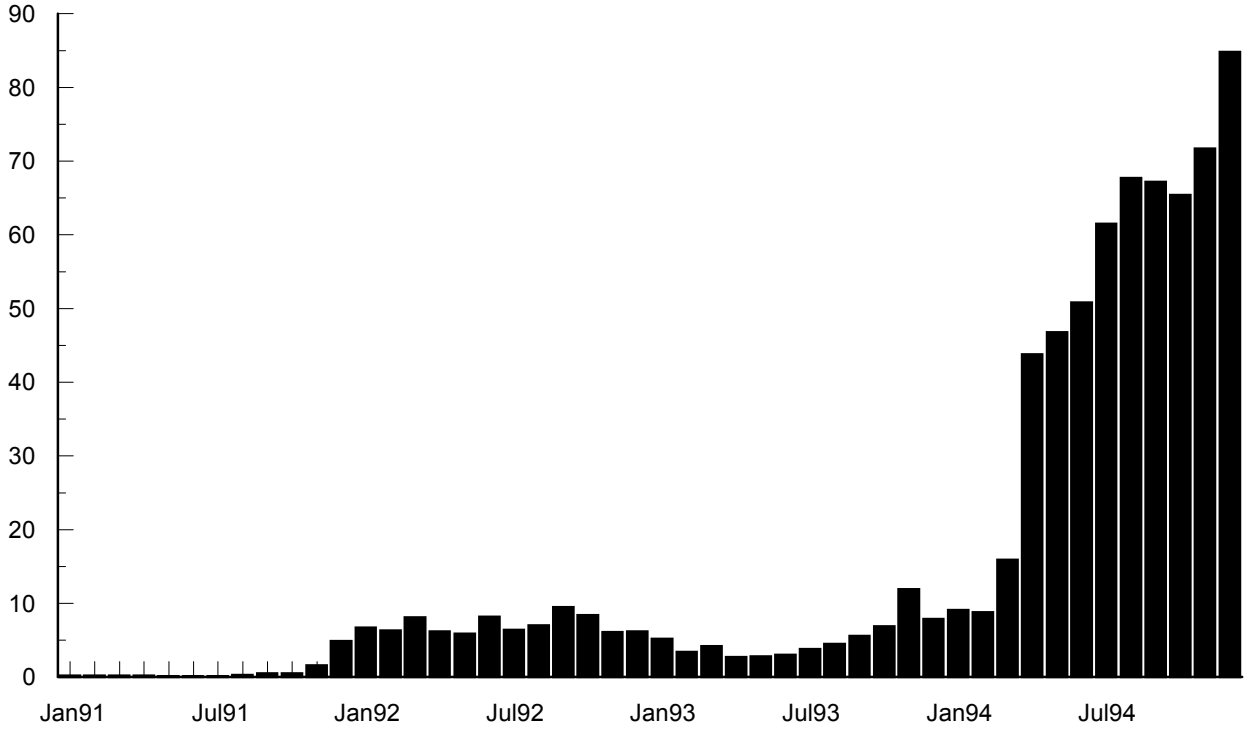
Source: International Monetary Fund and OECD.
1/ An increase is a depreciation.

Figure 4
Mexico: Currency Risk and Country Risk Indicators, 1991-94
(In percent)



Sources: Bank of Mexico and Bloomberg, Inc.
1/ Based on monthly averages of weekly auction rates.
2/ Based on monthly averages of weekly auction rates of tesobonos.

Figure 5
Mexico: Share of Tesobonos
Held by Commercial Banks and the Nonfinancial Private Sector, 1991-94 1/
(In proportion of total stock of Cetes and Tesobonos)



Source: Bank of Mexico.
1/ Includes residents and nonresidents.