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Interest Rates in Mexico: The Role of Exchange Rate
Expectations and International Creditworthiness

Prepared by Hoe E. Khor and Liliana Rojas-Suarez*

Authorized for Distribution by Claudio Loser and Donald J. Mathieson

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Abstract

This paper explores how interest rates on domestic financial assets in Mexico are linked to expectations of exchange rate changes and to perceptions about the default risks contained in Mexico's external debt.

It is shown that the interest rate differentials between peso- and U.S. dollar-denominated domestic assets reflected some concerns about the exchange rate policy during the period under study. In addition, the evidence suggests that the interest rate on a U.S. dollar-denominated Mexican domestic asset is linked (i.e., cointegrated) to the yield implicit in the secondary market price for external debt issued by Mexico.

<u>Table of Contents</u>   <u>Page</u>

Summary

This paper tests whether the recent behavior of interest rates in Mexico can be linked both to expectations of exchange rate changes and to the international perception of Mexico's creditworthiness.

Tests of covered and uncovered interest parity were conducted using two domestic assets identical in all respects except for the currency of denomination. The tests show that, except for a short episode during the period under study, the relationship between the interest rates on the two assets satisfied the covered interest parity condition. In addition, the evidence suggests that a "peso problem" prevailed during the same period; that is, expectations of the future spot exchange rate consistently overestimated the actual future rate in a regime in which the exchange rate was not allowed to float freely.

The paper also investigated the extent to which Mexican issues of domestic debt and of external debt, both denominated in U.S. dollars, were linked. For this purpose, tests were conducted under the hypothesis that the interest rate on a U.S. dollar-denominated domestic asset was "cointegrated" with the yield implicit in the secondary market price for external debt issued by Mexico. On balance, the evidence was found to support the hypothesis.

A policy implication of these results is that permanent reduction of interest rates in Mexico is not only linked to the elimination of the wedge between public expectations of exchange rate devaluations and the preannounced rate of depreciation, but is also associated with an improvement in the underlying conditions of the Mexican economy affecting international perceptions about the creditworthiness characteristics of the country.

I. Introduction

This paper investigates the recent behavior of interest rates in Mexico by exploring their links to expectations of exchange rate changes and perceptions about the default risk associated with holding Mexican financial assets. A central theme of the paper is the extent to which both the domestic and external U.S. dollar-denominated debt issued by Mexico are linked; namely, the extent to which the interest rate on domestic debt denominated in U.S. dollars and the implicit yield on external debt are closely associated on the basis of default risk. During the period covered in this study, namely from January 1987 to July 1990, 1/ the Mexican authorities were engaged in a major effort of macroeconomic adjustment and structural reforms including the liberalization of financial markets. In response, the inflation rate declined sharply from an average of 8 percent a month during 1987 to an average of 1 1/2 percent per month since the middle of 1988. However, domestic nominal interest rates declined to a lesser extent and, in real terms, ex-post interest rates on domestic financial assets shifted from being negative during 1987 to being highly positive subsequently, notwithstanding an improvement in the overall fiscal performance on the basis of strong fiscal actions by the authorities.

It is in this context that we test the validity of the following hypothesis: the recent behavior of interest rates in Mexico has been closely linked to both expectations of exchange rate changes and to international perceptions of Mexico's creditworthiness where the latter is assumed to be represented by the yield implicit in the secondary market price of external debt issued by Mexico. It is argued that this hypothesis will hold if there are no perceived differences in the credit standing of domestic and external debt of Mexico. This is so because in that case both the domestic and external debt would be subject to the same country risk premium.

The methodology adopted to give empirical content to this hypothesis is presented in Section II. As explained there, because of some important differences in the characteristics of domestic versus external debt issued by Mexico, the hypothesis is split in two components. The first part of the hypothesis concentrates on the role of expectations of exchange rate changes and states that some form of interest rate parity (covered and/or uncovered) should hold between two assets issued by the Mexican government which are identical in all respects except for the currency of denomination. The second part of the hypothesis deals with the country risk component of Mexican interest rates and states that the interest rate on domestic debt denominated in U.S. dollars should be closely linked to the yield to maturity implicit in the secondary market price issued by Mexico.

1/ For some of the tests conducted in this paper, we were able to extend the sample period somewhat.

Section III tests the first component of the hypothesis. Our investigation shows that when applied to specific financial assets to be discussed below, deviations from the covered interest parity condition (CIP) have been small and random occurrences most of the time. However, significant but brief deviations from CIP have occurred in periods when uncertainties in the economy were unusually large, for instance between late 1987 and early 1988 when the authorities implemented a comprehensive adjustment program. The results from testing the uncovered interest parity hypothesis (UIP) suggest that the exchange rate policy suffered from a lack of complete credibility (also known as the "peso problem") during the period under study. Under those circumstances, no strong conclusions can be derived about the validity of the UIP.

Section IV uses the observed price in the secondary market for Mexican external debt to obtain the implicit yield associated with holding assets issued by Mexico abroad. This section then uses cointegration techniques to show that domestic interest rates of Mexican assets denominated in U.S. dollars are closely linked to the behavior of the implicit yield derived from the secondary market for Mexican debt. This result, combined with our findings on interest rate parity, lead to an important policy implication, namely, that a sustained decline in domestic interest rates is linked not only to the elimination of the wedge between public expectations of exchange rate devaluations and the preannounced rate of depreciation but is also associated with an improvement in the underlying conditions on the Mexican economy which affect international perceptions about the creditworthiness characteristics of the country. Section V presents some preliminary conclusions.

II. Methodology of the Study

The main hypothesis of this study, advanced in the previous section, can be expressed as:

$$(1) \quad \frac{(1+i_t)S_t}{E_t(S_{t+1})} = (1 + g(i_t^{sm}))$$

where i_t is the domestic nominal interest at time t on peso-denominated treasury bills, i_t^{sm} is the implicit yield at time t from the secondary market of Mexico's external debt, S_t is the spot exchange rate at time t, defined as the price of one U.S. dollar expressed in Mexican pesos and $E_t(S_{t+1})$ is the expected value at time t of the t+1 spot exchange rate conditional on information available in time t. $E_t(S_{t+1})/S_t$ represents the expected rate of depreciation (or appreciation) of the Mexican peso.

Equation (1) states that domestic interest rates in Mexico, adjusted for expectations of exchange rate changes are linked (through a "g" function) to the implicit yield from the secondary market of Mexico's external debt. That is, it is postulated that domestic interest rates in Mexico are closely associated to the international perception of Mexico's creditworthiness, which is captured in the behavior of i_t^{sm}. 1/ The implicit hypothesis behind this postulate is that there are no perceived differences in the credit standing of domestic and external debt of Mexico; so that both kinds of debt share the same country risk premium.

Equation (1) would have been a form of uncovered interest parity (UIP) between i_t and i_t^{sm} if g were to take a unitary value. This is very unlikely, however, since the assets involved in equation (1) have very different maturities. Indeed, while the representative Mexican Treasury bills are of 28-days maturity, commercial bank claims on Mexico which are traded in the secondary market, have a long-term maturity that run between 20 and 30 years. Moreover, in contrast to the market for Mexican Treasury bills, the secondary market for Mexico's external debt is subject to barriers to entry as each transaction requires high entry costs and complex documentation. In view of these differences, one cannot expect that domestic interest rates in Mexico, once taking expectations of exchange rate changes into account, would always equal the implicit yield on Mexico's external debt. Instead, it is postulated that such variables "move together" at least in the long-run; that is, that they are cointegrated, where g is the parameter of cointegration.

To test this hypothesis, the following procedure was used. First, it was tested whether UIP held between two Mexican assets which have identical characteristics except for the currency of denomination. Then, it was tested whether a Mexican asset denominated in U.S. dollars was cointegrated with the implicit yield for Mexico's external debt. The remaining of this section explains the rationale and the details of such procedures.

1/ Since 1982, Mexico's access to international capital markets has been severely restricted and virtually all new lendings to the country have taken the form of concerted facilities in the context of debt restructuring arrangements. The few voluntary bond issues that have taken place in recent years have been subject to a high--albeit declining--coupon rates, providing further evidence of the lower credit rating of Mexico relative to industrial countries.

Since August 1986, the Mexican authorities have been issuing PAGAFES, 1/ an instrument denominated in U.S. dollars but payable in pesos at the prevailing controlled exchange rate. 2/ This asset is identical to the CETES, 3/ a peso-denominated treasury bill, except for the currency of denomination. Since both assets are issued by the Mexican government, they contain the same country-risk premium. The primary interest rates on both PAGAFES and CETES are determined during weekly auctions. Although the Bank of Mexico has intervened at times in order to tighten or ease monetary policy, by and large, interest rates have been freely determined. Furthermore, both assets are freely traded in the secondary markets although the market for PAGAFES is much thinner. Since the only difference between CETES and PAGAFES is the currency of denomination, if UIP holds, the interest rate differentials between the two assets should reflect only the expected depreciation (or appreciation) of the exchange rate in the controlled market.

That is, if UIP holds

$$(2) \quad (1 + i_t) \approx (1 + i_t^*) \quad \frac{E_t(S_{t+1})}{S_t}$$

where, from now on, i_t will refer specifically to the 30-day nominal yield on 28-day nonindexed domestic treasury bill (CETES) at time t and i_t^* is the 30-day nominal yield on 28-day domestic treasury bill (PAGAFES) at time t. 4/

1/ Pagares de la Tesorería de la Federación.
2/ The interest rate on PAGAFES is indexed to the exchange rate in the controlled market so that there is still a risk of an exchange loss in the event of a divergence in the spread between the exchange rates in the controlled and free markets. As the investor would ordinarily have to remit his gains through the free market, an unanticipated increase in the spread between the controlled and free rates would lead to an exchange loss. During the period under study, the spreads between the two rates have been less than 2 percent except for a short episode in November-December 1987 when the spread widened to about 25 percent. However, the risk of a widening spread between the exchange rates in the controlled and free markets should affect equally the interest rates on both CETES and PAGAFES.
3/ Certificados de la Tesorería.
4/ 28-day PAGAFES were issued starting only in January 1988. Hence, data for PAGAFES in 1987 were proxied by using interest rates on PAGAFES of 91 and 182 day maturity. Data for interest rates and exchange rates are closing bid rates corresponding to the last Wednesday of every month.

Equation (2) is tested in Section III. The test enables one to determine the role of expectations of exchange rate changes on the behavior of the interest rates on CETES. Notice also that the hypothesis contained in equation (1) can be framed in terms of covered interest parity (CIP). That is, a CIP version of equation (1) is:

$$(3) \quad \frac{(1+i_t)S_t}{F_t} = (1 + g(i_t^{sm}))$$

where F_t is the 30-day forward exchange rate at time t.

Correspondingly, a CIP version of equation (2) is:

$$(4) \quad (1 + i_t) = (1 + i_t^*) \frac{F_t}{S_t}$$

Section III will explore the validity of both the covered and uncovered versions of interest rate parity, namely it will test whether equations (2) and (4) held in Mexico during the period under study.

Next, we have to deal with the country risk component of domestic interest rate. Notice that equations (1) and (2) (or equations (3) and (4)) imply:

$$(5) \quad i_t^* = g(i_t^{sm})$$

Therefore, equation (5) states that the interest rate on PAGAFES is some function of the yield to maturity of Mexico's external debt. This equation holds true for either the covered or uncovered version of interest parity.

As mentioned before, the maturities (and some other market characteristics) of Mexico's external debt and PAGAFES are very different. However, if the main hypothesis of this paper is true (namely, that after taking expectations of exchange rate changes into account, domestic interest rates are linked to the implicit yield on Mexico's external debt), one would expect the two interest rates to "move together" at least in the long-run; that is, we postulate that i_t^* and i_t^{sm} are cointegrated. Section IV presents tests for that hypothesis.

III. Covered and Uncovered Interest Rate Parity

CIP and UIP are alternative hypotheses about the nominal interest rate differentials between financial assets that are identical in all respects except for the currency of denomination. CIP relates this interest rate differential to the forward premium (or discount) on foreign exchange, while UIP relates the interest rate differential to the expected change in the spot exchange rate between the currencies of the two countries over the holding period. 1/

1. Covered interest parity (CIP)

Equation (4) represents a CIP relationship between CETES and PAGAFES. Chart 1 presents the evolution of $(1+i_t)$ and $(1+i_t^*)$ (F_t/S_t) over the period January 1987 to July 1990. The chart shows that deviations from covered interest arbitrage were small for most of the observations with notable exceptions occurring between November 1987 and March 1988. That period, however, coincided with the beginning of the current stabilization program in Mexico, when a series of structural reforms were announced, a major devaluation took place and the authorities implemented a price-wage pact between the government, labor and business with the aim of controlling prices. These developments undoubtedly increased uncertainties about the future course of the economy which, combined with some official intervention in domestic financial markets, might have prevented covered arbitrage from holding.

An analysis of the deviations from CIP is presented in Table 1. As the table shows, 71 percent of the deviations are less than 0.5 percentage point and 86 percent of the deviations are less than 1 percentage point. By comparison, the average bid-ask spreads of the exchange rate in the controlled and the free markets during the period were 0.95 percent and 2.1 percent, respectively. Besides being small, the deviations from interest parity have a mean very close to zero and are uncorrelated at all lags. Indeed, the results of a Q test for serial correlation indicate that the null hypothesis that the series is white noise cannot be rejected at the 1 percent significance level.

1/ Tests for developed countries have usually validated the CIP but do not support UIP. See, for example Cumby and Obstfeld (1980).

CHART 1
MEXICO
CETES VS PAGAFES (ADJUSTED) 1/
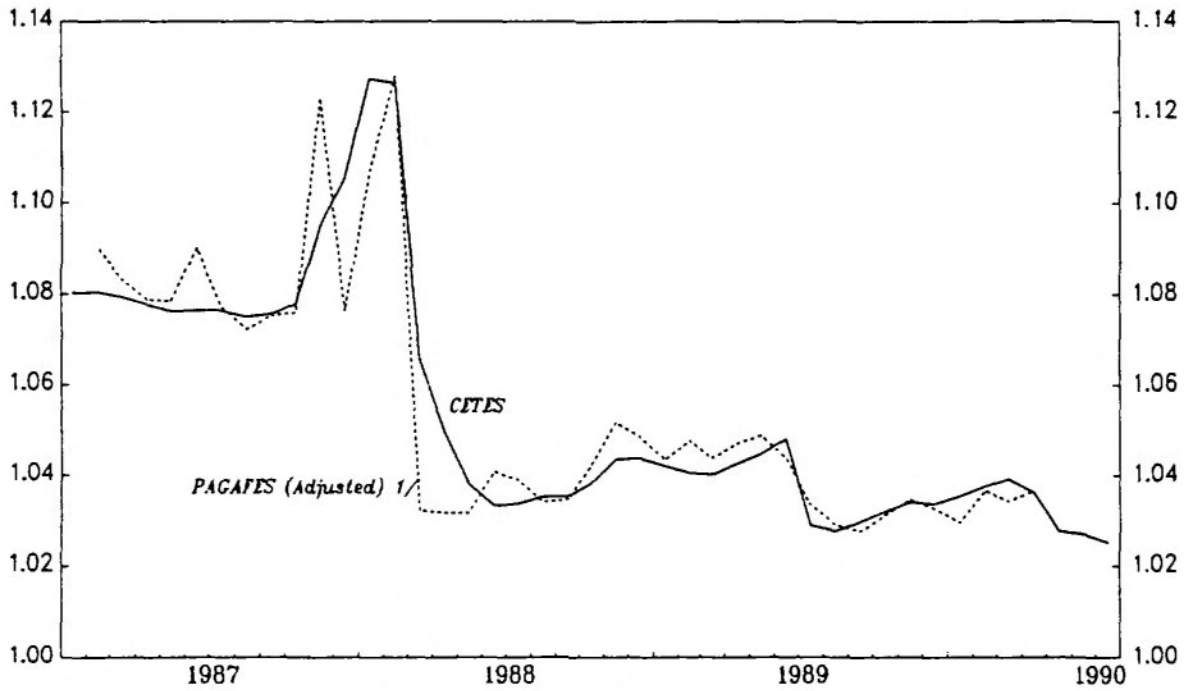
nb. The unit on the y-axis is 1 + i, where i is the interest rate per month.
1/ Adjusted for the premium in the forward market.

Table 1. Analysis of the Deviations from Interest Rate Parity

Series: $(1+i_t) - (1+i^*_t)(F_t/S_t)$	
Number of observations:	43
Mean	0.0004
Standard deviation	0.010
<u>Proportion of deviations</u>	
Less than 0.5 percentage points	71
Less than 100 percentage points	86
<u>Q test</u>:	
Degrees of freedom	9
χ^2 statistic <u>1</u>/	7.88

<u>1</u>/ The null hypothesis of no serial correlation is rejected at the 1 percent level only if the value of χ^2 is greater than the critical value of 21.7.

The above results indicate that, with the exception of a short period of time, when uncertainties in the economy were unusually large, deviations from interest rate parity have been small and random occurrences. This evidence seems to provide strong support for CIP. 1/

2. Uncovered interest parity (UIP)

The uncovered version of interest parity between CETES and PAGAFES is represented by equation (2).

The empirical literature on UIP has broadly tested equation (2) (see, for example, Cumby and Obstfeld (1980) and Lizondo (1983a)). However, since $E_t(S_{t+1})$ is an unobservable variable, the empirical tests have been joint tests of equation (2) and two hypotheses of expectations behavior: (1) the rational expectations hypothesis that states that $E_t(S_{t+1})$ is a mathematical conditional expectation, based on the true probability distribution underlying the behavior of the exchange rate; and (2) the hypothesis that the foreign exchange market is "weakly" efficient in that expectations of the future exchange rate incorporate all information contained in past forecast errors of the exchange rate. These joint hypotheses imply that the forecast error:

$$(6) \quad \epsilon_t = \frac{S_t (1+i_t)}{(1+i_t^*)} - S_{t+1}$$

should have zero mean and be serially uncorrelated.

The joint hypothesis containing UIP and the hypothesis of "weak" market efficiency was tested for Mexico using non-overlapping monthly observations covering the period January 1987-July 1990. Before discussing the results of the tests, it should be pointed out that over this period, the exchange rate was not freely floating but managed by the authorities and followed three different regimes: (1) from January 1987 to December 1987 the exchange rate was depreciated by an unspecified amount each day; (2) from

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1/ Some of the empirical tests have analyzed the extent to which deviations from covered arbitrage can be explained by transaction costs. Many of these tests have followed the methodology suggested by Frenkel and Levich (1975) by which four transaction costs are identified: the cost of transactions in domestic and foreign securities and in spot and forward exchange rates. This methodology is not applicable here, however because transactions in both CETES and PAGAFES are done in Mexican pesos; hence the transaction costs of moving from one currency to another are not present. However, there still remain some transaction costs involved in the sales and purchase of the two assets which can account for the small deviations from covered arbitrage.

January 1988 to December 1988 the exchange rate was fixed except for a small change in February; and (3) from January 1989 to May 1990 the exchange rate was depreciated by an announced 1 peso per U.S. dollar a day. 1/ Recent studies have analyzed the problems involved in testing the UIP hypothesis in the presence of intervention in exchange rate markets. In particular, Krasker (1980) and Lizondo (1983b) have shown that in the presence of a small and positive probability of a devaluation, an efficient exchange rate market will imply that the expected value of the future spot rate will reflect the probability of that event. However, as long as the devaluation does not take place, the expectation of the future spot rate will consistently overestimate the realized future spot rate. As a result, the forecast error in the exchange market will show a positive bias, 2/ but this will not be sufficient to reject the joint hypothesis that UIP holds and that the market is "weakly" efficient.

Table 2 presents an analysis of the forecast error ϵ_t. The most important result is that although the Q test indicates that at the 1 percent significance level we cannot reject the hypothesis that the errors are uncorrelated, the mean of the forecast error is positive. 3/ These results imply that $S_t((1+i_t)/(1+i_t^*))$ overstates the future spot rate. Based on our previous discussion, however, the existence of a positive mean in the forecast errors does not allow us to accept or reject that UIP holds under conditions of "weakly" market efficiency, since the tests for UIP are not appropriate in the context of a "peso problem." However, the lack of auto-correlation in the forecast errors seems to indicate that the interest rate differentials between CETES and PAGAFES incorporated all the information available to generate predictions of the future exchange rate in conditions where the "peso problem" prevailed, namely in a situation where the exchange rate was not allowed to float freely and there was always a small

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1/ At the end of May 1990, the authorities reduced the depreciation of the exchange rate to 0.80 peso per U.S. dollar a day, and in mid-November, the depreciation was further reduced to 0.40 peso per U.S. dollar a day.

2/ This is the well known "peso problem." Formally, $E_t(S_{t+1}) = \bar{S}(1+\alpha Q_t)$ where $\bar{S}$ is the fixed exchange rate, Q_t is the probability of a devaluation and α is the amount of a devaluation in percent. Hence, the forecast error $\epsilon_t = E_t(S_{t+1}) - S_{t+1} = \bar{S} \alpha Q_t > 0$ as long as the devaluation does not take place (i.e., as long as $S_{t+1} = \bar{S}$).

It has also been argued that if the probability of a devaluation depends on economic variables which tend to show auto-correlation (such as the level of international reserves or the credit expansion to the public sector), the forecast error in the exchange rate market will also show auto-correlation.

3/ Only five of the forecast errors were found to be negative. Again, in line with predictions from the model of the peso problem, a large and negative forecast error was observed in November 1987 when the peso was actually depreciated by 18 percent.

Table 2. Analysis of the Forecast Error

$$\epsilon_t = S_t \ ((1+i_t)/(1+i_t^*)) - S_{t+1}$$

Number of observations	43
Mean	25.762
Standard deviation	68.580
Q-test:	
Degrees of freedom	9
χ^2 statistic 1/	1.83

1/ The critical value for the test with nine degrees of freedom at the 1 percent level is 21.7.

probability of a devaluation. 1/ Indeed, the differential between the spread in the interest rates on CETES and PAGAFES and the preannounced depreciation of the exchange rate was greatest in the early part of 1988 following the transition to a fixed exchange rate regime, which can be taken as an indication of a lack of full credibility in the exchange rate policy (Chart 2). However, as the authorities persisted in their policies and financial conditions improved, the differential has tended to decline.

IV. Domestic Interest Rates and the Risk of Default in the Secondary Market for Mexico's External Debt

In the previous section we showed that the interest rate differentials between domestic nonindexed assets (CETES) and dollar-denominated domestic assets (PAGAFES) have, in general, satisfied the CIP condition. The evidence also seemed to indicate the presence of a "peso problem," and, therefore, the interest rate differentials may be attributable to expectations of large exchange rate changes (which actually did not take place). These results, however, do not explain the persistence of high interest rates on domestic dollar-denominated assets (PAGAFES); these ranged between 14 percent and 44 percent per annum in the period under study. In the context of a relatively open economy with few restrictions on financial flows, a plausible explanation is that all Mexican assets (indexed or not) contain a risk premium that reflects the market perception of the country's credit standing. Therefore, it can be argued that the interest rate differential between PAGAFES and a risk-free asset reflects primarily the country-risk premium. 2/ Chart 3 shows the recent evolution of the interest rate on PAGAFES versus LIBOR, which can be considered a relatively risk-free interest rate.

In this section, the hypothesis, as represented in equation (5), that the interest rate on PAGAFES is linked to the yield to maturity implicit in the secondary market price for external debt issued by Mexico is tested. The rationale behind this hypothesis is that, from the point of view of creditworthiness, there should be no distinction between the domestic and

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1/ In a previous study of UIP in Mexico, Lizondo (1983a) found that during the period from May 1977 to December 1980, the forecast errors also had a positive mean but showed a small positive auto-correlation at the first lag. A possible explanation for the discrepancy between his results and the ones presented in this study is that, over the period covered in the Lizondo's study, the interest rate was regulated by the Mexican authorities. This is in contrast with the most recent period covered in the present study when, with the exception of brief sub-periods, the interest rate was allowed to float.

2/ As noted in the previous section, the interest rate on PAGAFES should also incorporate a premium reflecting the risk of a divergence between the free and the controlled exchange rates.

external components of the debt. 1/ Hence, the country risk premium implicit in the secondary market price for Mexican debt issued abroad should be equal to the country-risk premium contained in domestic debt of identical characteristics.

As mentioned in Section II, in testing the above hypothesis, one encounters the problem that the characteristics of the assets, i.e., external claims on Mexico and PAGAFES, are very different in terms of maturities and market access. 2/ However, if our hypothesis is correct, one would expect the two interest rates to "move together", at least in the long-run.

Traditional econometric theory cannot help in testing the hypothesis A basic assumption underlying most econometric analyses is that the data processes involved are stationary and ergodic. As will be shown below, however, the series for both PAGAFES and the implicit yield for Mexico's external debt are integrated processes of order one, I(1), and become stationary only in their first difference. Since the original series are nonstationary, the means and variances of the series are not constants, and the usual statistical properties of convergence to the population mean and variance do not apply. As a result, traditional regression analysis relating the behavior of these variables might just reflect "spurious correlations." Recent developments in cointegration analysis, however, has provided a tool to analyze if there is a meaningful close relationship in the long-run for variables that are I(1) processes. 3/

Two variables, x and y, following an I(1) process are said to be cointegrated if there exist a constant A, such that

$$(7) \quad z_t = x_t - Ay_t$$

is a stationary process; that is the series z_t is integrated of order zero, I(0). An important result of cointegration analysis is that if two variables are I(1) and cointegrated, there must be Granger causality in at least one direction, as one variable can help forecast the other. 4/ This corollary will be used in interpreting the results.

1/ On the appropriateness of treating domestic and external debt in a similar way, see Dooley (1987) and Guidotti and Kumar (1990).

2/ Some have argued that the effective maturity of Mexico's external debt is infinite since they are subject to repeated rescheduling. However, this argument is no longer valid as most loans have been converted into 30-year bonds whose principals are collateralized.

3/ See Granger and Weiss (1983) and Granger and Engle (1987).

4/ See Granger (1986).

CHART 2
MEXICO
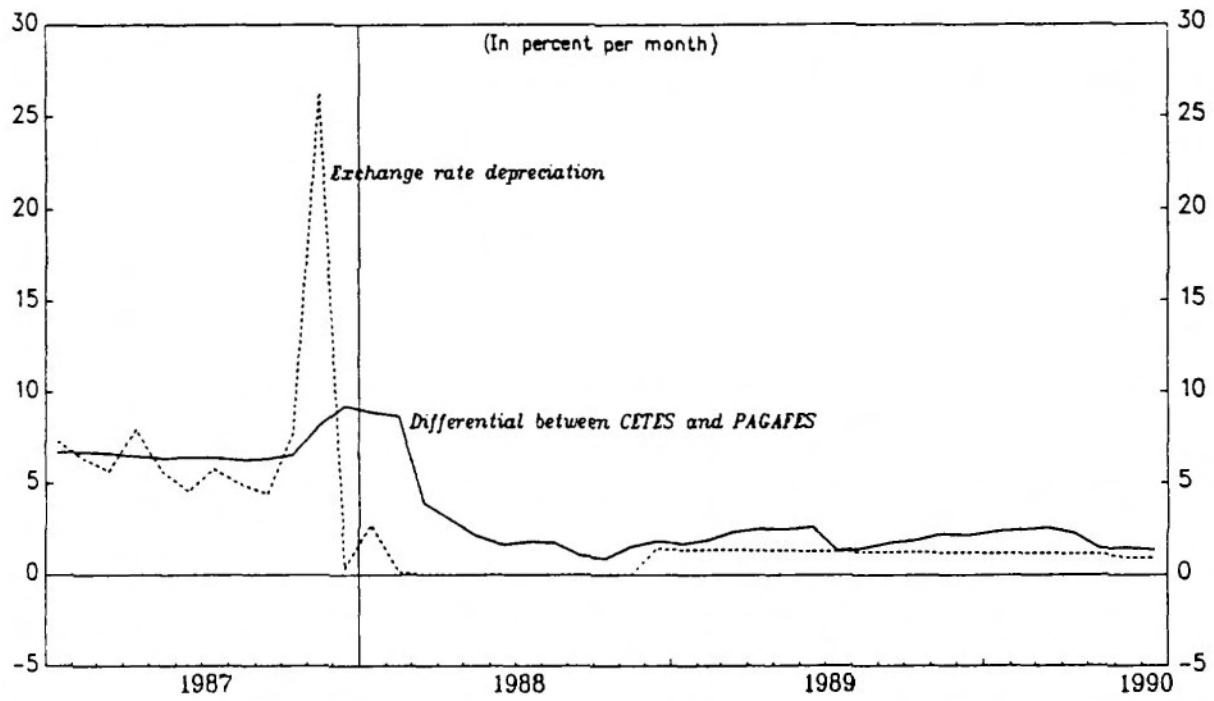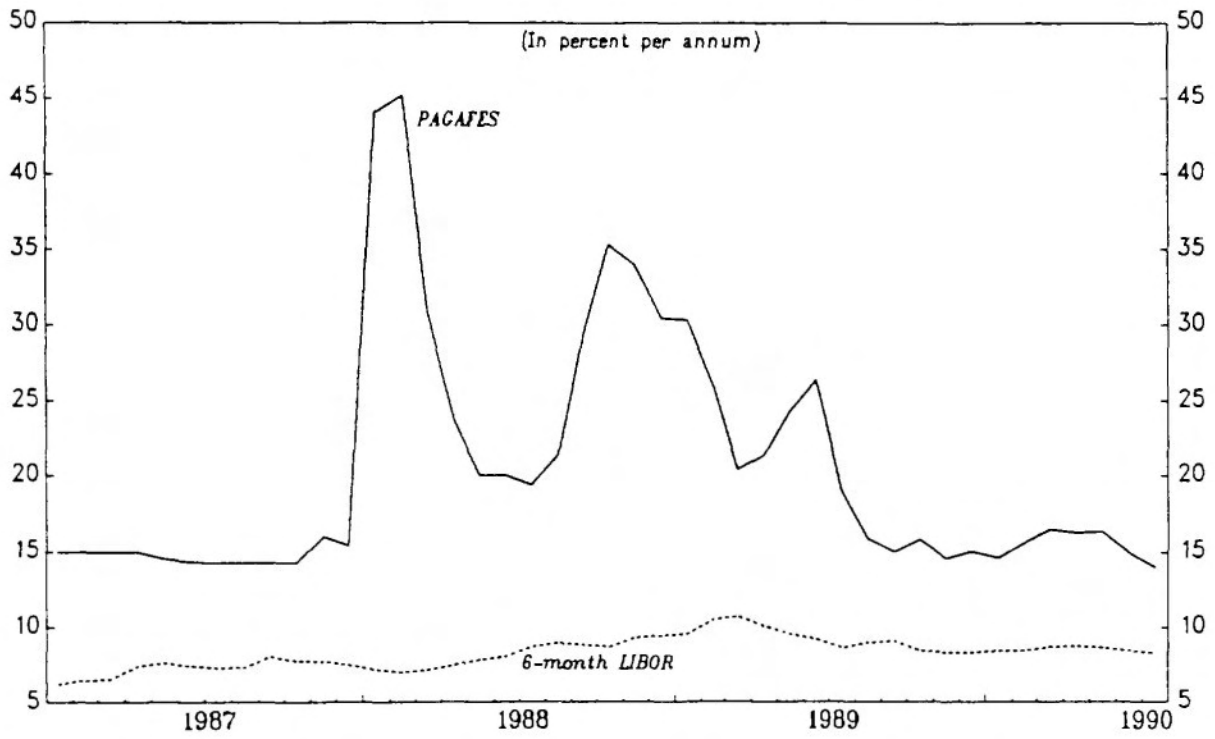# INTEREST RATE DIFFERENTIALS VS EXCHANGE RATE DEPRECIATION

(In percent per month)

Exchange rate depreciation

Differential between CETES and PAGAFES

CHART 3
MEXICO
INTEREST RATES ON PAGAFES VS LIBOR

(In percent per annum)

PAGAFES

6-month LIBOR

The rest of this section will proceed as follows: first, we will derive the yield to maturity implicit in the secondary market price of Mexico's external debt; then we will test the hypothesis that the interest rate on PAGAFES can be explained by the yield to maturity in the secondary market by testing if both variables are cointegrated, and the direction of the Granger causality. Finally, we present an "error correction" model of the short-run dynamics of the adjustment process.

1.   The implicit yield in the secondary market for
     Mexico's external debt

The implicit yield to maturity for Mexico's external debt was obtained from the observed secondary market price on Mexico's external debt (P_t) (from Solomon Brothers data) 1/ and the application of the following present value formula:

$$(8) \quad P_t = \sum_{k=1}^{n} \frac{C_t}{(1+i_t^{sm})^k} + \frac{FV}{(1+i_t^{sm})^n}$$

where i_t^{sm} represents the implicit annual yield to maturity evident in the secondary market price for Mexico's external debt in period t. The face value (FV) is set at 100 since the discounts quoted in the secondary markets apply to US$100 worth of contractual debt; the contractual coupon payment (C_t) is the interest rate on six month LIBOR plus the interest rate spread paid by Mexico (assumed to be 13/16 percent over the entire period); and the average maturity (n) was assumed to be equal to 20 years. A monthly series for i_t^{sm} was constructed covering the period August 1986-July 1990.

In modeling the market value of claims of debtor countries, Dooley (1988) has argued that the secondary market price of debt should equal the creditor's expected present value of total debt service payments. This argument, which requires the assumption that creditors are risk-neutral can be formalized as:

$$(9) \quad P_t = E_t \left[\sum_{k=1}^{n} \frac{C_t}{(1+i_t^{f})^k} + \frac{FV}{(1+i_t^{f})^n} \right]$$

1/ The series used correspond to the average price on restructured obligations for which data is available since 1986. Data on trade credits are available only since July 1988.

where E_t is the expectations operator during period t and i_t^f stands for the risk-free market rate (which in this case is taken as corresponding to the rate on six-month LIBOR prevailing at period t).

A comparison between equations (8) and (9) reveals that the implicit yield obtained from the price in the secondary market depends on the creditor's expectations about receiving full payments on the contractual debt. The derivation of a specific formula for the probability of default on Mexico's external debt is subject to specific assumptions about the distributional properties of debt service payments. 1/ In what follows, no attempt is made to derive a measure of the probability of default. Instead, by testing the hypothesis that the long-run behavior of the interest rate on PAGAFES can be explained by the behavior of the implicit yield for Mexico's external debt, one is also implicitly testing the

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1/ Assuming that the probability distribution governing debt service payments is binomial, with π = probability of full payment and $1 - \pi$ = probability of default, equation (9) can be rewritten as:

$$P_t = \pi \sum_{k=1}^{n} \frac{C_t}{(1+i_t^f)^k} + \pi \frac{FV}{(1+i_t^f)^n}$$

Therefore, it is straightforward that the probability of full payment equals:

$$\pi = \frac{P_t}{\sum_{k=1}^{n} \frac{C_t}{(1+i_t^f)^k} + \frac{FV}{(1+i_t^f)^n}}$$

Since the denominator on the right hand side of the above equation equals the present value of full debt service, the probability of full payment is the ratio of the observed price in the secondary market to the present value of full debt service.

hypothesis that the probability of default on Mexico's external debt also applies to Mexico's domestic debt. 1/.

2.   The test for cointegration

The first step is to test whether the series on interest rate on PAGAFES (i_t^*) and on the implicit yield from the secondary market (i_t^{sm}) are I(0), i.e., to test whether the series are stationary. This is done by using the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) tests. In both tests, the null hypotheses are that the series have unit root and the alternative hypotheses are that the series are I(0). The ADF test consists in running the following regressions using OLS:

$$(10) \quad \Delta i_t^* = \beta_1 \, i_{t-1}^* + \sum_{j=1}^{p} \gamma_{1,j} \, \Delta i_{t-j}^* + \omega_{1,t}$$

$$(11) \quad \Delta i_t^{sm} = \beta_2 \, i_{t-1}^{sm} + \sum_{j=1}^{q} \gamma_{2,j} \, \Delta i_{t-j}^{sm} + \omega_{2,t}$$

where the number of lags in each equation (p or q) is selected such as $\omega_{1,t}$ and $\omega_{2,t}$ are white noise. The difference between the DF test and the ADF test is that in the former $\gamma_{1,j} = \gamma_{2,j} = 0$.

1/ We have also conducted the cointegration tests using an estimated yield from holding Mexico's external debt for one month i_t^h, i.e., the interest rate over a holding period identical to the maturity period of the domestic assets. Such interest rate was defined as:

$$i_t^h = \frac{C_t}{P_t} + \frac{EP_{t+1} - P_t}{P_t}$$

where C_t and P_t have been defined above and $(EP_{t+1} - P_t)/P_t$ represents the expected capital gains from holding the asset during one month. The series for EP_{t+1}, the one month ahead forecast of the price in the secondary market for Mexico's external debt, was constructed using an autoregression process.
The series i_t^h was found to be I(1) and the cointegration test results from using i_t^h were not very different from using i_t^{sm}. However, since in the process of forecasting EP_{t+1}, one year of observations is lost, in the following discussions, only the tests using i_t^{sm} will be reported.

In both the DF and the ADF tests, the test statistic is the ratio of each β_i (i=1,2) to its corresponding standard error. The null hypothesis is rejected if the β_i is negative and significantly different from zero. [1]/

The results from the tests are presented in Table 3. The tests covered the period August 1986-July 1990. In the case of the ADF test, two lags were needed for $\omega_{1,t}$ to be white noise (that is, p=1 in equation (10)), while only one lag was enough for $\omega_{2,t}$ to be white noise (that is, q=2 in equation (11)). As shown in the table, the null hypothesis of unit root cannot be rejected at the 5 percent significance level indicating that the series on both interest rates on PAGAFES and the implicit yield for Mexico debt are nonstationary processes (Chart 4).

Since the test statistics for i_t^* are negative, it can be concluded that i_t^* follows an I(1) process. However, since the test statistics for i_t^{sm} are positive, it is necessary to test for the stationarity of the first difference, that is Δi_t^{sm}. Indeed, the test statistics for Δi_t^{sm} are negative and significant, implying that the original series is I(1). The result that i_t^* and i_t^{sm} are I(1) is in line with the hypothesis of rational expectations and market efficiency.

As discussed above, given the characteristics of PAGAFES and commercial bank claims on Mexico traded in the secondary market, it is reasonable to expect divergence in the behavior of the variables in the short-run; however, we would expect the variables to move together in the long-run. To test if the two variables are cointegrated, we need to first form the cointegration equation:

$$(12) \quad \hat{i}_t^* = A\hat{i}_t^{sm} + z_t$$

where, as mentioned before, z_t should be an I(0) process if i_t^* and i_t^{sm} are cointegrated. In this sense, z_t measures the extent to which the system deviates from the long-run relationship between i_t^* and i_t^{sm}. If z_t is stationary, such relationship will hold in the long-run.

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[1]/ It should be noted that under the null hypothesis, all the test statistics have non-standard distributions and the critical values are taken from tabulations compiled by Dickey, Fuller, and other investigators.

CHART 4
MEXICO
INTEREST RATE ON PAGAFES VS YIELD TO MATURITY

(In percent per annum)

PAGAFES

Yield to maturity

1987   1988   1989   1990
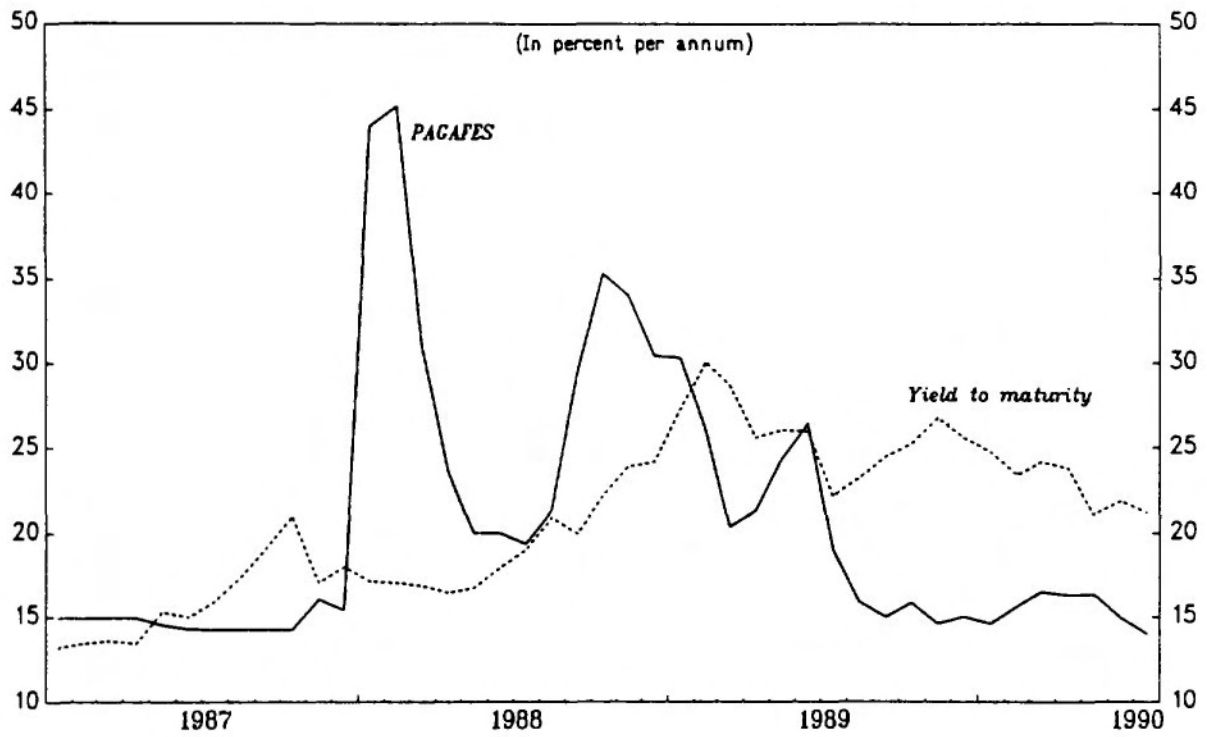
Table 3. Unit Root Test for i_t^* and i_t^{sm}

	DF	ADF [1]
i_t^*	-0.86	-0.71 (2)
i_t^{sm}	0.40	0.36 (1)
Δi_t^{sm}	-6.40	-4.7 (1)
Critical value at 5 percent level	-2.56	-2.9

[1] The number in parenthesis indicates the number of lags sufficient for $\omega_{i,t}$ (i=1,2) to be white noise.

An estimate of A, the long-run coefficient relating i_t^* and i_t^{sm}, is derived from the following vector autoregression (VAR) model:

$$(13) \quad i_t^* = 1.089 \ i_{t-1}^* \quad -0.325 \ i_{t-2}^*$$

$$\qquad\qquad (8.050) \qquad\qquad (2.353)$$

$$\qquad\quad + 1.184 \ i_{t-3}^{sm} \quad -0.978 \ i_{t-5}^{sm}$$

$$\qquad\qquad (3.509) \qquad\qquad (2.841)$$

$$R^2 = 0.693$$

where the numbers in parenthesis are t-values.

Using (13) to obtain the long-run relationship between i_t^* and i_t^{sm}, the estimated form of equation (11) is:

$$(14) \quad \hat{i}_t^* = 0.872 \ i_t^{sm}$$

where $\hat{i}_t^*$ is the estimated value of i_t^* and $z_t = i_t^* - \hat{i}_t^*$

To test whether z_t is an I(0) process, i.e., to test whether i_t^* and i_t^{sm} are cointegrated, we used again the DF and ADF tests. In addition we also analyzed the Durbin-Watson of the cointegration equation (CRDW). In the context of the present exercise, this test consists in obtaining the Durbin-Watson statistic from running z_t against a constant. The null hypothesis that z_t has a unit root will be rejected if the CRDW is significantly above zero.

The results from the tests are presented in Table 4, and they are somewhat mixed. The CRDW test rejects the hypothesis of a unit root in the residuals of the cointegration equation at the 5 percent significance level and therefore supports the hypothesis that i_t^* and i_t^{sm} are cointegrated. However, both the DF and ADF tests do not support the hypothesis of cointegration at the 5 percent significance level. The DF statistics is significant at the 10 percent level but the ADF statistics is on the borderline.

Table 4. Tests for Cointegration Between i_t^* and i_t^{sm}

	Statistic	Number of Lags	Critical Values	
			At the 5 percent level	At the 10 percent level
DF	-2.25	--	-2.56	-2.18
ADF	-2.77	1	-2.93 [1]	... [2]
CRDW	0.460	--	0.397	0.322

[1] The literature reports values ranging from -2.89 (Schwert (1988) to -3.17 (Hall and Henry (1989)).

[2] Hall and Henry (1989) report a value of -2.84; which likely corresponds to the upper end of the range.

Since our results are not conclusive, we further investigate whether i_t^* and i_t^{sm} are cointegrated by exploring if there exist a generating mechanism having what is called an "error-correcting" form: 1/

$$(15) \quad \Delta i_t^* = -\rho_1 z_{t-1} + \text{lagged } (\Delta i_t^*, \Delta i_t^{sm}) + d(B)v_t$$

where dB is a finite polynomial in the lag operator B and v_t is white noise.

Equation (14) is, therefore, a standard Error Correction Model (ECM) which includes the lagged residuals of the cointegration regression. The variables i_t^* and i_t^{sm} will be cointegrated if ρ_1, the coefficient of the lagged error term, is significantly negative. This is so because *equation (15) indicates that the amount and direction of a change in i_t^* will* take into account the size and sign of the previous deviation from equilibrium z_{t-1}. If the variables are cointegrated, z_t is stationary and, therefore, it is inclined to move towards its mean (which is zero), and hence the equilibrium relationship (14) tends to be restored.

Table 5 presents the results from estimating a simple ECM that includes the lagged error term z_{t-1}. Since ρ_1 is significant at the 5 percent level, this implies that there exists an error correlation mechanism that tends to restore the long-run equilibrium relationship between i_t^* and i_t^{sm}. Therefore, this test supports the hypothesis that i_t^* and i_t^{sm} are cointegrated.

Finally, as mentioned above, an important result of cointegration analysis is that if two variables are I(1) and cointegrated, there must be Granger causality in at least one direction. Our prior is that, Mexico being a small open economy, the implicit yield for Mexico's external debt Granger-causes the domestic interest rates on PAGAFES. Since the Granger test is an F test, it is applicable only to stationary variables; therefore, the test is applied to the first differences of i_t^* and i_t^{sm}. Table 6 reports the results from this test. As is shown, when Δi_t^* is the dependent variable, the F value is significant at the 5 percent level, supporting the hypothesis that i_t^{sm} Granger-causes i_t^*. Moreover, the test rejects the hypothesis that i_t^* Granger-causes i_t^{sm} since the F value was found to be not significant at the 5 percent level when Δi_t^{sm} was treated as the dependent variable.

On balance, the evidence seems to support the hypothesis that i_t^* and i_t^{sm} are cointegrated. Nevertheless, the tests are not very robust and further investigation would be useful as more data become available.

1/ Granger (1983) has shown that if two variables are both I(1) without trends in mean and are cointegrated, such data generating mechanism exists.

Table 5.   Error Correction Model 1/

(Dependent variable: Δi_t^*)

Variable	Coefficient	t-value
Constant	0.232	0.284
z_{t-1}	-0.224	-2.362
Δi_{t-1}^*	0.333	2.182
Δi_{t-2}^{sm}	-0.984	2.068
Δi_{t-3}^{sm}	0.981	1.878
Δi_{t-4}^{sm}	0.923	1.791

$R^2 = 0.378$

D.W. = 1.90

1/ It includes only the lagged variables that were found to be significant.

Table 6. Tests for Granger Causality

(Dependent variable: Δi_t^*)

F-Value	Dependent Variable	Independent Variables			
3.88 1/	Δi_t^*	Δi_{t-j}^*,	Δi_{t-k}^{sm}	j=1,2,3	k=1,2,3
2.74 1/	Δi_t^*	Δi_{t-j}^*,	Δi_{t-k}^{sm}	j=1,2,3	k=0,1,2,3
0.40	Δi_t^{sm}	Δi_{t-j}^{sm},	Δi_{t-k}^*	j=1,2,3	k=1,2,3,4
0.51	Δi_t^{sm}	Δi_{t-j}^{sm},	Δi_{t-k}^*	j=1,2,3	k=0,1,2,3

1/ - significant at the 5 percent level.

V. Concluding Remarks

This paper explored whether domestic interest rates in Mexico can be linked to expectations of exchange rate changes and to perceptions of the default risk contained in Mexico's external debt.

Tests were conducted on the covered interest parity (CIP) and uncovered interest parity (UIP) hypotheses using two assets that contain the same country risk premium but differ in the currency of denomination. It was shown that, with the exception of a short period of time when uncertainties in the economy were unusually large, deviations from covered interest parity were small and random occurrences. In addition, the evidence suggests that the "peso problem" prevailed during the period under study; that is, expectations of the future spot exchange rate consistently overestimated the actual future rate, in a regime where the exchange rate was not allowed to float freely. This result is consistent with rational expectations and efficiency in the exchange rate market and does not allow one to reject the validity of the UIP hypothesis.

A central issue in the paper was to investigate the extent to which both the domestic and external U.S. dollar-denominated debt issued by Mexico behave in the same fashion, i.e., that they are affected by the same considerations about prospects of the Mexican economy as reflected in the risk of default. In this context, this paper raised the hypothesis that the interest rate on a U.S. dollar-denominated domestic asset is linked to the yield implicit in the secondary market price for external debt issued by Mexico. This implies that, from the point of view of creditworthiness, there is no distinction between the domestic and external components of Mexican debt. The empirical tests conducted in this paper provide support for this hypothesis. It was found that, on balance, the evidence suggests that, once covered for exchange rate changes, domestic interest rates in Mexico and the implicit yield derived from the secondary market for Mexican external debt are cointegrated, i.e., they move together in the long-run. Moreover, it was shown that while the latter variable Granger causes the former, the inverse relationship does not hold.

An important policy implication derived from these results is that in order to achieve a permanent decline in domestic interest rates, the policies undertaken by the Mexican authorities need to be successful not only in reducing the wedge between public expectations of exchange rate devaluations and the preannounced rate of depreciation, but also in improving the underlying conditions of the economy which affect international perceptions about the creditworthiness characteristics of the country. This paper has not attempted to explain the factors underlying such perceptions of creditworthiness in Mexico. Such a task remains as a crucial next step in the current research.

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