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MARKET EFFICIENCY AND LONG RUN PURCHASING POWER PARITY DISEQUILIBRIA OF THE MEXICAN PESO UNDER CHANGING EXCHANGE RATE REGIMES

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Abstract

This paper tests if the efficient market version of Purchasing Power Parity (EMPPP) holds for the Mexican case for the 1970-2000 period in an environment of changing exchange rate regimes. Two regression analyses which extend PPP to a dynamic intertemporal model, based on market efficiency, are used, and in addition two unit root tests are applied. In general, the obtained empirical evidence does not support the EMPPP. Results suggest an inefficient market resulting from weak exchange rate policies and weak adoptions of several exchange rate regimes without proper inflation targeting and the application of strong and disciplined macroeconomic policies and structural changes.

1. Introduction

Numerous studies have been devoted to test the *Purchasing Power Parity (PPP)* theory. Empirical results show that in the short run generally it fails to hold, while in the long run the evidence is mixed. However, most tests in the past have followed inadequate specifications of PPP as an intertemporal theory. Roll's (1979) extension of PPP, based on market efficiency, that is, efficient market purchasing power parity (EMPPP) departs from the conventional vision of PPP, and overcomes such limitations. With few exceptions, research undertaken for the case of the developed economies supports this alternative proposition of PPP. However, limited studies have been conducted in the case of developing economies. Moreover, frequent changes in exchange rate systems adopted by these countries are greatly ignored in long run PPP studies devoted to emerging markets. The purpose of this work is to determine whether EMPPP exists in the long run for the case of Mexico. The evidence is presented with a background analysis of Mexico's patterns of growth and exchange regimes adopted during the last decade of the 20th century. Monthly data for nominal peso-dollar exchange rates and U.S. and Mexican inflation rates for the period 1970-2000 are used. The work is organized as follows. Section II highlights Mexico's long-run development patterns to present an overall framework of analysis for the

Mexican peso changes under different exchange rate regimes. Section III revises the PPP theory and the empirical evidence. Section IV presents the models to be tested, and describes the data utilized. Section V presents the results relating them to the impact of exchange rate regimes on market efficiency and economic performance. Two regression analyses and unit root tests are carried out. The first regression aims at determining whether past exchange rates, adjusted for inflation differentials, contain some information useful to predict future exchange rates. A second regression tests whether or not the exchange rate series follow a martingale process. This test is complemented with unit root tests. Previous to the analysis of the results, the stochastic characteristics of the series are examined. Section VI presents the conclusion.

2. Mexico's long run growth and exchange rate regimes

The decade of 1970 marks for Mexico the beginning of a period of irregular economic growth, characterized mainly by large recurrent economic crises. Previously, from the mid 1930's onward its economy had enjoyed annual average growth rates of 6.5 percent to the extent that it was identified as the "Mexican miracle," and it was commonly referred to other countries as an example to be followed for implementing successful development policies. However, many structural problems accumulated over the years and remained unsolved.[1] Particularly, from 1954 on, the government enforced a development model known as "stabilizing development," based basically in targeting low inflation levels (about 4.5 percent per year), fixed exchange rates (12.5 pesos per dollar), industrial promotion (but neglecting the agricultural sector), a severely controlled financial intermediation system, and in general high intervention of the state in the economy. Troublesome symptoms were already present by the mid 1960's, but only patch up measures were then implemented. Thus, the Mexican economy became fragile and vulnerable to any local or international economic shocks; it became unprepared to meet the challenges of economic globalization. Hence, during the last three decades of the 20th century growth of the Mexican economy was rather limited. As shown in Figure 1, measured in dollars, gross domestic product (GDP) increased 15.14 *times* from $35,542 million dollars in 1970 to $573,679 million in 2000. Additionally, growth was very irregular, often below population growth rates, even though large labour migration to the United States permanently served to diminish official unemployment and high disguised unemployment rates.

Poor government policies characterized particularly by weak control of inflation, lagged exchange rate adjustments, excessive government deficits, recurrent balance of payment deficits, and excessive international obliglations due to equally excessive foreign debt levels are the main factors contributing to such limited growth patterns. In fact, Mexico's growth during the last three decades of the 20th century can be described as a sequence of boom and bust cycles leading to and conditioned by three

[1] Analysis presented in this section are based on statistical and economic information reported in annual reports from Banco de Mexico. *Informe Annual*,Banco de Mexico, various issues, 1970.200; and statistical data reported annually by the International Monetary Fund, *International Financial Statistics*, various issues, 1970-2000.

large crises taking place in 1976, 1982, and 1995. The 1976 crisis was the result of the problems accumulated from previous decades, coupled with large foreign debt acqusitions, and the world oil shock of 1973. The 1982 crisis was triggrered by the inability of Mexico to fulfill its international obligations resulting from excessive short term foreign debt contracts and a dramatic fall in oil prices and a rise in international interest rates. Finally, the 1995 crisis followed a peso devaluation owing to large current account deficits, recurring fiscal deficits, and massive capital outflows due to foreign debt payments and withdrawals from the money and capital markets by international investors arising from a lack of confidence in the Mexican economy.

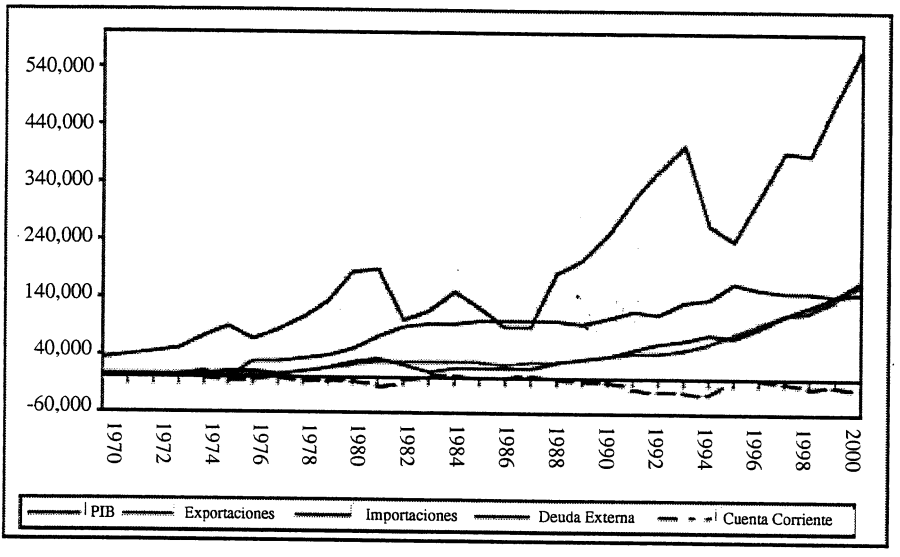

Fig. 1: Mexico's GDP and key external variables

Thus, following the favorable growth path from previous decades, in 1976 and 1977, real GDP growth fell to 4.2 and 3.4 percent, respectively. This was followed by an illusory oil boom bubble from 1978 to 1981; growth rates then averaged above 8 percent. However, this fictitious economic growth, as it was commonly labelled, could not be sustained; fooled by high oil revenues, the government engaged in extremely ambitious development plans, disregarding expected world tendencies for a fall in oil prices and increases in international interest rates in lieu of adjusting the economy, as originally agreed in an Letter of Intention with the International Monetary Fund. The Mexican Government increased its foreign debt beyond the country's capacity to pay, increased sharply the nation's budget deficit, and inculcated inflationary policies, mismanaged the external sector leading to increasing current account deficits, and maintained an overvalued peso. As a result, the world oil crisis of 1982 hit the Mexican economy hard and a long foreign "debt crisis" ensued. Indeed, for this reason, the 1980's were labelled as the "lost decade." GDP growth for the

entire1982-1987 period amounted to only 0.8 percent; a fall of 4.2 percent was registered in 1983 and the highest growth rate during that period was 3.6 percent in 1984. Liberalization policies began to be implemented following the peak of the debt crisis; Mexico joined the GATT in 1986, ending strong local oppositions from the past. However, an apparent full recovery began only in the early 1990's, partly because of successful debt renegotiotions, under the *Brady Plan*, and that led to diminished payments, freeing resources to promote development. Additionally, strong liberalization and deregulation policies in spite of the embedded fragility of the economy and its lack of competitiveness at the international level, induced some structural changes and economic growth led by large foreign direct and portfolio investments derived from a favorable international environment.

Consequently, growth was again illusory. From a peak of 5.2 percent growth in 1990, growth descended to 2.0 percent in 1993, increased to 4.3 percent in 1994, but following the macroeconomic problem of peso devaluation of December 1994, the economy fell down by 6.2 percent in 1995. Finally, during the last few years, the economy has been recovering and all main macroeconomic indicators have shown favorable trends, thanks to tight fiscal and monetary policies. By year 2000, GDP increased by 6.6 percent, fiscal deficit was virtually nil (= 0.013 percent in relation to GDP), and inflation had receded to 9.0 percent.

As previously pointed out, high inflation rates and mismanagment of the foreign sector are two major factors for Mexico's limited growth. In addition to GDP, Figure 1 depicts clearly the irregular growth path of imports, exports, the current account balance, and foreign debt levels. It is worth noting that foreign debt levels ammounted to only $3,226 million in 1970, increasing during the key crisis years to $25,813 million in 1976, $87,600 million in 1982, $157,755 million in 1995; by 2000 it had decreased slightly to $146,652 million. Also, it is important to notice that during 1986 and 1987 the external debt was greater than GDP. Overall, trade shows some favorable trends, spurred specially since the 1990's due to increased trade and foreign investment liberalization policies, and the implementation of the *North American Free Trade Agreement (NAFTA)* with Canada and the United States since January 1994. Exports increased from $2,868 million in 1970 to $166,455 million in 2000; similarly, imports increased from $3,296 million in 1970 to $174,458 million in 2000; in this respect, it is worth noting that foreign trade deficits have been constant in the Mexican economy, amounting, for example, to $10,236 million in 2000. A more dramatic situation has been present in the current account. In particular stands out the large deficit accumulated during the illusory 1988-1994 "first world vision" that Mexicans were led to believe by the government was the status of their economy; the current account deficit during that period totalled $105,667 million.

Mexico's poor economic management was also present in permissive inflationary policies and poor exchange rates policies. Indeed, inflation remained practically uncontrolled during the "lost decade" of the 1980's. Inflation reached two digit levels during the early 1970's, reaching 27.2 percent in 1976, the highest for the decade, and then during the 1980's it increased up to 98.2 percent in 1982, and a dramatic 159.2 percent in 1986. Following a "pact" between workers, peasants, and entreprenuers, induced by the government, inflation descended during the following

years reaching a low 7.2 percent in 1994. Due to the peso devaluation of December 1994 there was again by a high inflation rate of 52.0 percent in 1995 with government fiscal discipline, in the following years inflation receded, registering a 9.0 percent level in 2000.

Concerning exchange rates, during the period under analysis, the government used it both as a tool to control inflation levels, lowering particularly production costs, and as a tool to promote competitivity of Mexican exports basically due to the lack of internationally competitive productivity increases from the local industries. These policies have been followed under various exchange rates regimes during which creeping overvaluations and large devaluations leading to at least temporary undervaluation of the peso have alternated. For the period under analysis, from January 1970 to September 1976, fixed exchange rate regime prevailed in Mexico in spite of the fall of the Bretton Woods agreement in 1971, and in spite of the fact that the dollar was ever since fluctuating freely in the foreign exchange markets with respect to other hard currencies. As a result, the peso was placed on a (temporary) floating exchange system on August 31, 1976 and the price of the dollar increased from Mex$12.50 to Mex$20.60 per dollar. From September 1976 through to July 1982, a highly managed floating regime was adopted. The Government intervened frequently when it considered it necessary to maintain orderly conditions in the market. From October that year, the peso was devalued slowly, within a band of one percent, with periodic annoucements by the end of the year; the dollar was quoted at Mex$26.230 by December 1991. However overaluation of the peso was unsustainable considering the large fiscal and current account deficits, and the large foreign debt obligations. The peso was left to float freely in February 1982 (nearing Mex$49.oo per dollar) and by June the managed float was resumed allowing a daily depreciation of Mex$0.04 per dollar.

To cope with increased dollar demand arising from the debt crisis, a dual exchange rate regime was enforced from August 1982 to February 1988. Consisting of a preferential rate (originally, Mex$49.50 per dollar) applicable to priority imports, conversion of oil exports revenues, and foreign debt payments, and an official market rate (originally, Mex$70.00 per dollar) which was adjusted under a passive crawling peg system, supposedly designed to maintain purchasing power parity through frequent devaluations matching increasing inflation levels. Beginning September 23 1983, the peso was subjected to depreciation of 13 Mexican cents per day. Daily deprectiations were increased later on to 17 cents (December 1984) and 21 cents (March 6, 1985). Failure to achieve PPP (the peso was overvalued by nearly 30 percent) led to the institution of a managed floating system with daily fixing sessions on August 5, 1985. The 21 cents daily depreciation was abolished; the dollar closed at Mex$450 by December that year.

The government ended its intervention in the market on November 18, 1987. However, by February of 1988, a pegged exchange rate was adopted again, fixing the price of the peso to the U.S. dollar at Mex$2,281. Since this policy was implemented without adjusting the price of the dollar, overvaluation of the peso continued to increase and adjustments through government intervention were minimal; dollar quotations ended at Mex$2,295 on December that year. Thus, on

January 1989 an "active crawl" was adopted, prescheduling daily devaluations of one peso daily, which was subsequently reduced to Mex$0.80 on May 28, 1990, Mex$0.40 on Noviember 12, 1990, and Mex$0.20 on November 11, 1991, which was then reverted to daily depreciations of Mex$0.40 on October 20, 1992.

This crawling system became insufficient to maintain a realitic exchange rate, considering the huge desequilibria in the external sector, higher inflation rates than the United States, low productivity increases, coupled with increases in wages and salaries higher than appreciations of the dollar. As a result desequilibria in the exchange market aggravated the harmful effects that inflation and imbalances in the external sector were bringing about to the economy. However, high foreign direct investments, and massive foreign portfolio investments increased international reserve levels, making it possible to maintain the illusion of a strong peso and a strong economy. However, severe macroeconomic disequilibria were present; inflation and government fiscal deficit levels began to increase and GDP growth diminshed significantly throughout the years. Furthermore, the peso was substantially overvalued, mainly because the government used it as a tool to control inflation. In addition, as previously reported, the current account balance increased to a total of $$105,667 million for the 1988-1994 period, changing from favorable patterns which with great effort had been achieved from 1983 to 1987. An overvalued peso was therefore maintained artificially, delaying unduly needed adjustments; by November 30, 1994, the end of President Salinas de Gortari term (1988-1994), the dollar was priced at Mex$3.45 new pesos (1000 old pesos became equivalent to one new peso, implemented January 1993). An adjustment of the exchange rate was long overdue, but was postponed mainly due to the political turmoil that faced Mexico during 1994 and the personal political ambitions of the president in turn, Carlos Salinas de Gortari who wished to become President of the *World Trade Organization*. Thus, soon after President Ernesto Zedillo took office, on December 19, the band's ceiling was raised by 15.3 percent to Mex$3.99 pesos per dollar, maintaining the Mex$0.004 new pesos band.

Nevertheless, due to the magnitude of the desequilibria in the economy, particularly in its external sector, this policy proved unsustainable. Hence the band regime was abandoned on December 22; and a floating exchange system was adopted which prevails to the present; the government, however, maintains high international reserve levels, and intervenes occassionally, selling or purchasing dollars to stabilize the market . Under this scheme a peso depreciation took place in 1995, reaching a peak of Mex$7.91 per dollar on November 15, under very volatile conditions throughout the year. Volatility tended to diminish in the following year, ending the year on December 2000 at 9.572 new pesos per dollar.

In short, during the last three decades of the 20th century, five fairly distinguishable exchange rate regimes complemented with some intermediate transitional regimes have been enforced in Mexico. While the first four regimes might be in principle equally desirable to deal with, particularly in the short run, the international payments of the nation, it is worth noting now that Mexican authorities view floating rates as offering greater flexibility to adjust promply to changes in international prices which in turn reflect international competitiveness, derived from technological and

productivity improvments. Put in different words, a free foreign exchange market enhances the potential of a country to maintain a fully competitive economy and a balanced external sector. In this context, a fundamental question to ask countries which do not follow floating exchange rate regimes is whether different exchange rate regimes have succeeded in attaining, at least in the long run, their equilibrium purchaing power parity, - that is, to what extent their exchange rate regimes and recurrent devaluation policies have been a fair tool to maintain PPP; finally, these questions also imply to what extent non-floating exchange regimes enhance or restrict market efficiency. In the case of Mexico, a further question is implied considering its adoption of a floating system since the end of 1994, that is, whether or not the floating exchange regime has contributed to achieve equilibrium PPP.

3. Theoretical framework and key studies

For an international investor, risk at international capital and money markets is highly associated with exchange rates. For corporations operating internationally, transactions and economic risk are also determined by exchange rates; finally, macroeconomic performance depends greatly on exchange rate equilibrium, which depends to a great extent in timely exchange rate adjustments either *via* government policies under new floating rate regimes, or else on efficient markets under free floating rates regimes.

Purchasing Power Parity (PPP) is one of the oldest and most controversial doctrines in international finance. According to the traditional PPP theory, as originally defined by Cassel (1916; 1921), in perfect goods and financial markets, identical goods must have the same real price everywhere. Otherwise, commodity arbitrage will take place (leading to *Law of One Price*). Assuming that every country consumes the same basket of goods; this theorem also applies to the national price indexes. In other words, the variation in the exchange rate for two currencies is equal to the inflation differential in the two countries over a period of time, equal in magnitude but opposite in sign (relative version of PPP).

PPP is a fundamental concept in international economics, national exchange and for monetary policies, and also has important implications both for the financial manager of international portfolios as well as for financial corporate managers. Although PPP is supposed to hold in the long run, short term deviations from PPP give rise to cross-border transfers of commodities and capital. Most models of exchange rate determination (e.g., Dornbusch, 1976, Mussa,1982, Krugman and Obstfeld,1999) are largely based on long run validity of the PPP proposition. PPP provides an easy and inexpensive way to make medium to long run predictions about exchange rate movements. Sustained deviations of the actual real exchange rate from its long run equilibrium level create economic exposure for the firm, excessive exchange risk to international investors, and great macroeconomic fragility to external shocks, which might end up in severe currency and financial crisis. There is no practical reason why the equilibrium real exchange rate should not vary through time as sustained by PPP.

The path of the real exchange rate compatible with the attainment of internal and external equilibrium is affected by changing world conditions, productivity improvements, adjustments to trade barriers, and changes in taxation, among other factors (Edwards, 1989, p. 15). Globalization has led to increased importance of capital flows, particularly foreign direct and portfolio investments as determinants of international reserves and exchange rate levels (Bohn and Tesar, 1998; Goldberg and Klein, 1998; Agénor and Hoffmaister, 1998 and Ortiz, 2000). Finally, inadequate exchange rate regimes may hinder timely exchange rate adjustments, slow down economic recuperation from shocks and economic crises, hinder the exchange market efficiency and impact negatively economic growth (Giugale and Korobow, 2002; Haussman, Panizza and Stein, 2002; and Osakwe and Schembri, 1999).[2]

One of the most extensive reviews of the earlier tests of PPP was undertaken by Officer (1976). Since then evidence has been accumulating that demonstrates PPP's failure to hold in the short run. For instance, Frenkel (1981), Hakkio (1984), Krugman (1984), Dornbusch (1980; 1985), Broadberry (1987), Edison (1987), Murray and Papell (2002), Rogoff (1996), Taylor (2002) all confirm this result. Nevertheless, even on a long term basis mixed results are present (Engel, 1988).[3] Roll (1979) argued that a problem of past tests of PPP is an inadequate specification of PPP as a dynamic intertemporal theory. He formulated a superior theory of PPP from an efficient markets perspective based on international commodity arbitrage, i.e. the efficient markets PPP (EMPPP). Later Adler and Lehmann (1983) developed another version of the efficient markets PPP based on financial arbitrate in bonds. Empirical evidence on EMPPP can be found in the work of Adler and Lehmann (1983), Darby (1980), Dutt and Ghosh (1985), Huang (1987), Koveos and Seifert (1985), Roll (1979). On the whole, the empirical evidence supports the efficient markets view of PPP for most industrialized countries. A notable exception was Huang (1987) who reported that expected nominal exchange rate changes appear to deviate systematically from expected inflation rate differentials supporting the presence of time-varying risk premia in foreign exchange markets. More recently, Abuaf and Jorion (1990) re-examined the evidence on PPP using a first order autoregression model in a multivariate setting. They show that long run PPP might indeed hold, although there are substantial short term deviations from the parity condition. Examining the Australian case, Olekalns and Wilkins (1998) estimating fractionally integrated ARMA model found that PPP does have relevance for the long run behavior ot the exchange rate.

[2] This does not mean that floating exchange is "appropiate" for emerging markets; the choice between floating exchange rates and hard peg regimes (a bi-polar view) is one of the most contested debates in international economics today. However, many economists point out towards an inflation targeted framework in monetary policy, sustained with strong fundamentals, and pursuing sound macroeconomic and structural policies; in this respect countries must diagnose well their own problems and enforce specific answers to specific problems (Blejer and Skerb, 2002).

[3] An assessment of PPP studies can be found in Brauer,1994, and McDonald. (2003).

Previous studies have by and large been restricted to early time periods and especially to industrial countries.[4] The purpose of this paper is to investigate whether the EMPPP, as identified by Roll (1979), holds the case of the Mexican peso, for the period January 1970 - December 2000.[5]

4. The model and data sources

EMPPP is based on the constraint that, in efficient markets, the real return to an investor from intertemporal speculation on goods is anticipated to be zero. This paper investigates three testable implications of the efficient markets hypothesis, as suggested by Roll (1979). The EMPPP hypothesis stipulates that all available information is utilized by the market participants such that the present spot exchange rate contains all the information to predict the future spot rate adjusted for the inflation differential. The first testable version of EMPPP can be expressed in a regression format as:[6]

$$X_t = b_0 + b_1(\ln S_{t-1}) + b_2X_{t-1} + b_3X_{t-2} + b_4X_{t-3} + b_5X_{t-4} + b_6X_{t-5} + b_7X_{t-6} \ldots + b_nx_{t-(n-1)} \quad (1)$$

where, X_t = the natural logarithm of the spot exchange rate adjusted for the intercountry inflation differential in period t (i.e., $X_t = \ln S_t - DI_t$, where DI_t is the difference in the continuously compounded inflation rate between the home country and the foreign country. S_{t-1} = spot exchange rate in period t-1. The efficient markets version of PPP would be supported if equation (1) results in the b_1 coefficient to be equal to unity and the other coefficients to be zero.[7]

EMPPP also implies that the real exchange rates follow a martingale process. Therefore deviations from PPP from one period to the next should be serially

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[4] An exception is Roll (1979) who examined 23 countries, including Argentina, Brazil, Chile, Mexico and Venezuela (1957-1976). Another notable exception is Koveos and Seifert (1985) who tested the EMPPP for the Latin American black market currencies for the period April 1973-March 1983). The work by Mkend (2001) applied a panel data approach for selected African countries using annual data for the period 1965-1996.

[5] Currently foreign portfolio investments are very significative at the Mexican Stock Exchange, nearing 65 percent of total market value.. However, the internationalization of this market is recent; hence there are not yet time series about international arbitrage with Mexican securities; Therefore, it is not possible to carry out studies about EMPPP using Adler and Lehman extension.

[6] It is worth noting that parting from the conventional view on PPP, to examine efficiency of the exchange market this equation (Roll (1979) does not propose a regression analysis based on real exchange rate ($RXR = S_t/(IP_d/IP_e)$, donde RXR = Real exchange rate, S = tipo de cambio spot, and IP, price index, d = domestic, e = foreign.

[7] The number of lags can be greater than o less than 6 as shown in this equation. Roll (1979) uses six lags which is followed in this study. It is worth mentioning that according to interviews carried out among stock market brokers and exchange market brokers, six months

independent (Adler and Lehmann (1983, p. 1472). Equation (2) can be used to test this hypothesis:[8]

$$Y_t = b_0 + b_1 Y_{t-1} + b_2 Y_{t-2} + b_3 Y_{t-3} + b_4 Y_{t-4} + b_5 Y_{t-5} + b_6 Y_{t-6} \ldots + b_n Y_{t-(n-1)} \quad (2)$$

where Y_t = the difference between the rate of change in the spot exchange rate ($\ln S_t - \ln S_{t-1}$) and the intercountry inflation differential (DI_t) in period t (i.e., $Y_t = (\ln S_t - \ln S_{t-1}) - DI_t$).

The random walk hypothesis implies that the b_i (i = 1,...,n) coefficients should be zero for all i. Both equations, (1) and (2), are estimated to test the relevance of EMPPP for the Mexican peso.

Finally, if the time series of changes in the exchange rate follow a martingale process and should therefore be characterized by a random walk process, the time series should be a non-stationary series. Thus, to support the EPPP we should be able to prove that the changes in real exchange rates have a unit root. The *Augmented Dickey-Fuller* test (ADF) and the *Phillip-Perron* test are used to test this hypothesis. The two statistics tests are for a unit root in the univariate representation of a time series to exist. For a series Y_t the ADF test (Dickey and Fuller, 1979) consists of a regression of the first difference of the series against the series lagged k times as shown in equation (3):

$$\Delta y_t = \alpha + \lambda y_{t-1} + \sum_{s=1}^{k} \beta_s \Delta y_{t-s} + \varepsilon_t \quad (3)$$

The null and alternative hypothesis are: H_0: $\gamma = 0$; H_1: $\gamma < 1$; acceptance of the null hypothesis implies nonstationarity. Control for higher-order correlation in a series the ADF approach adds lagged differenced terms in the right high of the equation. Similarly, the Phillip-Perron test (1988) aims at controlling for higher-order serial correlation in a series making a correction to the t-statistic of the γ coefficient of the AR(1) regression to account for the serial correlation on ε. Unit root tests have become useful due to their increased test power.[9]

Important long term tests of PPP have been recently carried out by Lothian and Taylor (1996) and Cuddington and Liang (1998). The former conclude that PPP is valid in the long run for the bilateral real rates of exchange they considered. The finding of Cuddington and Liang contradicts those findings; using a two hundred years series for the dollar-sterling real rates they find that the choice in the lag length might influence the results,[10] or else deterministic trends and structural breaks can

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is generally the information time horizon used by investors to take their decisions, albeit previous years performance is also analyzed to assess their annual portfolio performance.

[8] As in the case of equation (1), nominal exchange rates are adjusted by the differential in inflation rates following Roll's (1979) proposition.

[9] This adjusted t statistic is known as tau (J), but often is only refered as t statistic from the unit root test, denomination followed in this work.

[10] On this issue see: Ng and Perron (2001).

give rise to nonstationarity. However, their findings are limited to real exchange rates. This study extends the unit root test to the series of changes in exchange rates to complement the martingale test proposed by equation (2).

Although the econometric tests in this work concentrate on market efficiency, it is important to note that failure to meet efficiency in the case of emerging markets, and concretely in the case of Mexico for the period under analysis will be indicative that exchange rate policies implemented under different exchange rate systems have failed to attain an equilibrium PPP in the long run, not only because untimely adjustments, but mostly due to repression of the market.

The primary source of data for this study is the International Monetary Fund's International Financial Statistics, which include end-of-month exchange rates relative to the U.S. dollar and end of month consumer price indexes. The exchange rate data used in testing the efficient markets hypotheses cover the period January 1970 - December 2000.[11]

5. Empirical results

A. Basic Statistics

Table 1 summarizes the main stochastic characteristics of the Mexican peso on a long term basis. Statistics are shown for the bilateral real peso (in terms of the U.S. dollar) and for changes in the real peso series. The data includes a total of 372 observations. To apprehend fully the nature of the series, these statistics are shown in terms of the old peso, for early January 1993 three zeros were dropped from the old peso. By 1970 the exchange rate for the dollar in pesos was $12.50 pesos per dollar, a rate that remained, with slight variations, stable since devaluations that took place from 1954 to 1976, when Mexico suffered its first crisis of the second half of the 20th century. Thus, the minimum dollar price for the period was $12.11 pesos per dollar; the maximum is $10,404.06 pesos per dollar, which in new pesos nears the exchange rates slightly below ten pesos (new pesos) prevailing today; the mean for the period is 2,402.71 pesos per dollar (24.03 in new pesos). Considering such large changes, it is not surprising that the standard deviation amounts to 3,246.21 pesos, that is, 32.46 in new pesos. A similar situation is present for the case of changes in real prices. The mean monthly change during the period was -0.043; the maximum change 65.01 points and the minimum change were - 44.61 points. It is also worth noting that both series are skewed to the right and lack normality. However, the price series is practically mesokurtic while the change in real price series is very flat, platykurtic.

[11] Actually the exchange series data includes December 1969, end of period, i.e. opening price for January 1970, to be able to complete series of 12 months changes in exchange rates and inflation rates for all years for the period under analysis.

Table 1
Basic statistics for the Mexican real exchange rates

	Real Prices	Changes of Real Prices
Mean	2402.70709	-0.04295
Median	261.42182	-0.45938
Maximun	10404.05637	65.01778
Minimun	12.10978	44.60666
Std. Dev.	3246.20990	6.53593
Skewness	1.21957	4.65403
Kurtosis	3.07055	52.43146
Jarque-Bera	92.29255	39216.69
Probability	0	0
Observations	372	372

B. Efficient Markets PPP Tests

The estimated coefficients and the results of hypothesis tests pertinent to equation (1) are presented in Table 2. The null hypothesis, formulated in accordance with EMPPP, is that the coefficient of the previous period's spot exchange rate is equal to one and that the coefficients of past exchange rates adjusted for inflation are equal to zero. The t-statistic can be used to test the significance level for each individual coefficient. An F-statistic and Chi-square tests can utilized to test the hypothesis that $b_1 = 1$ and $b_i = 0$ $(i > 1)$.

Table 2
Efficient market test of purchasing power parity

	b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7
Coefficients	0.0089	1.0449	-0.2146	0.0417	0.0147	0.2008	-0.0719	-0.0165
t-Statistics	1.0655	5.0062	-0.9170	0.5981	0.2135	2.9119	-1.0354	-0.3006
Probability	0.2873	0.0000	0.3598	0.5501	0.8311	0.0038	0.3012	0.7639
R^2	0.9994							
F-statistics	85205							
Durbin-Watson	2.0268							

	Statistics	Probability
F-Test	3.4494	0.0014
Chi-Square	24.1461	0.0011

The results provide only weak support for the efficient markets version of PPP. Although the coefficient for the spot exchange rate in the previous period is close to

unity (i.e., $b_1 = 1$), and apparently statistically significant, the remainder of the coefficients are different from zero, particularly b_5 (fourth lag) which is statistically significant. Moreover, the high R- square and insignificant t-tests for the remainder b_i coefficients signal multicolinearity. Therefore, we can convincingly reject the hypothesis that $b_2 = b_3 \ldots b_7 = 0$. This is confirmed by the Wald test. As shown in Table 1 the F and Chi-square statistic decisively reject the null hypothesis at a one percent significance level. Thus in a long term basis, past spot rate adjusted for inflation from previous periods seem to contain some information about current spot exchange adjusted for inflation. This reflects the fact that during long periods authorities from Banco de Mexico "pegged" the peso to the dollar (earlier phase of the period under analysis) and implemented rather predictable programmed and dirty float regimes during other periods (following the crisis of 1982). Moreover, although a floating exchange rate regime has been adopted by Mexican authorities since the end of 1994, the market seemingly remains repressed for by year 2000; long run PPP equilibrium is absent.

Table 3 summarizes the results of the tests of equation (2). The null hypothesis that the differentials in real exchange rates follow a martingale process is not supported for the Mexican case, in a long term basis. All b_i ($i > 0$) have coefficient greater than zero; particularly, b_1, b_2, b_3 and b_6 have a t-statistic highly significant. These results indicate that the difference between the rate of change in the spot exchange rate and the inter-country inflation differential is correlated for the Mexican peso. The F-statistic and the Chi-square test from the Wald test confirm this result. According to this test, the hypothesis that all of the coefficients in equation (2) are equal to zero can be rejected at the 1% level of significance.

Table 3
Test of martingale process of Mexican real exchange rates

	b_0	b_1	b_2	b_3	b_4	b_5	b_6
Coefficients	-0.0529	-0.1688	-0.1532	-0.1180	0.0846	0.0200	0.2099
t-Statistics	-0.1610	-3.2705	-2.9252	-2.2350	1.6029	0.3816	4.0597
Probability	0.8722	0.0012	0.0037	0.0260	0.1098	0.7030	0.0001
R^2	0.1042						
F-statistics	6.9574						
Durbin-Watson	1.9655						
	Statistics		Probability				
F-Test	6.9574		0.0000				
Chi-Square	41.7443		0.0000				

The unit root test confirms the previous results. As shown in Table 3, the real price series has a unit root. The t-statistic for both the ADF and Phillips-Perron test are smaller (light to the right) than the critical value needed to reject the null hypothesis either at one percent, five percent or 10 percent levels of significance.[12] These series

therefore follow a random walk process and are therefore nonstationary, However, the series of changes in exchange rates also analyzed in equation (2) are stationary; the series do not follow a random walk process.[13]

Furthermore, the existence of stationarity in the real exchange series can be explained by the findings by Cuddingham and Liang. In some cases, this is due to the presence of time trends and structural break. In the case of Mexico this is obvious. As previously analyzed in Section II, during the period under analysis, five different exchange regimes were implemented bringing about in each occasion abrupt devaluations and increased volatility of the peso. In short, the exchange rate was deeply impacted by three severe crises that affected the economy in 1976, 1982 and 1994 and the exchange market was affected by changing exchange rate regimes, which in turn affected its efficiency. These impacts are well depicted in the evolutions of the real price series, Figure 1, and changes in real exchange rate series in Figure 2.

Table 4
Unit root tests

Augmented Dickey-Fuller Unit Root Test for the Mexican Real Exchange Rate

	Constant	Time	Variable	Lags
Coefficients	0.0218	0.0002	-0.0077	5
t-Statistics	2.2433	1.4420	-1.4416	
Valores Críticos	T	1%	5%	10%
	-1.4317	-3.9870	-3.4238	-3.1346

Phillips-Perron Unit Root Test for the Mexican Real Exchange Rate

Constant	Time	Variable	Lags	
Coefficients	0.0246	0.0002	-0.0073	5
t-Statistics	2.5184	1.45187	-1.3845	
Valores Críticos	T	1%	5%	10%
	-1.4317	-3.9870	-3.4238	-3.1346

[12] All statistical tests were made using the E-Views package. In the case of unit root tests in this software the null hy´pothesis of a unit root is rejected against the one side alternative if the t statistic is less than (lies to the left) of the critical value.

[13] The series of nominal prices and changes in nominal prices follow similar patterns of behavior. That is nominal exchange rates have a unit root, but the series of changes in nominal exchange rates do not present a unit root. These results are not presented for consistency in the presentation of the evidence in terms of the hypothesis derived from equation (2).

Table 4
Unit root tests (con't.)

Augmented Dickey-Fuller Unit Root Test for the Mexican Real Exchange Rate Changes				
Constant	Time	Variable	Lags	
Coefficients	0.1257	-0.0010	-1.2857	1
t-Statistics	0.1860	-0.3085	-16.3740	
Valores Críticos	T	1%	5%	10%
	-16.3740	-3.9867	-3.42365	-3.1345

Phillips-Perron Unit Root Test for the Mexican Real Exchange Rate Changes				
	Constant	Time	Variable	Lags
Coefficients	0.1046	-0.0008	-1.1454	1
t-Statistics	0.1549	-0.2671	-22.2081	
Valores Críticos	T	1%	5%	10%
	-22.2373	-3.9867	-3.4236	-3.1345

However, it is worth noting that applying a Chow break point test, the real rate of exchange had a rupture in 1982, most likely associated with the debt crisis devaluations, while the changes in real exchange rate series present a rupture in 1994, clearly associated with the problems that led to the peso devaluation at the end of that year. Table 5 shows these results. Finally, it must be pointed out that the unit root test for the Mexican case differs for that presented by Kahn and Parikh (1998) for the South African case. Despite drastic changes in exchange rate policy they found no evidence of unit root nonstationarity and the behaviour of real exchange rate was stable but not constant.[14]

Table 5
Chow's breakpoint tests for the Mexican real exchange rates series 1970-2000

Index	Breakpoint	F-Statistic	Probability	Log Likelihood Ratio	Probability
REAL	12/31/1994	51.9625	0.0000	92.5040	0.0000
CHANGES	12/31/1981	6.3282	0.0020	12.5787	0.0019

[14] These two facts suggest the need for further studies on PPP parity for the case of Mexico, including EPPP with the identification of optimal breakpoints. Because the breakpoint for the real exchange rate implies a shorter period for analysis, this study does not include further research on the EPPP for the Mexican case. On the issues concerning unit root test and structural breakpoints see: Perron an Vogeslang (992), Perron (1997) Baum, Barkoulas and Caglayan (2000).

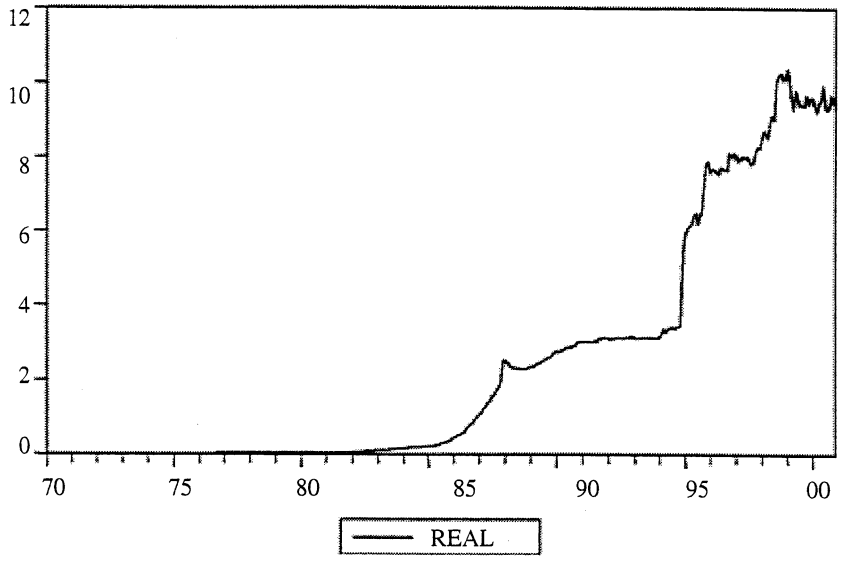

Fig. 2: Mexican real exchange rate

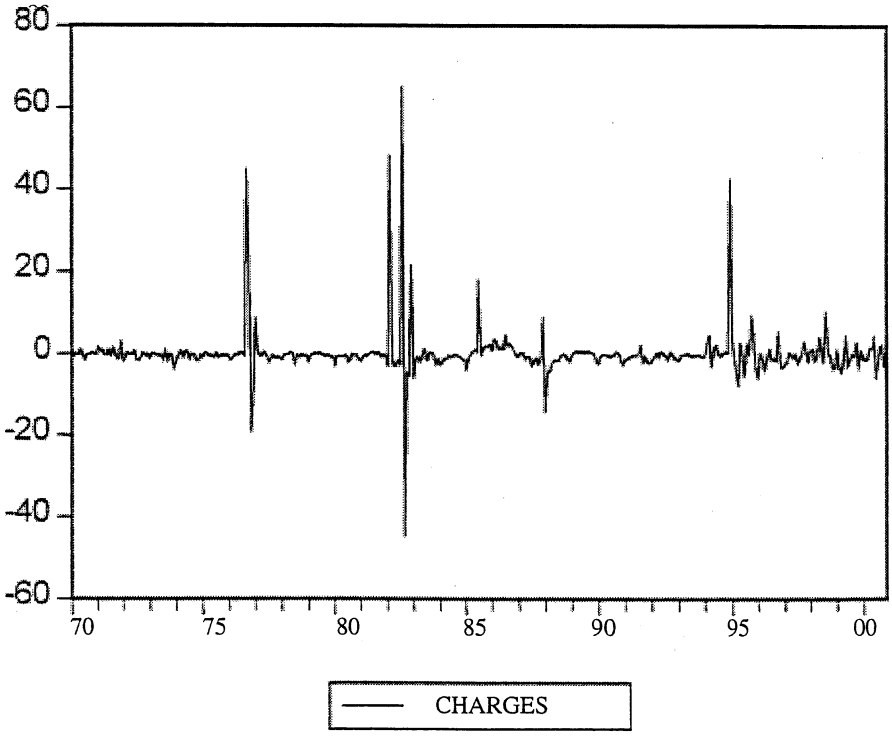

Fig. 3: Mexican real exchange rate changes

In sum, the three tests applied the Mexican peso do not support the EMPPP theory. In terms of efficiency, pegging, excessive control over the Mexican exchange rate, delayed adjustment of the exchange rate *vis a vis* the U.S. dollar, and repeated changes in exchange rate regimes have led to an inefficient market; past prices, and past changes in the exchange rate seem to have some useful information about the present price of the Mexican exchange rate. Past market information could be used to obtain extraordinary gains by speculating in exchange rates. Indeed, volatility of exchange rates in Mexico might be associated with speculation and abuse of inside information.[15] Similarly, empirical findings suggest the need to develop exchange rate futures in Mexico to provide alternatives for hedging for the international investor, corporations, and financial institutions that carry out business involving peso-dollar transactions.[16] This empirical evidence is in disagreement with the results for Latin American black market rates as reported by Koveos and Selfert (1985). Using market exchange rates reported for the case of the Mexican peso, the results are not favorable to their conclusion that the efficient markets version of PPP appears to be the appropriate framework for many currencies in Latin America. The fact is that by December 2000 equilibrium PPP was absent in spite of the final application of floating rates since the end of 1994. Considering undervaluations of the peso registered when adjustments were applied, including the market adjustment of 1994-1995, also suggests that free floating is far from appropiate implementation; indeed, the peso was again overvalued. Finally, the evidence also suggests that the unstable application of exchange regimes, without controlling properly inflation and implementing simultaneously, and sustaining sound macroeconomic policies and pursuing needed structural changes has been costly for Mexico. Indeed, although the issue of echange rate regimes is debatable, as previously explained, recent studies evidence that Mexico's recovery is faster when the country's policy makers let the peso float freely than when they fix it (Giugale and Korobow, 2002); similarly, Osakwe and Schembri (1999) show that had Mexico been on a flexible rate for a study period from 1972 to 1995, instead of a series of collapsing exchange rate regimes, the variance in output would have been reduced by half.

6. Conclusion

This paper has investigated, in the context of changing exchange rate regimes, whether the efficient markets version of Purchasing Power Parity holds for the Mexican case for the period of 1970 – 2000. To test the EPPP two seemingly unrelated

[15] This fact could be related to some corrupt activities undertaken by some government officers, as well by agents from the private sector who have access to privileged information.

[16] The Mexican Derivatives market, known as Mexder, was formally created in August 1998 and started operating in December of that year in peso-dollar futures. However its growth has been slow and limited. Currently, in addition to the peso-dollar futures, futures on the stock market index, some interest rates, and stocks of some corporationss are traded. However, the market remains very thin and trade is nil in some days. The options market was only recently launched, April 26, 2004.

regressions were used and in addition a unit root test was applied. In general, the obtained empirical evidence does not favor to the EPPP. Results suggest an inefficient market resulting from weak exchange rate policies and weak adoptions of several exchange rate regimes without proper inflation targeting and the application of strong and disciplined macroeconomic policies and structural changes. Contrary to prior evidence that the efficient markets version of PPP generally holds, the results show that this conclusion cannot be generalized for the Mexican case. Since the Mexican peso has been subject to tight government controls, although moving toward freer markets since the peso devaluation of 1994, and because the Mexican economy has been affected by three severe crises since the 1970's, further research is necessary to test PPP for this economy, particularly with a view to determining optimal structural changes. The evidence strongly suggests the fact that the exchange market has been unduly repressed. Exchange rate stability and PPP equilibrium would be only achieved by targeting (and maintaining) low inflation rates and implementing sound and disciplined macroeconomic policies. The results also stress the need to develop the derivatives markets in Mexico to provide a mechanism for hedging and exchange rate stability.

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