www.cya.unam.mx/index.php/cya

Contaduría y Administración

Accounting & Management

Contaduría y Administración 68 (1), 2023, 1-17

The exchange rate and the oil price: An analysis of the Mexican economy

El tipo de cambio y el precio del petróleo: un análisis para la economía mexicana

Jesús Lechuga Montenegro[1*], Faustino Vega Miranda[2], Edson Valdés Iglesias[3]

[1]Universidad Autónoma Metropolitana, México
[2]Universidad Nacional Autónoma de México, México
[3]Universidad Veracruzana, México

Received December 7, 2021; accepted October 28, 2022
Available online August 8, 2024

Abstract

This research investigates the determinants of the Mexican exchange rate in the period 1994q1-2021q4, emphasizing the relationship between this variable and the price of the Mexican oil mix. Using an ADRL model with error correction, it is concluded that there is an inverse relationship between the exchange rate and the price of oil in the short and long term. This offers empirical evidence in favor of the fact that the variability of the exchange rate has largely been detached from fluctuations in the price of oil; this is because it is assumed that the depetrolization observed in the study period had a determining impact on the composition of exports and on public income.

JEL Code: O24, E31, C40
Keywords: exchange rate; oil price; causality; short and long term effects

---

*Corresponding author.
E-mail address: montenegro@azc.uam.mx (J. Lechuga Montenegro).
Peer Review under the responsibility of Universidad Nacional Autónoma de México.
E-mail address: edsonvaldes@gmail.com (E. Valdés Iglesias).

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

Resumen

En esta investigación se indagan los determinantes del tipo de cambio mexicano en el periodo 1994-2021, poniendo énfasis en la relación entre esta variable y el precio de la mezcla mexicana de petróleo. Por medio de un modelo econométrico ADRL con corrección de errores, la evidencia empírica sugiere la existencia de una relación inversa y de largo plazo entre el tipo de cambio y el precio de petróleo. Los resultados de la investigación coinciden con el estado del arte de la literatura contemporánea especializada, la cual resalta el papel de la variabilidad del tipo de cambio en las economías desarrolladas y en vías de desarrollo. En el caso de México, la volatilidad del precio de las divisas se ha desprendido en buena medida de las fluctuaciones del precio del petróleo; esto por cuanto se asume que la despetrolización observada en el periodo de estudio tuvo un impacto determinante en la composición de las exportaciones y en el ingreso público.

Código JEL: O24, E31, C40
Palabras clave: tipo de cambio; precio del petróleo; causalidad; efectos de corto y largo plazo

---

Introduction

Beyond its intrinsic use value, the importance of oil in the economy has multiple aspects. One of these aspects can be assumed as a financialized asset when speculating with the prices or securitization of the hydrocarbon in the futures markets.[1] This difference between physical and futures markets is the speculation space that gives rise to oil as a financial asset. Thus, futures contracts of this primary good are part of risk diversification strategies of investment portfolios or hedging portfolios, rather than speculative, such as sovereign wealth funds, in which the case of Mexico can be positioned (Sierra-Juárez & Méndez, 2017). Another aspect is the bidirectional influence of international oil price markers or benchmarks for Mexican export prices. On this subject, Gutiérrez (2018, p. 11), in an analysis of information transmission of mean and volatility, finds evidence that "oil futures markets have destabilizing effects on Mexican physical oil markets" as well as the dependence of the Mexican blend on international markets to set export prices.

The association between oil exports and public revenues is another significant aspect, which became relevant in 1975 when 36.9 million barrels were exported, compared to a meager 6.4 million barrels in the previous year; at the same time, the value of exports increased 11.5 times. From oil exports onwards, Pemex's tax regime implied an increasing contribution as part of budgetary income, reaching a historical maximum of 43% on average from 1983 to 1985. Nevertheless, for the period under study, while

[1]Under conditions of macroeconomic stability, oil prices do not have great variability, given that are were no major extra-economic or technological events that introduce frictions in the oil market, such as acts of terrorism, war, or political events. For example, hydrocarbon prices increased after the attacks on the Twin Towers in New York (Stratta, 2016).

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

in 1995 oil revenues as part of public revenue represented 36.8% of public revenue, this figure decreased to 11.1% in 2017 (Banxico 1995, 2018a, 2018b), which means a sort of "depetrolization" of public revenue. This aspect is relevant to the impact on the exchange rate variability.

Foreign exchange rate, inflation, oil price

Regarding the specific subject of this research, the analysis of the exchange rate and the oil price, the former has a certain margin of internal regulation by the monetary authority, and in the case of the latter, there is no margin of influence on the international price. Indeed, since 1995, when inflation was recorded at 50% and there was a macro-devaluation of 90%, a persistent reduction in the price level has been observed until a minimum of 2.1% in 2015, subsequently, a rebound to 6.7% in 2017, and then a rebalancing to converge to 2.8% in 2019. At the same time, the exchange rate has registered a sort of regulated depreciation at a rate of 2% throughout the 1995-2019 period.[2] In the case of oil, on the other hand, there have been periods of low prices with a slow pace of average growth (1995-2003), a persistent rise of 23% until a pronounced peak at the end of the 2004-2012 period, and then the inverse of a persistent fall at a rate of -45% until 2019.

It is common to find opinions indicating an inverse correlation between oil prices and the exchange rate, i.e., if the oil price rises, the peso-dollar exchange rate falls, and vice versa. The data reflect that since the peak of the Mexican blend oil price in 2012 at 102.5 dollars per barrel and the subsequent 50% drop in its quotation in 2019, the exchange rate recorded a depreciation of the same order.

Over twenty-five years after 1995, inflation and the exchange rate have converged toward macroeconomic stability without correlating with the variability of oil prices. After the traumatic "Tequila effect" in 1995, periods of exchange rate stability around an average value of the exchange rate with an increase in the oil price and vice versa were observed; but in the long run, a devaluation trend was sustained during four periods:

1. 1998-2002: average exchange rate around 9.36 pesos per dollar and a 111% increase in oil prices.
2. 2003-2008: average exchange rate around 11 pesos per dollar and a 240% increase in oil prices.
3. 2009-2014: average exchange rate around 13 pesos per dollar and a 52% increase in oil prices, including 100 dollars per barrel mega-prices in 2011 and 2012.

[2]The calculation was made taking Banxico's FIX exchange rate used to settle foreign currency obligations presented in the Annual Report. In nominal terms, the exchange rate went from 6.41 to 19.20 pesos per dollar in the referred years.

4. 2016-2019: average exchange rate around 19 pesos per dollar, with the lowest oil price in the entire series: in the first year at 35.77 dollars per barrel and a rebound to 56 dollars per barrel in 2019.

Given the above context, this research aims to determine the relation between the exchange rate and the oil price for the Mexican economy from 1994-2021 through an autoregressive model with distributed lags (ARDL) with error correction. The spatial cut-off was thus determined by data availability.[3] The paper's hypothesis is to prove the existence of a negative relation between these variables.

The first part of this study reviews national and international empirical evidence focused on analyzing the variables that influence the determination of the exchange rate. The second part describes the methodology and data used in the research. In the third part, a series of econometric exercises are carried out to determine the relation between the exchange rate and the price of the Mexican oil blend. The paper ends with some conclusions.

Reference literature on exchange rates and their determinants

National studies

The exchange rate is an essential price in the economic decisions of agents for social researchers and monetary authorities since expectations are formed in the market based on the trajectory of this variable, which reflects, to a certain extent, the economic situation of a country. The Central Bank monitors the behavior of the exchange rate as a major factor in formulating monetary policy, and the transmission mechanisms are analyzed from a theoretical standpoint.

From a theoretical point of view,[4] free market forces determine the movement of the external price—i.e., the supply and demand of foreign exchange—in a flexible exchange rate regime. This dynamic may coincide with the reality of developed countries.

---

[3]In addition to the above, the year 2020 is totally atypical in the world economy. The price of the Mexican blend in 2018 and 2019 and its eventual impact on the Fix exchange rate show no major association: in the first year, the price of the Mexican blend was erratic, with 57 dollars per barrel in January, 70 dollars in October, and falling to 44 dollars in December. On the other hand, the exchange rate recorded a gradual annual depreciation of 6.4%. In 2019, the exchange rate remained practically stable at around 19.15 pesos per dollar and the price of the blend had high variability with a rise of up to 63 dollars in April and a drop to 57 dollars in December (CEFP, 2018; SIE, 2021).

[4]Clavellina (2018) provides a rigorous theoretical review of the determinants of the nominal exchange rate among which the following stand out: low dollar supply, the Mexico-US price differential, and trade barriers between the two countries.

Nevertheless, the exchange rate in developing countries shows the economy's structural problems; therefore, the theory may not hold true due to these imperfections.[5] Empirical evidence suggests that, in addition to the foreign exchange market, there are other determinants of the external price, such as inflation, interest rate, or monetary aggregates, to mention a few.

In certain countries—Nigeria, Russia, Mexico—one variable to consider in the analysis of the exchange rate behavior is the oil price since these economies are highly dependent on the income from this commodity and suffer the ravages of fluctuations in its international price. In the contemporary and national context, the central authority recognizes that the exchange rate has been affected by the liberalization of energy prices (Banxico, 2018b).

Nonetheless, in several studies, oil is not considered a vector of influence on the exchange rate. Thus, Morales (2008) finds in a study for Mexico using a multiple linear regression model that the exchange rate has as determinants the National Consumer Price Index (NCPI) from Mexico and the United States (US), treasury certificates (CETES), US treasury bonds, Banxico's international reserves, M1, and the Industrial Activity Index. The econometric results confirm a positive and significant relation between the exchange rate, Mexican inflation, and the national interest rate. The relation between the exchange rate and international reserves is inverse.

Considering a long-run period, Segovia (2001) studies the Purchasing Power Parity (PPP) for the Mexican economy utilizing the cointegration approach, finding that from 1970 to 2000, the evidence shows that the exchange rate was in line with the theory. Nonetheless, the validity of the PPP is doubtful for the period 1996-2000. These results are a consequence of the change in the exchange rate regime in the 1990s. The author also finds a causal relation between prices (domestic and foreign) and the exchange rate. This evidence is consistent with Torre's report (2009) according to which the exchange rate causes, following the Granger test, its determinants since 1995: M1, Industrial Activity Index, NCPI, and CETES.

One of the cases in studies of more recent periods provides evidence on the impact of the international oil price in real terms on inflation in Mexico through its effect on changes in the real exchange rate. The evidence comes from Rodriguez and Perrotini (2018) through a Vector Autoregressive (VAR) model considering a period from January 1996 to November 2016.

Using a VAR model, Garcia *et al.* (2018) studied the effects in the Mexican economy on the exchange rate when faced with changes in the oil price in the period 1991-2017. The results are statistically significant, i.e., increases in spot oil prices create an appreciation in the spot value of the Mexican peso

[5]Cuevas (2017) finds an opposite result to that expected by economic theory. A depreciation of the real peso-dollar exchange rate reduces Mexican manufacturing exports to the US because it generates an increase in the prices of imported intermediate inputs. These findings are consistent with research by Cuevas (2014), Bergin *et al.* (2009), and Hanson (2012).

against the US dollar. Nonetheless, the evidence does not validate the importance of changes in future oil prices as a key determinant.

In an investigation in Mexico from 1983 to 2017 using time series econometrics, Rodriguez and Lopez (2019) found results indicating that oil price shocks negatively and significantly affected aggregate real economic activity.

Goda and Priewe (2020) study the determinants of exchange rate movements in 15 emerging economies. The quantitative results, using a dynamic panel model, show that volatility in the real exchange rate is higher in countries that export commodities (raw materials) compared to countries that export industrial goods. In the case of Mexico, the authors comment that the peso is a currency that tends to depreciate, and its manufacturing has a downward trend.

According to Loría (2020), this scenario of depreciation for the Mexican currency deepens in the context of the pandemic and in a pessimistic scenario because, in the absence of a deep fiscal reform, the federal government could raise the price of energy to obtain higher revenues but would thereby pressure a rise in prices, the interest rate, and the exchange rate, which would complicate the country's macroeconomic stability.

International evidence

In the review of the international literature, a fundamental issue is the review of the exchange rate since it plays a key role in economies as it facilitates economic integration, trade, and capital flows between countries. It also determines the value of the amount of external debt to be paid in foreign currency (Dawood *et al.*, 2021).

In studies for several different economies, the international oil price is not included among the variables considered relevant in the exchange rate behavior. For Argentina's economy, the Rosario Stock Exchange (BCR, 2010) identifies six exchange rate determinants: inflation differentials, interest rate differentials, current account deficit, public debt, terms of trade, and political stability. Each factor has a specific weight depending on the structural characteristics of the economy analyzed.

Benazic and Kersan-Skabic (2016) studied the long-run dynamics of the exchange rate in the Croatian economy utilizing a cointegration model from 1998-2013. The variables that best describe the exchange rate behavior are: relation of foreign currency loans to total loans, Foreign Direct Investment, and consumer prices. An interesting aspect of this small and highly importing economy is the irrelevance of international reserves in explaining exchange rate variations over a long period.

For India, Mirchandani (2013) examines the variables that best explain the volatility of the exchange rate in the period 1991-2010, since from the Great Recession onwards, the arrival of external capital flows was interrupted and caused highly volatile behavior. In this context, the correlation analysis suggests that the interest rate, the inflation rate, and the GDP growth rate affect the behavior of this key variable for the external economy. Furthermore, the same statistical methodology confirms a positive relation between foreign direct investment and the exchange rate.

Hamid and Sarosh (2017) studied the exchange rate policy from 1980 to 2017 in Pakistan. The authors find two factors affecting the behavior of the rupee, imports and the price level, which are both obstacles to adopting a new economic policy agenda. Nonetheless, recent research recommends applying a more sophisticated policy by restoring economic competitiveness by eliminating overvaluation, leaving behind the conventional canons that prioritize exchange rate management. Two success stories are cited in the text, Japan in 1960 and China in 1990, when these countries faced this dilemma by accumulating international reserves and restricting capital mobility.

Within studies of greater coverage, using conventional logic, Kakkar and Yan (2014) can be cited. They estimate a panel-type model for 15 economies of the Organization for Economic Cooperation and Development in the period 1970-2006, where sectoral factor productivities and the interest rate differential explain the exchange rate. The econometric results show that the regression arguments have strong explanatory power for exchange rate deviations. Seixas *et al.* (2018) estimate an unconventional panel-type model for 45 developing countries over the period 1990-2008; the dependent variable, the real exchange rate, is set from producer prices, spot exchange rate, productivity, international reserves, foreign indirect investment, interest rate differential, and GDP per capita. The empirical results indicate that financial variables can be the main determinants of the real exchange rate in the long run, suggesting that countries adopt regulations to develop a growth strategy.

In contrast, Hassan *et al.* (2017) estimate a model using cointegration methodology for Nigeria for 1989-2015, where the exchange rate is determined by the following variables: net foreign assets, fiscal balance, trade openness, oil price, nominal GDP, and interest rate. The econometric results show that all the variables are positively associated with exchange rate volatility, except for nominal GDP; this indicates a negative and statistically non-significant relation in explaining exchange rate changes. The Granger test yields the result that the direction of causality is unidirectional, i.e., oil price causes exchange rate volatility. Moreover, Gong and Zhou (2017) study the determinants of the exchange rate in the Russian economy, emphasizing the relation with the oil price. The authors estimate a multiple regression model taking oil price, international reserves, government revenues, consumer price index, producer price index, M1, exports, and foreign indirect investment as arguments. The results confirm a significant relation between the ruble and oil prices, an element the authors translate as an important variable in exchange rate policy.

A study of the Indian economy, using a sample of 260 companies and a panel model, shows that they react differently to exchange rate changes. Agnihotri and Arora (2021) find that exchange rate fluctuation is minimized considering the company's size, as portfolio managers and investors play a key role in these large entities' hedging strategies. This result is similar to what Begum and Gayathri (2021) also investigated for India using a multinomial logistic regression model by considering that companies suffer from exposure to exchange rate volatility. The authors propose using this surprise element in the exchange rate to their advantage, i.e., to hedge cash flows to preserve profits selectively, based on analysis in optimization models.

Finally, a more robust study investigates the variables influencing exchange rate volatility in six Asian economies: Bangladesh, China, India, Indonesia, Malaysia, and Pakistan. Using a multivariate ARMA-GARCH (1,1) model, Rashid and Bast (2022) find that unexpected changes in government expenditures, industrial production, and terms of trade affect the exchange rate in almost all of the economies analyzed while noting that these countries are heterogeneous among themselves and the effects on the exchange rate are also heterogeneous. An important component highlighted by the authors is that a strong exchange rate is linked to governments formulating fiscal and monetary policies that improve industrial production.

Given the above context, on the one hand, several vectors influence the exchange rate; on the other hand, the long-standing importance of oil activity in the economic history of some countries supports the interest in understanding the influence of oil prices on the exchange rate. In the specific interest of this paper, the following section estimates an econometric model to evaluate the initial hypothesis, which states that there is a negative relation between the exchange rate and the price of the Mexican oil blend in the period 1994-2021. In this aspect, a methodological proposal is established in three stages: the econometric technique used for the estimation is explained, the set of variables used in the study is described, and the paper concludes with the presentation of the results.

Methodology

An autoregressive model with distributed lags (ARDL) is used to capture the short- and long-run effects of oil price variations on the exchange rate. According to Pesaran *et al.* (2001), this type of model is effective regardless of whether the regressors are integrated of order I(0) or I(1) or are cointegrated with each other. Therefore, the appropriate lag for each variable can be included. The equation of an ARDL model can be specified as:

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

$$\Delta y_t = c_0 + y_{t-1} + \theta x_t + \sum_{i=1}^{p} \phi_i \, \Delta y_{t-1} + \sum_{j=0}^{q} \beta_j \, \Delta x_{t-j} + u_t \tag{1}$$

where Δ denotes the difference operator for the time series, and in the case of the dependent variable y_{t-1} and the explanatory x_t they are considered in levels if they do not have the difference operator associated with them. To include short and long-run dynamics, the ADRL can be reformulated as an error correction model (ECM) as follows:

$$\Delta y_t = c_0 \; - \alpha(y_{t-1} + \theta x_{t-i}) + \sum_{i=1}^{p} \phi_i \, \Delta y_{t-1} + \sum_{j=0}^{q} \beta_j \, \Delta x_{t-j} + u_t \tag{2}$$

If the sign of the coefficient α is negative and is statistically significant, it will imply that any long-run disequilibrium between the dependent variables and several independent variables will converge back to its long-run equilibrium. The long-run coefficients θ are the equilibrium effects of the independent variables on the dependent variable, for which it will be necessary to verify whether the coefficients of the matrix θ are non-zero and for this purpose, the Bound Test proposed by Pesaran et al. (2001) is used. The short-run coefficients β_j will be the fluctuations that are not due to deviations from the long-run equilibrium.

Data and graphic evidence

The data used in the research come from the National Institute of Statistics and Geography (INEGI; Spanish: Instituto Nacional de Estadística y Geografía) for the period 1994-2021, and the spatial cut-off was determined in this way due to the availability of data already mentioned. Thirteen variables were initially selected: Gross Domestic Product (Y), Exports (X), Gross Fixed Capital Formation (FBKF), Imports (M), National Consumer Price Index (NCPI), Producer Price Index (PPI), Monetary Aggregates (M1 and M2), Government Revenues (GR), International Reserves (IR), Price and Quotations Index (PQI), Mexican Blend Price of Crude Oil (Petro) and Interbank Exchange Rate (ER). Data are expressed in indices, with base year 2008=100, with quarterly frequency, and all were seasonally adjusted.

As a first approximation to the research, the evolution of the reference variables in the period 1994-2021 is presented separately. Thus, in Figure 1, the evolution of the exchange rate has an irregular behavior with very marked depreciations in the years of crisis: the first quarter of 1995 and the fourth quarter of 2008.

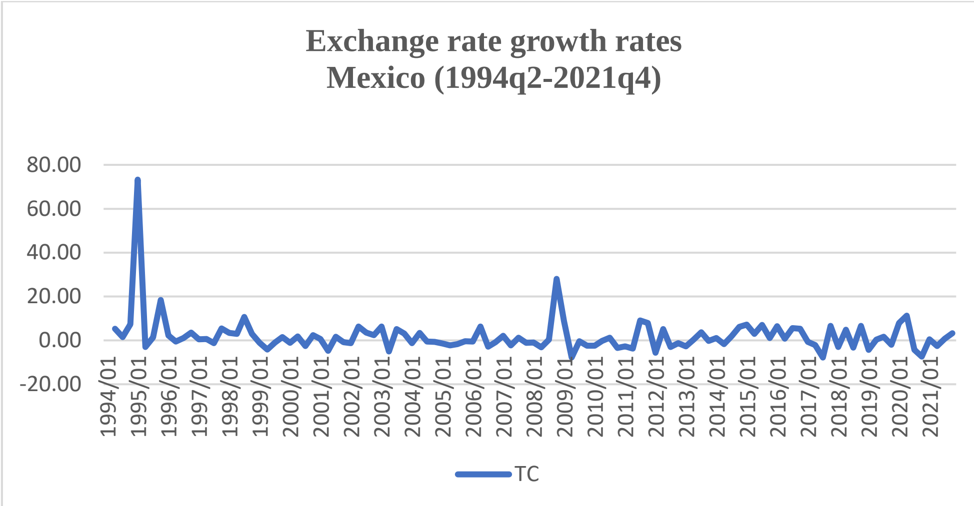

Figure 1. Mexico's exchange rate growth rates (1994q2-2021q4)
Source: created by the authors based on INEGI.

Figure 2 shows the dynamics of the price of the Mexican oil blend, an indicator that exhibits an upward trend until the third quarter of 2008 with a value of 104 dollars per barrel.

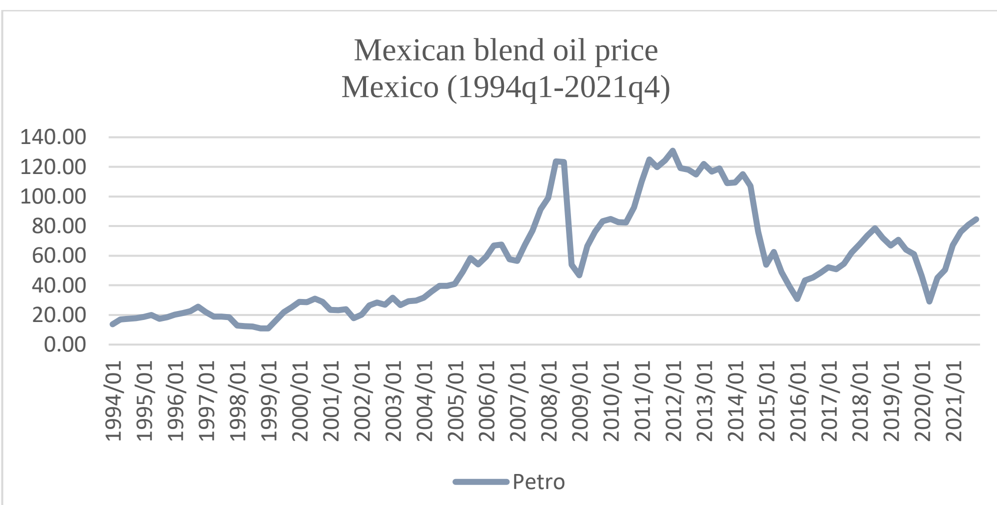

Figure 2. Mexican blend oil prices
Mexico (1994q1-2021q4)
Source: created by the authors based on INEGI.

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

Then, there was a sharp fall during the financial crisis when the variable reached a price of 39.41 dollars in the first quarter of 2009. Subsequently, the price rose steadily until it surpassed the previous maximum, then stabilized at around 100 dollars and, starting in the third quarter of 2014, plummeted to 26 dollars in the first quarter of 2016. From then on, recovery was observed to reach an average price per barrel of 43.49 dollars in 2017.

From the above, it is only in the fourth quarter of 2008 that there is an inverse coincidence between depreciation and the oil shock.

Econometric estimation results

Pesaran et al. (2001) emphasize that ARDL models are not subject to the determination of the order of integration of the underlying regressors before testing for the existence of a level relation between the regressors and the variable of interest, since, unlike typical applications of cointegration analysis, this method is not subject to this particular type of pretesting problem. Notwithstanding, as Philips (2018) points out, in order to use an ARDL-bounds, it is necessary that the order of integration of the variables used is not greater than I(1). For this, the order of integration of the series is corroborated by the Augmented Dickey-Fuller (ADF), Phillips Perron (PP), Dickey-Fuller Generalized Least Squares (DF-GLS), and the Zivot-Andrews (Z-A) tests for the existence of a unit root in a variable in the presence of a structural change.

Table 1
Unit root and stationarity tests

Variable	Specification	ADF	DF-GLS	Z-A	order
log TC	intercept	-5.531***	-4.633***	-7.303***	I(1)
	intercept and trend	-5.433***	-3.808***	-7.294***	I(1)
log Preto	intercept	-5.229***	-4.296***	-8.047***	I(1)
	intercept and trend	-5.215***	-4.201***	-7.755***	I(1)
log PIB	intercept	-5.618***	-5.816***	-13.042***	I(1)
	intercept and trend	-4.896***	-3.848***	-9.907***	I(0)
log Pt	intercept	-8.835***	-3.462***	-12.777***	I(1)
	intercept and trend	-6.512***	-3.692**	-12.954***	I(1)
log Ppro	intercept	-7.324***	-3.943***	-12.777***	I(1)
	intercept and trend	-5.591***	-3.933***	-10.569***	I(1)

Note: ***: p-value<0.01; **: p-value<0.05; *: p-value<0.10

Source: created by the authors.

As four series are stationary in their first difference with and without a structural break, and the GDP with intercept and integrated trend is of order 0, the optimal number of lags is chosen to present the

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

ARDL model with error correction to be estimated. In this regard, Shrestha and Bhatta (2018) show that this type of model integrates the short-run dynamics with the long-run equilibrium without losing long-run information and avoids problems such as spurious relations resulting from non-stationary time series data and mixed integration orders. According to the information criteria of Akaike and Schwartz[6], it is concluded that the model to be estimated is an ARDL (1,2,1,3,4) that captures the short and long-run dynamics between the exchange rate and oil prices based on the model proposed by Gong and Zhou (2017)[7], which the following equation will determine:

$$\Delta\log(TC_t) = c + \alpha[\log(TC_{t-1}) - \theta_0\log(Petro_{t-1}) - \theta_1\log(P_{t-1}) - \theta_2\log(Ppro_{t-1}) - \theta_3\log(Pib_{t-1})] + \sum_{i=1}^{p-1}\phi_i\Delta\log(TC_{t-i}) + \sum_{j=0}^{q-1}\beta_1\Delta\log(Petro_{t-j}) + \sum_{j=0}^{q-1}\beta_2\Delta\log(Pt_{t-j}) + \sum_{j=0}^{q-1}\beta_3\Delta\log(Ppro_{t-j}) + \sum_{j=0}^{q-1}\beta_4\Delta\log(Pib_{t-j}) + u_t \tag{3}$$

where TC is the exchange rate, Petro is the oil price, P is the National Consumer Price Index, Ppro is the Producer Price Index, and PIB is the GDP. All variables are expressed in logarithms and were corrected for seasonality. The results obtained are presented below:

Table 2
ARDL (1,2,1,3,4) model estimation with error correction for the Exchange Rate Equation

Variable	Coefficient	Standard Error	Statistic	p>value
(Adj α) lnTC_L1	-0.34773	0.08293	-4.193	0.0002
Long Run				
lnPetro_L1	-0.05360	0.01576	-3.401	0.0009
lnPib_L1	0.24580	0.09340	2.632	0.0099
lnP_L1	-1.07594	0.35258	-3.052	0.0029
lnPpro_L1	1.27889	0.37651	3.397	0.0010
Short Run				
lnPetro D1.	-0.07922	0.02338	-3.389	0.0010
lnPetro LD.	-0.07612	0.02165	-3.516	0.0006
lnPib D1.	0.44321	0.14148	3.133	0.0023
lnP D1.	-4.46825	0.64140	-6.966	0.0000
lnP LD.	2.58521	0.59052	4.37	0.0000
lnP L2D.	0.36409	0.64455	0.565	0.573530
lnPpro D1.	5.86049	0.53723	10.90	0.0000

[6]The model with the minimum value of the information criterion was ARDL(1,2,1,3,4) tested against 34 different combinations of lags.
[7]Gong and Zhou (2017) use an Ordinary Least Squares (OLS) model to search for the relation of Russia's exchange rate with the oil price and some macroeconomic variables.

http://dx.doi.org/10.22201/fca.24488410e.2023.4480

lnPpro LD.	-2.912019	0.59722	-4.876	0.0000
lnPro L2D.	1.23664	0.58386	2.118	0.036867
lnPro L3D	-0.99800	0.35651	-2.799	0.006238
_cons	-0.20880	0.27212	-0.767	0.444860

Source: created by the authors.

Table 2 shows the estimates of the ADRL model with error correction. The “Bound test” proposed by Pesaran *et al.* (2001) is performed to corroborate the correct specification of the model. This test will determine whether there is a long-run relation between the variables, the null hypothesis being the non-existence of a relation between the variables in levels. In turn, the test for normality of the residuals, heteroscedasticity, and the test for non-existence of serial correlation are performed. The results are presented in Table 3.

Table 3
Model Diagnostic Tests

Test	Statistic	p-value
Bound Test F I(0) 2.905 I(1) 4.170	5.216	I(0) 0.001 I(1) 0.012
Bound Test t I(0) -2.839 I(1) -3.960	-4.193	I(0) 0.001 I(1) 0.030
White (Heteroscedasticity)	108.00	0.4547
Breusch-Godfrey (no correlation)	0.084	0.7720
Jarque-Bera (normality)	0.48098	0.767

Source: created by the authors.

Serial correlation, heteroscedasticity, and normality tests show no problems in the model. In addition, the Bound Test (F and t) corroborates the existence of a long-run link between the variables in levels (they are cointegrated) at 95%.

The empirical evidence suggests a long-run relation between the exchange rate, the oil price, the producer price index, the national consumer price index, and the production level, as their long-run coefficients are statistically significant. In the case of oil price and consumer price level, the relation is inverse with exchange rate changes, issues that are consistent with the results obtained by Gong and Zhou (2017) for the Russian economy. Hassan et al. (2017) distinguish a positive relation between exchange rate volatility and oil prices in this economy for Nigeria. In the case of Mexico, Garcia et al. (2018) identify an inverse and significant relation between spot oil prices and the exchange rate but do not find a long-run relation between these variables. In addition, the sign of the coefficient α is negative and statistically significant, which indicates that any long-run disequilibrium between the variables will converge back to their long-run equilibrium.

In the case of the short-run coefficients, only oil price, NCPI, and NPPI are statistically significant. GDP has the expected sign but has no contemporaneous effect on the exchange rate as it is not significant at any level. Therefore, it will not contribute to explaining fluctuations that are not due to deviations from long-run equilibrium or, otherwise, in the short run, a 1% increase in the oil price causes the exchange rate to decrease by -0.079%. If the NCPI increases by 1%, the exchange rate decreases by -4.46%. And if the NPPI increases by 1%, the exchange rate increases by 5.86%. These results outline different contemporaneous dynamics between the exchange rate and the oil price, consumer prices, and producer prices.

Conclusions

The exchange rate is a critical variable in a country's economic structure, as many transactions depend on this price. Consequently, its study has been considered of great importance, whose determinants are anchored in the particular conditions of each country. For this research, the cases of Argentina, Croatia, India, Nigeria, Pakistan, and Russia, as well as two broad studies that analyze the behavior of 15 and 45 countries, respectively, were examined.

In general, it was observed that there are common variables directly influencing the exchange rate, such as inflation, external capital flows, and international reserves.

In particular, several countries—including Mexico—pay attention to the influence of oil prices on their economy. Accordingly, the ARDL model with error correction offers empirical evidence that supports the starting hypothesis: a negative relation exists between the exchange rate and the price of the Mexican oil blend. This relation is statistically significant in the short and long run in the study period, which is consistent with the results found by Gong and Zhou (2017) for the ruble and partially with the results obtained by Garcia *et al.* (2018) when distinguishing the short-run negative effect of the spot oil price on the exchange rate through a VAR model. Furthermore, there are key variables for analyzing the dynamics of the fundamental price of international trade: imports, consumer prices, producer prices, and the price and quotations index.

Nevertheless, the variability of the exchange rate has to a large extent detached itself from the oil price. This is because it is assumed that "depetrolization" had a determining impact on the economy and especially on government revenues.

References

Agnihotri, A. y S. Arora (2021). Asymmetric exchange rate exposure and its determinants: Analysis of the emerging market firms. Corporate Ownership & Control, 18(2), 154-161. https://doi.org/10.22495/cocv18i2art12

Banxico (1995). Informe anual 1994. México: Banco de México.

Banxico (2018a). Información oportuna de comercio exterior. México: Banco de México. Banxico (2018b). Programa Monetario 2018. México: Banco de México.

BCR (2010). Los seis factores que influyen en el tipo de cambio. Dirección de Informaciones y Estudios Económicos, 13(621), 1-8.

Begum, Z. y J. Gayathri (2021). Factors Determining the Exchange Rate Exposure of Firms: Evidence from India. Business Perspectives and Research. https://doi.org/10.1177/22785337211033766

Benazic, M. e I. Kersan-Skabic (2016). The determinants of exchange rate in Croatia. Eastern Journal of European Studies, 7 (1), 125-150.

Bergin, P. et al. (2009). Offshoring and volatility: Evidence from Mexico's maquiladora industry. American Economic Review, 99 (4), 1664-1671. http://dx.doi.org/10.1257/aer.99.4.1664

Clavellina, J. (2018). Determinantes del tipo de cambio y su volatilidad. Revista Economía UNAM, 15(45), 70-88. http://dx.doi.org/10.22201/fe.24488143e.2018.45.406

CEFP (2018). Precio de la Mezcla Mexicana de Exportación de Petróleo. Centro de Estudios de las Finanzas Públicas de la Cámara de Diputados. (Disponible en: https://www.cefp.gob.mx/new/graficas_interactivas.php)

Cuevas, V. (2017). The impact of the yuan-dollar exchange rate on Mexican manufacturing exports to the US: A cointegration approach. The World Economy, 41 (3), 866-883. https://doi.org/10.1111/twec.12542

Cuevas, V. (2014). La paridad yuan-dólar y su efecto en las exportaciones manufactureras mexicanas. Portes. Revista Mexicana de Estudios sobre Cuenca del Pacifico, 8(15), 7-34.

Dawood, M. et al. (2021). An empirical investigation into the determinants of external debt in Asian developing and transitioning economies. Development Studies Research, 8(1), 253-263. https://doi.org/10.1080/21665095.2021.1976658

García, S. et al. (2018). The effects of oil prices on the spot exchange rate (mxn/usd) a VAR analysis for Mexico from 1991 to 2017. Revista Análisis Económico, 33(84), 33-56. https://doi.org/10.24275/uam/azc/dcsh/ae/2018v33n84/Garcia

Gong, S. y Y. Zhou (2017). The enlightenment of the drop in oil prices and the ruble crisis. Advances in Economics, Business and Management Research, 33, 891-896. https://doi.org/10.2991/febm17.2017.120

Goda, T. y J. Priewe (2020). Determinants of real exchange rate movements in 15 emerging market economies. Brazilian Journal of Political Economy, 40(2), 214-237. http://dx.doi.org/10.1590/0101-31572020-3072

Gutiérrez, R. (2018). Mercados de futuros y físicos de petróleo: transmisión de media y volatilidad. Revista Problemas del Desarrollo, 49(192), 9-35. https://doi.org/10.22201/iiec.20078951e.2018.192.58715

Hamid, N. y A. Sarosh (2017). Exchange Rate Management and Economic Growth: A Brewing Crisis in Pakistan. The Lahore Journal of Economics, (22), 73–110.

Hanson, G. (2012). Understanding México's economic underperformance. Washington: Migration Policy Institute.

Hassan, A. et al. (2017). Determinants of Exchange Rate Volatility: New Estimates from Nigeria. Eastern Journal of Economics and Finance, 3(1), 1-12. . https://doi.org/10.20448/809.3.1.1.12

Kakkar, V. e I. Yan (2014). Determinants of real exchange rates: An empirical investigation. BOFITInstitute for Economies in Transition-Bank of Finland. https://helda.helsinki.fi/bof/bitstream/handle/123456789/8303/172944.pdf?sequence=1

Loría, E. (2020). México 2020-2024: dos escenarios macroeconómicos. Revista Mexicana de Economía y Finanzas, 15(2), 145-172. https://doi.org/10.21919/remef.v15i2.482

Mirchandani, A. (2013). Analysis of Macroeconomic Determinants of Exchange Rate Volatility in India. International Journal of Economics and Financial Issues, 3(1), 172-179.

Morales, A. (2008). México: factores determinantes del tipo de cambio, 1986-2000. Revista Comercio Exterior, 58(8-9), 588-597.

Pesaran, M. et al. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289-326. https://doi.org/10.1002/jae.616

Philips, A. (2018), Have Your Cake and Eat It Too? Cointegration and Dynamic Inference from Autoregressive Distributed Lag Models. American Journal of Political Science, 62, 230-244. https://doi.org/10.1111/ajps.12318

Rashid, A. y M. Basit (2022). Empirical determinants of exchange-rate volatility: evidence from selected Asian economies. Journal of Chinese Economic and Foreign Trade Studies, 15(1), 63-86 https://doi.org/10.1108/JCEFTS-04-2021-0017

Rodríguez, D. e I. Perrotini (2018). Impacto de los choques del precio del petróleo en el tipo de cambio y la inflación de México. Revista Economía: Teoría y Práctica, 4, 103-124. http://dx.doi.org/10.24275/ETYPUAM/NE/E042018/Rodriguez

Rodríguez, D. y F. López (2019). Efectos de la incertidumbre de los precios del petróleo en el crecimiento económico de México. Revista Investigación Económica, 78(309), 80-106. http://dx.doi.org/10.22201/fe.01851667p.2019.309.70120

Segovia, S. (2001). Determinantes fundamentales del tipo de cambio real de largo plazo: aplicaciones para el caso mexicano. Revista Cuestiones Económicas, 17(3), 39-85.

Seixas, L. et al. (2018). Determinants of the real exchange rate in the long-run for developing and emerging countries: a theoretical and empirical approach. International Review of Applied Economics, 32 (1), 62–83. https://doi.org/10.1080/02692171.2017.1332017

Shrestha, M., & Bhatta, G. (2018). Selecting appropriate methodological framework for time series data analysis. The Journal of Finance and Data Science, 4(2), 71-89. https://doi.org/10.1016/j.jfds.2017.11.001

SIE (2021). Mercado Cambiario. Sistema de información Económica. Banxico. (Disponible en: https://www.banxico.org.mx/tipcamb/main.do?page=tip&idioma=sp)

Sierra-Juárez, G. y D. Méndez (2017). Un modelo de inversión óptima para fondos soberanos: caso fondo mexicano del petróleo para la estabilización y el desarrollo. Revista El Trimestre Económico, 84 (335), 731-756. https://doi.org/10.20430/ete.v84i335.512

Stratta, E. (2016). El precio del crudo y su historia. Petrotecnia, Revista del Instituto Argentino del Petróleo y Gas, 3(16), 80-85.

Torre, L. (2009). Tipo de cambio y determinantes monetarios en el periodo de flotación en México. Revista EconoQuantum, 5(2), 47-71. https://doi.org/10.18381/eq.v5i2.94