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The relationship between oil prices, the stock market and the exchange rate: Evidence from Mexico

Nancy Areli Bermudez Delgado, Estefanía Bermudez Delgado, Eduardo Saucedo*

EGADE Business School, Tecnológico de Monterrey, Ave. Rufino Tamayo, Garza García, NL CP. 66269, Mexico

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ABSTRACT

This paper analyzes the variables of oil price, exchange rate and stock market index to explain how they interact with each other in the Mexican economy. The examined period includes monthly data from January 1992 to June 2017. A Vector Autoregressive Model (VAR) is implemented that includes oil prices, the nominal exchange rate, the Mexican stock market index, and the consumer price index. Results indicate that the exchange rate has a negative and statistically significant effect on the stock market index; this indicates that an appreciation of the exchange rate is related to an increase in the stock market index. It is also found that the consumer price index has a positive effect on the exchange rate and a negative effect on the stock market index. The results also indicate that oil prices are statistically significant against the exchange rate, concluding that an increase in oil prices creates an appreciation of the exchange rate. In addition, the impulse-response functions show that the effects found tend to disappear over time.

1. Introduction

In most industrial nations, energy expenditures account for a relatively large proportion of the Gross Domestic Product (GDP) and the variability in energy products, like oil, are an important factor that has an impact on the performance of important macroeconomic variables. For example, the spot prices in the West Texas Intermediate crude oil closed the year 2002 at $29.4 U.S. dollars (USD) per barrel. Nevertheless, by July of 2008, the price had reached an all-time high of $145.3 USD per barrel, which represented an increase of almost 400% in comparison with prices in 2002. Some years later, however, by March 2015, oil prices dropped to $42.4 USD per barrel. The effect of such variability in oil prices over time has attracted attention from investors, policy makers and researchers.

In a pioneering work, Hamilton (1983) indicates that higher oil prices were responsible for almost all the U.S. economic recessions after World War II. Jones and Kaul (1996) document that energy expenditures were as high as 14% of the GDP in the United States during the 1980s. Nevertheless, because of the reduction in fuel prices, the U.S. Energy Information Administration reported that energy expenditures decreased to 6.2% in 2002. Even with a reduction in GDP participation, oil prices are still a relevant factor to determine the performance of important macroeconomic variables. Similar figures that show the importance of oil in a country's GDP have been documented in Helliwell, Sturm, Jarrett, and Salou (1986). Similarly, Blanchard and Gali (2007) and Herrera and Pesavento (2009) analyzed the connections between the variability in oil prices and the performance of different economic variables.

In the case of Mexico, Bueno (1981) stated that the importance of petroleum for the Mexican economy is not in dispute; Mexico's exports and its government revenue have historically been highly dependent on this natural resource. Reyes and Benitez (2016) state

* Corresponding author.
E-mail addresses: a00510715@itesm.mx (N. Areli Bermudez Delgado), a00510714@itesm.mx (E. Bermudez Delgado), eduardo.saucedo@itesm.mx (E. Saucedo).

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that oil constitutes 11% of Mexico's total exports and around 30% of the government's budget. Given the importance of oil in the Mexican economy, diverse literature has emerged in which researchers analyze either the relationship between oil prices and the exchange rate or the relationship between oil prices and stock market returns. The most relevant literature about Mexico is described in Section 2, the literature review section. To the best of the authors' knowledge, there is only one prior paper, Coronado and Rojas (2016), that simultaneously analyzes the dynamism of oil prices, exchange rates and the stock market index for the Mexican economy. That study used an econometric model, which is highly different than the econometric model implemented in this paper.

Aloui and Ben (2016), in a paper that analyzed the dynamic relationship between those three variables stated: "It is important to understand the dependence between several variables interacting simultaneously, not in isolation of one another. The omission of one important variable in the extended system can be misleading because the channel through which the two other variables are connected is omitted from the incomplete system." In this sense, it is considered relevant to develop more research in this venue that analyzes the simultaneity among these three variables. For this reason, the objective of this paper is to help fill this gap in the literature regarding Mexico.

The rest of this paper is organized as follows: Section 2 reviews the empirical literature. Section 3 provides a description of the data, and explains the methodology and variables used in the implemented model. Section 4 summarizes the results obtained from the empirical tests, and Section 5 offers a conclusion of the paper's findings.

2. Literature review

Over the past few decades, a portion of the literature has analyzed the close relationship between oil prices and stock market returns, while a different portion of the literature has analyzed the connection between oil prices and exchange rates. Nevertheless, a small portion of the literature has addressed the relationship among all three variables—the exchange rate, oil prices, and the stock market index. The literature analysis is divided according to those segments and an additional section focuses on the literature developed regarding combinations of these variables in Mexico.

2.1. Studies on oil prices and the stock market

Although changes in oil prices are considered an important factor for understanding the volatility of stock markets, there is still no definite consensus regarding the relationship between oil prices and stock market returns. The diversity of results from different studies has encouraged many researchers to further analyze the connection between oil prices and stock market returns. For example, Kaul and Seyhun (1990) and Sadorsky (1999) found a negative effect of oil–price volatility on stock prices for the United States during the 1970s and 1980s. Papapetrou (2001), in a study developed for Greece during the late 1990s, reported that oil price shocks have a negative impact on stocks, since they negatively affect output and employment growth. Hong et al. (2002), in a study for the United States from 1970 to 2000, also identify a negative correlation between oil prices and stock market returns.

Basher and Sadorsky (2006) analyzed the impact of oil price risk on emerging stock markets. In the study, they pointed out that oil prices affect stock prices by having an impact on the cost structure of non-oil-producing companies. Evidence shows that such a change in the cost structure may not be fully transferred to consumers; therefore, stock prices are shocked by declining profits and dividends. In a similar approach, Chung-Rou and Shih-Yi (2014) studied the impact of oil price shocks on the stock prices of large emerging economies such as China, India, and Russia. They found that shocks in oil prices affect the stock returns in three of those emerging economies.

Yanfeng and Xiaoying (2017) analyze the relationship between oil price shocks and China's stock market. They state that the responses of stock return to oil shocks are different and are crucially related to the causes of the oil price changes, while the responses of stock volatility to oil shocks are almost insignificant. Gogineni (2008) explored the reaction of the stock market in different industries to daily oil price changes. He found that the direction and magnitude of the market's reaction to oil price changes depend on the magnitude of change in the oil price. He found that oil price changes caused by supply shocks have a negative impact on stock returns, while oil price changes caused by shifts in aggregate demand have a positive impact on the same day market returns.

In contrast, other studies have not found a significant relationship between oil prices and stock returns, such as Huang, Masulis, and Stoll (1996) who found that daily oil futures returns are not related with daily U.S. stock market returns. In contrast, Sadorsky (2001) found the opposite results, diverging from most of the literature—a positive relationship between oil prices and Canadian stock returns during the 1990s.

2.2. Studies on oil prices and exchange rates

Chaudhuri and Daniel (1998) investigated the relationship between oil prices and the exchange rate in 16 OECD countries. Their results show a non-stationary behavior of the U.S. dollar real exchange rate that is due to the non-stationary behavior of real oil prices. Amano and Van Norden (1998), in a study for Germany, Japan and the United States, analyzed the relationship between oil prices and the exchange rate. Their findings noted a robust and interesting relationship between the real domestic oil price and the real effective exchange rates.

Chen and Chen (2007), using a panel of G7 countries, tested whether or not exchange rates are cointegrated with real oil prices. Their results showed that real oil prices can be the dominant source of real exchange rate movements. In a more recent study, Mensah, Obi, and Bokpin (2017) examined the long-run dynamics between oil price and the bilateral U.S. dollar exchange rates for oil-dependent economies, such as India, Russia, South Africa, Ghana, and Nigeria, before the 2008–2009 financial crisis. Empirical results showed evidence of a long-run equilibrium relationship between oil prices and the exchange rate. Al-mulali and Che Sab (2012) investigated the impact of oil price shocks on the real exchange rate, covering the most recent oil shock from 2000 to 2010 in 12 oil-exporting countries. Their results show that increases in oil prices caused a real exchange rate appreciation in these countries.

2.3. Studies on oil prices, exchange rates, and the stock market

Basher and Sadorsky (2006) analyzed the dynamic relationship between oil prices, exchange rates and stock prices in emerging markets. They propose a structural VAR model to investigate the dynamic relationship between these variables. Their results support the fact that oil price risk impacts stock price returns. Aloui and Ben (2016) and Kayalar, Küçüközmen, and Selcuk-Kestel (2017) explored the structural dependence between crude oil prices, stock market indices and exchange rates for oil importers/exporters in the United States and in emerging markets, respectively. Both papers perform an econometric copula approach. The results showed that exchange rates and stock indices of most oil exporter countries have higher oil price dependency; whereas, emerging oil importer markets are less vulnerable to oil price fluctuations.

Basher, Haug, and Sadorsky (2012) also studied the relationship between oil prices, exchange rates, and stock markets. In their study, they showed that positive shocks in oil prices tend to depress emerging market stock prices and the U.S. dollar exchange rates in the short run. In a similar way, a positive oil production shock lowers oil prices, while a positive shock to real economic activity increases oil prices.

Sahu, Bandopadhyay, and Mondal (2014) investigated those three variables in India during the period 1993–2013. Their results suggest that there is a long-run, cointegrating relationship between crude oil prices and the Indian stock market index. However, their results also indicated that there is not enough statistical evidence to support the long-run relationship between oil prices and the Sensex (benchmark stock index). In a similar study, Jain and Biswal (2016) indicated that a fall in gold prices and crude oil prices cause a fall in the value of the Indian rupee and the benchmark stock index (i.e., Sensex).

2.4. Studies about Mexico on oil prices, exchange rates and the stock market

The Mexican economy is commonly included in research papers in which countries are categorized as emergent economies or oil exporter countries and studied in groups or panels. For example, Lizardo and Mollick (2010) in a study of oil exporter countries included Canada, Mexico, and Russia in an analysis that found that an increase in real oil prices leads to a significant depreciation of the U.S. dollar against local currencies, including an appreciation of the Mexican peso. Similarly, papers such as those by Mohammadi and Jahan-Parvar (2012), Rodríguez (2015), Volkov et al. (2016), and Zavala et al. (2016) found that oil revenue in a country is an important factor in determining the Mexican peso exchange rate with that country.

In addition, there are some other papers that study Mexico that analyze the effect of oil prices on stock market returns. Hammoudeh (2005), Filis, Degiannakis, and Floros (2011), Jawadi and Bellalah (2011), Raza, Jawad Hussain Shahzad, Tiwari, and Shahbaz (2016), Santillán et al. (2017) all concluded that oil prices have an impact on the Mexican stock market returns. Lastly, as mentioned previously, the only paper found in the literature that studies Mexico's oil prices, stock market returns and the exchange rate simultaneously was elaborated by Coronado and Rojas (2016). Their paper uses nonlinear and multivariate tests to detect not only the correlations among markets, but among the epochs in which such nonlinear dependence might occur.

3. Data analysis and methodology

This paper uses a monthly database that spans from January 1992 to June 2017. Using a VAR model, this paper analyzes the relationship between oil prices, the exchange rate, the stock market index and the consumer price index. By selecting this period, the analysis covers the transition of the Mexican economy in 1994 when the country moved from a fixed to a flexible exchange rate regime; the paper also covers the 2008–2009 financial crisis, which is an important period to analyze. The variables analyzed are the Mexican Mayan Crude Oil (MMCO), the Mexican Consumer Price Index (MCPI), the currency exchange rate of Mexican pesos per U.S. dollar (MXNUSD), and the Mexican Stock Market Index (MEXBOL).

Regarding the variable data, the Mexican Mayan Crude Oil data was retrieved from the U.S. Energy Information Administration. The Mexican Consumer Price Index and the exchange rate data were retrieved from the Mexican Central Bank website (Banxico), and the Mexican Stock Market Index was retrieved from Bloomberg. All these variables were log-transformed.

Table 1 presents the descriptive statistics of the variables used in this paper. Each variable has 305 observations that correspond to the number of months analyzed in this paper. The exchange rate (MXNUSD) is expressed as the number of pesos needed to equal one U.S. dollar. The table indicates the minimum exchange rate value during the analyzed period is \$3.02 and the maximum value is \$20.8 MXNUSD, which represents a depreciation of the Mexican peso of almost 600% against the U.S. dollar during the period.

Another variable in the table is the Mexican Stock Index (MEXBOL). The minimum value captured was in September 1992 when the MEXBOL scored 1327 points, and the highest value occurred in April 2017 when it reached 49,261 points. The vast difference in those numbers shows the attractiveness of the Mexican stock market during the period. Regarding the Mexican Mayan oil prices, the lowest price was \$6.37 USD in December 1998 and the highest value was in July 2008, when it reached \$121.3 USD per barrel.

Table 2 presents the correlation matrix among the variables analyzed in this paper. The results indicate a high correlation between some of the variables, which may be beneficial for the estimation of the VAR. In order to identify whether the variables are stationary or not stationary, three unit-root tests were conducted on each of the series, understanding the utilization of non-stationary variables in a regression analysis may produce spurious results. For the robustness check of the results, Table 3 shows the augmented

Table 1
Descriptive Statistics.

	MX Peso/U.S. Dollar MXNUSD	Mexican Consumer Price Index MCPI	Mexican Stock Market MEXBOL	Mexican Mayan Crude Oil MMCO
Mean	10.47	74.44	19,040.9	41.90
Median	10.79	78.06	10,957.3	29.22
Maximum	20.8	129	49,261	121
Minimum	3.02	15.88	1,327.07	6.37
Std. Dev.	3.84	33.13	16,312.9	31.19
Skewness	0.04	0.29	0.46	0.82
Kurtosis	3.30	1.99	1.58	2.35
Jarque-Bera	1.24	17.45	36.30	39.86
Probability	0.54	0.00	0.00	0.00
Observations	305	305	305	305

Sources: Banxico, U.S. Energy Information Administration, 305 observations, months between January 1992 and June 2017

Table 2
Correlation Matrix.

Correlation	MCPI	MEXBOL	MMCO	MXNUSD
MCPI	1.00	0.91	0.73	0.94
MEXBOL	0.91	1.00	0.80	0.82
MMCO	0.73	0.80	1.00	0.53
MXNUSD	0.94	0.82	0.53	1.00

Source: Authors' own with data from Banxico and the U.S. Energy Information Administration, January 1992 to June 2017.

Table 3
Unit-Root Test.

Variable	ADF	k	DF-GLS	k	KPSS	k	Determination
MXNUSD	−0.55	0	1.79	0	1.85***	14	I (1)
Log MXNUSD	−2.08	1	1.18	1	1.64***	14	I (1)
Δ Log MXNUSD	−14.90***	0	−14.47***	0	0.22	2	I (0)
MCPI	−1.04	13	0.93	13	2.08 ***	14	I (2)
Log MCPI	−3.21**	1	0.52	13	1.86***	14	I (1)
Δ Log MCPI	−5.09***	0	−2.10 **	12	1.00***	13	I (0)
MEXBOL	0.54	0	2.23	0	2.01***	14	I (1)
Log MEXBOL	−1.11	0	1.64	0	2.09***	14	I (1)
Δ Log MEXBOL	−17.37***	0	−1.48	7	0.09	6	I (0)
MMCO	−2.19	1	−1.48	1	1.50***	14	I (1)
Log MMCO	−1.89	1	−0.72	1	1.75***	14	I (1)
Δ Log MMCO	−12.05***	0	−12.04***	0	0.08	6	I (0)

Note: The values reported are the statistical t values. The values presented in the "k" column in Columns 2 and 3 refer to the selected lag length. The values in the "k" column in Column 4 use an automatic selection length of Newey-West bandwidth. The symbols *, ** and *** indicate the rejection of the null hypothesis of the test corresponding to a 10%, 5% and 1% level, respectively.
Source: Authors' own with data from Banxico and the U.S. Energy Information Administration.

Dickey-Fuller (ADF), Dickey-Fuller Generalized Least Squares (DF-GLS) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for the financial variables studied. The ADF and DF-GLS unit-root tests check the null hypothesis that a time series is I(1). Stationarity tests, like the KPSS, on the other hand, check the null hypothesis that a time series is I(0).

If the variables are I(1), it indicates that they have a unit root. That is, the series does not converge to a long-term mean and the variances depend on time and tend toward infinity. The results of the three unit-root tests for the financial variables in levels (log-prices) and their first-differences (log-returns) indicate that the variables are not stationary in levels, but are stationary in first differences. If two out of three of the tests confirm the presence of a unit root, then it is concluded that the series has a unit root. Since the other two variables used in the study also have a unit root, it is necessary to determine a first difference for MMCO and for MCPI.[1] All the variables are I(1) in levels, except MCPI, which is I(2) in levels.

Given the evidence of non-stationarity in the series, cointegration tests were carried out among the relevant variables of the study: MMCO, MXNUSD, and MEXBOL. The next step is to specify the model correctly, the degree of integration and the presence of cointegration among the analyzed variables. If cointegration is found, the empirical model must be estimated including a Cointegration Equation as an additional regressor and the VAR model should take the form of a Vector Error Correction Model (VECM). This explains why Johansen Cointegration Tests and Engle-Granger Cointegration Tests are performed for the MMCO,

[1] MCPI is stationary at 10% with first differences.

Table 4
Johansen Cointegration Test.

	MMCO		MEXBOL		MXNUSD	
	Statistics	Prob.	Statistics	Prob.	Statistics	Prob.
Trace Statistics						
None	4.93	0.82	5.27	0.78	7.75	0.49
At most 1	0.31	0.58	0.52	0.47	1.26	0.26
Max Eigen Statistic						
None	4.62	0.79	4.74	0.77	6.49	0.55
At most 1	0.31	0.58	0.52	0.47	1.26	0.26

Note: Test allow for linear deterministic trend in data (i.e., with intercept in the cointegrating vector). McKinnon-Haug-Michelis (1999) p-values. Null hypothesis indicates no cointegration at the 0.05 level.
Source: Authors' own with data from Banxico and the U.S. Energy Information Administration.

MEXBOL and MXNUSD variables. The results are shown in Tables 4 and 5. According to the trace p-value test and the maximum eigenvalue test in the Johansen Cointegration Test, the results indicate that the variables are not cointegrated in the long run. For this reason, it is unlikely they will move together in the long run; therefore, there is no need to implement a VECM. This result is in line with Shirodkar (2017), who analyzed India and did not find a long-term relationship among the exchange rate, the price of oil, and the stock market returns in that country.

Table 4 shows the results of the Johansen cointegration test and indicates a non-existence of cointegration among the three analyzed variables. However, the result could be interpreted as inconclusive since the hypothesis of the existence of a cointegration vector is not rejected either. Therefore, to reinforce the results about the non-existence of cointegration in the analyzed variables an Engle-Granger cointegration test is additionally included in Table 5.

Table 5 confirms the existence of non-cointegration in the system of equations. In the absence of cointegration, the variables need to be differentiated to procure their stationarity to subsequently carry out the Granger causality tests. The Granger causality tests indicate the variables that should be considered endogenous and the variables that should be considered exogenous in the empirical model. When cointegration between variables is not found, as suggested by the tests in Tables 4 and 5, differentiating the variables to be tested must perform Granger causality tests. The results of the causality tests in Table 6 show that MXNUSD Granger-cause MEXBOL and MCPI. In the first case, the null hypothesis of non-causality is rejected at a level of 95% confidence and in the second case, it is rejected at a level 99% of confidence. Additionally, the Granger causality tests show that MEXBOL is also Granger-caused by MCPI. However, none of the causalities is found in both directions. Results also indicate that the variables of MXNUSD and MMCO are not Granger-caused by any of the other variables.

Therefore, the results indicate that MXNUSD, MCPI, and MEXBOL should be considered as endogenous variables in the VAR model. The equation to be estimated in the study is presented below:

$$y_{t=}c + A(L)y_t + x_t + \delta + u_t \tag{1}$$

where $y_t = [\Delta_1 lnMXNUSD_t, \Delta_1 lnMCPI_t, \Delta_1 lnMEXBOL_t]$ is a vector of endogenous variables, A(L) is a polynomial matrix in the lag operator L, $x_t = [\Delta_1 lnMMCO_t]$ is a vector of exogenous variables (as no causality was found for this variable), c is a vector of constants and u_t is a vector of residuals. The optimal number of lags for the model was obtained through the AIC criteria; information about the lag order selection criteria is included in the Appendix. Lastly, δ is a vector of dummy variables that controls the effect of the financial crises in 1994 and 2008, and the effect of the implementation of the flexible exchange rate regime in Mexico in 1995. To decide the appropriate periods for the structural breaks, various econometric tests were performed. The results are shown in the Appendix. The results also indicate a structural break in 2013, but it was omitted because it was not statistically significant in the regression analysis.

4. Results

Table 7 displays the regression results of an unrestricted VAR model. The possible existence of autocorrelation in the model was tested using the Lagrange Multiplicator (LM) test. The results show evidence of no autocorrelation problems in the regression. LM tests about autocorrelation are included in the Appendix. The results indicate that the first two lags of the exchange rate (MXNUSD)

Table 5
Engle - Granger Cointegration Test.

	T Statistic	Prob. *	Z Statistic	Prob. *
Dependent				
MEXBOL	−2.37	0.55	−11.34	0.52
MMCO	−2.68	0.39	−15.93	0.28
MXNUSD	−2.74	0.36	−11.96	0.48

Note: null hypothesis is that the series are not cointegrated. MacKinnon (1996) p-values.
Source: Authors' own with data from Banxico and the U.S. Energy Information Administration, January 1992 to June 2017.

Table 6
Granger Causality Tests.

Sample:	1992M01 2017M05		
Included observations:	302		
Dependent variable: Δ Log MXNUSD			
Excluded	Chi-sq	df	Prob.
Δ Log MMCO	0.55	4.00	0.76
Δ Log MEXBOL	0.12	4.00	0.94
Δ Log MCPI	2.37	4.00	0.31
Dependent variable: Δ Log MMCO			
Excluded	Chi-sq	df	Prob.
Δ Log MXNUSD	0.61	4.00	0.74
Δ Log MCPI	0.51	4.00	0.77
Δ Log MEXBOL	2.04	4.00	0.36
Dependent variable: Δ Log MEXBOL			
Excluded	Chi-sq	df	Prob.
Δ Log MMCO	0.36	4.00	0.84
Δ Log MXNUSD	7.75	4.00	0.02
Δ Log MCPI	6.49	4.00	0.04
Dependent variable: Δ Log MCPI			
Excluded	Chi-sq	df	Prob.
Δ Log MMCO	4.22	4.00	0.12
Δ Log MXNUSD	74.43	4.00	0.00
Δ Log MEXBOL	2.59	4.00	0.27

Source: Estimations with data from Banxico, U.S. Energy Information Adm., January 1992 to June 2017.

Table 7
Unrestricted VAR.

Variables	Δ Log MXNUSD	Δ Log MCPI	Δ Log MEXBOL
Δ Log MXNUSD (−1)	0.021	0.048	−0.216
	(0.374)	(0.000)***	(0.040)**
Δ Log MXNUSD (−2)	−0.034	0.015	−0.209
	(0.311)	(0.024)	(0.054)*
Δ Log MXNUSD (−3)	0.041	0.036	0.039
	(0.276)	(0.024)**	(0.383)
Δ Log MCPI (−1)	−0.642	0.693	−0.659
	(0.108)	(0.000)***	(0.250)
Δ Log MCPI (−2)	0.413	−0.033	2.032
	(0.259)	(0.321)	(0.046)**
Δ Log MCPI (−3)	−0.807	0.036	−0.399
	(0.052)**	(0.253)	(0.334)
Δ Log MEXBOL (−1)	−0.039	−0.003	−0.060
	(0.121)	(0.173)	(0.062)*
Δ Log MEXBOL (−2)	−0.003	−0.003	−0.096
	(0.464)	(0.210)	(0.062)*
Δ Log MEXBOL (−3)	0.003	0.007	0.032
	(0.462)	(0.024)**	(0.304)
Δ Log MMCO	−0.059	0.000	0.044
	(0.004)***	(0.493)	(0.144)
D_{FLEX}	−0.012	0.000	0.003
	(0.037)**	(0.334)	(0.396)
$D_{CRISIS\ 1994}$	0.058	0.005	0.000
	(0.000)***	(0.002)***	(0.499)
$D_{CRISIS\ 2009}$	−0.007	0.001	0.020
	(0.4753)	(0.173)	(0.166)
Constant	0.023	0.002	0.004
	(0.001)***	(0.025)**	(0.386)

P- values in parenthesis. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source: Authors' estimations with data from Banxico and the U.S. Energy Information Administration. Lags were chosen with the AIC criteria, January 1992 to June 2017.

have a negative and statistically significant effect on the Mexican stock market index (MEXBOL). This indicates that an appreciation of the Mexican peso creates a positive effect on the stock market index.

Despite the finding of a unidirectional causality in the Granger sense, where the MXNUSD Granger-cause MCPI, the estimate shows that the third lag of MCPI generates a negative effect on the MXNUSD. The results also indicate that the exchange rate has a positive effect on the consumer price index. Thus, a depreciation of the exchange rate eventually translates into increases in the MCPI. This is commonly known as the pass-through effect between the exchange rate and the inflation rate. Abundant literature discusses

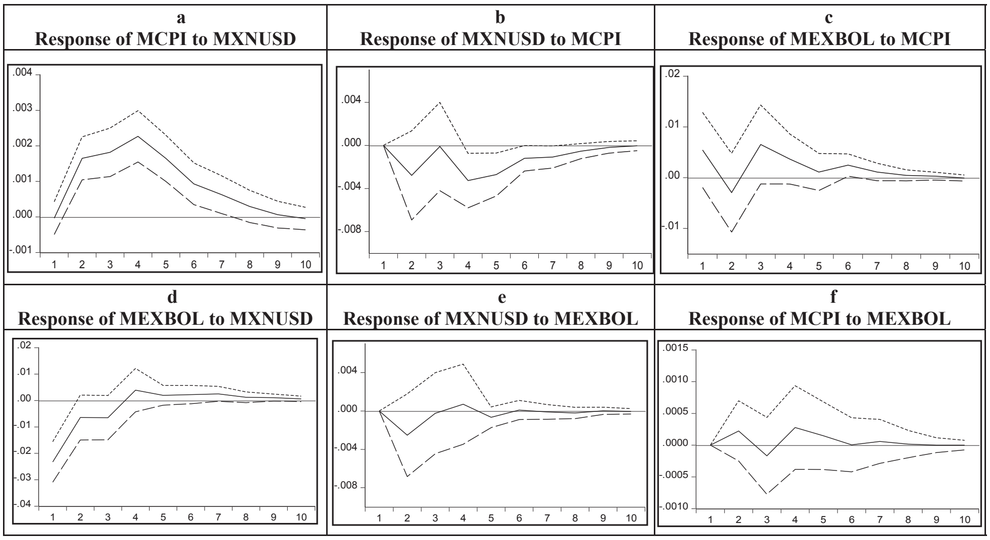

Fig. 1. Impulse-Response Functions. Note: Response to Cholesky One S.D. Innovations ± 2 Standard Errors. Source: Authors' estimations with data from Banxico and the U.S. Energy Information Administration.

this phenomenon.

Granger causality test found only a causality of MCPI on MEXBOL. However, the results show that there is both an effect of MEXBOL on MCPI and effect of MCPI on MEXBOL— first in the case of the third lag and second in the case of the second lag, positive in both cases.

The results also show that there is no statistical significant effect generated by increases in the oil price (MMCO) on the stock market index (MEXBOL). This result is complemented by the fact that in the Granger causality tests, no causality was found between the variables. Additionally, the results also show that there is no statistical significant effect generated by increases in the oil price on the consumer price index. In addition, no Granger causality was found for these variables. Since MMCO is an exogenous variable, it was not convenient to include it as a dependent variable in the model. Therefore, it is not possible to determine the effect generated by the rest of the variables in oil prices. This is not difficult to understand since, intuitively, those variables do not have a reasonable reason to generate an effect on oil prices.

Because no causality, in any direction, between the variables was found, the estimation results indicate a negative effect of oil prices on the exchange rate. Such results make sense because Mexico has been highly dependent on oil exports in its history. When Mexico is affected by a fall in oil prices, financial capital usually leaves the country, which depreciates the Mexican peso, as has been seen in recent years. Basher et al. (2012) have shown that a positive shock to oil prices tend to depress the U.S. dollar exchange rates in the short run for emerging countries. This supports the findings of this study for Mexico, in which an increase in the price of oil generates a depreciation of the U.S. dollar or an appreciation in the Mexican peso.

To obtain a broader picture of the results of the study, the impulse-response functions derived from the VAR model appear in Fig. 1. Fig. 1a shows that the MXNUSD has a significant effect on the MCPI. Thus, as explained previously, increases in the depreciation of the exchange rate eventually translates into increases in the MCPI. At the same time, changes in MCPI promote movements in the exchange rate (as shown in Fig. 1b) and increases in MEXBOL (as shown in Fig. 1c).

Moreover, increases in the exchange rate (depreciation of the Mexican peso against the U.S. dollar) generate a negative effect on the MEXBOL (as shown in Fig. 1d). On the other hand, changes in MEXBOL bring an increase in the MXNUSD (as shown in Fig. 1e) and in the MCPI (as shown in Fig. 1f). The responses of the exchange rate to the consumer price index and the Mexican stock market index are immediate effects that decrease abruptly and disappear after about 10 periods. In the case of MCPI, the strongest response is presented after four periods. In the case of the MEXBOL, the response of the other two variables is not widely dispersed. The greatest impact comes along after one period for the exchange rate and after three periods for MCPI.

5. Conclusions

This paper analyses how exchange rates, the stock market, the consumer price index, and oil price variables interact with each other in the Mexican economy. These variables are analyzed in this paper because Mexico is an oil producer and the Mexican government, historically, has been highly dependent on its oil revenues. A very small portion of the prior literature has been focused on analyzing the simultaneity of oil prices, exchange rate, and stock market returns, especially for Mexico alone. As mentioned by Jain and Biswal (2016), it is very important to understand the simultaneity of those variables so investors, portfolio managers, and policy makers can make better decisions.

This paper is a novel attempt to analyze the dynamics between oil prices, exchange rates, and stock market indices, jointly in the Mexican economy. According to the results obtained from the Johansen cointegration test and the Engle-Granger cointegration test, the analyzed variables are not cointegrated in the long run. For this reason, an unrestricted VAR model is implemented. The results indicate that, on the one side, the exchange rate has a negative and statistically significant effect on the Mexican stock market index and a positive and statistically significant effect on the Mexican consumer price index. In other words, an appreciation in the Mexican peso creates a positive effect in the stock market, while a depreciation in the Mexican peso increases the Consumer Price Index.

The results also indicate that Mayan crude oil has a negative and statistically significant effect on the exchange rate, indicating that an increase in oil prices creates an appreciation in the Mexican peso against the U.S. dollar. Correspondingly, the results also indicate that an appreciation of the exchange rate has a positive impact on the Mexican stock market index. These results are in line with Jain and Biswal (2016) and Arfaoui and Ben Rejeb (2017) who found that a fall in gold prices and crude oil prices cause a drop in the value of the Indian Rupee and the benchmark stock index.

Given the lack of literature analyzing the simultaneity between the important variables of oil prices, exchange rate, and stock market returns for the Mexican economy; it is expected this paper can motivate further research in this area.

Appendix A.

Chow Breakpoint Test: MXNUSD

Breakpoint Test Date:	1995M01			Breakpoint Test Date:	2009M01		
Null Hypothesis:	No break at specified breakpoint			Null Hypothesis:	No break at specified breakpoint		
Varying regressors:	All equation variables			Varying regressors:	All equation variables		
Equation Sample:	1992M01 2017M05			Equation Sample:	1992M01 2017M05		
F-statistic	160.94	Prob. F(2301)	0.00	F-statistic	0.22	Prob. F(2301)	0.80
Log likelihood ratio	221.81	Prob. Chi-Sq(2)	0.00	Log likelihood ratio	0.44	Prob. Chi-Sq.(2)	0.80
Wald Statistic	321.88	Prob. Chi-Sq(2)	0.00	Wald Statistic	0.44	Prob. Chi-Sq.(2)	0.80

Source: Own estimations using date from Banxico, January 1992 to June 2017.

Chow Breakpoint Test: MEXBOL

Breakpoint Test Date:	1995M01			Breakpoint Test Date:	2009M01		
Null Hypothesis:	No break at specified breakpoint			Null Hypothesis:	No break at specified breakpoint		
Varying regressors:	All equation variables			Varying regressors:	All equation variables		
Equation Sample:	1992M01 2017M05			Equation Sample:	1992M01 2017M05		
F-statistic	40.32	Prob. F (2301)	0.00	F-statistic	150.07	Prob. F(2301)	0.00
Log likelihood ratio	72.40	Prob. Chi-Sq.(2)	0.00	Log likelihood ratio	210.98	Prob. Chi-Sq.(2)	0.00
Wald Statistic	80.65	Prob. Chi-Sq.(2)	0.00	Wald Statistic	300.14	Prob. Chi-Sq.(2)	0.00

Source: Own estimations using date from Banxico, January 1992 to June 2017

Chow Breakpoint Test: MMCO

Breakpoint Test Date:	1995M01			Breakpoint Test Date:	2009M01		
Null Hypothesis:	No break at specified breakpoint			Null Hypothesis:	No break at specified breakpoint		
Varying regressors:	All equation variables			Varying regressors:	All equation variables		
Equation Sample:	1992M01 2017M05			Equation Sample:	1992M01 2017M05		
F-statistic	103.9	Prob.F (2,301)	0.00	F-statistic	220.35	Prob. F(2,301)	0.00
Log likelihood ratio	160.2	Prob. Chi-Sq.(2)	0.00	Log likelihood ratio	275.05	Prob. Chi-Sq.(2)	0.00
Wald Statistic	207.9	Prob. Chi-Sq.(2)	0.00	Wald Statistic	440.70	Prob. Chi-Sq.(2)	0.00

Source: Own estimations using date from Banxico, January 1992 to June 2017

Bai-Perron Multiple Breakpoint Test

Sample:	1992M01 2017M05		
Breaking Variable:	MEXBOL		
Break test options:	Trimmin 0.15, Max break 5, Sig. Level 0.05		
Break Test	F-statistic	Scaled F-statistic	Critical Value∗∗
0 vs. 1 ∗	154.92	309.84	11.47
1 vs. 2 ∗	83.06	166.13	12.95
2 vs. 3 ∗	37.99	75.98	14.03
3 vs. 4 ∗	51.18	102.35	14.85
4 vs. 5	0.00	0.00	15.29
∗ Significant at the 0.05 level.			
Break dates:	Sequential	Repartition	

1	1995 M10	1995 M10
2	2013 M09	2002 M09
3	2002 M09	2008 M10

Source: Own estimations using data from Banxico

VAR Lag Order Selection Criteria

Endogenous variables:	Δ Log MXNUSD, Δ Log MMCO, Δ Log MEXBOL				
Exogeneous variables:	Constant, Δ Log MCPI, D_{FLEX}, $D_{CRISIS\ 1994}$, $D_{CRISIS\ 2009}$				
Sample:	1992M01 2017M05				
Included observations:	296				
Lag	LogL	FPE	AIC	SC	HQ
0	2,025.53	0.00	−13.58	−13.40	−13.51
1	2,168.72	0.00	−14.49	−14.19*	−14.37*
2	2,181.13	0.00	−14.51	−14.10	−14.35
3	2,196.11	0.00*	−14.55*	−14.03	−14.35
4	2,204.00	0.00	−14.55	−13.91	−14.29
5	2,209.85	0.00	−14.53	−13.78	−14.23
6	2,214.51	0.00	−14.50	−13.64	−14.15
7	2,230.41	0.00	−14.54	−13.57	−14.15
8	2,236.42	0.00	−14.52	−13.44	−14.09

* indicates lag order selected by the criterion. FPE: Final Prediction Error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information cr.

Source: Authors' own with data from Banxico, U.S. Energy Information Administration, January 1992 to June 2017

VAR Residual Serial Correlation LM Tests			VAR Residual Portmanteau Tests for Autocorrelations					
Null Hypothesis:	No serial correlation at lag order h		Null Hypothesis:	No serial correlation at lag order h				
Sample:	1992M01 2017M05		Sample:	1992M01 2017M05				
Included obs.:	303		Included obs.:	303				
Lags	LM-Stat	Prob	Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	11.92	0.22	1	0.75	NA*	0.75	NA*	NA*
2	13.70	0.13	2	13.60	0.14	13.69	0.13	9.00

Source: Authors' own with data from Banxico, U.S. Energy Information Adm. January 1992 to June 2017.

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