Reyes Guzmán, G., Pimentel Canizales, M. E., y Rostro Hernández, P. E. (2023). Exchange Rate and Stock Market in Mexico: A Correlation Analysis (1993-2022). Nova Scientia, 31(15), 1-11.
https://doi.org/10.21640/ns.v15i31.3452

Nova Scientia
Revista de Investigación de la Universidad De La Salle Bajío

Exchange Rate and Stock Market in Mexico: A Correlation Analysis (1993-2022)
Tipo de Cambio Nominal y Bolsa Mexicana de Valores: Un Análisis de Correlación (1993-2022)

Gerardo Reyes Guzmám [1] / María Esther Pimentel Canizales [2] / Perla Esperanza Rostro Hernández [1]

[1] Universidad La Salle Bajío, Facultad de Estudios Superiores Salamanca
[2] Universidad Autónoma de Sinaloa
✉ Autor de correspondencia: greyes@lasallebajio.edu.mx

Recepción: 23-08-2023 / Aceptación: 09-11-2023 / Publicación: 30-11-2023

Abstract: the aim of this paper is to estimate using monthly data the influence of the Mexican Stock Market in the nominal Exchange Rate from 1993 to 2022. We conducted an Exploratory Data Analysis to identify the most important correlations of the following monetary variables: 28-day Mexican Debt bills/ (T-Bill), interest rates, inflation, and Stock Exchange Market both from Mexico and from the USA respectively. We then resorted to a VAR model to indentify which of these variables determined changes in Mexico´s nominal Exchange Rate more significantly. During the period in question the model showed, that Exchange Rate variations were driven by the Mexican Stock Exchange Market, the Dow Jones Industrial Average and the US Treasury Bills. The model also pointed out that variations in Mexican Stock Market were determined by the Mexican Stock Market itself, the Dow Jones Industrial Average and the US Treasury Bills (T-Bills).
Keywords: nominal exchange rate; mexican stock market; dow jones; average; rates; inflation; Mexico; USA

Resumen: el propósito de este escrito es estimar con datos mensuales la influencia de la Bolsa Mexicana de Valores en el Tipo de Cambio Nominal peso-dólar durante el periodo 1993-2022. Para ello se llevó a cabo un análisis estadístico exploratorio en aras de identificar las correlaciones más importantes de las siguientes variables monetarias: tasa de interés CETES a 28 dias /(T-Bills), inflación y Mercado bursátil, tanto para México como para los Estados Unidos, respectivamente. Acto seguido, usamos un modelo VAR para buscar cuál de estas variables determinaron los cambios más significativos en la paridad peso-dólar. Se halló que el Índice de Precios y Cotizaciones de la Bolsa Mexicana de Valores, el índice Dow Jones y las tasas de interés de los bonos del tesoro de los Estados Unidos (T-Bills) influyen en el Tipo de Cambio Nominal peso-dólar. A su vez, el Indice de Precios y Cotizaciones de la Bolsa Mexicana de Valores, se determina por si mismo, por el Dow Jones y por las tasas de interés de los Bonos del Tesoro de los EUA (T-Bills).
Palabras clave: tipo de cambio nominal; bolsa mexicana de valores; dow jones; tasa; interés; inflación; México; USA

1. Introduction

The relationship between nominal Nominal Exchange Rate ($e_{MXN/USD}$; ER) and Mexican Stock Exchange Market (MXX) has been investigated on a regular basis in several researche papers. ER or $e_{MXN/USD}$ in Mexico has been a key variable to gauge both economic and political performance in Mexico along 1993-2021. The MXX had an estimated capitalization value in 2021 of 35.6% of the Mexican GDP with which it has become an important indicator in Mexico´s business climate. Specially in episodes of crisis, volatility in both variables occur barely before the GDP plunges turning them into an economic recession (e.g. 1995, 2009, and 2020). For instance, and based on monthly data, MXX reached a record of 2,779.43 points in January 1994. It then began to fall constantly until it touched it´s bottom in February 1995 at 1,556.20 points making a -44% losses. Analogously, $e_{MXN/USD}$ depreciated by 200% going from 3.10 MXN/USD on January 1994 to 6.30 MXN/USD in April 1995. Therefore, it seems that MXX´s downtrend triggered a depreciation spiral of Mexican Peso (MXN) that lasted two months after the Stock Market reached its bottom. Within the same time span, the Dow Jones Industrial Average (DJ) went from 3,983.83 to 3827.63, a barely -3.9% drop. In September 1997, as the Asian Crisis stroke financial markets, the MXX fell by -44% from 5,324.11 to 2,980.96 in August 1998, whereas the the DJ diminished by -4.8% from 7,942.63 to 7,555.27. ER depreciated by -23.3% going from 8.08 MXN/USD to 9.97 MXN/USD within the same interval. During the Great Recession, MXX plunged by -44.5% from 31,888.48 in May 2008 to 17,676.65 in February 2009. The DJ decreased by -44% from 12,581.72 to 7,044.48 and $e_{MXN/USD}$ depreciated by 46% from 10.28 MXN/USD to 15.03 MXN/USD within the same time span. Finally, during the Covid-19 crisis, the MXX plunged by -22.5% from 44,597.00 on April 2019 to 34,554.53 March 2020, whereas the

MXN lost 27.5% value against the USD going from 18.94 MXN/USD April 2019 to 24.16 MXN/USD a year later. The DJ also scored a setback of -22.4% going from 28,256.03 on December 2019 to 21,917.16 February 2020. It seems that MXX and $e_{MXN/USD}$ are becoming more vulnerable to external shocks due to a larger share of foreign trade in Mexico´s GDP, known also as foreign trade openness (X+M/GDP). This indicator, went from 23% in 1993 to 75% in 2020. Furthermore, monetary theory establishes a direct linkage between Central Bank interest rates, inflation, economic growth, and monetary supply on the one side and adjustments in the $e_{MXN/USD}$ on the other (Krugman, 2000). External shocks in the home country trigger a depreciation spiral of its currency that potentially leads to inflationary pressures. That is why central banks respond with a restrictive monetary policy by rising up interest rates. Domestic Exchange Rate often experiences an overshooting effect expressed by a currency appreciation short after the initial depreciation caused by the outbreak of the external shock. In hindsight, the parity does not get back to the levels before the crisis. Interest rates and inflation in home-and-partner country follow an adjustment path to compensate differences through an appreciation or depreciation of its respective Exchange Rates, a phenomenon known as Fisher Effect (Krugman, 2000).

The purpose of this paper is to find out how intertwined are the financial Markets between Mexico and USA regarding $e_{MXN/USD}$ and MXX on the one side, and inflation and interest rates on the other. The questions we have posed to develop this analysis are: does MXX triggers volatility in $e_{MXN/USD}$ or is the other way around, $e_{MXN/USD}$ unleashes changes in MXX? In what extend are DJ and MXX correlated and how do interest rates and inflation affect them? and how do these key monetary variables are related to each other in short and long term? We have divided this investigation into three sections. Section 2.1 involves a revision of the state-of-the-art literature addressing this topic, either at international or national level. In section 2.2, we run an Exploratory Data Analysis to compare the aforementioned variables with one another. In section 2.3 we run a VAR model to test the null hypothesis (Ho) that no correlation exists among ER, MXX, Dow Jones Industrial Average, inflation, and interest rates both in Mexico and in the USA. In part 3, we discuss and conclude that the Ho was rejected so that $e_{MXN/USD}$ is determined by MXX at a first lag and by the DJ and Treasury Bills (Tbills) at the first lag as well. MXX is determined by MXX itself at a first lag; by the DJ at first lag and by Tbills at a first lag as well.

2. Methods, techniques and instruments

Muhammand Kamran Kahn resorted to an ARDL model finding that inflation rate, interest rate and exchange rate had negative and statistically significant effect on the returns of Shenzhen Stock Market (Khan, 2019). Muhammad Gopalan Kutty made an analysis regarding the influence of Exchange rate in the Mexican Stock Exchange using data from the first week of January 1989 to the last week of December 2006. He applied a Granger Causality Test finding that stock prices influence exchange rates in the short run and that there was no relationship between both variables in the long run (Kutty, 2010). Warren Bailey and Peter Chung took monthly data from January 1986 to June 1994 to estimate the effect of political risk in exchange rate; changes in the free market premium for dollars; return spread between Mexican and US government dollar debt and rate of change of stock market index in excess of riskless rate. They hypothesized that "*credit risk and political risk are positively correlated. When political risk declines, the probability of default decreases and Mexican dollar bonds experience price appreciation relative to U.S. Treasury debt*" (Chung, 1995: 546). In their statistical analysis, the rate of change of official pesos per dollar was negatively correlated with changes in the free market premium for dollars, which meant that when currency and political risk measured by free market dollar premium were high, the stock market declined; they also found that high expected currency depreciation was associated with heightened political uncertainty (Chung, 1995). Shell Singhal et al., studied the dynamic relationship among international oil prices, international gold prices, exchange rate and stock market index in Mexico using daily data from January 2006 to April 2018. They found that exchange rate, gold prices and stock prices move in the same direction. Oil prices were negatively correlated with stock prices and exchange rate movements; and exchange rate variations were highly correlated with stock prices. Exchange rate, gold prices and stock prices tend to move in the same direction. To prove whether these variables were associated in the long run, they used a cointegration test. By applying a ARDL model they found cointegration among the variables when stock price was kept as a dependent variable. Thus, whenever there was a shock in the system, oil prices, gold prices and exchange rate variations moved first, followed by changes in the stock market. When exchange rate was taken as dependent variable, movements in oil-and-gold prices were independent of movements in stock prices and exchange rate. Furthermore, gold prices affected stock prices positively since Mexico is a gold exporting country but did not affect exchange rate. An increase in oil prices appreciates exchange rate in the long run, which is common among oil exporting countries. Thus, ER depreciation up 2015 was attributable to a drop in oil prices, which at the same time unleashed inflationary pressures through costlier energy prices (Shell Singhal, 2019). Finally, López Herrera and Vázquez Téllez found that economic activity, market confidence, inflation, exchange rate and balance of payments determined changes in 31 companies´ stocks listed in the MXX (Téllez, 2002). Arnoldo López-Marmolejo (et al, 2021) affirmed, using a panel data model, that exchange rates in several Latin American countries (North, Central and South), were significantly influenced by remittances, reserves, and debt. Countries where net inflows of remittances had appreciated the real exchange rate were El Salvador, Nicaragua, Haiti, Bolivia and Brazil among others, a fact that brought them in a “Dutch disease” situation. Thus, their appreciated currencies made their exports less competitive and slowed economic growth (Arnoldo López-Marmolejo, 2021). In a more recent study, Francisco López Herrera and Martha Beatriz Mota, used GARCH-Markow_Switching models with 5,782 observations – from January 2nd 1995 to December 29th 2017– to prove an important correlation in returns obtained from the MXX and ER volatility, specially in episodes of economic stress (López H. & B. Mota, 2019).

The Mexican Central Bank (Banxico) found that changes the US 10-year interest rate trigger significant changes in Mexican financial variables. An increase in the US 10-year interest rate triggers a depreciation of the Mexican currency (MXN) with respect to the USD and drives Mexican long term interest rates and debt sovereign risk rates upwards. Analogously, adjustments in monetary policy conducted by the US-Federal Reserve release significant pressures in Mexican financial markets (Banco de México, 2021). The same source states that exchange rate volatility in Mexico drives capital flows out of the country, mainly those resources invested in Mexican debt bills. Banxico points out that the way back to stability in exchange rate doesn´t bring back capital flows to the original level. The private sector postpones investment plans with which economic performance wanes. If exports diminish, and economic downturn becomes imminent. By using a VAR model, Banxico also shows an immediate collapse in holding Mexican debt bills after a currency depreciation. This also causes negative effects in debt sovereign risk rate and economic activity (Banco de México, 2021). In this same context, Jorge López and Miriam Castro resorted to daily data from 2000 to 2020, extracted from investing.com, to feed several econometric models (GARCH, APARCH, EGARCH y TACH). They inquiered the relationship between exchange rate and stock market in Mexico and Brazil and found a negative relationship between both variables in the short term in both cases. They also affirmed that a contagion phenomenon was perceived from exchange rate volatility to the stock market in three episodes: 2007-2012; 2016-17 and 2020 in the case of Mexico. They concluded that negative external shocks have more impact in the economy than positive shocks (Castro, 2021).

2.1. Exchange Rate and Stock Market: Exploratory Data Analysis

Figure 1 reflects a harmonious trend between ER, MXX, and the DJ. The economic crisis of 1995, 2009 and 2020 are represented through inflection points. In the right side we observe a long period of low inflation and interest rates levels. The currency depreciation seems to have spurred economic activity in the long run, animating investors to participate in the MXX. Changes in this index are induced by investors responding to short term windfall as a reaction of an ongoing positive economic episode. Therefore, it reflects an in/out flow of capital that permeates other immediately connected variables like Economic Growth and Exchange Rate among others (Herrera, 2004). Galicia Salvador pointed out that from 2012 to 2016, 259 companies were registered at the MXX: 0.7% belonging to the primary sector; 42%: industrial sector and 57%: services. He also found that only 5.4% of the companies remains at MXX for more than 21 years and half of them leave the MXX within the first 5 years. (Galicia Anaya S.A., 2020).

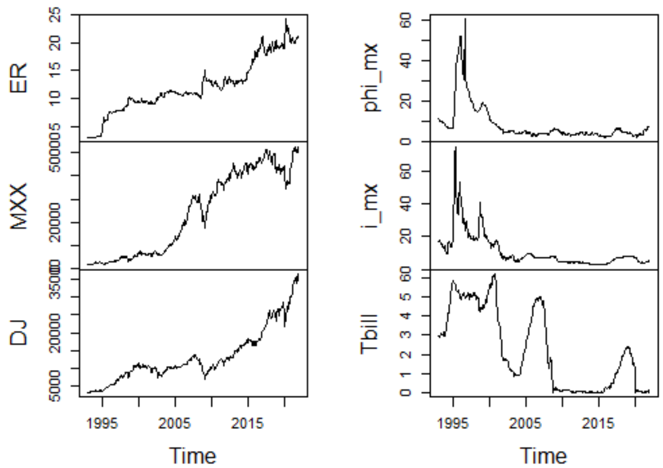

Figure 1. Exchange Rate, Mex Stock Market, Dow Jones, Inflation, interest rates and T-bills.
Source: (Investing.com, 2022).

We recorded 349 observations of seven variables on monthly basis from January 1993 to January 2022, where ER states for nominal Exchange Rate ($e_{MXN/USD}$); MXX: Mexican Stock Market; π_{mx}: Inflation in Mexico; i_{MX}: short-term Mexican Debt bill returns (known as CETES); DJ: Dow Jones Industrial Average; Tbill: Treasury Bills and π_{USA}: Inflation in the USA.

In figure 2 we can spot several correlations among the appearing variables. We start with the most remarkable positive correlations: 0.91, between Exchange Rate, $e_{MXN/USD}$, (ER) and Dow Jones Industrial Average (DJ); 0.85, between ER and Mexican Stock Market (MXX); 0.84, between inflation in Mexico (π_{mx}) and short-term Mexican instrument rates (i_{MX}); 0.70, between US Treasury Bills (Tbill) and i_{MX}; 0.58, between π_{mx} and Tbill and 0.33, between Tbill and US inflation (π_{USA}). On the other side, the most outstanding negative correlations are: -0.72, between MXX and Tbill; -0.61, between MXX and i_{MX}; -0.52, between MXX and π_{mx}; -0.51 between ER and i_{MX}; -0.50 between DJ and Tbill; -0.46 i_{MX} and DJ; -0.44 ER and π_{mx}; -0.40 π_{mx} and DJ and -0.21 between ER and π_{USA}.

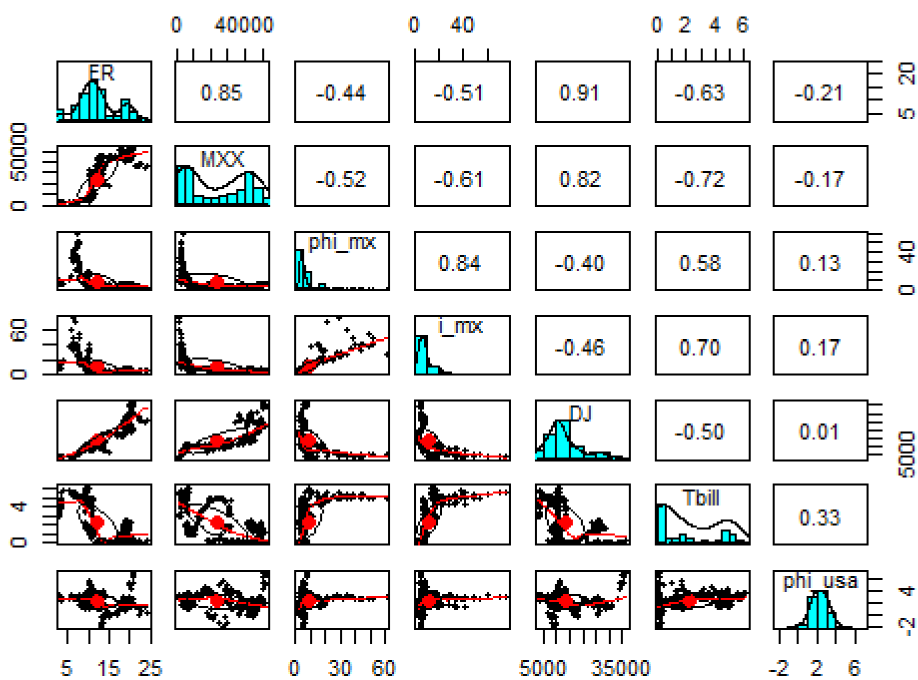

Figure. 2. Exploratory Data Analysis.
Source: (Yahoo finance, 2022)

The ER has moved along with the DJ and the MXX. The constant ER depreciation has made Mexican exports more competitive and the exporting companies listed on the MXX more prosperous. This trend proves to be true only in the run, otherwise, ER and MXX show an inverse correlation as stated in the above quoted literature and the introduction of this paper. This temporary phonemenon has been classically addressed under the monetary approach and the so called Fisher Effect respectively (Krugman, 2000). Thus, the price of a dollar has increased 6.6 times from 3.10 MXN-USD in January 1993 to 20.65 MXN-USD in January 2022, whereas the MXX augmented 30.3 times from 1652.43 points to 50,050 points. The DJ did it 10.6 times from 3,294.47 points to 35,131 points within the same time span. i_{MX} also known as CETES have kept pace with inflation to maintain positive real interest rates and remain as an attractive alternative for low-risk investors. The same can be observed between π_{USA} and Tbill. Mexican Interest rates in Debt bills reflect Banxico´s ongoing monetary policy whose main task is to offset inflation. Thus, there has been a constant monitoring of Banxico to keep pace with the Federal Reserve´s monetary policy following a *mirror strategy* to keep Mexican Debt bills attractive to foreign investors. It is widely known in academic circles, that market forces in ideal conditions tend to preserve an equilibrium represented by the classical equation *i=r+e,* where *i* stands for domestic interest rate, *r* for external interest rate and *e* for appreciation/depreciation of the domestic currency (Frenkel, 2008). Central bank´s main purpose is not only to maintain the value of the domestic currency, but also to remain competitive in foreign direct capital markets through an attractive exchange rate. Regarding the negative correlations, we see in figure 2 the classic inverse correlation between public debt interest rates and Stock Market both in Mexico and in the USA. Thus, an increase in the interest rates conducted by the respective central banks usually leads to a collapse in bond prices and to a worsening of debt positions. All that drives investors out of the Stock Market making the index to fall. Bankruptcies are common among those agents who are obliged to sell their bonds at lower prices to rollover their debts. That is why Inflation also turned to be also an important trigger to MXX setbacks. Furthermore, we calculated the difference between Mexican and US inflation on the one side and Mexican and US interest rates on the other, obtaining a correlation of 0.80. That confirms the Fisher effect that states: "*all else equal, a rise in a country´s expected inflation rate will eventually cause an equal rise in interest rate that deposits of its currency offer. Similarly, a fall in expected inflation rate will eventually cause a fall in the interest rate*" (Krugman, 2000: 402).

3. Results

3.1. VAR Model

We will apply a Vector Autoregressive (VAR) Model based on Robert H. Shumway (Robert, 2017) to find out which variables determines changes in the $e_{MXN/USD}$ and MXX along the time span in question. First, we took the first difference to make sure all variables in the analysis are stationary confirming it with a Dicky Fuller test each. Figure 3 displays first difference in: diff(ER): Exchange Rate; diff(MXX): Mexican Stock Market Index; diff(DJ): Dow Jones Industrial Average; diff(π_{mx}): Inflation in Mexico; diff(i_{MX}): short-term Mexican instrument rates and diff(Tbill): US treasury bills.

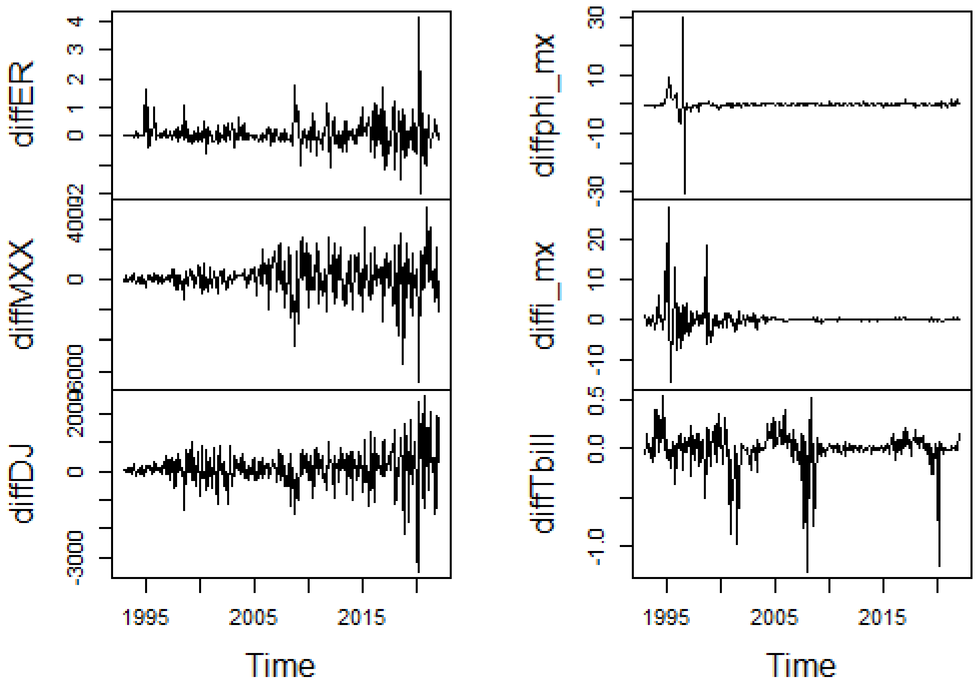

Figure. 3. Stationary Variables.
Source: Own work with data of (Investing.com, 2022).

We run the following 6 equations for evey variable plotted in figure 3, using Softwar RStudio:

$$x_{t1} = \alpha_1 + \beta_1 t + \emptyset_{11} x_{t1.1} + \emptyset_{12} x_{t-1.2} + \emptyset_{13} x_{t-1.3} + \emptyset_{14} x_{t-1.4} + \emptyset_{15} x_{t-1.5} + \emptyset_{16} x_{t-1.6} + w_{t1} \quad (1)$$

which expresses the current value of Exchange Rate (diffER= x_{t1}) as a linear combination of trend and its immediate past value and the past value of Mexican Stock Market (diffMXX= x_{t2}), Dow Jones Industrial Average (diffDJ=x_{t3}), Inflation in Mexico (diffphi_mx=x_{t4}), shorterm Mexican debt bill rates (CETES-28) (diffi_mx=x_{t5}) and US treasury bills (diffTbill=x_{t6}). Similarly:

$$x_{t2} = \alpha_1 + \beta_1 t + \emptyset_{21} x_{t1.1} + \emptyset_{22} x_{t-1.2} + \emptyset_{23} x_{t-1.3} + \emptyset_{24} x_{t-1.4} + \emptyset_{25} x_{t-1.5} + \emptyset_{26} x_{t-1.6} + w_{t2} \quad (2)$$
$$x_{t3} = \alpha_1 + \beta_1 t + \emptyset_{31} x_{t1.1} + \emptyset_{32} x_{t-1.2} + \emptyset_{33} x_{t-1.3} + \emptyset_{34} x_{t-1.4} + \emptyset_{35} x_{t-1.5} + \emptyset_{36} x_{t-1.6} + w_{t3} \quad (3)$$
$$x_{t4} = \alpha_1 + \beta_1 t + \emptyset_{41} x_{t1.1} + \emptyset_{42} x_{t-1.2} + \emptyset_{43} x_{t-1.3} + \emptyset_{44} x_{t-1.4} + \emptyset_{45} x_{t-1.5} + \emptyset_{46} x_{t-1.6} + w_{t4} \quad (4)$$
$$x_{t5} = \alpha_1 + \beta_1 t + \emptyset_{51} x_{t1.1} + \emptyset_{52} x_{t-1.2} + \emptyset_{53} x_{t-1.3} + \emptyset_{54} x_{t-1.4} + \emptyset_{55} x_{t-1.5} + \emptyset_{56} x_{t-1.6} + w_{t5} \quad (5)$$
$$x_{t6} = \alpha_1 + \beta_1 t + \emptyset_{61} x_{t1.1} + \emptyset_{62} x_{t-1.2} + \emptyset_{63} x_{t-1.3} + \emptyset_{64} x_{t-1.4} + \emptyset_{65} x_{t-1.5} + \emptyset_{66} x_{t-1.6} + w_{t5} \quad (6)$$

The R package vars calculations are presented in the following tables:
VAR Estimation Results:
=========================
VAR Estimation Results:
=========================
Endogenous variables: diffER, diffMXX, diffDJ, diffphi_mx, diffi_mx, diffTbill
Deterministic variables: both
Sample size: 346
Log Likelihood: -7328.065
Roots of the characteristic polynomial:
0.2744 0.2614 0.2501 0.1445 0.1445 0.08964
Call:
VAR(y = y, p = 1, type = "both")

Table 1. *Estimation results for equation (1) diffER:*					
diffER = diffER.l1 + diffMXX.l1 + diffDJ.l1 + diffphi_mx.l1 + diffi_mx.l1 + diffTbill.l1 + const + trend					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	-7.860e-02	5.861e-02	-1.341	0.180860	
diffMXX.l1	-6.582e-05	2.301e-05	-2.861	0.004488	**
diffDJ.l1	-1.394e-04	4.139e-05	-3.369	0.000841	***
diffphi_mx.l1	-3.440e-03	9.902e-03	-0.347	0.728551	
diffi_mx.l1	4.762e-03	8.962e-03	0.531	0.595489	
diffTbill.l1	-3.374e-01	1.301e-01	-2.593	0.009938	**
const	6.594e-02	4.975e-02	1.325	0.185937	
trend	5.192e-05	2.478e-04	0.209	0.834188	
Residual standard error: 0.4578 on 338 degrees of freedom Multiple R-Squared: 0.1035, Adjusted R-squared: 0.08491 F-statistic: 5.573 on 7 and 338 DF, p-value: 4.317e-06					

Table 2. *Estimation results for equation (2) diffMXX:*					
diffMXX = diffER.l1 + diffMXX.l1 + diffDJ.l1 + diffphi_mx.l1 + diffi_mx.l1 + diffTbill.l1 + const + trend					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	-195.13928	150.70257	-1.295	0.1963	
diffMXX.l1	-0.11815	0.05916	-1.997	0.0466	*
diffDJ.l1	0.58078	0.10641	5.458	9.32e-08	***
diffphi_mx.l1	7.13507	25.45991	0.280	0.7795	
diffi_mx.l1	5.75211	23.04133	0.250	0.8030	
diffTbill.l1	777.10482	334.57493	2.323	0.0208	*
const	126.98678	127.92157	0.993	0.3216	
trend	-0.02276	0.63721	-0.036	0.9715	
Residual standard error: 1177 on 338 degrees of freedom Multiple R-Squared: 0.1137, Adjusted R-squared: 0.09537 F-statistic: 6.196 on 7 and 338 DF, p-value: 7.733e-07					

Table 3. *Estimation results for equation diffDJ:*					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	30.23023	81.91945	0.369	0.7123	
diffMXX.l1	0.03040	0.03216	0.945	0.3451	
diffDJ.l1	-0.08509	0.05784	-1.471	0.1422	
diffphi_mx.l1	6.17806	13.83959	0.446	0.6556	
diffi_mx.l1	1.91986	12.52489	0.153	0.8783	
diffTbill.l1	131.16069	181.86947	0.721	0.4713	
const	-23.73010	69.53607	-0.341	0.7331	
trend	0.69868	0.34638	2.017	0.0445	*
Residual standard error: 639.8 on 338 degrees of freedom Multiple R-Squared: 0.01947, Adjusted R-squared: -0.0008334 F-statistic: 0.959 on 7 and 338 DF, p-value: 0.4612					

Table 4. *Estimation results for equation diffphi_mx:*					
diffphi_mx = diffER.l1 + diffMXX.l1 + diffDJ.l1 + diffphi_mx.l1 + diffi_mx.l1 + diffTbill.l1 + const + trend					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	-3.474e-02	2.967e-01	-0.117	0.907	
diffMXX.l1	7.925e-06	1.165e-04	0.068	0.946	
diffDJ.l1	-6.019e-05	2.095e-04	-0.287	0.774	
diffphi_mx.l1	-3.001e-01	5.013e-02	-5.987	5.46e-09	***
diffi_mx.l1	2.654e-01	4.537e-02	5.850	1.16e-08	***
diffTbill.l1	-5.715e-02	6.588e-01	-0.087	0.931	
const	-2.215e-02	2.519e-01	-0.088	0.930	
trend	1.313e-04	1.255e-03	0.105	0.917	
Residual standard error: 2.318 on 338 degrees of freedom Multiple R-Squared: 0.1635, Adjusted R-squared: 0.1462 F-statistic: 9.441 on 7 and 338 DF, p-value: 1.044e-10					

Table 5. *Estimation results for equation diffi_mx:*					
diffi_mx = diffER.l1 + diffMXX.l1 + diffDJ.l1 + diffphi_mx.l1 + diffi_mx.l1 + diffTbill.l1 + const + trend					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	3.510e-01	3.482e-01	1.008	0.314	
diffMXX.l1	-6.577e-05	1.367e-04	-0.481	0.631	
diffDJ.l1	-2.819e-04	2.458e-04	-1.147	0.252	
diffphi_mx.l1	-7.494e-02	5.882e-02	-1.274	0.204	
Diffi_mx.l1	2.691e-01	5.323e-02	5.055	7.05e-07	***
diffTbill.l1	6.809e-01	7.729e-01	0.881	0.379	
const	-5.851e-02	2.955e-01	-0.198	0.843	
trend	3.059e-04	1.472e-03	0.208	0.836	
Residual standard error: 2.719 on 338 degrees of freedom Multiple R-Squared: 0.09329, Adjusted R-squared: 0.07451 F-statistic: 4.968 on 7 and 338 DF, p-value: 2.285e-05					

Table 6. *Estimation results for equation diffTbill:*					
diffTbill = diffER.l1 + diffMXX.l1 + diffDJ.l1 + diffphi_mx.l1 + diffi_mx.l1 + diffTbill.l1 + const + trend					
	Estimate	Std. error	t value	Pr(>|t|)	Signif. codes
diffER.l1	3.166e-02	2.417e-02	1.310	0.1910	
diffMXX.l1	9.909e-06	9.486e-06	1.045	0.2969	
diffDJ.l1	4.023e-05	1.706e-05	2.358	0.0189	*
diffphi_mx.l1	1.038e-03	4.083e-03	0.254	0.7995	
diffi_mx.l1	-4.049e-03	3.695e-03	-1.096	0.2740	
diffTbill.l1	2.114e-02	5.365e-02	3.940	9.92e-05	***
const	9.894e-04	2.051e-02	0.048	0.9616	
trend	-7.969e-05	1.022e-04	-0.780	0.4360	
Residual standard error: 0.1888 on 338 degrees of freedom Multiple R-Squared: 0.0834, Adjusted R-squared: 0.06441 F-statistic: 4.393 on 7 and 338 DF, p-value: 0.0001101					

Covariance matrix of residuals:						
	diffER	diffMXX	diffDJ	diffphi_mx	diffi_mx	diffTbill
diffER	2.096e-01	-214.43	-50.006	0.01113	0.249937	-5.502e-05
diffMXX	-2.144e+02	1385538.75	225009.318	43.57912	13.869032	1.497e+01
diffDJ	-5.001e+01	225009.32	409403.433	-9.83161	-43.018693	2.602e+01
diffphi_mx	1.113e-02	43.58	-9.832	5.37169	-0.074218	-3.626e-02
diffi_mx	2.499e-01	13.87	-43.019	-0.07422	7.394908	4.092e-03
diffTbill	-5.502e-05	14.97	26.021	-0.03626	0.004092	3.563e-02

Correlation matrix of residuals:						
	diffER	diffMXX	diffDJ	diffphi_mx	diffi_mx	diffTbill
diffER	1.0000000	-0.397902	-0.17071	0.01049	0.200756	-0.0006367
diffMXX	-0.3979019	1.000000	0.29876	0.01597	0.004333	0.0674000
diffDJ	-0.1707076	0.298755	1.00000	-0.00663	-0.024724	0.2154554
diffphi_mx	0.0104869	0.015974	-0.00663	1.00000	-0.011776	-0.0828901
diffi_mx	0.2007565	0.004333	-0.02472	-0.01178	1.000000	0.0079722
diffTbill	-0.0006367	0.067400	0.21546	-0.08289	0.007972	1.0000000

For this case, we obtain:

$\hat{\alpha} =$	6.594e-02	126.98678	-23.73010	-2.215e-02	-5.851e-02	9.894e-04
$\hat{\beta} =$	5.192e-05	-0.02276	0.69868	1.313e-04	3.059e-04	-7.969e-05
$\hat{\Phi}$	-7.8e-02 (5.8)	-6.5e-05 (2.3)	-1.3e-04 (4.1)	-3.4e-03 (9.9)	4.7e-03 (8.9)	-3.3e-0 (1.3)
$=$	-195.1 (150.7)	-0.1 (0.06)	0.6 (0.10)	7.1 (25.4)	5.7 (23.04)	777.1 (334.5)
	30.2 (81.9)	0.03 (0.032)	-0.08 (0.057)	6.1 (13.8)	1.9 (12.5)	131.1 (181.8)
	-3.47 (2.9)	7.92 (1.16)	-6.0 (2.09)	-3.0 (5.0)	2.6 (4.5)	-5.7 (6.6)
	3.5 (3.48)	-6.5(1.3)	-2.8(2.45)	-7.5 (5.8)	2.7 (5.3)	6.8(7.7)
	3.16 (2.4)	9.9(9.4)	4.02 (1.7)	1.03 (4.08)	-4.0 (3.7)	2.1(5.3)

With the following results depicted in table 1 we obtain the prediction equation (7) based on equation 1 for Exchange Rate and Mexican Stock Market:

$$\widehat{ER}t = 0.06594 + 0.000051_{t} - 0.078_{t-1} - 0.000065_{t-1} - 0.00013_{t-1} - 0.0034_{t-1} + 0.0047_{t-1} - 0.33_{t-1} \quad (7)$$

Based on the results depicted in table 1, we reject the Ho by means of this model showing a multiple R^2 of about 0.1035. Thus, Exchange Rate is determined by Mexican Stock Market at a first lag by -0.000065 with a p-value between 0.001 and 0.01 (two stars); by the Dow Jones Industrial Average at a first lag by -0.00013 with a p-value between 0 and 0.001 (three stars) and by Treasury Bills at a first lag by -0.33 with a p-value between 0.001 and 0.01 (two stars).

$$\widehat{\mathrm{MXX}}t = 126.9 - 0.02276_{t} - 195.13._{t-1} - 0.118_{t-1} + 0.58078_{t-1} + 7.13_{t-1} + 5.75_{t-1} - 777.10_{t-1} \quad (8)$$

Analogously, and following the results depicted in table 2, we obtained the prediction equation 8 based on equation 2. We reject the Ho by means of this model showing a multiple R^2 of 0.1137, equation (8) stating that Mexican Stock Market is determined by Mexican Stock Market itself at a first lag by -0.11815 with a p-value between 0.01 and 0.05 (one star); by the Dow Jones Industrial Average at first lag by 0.58078 with a p-value between 0 and 0.001 (three stars) and by 777.10 Treasury bills at a first lag with a p-value between 0.01 and 0.05 (one star).

$$\widehat{\pi_{mx_t}} = -0.0221 + 0.000131_{t} - 0.034_{t-1} + 0.000008_{t-1} - 0.00006_{t-1} - 0.3_{t-1} + 0.265_{t-1} - 0.05715_{t-1} \quad (9)$$

Thirdly, and following the results depicted in table 4, we obtained the prediction equation 9 based on equation 4. We reject the Ho by means of this model which shows a R^2 of 0.1635, equation (9) stating that inflation in Mexico is determined by inflation itself at the first lag by -0.3 with a p-value between 0 and 0.001 (three stars) and by short-term Mexican debt bill rates at first lab by 0.265 with a p-value between 0 and 0.001 (three stars).

4. Conclusions

We found the following answers to the initially posed questions: to begin with, several papers quoted in this study, have detected correlations between Exchange Rate and Stock Market in different forms. They have used different data intervals and methodologies, including ARDL models, Granger Causality Test, VAR models, GARCH-Markov-Switching models and Panel Data among others. Some of them have associated the volatility of these variables with monetary policy in Mexico and the USA. Others have found important correlations between ER vs gold and ER vs oil prices respectively; and between volatility in MXX vs volatility in ER. Based on the Exploratory Data Analysis used for this paper, we spotted at a first glance the following positive correlations: (0.91) between ER and the DJ; (0.85) between ER and MXX; (0.84) between π_{mx} and i_{mx} and (0.70) between US T-Bills and i_{mx}. On the other side, important negative correlations were also singled out: (-0.72) between MXX and US T-Bills; (-0.61) between MXX and i_{mx}; (-0.52) between MXX and π_{mx}; (-0.51) between ER and i_{mx} and (-0.50) between DJ and T-Bills. According to the results derived from the VAR model (table 1 and 2), we rejected the Ho finding out that Exchange Rate variations were determined by ER itself, MXX, DJ and US T-Bills. The most meaningfull variable influencing the ER turned to be the DJ. That speaks for the high financial dependence of Mexican Stock Exchange from changes in the US economy. Variations in MXX were associated by MXX itself, DJ and US T-Bills. In these calculations the DJ turned to be a key variable forming a dependence triangle: ER, Dow Jones and MXX. The same model also rejected the Ho by proving an important correlation between i_{mx} and π_{mx} (table 4). These calculations also proved the validity of the Fisher Effect where interest rates and inflation behave accordingly. It seems that monetary policy in Mexico is deeply intertwined with the US Federal Reserve´s policy and the Dow Jones Industrial Average, so that changes in the US interest rates affect the Dow Jones Industrial Average and immediately the Mexican Stock Market, which drives adjustments in Mexico´s nominal Exchange Rate. The conection between monetary policy, inflation, exchange rate variations and Stock Exchange adjustments is dynamic and goes forwards and backwards. Eventhough this topic has been addressed in several research papers, structural economic changes like nearshoring and remittances in Mexico, demand further and more diverse analysis in this regard.

References

Arnoldo López-Marmolejo, C. V.-C.-S. (2021). Remittances at record highs in Latin America: Time to revisit the Dutch disease. *Economics Bulletin, V. 4, Issue 3*, https://www.researchgate.net/profile/Daniel-Ventosa-Santaularia/publication/355155320_Remittances_at_record_highs_in_Latin_America_Time_to_revisit_the_Dutch_disease/links/616068790bf51d481755bd5d/Remittances-at-record-highs-in-Latin-America-Time-to-revisi.

Banco de México. (2021). *Impacto de la volatilidad Cambiaria sobre los Flujos de Capital en México.* https://www.banxico.org.mx/publicaciones-y-prensa/informes-anuales/%7B4BE24ECE-CA65-25A0-91AE-6129E55D73A5%7D.pdf: Informe anual. Recuadro 6.

Banco de México. (2021). *Relación entre la tasa de interés a 10 años de Estados Unidos y la Evolución de los Mercados Financieros en México.* https://www.banxico.org.mx/publicaciones-y-prensa/informes-anuales/%7B4BE24ECE-CA65-25A0-91AE-6129E55D73A5%7D.pdf: Informe Anual, Recuadro 8.

Castro, J. L. (2021). Contagio en la volatilidad entre los mercados de capital de divisas en México y Brasil (2000-2020). *Revista Mexicana de Economía y Finanzas*, DOI: https://doi.org/10.21919/remef.v16i0.701.

Chung, W. B. (1995). Exchange Rate Fluctuations, Political Risk and Stock Returns: Some Evidence from an Emerging Market. *Journal of Financial and Quantitative Analysis*, 541-561.

Frenkel, R. (2008). Tipo de cambio competitivo e inlación. *Revista de la CEPAL 96, diciembre*, 189-199.

Galicia Anaya S.A., R. T. (2020). Evolución y perdurabilidad de empresas bursátiles de la bolsa mexicana de valores 1895-2016. *Revista Universidad y Empresa*, 183-210.

Herrera, F. L. (2004). Modelado de la volatilidad y pronóstico del Índice de Precios y Cotizaciones de la Bolsa Mexicana de Valores. *Contaduría y Administración*, 43-72.

Investing.com. (23 de Diciembre de 2022). *S&P/BMV IPC (MXX)*. Obtenido de Indices: https://mx.investing.com/indices/ipc

Khan, M. K. (2019). Impact of Exchange Rate on Stock Returns in Shenzhen Stock Exchange: Analysis Through ARDL Approach. *International Journal of Economics and Manaement*, 15-26.

Krugman, Paul R., Obstfeld, Maurice (2000). International Economics: theory and policy. (Ed. 5th) Massachusetts: Addison-Wesley.

Kutty, G. (2010). The Relationship between Exchange Rates and Stock Prices: The Case of Mexico. *North American Journal of Finance*, 1-12.

López Herrera, Francisco; Mota Aragón, Martha Beatriz (2019). Rendimiento y volatilidades de los mercados mexicanos bursátil y cambiario. Revista Mexicana de Economía y Finanzas Nueva Época REMEF, 633-650.

Robert, S. H. (2017). *Time Series Analysis and its Applications.* Cham, Switzerland: Springer.

Shell Singhal, S. C. (2019). Return and volatility linkages among International crude oil price, gold price, exchange rate and stock markets: Evidence from Mexico. *Resources Policy*, 255-261.

Téllez, F. L. (2002). Variables económicas y un modelo multifactorial para la bolsa mexicana de valores: análisis empírico sobre una muestra de activos. *Academia. Revista Latinoamericana de Administración*, 5-28.

Yahoo finance. (30 de March de 2022). *Historical data*. Obtenido de Financial Markets: https://finance.yahoo.com/quote/%5EDJI?p=%5EDJI