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Monetary impacts on mexican stock market index, ESG stock market index and exchange rate; Structural vector autorregressive approach

Impactos monetarios en el índice bursátil mexicano, el índice bursátil ESG y el tipo de cambio; enfoque de vectores autorregresivos estructurales

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Abstract

We analyze the impact of the local and U.S. interest rate structure, the spread of short medium, and long-term interest rate differentials between Mexico and the U.S., and the uncertainty of the U.S. Monetary Policy (MPU) on the general Mexican Stock Market Index (IPC35), the ESG Mexican Stock Market Index (IPC-ESG), and the MXN/USD exchange rate, from April 2014 to April 2023. The Structural Vector Autoregressive (SVAR) models are proposed. Findings reveal that the exchange rate is the market with the lower level of response to Monetary shocks. Additionally, the evidence shows that the stock market (IPC35) absorbed faster the monetary policy changes (three months), while the currency market takes four months to reflect that information, and the Sustainable IPC (ESG) takes six months to respond to changes in monetary policy. The impulse response analysis reveals that the local and foreign yield curve, the 5-year, and 10-year spread and the MPU index are the main factors to which the currency and the stock market respond.

JEL Code: D53, E52, B23
Keywords: U.S. monetary policy; mexican financial markets; stock exchange; exchange rate; ESG index

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Resumen

Este estudio analiza el impacto de la estructura de tasas de interés locales y de Estados Unidos, los diferenciales de tasas a corto, mediano y largo plazo entre México y EE. UU., así como la incertidumbre de la política monetaria estadounidense (MPU) en el Índice de Precios y Cotizaciones de la Bolsa Mexicana (IPC35), el Índice de Mercado Sostenible (IPC-ESG) y el tipo de cambio MXN/USD, desde abril de 2014 hasta abril de 2023. Para ello, se emplean modelos de Vectores Autorregresivos Estructurales (SVAR). Los resultados indican que el tipo de cambio es el mercado que menos reacciona ante shocks monetarios. Además, se observa que el mercado accionario (IPC35) absorbe más rápido los cambios en la política monetaria (tres meses), mientras que el mercado cambiario tarda cuatro meses en reflejar dicha información, y el IPC sostenible (ESG) tarda seis meses en responder a estos ajustes. El análisis de funciones de impulso-respuesta revela que la curva de rendimientos local y extranjera, los diferenciales a 5 y 10 años, así como el índice MPU, son los principales factores que influyen en las respuestas del mercado cambiario y bursátil.

Código JEL: D53, E52, B23
Palabras clave: incertidumbre de la política monetaria estadounidense; mercados financieros mexicanos; bolsa de valores; tipo de cambio; índice sostenible (ESG)

Introduction

The unresolved financial fragilities of the global financial crisis and the monetary and fiscal policy measures employed to mitigate the effects of the COVID-19 pandemic and geopolitical conflicts have created a highly complex global economic and financial environment (Ozili & Arun, 2023). High inflationary levels appear to be subsiding much more slowly than anticipated due to some supply chain disruptions, and economic growth continues to be adjusted downward for 2024 due to increasing political tension and international uncertainty (Corhay & Tong, 2024).

This international financial context, together with crucial factors such as globalization (Obstfeld, 2021), financialization (Hardie & Thompson, 2021), financial engineering (the generation of new financial products), the growth of financial markets and financial technology (Zhou, 2021), have given monetary policy a crucial and definitive role in creating the conditions for a stable and prosperous economic environment.

Similarly, increased interconnectedness of economies worldwide has made the impact of monetary policy more significant. Changes in monetary policy in one country can have an impact on factors in other countries. Thus, Zhang (2022) and Gonçalves (2023) argue that monetary policy of the US Federal Reserve has important financial effects on the high degree of co-movement in risky asset prices, capital flows, leverage and financial aggregates around the world, a phenomenon called the Global Financial Cycle (GFC) (Rey, 2013).

Consequently, Central banks face increasing and new challenges, which have led them to increasingly resort to unconventional monetary policies to mitigate the effects of disequilibria, such as quantitative easing and forward guidance, such as low inflation, deflationary pressures and the zero lower bound on interest rates (Ntshangase, Zhou & Kaseeram, 2023). All these measures are focused on achieving the primary goals of monetary policy price stability, economic growth, financial stability, interest rate management, exchange rate stability, inflation expectations, liquidity, and monetary conditions, mitigating economic downturns and communication and transparency (Chugunov *et al.*, 2021).

Emerging markets are integrated into the global financial system, and U.S. financial markets are central to this scheme. Changes in U.S. interest rates influence global capital flows, impacting asset prices and financial conditions in emerging markets (Bräuning & Ivashina, 2020). U.S. interest rates play a pivotal role in determining global interest rate differentials. Investors often seek the highest returns for their investments, so changes in U.S. rates can attract or repel capital from emerging markets depending on the perceived risk-return trade-off.

In terms of currency markets, the U.S. dollar is the world's primary reserve currency. Changes in U.S. monetary policy affect the value of the dollar, influencing exchange rates globally. Many commodities and debts in emerging markets are denominated in dollars, making them sensitive to dollar fluctuations (Obstfeld & Zhou, 2023). U.S. monetary policy decisions influence global risk sentiment. Tightening monetary policy in the U.S. can lead to a reduction in risk appetite, causing capital to flow away from riskier assets in emerging markets (Yu, Liu & Yang, 2023).

In the specific case of Mexico, a high political-economic dependence relation with the U.S. tends to prevail. This dependence is extended to trade (Romero-Ramírez, 2023), remittances (Dieck-Assad, Peralta, & Carbajal-Huerta, 2020), foreign direct and indirect investments (Stojčić & Orlić, 2020 and Arreola Hernandez & Al Janabi, 2020), and financial markets (Heliodoro, Dias & Alexandre, 2020 and Bucio Pacheco, Villanueva & De Jesús Gutiérrez, 2021). Ample research has documented that the Mexican peso is influenced by developments in the U.S. financial markets. Changes in U.S. interest rates, monetary policy decisions, and economic conditions can impact the exchange rate between the U.S. dollar and the Mexican peso. Investors in both countries are connected through financial markets. U.S. investment in Mexican securities and *vice versa* contributes to capital flows and financial market dynamics (Alam & Istiak, 2020).

Based on the aforementioned literature, this paper aims to analyze how US Monetary Policy Uncertainty, the local and foreign yield curve and the short, medium, and long term spread between Mexico and the US impact the Mexican stock and currency markets. The period of study comprises April 2014 to April 2023. To achieve this purpose, we employ a Structural Vector Autoregressive Model

(SVAR) which offers several advantages such as: allows to explore causal relationships, enable the examination of dynamic responses to shocks over time, no need to impose strict assumptions, offers flexibility in the specification and can be used for forecasting future values.

The contribution of this paper is threefold. First, we employ different variables related to domestic and foreign monetary policy, thus providing a complete picture of how domestic and foreign monetary policy, the domestic and foreign yield curve, and U.S. uncertainty affect the Mexican foreign exchange and equity markets. Second, we employ a dynamic and robust approach, the SVAR model which consists of a set of multivariate linear autoregressive equations that characterize the joint dynamics of economic variables (Gambetti, 2020). Third, we analyze the research problems for a very relevant period, which includes important international events such as the financial crises, the COVID-19, the conflict between Russia and Ukraine and captures both conventional and unconventional monetary policy decisions of the US Federal Reserve, as well as significant local phenomena such as the political alternation and the "super peso" (period of unprecedented appreciation of the Mexican peso).

The remainder of this paper is organized as follows. The second section describes the Literature Review. The third section comprises the theoretical framework. The fourth section explains the methodology and data. The fifth section describes and analyzes the results. The last section concludes the paper.

Literature review

Since the monetary, and financial incidence of the U.S. is very important globally, several research has been conducted to analyze how the U.S. monetary policy is transmitted to other countries (Ansari, 2019; Wang, 2020; Ha, 2021). Degasperi, Hong & Ricco (2020) employ large Vector Autoregressive (VAR) techniques to analyze large macro-financial dataset of global and national indicators. Findings indicate that policy shocks originating in the U.S. have substantial repercussions on both advanced economies and emerging markets, impacting real and nominal variables significantly. They also identify that there are two main transmission of U.S. monetary policy channels trade and financial and contrary monetary policy shocks have larger effects.

Aor et al. (2021) measure the ripple effects of the U.S. monetary policy uncertainty (MPU) shock on the equity prices of 33 advanced and emerging economies from 1980Q1 to 2019Q4. They employ an extensive global vector autoregressive (GVAR) model that considers the individual macroeconomic conditions of each country, along with regional and global trade and financial interconnections among them. Results reveal that the U.S. MPU shock induces negative, albeit temporary, impacts on real equity prices. The effects are more pronounced in advanced markets, primarily due to their stronger ties with the U.S. economy.

Lastauskas & Nguyen (2023) develop an approach to time-varying variances of local structural shocks to measure the worldwide incidence of increasing U.S. volatility monetary policy shocks. They find global impacts synchronizing the world markets movement. Spillback effects are founded, even for the U.S. economy.

Chiang (2020) investigates how unexpected monetary growth and variations in Monetary Policy Uncertainty impact global stock returns. Results reveal that U.S. MPU have significant negative impact on international markets. A rise in unexpected monetary growth has a lower effect on Latin American and Asian stock markets.

Recent studies about the US monetary policy on emerging markets are diverse in terms of the countries under study and the quantitative techniques employed. Aftab et al. (2023) explore the incidence of uncertainties (economic policy, monetary policy, and global financial markets) on exchange rate volatility. They employed a GARCH (1,1) model to estimate exchange rate volatility. Uncertainties are measured using news-based indices and global financial volatility market is measured using the implied volatility index. To examine the impact of the uncertainties on exchange rate volatility, a Panel autoregressive distributed lag modeling is employed. They analyze 26 developed and emerging markets during the period 2005-2020.

Gupta, Nel and Nielsen (2023) examine how the U.S. monetary policy impact the BRICS stock market, particularly, the extreme behavior of them represented by asset bubbles. First, they detect asset bubbles for different maturities by using the multi-scale Log-Periodic Power Law Singularity (LPPLS). Evidence suggests that there is convergence among boom-bust cycles for BRICS markets. Then, they employ impulse-responses obtained from the local projection method (LPM) framework. Results show limited impact of US monetary policy in the bubble indicators.

Lee and Lee (2023) show that the US monetary spillovers are important, but also the Chinese monetary policy changes effects are very significant to other markets. They investigate the causal linkages among U.S. monetary policy uncertainty (USMPU), equity market volatility, and China's stock price index over the period from January 1994 to August 2021. They employ Granger causality in quantile analysis. Findings revealed that equity market volatility and prices in Chinese markets have a mildly impact on U.S. Monetary Policy Uncertainty. In addition, monetary policy uncertainty and equity market volatility in the United States Granger-cause China's stock prices.

In terms of Mexico, the works by Alam & Istiak (2020), Bush and Noria (2021), Sosa, Cabello & Ortiz (2023), research how U.S. uncertainty impacts financial markets.

Alam & Istiak (2020) employ a SVAR model, to analyze how U.S. uncertainty impacts Mexican macroeconomic variables. They concluded that economic policy uncertainty (EPU) in the United States results in a decline in Mexican industrial production, the price level, and the policy interest rate, and that foreign EPU has higher impact than local.

Bush and Noria (2021) analyze the impact of different types of uncertainty on the volatility of the Mexican peso-US dollar exchange rate (1999-2018). They construct four measures of uncertainty and two indicators of macro surprise, and employ text-based indices (EPU and VIX). The results indicate that higher uncertainty causes higher exchange rate volatility. Local measures appear to have an amplified effect during recessionary periods.

Sosa, Ortiz and Cabello (2023) assess the influence of both domestic and U.S. Economic Policy Uncertainty on Mexico's economic and financial dynamics, using monthly data covering January 1996 through September 2019. For this analysis, they employ the Dynamic Conditional Correlation methodology. The results indicate that local Economic Policy Uncertainty (EPU) exerts a notable impact on financial indicators, specifically affecting the stock and foreign exchange markets. However, there is no significant influence on economic variables such as Economic Activity and Industrial Production. On the contrary, Economic Policy Uncertainty in the United States does not show a significant impact on real and financial variables in Mexico.

Motivated by the studies and the spillovers of U.S. monetary policy on global financial markets, especially in emerging markets. This study contributes to the existing literature to analyze from different perspectives the impacts of U.S. monetary policy on the Mexican stock and foreign exchange markets, during a very interesting period in which several local and international political, economic, and financial events took place.

Monetary policy and financial markets

Monetary policy uncertainty

Information uncertainty can have a significant impact on individuals, businesses, and economies. This uncertainty arises when individuals or organizations lack complete and accurate information about the future, which can complicate to make informed economic decisions (Sniazhko, 2019). Some keyways by which informational uncertainty affects economic decisions are: it reduces investment and changes capital allocation, increases caution in consumption and savings, increases risk aversion, challenges business planning, promotes fine-tuning in economic policies, inhibits international trade, and decreases consumer confidence (Chistyakov and Eletsky, 2020).

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It's important to note that not all uncertainty is harmful. Some level of uncertainty is a natural part of economic life, and it can also create opportunities for innovation and entrepreneurship (Hariri, et al. 2019). However, excessive, or prolonged uncertainty can lead to negative economic consequences by inhibiting decision-making and investment (Karin, et al., 2020).

Policymakers and central banks often aim to reduce excessive uncertainty through clear communication, stable policy frameworks, and measures to mitigate economic risks, as doing so can help support economic stability and growth (Kryvtsov & Petersen, 2021).

Monetary Policy Measures

Monetary policy, which is set by a country's central bank, can have a significant impact on decision-making analysis. The central bank's primary tool for influencing monetary policy is the adjustment of interest rates and the management of the money supply. Here are some ways in which monetary policy can affect stock and exchange markets:

(i) changes in interest rates influence economic activity and promote higher dividend payouts (Conrad, 2021)

(ii) lower interest rates concentrate resources in stocks, as they offer a higher yield compared to bonds (Fabozzi, Simonian & Fabozzi, 2021)

(iii) monetary policy can affect investors' perception of risk, higher interest rates denote higher risk (Kalemli-Özcan, 2019)

(iv) changes in interest rates affect corporate profits, lower interest rates can reduce a company's borrowing costs, which can translate into higher profits and vice versa (Flannery, Hong & Wang, 2023)

(v) changes in monetary policy can affect a country's currency exchange rates (Inoue & Rossi, 2019). A weaker currency can benefit export-oriented companies by making their products more competitive in international markets. This can boost the stock prices of companies that rely heavily on exports (Saxegaard et al., 2022)

(vi) changes in interest rates have an impact on market sentiment (Frydman, Mangee, & Stillwagon, 2021)

(vii) sudden or unexpected changes in monetary policy can cause volatility in markets as investors adjust their portfolios in response to new information (Ouerk, 2023).

Yield Curve and Financial Markets

The spread between long-term and short-term interest rates, often referred to as the yield curve spread, can have significant implications for the economy and financial markets. In a normal or upward-sloping yield curve, where long-term interest rates are higher than short-term rates, this suggests expectations of economic growth. Borrowing costs are relatively low, encouraging investment and spending (Imakubo, Kojima & Nakajima, 2018).

Conversely, an inverted yield curve, where short-term rates exceed long-term rates, may signal expectations of an economic downturn. Investors may interpret this as a sign of potential recession, impacting consumer and business confidence (Wu & Xia, 2020).

Changes in the yield curve have implications in terms of borrowing and lending. In a rising interest rate environment, borrowing becomes more expensive, potentially slowing down consumer spending and therefore also generates income redistribution (Auclert, 2019). Companies may adjust their borrowing and investment decisions based on the yield curve. Higher long-term rates may increase the cost of capital for businesses, affecting their expansion plans (Vernimmen, Quiry & Le Fur, 2012).

While the yield curve generates important impacts on the economy, financial markets are particularly sensitive to changes in the yield curve. The bond market is one of the most affected, bond prices and yields have an inverse relationship. When interest rates rise, bond prices fall, and vice versa. Changes in the yield curve can influence the prices of existing bonds and impact the returns investors receive.

The equity markets are also susceptible to changes in the interest rate term structure. Changes in interest rates, as reflected in the yield curve, influence the discount rates used to value future cash flows. Higher interest rates can lead to higher discount rates, potentially impacting stock valuations. Thus, a rise in interest rates drive down the value of stocks. An asset allocation phenomenon occurs, increasing volatility and stock index declines. Companies pay higher dividends to keep the stock market available as a financing channel. Raising the cost of financing for companies1 (Kekre & Lenel, 2022).

Studies developed by Dong, Miao and Wang (2020), Bonchi (2023) and Gupta, Nel & Nielsen (2023) also argue that monetary policy is related with speculation and asset bubbles. Monetary policy influences the circumstances under which a bubble can arise, its equilibrium magnitude, and its dynamics, including its initial size.

Currency markets are also influenced by yield curve. Changes in the yield curve affect interest rate differentials between countries, influencing currency exchange rates. Higher interest rates in one country relative to another can attract foreign capital and impact currency values (Brandao-Marques, 2020 & Zhang, 2022).

It's important to note that the relationship between monetary policy and financial markets can be complex and can vary depending on a range of factors, including the overall economic environment,

[1] Some sectors, such as financials, may benefit from a steeper yield curve, while interest-sensitive sectors, such as utilities, may be negatively affected. The performance of different sectors may be influenced by expectations about future interest rates.

market conditions, and the specific goals of the central bank. Additionally, while expansionary monetary policy can generally be positive for stock markets, excessively low interest rates or an extended period of loose monetary policy can lead to concerns about asset bubbles and financial stability (Lian, Ma y Wang, 2019).

In this paper, considering the close relationship between the US and Mexico, and the influence of the US economy and financial system, we aim to analyze how US Monetary Policy Uncertainty, the local and foreign yield curve and the short, medium, and long term spread between Mexico and the US impact the Mexican stock and currency markets.

Data and methodology

The period of analysis comprises from May, 2014 to April, 2023. We employ monthly data from Federal Reserve and Banxico web pages. We propose three models to analyze how Monetary Policy Uncertainty impacts the returns of Mexican stock market, the ESG2 stock market and the exchange rate MXN/USD.

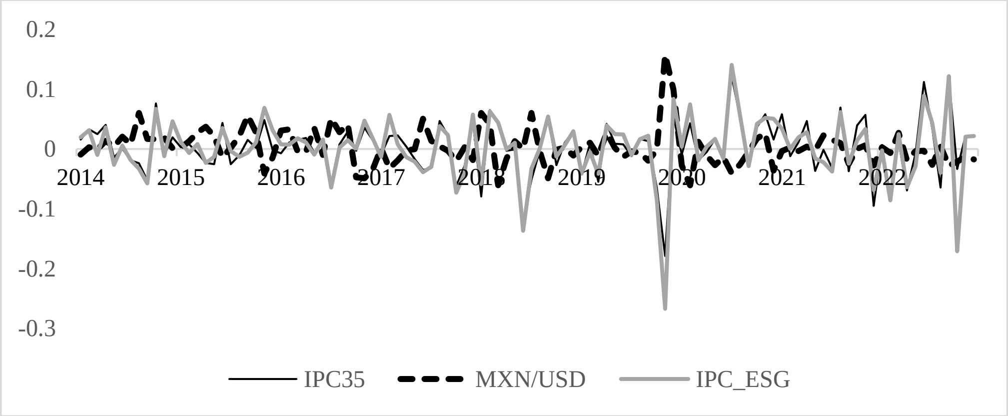

Figure 1. Stock Market Indices and Exchange Rate Returns

Source: Own elaboration

Figure 1 shows how the variables of interest evolved during the period of study. It seems that there is a negative relationship between the exchange rate and Mexican stock market. It is logical due to

[2] We use ESG and conventional stock indices to analyze whether the sustainable index is less/more vulnerable to monetary policy, relative to the conventional stock index. This issue is particularly relevant in the current context, where a greening of the financial system is being promoted as part of climate action.

exchange rate variations impact the real return on foreign portfolio investments. Thus, when the Mexican peso depreciates against the dollar, capital outflows occur.

The general and ESG stock market indexes present a very alike performance from 2014 to 2020. It is as expected because some assets are included in both indices. However, since 2020 the ESG index seems to be more volatile, i. e. in March 2020 it displayed a 26% fall, and in February 2023 of 17%.

Structural vector autoregressive model

Structural Vector Autoregressive (SVAR) model is an extension of Vector Autoregressive (VAR) method proposed by Sims (1980). A SVAR model is a statistical and econometric tool used to analyze the dynamic relationships and interactions among a set of time series variables. SVAR models are widely employed in macroeconomics and finance to understand how shocks or changes in one variable can impact other variables in the system (Tiwari, 2011 and Liu, Meng and Wang, 2020).

Through VAR analysis, we can establish connections between variations in a specific variable and variations in its own previous values, as well as the previous values of other variables.

The model in structural form is given by:

$$A(L) = x_t = \rho + \theta z_t + \epsilon_t \tag{1}$$

$$\epsilon_t \sim N(0, D), D(\text{diagonal}) e \; E(\epsilon_t \acute{\epsilon}_s)=0, \forall \; t \neq s \tag{2}$$

where $\rho = A_0\mu$, $\theta = A_0\Phi$, $A(L) = A_0B(L)$, $\epsilon_t = A_0\nu_t$, A_0 is a full rank matrix with each element in its main diagonal equal to one (Cespedes, Lima and Maka, 2008).

The relationships between the residuals e_t and ν_t, and the covariances D and Σ, are given by:

$$v_t = (A_0)^{-1}\epsilon_t \text{or alternatively } v_t = [I - A_0]v_t + \epsilon_t \tag{3}$$

$$A_0 \sum A'_0 = \mathrm{D} \tag{4}$$

Given an estimate of A_0 it is possible to estimate structural form parameters from estimates of reduced form parameters. The reduced form VAR is estimated restricting only the number of lags (chosen

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as the same in all equations and for all variables). Short-run and/or long-run restrictions have been applied to identified SVAR models.

In this research we propose three SVAR models where IPC35, IPC35ESG and MXN/USD[3] are the exogenous variables, and the endogenous variables are the interest rate spreads and Monetary Policy Index described in the Table 1.

Table 1
Endogenous variables

TICKER	DESCRIPTION
MX10Y-3M	10 years- 3 months Mexican interest rate spread
EU10Y-3M	10 years- 3 months US interest rate spread
MX1M-EU1M	1 month Mexican interest rate - 1month US interest rate
MX5Y-EU5Y	5 years Mexican interest rate - 5 years US interest rate
MX10Y-EU10Y	10 years Mexican interest rate - 10 years US interest rate
MPU BBD	BBD Monetary Policy Uncertainty Index
MPUHRS	HRS Monetary Policy Uncertainty Index

To account for monetary policy, the federal funds rate of the US and interest rates of Mexico are used. The source of the US data is the IFS FRED (St Louis FED). The source of Mexican data is Banco de Mexico, the central bank of Mexico.

BBD Monetary Policy Uncertainty Index was developed by Baker, Bloom, and Davis in 2016. The authors construct monthly Monetary Policy Uncertainty (MPU) Indices for the United States by identifying newspaper articles that contain specific terms related to economic policy uncertainty. The criteria involve terms related to economic activity, legislative and regulatory actions, uncertainty, and monetary policy. The indices are calculated by summing the counts of relevant articles and normalizing the frequency to have an average value of 100 from January 1985 through December 2010 (Baker, Bloom and Davis, 2016).

Husted, Rogers, and Sun (2017) develop a monthly index of Monetary Policy Uncertainty (MPU) by searching for specific keywords related to monetary policy uncertainty in major newspapers such as the New York Times, Wall Street Journal, and Washington Post. The keywords include terms like "uncertainty," "monetary policy," "interest rates," and references to the Federal Reserve. The index is computed by dividing the count of relevant articles by the total number of news articles mentioning the Federal Reserve for each newspaper and then standardizing the results. They also perform an audit, comparing their computer-based index with a "human index" based on human readings of 8,000 randomly selected articles.

[3] Stock indexes and exchange rate were employed in log-returns and interest rates and MPU indexes in rate of change.

This MPU index differs from the Baker, Bloom, and Davis (BBD) indices in terms of the newspapers covered, keyword focus, and scaling methodology. HRS focus on three major newspapers, center their keywords on U.S. monetary policy, and scale by the total number of articles mentioning the Federal Reserve. In contrast, BBD use a larger set of newspapers, broader keyword terms, and scale by the total number of articles. The imperfect correlation between the two indices is attributed to differences in newspapers, keywords, and scaling methods according to HRS.

As previously mentioned, our main purpose is to extend the knowledge about how monetary policy uncertainty, represented through different variables impacts the stock market and the exchange rate in Mexico during the period 2014-2023. The choice of sample period is based on the availability of data. In the VAR model, we use all the variables in logarithmic form except for the indices of uncertainty and interest rate.

Section 5 presents the following tests: stationarity of individual variables to reduce the probability of estimating spurious regressions; stability, lag length criteria and Lagrange multiplier serial correlation test, all to have valid impulse reaction functions.

Empirical results

Unit root tests

Variables are used in log-differences, except for interest rate and MPU Indexes where the rate of change is estimated. Table 2 shows unit root tests results for the ADF and Phillips Perron methods. The results show that null hypothesis of the presence of unit root tests is rejected, indicating that the series present stationarity.

Table 2
Augmented Dickey Fuller (ADF) and Phillips Perron (PP) Unit Root Tests

	ADF Test		PP	
Variable	Intercept	Trend and intercept	Intercept	Trend and intercept
MXN/USD	-8.529***	-8.075***	-7.598***	-8.429***
IPC35	-11.740***	-11.700***	-11.740***	-11.700***
IPC35-ESG	-11.424***	-11.371***	-11.717***	-11.657***
MX10Y-3M	-10.043***	-9.997***	-10.043***	-9.997***
EU10Y-3M	-9.834***	-7.363***	-11.117***	-12.186***
MX1M-EU1M	-3.538***	-3.564**	-3.642***	-3.750**
MX5Y-EU5Y	-9.981***	-9.932***	-9.666***	-9.652***
MX10Y-EU10Y	-10.014***	-9.950***	-9.493***	-9.433***
MPU BBD	-12.275***	-12.218***	-38.686***	-39.689***
MPUHRS	-9.682***	-9.634***	-34.812***	-34.564***

Note: *** and ** denotes statistical significance at 1 and 5%, respectively

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Table 3
Roots of Characteristic Polynomial

IPC	IPC/ESG	MXN/USD
0.900174	0.987965	0.917552
0.900174	0.987965	0.778496
0.895381	0.986584	0.749202
0.895381	0.986584	0.749202
0.862846	0.984144	0.744699

Note: only the higher modules are reported

The ARCH effect (heteroskedasticity) is also tested, results are shown in Table 4. It can be noticed that some of the variables do not present heteroscedasticity, but stock indexes and some monetary spreads do, in consistency with the financial variables stylized facts.

Table 4
ARCH-LM Heteroskedasticity Test

Variable	F-stat	
XR	6.417325	*
IPC ESG	1.046183	
IPC	1.520911	
MX10Y-3M	0.005587	
EU10Y-3M	0.012084	
MX1M-EU1M	2.087624	*
MX5Y-EU5Y	1.205445	
MX10Y-EU10Y	1.432579	**
MPU BBD	3.426082	***
MPUHRS	12.39328	***

Note: Null Hypothesis is there is no ARCH effect in the residuals
*,** and *** represents 1, 5 and 10% statistical significance, respectively

Once the model stability is confirmed, the lag length criteria for each model is determined. Tables 5, 6 and 7 show the Lag length order selection criteria: LR: sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion and HQ: Hannan-Quinn information criterion.

Lag length criteria determination

Table 5 shows that there is no consensus among the Lag length criteria. However, the model is stable with 4 lags.

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Table 5
Lag length criteria for IPC model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	122.9248	NA	8.37e-12	-2.803045	-2.568243*	-2.708776*
1	211.0050	156.8257	4.69e-12*	-3.390366	-1.277149	-2.541942
2	264.6943	85.11716	6.28e-12	-3.138885	0.852747	-1.536306
3	315.4175	70.51760	9.71e-12	-2.81506	3.054986	-0.458326
4	389.6747	88.74647	9.47e-12	-3.065237	4.683225	0.045652
5	476.9165	87.24172*	8.04e-12	-3.632109	5.994768	0.232935
6	578.2017	81.52225	6.39e-12	-4.541504	6.963788	0.077695
7	694.6576	71.00973	5.53e-12	-5.820918	7.562789	-0.447564
8	824.4630	53.82173	7.98e-12	-7.425926*	7.836196	-1.298418

Note: * indicates lag order selected by the criterion

Table 6 exhibits lang length criteria for IPC/ESG model. Despite of the fact that, SC and HQ criteria suggests cero lags. It implies a simple Ordinary Least Squares model, and a six lags model shows stability and goodness of fit.

Table 6
IPC/ESG model lag length criteria results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	115.1077	NA	1.01e-11	-2.612382	-2.377581*	-2.518113*
1	201.5708	153.9465	5.90e-12	-3.160263	-1.047047	-2.311839
2	265.4748	101.3113	6.16e-12	-3.157923	0.833709	-1.555343
3	316.7543	71.29092	9.40e-12	-2.847665	3.022382	-0.490931
4	387.7274	84.82158	9.94e-12	-3.017742	4.730720	0.093147
5	477.7499	90.02252	7.88e-12	-3.652437	5.974440	0.212606
6	584.5683	85.97579*	5.47e-12*	-4.696789	6.808503	-0.07759
7	689.9049	64.22960	6.21e-12	-5.704997	7.678710	-0.331643
8	816.6275	52.54353	9.66e-12	-7.234817*	8.027305	-1.107309

Note: * indicates lag order selected by the criterion

Table 7 presents the lag length criteria for MXN/USD model. There is no consensus among the criteria. However, a model with three lags shows stability.

Table 7
Lag length criteria for MXN/USD model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	162.8493	NA	3.16e-12	-3.776813	-3.542011*	-3.682544
1	258.3353	170.0116	1.48e-12	-4.544764	-2.431547	-3.696339*
2	306.3209	76.07468	2.28e-12	-4.154168	-0.162536	-2.551589
3	364.9319	81.48360	2.90e-12	-4.022729	1.847318	-1.665995
4	464.0072	118.4070*	1.55e-12	-4.878223	2.870239	-1.767334
5	547.3199	83.31272	1.44e-12	-5.349265	4.277612	-1.484222
6	632.5700	68.61597	1.70e-12	-5.867562	5.637730	-1.248363
7	756.0135	75.27040	1.24e-12	-7.317402	6.066305	-1.944048
8	922.3701	68.97713	7.33e-13*	-9.813905*	5.448217	-3.686396

Note: * indicates lag order selected by the criterion

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Once that models were estimated, serial correlation is tested through Lagrange Multiplier Tests, the null hypothesis is there is no serial correlation at lag h. Table 8 shows that IPC and IPC/ESG models are free of autocorrelation. In the case of MXN/USD model, following Ouliaris et al. (2016) and Cernichiaro (2020), the correlogram (Table 8) shows no autocorrelation in the short term, sinusoidal motion, nor numerous statistically significant autocorrelations.

Serial correlation analysis

Table 8
VAR Residual Serial Correlation LM Tests

	IPC		IPC/ESG		MXN/USD	
Lag	LRE* stat	Prob.	LRE* stat	Prob.	LRE* stat	Prob.
1	63.04559	0.5103	38.52395	0.9952	95.23659	0.0069
2	70.27536	0.2756	62.14307	0.5425	78.70779	0.1021
3	71.55331	0.2415	48.62700	0.9230	81.56193	0.0685
4	71.33158	0.2472	65.84658	0.4127	101.2675	0.0021
5	64.55016	0.4572	53.92942	0.8111	74.32633	0.1772
6	60.83557	0.5891	61.17402	0.5771	54.37378	0.7990
7	68.06300	0.3407	63.61346	0.4901	84.43004	0.0445
8	65.51392	0.4240	43.59303	0.9762	53.60329	0.8197
9	58.76817	0.6614	65.58158	0.4217	55.99790	0.7516
10	72.64415	0.2146	56.59632	0.7330	66.44407	0.3928
11	51.76203	0.8642	44.98905	0.9658	64.64310	0.4540
12	65.25243	0.4330	50.10531	0.8980	51.73343	0.8649

Impulse response analysis

The responses to monetary policy uncertainty variables are plot with impulse response functions in Fig. 2.

It appears that the MXN/USD exchange rate has a negative impact (appreciation) when the long and short term spread (10-year rate minus 3 months) increases in Mexico and the U.S. It is important to note that changes in the U.S. yield curve have a greater impact on exchange rates, relative to changes in the local yield curve. This phenomenon could be explained since, the yield curve spread is often considered an indicator of market expectations for future interest rates.

In terms of risk perception, changes in the yield curve spread can impact risk perceptions. An inverted yield curve (short-term rates higher than long-term rates) is often seen as a potential indicator of an economic downturn, increasing risk aversion. In this case, the widening of the U.S. yield curve spread generates a reallocation of assets to the Mexican market and capital inflows appreciate the Mexican Peso.

Apparently, the short, medium and long-term spreads between the Mexican and the U.S. rate has a very low impact on the exchange rate and is present in the third month.

When the interest rate spread increases, it generates a negative response in the exchange rate (appreciation). This is explained because if a country experiences a rise in long-term interest rates while rates in other countries remain stable or decrease, it can attract foreign capital seeking higher returns.

Higher long-term interest rates may lead to an appreciation of the currency as investors seek to take advantage of the better yield opportunities. In this case, when long term interest rate increase Mexico becomes more attractive (it gives higher premiums) and foreign capital flows into the economy, increasing the availability of dollars, decreasing the price of the dollar, in terms of the Mexican peso.

The response to the BBD index is positive, as expected by theory, but the response to the HRS index is negative. An increase in the MPU in the U.S. encourages capital to go to other countries, in this case Mexico, increasing the supply of dollars in the economy, appreciating the local currency.

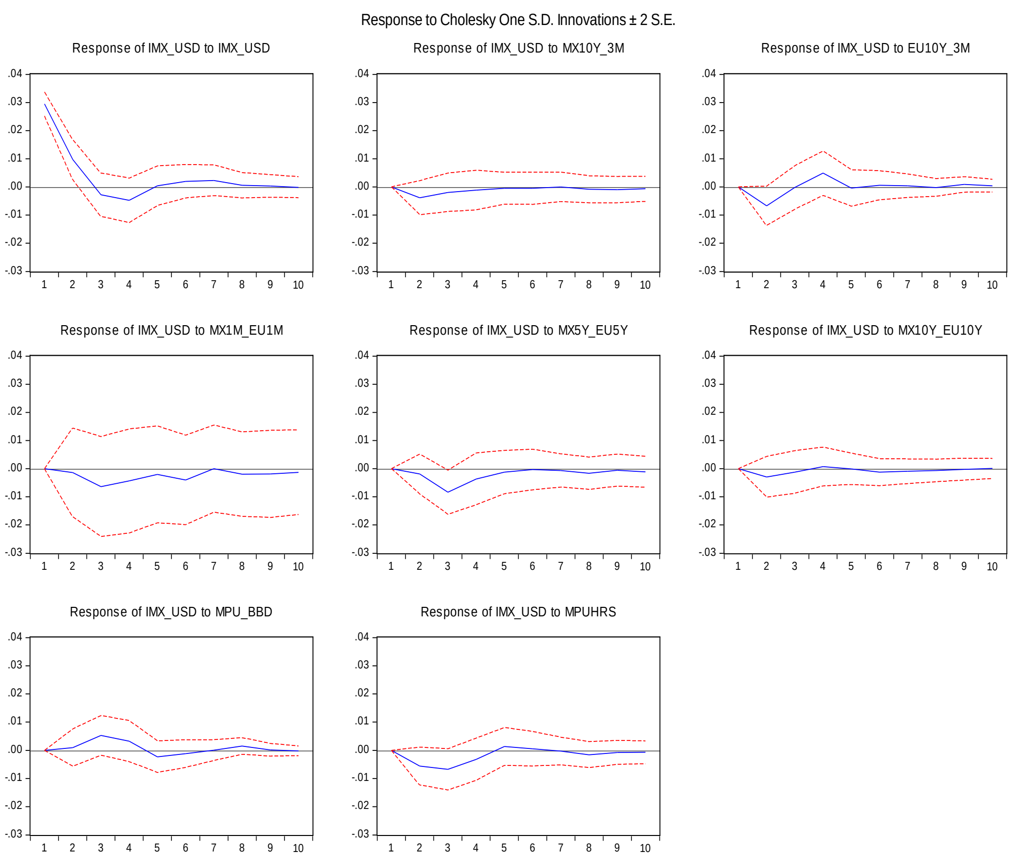

Figure 2. Impulse-Response Function Monetary Uncertainty Variables impact on Exchange Rate MXN/USD (in percentage)
Source: Own elaboration with estimation results

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Figure 3 shows the IPC ESG market response to changes in the local yield curve. The response appears to be very small, but negative in the first three months, positive from the third to the eighth month and negative the rest of the year in the case of the Mexican yield curve. This response can be explained by the fact that as the spread between long-term and short-term interest rates increases, risk-averse investors will prefer to invest in long-term bonds rather than equities[4].

In the case of the IPC ESG response to US yield curve, short-term spread is the variable with the largest impact on IPC ESG. The 5 years spread has a positive impact in the second month. The 10-year spread is almost zero, but negative and is present until the 4th month.

US monetary policy, represented by the BBD index appears to have a negative impact on the IPC ESG during the first 4 months of analysis, and a positive impact, in the 5th month. It could already be understood that monetary policy uncertainty can have significant effects on the stock market, as it introduces uncertainty about the future direction of interest rates and the general economic environment. First, monetary policy decisions can lead to increased volatility. Second, investors may become more risk-averse during periods of heightened uncertainty, leading to selling pressure on riskier assets such as equities. Third, if companies are uncertain about future interest rates or economic conditions, they may delay their investment or borrowing decisions, which could affect corporate earnings and stock prices.

On the other hand, the uncertainty of US monetary policy as measured by the HRS index has a positive effect for the first 4 months and a negative effect from the 4th to the 6th month. In the 7th month it becomes positive and then decreases. This result could be explained by the fact that an increase in US monetary policy uncertainty could encourage investors to seek other markets, thus benefiting the Mexican market.

[4] It is important to mention that changes in interest rate expectations can impact various sectors of the stock market. For example, rising interest rates may negatively affect interest-sensitive sectors like real estate and utilities, while financial stocks may benefit from higher rates.

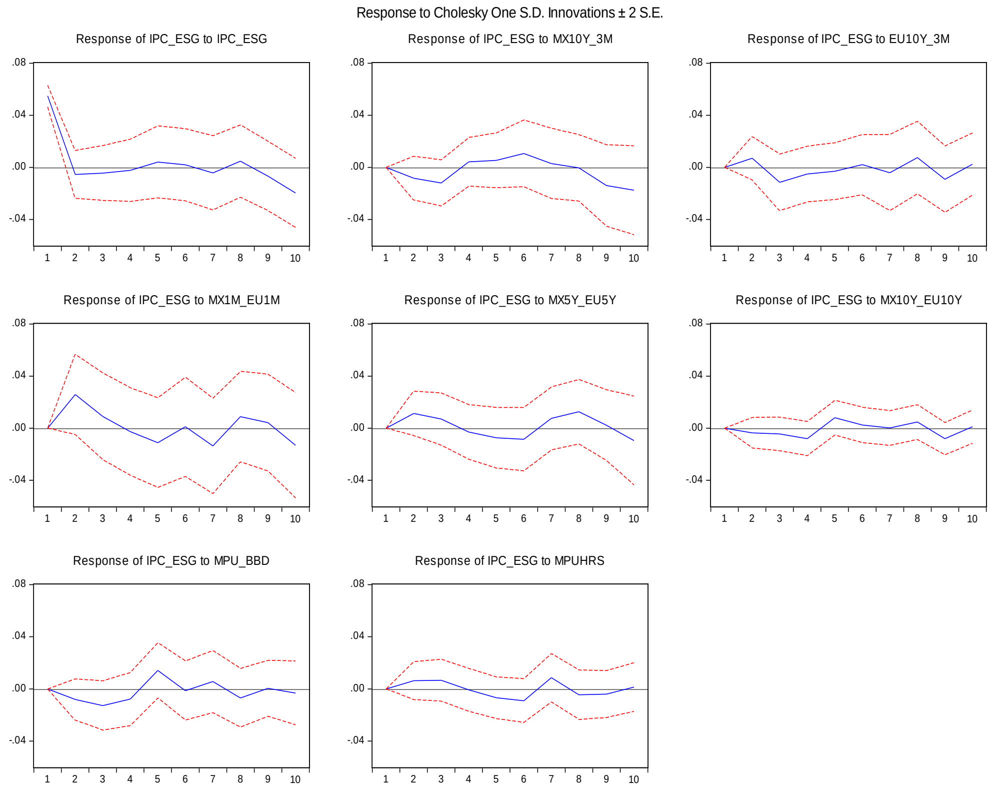

Figure 3. Impulse-Response Function Monetary Uncertainty Variables impact on IPC ESG (in percentage)
Source: Own elaboration with estimation results

Figure 4 shows The Mexican Stock Market (IPC) response to Monetary Uncertainty Variables. The IPC Index seems to be less sensitive to changes in foreign and local yield curve, in comparison to IPC ESG.

The IPC Index shows a positive response to the steepness of the US yield curve during the first month, and negative from the second to the seventh month. The immediate result could be explained by the fact that some investors focus on short-term gains and, if long-term interest rates rise or short-term interest rates are cut, they would prefer higher and more immediate returns in the stock market.

The IPC Index shows low sensitivity and a positive sign to the 5-year local and foreign interest rate differential. The response of the IPC Index to the long-term interest rate spread also appears to be small and negative until the fourth month. These results could be explained by the fact that the most liquid maturities of Treasury bonds tend to be the 2-, 5- and 10-year bonds.

Evidence from Chen (2023) points out that the 5-year Treasury yields serve as the conduit for other yields, communicating their liquidity and central position in the yield curve's benefits. Crucially, the role of 5-year Treasury yields as an information transmitter stays consistent during unconventional monetary policies, despite these policies reduces the overall interconnectivity of Treasury yields.

Chen op cit. also explains that the U.S. Federal Reserve's focus on longer maturity bonds and its influence on the future trajectory of short-term bond yields can be notably mirrored in the 5- to 10-year Treasury yields. Consequently, these yields may exert a substantial influence on the configuration and alterations observed in the yield curve for U.S. Treasuries. This fact could explain why the exchange rate, the IPC ESG Index and the IPC present a strong reaction to 5 years and 10 years interest rate spreads.

The IPC Index response to US MPU BBD Index and US MPU HRS Index is very similar to the IPC ESG Index.

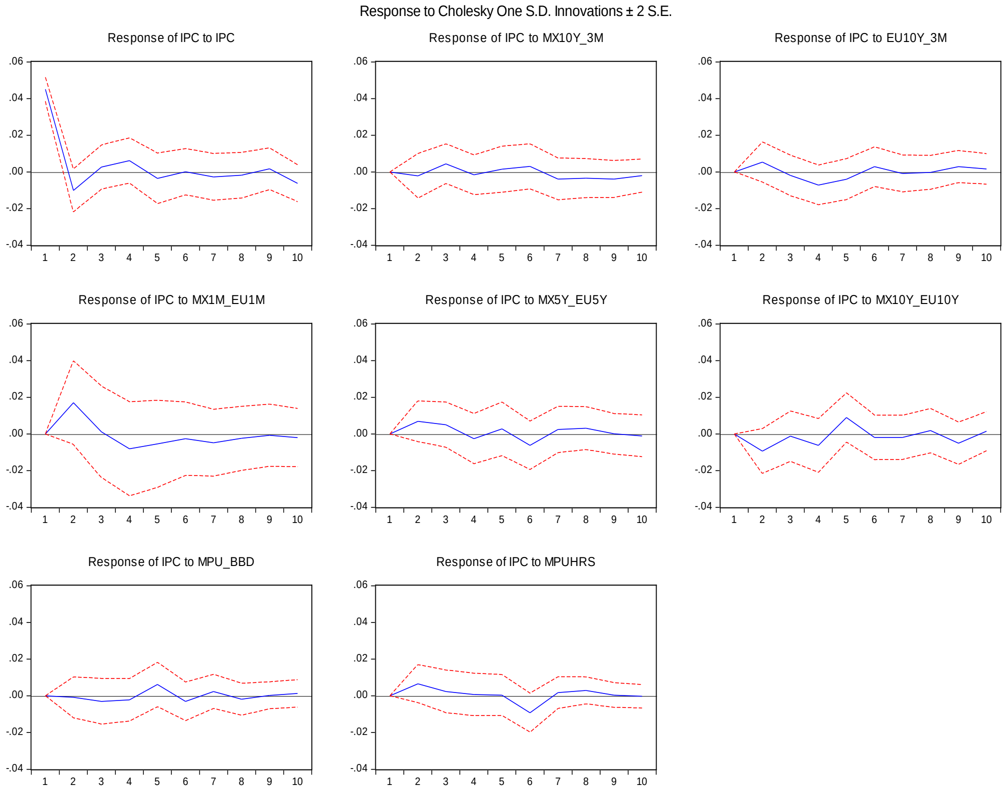

Figure 4. Impulse-Response Function Monetary Uncertainty Variables impact on IPC %

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Table 9
Variance Decomposition of exchange rate, IPC and IPC ESG response to monetary variables

	ITS OWN	MX10Y-3M	US10Y-3M	MX1M-US1M	MX5Y- US US 5Y	MX10Y-US 10Y	MPU BBD	MPU HRS
IPC	80.930	0.176	1.088	11.004	1.772	3.354	0.027	1.649
XR	91.959	0.714	2.839	2.621	0.177	1.136	0.061	0.493
ESG	90.276	0.47	6.11	0.658	0.006	0.044	1.692	0.744

Source: Own elaboration with estimation results

Table 9 shows the variance decomposition of the responses of the exchange rate to the monetary variables. It appears that, for the IPC, ESG and XR the largest response of each indicator is explained by their own lagged values. These results could be a sign of weak Efficiency of the Mexican stock and exchange markets. For the IPC35 the second most important variable is the short-term interest rate differential (MX1M-US1M). The third is the long-term interest rate (MX10Y-US10Y). In the exchange rate market (XR), the second most important response is to changes in the US yield curve (US10Y-3M), and the third most important variable is the short-term interest rate differential (MX1M-US1M). Finally, for the IPC ESG its responses are apparently explained by the US yield curve (US10Y-3M), and, secondly, the Monetary Policy Uncertainty Index BBD.

Conclusions

This paper analyzes the Mexican stock and currency markets response to local and US monetary policy changes. To achieve that purpose, we employed short, medium, and long-term spreads between Mexico and U.S. interest rates, US and Mexican yield curve and US Monetary Policy Indexes.

The empirical evidence shows that the stock market (IPC35) absorbed monetary shocks faster than the currency market and the Sustainable IPC (ESG) the monetary policy changes under study. The IPC35 absorbed this change in three months, while it took 4 for months and 6 months to the currency market and ESG, respectively, to respond to changes in monetary policy.

The impulse response graphical analysis shows that the exchange rate is which has a lower reaction to monetary policy. This result is consistent with Solis (2023), who argued that the null or weak response of emerging market currencies to domestic monetary policy documented in the literature is the result of wide event windows. One proposal to address this problem is to employ an event study with intraday data.

The impulse response analysis reveals that the local and foreign yield curve, the 5-year and 10-year spread and the MPU index are the main factors to which the currency and the stock market respond.

Variance decomposition results point out a weak level of efficiency in the currency and general stock market index (IPC), the largest response of each indicator is explained by their own lagged values. The main responses from IPC and XR are to changes in short and long-term interest rates spreads, and U.S. yield curve. In the case of ESG index, its responses are apparently explained by the US yield curve, the Mexican yield curve, and it presents negative responses to the MPU indices.

The results are crucial for investors, especially those interested in non-sustainable assets in the Mexican Stock Exchange. The IPC35 is especially sensitive to the local and U.S. yield curve, the 5 and 10-year spread and the U.S. MPU. It is important to mention that the foreign exchange market has a low level of reaction because it responds to circumstantial situations and certain unique events, i.e., near shoring phenomena, new projects and increased investment in Mexico and increased remittance levels.

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