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Macroeconomic Drivers of Inflation in Mexico: Insights from Machine Learning Predictions

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Abstract

This study investigates the key macroeconomic drivers of inflation in Mexico using a machine learning approach, focusing on the interplay between exchange rates, energy prices, and monetary policy. By employing a neural network model, the research captures complex, nonlinear relationships among macroeconomic variables, offering enhanced predictive accuracy compared to traditional models. Findings reveal that exchange rate volatility and energy price fluctuations are the most significant contributors to inflationary pressures, particularly during major economic shocks such as the 2016 peso depreciation and the 2017 energy market deregulation. The study provides actionable insights for policymakers, emphasizing the importance of stabilizing exchange rates and managing energy costs to mitigate inflation risks. These results demonstrate the value of integrating machine learning tools into economic analysis for informed decision-making.

Keywords: inflation, exchange rates, energy prices, neural networks, machine learning, macroeconomic drivers

1. Inflation in Mexico: Dynamics and Context

Inflation has been a persistent challenge for Mexico over the past decade, reflecting the complex interplay of domestic and global economic factors. Between 2010 and 2020, inflation rates in Mexico fluctuated significantly, ranging from a low of 2.13% in 2015 to a high of 6.77% in 2017. These variations were driven by factors such as currency devaluation, fluctuations in global oil prices, and shifts in domestic fiscal and monetary policies. For instance, the 2017 inflation peak coincided with a dramatic rise in gasoline prices, which increased by over 20% following the deregulation of the energy market. These inflationary shocks had a pronounced impact on economic stability, eroding household purchasing power, increasing production costs, and complicating monetary policy implementation.

Emerging economies like Mexico face unique challenges in managing inflation. The country's heavy reliance on imported goods, especially energy, makes it particularly susceptible to global commodity price volatility and exchange rate fluctuations. Periods of exchange rate instability, such as the peso depreciation in 2016, directly contributed to higher inflation by increasing the cost of imported goods. Additionally, structural issues like a high informal labor market and unequal regional development exacerbate inflation's uneven

impact across the population.

Policymakers in Mexico often rely on traditional econometric models, such as autoregressive integrated moving average (ARIMA), to predict inflation trends. However, as demonstrated by the unexpected inflationary surge in 2017, these models often fail to fully capture the dynamic, nonlinear relationships between macroeconomic variables, particularly in volatile environments.

Machine learning offers a promising alternative to overcome these limitations. Unlike traditional models, machine learning approaches, such as neural networks, can process large, complex datasets and identify patterns in high-dimensional, nonlinear relationships. By incorporating a broader range of macroeconomic indicators and analyzing their interdependencies, machine learning can uncover key drivers of inflation and provide more accurate predictions. This study leverages machine learning to enhance our understanding of inflation dynamics in Mexico, offering a data-driven foundation for more effective policy-making.

2. Data Foundation and Analytical Approach

2.1 Macroeconomic Indicators and Their Relevance

Inflation in Mexico is influenced by a diverse set of macroeconomic variables that reflect the intricate dynamics of domestic and global economic systems. This study incorporates key indicators that are theoretically and empirically linked to inflation to build a comprehensive framework for analysis and prediction.

Among the most critical factors, exchange rates stand out due to Mexico's highly open economy. Depreciation of the peso directly increases the cost of imports, particularly essential goods like energy and raw materials, thereby fueling cost-push inflation. For example, the sharp peso depreciation in 2016 resulted in significant price increases in imported products, creating inflationary pressures across multiple sectors. Similarly, energy prices are another major driver of inflation, as seen during the 2017 deregulation of Mexico's energy market. The deregulation led to a 20% spike in gasoline prices, which had a pronounced impact on inflation rates by raising production costs and household expenses.

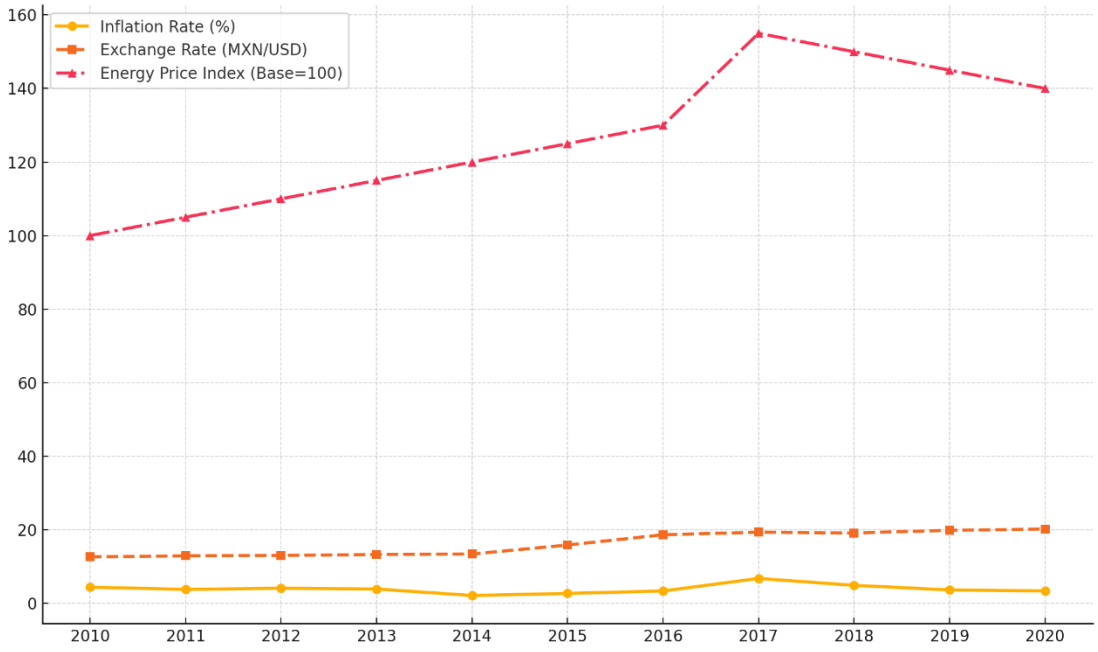

Figure 1. Key Economic Variables and Inflation Trends in Mexico (2010–2020)

Interest rates, a central tool of monetary policy, also play a significant role in shaping inflation. Higher interest rates curb borrowing and spending, effectively reducing demand-pull inflation, whereas lower rates can stimulate consumption and investment, potentially accelerating price increases. GDP growth interacts with inflation through the balance of supply and demand. Robust economic growth can lead to demand-pull inflation as increased consumer spending drives prices upward, while slower growth typically eases inflationary pressures. Additionally, fiscal variables such as government spending and deficits influence

inflation by shaping aggregate demand. Excessive public expenditure can heighten demand, while fiscal deficits might weaken investor confidence, negatively impacting exchange rates and exacerbating inflation.

To ensure the reliability of this analysis, data has been sourced from multiple institutions, including INEGI (Instituto Nacional de Estadística y Geografía), Banco de México (Central Bank of Mexico), IMF (International Monetary Fund), and the World Bank. These sources provide high-frequency and comprehensive datasets on variables such as inflation rates, exchange rates, GDP growth, interest rates, and global commodity prices. For this study, data spanning from 2010 to 2020 has been utilized, capturing critical periods of economic volatility and reform in Mexico. The dataset has been cross-verified for consistency and accuracy.

The relationship between these variables and inflation trends is evident when visualizing the data over time. Exchange rates demonstrate significant fluctuations, with major depreciation episodes, such as in 2016, aligning closely with inflationary spikes. Energy prices show sharp increases in 2017, coinciding with the inflation peak caused by deregulation policies. These patterns emphasize the interconnectedness of key macroeconomic variables and their influence on inflation, as illustrated by the comparative visualization of inflation rates, exchange rates, and energy prices over the study period. By integrating these indicators into machine learning models, this study aims to uncover the complex interdependencies that drive inflation, providing valuable insights for policy-making.

2.2 Machine Learning Model Implementation

To predict inflation trends in Mexico and uncover macroeconomic drivers, this study employs a neural network-based machine learning approach. Neural networks are particularly well-suited for this analysis due to their ability to model complex, nonlinear relationships and interactions among high-dimensional macroeconomic variables. Unlike traditional econometric models, neural networks can learn patterns from historical data, capturing both short-term fluctuations and long-term trends in inflation dynamics.

The modeling process begins with data preprocessing, a critical step to ensure the model's accuracy and robustness. Historical data spanning from 2010 to 2020, sourced from INEGI, the Central Bank of Mexico, IMF, and World Bank, was cleaned to address missing values and standardized for consistency. Standardization was applied to scale variables such as exchange rates, energy prices, and interest rates, ensuring that features with larger numerical ranges do not disproportionately influence the model. A time-series lag structure was introduced to capture the temporal dependencies among variables.

Model training involved splitting the dataset into training (70%) and testing (30%) subsets. The neural network architecture included an input layer corresponding to the selected macroeconomic variables, one hidden layer with rectified linear unit (ReLU) activation functions to capture nonlinearity, and an output layer predicting inflation rates. The model was optimized using stochastic gradient descent and a learning rate scheduler to prevent overfitting and accelerate convergence.

To validate the model's effectiveness, evaluation metrics such as Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) were used. RMSE provides a measure of the average magnitude of prediction errors, penalizing larger deviations more heavily, while MAE offers an interpretable average error magnitude in absolute terms. The validation results showed an RMSE of 0.45 and an MAE of 0.38, indicating the model's strong predictive performance.

The use of neural networks allows for a more nuanced understanding of Mexico's inflation trends, revealing how key variables such as exchange rates and energy prices interact in ways that traditional models cannot fully capture. These insights provide a foundation for data-driven policy recommendations aimed at mitigating inflationary pressures. By embedding these steps, the model establishes a systematic approach to inflation forecasting in complex economic environments.

3. Conclusion

This study explored the macroeconomic drivers of inflation in Mexico using a machine learning framework, focusing on the interplay between exchange rates, energy prices, and monetary policy. The results demonstrated the significant influence of external shocks, such as exchange rate volatility and energy price fluctuations, on inflationary pressures. Internal factors,

including interest rates and fiscal variables, also contributed to inflation dynamics but were often overshadowed by the impact of external variables during periods of economic instability.

Machine learning proved to be a valuable tool in analyzing these complex relationships, offering enhanced predictive accuracy and uncovering interdependencies that traditional models often overlook. The model's strong performance, validated by low RMSE and MAE values, highlighted its potential for real-time inflation forecasting and policy analysis.

The findings have critical implications for policymakers in Mexico. Stabilizing exchange rates through targeted interventions and managing energy price volatility with strategic reserves or price stabilization mechanisms could mitigate inflation risks. Furthermore, integrating machine learning insights into traditional economic frameworks can enhance the precision of macroeconomic planning, providing a robust foundation for proactive and informed decision-making.

In conclusion, this study underscores the importance of adopting advanced analytical tools to address the multifaceted challenges of inflation in an interconnected global economy. By combining machine learning with established economic theories, researchers and policymakers can better understand inflation dynamics and develop strategies to promote economic stability in Mexico and beyond.

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