Determining co-movements of tomato prices in the United States and macroeconomic variables in Mexico for 2023

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ABSTRACT

Objective: To analyze the co-movements of macroeconomic variables in Mexico and prices of Mexican tomato exports and to estimate the prices of Mexican tomatoes in American and Canadian supply markets based on Mexican macroeconomic variables.

Design/Methodology/Approach: The research was conducted using Pearson's coefficient —calculating the standard scores for X and Y. We determined the co-movements of Mexican tomato market prices and Mexico's GDP, the Interbank Equilibrium Interest Rate (IEIR), natural gas prices, and consumer inflation. Econometric techniques were thus combined with agricultural sector variables as a reliable precedent of the relation intensity between said variables.

Results: The coefficient of determination showed an acceptable degree of linear relationship between the market prices of Mexican tomatoes in different cities and the selected macroeconomic variables, with an average correlation of 20%. We concluded that the variables are not entirely independent since they show a weak linear relationship between them.

Study limitations/implications: It is crucial to conduct studies to determine whether the coefficients of determination support linearity or independence between the evaluated macroeconomic variables.

Findings/Conclusions: Econometric techniques were combined with agricultural sector variables as a reliable precedent of the relation intensity between said variables. The coefficient of determination showed an acceptable degree of linear relationship between the market prices of tomatoes in different cities and the selected macroeconomic variables. We recommend the creation of a price forecasting model.

Keywords: Agricultural producer regions, Vegetables, Growth, Market, Fluctuation.

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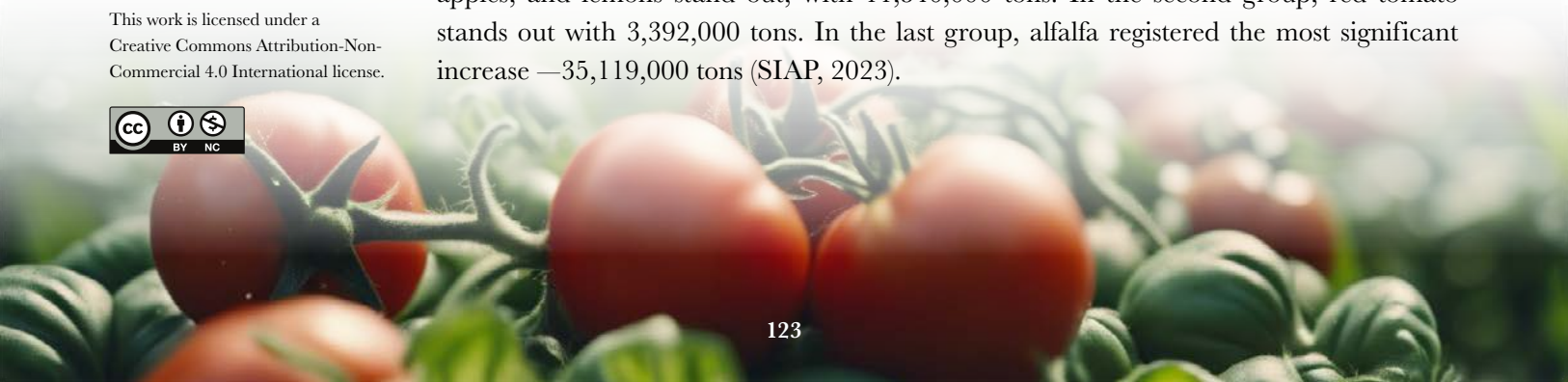
INTRODUCTION

According to the Agri-food and Fishing Information Service (Servicio de Información Agroalimentaria y Pesquera, SIAP, 2023), the Mexican regions devoted to agricultural production generate food and raw materials for the agri-food industry. In 2022, these regions produced 297.6 million tons of food, increasing to 301.3 million tons by 2023. This increase occurred for fruits, vegetables, and forages. In the first group, oranges, bananas, apples, and lemons stand out, with 11,340,000 tons. In the second group, red tomato stands out with 3,392,000 tons. In the last group, alfalfa registered the most significant increase —35,119,000 tons (SIAP, 2023).



The Economic Information System (Sistema de Información Económica, SIE, 2023) points out that the fluctuations in supply and demand for these and other commodities in the markets have a complex explanation from the rich theoretical viewpoint of micro and macroeconomics. While demand is explained by the price of goods, the income of consumers, the demand for substitutes and complements, and consumers' tastes and preferences, supply can be explained by the price of goods, costs, competitive supply, joint supply, and unexpected events (Young, 1987).

Hence, price plays an important role when observing these fluctuations. From Oxenfeldt (1973) onwards, we have strived to know which methods are best to understand price behavior. To this day, there are still difficulties in determining the sensible reasons underlying said behavior. In this context, Chunrong, Arjun, and Song (2006) show how fluctuations observed in macroeconomic variables can signal the price trend of daily consumption goods. According to the same authors —who cite Pindyck and Rotemberg (1990); Scott (1999); and Pagan (1999)— there is evidence that the prices of seemingly unrelated products move together, even after controlling macroeconomic indicators such as inflation, industrial production, and interest rates, among other variables.

Thus, the "excess co-movement hypothesis" calls into question the rationality of commodity markets and opens the debate to the relevance of the competitive model of price formation.

Therefore, the analysis of price co-movement has proven to be an appropriate tool to delve into price fluctuations by establishing a correlation between variables. Still, applying this or other similar techniques to determine price behavior continues to pose empirical challenges to explain the phenomenon of fluctuation. Based on the above, the objective of our research was to estimate the correlation between Mexican tomato prices in American and Canadian supply markets and some Mexican macroeconomic variables such as GDP, natural gas prices, IEIR, and inflation.

MATERIALS AND METHODS

This study was conducted following Chunrong, Arjun, and Song (2006), who maintain that a) markets enable transactions between buyers and sellers; b) specific quantities of goods are sold at specific prices; c) in a perfectly competitive market, there is only one price: the market price. The authors argue that, in markets that are not perfectly competitive, each company can charge a different price for the same product attempting to attract customers from its competitors or knowing that customers are loyal to the brand, which allows some companies to charge higher prices.

In this study, market price refers to the average price of all brands and/or supermarkets. Market prices for most goods fluctuate over time, and for many products, fluctuations can be fast, especially for those sold in competitive markets (Pindyck and Rubinfeld, 2009).

Regarding competitive market prices for agricultural products, it must be noted that all producers know the conditions under which their production will be placed on the market. Prices vary from city to city. The data used in the current work are tomato market prices

in 17 cities of the United States and Canada where Mexican tomato is sold. The data was collected from the US Department of Agriculture website and modified to reflect quarterly periods from 2010 to 2022.

The Instituto Nacional de Geografía y Estadística (INEGI) measures and publishes the Gross Domestic Product quarterly. Such information was considered to relate the values of the TIIE (Interbank Equilibrium Interest Rate), which is a representative rate of credit operations between banks. The IEIR is calculated daily (for terms of 28, 91, and 182 days) by the Banco de México based on quotes presented by banking institutions and through a mechanism designed to reflect the conditions of the money market in national currency.

To learn the behavior that natural gas had during the years analyzed in this study, we considered the INEGI (2023) database. INEGI presents the main indicators of the recorded price evolution for various goods and services marketed by different sectors of the economic activity.

To calculate the National Consumer Price Index (NCPI) starting from the first half of January 2011, the second half of December 2010=100 was taken as a reference, along with the Monthly National Consumer Price Index and the Fortnightly National Consumer Price Index.

Inflation is a continuous increase in the general price level, the magnitude of which is measured from one period to another using a percentage rate. The inflation rates refer to a) the previous month, interannual monthly inflation, or annual accumulated inflation, and b) the biweekly price index, *i.e.*, the variation in prices compared to the previous fortnight (INEGI, 2023).

RESULTS AND DISCUSSION

The data collected from the US Department of Agriculture website and modified to reflect quarterly periods from 2010 to 2022 shows that Mexican tomato was not sold in 2012 and 2023, nor in the city of Chicago in 2016 (Figure 1). Prices vary from USD $2.25 to USD $37.00, depending on the season and destination. It should be noted that

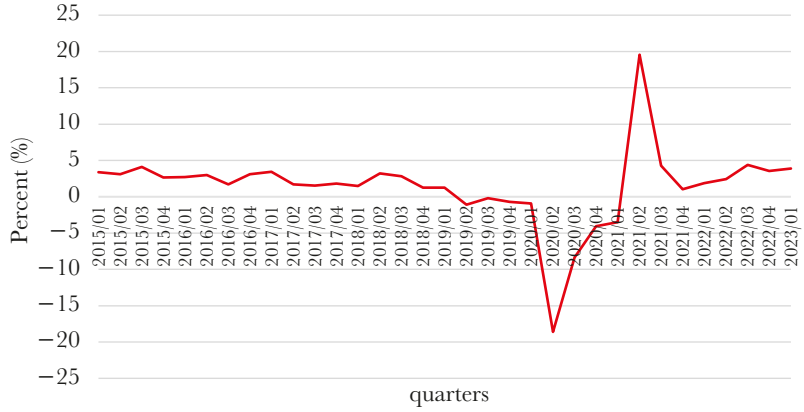


Figure 1. Tomato market prices from 2010 to 2022 in cities of the United States and Canada. Source: Own elaboration based on data from USDA (2023).

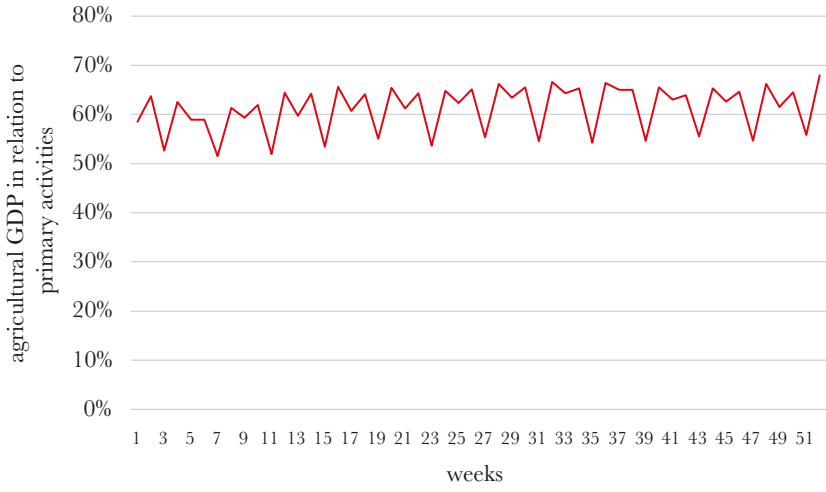


Figure 2. Quarterly GDP, base year 2013: Behavior of primary activities as regards total activity in 2010-2022. Source: Own elaboration based on INEGI, Sistema de Cuentas Nacionales de México, 2023.

the prices pertain only to products of Mexican origin and greenhouse production, which means they are comparable. Figures 1 and 2 show that primary activities diminished as regards global economic activity during 2020, in times of the COVID-19 pandemic. However, starting from the first quarter of 2021, there is a recovery and a stabilization, reaching pre-pandemic percentages with an upward trend.

Economic activity in Mexico during the COVID-19 pandemic dropped almost 20% in the first quarter of 2020. After the pandemic, participation increased conservatively for the same period of 2021, showing moderate growth and reaching a total value of 18,925,112.06 pesos on average for 2023.

Figure 3 shows that agriculture is a crucial part of Mexican primary activities. On average, between 2010 and 2022, agriculture accounted for 62.95% of that economic

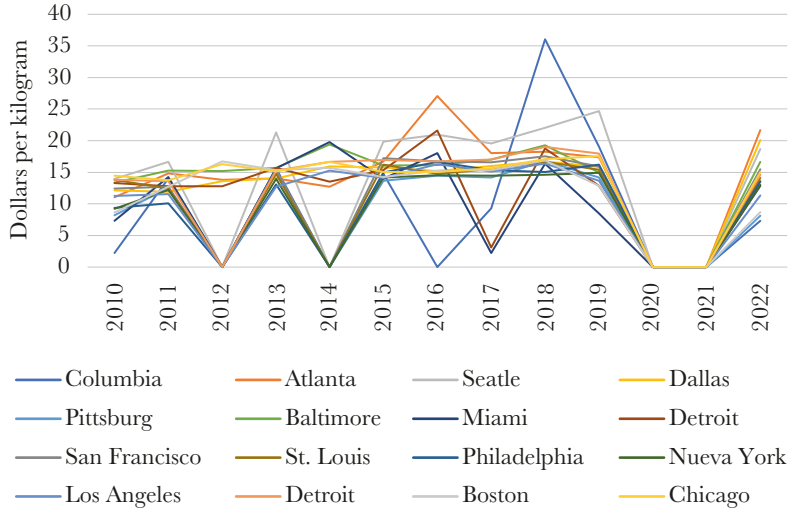


Figure 3. Quarterly GDP, base year 2013: Behavior of agriculture as regards primary activities, 2010-2022. Source: Own elaboration based on data from USDA (2023).

sector, which leads us to assert that it directs the behavior of primary activities in Mexico.

The long-term trends established by global economic activity are an important tool to determine the future behavior of specific activities characterized by uncertainty. According to Canova (1996), studying economic cycles presents difficulties because there are multiple parametrizations for their definition and classification. However, the study of some economic variables with stable behavior and available time series offers the opportunity to determine whether there is any point of comparison with other variables in the sector. Figure 2 shows the decrease of primary activities as regards global activity. The export market offers Mexican rural producers the chance to improve the quality and price of their merchandise. To access this market, producers must comply with certain non-tariff barriers imposed by the market, such as quality, safety, transportation, logistics, and company administration, which will allow them to take advantage of the marketing opportunity. These barriers can be addressed using controlled systems, as happens in protected agriculture —a form of agricultural production that cultivates and protects plants using metal structures and a translucent plastic cover that prevents atmospheric phenomena from damaging the harvest and whose objective is to reproduce or simulate the most appropriate climatic conditions for the growth and development of plants, providing some degree of independence from the outside environment and spacious enough for people to work inside (NMX-E-255-CNCP-2008). Most of the merchandise produced in protected agriculture is sent to the export market. Therefore, in this study, the market price of the goods produced under such system constitutes the guideline to determine whether there are co-movements between the macroeconomic variables mentioned above and the market price as a proxy for the relationship between said variables and protected agriculture.

Concerning the GDP —measured and published quarterly by INEGI— we confirmed that the information matched the series prepared considering the base year 2003. These series use the same conceptual and methodological framework as the estimation of the Goods and Services Accounts within the System of National Accounts of Mexico, which, in turn, uses the same criteria as the North American Industrial Classification System (NAICS). The figures pertain to the total economy, as well as to each of the 20 sectors into which it is divided according to the NAICS classification. The information is supplemented with the Implicit Price Indices, which result from relating the current values with the GDP constants for each quarter. To select the appropriate indicators, we considered the conceptual and methodological scope of the activities and the type of goods and services produced (INEGI, 2023). Figure 4 shows how the product maintains an increasing trend during the analyzed period. A similar behavior occurred with the IEIR obtained from the Banxico database (2023), displayed in Figure 5.

Throughout the Mexican territory, different regions have contrasting climates, altitudes, and meteorological conditions. Many of them could use protected agriculture. Figure 6 shows the behavior of natural gas prices during the years studied in this analysis. We can see how it reaches a maximum level during the third quarter of 2015 and a minimum during the first quarter of 2020. Fluctuations respond to various infrastructure developments, distance from the border, labor facilities, government support, and natural

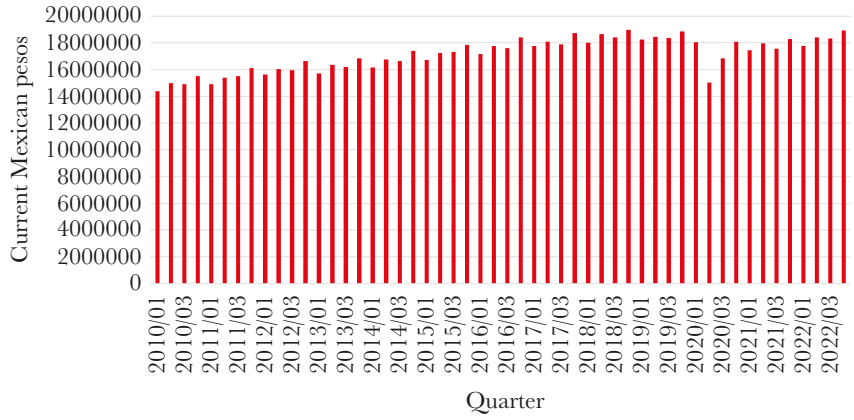


Figure 4. Quarterly GDP in Mexico, 2010-2022 (second quarter).
Source: Own elaboration based on data from INEGI (2023).

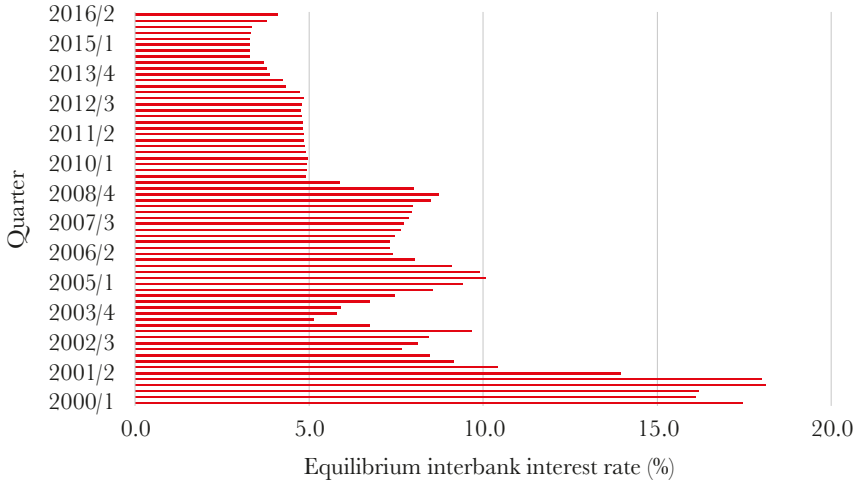


Figure 5. Quarterly IEIR (28-day term), 2010-2022.
Source: Own elaboration based on data from Banxico (2023).

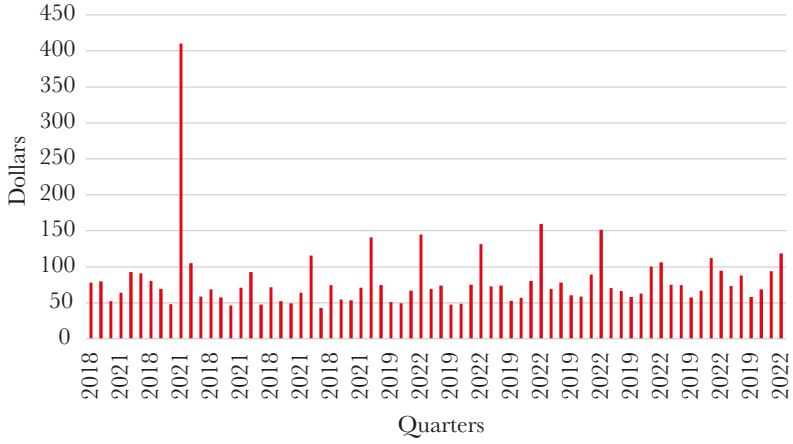


Figure 6. Price of natural gas in dollars, 2010-2022.
Source: Own elaboration based on data from CRE (2023).

gas availability (we must note that this type of gas is cheaper than propane). Mexico can achieve considerable progress in protected agriculture by leveraging its geographical conditions (CRE, 2023). Figure 7 shows how inflation levels from 2010 to 2023 have a sustained increase.

The Pearson coefficient was used to determine the possible cyclical co-movements of the variables that make up the market prices of Mexican greenhouse tomato exports, considering the total GDP of the economy, the IEIR, the prices of natural gas, and inflation. Table 1 presents the price correlation coefficients of the proposed macroeconomic variables by city. We include 15 cities from the United States and two from Canada, each fulfilling the abovementioned considerations.

We can observe how the GDP and inflation maintain a direct, although not perfect, correlation with the market prices in each studied city. These coefficients range between 0 and +1, with the highest being 0.799 for the inflation variable in the city of Dallas and the lowest being 0.113 for the GDP variable in Pittsburgh (Table 1). As for the IEIR variable, it maintains an inverse correlation, although not perfect either, in all studied cities. Its extreme values are observed in Dallas, with −0.601, and Toronto, with 0.066.

In the case of natural gas (Table 1), the Pearson correlation coefficient shows levels of direct correlation in almost every city except for Dallas, where the coefficient shows an inverse correlation with a value of −0.004.

Overall, the coefficient of determination shows an acceptable degree of linear relationship between market prices in the different cities and the selected macroeconomic variables, with an average correlation of 20%. We can conclude that the variables are not entirely independent since they show a weak linear relationship between one another.

However, we must stress the high linear relationship between the proposed variables shown by Dallas and Atlanta, with more than 63% and 45%, respectively (Table 2).

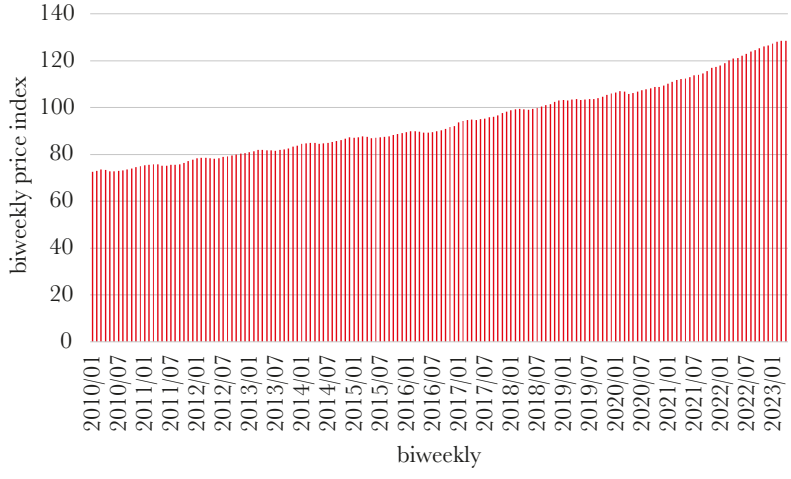


Figure 7. Inflation in Mexico, 2010-2023.
Source: Own elaboration based on data from INEGI (2023).

Table 1. Pearson correlation coefficient between GDP and market prices by city, 2023.

City	Gross Domestic Product (GDP)	Equilibrium interbank interest rate (EIIR)	Natural gas price	Inflation
Atlanta	0.672	−0.489	0.103	0.643
Baltimore	0.489	−0.434	0.151	0.529
Boston	0.186	−0.335	0.259	0.221
Chicago	0.381	−0.351	0.094	0.439
Columbia	0.196	−0.189	0.129	0.247
Dallas	0.777	−0.601	−0.004	0.799
Detroit	0.520	−0.229	0.383	0.496
Los Ángeles	0.469	−0.198	0.458	0.397
Miami	0.161	−0.170	0.215	0.207
Montreal	0.379	−0.173	0.303	0.380
Nueva York	0.549	−0.252	0.190	0.539
Philadelphia	0.571	−0.278	0.245	0.562
Pittsburgh	0.113	−0.056	0.360	0.120
San Francisco	0.578	−0.197	0.233	0.531
Seattle	0.381	−0.151	0.248	0.390
St. Louis	0.547	−0.158	0.171	0.510
Toronto	0.466	−0.066	0.439	0.383

Source: Own elaboration based on (Banxico, 2023) (CRE, 2023) (INEGI, 2023) (USDA, 2023).

Table 2. Coefficient of determination for GDP *vs.* market prices by city.

City	Gross Domestic Product (GDP %)	Equilibrium interbank interest rate (EIIR %)	Natural gas price (%)	Inflation (%)
Atlanta	45.16	23.96	1.07	41.37
Baltimore	23.95	18.82	2.27	28.00
Boston	3.46	11.25	6.72	4.90
Chicago	14.55	12.31	0.87	19.29
Columbia	3.83	3.56	1.66	6.12
Dallas	60.31	36.10	0.00	63.87
Detroit	27.01	5.25	14.69	24.56
Los Ángeles	22.03	3.92	20.95	15.78
Miami	2.60	2.88	4.61	4.27
Montreal	14.39	3.00	9.15	14.43
Nueva York	30.10	6.34	3.60	29.10
Philadelphia	32.66	7.71	6.00	31.59
Pittsburgh	1.27	0.31	12.96	1.45
San Francisco	33.46	3.87	5.45	28.24
Seatle	14.55	2.29	6.13	15.24
St. Louis	29.88	2.51	2.93	26.01
Toronto	21.68	0.43	19.29	14.67

Source: Own elaboration based on (Banxico, 2023) (CRE, 2023) (INEGI, 2023) (USDA, 2023).

CONCLUSIONS

The variables considered in this study were the quarterly GDP from 2010 to 2022, the 28-day IEIR considered by quarterly average, the price of natural gas reported by the Comisión Reguladora de Energía in Mexico, and inflation for the same period. We observed that GDP and inflation maintain a direct, although not perfect, correlation with the market prices of each studied city. The IEIR variable showed an inverse correlation. In the case of natural gas, the Pearson correlation coefficient shows direct correlation in almost all cities, except for Dallas. The coefficient of determination shows an acceptable degree of linear relationship between market prices in the different cities and the selected macroeconomic variables. Finally, we conclude that the variables are not entirely independent since they show a weak linear relationship.

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