Interrelationship between Average Monthly Temperature and the Agricultural Input Price Index in the Republic of Colombia: A Correlation Study

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Abstract

The purpose of this study was to establish whether there was a significant linear relationship between the average monthly temperature recorded and the agricultural input price index in Colombia. Using information obtained from secondary sources, including the Official Page of the National Open Data Platform of Colombia, the data on average monthly temperature at the national level and the values of the agricultural input price index of Colombia were reviewed, from January to October 2024. Once collected, the data were analyzed with the RStudio Team statistical program. Spearman correlation test was used to assess the degree of association between the two variables after the Shapiro–Wilk normality test confirmed that the monthly average temperature variable was normally distributed, while the agricultural input price index variable was not. With a correlation coefficient of -0.7939394, indicating a strong negative relationship, the statistics showed a significant linear relationship between the monthly average temperature in the country and the agricultural input price index in Colombia, confirmed by the p-value of 0.009844, which is clearly below the 0.05 significance level. These results allow us to say that, from a practical approach, it is reasonable to maintain that, when the average monthly temperature rises, the agricultural input price index tends to fall, without this meaning that one variable directly causes the other, since many factors can influence this dynamic. Therefore, the need for further research is highlighted to better understand the reasons behind the increase or decrease in the agricultural input price index in Colombia and how climatic conditions may be affecting this phenomenon.

Keywords: climate, environment, agriculture, price index, agricultural inputs, correlation.

Indexing agricultural input prices in Colombia has transformed into not only a key factor of Colombian agriculture, but to the entire economy too. The latter sector is affected by many factors, and climate is one of the most influential ones (Feola et al., 2015). For example, the annual mean temperature should have strong effect on the amount of these price changes.

This phenomenon can be due to various reasons: The increased temperature affects the growth cycle of plants, reducing the supply of agriculture's products; increased temperature greatly increases the need for some resources (Ul Hassan et al., 2021). Their prices could increase when the demand for irrigation water increases and revert when the opposite occurs (Mishra, 2023). Finally, changes in temperature can affect the activity and spread of diseases and pests, increasing the demand for pesticides and other plant care products (Skendzic et al., 2021).

The global average temperature has risen in recent years due to shocks such as climate change, which is directly linked to shifts in agricultural prices (Godde et al., 2021). For instance, extreme temperatures lead to strong fluctuations of agricultural harvest, causing shortages and increased prices of these goods (Schmitt et al., 2022). Furthermore, as temperatures increase, certain crops may grow faster resulting in shorter production times and increased demand for primary production in order to replace for this acceleration (Zhu et al., 2021).

Keeping this in consideration, this paper uses statistical correlation analysis (Amat, 2016) to determine the degree of linear correlation between monthly average temperature in Colombia and the agricultural input price index. This is not for the purpose of determining the effect of this specific climate variable on the price index behavior demonstrated above. This analysis used data from January to October 2024 obtained from secondary data sources such as the Colombian government's National Open Data Platform and UPRA − Rural Land Planning, Land Adaptation and Agricultural Uses Unit.

These study results can be found both within Colombia and in any other countries or geographic areas where there are similar scenarios regarding climate change and agriculture (Habib-ur-Rahman et al., 2022). The assessment of these features in context will provide useful data for designing appropriate and more efficient climate and agricultural mitigation measures in different regions.

Materials and methods

In this research, the focus is on the relationship between "Average monthly temperature" and "Agricultural input price index". The data was drawn from a variety of secondary sources such as the Official Web Page of the National Open Data Platform of the Republic of Colombia. The first variable represents the average monthly temperature data at the national level from January 2024 to October 2024. The second variable indicates the values of the agricultural input price index for Colombia during the ten months from January to October 2024 (UPRA, 2024). The data analysis was carried out using the statistical software RStudio Team (2020).

First, the normality of the distribution of each of the two variables was tested using the Shapiro-Wilk test, which was chosen because the total number of data was less than 50 (Afifah et al., 2022). The Shapiro-Wilk test is notable for being a pioneer in detecting deviations from a normal distribution, whether they are due to skewness, kurtosis, or both. This choice is based on its exceptional test power, which is superior to some alternative tests (Ramirez et al., 2023). According to Shapiro and Wilk (1965), the test statistic is defined as follows:

$$W = \frac{(\sum_{i=1}^{n} \quad a_i x_i)2}{\left[\sum_{i=1}^{n} \quad \left(x_i - \underline{x}\right)2\right]}$$

Pearson correlation analysis will be performed if the variables "Agricultural Input Price Index" and "Average Monthly Temperature" are normally distributed (Hatem et al., 2022). On the contrary, Spearman correlation analysis will be performed if any of the variables "Agricultural Input Price Index" and "Average Monthly Temperature" are not normally distributed (Temizhan et al., 2022). Provided that three (3) assumptions are met, this test is used to assess the degree of dependence between two sets of paired observations: 1) "freely distributed variables or ordinal data", 2) "observations xi, yi are obtained in pairs", and 3) "monotone trend in the analysis of variance" (Mendivelso, 2021).

The formula for Spearman's correlation coefficient is as follows:

$$rs = 1 - \frac{(6R)}{\left(n \times (n^2 - 1)\right)}$$

Finally, hypothesis tests were formulated to determine the magnitude of the correlation and also, according to the p-value to be obtained, whether the observed correlation was statistically significant. Table 1 illustrates the denomination of each magnitude of the correlation based on the value of the coefficient obtained (Akoglu, 2018).

Table 1. Interpretation of the Pearson's and Spearman's correlation coefficients.

Correlation Coefficient		Interpretation
+1	-1	"Perfect correlation"
+0.9	-0.9	"Strong correlation"
+0.8	-0.8	"Strong correlation"
+0.7	-0.7	"Strong correlation"
+0.6	-0.6	"Moderate correlation"
+0.5	-0.5	"Moderate correlation"
+0.4	-0.4	"Moderate correlation"
+0.3	-0.3	"Weak correlation"
+0.2	-0.2	"Weak correlation"
+0.1	-0.1	"Weak correlation"
0	0	"Zero correlation"

Note: adapted from Akoglu (2018).

Results

The data for the variables "Average monthly temperature" and "Agricultural input price index" between January and October 2024 are summarized below. These variables are essential to understand the relationship between the average temperature recorded each month and the agricultural input price index in the country. This table provides a detailed overview of the average monthly temperature data at the national level in each period and the corresponding agricultural input price index values, allowing a comparative analysis by month.

Table 2. Information on the variables "Average monthly temperature" and "Agricultural input price index" between January and October 2024.

Month	Average monthly temperature (°C)	Agricultural input price index
Ene-2024	25	146.01
Feb-2024	23.4	144.01
Mar-2024	26.6	140.63
Abr-2024	26.5	137.63
May-2024	28	134.75
Jun-2024	27.5	134.78
Jul-2024	28.6	135.82
Ago-2024	28.55	135.92
Sep-2024	28.4	136.21
Oct-2024	26.75	136.96

Note: Prepared by the authors (2025) with the monthly average temperature data at the national level, the values of the Colombian agricultural input price index for 10 months from January to October 2024. The data on the value of the agricultural input price index were gathered from the Rural Land Planning Unit, Land Adaptation and Agricultural Uses (UPRA, 2024) while the temperature data were received from Meteoblue (2024).

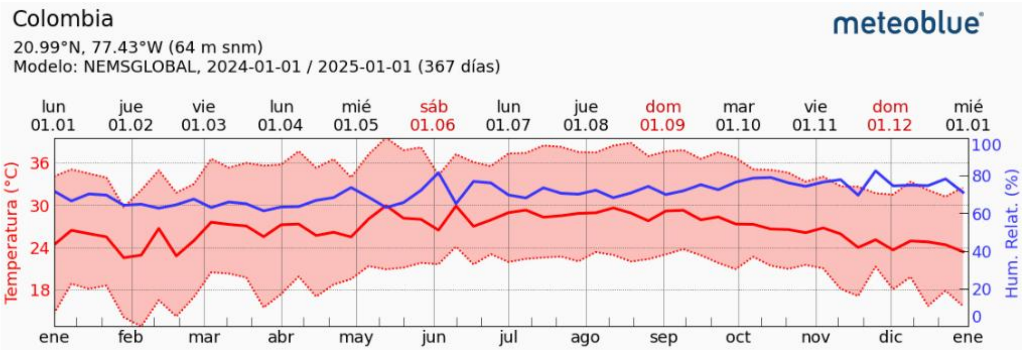

Figure 1. Average monthly temperature observed in Colombian territory during the year 2024. Source: Meteoblue (2024).

Table 1 presents the existing information regarding national level agricultural input price index and monthly temperature average throughout the analyzed period. This data set is crucial to comprehend how prices of agricultural input can correlate with shifts in monthly average temperature levels in a country through time, which may have significant economic impacts in short, medium and long term.

And now entering into the test of normality that has been based on the following hypotheses:

H0: The variables "Average monthly temperature" and "Agricultural input price index" fit a normal distribution.

H1: The variables "Average monthly temperature" and "Agricultural input price index" do not fit a normal distribution.

```
        Shapiro-Wilk normality test

data:  datos$Temperatura
W = 0.88673, p-value = 0.1558
        Shapiro-Wilk normality test

data:  datos$Indice_Precios
W = 0.8229, p-value = 0.02748
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Figure 2. Results of the Shapiro-Wilk normality test, performed in RStudio.

Figure 2 presents test results for the normality tests of the variables "Average monthly temperature" and "Agricultural input price index". Results of predicting monthly temperature shows a p-value greater than 0.05, which implies it is normally distributed. In contrast, the p-value calculated for the agricultural input price index variable is lower than the significance level of 0.05, which implies that we have adequate evidence to reject that the data for this variable is normally distributed. Therefore, the Spearman correlation coefficient was chosen to be used.

Once the correlation analysis was started, the following hypotheses were formulated:

H0: There is no significant linear association between the variables "Average monthly temperature" and "Agricultural input price index".

H1: There is a significant linear association between the variables "Average monthly temperature" and "Agricultural input price index".

```
        Spearman's rank correlation rho

data:  datos$Temperatura and datos$Indice_Precios
S = 296, p-value = 0.009844
alternative hypothesis: true rho is not equal to 0
sample estimates:
       rho
-0.7939394
```

Figure 3. Results of the Spearman correlation test performed in RStudio.

The hypothesis test yielded a p-value of 0.009844 as shown in Figure 3. The null hypothesis was rejected in favor of the alternative hypothesis stating that there is sufficient statistical evidence to conclude that the variables “Average Monthly Temperature” and “Agricultural Resource” Product Price Index show a significant linear relationship, as the p-value obtained is less than the significance level α = 0.05.

After confirming the linear relationship between the research variables, Spearman correlation coefficient was calculated, allowing to assess the magnitude and direction of the linear relationship between the variables "Average monthly temperature" and "Agricultural input price index". The correlation coefficient obtained was R = -0.7939394, indicating a strong negative correlation (Akoglu, 2018). In practical terms, this means that, from a statistical point of view, it is plausible to affirm that, as the average monthly temperature increases, the price index of agricultural inputs tends to decrease. Figure 4 graphically represents the level of linear association obtained for the two variables studied.

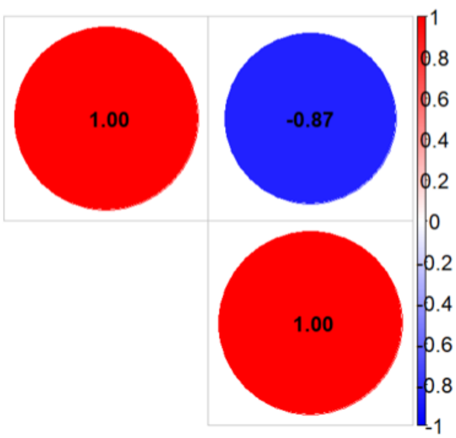

Figure 4. Spearman correlation between the variables "Average monthly temperature" e "Agricultural input price index".

The coefficient of the results in Figure 4 is -0.87, represented by a large deep blue circle. This indicates a strong negative correlation between both variables, reinforcing the argument that as the temperature increases, the price index tends to decrease, and vice versa.

Conclusions

With an estimated correlation value of -0.7939394, the statistical data obtained in the correlation study allow us to conclude that the national average monthly temperature and the agricultural input price index in Colombia show a significant linear relationship. This means that, statistically speaking, there is sufficient evidence to conclude that the decrease in the agricultural input price index in Colombia is related to the increase in the average monthly temperature observed in the country. Strong evidence that the observed linear relationship is statistically significant and not a coincidence is the p-value of 0.009844 obtained in the correlation analysis between the two variables. This value is close to zero and thus much lower than the applied significance level of 0.05.

These results have important economic and environmental implications for Colombia. The high negative relationship mentioned above confirms that the monthly average temperature in Colombia has a significant impact on the agricultural input price index in the Republic of Colombia, or in other words, the months with the highest average temperature are the same as the months with the lowest agricultural resource price index. However, we must always remember that correlation between variables does not imply causation. Although there is a strong correlation between both variables, the analysis does not allow us to state clearly that the increase in average monthly air temperature in Colombia is the direct cause of the decrease in the agricultural input price index in Colombia, since other social, economic and political factors may play an important role in this context.

One might object that increases in one variable often coincide with decreases in the other. Therefore, further research is needed to fully understand the reasons for increases or decreases in the agricultural input price index in Colombia, as well as the potential impact of climate on this phenomenon. Conducting more thorough research will allow us to explore potential causal relationships and develop more effective strategies to combat the impacts of climate change on the Colombian economy, especially in the agricultural resource sector.

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