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Article

# The relationship between inflation and unemployment: Empirical evidence for Colombia (2007–2024)

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**Abstract:** The objective of this study was to analyze the relationship between inflation and unemployment to provide empirical evidence on the Phillips Curve in Colombia, using data from the National Administrative Department of Statistics (DANE) and the Bank of the Republic for the period 2007–2024. Descriptive statistical techniques, graphical analysis, correlograms, unit root tests, cointegration analysis, and estimation using the ordinary least squares (OLS) method were applied. The results revealed a negative relationship of −0.26 between inflation and unemployment, indicating that a 1% increase in unemployment reduces inflation by 0.26%. Furthermore, the unemployment gap was estimated at 0.34. The study concludes that the inverse relationship between inflation and unemployment remains stable, reflecting a trend toward stability in both the labor market and price levels over time. This inverse relationship in the Colombian context is primarily attributed to the pass-through of labor costs to the prices of goods and services.

**Keywords:** inflation; prices; trend; interest rate; money supply

## 1. Introduction

One of the main macroeconomic challenges faced by governments and economic policymakers is related to inflation and unemployment. It is essential to have clear policies to ensure economic management that leads to sustained growth and overall well-being. A well-balanced economic performance by a government should foster confidence, create a favorable environment for investment, and, as a result, achieve economic growth and general welfare.

Uncontrolled and runaway inflation can lead to the deterioration of workers' real wages. In this sense, the constant and sustained increase in prices [1] has a negative impact on individuals' purchasing power. As the relative prices of goods and services rise, the quality of life is threatened due to the decline in real income. Furthermore, persistent price increases jeopardize economic stability, as households and individuals reduce consumption, leading to a decrease in aggregate demand and, consequently, economic growth.

The other variable in this analysis is unemployment, defined as the condition in which individuals who are actively seeking work and are willing to work are unable to find a job [2]. It is generally measured as the proportion of the working-age population that is not effectively employed and is commonly expressed as the unemployment rate. The consequences of unemployment include reduced economic growth, lower levels of consumption and investment, increased inequality, and the emergence of social problems.

The analysis of the relationship between inflation and unemployment is

summarized in the so-called Phillips Curve [3], which proposes an inverse relationship between the inflation rate and the unemployment rate in an economy. In this sense, low unemployment rates are typically associated with high inflation rates. This occurs because, with low unemployment, the labor supply is limited, which tends to drive wages up.

In turn, the increase in production costs is passed on to the prices of goods and services, leading to higher inflation. Conversely, when unemployment is high, there is an excess supply of labor, which tends to reduce nominal wages. This decline in wages may reduce the demand for goods and services, thereby exerting less inflationary pressure and resulting in lower inflation.

Since its original formulation by Samuelson and Solow in 1960, the Phillips Curve has undergone various interpretations and adjustments. One of the most notable modifications is the introduction of the Non-Accelerating Inflation Rate of Unemployment (NAIRU) by [4] Friedman and Phelps [5]. These authors questioned the stability of the inverse relationship between inflation and unemployment due to the presence of inflation expectations, which affect real wages [6,7]. As a result, it has been argued that this inverse relationship does not hold in the long run, leading to a vertical Phillips Curve.

Friedman's argument was based on the idea that the original Phillips Curve did not take inflation expectations into account, which can vary over time and disrupt the presumed stable relationship between inflation and the unemployment rate.

The critique of the original Phillips Curve [3] by monetarist economists, particularly Milton Friedman and Edmund Phelps, centers on the idea that the inverse relationship between inflation and unemployment is not stable over time. They argued that this relationship is only temporary and depends on the inflation expectations of economic agents [7].

Later, Gordon [8] proposed an empirical model known as the "triangle model," which links the inflation rate to agents' inflation expectations, demand, and supply, and examines its implications for economic policy and stabilization.

The original formulation of the Phillips Curve was reinterpreted by New Keynesian authors such as Calvo [9], Galí [10], Goodfriend and King, Clarida, Galí, and Gertler, and Woodford [11], who introduced a microeconomic approach based on monopolistic competition and nominal rigidities. Within this framework, firms set prices under constraints—such as the staggered pricing mechanism proposed by Calvo—and make intertemporal decisions aimed at maximizing profits. Inflation, therefore, depends not only on real variables like the output gap but also on rational expectations. Firms adjust prices by anticipating future conditions, minimizing the deviation from the projected optimal price [10]. This gives rise to the New Keynesian Phillips Curve (NKPC), widely used in Dynamic Stochastic General Equilibrium (DSGE) models and monetary policy analysis.

Additionally, a similar study for Ecuador was found by Campoverde et al. [7], who analyzed the effect of unemployment on inflation for Ecuador, Latin America, and the world during the period 1991–2015. The study concludes that the Phillips Curve, at least for the analyzed period, does not hold in the case of Ecuador.

Rodríguez [12] conducted a study on the Phillips curve for the Mexican case, finding a positive long-term relationship between inflation and real wages, the real

exchange rate, and the output gap. The annual estimation between 1969 and 2008 shows that inflation depends positively on these variables, suggesting that strong permanent increases in inflation would be needed to achieve even a small improvement in the other variables.

The objective of this study is to conduct an analysis of empirical evidence regarding the Phillips Curve in Colombia during the period 2007–2024 in order to compare economic theory with observed reality.

## 2. Method

To determine the relationship between inflation and unemployment, data were obtained from official, unrestricted public sources. Unemployment data were collected from the website of the National Administrative Department of Statistics (DANE) [13], while inflation data, represented by the Consumer Price Index (CPI), were retrieved from the time series published by the Central Bank of Colombia (Banco de la República). Both variables cover the period from January 2007 to June 2024, totaling 208 monthly observations.

Using the data on inflation and unemployment, a general model was formulated as follows:

$$Y_t = \alpha_0 + Y_t - 1 + \beta_1 t + \mu t \quad (1)$$

where:

$Y_t$ = Dependent variable (inflation).

$\alpha_0$ = Intercept or cutoff point of the function.

$\beta$ = Regression parameter.

$\mu$ = Error term.

The dependent variable, inflation, is explained by its own lags, as well as the current and lagged values of the unemployment variable. The aim is to evaluate how past and present variations in the explanatory variable, unemployment, affect the dependent variable, inflation, over time.

The following equation models the relationship between inflation and unemployment for the Colombian case during the period 2007–2024.

$$\text{IPC} = \alpha + \beta x_1 + \mu.$$

where:

IPC = Inflation $X_1$

$\alpha$ = Intercept

$\beta x_1$ = Parameter for the explanatory variable (unemployment rate)

$\mu$ = Error Term

The estimation of the parameters was carried out using the ordinary least squares (OLS) method. It was based on the assumption that there is an inverse relationship between inflation and unemployment, as posited by the Phillips Curve, and thus, the parameter is expected to have a negative sign.

The monthly series for inflation and unemployment, from 1 January 2007 to 30 June 2024, were organized in flat files. The purpose of creating these files was to conduct graphical analysis and preliminary diagnostics, such as descriptive statistics, measures of dispersion, and correlation analysis. Additionally, the quality of the data

was assessed before applying further techniques.

The steps followed were as follows: graphical analysis, correlograms, and stationarity analysis of the series to rule out the possibility of spurious regressions. Unit root tests and cointegration tests were conducted. A graphical analysis of each series separately, as well as the total set of series, was performed. The unemployment series showed unit roots at levels.

In the stationarity analysis, unit roots were calculated using the Engle and Granger [14] test. According to the decision rule, if the root value is equal to 1, the series has a unit root, indicating that it is non-stationary. This means that the series experiences structural variations over time, which can cause problems in subsequent tests and make the conclusions unreliable.

The results of the stationarity test indicated that the series were non-stationary at levels, prompting the test to be conducted at first differences, where both series were found to be stationary.

The cointegration analysis revealed that both series share a common trajectory, indicating that they remain stable over time with an integrated combination of order I(d-b), where b is greater than 0, which makes them stable over time [15].

## 3. Results and discussion

The first step was to perform a graphical analysis of both the inflation and unemployment series on a monthly basis from 1 January 2007 to 30 June 2024. See **Figure 1**.

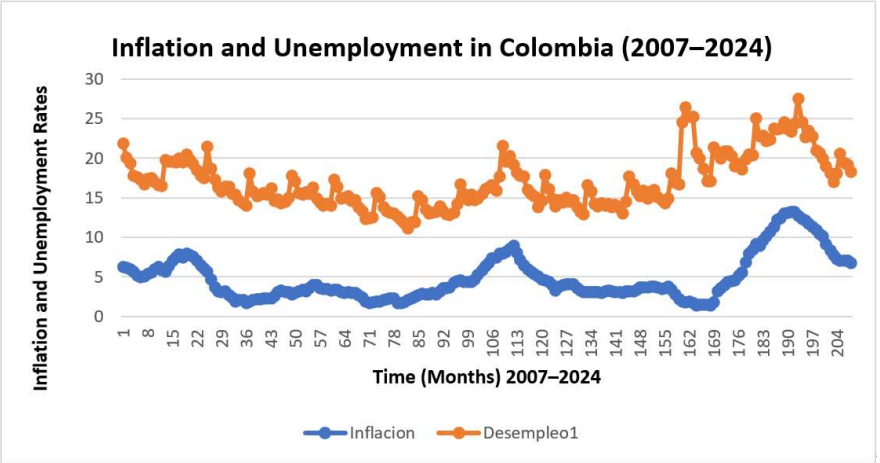


**Figure 1.** Inflation and unemployment in Colombia, January 2007–June 2024.
Source: Prepared by the author based on DANE and Bank of the Republic data, 2024.[15]

**Figure 1** shows the evolution of the inflation and unemployment variables for Colombia during the period from January 2007 to June 2024. The series exhibit a uniform increasing trend, which is more pronounced in the case of inflation, and always follow the same direction throughout the analyzed period, suggesting that the series are stationary in first differences.

As a reference and to reaffirm the stability of the data, descriptive statistics were calculated, which are presented in **Table 1**.

Inflation and unemployment statistics:

**Table 1.** Descriptive statistics of inflation and unemployment for Colombia, 2007–2024.

| Statistics | Inflation | Unemployment |
|---|---|---|
| Average | 4.9 | 12.2 |
| Standard error | 0.2 | 0.2 |
| Median | 3.8 | 11.7 |
| Mode | 7.2 | 13.2 |
| Standard deviation | 2.9 | 2.5 |
| Sample variance | 8.2 | 6.3 |
| Kurtosis | 0.9 | 7.1 |
| Skewness | 1.2 | 2.2 |
| Range | 11.9 | 16.3 |
| Minimum | 1.5 | 8.4 |
| Maximum | 13.3 | 24.7 |
| Coefficient of variation (CV) | 58.4 | 20.6 |
| Number of observations | 208 | 208 |

Source: Own calculations based on data from the Bank of the Republic [15] and DANE, 2024 [14].

The data diagnostics are presented in **Table 1**. First, the measures of central tendency suggest that the data follow an approximately normal distribution, with a coefficient of variation of 58.4% for inflation and 20.6% for unemployment. In this case, the inflation series shows greater variability, while the unemployment series exhibits lower variability. This low dispersion suggests that the series is consistent; however, this conclusion will be confirmed through additional tests. The consistency is attributed to the fact that the data come from official institutions and are publicly available.

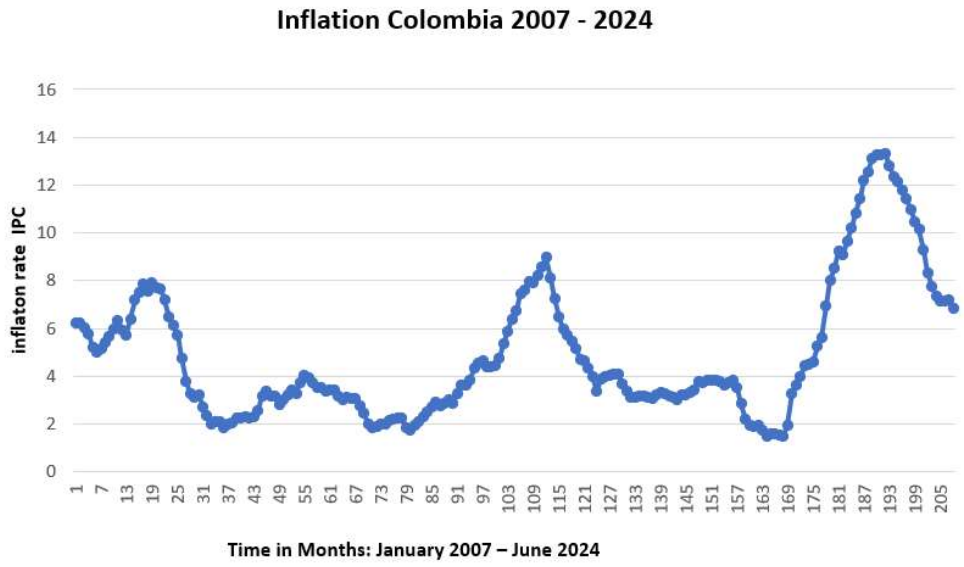


**Figure 2.** Inflation in Colombia, 2007–2024.

Source: Prepared by the author based on DANE, 2024 [14].

It is important to clarify that although the series are highly correlated—close to

1%—this does not imply causality, at least at this stage of the analysis. Therefore, additional tests are necessary to confirm or refute this relationship.

In accordance with the methodology, the analysis continued with graphical exploration, this time examining each variable individually. In this case, **Figure 2** presents the money supply.

**Figure 2** shows the series of the inflation variable in the original data. It can be observed that some periods are well below the trend line, as seen in August 2019, in the third quarter. The highest peak of the series occurred in January 2022, during the first half of 2022. There are also large intervals between the minimum value (1.5) and the maximum value (13.3). However, the standard deviation was low, with a value of 2.9. The total variation between the maximum and minimum values was 88.7%, which is considered high.

The graphical analysis and behavior of the unemployment variable are presented in **Figure 3**.

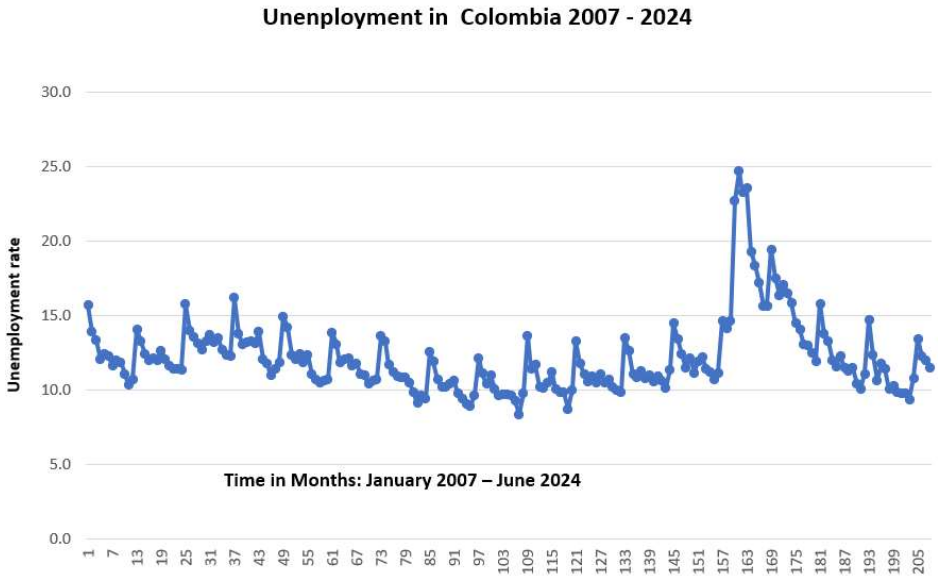


**Figure 3.** Unemployment in Colombia, 2007–2024.

Source: Prepared by the author based on the Bank of the Republic, 2024 [15].

**Figure 3** shows the series of the unemployment variable obtained from the Bank of the Republic in the original data. It can be observed that some periods are well below the trend line, such as in November 2014 and the fourth quarter of 2014. On the other hand, the highest values were recorded in May 2029, during the second quarter. There are also large intervals between the minimum value (8.4%) and the maximum value (24.7%). However, the standard deviation was 2.5. The total variation between the maximum and minimum values was 65.9%, which is considered moderate.

**Table 2.** Dickey-Fuller unit root tests for inflation and unemployment in Colombia, 2007–2024.

| Variable | Dickey-Fuller First differences | Probability |
|---|---|---|
| Inflation | −6.732230 | 0.0000 |
| Unemployment | −0.1241015 | 0.0393 |

Source: Prepared by the author based on DANE and the Bank of the Republic.

**Table 2** presents the results of the Dickey-Fuller [16] unit root test for the variables inflation and unemployment in first differences. The results show the absence of unit roots, suggesting that both variables in the model are integrated of order 1, with a 5% significance level. Therefore, it can be concluded that the series for the inflation and unemployment variables follow the same trend over time and are independent of each other, allowing for the proceeding to the cointegration analysis.

To determine the dependence between the variables of inflation and unemployment, as well as the relationship between them, a model was estimated using the ordinary least squares method. In this model, the dependent variable was inflation, and the independent variable was the unemployment rate. The results of this estimation are presented in **Table 3**.

**Table 3.** Output of the ordinary least squares estimation of inflation and unemployment in Colombia, 2007–2024.

| Variable | Coefficient | Standard Error | *t*-Statistic | Probability |
|---|---|---|---|---|
| C | 8.147715 | 0.961265 | 8.476033 | 0.0000 |
| Unemployment | −0.266000 | 0.077329 | −3.439839 | 0.0007 |

Source: Prepared by the author with data from DANE and the Bank of the Republic.

The results of the model estimation, presented in **Table 3**, reveal an inverse relationship between inflation and unemployment, in line with the original formulation of the Phillips Curve. This indicates that, in the Colombian case, the classical version of this curve is confirmed. Additionally, the model shows a 95% significance and a negative sign for the parameter, which supports its consistency in explaining the dependence of inflation on the behavior of unemployment. In other words, an increase in unemployment is associated with a decrease in inflation, primarily explained by the reduction in wages due to the increase in the labor supply. The unemployed workforce contributes to a decrease in labor costs, which is reflected in lower prices for goods and services.

The equation, as planned in the model design, was fulfilled and is expressed as follows:

$$\text{Inflation} = \alpha + \beta x1 + \mu \tag{2}$$

Substituting with the estimation data, it becomes as follows:

$$\text{Inflation} = 8.147715 - 0.266000 \times \text{unemployment} + \mu \tag{3}$$

This equation demonstrates that the behavior of inflation is inversely related to unemployment. That is, when unemployment rises, inflation tends to decrease, as a greater supply of labor puts downward pressure on wages. This reduction in wages can lower production costs, which in turn leads to lower prices for goods and services. In contrast, a decrease in unemployment can lead to labor shortages, which raises wages due to increased competition for workers. This rise in production costs is reflected in higher prices for goods and services, resulting in higher inflation. The regression analyses confirm this inverse relationship between inflation and unemployment, as stated by the Phillips Curve theory.

A more precise interpretation of the results of the equation reveals the magnitude

of the change in inflation in response to variations in unemployment for the Colombian economy. Specifically, a 1% increase in unemployment is associated with a 0.26% decrease in inflation. This finding indicates that changes in the unemployment rate inversely affect inflation. Based on this discovery, economists developed the theory of the non-accelerating inflation rate of unemployment, known as NAIRU (Non-Accelerating Inflation Rate of Unemployment).

Next, the results of the cointegration tests are presented, which are shown in **Table 4**.

**Table 4.** Cointegration measurement, Engle and Granger test for inflation and unemployment in Colombia, 2007–2024.

| | | ***t*-Statistic** | **Prob.*** |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | −11.29486 | 0.0000 |
| Test critical values: | 1% level | −3.462095 | |
| | 5% level | −2.875398 | |
| | 10% level | −2.574234 | |

*MacKinnon (1996) one-sided *p*-values.

**Table 4** demonstrates that the residual series is stationary, which implies that it does not exhibit a unit root. This confirms that the variables inflation and unemployment are cointegrated of order one, establishing a long-term equilibrium relationship between them. In other words, despite the possibility of temporary fluctuations between inflation and unemployment, the structural relationship between the two variables remains stable over time.

When comparing the results of this study with those of Ortiz [17], who analyzed the relationship between inflation and unemployment in Mexico, it is observed that both studies find an inverse relationship between these variables. However, there are significant differences in the magnitude of this relationship. In contrast, the analysis for Colombia shows that a 1 percentage point increase in unemployment results in a 26% decrease in inflation, indicating a more pronounced effect in the case of Colombia.

Once the inverse relationship between inflation and unemployment in Colombia was evidenced, it was recommended that policymakers implement a restrictive monetary policy, as adopted by the Banco de la República by maintaining its interest rate at 9.5% in January 2025. This approach aims to moderate aggregate demand and prevent unemployment from falling below its natural rate, known as NAIRU. Additionally, it is essential that labor and fiscal policies align with these objectives by promoting the creation of formal employment and reducing labor informality, thereby maintaining the country's economic and social stability.

## 4. Conclusions

Based on the data analysis and the application of statistical techniques, it can be concluded that the information available from public institutions, such as DANE and the Bank of the Republic, is consistent for establishing empirical evidence on the inverse relationship between the inflation rate and the unemployment rate. This

confirms the validity of the economic concept that links these two variables.

The statistical techniques, in line with the theory, have demonstrated the inverse relationship between inflation and unemployment in the Colombian case, as established in the original Phillips Curve. The results indicate that a one-percentage-point increase in the unemployment rate is associated with a 26% reduction in inflation. This confirms that the relationship is indeed inverse—meaning that an increase in unemployment is linked to a decrease in inflation. This phenomenon is mainly explained by the transfer of labor costs to the prices of goods and services.

The evidence obtained in this study, which shows an inverse relationship between inflation and unemployment in Colombia, has been compared with previous research, such as the study by Ortiz for Mexico [17]. Although both studies confirm the existence of an inverse relationship, the magnitude of this relationship is found to be smaller in Mexico compared to Colombia. These findings reinforce the validity of the Phillips Curve in different contexts, highlighting the importance of considering regional variations in the dynamics between inflation and unemployment.

The analysis of the Phillips Curve for Colombia reveals that, despite temporary fluctuations in the inverse relationship between inflation and unemployment, these deviations tend to correct themselves over time. The evidence of cointegration supports this observation, indicating that although short-term variations may occur, the economic series adjust toward a long-term equilibrium. In summary, the inverse relationship between inflation and unemployment remains stable, highlighting a trend toward stability in the labor market and prices over time. These results underscore the importance of considering long-term behavior in economic analysis.

It is essential to acknowledge the limitations of the study, particularly the lack of complete monthly data for other variables that could have been included in the model, which may affect the robustness of the results. The conclusions are not definitive but rather a reflection of the feasibility of the analysis based on the available information. Further research with more comprehensive data is required for a more robust understanding.

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