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# THE INFLATION- UNEMPLOYMENT TRADEOFF IN A MACROECONOMETRIC MODEL

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**Abstract**

The importance of the relationship between economic phenomena like inflation and unemployment has been studied since 1958 when Philips analysed and plotted on a scatter diagram the annual wage inflation and unemployment rate in the UK for the period 1860 – 1957. The relevancy of the Phillips curve is mainly related to the fact that both inflation and unemployment are key measures of economic performance and policymakers use the Phillips curve to keep a stable price level and low unemployment rates. One of the questions addressed in this article is related to the existence of a causal relationship between the unemployment and the inflation rate in the Unites States between 1961 and 2013. By validating the Phillips curve hypothesis the objective of the article is to estimate the relationship between unemployment and inflation by employing a Vector Autoregressive model. The results suggest there is a tradeoff between the two variables, at least in the short term and that since current inflation rates accompany economic growth, the inflation targeting should be pursued in a short time frame.

**Keywords:** Inflation, Unemployment, VAR.

## INTRODUCTION

The importance of the relationship between economic phenomena like inflation and unemployment has been studied since 1958 when Philips analyzed and plotted on a scatter diagram the annual wage inflation and unemployment rate in the UK for the period 1860 – 1957. The interpretation of his result is that there is an inverse and stable relationship between wage inflation and unemployment.

Lately, the combination of low inflation and low unemployment has led to different questions whether the short-run Phillips curve trade-off is dead and some economists explained this new theory by proving there is a series of short run Phillips Curves and only a long run Phillips Curve (Newhouse et al. 1972).

The importance of the Phillips curve is mainly related to the fact that both inflation and unemployment are key measures of economic performance and policymakers use the Phillips curve to keep a stable price level and low unemployment rates.

However, this topic is one of the most controversial topics in macroeconomics and yet, the relationship between the inflation rate and unemployment remains one of the most important subjects thatmacroeconomists analyze.

One of the questions addressed in this article is related to the existence of a causal relationship between the unemployment and the inflation rate in the Unites States between 1961 and 2013. By validating the Phillips curve hypothesis the objective of the article is to estimate the relationship between unemployment and inflation by employing a Vector Autoregressive model.

Considering that the Phillips curve has taught us about how the economy works, this article aimsto answer the following question: how can we apply the lessons learned from the Phillips curve approach to improve the conduct of monetary or fiscal policies?

The paper is divided into the following sections: section two reviews the empirical and

theoretical literature related to the study, section three describes the economic model employed and section four presents the econometric model. The next section describes the data used and the estimation procedure. The sixth section presents the regression results and their interpretations while the last section of the articles provides a summary and the conclusion of the main findings as well as their implication for policy.

## LITERATURE REVIEW

There is a large variety of conclusions that resulted from the empirical studies on the relationship between inflation and unemployment. Some economists found the trade-off relationship between unemployment and inflation as significant, while others did not.

The results that showed no causal relationship between unemployment and inflation were explained by economists as being caused by the foreign labor, which is not involved in the unemploymentrate calculation. In these studies, the economists recommend that policymakers should pay attention to these findings and suggest that programs to reduce unemployment should be conducted.(Al-zeaud, 2014)

Lately, the inflation developments in the US and Eurozone are very similar and there are steadily declining rates on both sides. Berk & Swank (2011) use panel estimates of regional Phillips curves to study price level convergence in the US and EMU. The policy implication of their study is that regional inflation differentials should not be more of a concern to the ECB than they are to the Fed and concludes that inflation persistence is significant in both monetary unions.

There is a debate related to the importance of backward and forward-looking behavior in determining inflation. Lanne & Luoto (2013) suggested an autoregressive model for the inflation rate to estimate a new Keynesian Phillips curve. They used a dynamic panel data model and found that expected future inflation and lagged inflation have an important role in determining the inflation rate, but the former one is more significant.

(Llaudes, 2005) investigate the long-term relationship between unemployment and the determination of prices and wages and show that show that unemployment duration is important and determines prices and wages.

By investigating if the short-run Phillips curve trade-off is dead, Crary (2000) argues that the improved trade-off has resulted from improved labor quality in the form of increased average years of work experience and education and find strong support for a time-varying natural unemployment rate.

Berentsen et al. (2009) concentrate their research on the long-run relationship between monetary policy measured by inflation and labor market performance measured by unemployment. They use quarterly data from US between 1955-2005 to study and explain the effect of the natural rate of unemployment.

Other authors argue argued that rational employers and workers would pay attention only to real wages and these would adjust to make the supply of labor equal to the demand. As a consequence, the unemployment rate would stand at a level uniquely associated with the real wage which is the “natural rate” of unemployment (Friedman, 1977).

Liu (2011) assumes that employers and workers update their expectation period by period and by using recursive Vector Auto regression model find out that the traditional output gap measure is a very significant variable explaining the dynamics of the inflation rate.

Other analyzes offer some evidence that the “standard Phillips curve may no longer provide a reasonable description of the behavior of inflation in an era where inflation expectations are

well anchored." The authors suggest that when designing monetary policy, policymakers cannot take as given the recent low level of inflation. (Williams 2006)

**The Economic Model**

The theoretical framework to study the trade-off between unemployment and inflation adopted forthis article is the Philips curve hypothesis. The specification of the Philips curve implies that changes in the level of unemployment have a direct and predictable effect on the level of price inflation. Thus, the economic model suggests that a fiscal stimulus triggers responses like an increase in the demand forlabor, a fall in unemployment, which leads to firms competing for fewer workers by raising nominal wages. As a consequence, wages rise and firms pass on these cost increases in higher prices.

The three most relevant specifications of the Phillips curve developed by economists and encountered in the literature are the following: "the New Classical, the New Keynesian and the Hybrid Phillips" (Paloviita, 2008).

All these specifications involve different assumptions. Thus, the New Classical specification relates the current inflation rate to the previously expected current inflation rate and to current excess demand, while the New Keynesian Phillips curve assumes that the current inflation rate is a function of the currently expected future inflation rate and current excess demand. Finally, the specification of the Hybrid Phillips implies persistence in inflation and that the current inflation rate depends on both the expected path of the driving variable and on the lagged inflation rate (Kanayo, 2013).

**The Econometric Model**

Using annual data from Federal Reserve Bank of St. Louis database (FRED, 2015) the article examines the relationship between inflation and unemployment in the US in the period 1961-2013, by estimating the following VAR models:

$$UN_t = \alpha_0 + \alpha_1 INF_{t-1} + \alpha_2 INF_{t-2} + \alpha_3 UN_{t-1} + \alpha_4 UN_{t-2} + \varepsilon_t (1)$$

$$INF_t = \alpha_0 + \alpha_1 INF_{t-1} + \alpha_2 INF_{t-2} + \alpha_3 UN_{t-1} + \alpha_4 UN_{t-2} + \varepsilon_t (2)$$

Where UN is the unemployment, INF is the inflation, $\alpha_0$ $\alpha_1$ $\alpha_2$ ,$\alpha_3$ , , $\alpha_4$ and are the coefficients to be estimated and $\varepsilon$ is the error term.

The following table contains the description of the variables included in the model (J.m.wooldridge, 2011).

| | |
|---|---|
| *UN* | annual percentage change in unemployment, 2000-2013 |
| *INF* | annual percentage change in inflation, 2000-2013 |

**The Data**

The macroeconomic variables used for the estimation of the ECM model are the unemployment rate (%) and the inflation rate (%) for the US and the time period is 1961-2013. The source of the data is Federal Reserve Bank of St. Louis website and the representation of the data is annual time series.

Time series data sets and their transformation require a lot of attention. Because in this article we are using annual data expressed as rates, the first step in analyzing the time series is to see the graphic of the observed value in time (J. m. wooldridge, 2011).

The figure below presents the inflation rate and the unemployment rate in the US between 1961 and 2013. By seeing this graphic, it can be observed that while there is an inverse relationship between rates of unemployment and corresponding rates of inflation. While the inflation rate increases,the unemployment decreases and vice versa.

We can see that there is a trade-off between inflation and unemployment. For example, between 1961 and 1968, the inflation rises from 1.08% to 4.22%. During this period, we see a fall in unemployment from 6.77% to 3.61%. In 2009 we saw inflation fall from 3.84% in to -0.36%. During this time, there is also a significant rise in unemployment from 5.85% to over 9.38%. This suggests the presence of a trade-off between unemployment and inflation is possible.

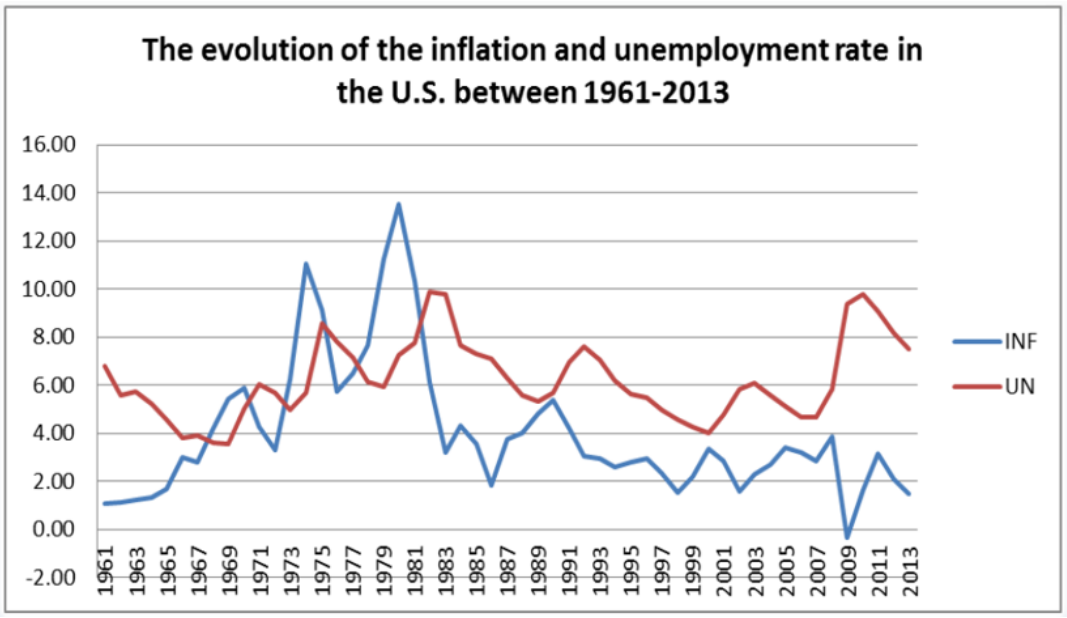


**Figure 1: The Evolution of the Inflation and Unemployment Rate in the U.S. during 1961-2013**

Source: Author's computation

The goal of the summary statistics is to calculate the mean and the standard deviation. For example, we can see that between 1961 and 2013 the mean of the inflation rate in the US is 4%, while the average unemployment rate is 6.19. Furthermore, the standard deviation is 2.82 for the inflation rate and

1.63 for the unemployment. We also have the minimum inflation rate at -0.355 and the maximum of 13.5%. On the other hand, the minimum unemployment rate in the US between the period analyzed is 3.55%and the maximum is 9.86%.

**Table 1: Summary Statistics**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| INF | 53 | 4.006273 | 2.821474 | -.3555463 | 13.50937 |
| UN | 53 | 6.197546 | 1.632176 | 3.557987 | 9.860857 |

Source: Author's computation in Stata

**The Estimation Procedures**

The objective of this section is to examine the presence of interdependence and directions of causality between inflation and unemployment in the case of US. The econometric model employed for the analysis is a Vector Autoregressive model. The software used is Stata.

The VAR model has the advantage that captures the linear interdependencies among multiple timeseries (Koop & Onorante, 2012). In order to estimate the VAR model, the stationarity of

the data should be tested. In order to analyze the stationary properties of the two time series, we need to test the presence of unit-roots in the time series. In this paper we use the Augmented Dickey-Fuller (ADF) test. The next step is to check if there is cointegration between the two variables and this is done by using a Johansen- Juselius procedure.

**Potential**

Firstly, the variables are tested for stationarity by using the ADF test before the VAR estimation isconducted. We have tested the two time series in the levels and in the first difference in order to establish if they are stationary.

The results of the ADF test are reported in the below table for the level as well as for the first difference of each of variable.

**Table 2: Stationarity Test Results**

| Variable | Level | First difference |
|---|---|---|
| Inflation | -2.344 | -2.951* |
| Unemployment | -2.229 | -3.408* |

Note: * denotes significance at 5% level

**Source: Author's computation in Stata**

The test results suggest that the first difference of both inflation and unemployment is stationary,which means the series are integrated of order 1, I (1).

Given the above results, the Johansen has been applied in order to check the co-integrationbetween inflation and unemployment.

The following table presents the results of this test.

**Table 3: Cointegration Test Results**

```
        Johansen tests for cointegration
        Trend: constant                                          Number of obs =
51
        Sample:  1963 - 2013                                               Lags =
2
        ------------------------------------------------------------------------------------------------------
--------
        5%
        maximum                                          trace    critical
        rank    parms       LL       eigenvalue  statistic    value
        0       6      -156.57851          .       16.8306    15.41
        1       9      -150.38888      0.21552      4.4513     3.76
        2       10     -148.16322      0.08358
```

Source: Authors' computation in Stata

If the trace statistic is greater than the 5% value, we can reject the null hypothesis that says there isno cointegration. From the above results, we can reject the null hypothesis because 16.8>15.41. On the next row, we observe that the trace statistic is less than the critical value, which means there is no cointegration between inflation and unemployment in the US.

**Regression Results and Their Interpretations**

Taking into consideration the above results, we can say that the two variables don't have long run association and they don't move together in the long run. Because the variables are not cointegrated, we employ a Vector Auto regression Model (VAR).

**Table 4: Vector Autoregression Model Output**

```
Vector autoregression

Sample:  1963 - 2013                            No. of obs      =        51
Log likelihood = -148.1632                      AIC             =  6.202479
FPE            =  1.695519                      HQIC            =  6.347226
Det(Sigma_ml)  =  1.144043                      SBIC            =  6.581269

Equation           Parms      RMSE     R-sq       chi2     P>chi2
------------------------------------------------------------------
INF                    5     1.61513   0.6972   117.4521   0.0000
UN                     5     .778435   0.7978   201.1956   0.0000
------------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
INF          |
         INF |
          L1. |   .9516727   .1426901     6.67   0.000     .6720053     1.23134
          L2. |  -.1417063   .1609589    -0.88   0.379    -.4571799     .1737673
              |
          UN |
          L1. |  -.5099297   .2778968    -1.83   0.067    -1.054597      .034738
          L2. |   .4782207    .247665     1.93   0.053    -.0071937     .9636351
              |
       _cons |   .9942391   .9529981     1.04   0.297    -.8736027     2.862081
-------------+----------------------------------------------------------------
UN           |
         INF |
          L1. |   .2318647   .0687717     3.37   0.001     .0970747     .3666547
          L2. |  -.1187234   .0775766    -1.53   0.126    -.2707707      .033324
              |
          UN |
          L1. |   1.206763   .1339366     9.01   0.000     .9442518     1.469274
          L2. |   -.444409    .119366    -3.72   0.000     -.678362    -.2104561
              |
       _cons |   1.021305   .4593121     2.22   0.026       .12107     1.92154
------------------------------------------------------------------------------
```

Source: Author's computation in Stata

The results of the estimation can be written using the following model:

$$INF_t = 0.99 + 0.95\ INF_{t-1} - 0.14\ INF_{t-2} - 0.5\ UN_{t-1} + 0.47\ UN_{t-2} \quad (3)$$

In the first model, the probability value of the lag value of the inflation rate is significant. This means that if the inflation rate in the previous period increases with 1%, the current inflation rate will increase by 0.95%. On the other hand, the coefficient of the second lag value of the inflation rate is not significant to explain the inflation.

Furthermore, the coefficient of the past value of the unemployment can be used to explain the inflation rate because this is significant at 10% probability. Therefore, we can say that a 1% increase in unemployment will cause the inflation rate to decrease by 0.5% on average. On the other hand, a 1% increase in the unemployment at t-2 will cause a 0.47% increase in the inflation rate.

The second model estimated using the VAR model is:

$$UN_t = 1.02 + 0.23\ INF_{t-1} - 0.11\ INF_{t-2} + 1.2\ \ UN_{t-1} - 0.44\ UN_{t-2} \quad (4)$$

All the coefficients are significant at 5% except for the coefficient of the second lag of the inflation rate that is significant at 10%. First of all, we can say that if the inflation rate is 0, the unemployment will be 1.02. Moreover, if there is a 1% increase in the past inflation rate, the unemployment will increase by 0.23%. It seems that, in this case, there is a negative relationship between the second lag of inflation and unemployment in the US. Also, a 1% increase in the lagged value of the unemployment leads to 1.2 increase in the unemployment. Finally, a 1% increase in the second lag of the unemployment will lead to a 0.44% decrease

in the unemployment.
There is no long-run causality but only short-run causality running from independent variable to the dependent variable.
Moreover, we check if all the lags of the variables are jointly causing the dependent variable by using the Granger causality test in the short-run. The null hypothesis is that the lagged variables of unemployment do not cause inflation. Since the probability is greater than 0.05, we should accept the nullhyphotesis, meaning there is no short run causality running from unemployment to inflation.
For the second equation, we can see that p value is 0, which means the inflation causes the unemployment on the short run.

**Table 5: Granger Causality Test Results**

| Equation | Excluded | chi2 | df | Prob > chi2 |
|---|---|---|---|---|
| INF | UN | 3.8934 | 2 | 0.143 |
| UN | INF | 16.811 | 2 | 0.000 |

Source: Author's computation in Stata

Based on the above results the second model is the one that best describes the relationship between inflation and unemployment. This implies that, inflation would be specified as the independent variable, while unemployment would be specified as the dependent variable.

## SUMMARY AND CONCLUSIONS

The main purpose of this paper is to test the validity of the Philips curve hypothesis and for theUS economy between 1961 and 2013 by employing a Vector Autoregressive model. In order to determine which type of model best describes the relationship between unemployment and inflation, a unit root anda cointegration test were performed. The results of the ADF unit root test suggest that the inflation and unemployment rate are I(1), while the Johansen cointegration test results showed there is no cointegrationbetween the two variables. The results suggest there is a trade-off between the two variables, at least on the short term. Therefore, the best way to describe the Phillips curve and the trade-off between inflation and unemployment was to estimate the coefficients of a VAR model. For the first model where the inflation isexplained by past values of the unemployment and its past values, the short run coefficients are significant for the first lag of inflation and the first and second lags of unemployment. As expected, the short run coefficient of the unemployment is negative, as well as the coefficient of the first lag of the inflation rate.
The second VAR model explains the unemployment rate as a dependent variable of past values of unemployment and inflation rate. All the coefficients are significant and the results suggest that the unemployment is negatively related to the second lag of the inflation rate and the second lag of the unemployment. It seems that there is a positive relationship between the past value of the inflation rate and the current value of the unemployment.
The Granger test was used to determine the short run causality between the inflation and unemployment rates and the results suggest that the past values of the inflation rate are the mostsignificant to cause the unemployment. The VAR estimates imply that a 1 % increase in the past value of unemployment leads to a 0.5% decrease in the inflation rate. On the other

hand, for every 1 % increase inthe past value of inflation, the current unemployment would decrease on average with 0.55%

Since the Phillips curve shows the short-run tradeoff between inflation and unemployment, the policymakers can use monetary or fiscal policy to affect the output, unemployment, and inflation. Even though they do not have controls upon the expected inflation and supply shocks, policymakers can choosea combination of inflation and unemployment on the short-run Phillips curve. The policy implication is that since economic growth is accompanied by current inflation rates, the inflation targeting should be pursued in a short time frame. Accordingly, policymakers should pay attention when dealing with unemployment issues, as they have to conduct programs that aim at reducing unemployment rate by creating productive labor projects and in the same time controlling the inflation rate. Furthermore, they should focus on replacing foreign labor with local labor and ensure that the U.S. accomplish a proper rate of unemployment and inflation, which in turn brings long term economic growth.

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