

EMPIRICAL STUDIES ON PHILLIPS CURVE IN USA DURING 1948-2016

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Abstract: In this paper, the author tested to estimate Phillips curve from classical to modified new Keynesian Phillips curve in USA during 1948-2016 where long term Phillips curve is not significant in most cases in USA except in new Keynesian Phillips curve.

Keywords: Cointegration, Employment Gap, Inflation Rate, Inflation Expectation, Output Gap, Natural Rate Of Unemployment, Phillips Curve, Unemployment Rate, Vector Error Correction

JEL-C32,C52,D12,E31,E32,E40,E50,E52.

Concept: The idea of trade-off between unemployment and inflation was originated in 1958 by A.W. Phillips, who showed a negative and non-linear relationship between unemployment and wage inflation in the U.K over the period of 1861-1957. As shown in figure 1, higher wage inflation means lower unemployment, and lower wage inflation means higher unemployment. However, low inflation and low unemployment are unlikely. In other words, Phillips Curve is a curve showing an inverse relationship between the inflation rate and the unemployment rate, such that the opportunity cost of more employment is more than inflation and vice versa.

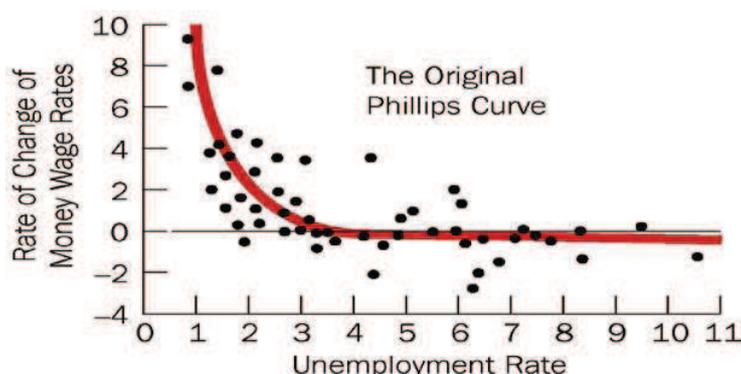


Figure 1: Phillips Curve

Source: Abel et al., 2008

The findings of the study of Al-zeaud & Al-hosban (2015) show a negative relationship between unemployment and inflation. The lowest limits of inflation and unemployment were estimated to be 3.779% and 11.077% respectively. Also, the elasticity of inflation with respect to unemployment and the elasticity of unemployment with respect to inflation were estimated to be -0.23% and -0.02% respectively. Therefore, this study provides a strong empirical existence of Phillips Curve on Jordanian economy over the period of 1976-2013.

The New Keynesian Phillips Curve was developed as $\pi_t = \alpha + \pi_{t-1} + \beta U_t + \gamma(U_t - U^*)$ where π_t = inflation rate, U_t = unemployment rate and U^* = natural rate of unemployment, $U_t - U^*$ = gap of unemployment, α , β and γ are constants. According to Ball & Mankiw (2002), estimation of Phillips curve through Non Accelerating Inflation Rate of Unemployment (NAIRU) is $\pi_t = \pi^e - a((U_t - U^*) + v$ where π_t = inflation rate, π^e = inflation expectation, U_t = unemployment rate, U^* = natural rate of unemployment, a = slope of Phillips

curve, v =error. They estimated NAIRU in US over last 40 years is 5.4% in 1960, 6.8% in 1979 and 4.9% in 2000 by using Hodrick Prescott Filter model (1997).

The Phillips curve which is broadly understood as the relationship between inflation and economic slack, is a standard framework for explaining and forecasting developments in inflation. At the same time, the framework is surrounded by considerable uncertainty, both conceptually and empirically. The Phillips curve is regaining interest after a period in neglect and there has been considerable theoretical work suggesting a nonlinear relationship between inflation and unemployment. The so called “new Phillips curves” explained by Gali and Gertler (1998) are based on early studies of Taylor (1980) and Calvo (1983) using staggered nominal wage contracts and price setting by forward looking individuals and firms. Ismael and Sadeq (2016) fitted time series data from (1996Q2 - 2015Q3) for both unemployment rate and inflation in Palestinian economy and aimed to check whether Phillips curve is applicable in Palestinian economy or not. They apply the unit root test for both series and get that both series are stationary at level. Granger causality test is also applied to test for the direction of the relation between inflation and unemployment. It is shown that inflation causes unemployment to fluctuate and unemployment does not cause inflation to change. They find an inverse relationship between inflation rate and unemployment rate where inflation causes fluctuations in unemployment.

Objective of the Paper: In this paper, the author has analyzed the theoretical development of Phillips Curve and attempted to verify its empirical evidences and the author computed models of Phillips curve for long run in USA from 1948 to 2016 through econometric analysis.

Data and Methodology: The US data of Inflation rate measured by CPI and data of unemployment rate from 1948-2016 were collected from Bureau of Labour Statistics and U S data on natural rate of unemployment from 1949-2016 were collected from St.Louis Fed of USA. Double log regression and multiple regression models were used to form various models of Phillips curve of USA during 1948-2016. Granger Causality test (1969) was done to verify causality among variables like unemployment gap, output gap, inflation rate and inflation differentials. Hodrick Prescott Model (1997) was used to calculate NAIRU.

Observations from Econometric Models:

[1] **Classical Phillips Curve:** In USA, the tradeoff between inflation and unemployment during 1948-2016 is found to be negative but it is insignificant where it states that one percent increase in inflation rate per year led to 0.021489 per cent decrease in unemployment rate per cent per year in USA. The estimated equation is given below.

$$\text{Log}(y) = 0.836925 - 0.021489 \text{log}(x) + e_i$$

(0.799) (-0.0357)

$R^2 = 0.000019$, $F = 0.00128$, $DW = 1.51$, x = rate of unemployment per cent per year, y = inflation rate per cent per year (measured by CPI).

During 1948-2016 in USA, there was no uni-directional or bi-directional causality between inflation rate and unemployment rate which is shown by Granger-Causality test.

Table 1: Granger Causality test

Null Hypothesis	Observation	F Statistic	Prob
Log(y) does not Granger Cause log(x)	68	3.72260	0.058
Log(x) does not Granger Cause log(y)		1.41217	0.239

Source: Computed by author

[2] **Modified version of Phillips Curve:** It was assumed that output gap is the function of gap between inflation and inflation expectation in modifying the basic concept of Phillips curve.

It is assumed that $(Q-Q^*)=\beta(\pi_t-\pi^e)$ where Q = Actual output , Q^* =estimated trend value of output, π^e =inflation expectation, π_t =inflation rate at t and $\beta < 0$ as expected in general.

Thus output gap is the gap obtained by extracting short run fluctuations from long run trend via Hodrick-Prescott Filter. In USA during 1948-2016, the estimated Phillips curve is shown below.

$$(\pi_t-\pi^e)=-0.113417+8.5949(Q-Q^*)$$

(0.435) (2.06)*

$R^2=0.06$, $F=4.24^*$, $AIC=4.39$, $SC=4.46$, * =significant at 5% level.

The gap between inflation and inflation expectation is positively related with the output gap in USA during the survey period.

But if we estimate the equation in the following manner, then it is a good fit and Phillips curve is significant where inflation is positively related with output gap significantly.

$$\pi_t=1.295751+0.603374\pi_{t-1}+13.616(Q-Q^*)$$

(3.48)* (7.25)* (3.61)*

$R^2=0.572$, $F=43.57^*$, $DW=1.64$, $AIC=4.12$, $SC=4.22$, * =significant at 5% level

According to Ball and Mankiw (2002), Phillips curve is estimated as follows,

$$Y_t=0.978867+0.727789y_{t-1}-0.33590(u_t-u^*)$$

(2.53)* (8.38)* (-2.113)*

$R^2=0.519$, $F=35.19^*$, $DW=1.64$, $AIC=4.24$, $SC=4.33$ where u_t-u^* =unemployment gap,

It states that unemployment gap is negatively related with current output significantly in USA during 1948-2016.

The new Keynesian Phillips curve is estimated during 1949-2016 in USA which is given below. It is highly significant for all coefficients and a high R^2 value and was also satisfied Phillips curve inverse relation with unemployment gap.

$$Y_t=-9.7222+0.52065y_{t-1}+2.0641U_t-2.29122(u_t-u^*)$$

(-2.89)* (5.02)* (3.209)* (-3.65)*

$R^2=0.586$, $F=30.25^*$, $AIC=4.12$, $SC=4.25$, * =significant at 5% level.

In causality test we found that $(y_t, y_{t-1}), (y_t, u_t), (y_t, u_t-u^*), (y_{t-1}, u_t-u^*)$ are unidirectional and (u_t, u_t-u^*) is bidirectional.

The latest modified New Keynesian Phillips curve is estimated for USA during 1953-2016 which is given below.

$$\pi_t=-7.604181+0.756579\pi_{t-1}-0.255005\pi_{t-2}+0.210627\pi_{t-3}-0.086138\pi_{t-4}+1.611365U_t-1.790362(U_t-U^*)$$

(-2.26)* (6.198)* (-1.719) (1.45) (-0.82) (2.426)* (-2.89)*

$R^2=0.697$, $F=22.33^*$, $AIC=3.87$, $SC=4.11$, $DW=1.52$, * =significant at 5% level, where π =inflation rate, U_t =unemployment rate, U^* =NAIRU=Non Accelerating Inflation Rate of Unemployment, the coefficient of π_{t-2} is significant at 10% level.

Thus, in USA during 1948-2016, inflation rate and unemployment rate in current period is positively significantly related whereas inflation and unemployment gap is significantly inversely related in the longer period. Actually the fitted Phillips curve has two distinct phases, 1948-1983, and 1983-2016, in which inverse flattened U shaped shown in Figure 2.

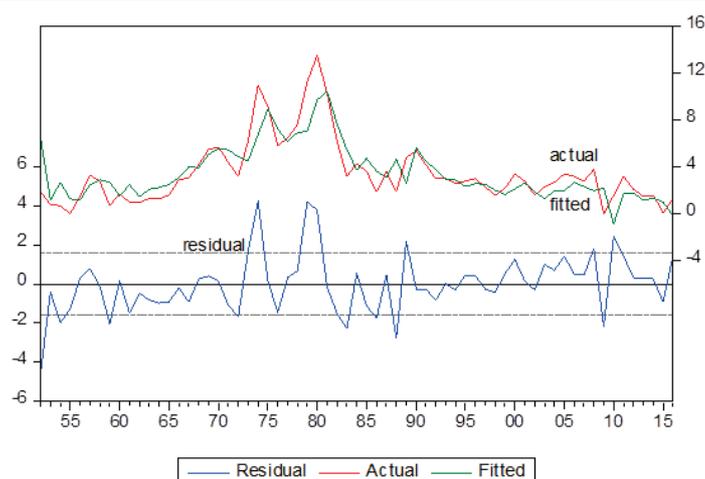


Figure 2: Modified new Keynesian Phillips curve
Source: Plotted by author

Limitation and Future Scope: This empirical computation of Phillips curves are not directly analyzed through Okun's law (1962) and output gap has not computed through H.P.Filter directly. Inflation expectations have also limitations. Explanations of non-linearity are exempted. All these shortcomings are open for future research in connection of this paper.

Conclusion: The paper concludes that US Phillips curve during 1948-2016 is negatively related with unemployment rate and inflation rate but it is insignificant. The author fitted Phillips curve using inflation differential and output gap in USA during 1949-2016 which showed significant but relation is positive and even it is fitted with inflation expectation and output gap, then it also significant positively. If Keynesian Phillips curve is fitted in USA during 1949-2016 taking inflation rate, inflation expectation, and employment gap, the estimation is significant for all coefficients and found negatively related Phillips curve. Again author fitted new Keynesian Phillips curve in USA during 1949-2016 taking inflation rate, inflation expectation, unemployment rate and unemployment gap where he found all significant coefficients with satisfying Phillips curve principles .Lastly author showed estimated modified new Keynesian Phillips curve in USA during 1948-2016 taking inflation rate, inflation expectation with five years, unemployment rate and unemployment gap. The estimation of Phillips curve showed good fit with significant inflation expectation up to three years, significant unemployment gap verifying inversely related Phillips curve.

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