

**The Phillips Curve: Classical, New Consensus and
Post-Keynesian views**

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Abstract

This paper explores the shape of the original Phillips curve, the development of the Phillips curve and the controversies related to the Phillips curve among different economic schools of thought. Using data from the United States, this paper also examines the relationship between the inflation rate, capacity utilization and lagged inflation rates. Empirical evidence shows that the Phillips curve has changed a lot in the last decades. There is no long run relationship between the inflation rate and capacity utilization rates any more since 1990. Moreover, the paper also brings forward a different way to depict the Phillips curve in terms of capacity utilization rates, based on the post-Keynesian point of view.

Keywords: Classical Phillips curve, New Consensus Phillips curve, US inflation, US capacity utilization rate, Unit root, Cointegration,

Introduction

During the post-war period, Keynesian economics has been criticized a lot, since many phenomena seemed to contradict Keynesian theory. In the 1970s, inflation, to the Keynesians' lament, and quite differently from previous years, started to rise despite high unemployment and low economic growth. Inflation would accelerate even with high unemployment. However, in the 1990s, high economic growth and low employment coexisted with low inflation. Both of the two questions, inflation and unemployment, have always puzzled economists. They do not really know how to deal with these two scourges.

The Phillips curve, based on Keynesian theory, seems to have run into a big question mark. Many economists argued that the long-run trade-off relationship between inflation and unemployment does not exist. When exploring the reason why this happens, the focus is on rational expectations. As told by Abraham Lincoln: "You

can not fool all people all the time.”

According to traditional Keynesian theory, government deficits and credit expansion are efficient ways to increase employment since Keynesians assume workers will be fooled by the decrease in real wage which is caused by the rise of prices. Moreover, the lower labor costs raise the demand for labor, and hence reduce unemployment. The assumption is entirely dependent on workers being deceived, considering they will accept losses in their real income voluntarily.

However, even though workers are not economists, they still know that rising prices will decrease their purchasing power of labor income. They will strongly request wage boosts to compensate for the rise in prices. In addition, they may ask for higher labor income to deal with expected future price increases. These points, together with the demand for higher real wages due to “rising labor productivity”, modify the original Phillips curve.

Over the years, neoclassical economists have proposed a more advanced Phillips curve, introducing the expected inflation rate variable into the Phillips curve equation. They argue that if workers and firms anticipate that the general price level will be increasing, they will build their expectations of inflation into wage contracts and into the prices of good that firms sell. The result of this change is that there is no long run trade-off between output and inflation any more.

Nowadays, strong growth and historically low rates of inflation in the United States have sparked considerable debate among economists and Fed officials. Some

researchers argue that inflation has shown behavior more consistent with the current capacity utilization rate rather than the NAIRU¹ gap. Post-Keynesian economists propose their own perspective to depict Phillips curves, arguing that there exists a range of growth rates or capacity utilization rates for which increases in economic activity would not have any effect on inflationary forces. In their view, the long-run Phillips curve is horizontal within that range.

The first section of this paper elaborates the background argument of the early Phillips curve, analyzing the theories proposed by A.W. Phillips and M. Friedman, providing the advantages and disadvantages of those kinds of Phillips curve. The second section describes the New Consensus. Actually, it constructs a bridge connecting Neo-Classical Keynesians and Post-Keynesians. The third section portrays a modified perspective of the Phillips curve, which is quite different from the previous ones. Section 4 to 6 present empirical evidence testing whether the U.S. economy operates within the Post-Keynesian's Phillips curve, indicating that the Post-Keynesian perspective is a reliable indicator of inflation pressures.

1 The background of the Phillips Curve

1.1 The original Phillips curve was established by A.W. Phillips.

The original Phillips curve was established by Professor A.W. Phillips' famous paper, *The relation between unemployment and the rate of money wage rates in the*

¹ NAIRU (non accelerating inflation rate of unemployment): the unemployment rate consistent with a constant inflation rate. An unemployment rate higher than the NAIRU indicates downward pressure on inflation, whereas an unemployment rate lower than the NAIRU indicates upward pressure on inflation. Estimates of the NAIRU are based on the historical relationship between inflation and the unemployment rate.

United Kingdom, 1861-1967, published in 1958. He suggested that there was a stable relationship between the level of economic activity and the rate of inflation. The purpose of Phillips was,

“... to see whether statistical evidence supports the hypothesis that the rate of change of money wage rates in the United Kingdom can be explained by the level of unemployment and the rate of change of unemployment ...” (A.W. Phillips, 1958, p.284)

He discovered that over several sub samples within the period between 1861 and 1957, the rate of change of wages and the unemployment rate tended to be negatively related. When unemployment was low, the rate of change of wages was high and vice versa. Moreover, with respect to the labor market, he held the idea that, in particular in static demand and supply conditions:

“When the demand for a commodity or service is high relatively to the supply of it, we expect the price to rise, the rate of rise being greater the greater the excess demand. Conversely when the demand is low relatively to the supply we expect the price to fall, the rate of fall being greater the greater the deficiency of demand. It seems plausible that this principle should operate as one of the factors determining the rate of change of money wages rates, which are the price of labor service” (A.W. Phillips, 1958, p.283)

The original relationship was set out between unemployment and wages but later the Phillips curve was subsequently also expressed as a positive relationship between unemployment and the rate of change in prices (inflation), due to the general

assumption that these two series move in the same direction.

The argument of Professor Phillips in terms of aggregate demand and supply curves runs as follows.

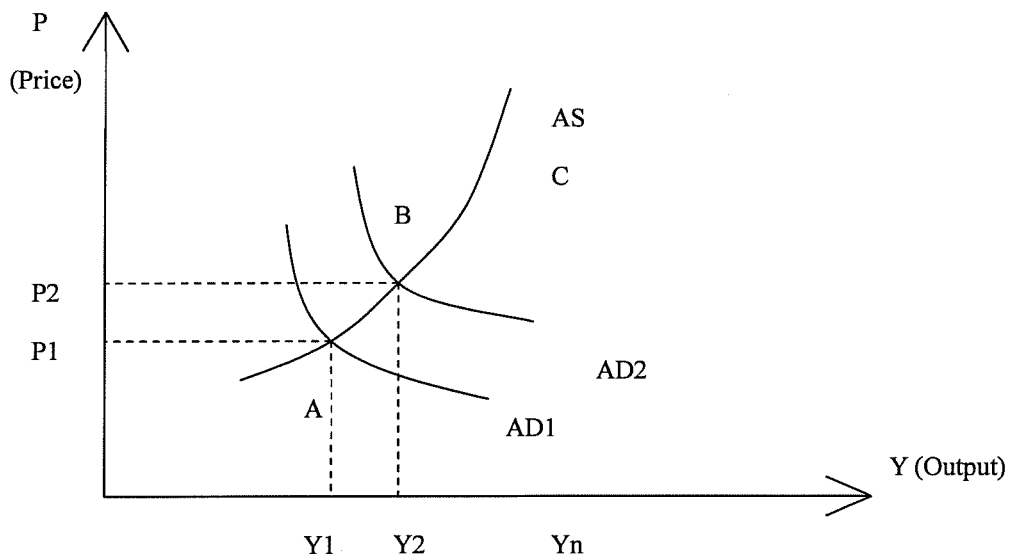


Figure 1

As shown in Figure 1, when the economy is on point A, which is far from potential production or full employment output (Y_n), it represents a high rate of unemployment. If the aggregate demand curve shifts up from AD1 to AD2, the economy moves to point B and hence production and employment rise. Meanwhile, prices also rise from P_1 to P_2 . Thus, governments can use some appropriate policies to reduce unemployment at the cost of higher price levels (inflation risk). As

production rises, more employees are needed, which leads to the decline of unemployment. This is the Keynesian zone. However, if the economy is in C, which means it is close to full employment or potential production (neoclassical zone), shifts in aggregate demand produce only inflation without more production and employment, since, under those economic conditions, it is impossible to move production and employment beyond Y_n where the rate of unemployment is the natural rate. The AS curve becomes vertical.

The Phillips curve was subsequently expressed as the relationship between the inflation rate and output, where the inflation rate $\pi = \ln P_t - \ln P_{t-1}$. As explained by Tiff Macklem (1997, p41) "The basic idea behind the Phillips curve was that the sort of price adjustment that is observed in the markets for individual goods should carry over to the economy as a whole." Phillips (1958, p283) also argued "When the demand for a commodity or service is high relatively to the supply of it we expect the price to rise, the rate of rise being greater the greater the excess demand. Conversely when the demand is low relatively to the supply we expect the price to fall, the rate of fall being greater the deficiency of demand." Thus, if the aggregate demand of the whole economy goes up from AD1 to AD2 in Figure 1, upward pressures on prices would increase and hence so would the inflation rate.

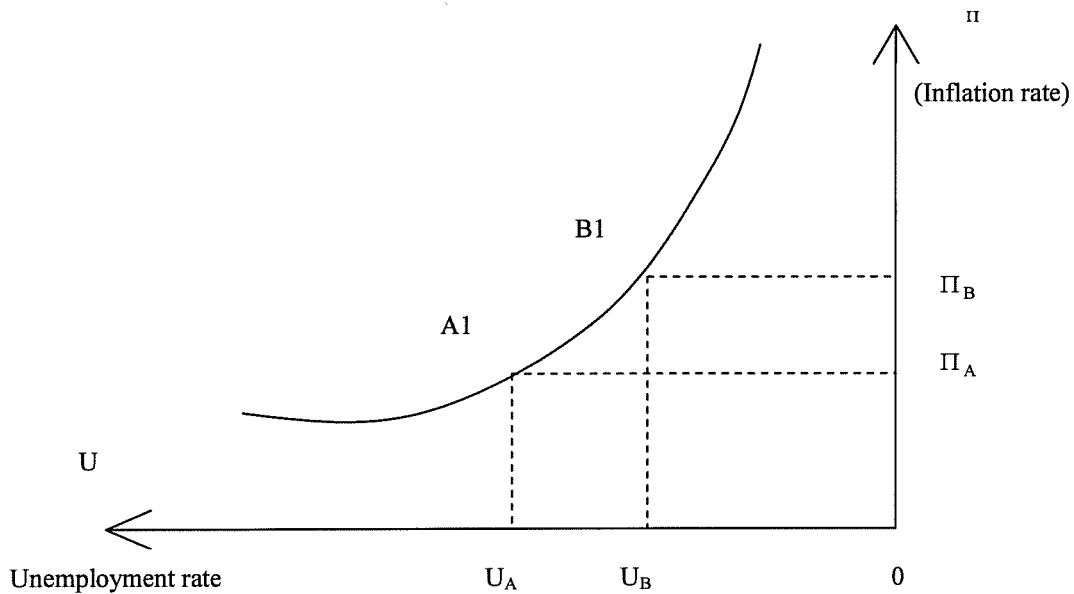


Figure 2

From the above description, we can draw the so-called Phillips curve, shown in Figure 2. Point A in Figure 1 represents a production level of Y_1 , which corresponds to point A1 in Figure 2 (rate of unemployment, U_A). If government implements some policies to shift the demand curve from AD_1 to AD_2 , which means the economy moves from A to B in Figure 1, more production and employment will be forthcoming, but at a higher rate of change in price level (inflation rate), as shown with point B1 in Figure 2. As it can be seen from the figure, the relationship is best assumed to be non-linear, with excess demand predicted to increase inflation more than excess supply would decrease it. The closer the economy gets to potential production or the level of full unemployment, the more difficult it is to reduce unemployment and vice versa.

Following the original Phillips curve, the model was tested for most industrial

countries, and most countries were shown to have a stable Phillips curve over some periods, particularly the 1960s. Early proponents of the Phillips curve viewed the relationship as a stable long run trade-off. Hence, it was argued, the economy could arrive at a higher level of production or unemployment, at the cost of a permanently higher rate of inflation. However, these perspectives were strongly criticized by Milton Friedman (1968) and Edmund Phelps (1970).

1.2 The criticism proposed by Friedman

In the 1970s, empirical evidence showed that in many countries, high levels of unemployment and inflation occurred at the same time, which contradicted the original Phillips curve. Therefore, the Phillips trade-off long run relation turned out to be controversial and implausible.

As early as the eighteenth century, Hume claimed (1752, p37-40), *“In my opinion, it is only in the interval or intermediate situation between the acquisition of money and the rise in prices, that the increasing quantity of gold or silver is favorable to industry...”*

Obviously, the Phillips trade off relation was considered to be valid by Hume in the short run only. Friedman also relied on Fisher (1926), who considered an additional relation. *“What mattered for unemployment, we argued, was not wages in dollars or pounds or kronor, but real wages.”* (Friedman,1976)

Hence, we find the difference between Phillips and Fisher. According to the first view, presumably endorsed by Phillips and Keynesians, causation runs from unemployment to wages (prices). This causation is reversed by Fisher, who held the

view that the causality runs from real wages to unemployment. In addition, there might be a mistake in relating a real variable (unemployment) to a nominal variable (prices).

With respect to this point, the argument in section 1.1 does not seem right. In that section, Phillips mistook real and nominal prices due to the Keynesian assumption of sluggish prices. According to Keynes, workers demand a given nominal wage rather than a real wage, "*A fall in real wages due to a rise in prices, with money-wages unaltered, does not as a rule, cause the supply of available labor on offer at the current wage to fall below the amount actually employed prior to the rise of prices.*"(Keynes, 1936 p.12)

Thus it is fortunate that the workers, though unconsciously, are instinctively more reasonable economics than the classical school, as much as they resist reduction of money wages, ... even though the existing real equivalent of these wages exceeds the marginal disutility of existing unemployment; whereas they do not resist reductions on real wages, which are associated with increases in aggregate employment. (Keynes, 1936 p.14)

From the above point of view, the Phillips curve is dependent on the assumption that households are fooled by money illusion, which is not a reasonable assumption. Workers realize eventually that inflation is eroding their nominal wage, and hence they refuse to offer the required level of employment unless wages rise. Therefore, the level of employment falls while inflation is high and the postulated long run Phillips trade-off relation will disappear.

Instead, Friedman and Phelps proposed the *accelerationist* hypothesis.

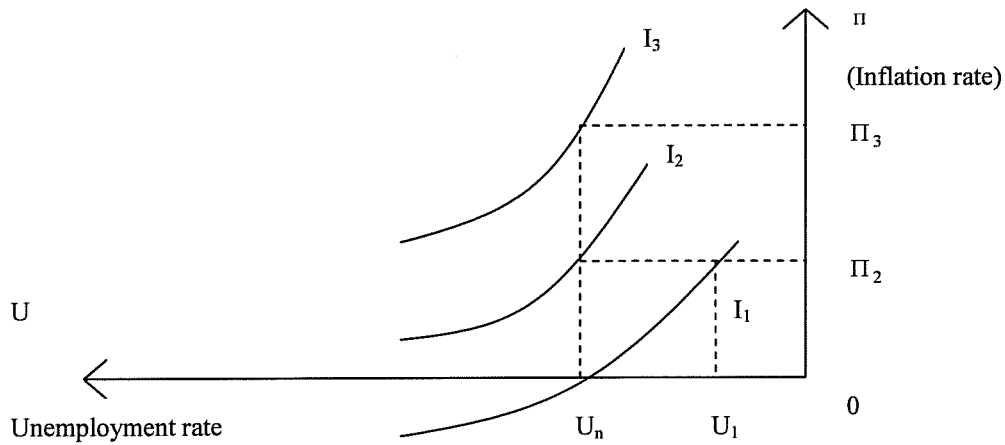


Figure 3

From their point of view, a key role is played by consumers' inflation expectations. As shown in Figure 3, U_n is the natural rate of unemployment rate. At first, the economy is at equilibrium, which means the unemployment rate is U_n and the inflation rate is zero. This situation happens on the I_1 curve in Figure 3. Then, government plans to reduce the unemployment rate. The expansion in aggregate demand, introduced by government policy, reduces unemployment from U_n to U_1 . Meanwhile, economic agents change their expectations on the basis of recent experience. Hence, the reduction in unemployment is only possible when workers are not able to anticipate the faster rise in prices. As soon as they realize that inflation reduces their real wages, they demand higher wages to offset the reduction. However, the increase in wages will cause the employment to fall back. According to the accelerationist economists, unemployment will move back from U_1 to U_n on Phillips curve I_2 . As a result, the unemployment situation is the same as that of the previous

period, but with a new inflation rate $\pi_2 > 0$. Any attempt to reduce unemployment with expanding aggregate demand will shift the Phillips curve from I_2 to I_3 and so on. Therefore, a reduction of unemployment is only possible in the short run, not in the long run. If government would like to keep unemployment at a lower level, it would have to implement the adjustment period by period. Otherwise, unemployment will return to the natural level U_n . The Phillips curve is completely vertical in the long run at U_n . This goes beyond the initial standard difference between the short run and the long run, where the long run curve also had a negative slope, although steeper than that of the short run curve.

As analyzed above, Friedman and Phelps introduced the inflation expectations hypothesis: as soon as economic agents hear about monetary expansion, they anticipate its consequences. Predicted expansionary policies will be powerless.

2 New Consensus' view of the Phillips curve

The New Consensus has been put forward by New Keynesians, who propose a new model that has some appealing features that are consistent with those advocated by Post-Keynesians. The purpose of discussing the New Consensus is to elaborate on the similarities between New Keynesian and Post-Keynesian models, especially in the fields of monetary economics and Phillips curve analysis.

This new Consensus, championed largely by New Keynesians, is also labeled "Modern macroeconomics"². It focuses on the exogeneity of the rate of interest, which originates with Taylor(1993,2000). As Yellen remarked back in 1995: " *It*

² See Taylor, 2000, p.90

seems to me that a reaction function in which the real funds rate changes by roughly equal amounts in response to deviation of inflation from a target of 2 percent and to deviation from potential output describes reasonably well what this committee has done since 1986. ... I think that's what sensible central bank do (quoted in Carlstrom and Fuerst, 2003, p.1)."

This new consensus is also being heralded by John B. Taylor (2000, p.90), according to whom *"At the practical level, a common view of macroeconomics is now pervasive in policy-research projects and universities and central banks around the world... It differs from past views, and it explains the growth and fluctuations of the modern economy; it can thus be said to represent a modern view of macroeconomics."*

So, what is this New Consensus? What are its core elements, or as Blinder (1997) says its "core macroeconomic beliefs?" Overall, the New Consensus can be reduced to essentially two basic elements: an exogenous interest rate rule and an inflation target (Rochon 2004). Combined with price fixity (Romer 2000), the New Consensus model generates all the more conventional short run Keynesian conclusions.

2.1 An exogenous interest rate

The new consensus is suspicious of the IS/LM model. The main change is that it discards the assumption that the central bank controls the money supply and suggests that the money supply should follow a simple interest rule which is dominated by central bank (Romer, 2000, p.154). According to the new consensus view, the central bank determines the price at which they lend and supply money. As claimed by

Allsopp and Vines (2000, p.7), the interest rate instrument can affect the amount of money, which is endogenous. The Post-Keynesian view of the money supply, based on a systematic process of endogenous and demand-led money supply, seems to have been accepted by the better-know New Keynesian economists, who often give advice to central banks. As claimed by Lavoie (2004, p. 16): *“These same New Keynesians now argue in terms of central bank determined interest rates, going so far as to argue that central banks have the power to determine real interest rates.”*

Therefore, these claims, suggested within the New Consensus, are very similar to the longstanding Post-Keynesian views, according to which interest rates ought to be regarded as the exogenous element in economic models, being understood that central banks set interest rates on the basis of their desired goals and on the basis of realized and anticipated fluctuations in the main economic variables.

In this way, the New Consensus view argues that government is able to use the interest rate instrument to adjust the money supply and inflation. Higher inflation rates generate higher real interest rates as a response (the reaction function).

2.2 Phillips curve in the New Consensus model

Like Friedman, New Consensus authors view the long run Phillips curve as being vertical at the NAIRU, or at some similar supply-side determined concept, with monetary policy having no impact on real activity in the long run:

“There is substantial evidence demonstrating that there is no long run trade-off between the level of inflation and the level of unused resources in the economy – whether measure by the unemployment rate, the capacity utilization rate, or the

deviation of real GDP. Monetary policy is thus neutral in the long run. An increase in money growth will have no long run impact on the unemployment rate; it will only result in increased inflation.” (Taylor 1999, p, 29-30)

In other words, the inflation falls when unemployment is above NAIRU, and increases when unemployment is below it. This is now most often described in terms of output gaps, i.e., the difference between actual output and potential output or in terms of deviation between the actual capacity utilization rate and the normal capacity utilization rate. We choose an equation to express the Phillips curve as an example:

$$\Delta \pi = \beta * (U - U_n)$$

This is, of course, the vertical long run Phillips curve, since any deviation of capacity utilization rate, real GDP, or unemployment from their normal levels leads to changes in the inflation rate. If the actual capacity utilization rate remains above its normal level, this will quickly lead to accelerating inflation. Obviously, there is no long term trade-off between inflation and some measure of the output gap.

With the help of a graph, it is easy to illustrate the movement of economy in the New Consensus model, as shown in Figure 3 (Rochon, 2004, p. 12).

Assume that the initial position of the economy is on the target inflation rate (π^T), and that the government undertakes a permanent increase in fiscal expenditures (from G_0 to G_1), which causes AD curve to shift from $AD(G_0)$ to $AD(G_1)$. Since prices are sluggish, output goes up from Y^* to Y_1 , which means output is beyond the natural rate. An increase in fiscal policy also shifts the IS curve to the right (from IS_0 to IS_1), hence the economy moves from point A to point B. Given the higher output, inflation begins

to rise. The economy moves to point C and the economy settles in its new long run value of output, the natural rate, with a higher rate of interest and a higher inflation rate.

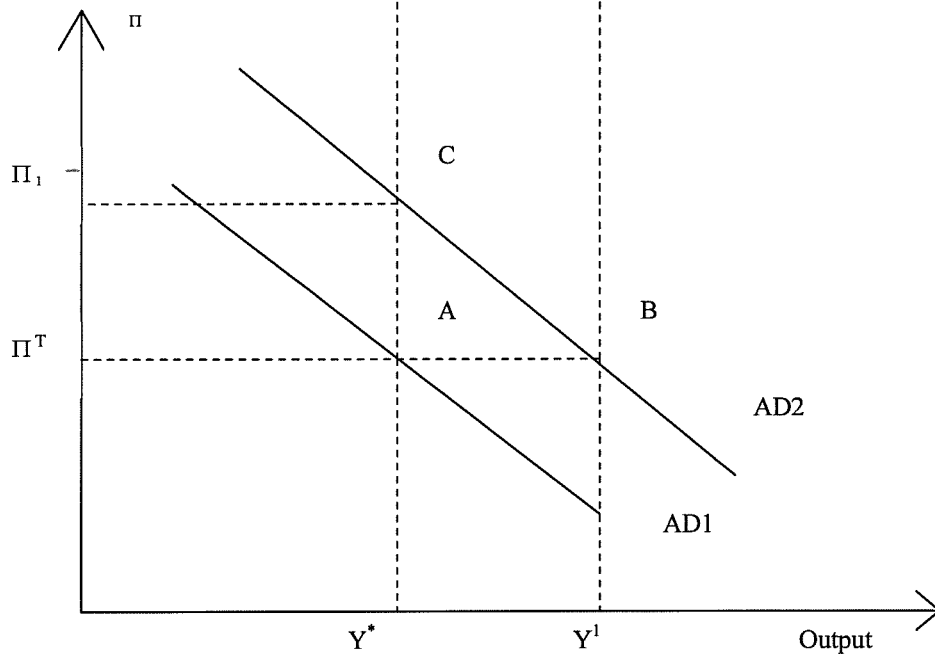
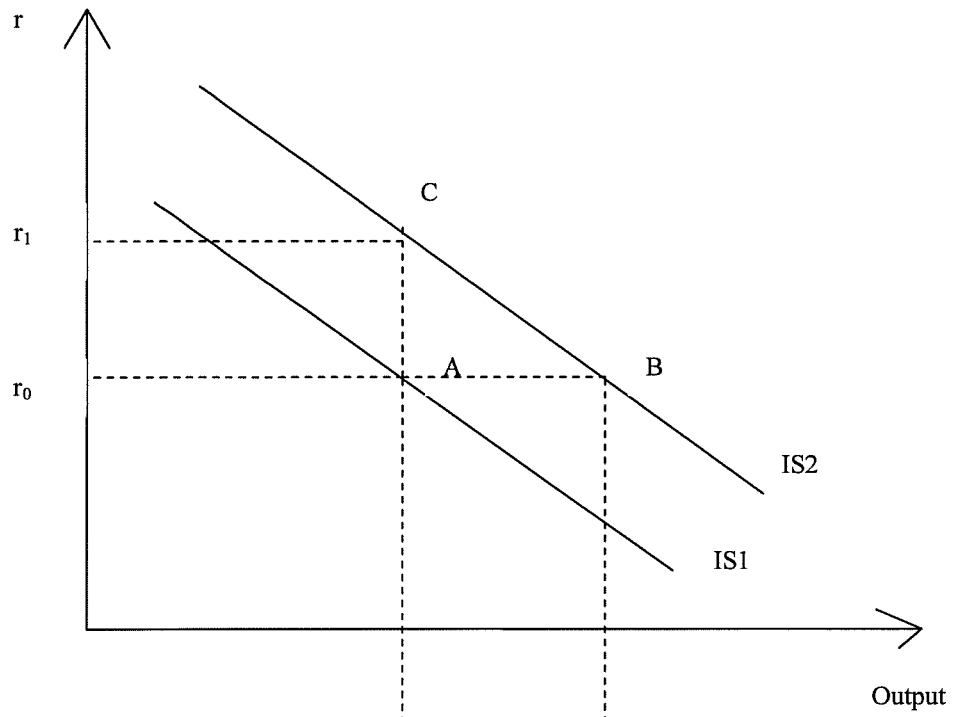


Figure 3

Therefore, two conclusions follow: first, the increase of the interest rate is the

However, many Post-Keynesians argue that inflation needs to rise when capacity utilization increases. As mentioned above, they argue that, there exists some impact on inflation when the level of output is very large. In other words, when the level of capacity is nearly fully utilized, changes in capacity utilization need only be inflationary. Similarly, we would expect some reduction of the inflation rate only at low levels of capacity. As argued by Freedman, Harcourt and Kriesler (2004), there would be a trade-off between inflation and unemployment only at very low and very high levels of capacity utilization, while the inflation rate keeps constant for levels of a large intermediate range of capacity. The Phillips curve would be horizontal for large ranges of output and employment.

According to the above perspective, a replacement of the Phillips curve equation is proposed by Kriesler and Lavoie (2004, p, 16):

$$\Pi = \beta_1 * (U - U_m) + \beta_2 * (U - U_{fc}) + \Pi_e$$

Where: U_{fc} represents full capacity utilization.

U_m is some low level of capacity utilization, below which the inflation rate falls.

$$\beta_1 = 0 \text{ for } U > U_m \text{ and } \beta_1 > 0 \text{ for } U < U_m$$

$$\beta_2 = 0 \text{ for } U < U_{fc} \text{ and } \beta_2 > 0 \text{ for } U > U_{fc}$$

Π_e represents the rate of inflation associated with the normal range of output, subject to supply side shock.

result of an administrative decision by the central bank, dictated by this specific interest rate rule; second, fiscal policy is neutral in the long run. In other words, fiscal policy has no long run effect on real output.

3 Post-Keynesian responses to the Phillips curve

Post-Keynesians not only reject the vertical long run Phillips curve, but also many of them even don't agree with the concept of a short-run trade-off between GDP/capacity and inflation. There are two reasons for this. First, there is a large range of capacity utilization rates which are consistent with an absence of demand-led pressures, for reasons tied to the absence of decreasing returns over a large range of production levels (Lavoie 2004, p. 24). Second, it is believed that with *“co-coordinated wage bargaining a constant inflation rate becomes compatible with a range of employment levels and the NAIRU as the short run limit to employment is no longer unique”* (Hein 2002, p.314).

In his critique of the New Consensus (2004), Setterfield emphasizes a similar Post-Keynesian modification. His focus is on the nature of the Phillips curve. He points out that not only demand-type considerations, but also cost considerations and institutional variables reflect the wage and price setting process that have a significant influence on the inflation rate. As a result, he used only one equation to represent these more intricate explanations of inflation, to go beyond the vertical Phillips curve:

$$\pi = \beta_1 * \pi_{-1} + \beta_2 * U + \pi_c$$

where $0 < \beta_1 < 1$, and π_c is a vector of institutional variables that affect aggregate wage and price setting behavior. (Setterfield, 2004, p.40)

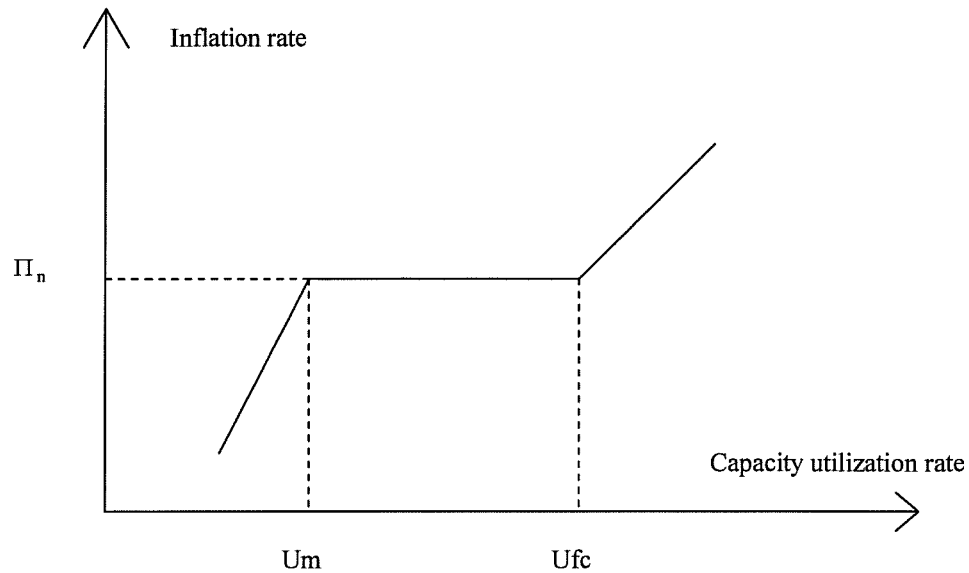


Figure 4

Figure 4 shows a Post-Keynesian Phillips curve. As shown in the graph, $\Delta\pi = 0$ for a large range of capacity utilization U such that $U_m < U < U_{fc}$. In this case, central bank policy should set the interest rate at a fair rate, based on income distribution considerations, in particular the distribution between debtors and creditors, and allow fiscal policy to set the output/capacity level, as more recently recommended by Arestis and Sawyer (2003).

These two modifications of the vertical (expectations augmented) long run Phillips curve, are derived from upward sloping short run curves. The first modification is in the manner suggested by Setterfield. He points out that the effects of inflation expectations are only partially transmitted to the current inflation rate. The second modification is to argue that for a large range of output (capacity utilization rates), higher levels of utilization will not lead to higher rates of inflation for given

inflationary expectations. In other words, for a certain range of the Phillips curve, the (short-run) expectations have no influence. The Phillips curve keeps being constant at that range. Therefore, the inflationary expectations will not be changed (with the target inflation rates set by the central bank possibly playing a key role) since the actual inflation is not changing. In this paper, based on a Post-Keynesian point of view, I expect to find a horizontal relationship over a relevant range of capacity utilization rate.

4 Econometric methodologies

In this paper, I use a well-known econometric methodology to test the significance of the coefficients of capacity utilization rates and the long run relationship between inflation rate and capacity utilization rate, based on the data from 1970 to 2003. Furthermore, I also use the Johansen Cointegration method to test for the long run relationship between the inflation rate and the capacity utilization rate from 1990 to 2003, since as discussed above, many Post-Keynesians have argued that there is no obvious long run relationship between these two variables over the last ten or fifteen years. We shall see whether the results of these tests are consistent with the Post-Keynesian point of view.

4.1 OLS test and significance of coefficients

Econometricians have proposed many different approaches to estimate the parameter of the linear regression model. The method of Ordinary Least Squares (OLS) has long been the most popular. In my test, I use the OLS method to choose the estimator so as to minimize the sum of squared errors or residuals of the regression

model and test the significance of coefficients.

To test the significance of coefficients, we should add the linear restriction in the model. There are two different kinds of tests used in this paper.

(1) The test of single variable significance of the regression.

It is a t-test that is performed for every regression equation, since it tells us whether or not the single independent variable significantly impacts on the dependent variable. If the variable seems not significant, it indicates that there is some problem to introduce this variable into the model. The null and alternative hypotheses for this test is:

H_0 : The slope coefficient of this variable is zero (or $\beta_i = 0$).

H_1 : The slope coefficient of this variable is not equal to zero (or $\beta_i \neq 0$).

If the t-statistic is less than the critical value, determined by the significance level, i.e. the P-value is greater than 0.05³, we can not reject the null hypothesis. The independent variable does not significantly impact on the dependent variable. Otherwise, we can reject the null hypothesis.

(2) The test of overall significance of the regression

It is an F-test that is also used in every regression equation, since it shows us if the model we have estimated appears to have any explanatory power. If the model does not seem to have any explanatory power at all, there is clearly something wrong with the data used or with the specification of the model. The null and alternative hypotheses for this test is:

³ We assume the significance level is 0.05.

H_0 : All the slope coefficients are zero (or $\beta_2 = \beta_3 = \beta_4 = \dots = \beta_k$).

H_1 : At least one of the slope coefficients ($\beta_2 \dots \beta_k$) is not equal to zero.

As with the t-test, if the F-test is less than the critical value, we can't reject the null hypothesis. The model does not have explanatory power. Otherwise, we should reject the null hypothesis.

I will not elaborate any further, since the OLS estimator and test statistic are commonly used in econometrics². In addition, I perform those tests with the help of Eviews 4.0.

4.2 Unit root test⁴

In my test, I use the traditional Augmented Dickey-Fuller (ADF) Test to determine the presence of unit roots, which is proposed by Dickey and Fuller (1979). The ADF test constructs a parametric correction for higher-order correlation of the residuals by assuming that the series follows an AR(p) process and adding lagged difference terms of the dependent variables to the right-hand side of the regression:

$$\Delta y_t = \gamma y_{t-1} + \beta_1 \Delta y_{t-2} + \dots + \beta_p \Delta y_{t-p} + \varepsilon_t \quad (4-1)$$

The null and alternative hypotheses are written as

$$H_0: \gamma = 0; \quad H_1: \gamma < 0$$

In this regression, Dickey and Fuller (1979) have shown that the distribution of the t-statistic under the null hypothesis is nonstandard, and it is independent of the number of lagged first differences included in the ADF regression. The critical values for the test depend on whether or not a constant (or/ and a trend) are included in the

⁴ See Eviews 4.0 unit root tests introduction

regression⁵.

4.3 The Johansen's Cointegration Test

Johansen's procedure requires rewriting a vector auto-regression (VAR) model of order k :

$$X_t = \mu + A_1 X_{t-1} + \dots + A_k X_{t-k} + \varepsilon_t \quad (4-2)$$

where X_t is an n -vector of non-stationary $I(1)$ variables, A_i is an $n \times n$ matrix of parameters, μ is an n -vector containing deterministic terms, and ε is a vector of residuals assumed to be independently and identically distributed. Equation (4-2) can be transformed into the following model known as VECM (vector error correction model):

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \quad (4-3)$$

where $\Pi = -I + A_1 + \dots + A_k$,

and $\Gamma_i = -I + A_1 + \dots + A_i$, $i = 1, \dots, k-1$.

The Γ_i represents the matrix of the traditional first-difference coefficients which reflect the short-run dynamics of the model. The matrix of coefficients Π captures the information about the long-run relationships among the n variables in the equation. Johansen's method can determine the number of roots that are statistically different from zero. The rank r of the matrix Π indicates the number of cointegrating vectors. Granger's representation theorem states that if Π has a reduced rank r ($0 < r < n$), there

⁵ In practice, if the series exhibits a trend (either deterministic or stochastic), we should include both a constant and a trend in the regression. If the series has a nonzero mean and does not contain a trend, we simply need include a constant in the regression. In the case that the series seems to fluctuate around a zero mean, we need include neither a constant nor a trend in the regression (Hamilton, 1994).

exist $n \times r$ matrices α and β such that $\Pi = \alpha \beta$. The r columns of β are the cointegrating vectors such that βX_t is stationary, while $n-r$ represents the number of common stochastic trends. Each factor of α represents the speed of adjustment for each variable. The larger the value of the factor in α , the faster the variable adjusts. If Π has full rank ($r=n$), all the time series are themselves stationary. On the other hand, if Π has a rank of zero ($r=0$), equation (4-3) can be rewritten as a VAR in first differences, and there is no stationary long-run relationship among the series. Therefore, Johansen's method can not only test the presence of a cointegrating relationship, but it can also examine the relative adjustment speed of each series to the steady state.

We can use the trace statistics to identify the number of cointegrating vectors r . The null hypothesis is that there are at most r cointegrating vectors, while the alternative is that there are less than r cointegrating vectors. The statistic is as follows:

$$\lambda_{\text{trace}} = -T \sum_{i=r+1}^n \ln(1-\lambda_i) \quad (4-4)$$

where λ_i is the characteristic root of matrix Π (for $i=1,2,\dots$) and T is the number of observations. This test can determine the number of roots that are statistically different from zero. ⁶

Another method to determine r is the maximum eigenvalue statistic. In this test, the null hypothesis is that there exist r cointegrating vectors, against the alternative that there are $r+1$ cointegrating vectors. The statistic is as follows:

$$\lambda_{\text{max}} = -T \ln(1 - \lambda_{r+1}) \quad (4-5)$$

The critical values of both statistics are provided by Osterwald-Lenum (1992). It

⁶ The test will begin from $r=0$, until we cannot reject the null hypothesis that there are r cointegrating vectors.

should be noted that the specifications of the alternative hypothesis for these two tests are different and may lead to different results. Moreover, the results of cointegration tests are very sensitive to the choice of lag length for the VECM. It is important to select an appropriate number of lags to construct the error correction model. In this paper, I use the lag intervals as 1 to 4, since I make use of quarterly data and this is frequently used in the literature.

5 The data

In this paper, I will use the inflation rate and the capacity utilization rate. The inflation rate is calculated from the Consumer Price Index (CPI-U) which is compiled by the U.S. Bureau of Labor Statistics and is based upon a 1982 base of 100. The capacity utilization rate is given by the ratio of actual production by business sector factories and other productive establishments in the economy to the potential production of these establishments. The inflation rate data are retrieved from the Bureau of Labor Statistics. Since I can not access the quarterly data for the inflation rate, I transformed the monthly data which I have found into the quarterly data with the help of Eviews4.0. The capacity utilization rate data are obtained in quarterly frequency data directly from Federal Reserve Statistics. Further, for the sake of comparison, the data has been divided into two groups, dependent on the time period. In the first group, the data goes from 1970 to 2003. In the second group, the data goes only from 1990 to 2003.

6 Empirical Results

In a recent paper, a new model with a new view of the Phillips curve is

introduced by Kriesler and Lavoie (2004):

$$\Pi = \beta_1 * (U - U_m) + \beta_2 (U - U_{fc}) + \Pi_n$$

U_{fc} represents full capacity utilization

U_m is some low level of capacity utilization, below which the inflation rate falls

Π_n represents the rate of inflation associated with the normal range of output, subject to supply side shock.

The new model takes into account the fact that there might be a range of growth rates or capacity utilization rates for which increases in economic activity would not have any effect on inflation forces.

In this paper, for the sake of simplicity, I introduce some dummy variables into the model and separate the model into three parts based on the break point of capacity utilization rate, estimating the coefficients and testing the significance of coefficients respectively.

6.1 Test with data from 1970 to 2003

At first, I use the original data of inflation rates and capacity utilization rates from 1970 to 2003 to see the relationship between the two variables.

The results of the ADF tests are reported in Table 1. Since the time series data do not show an obvious trend from Figure 1, hence I test the presence of a unit root in levels including a constant term, but without a trend in the regression. According to the results, the null hypothesis should not be rejected for the inflation series at all 1%, 5% and 10% level of significance. However, the null hypothesis should be rejected for the capacity utilization rate at those levels of significance. The result shows that there

exists a unit root in the inflation series, which means the inflation series are not stationary. Therefore, I use the Johansen Cointegration method to study if there is a long run co-movement between the inflation and capacity utilization rates. Table 2 summarizes the result of the Johansen Cointegration test. The result indicates that for the data from 1970 to 2003, the inflation rate and the capacity utilization rate definitely have the long run relationship which is shown in Figure 7.

Since we have known that there exists a long run co-movement between the inflation rate and the capacity utilization rate, I can use the OLS method to run the regression model to compute the estimates of coefficients and test the significance of coefficients. In my computation, first, I regress the model without interaction variables. Further, considering many neoclassical supporters' point that the empirical Phillips curve has always been implemented by estimating a specification that includes lagged inflation, I use the model:

$$\Pi = \beta_1 * U + \beta_2 * \Pi(-1) + \beta_3 * \Pi(-2) + \varepsilon$$

Where Π is the inflation rate and U is the capacity utilization rate.

The result of the OLS test is shown in Table 3. According to the p-value of the F-statistic, we can conclude that the model does have an obvious explanatory power. The p-values of the t-ratios for all three variables are all equal to 0, which shows that the coefficients of all the independent variables including the constant term are significantly different from zero. Hence, the capacity utilization rate and past inflation rates have a significant impact on the inflation rate. The coefficient of U equals 0.08 meaning that one additional point in the capacity utilization rate will increase the

inflation rate by nearly one tenth of a point. Note however that while this coefficient is highly statistically significant, its economic significance is not so large. The rate of utilization would need to move up by ten points for the rate of inflation to increase by slightly less than one point. Moreover, another interesting finding is that the summation of coefficients of $\Pi(-1)$ and $\Pi(-2)$ is around 1, implying the change of inflation rate is one-to-one with respect to the change of last year's inflation rate, which reflects the point of neoclassical economists who argued that expected inflation rates should fully reflect last year's inflation rate.

Secondly, what I have to do is to determine the values of U_m and U_{fc} . Past economic research found that the stable inflation capacity utilization rate in the manufacturing sector was about 82 percent. For example, McElhattan (1985) estimated a stable-inflation capacity utilization rate of 81.7 percent for 1959-1983. More recent work by Franz and Gordon produced an identical estimate for 1973-1990 even though they used a different estimating equation and a different inflation measure³. Therefore, I try to use 82 percent as the full capacity utilization rate (U_{fc}). Unfortunately, there is no article to provide a clear value for the low level of capacity utilization rate, or even a way to estimate this value. Hence, I will use a method of trial and error to estimate the low level of capacity utilization rate (U_m).

At the beginning, I define three dummy variables to distinguish different ranges of capacity utilization rate. And then, I establish the three models as follows:

$$\Pi = C + \beta_1 * D_1 * U + \beta_2 * \Pi(-1) + \beta_3 * \Pi(-2) + \varepsilon \quad (6-1)$$

$$\Pi = C + \beta_1 * D_2 * U + \beta_2 * \pi(-1) + \beta_3 * \pi(-2) + \varepsilon \quad (6-2)$$

$$\Pi = C + \beta_1 * D_3 * U + \beta_2 * \Pi(-1) + \beta_3 * \Pi(-2) + \varepsilon \quad (6-3)$$

Π and U are defined as the previous part.

D_1 equals 1 if $U > U_{fc}$ and 0 for otherwise.

D_2 equals 1 if $U_m > U > U_{fc}$ and 0 for otherwise.

D_3 equals 1 if $U < U_m$ and 0 for otherwise.

I have tried some capacity utilization rate data as the low level of capacity utilization rate (U_m), such as 75, 76 and 77. The first two experiments didn't give me a perfect result in support of the Post-Keynesian point. However, when I put 77 into the experiments, the results appeared to be reasonable. The results are shown in Table 4.1, 4.2 and 4.3.

Observing the three tables, some results are similar in all three tables. The p-values of F-statistic are all equal to zero. Therefore, the three models have explanatory power. Moreover, we also find the summation of coefficients of $\Pi(-1)$ and $\Pi(-2)$ is nearly equal to 1 in the three separate models, which confirm the conclusion that the inflation rate is truly affected by the expected inflation rate (last year's inflation rate, or at least the inflation rates of the two most recent quarters).

Furthermore, what I am really interested is the difference, especially in the fields of significance of coefficients, among the three models.

From Table 4.1, first, the sign of the coefficient for the variable $U * d_1$ is greater than zero, which means that the capacity utilization rate is positively related to the inflation rate. Then, looking at the p-values of t-statistic, we can see all of them equal 0.0000, less than 0.05 for the coefficients of lagged inflation rate and capacity

utilization rate. Thus the three variables can reject the null hypothesis that the coefficient is zero at the 5% level of significance. In other words, in the case of $U < U_m$ (77), the capacity utilization rate does have a significantly impact on the inflation rate.

Table 4.2 exhibits a quite different story. Even though the p-values of the t-ratios of the lagged inflation term are less than 0.05, the p-value of the capacity utilization rate is greater than this level of significance, i.e., in the case of $U_m(77) < U < U_{fc}$ (82), the dependent variable, the inflation rate, is not significantly affected by the capacity utilization rate. A change in the capacity utilization rate will not have any effect on the inflation rate. The Phillips curve would be a horizontal line within this range.

In Table 4.3, the situation is similar to that of Table 4.1. The positive sign of the coefficient for the variable U^*d3 shows that the inflation and capacity utilization rates are positively related. The p-values of the t-ratios for all variables reveal that the three variables significantly impact on the dependent variable. Consequently, in the case of $U > U_{fc}(82)$, the slope of the Phillips curve should be positive again.

Hence, the findings are consistent with the new view put forth by some Post-Keynesian authors. As argued by Kriesler and Lavoie(2004), there would only be a trade-off between inflation and unemployment at very low and very high levels of capacity utilization, with the inflation rate being constant for levels of a large intermediate range of capacity. In this case, the Phillips curve would be horizontal for large ranges of output and employment (Freedman, Harcourt and Kriesler 2004).

6.2 Test with data from 1990 to 2003

As discussed above, I have tested the Phillips curve using the data from 1970 to 2003, remembering that in the above case, the inflation and capacity utilization rates have a long run relationship, according to the result of the Johansen Cointegration test. However, recently, many economists have argued that capacity utilization is not a reliable inflation indicator after 1990. There is not a stable relationship between inflation and capacity utilization any more. In the following part, I will use the Johansen Cointegration test using data from 1990 to 2003 to see if there still exists any stationary relationship between the two variables.

First, I test for unit roots with the new data; the results are shown in Tables 5. According to the results, the null hypothesis should not be rejected for the inflation series at all 1%, 5% and 10% levels of significance. Moreover the null hypothesis should not be rejected for the capacity utilization rate at those levels of significance either. The result shows that the inflation rate series and capacity utilization rate series both have unit roots, which means the two series are not stationary.

Thus, I use the Johansen Cointegration method to study if there is a long run co-movement between inflation and capacity utilization rate with new data. Table 6 summarizes the result of the Johansen Cointegration test. The result indicates that for the data from 1990 to 2003, the inflation rate and the capacity utilization rate no longer have a long run stationary relationship. Since the result of the Johansen Cointegration test is sensitive to the chosen length of lagged variables, I take a longer lag. Nonetheless, the result shows there is no cointegration equation until the lag length is 11 (nearly three years). Therefore, I conclude that there is no stationary

relationship between the inflation rate and the capacity utilization rate.

This result is also consistent with recent findings by economists after 1990. During 1990-1992, the Phillips curve was healthy. However, since 1993, the Phillips curve seems to have disappeared. Inflation rates have kept at low levels, while capacity utilization rates moved up and down. During the second half of 1990s, statistics show that capacity utilization rates were high and then they fell down with the recession induced by the stock market crash and the September 2001 attacks. The relationship between the inflation and capacity utilization rates is not as obvious as before.

Conclusions

A.D. Phillips provided the original relationship between the wage inflation rate and unemployment. His claim, that inflation and unemployment should be negatively related in the long run, does not take into consideration consumers' rational expectations and is questioned by accelerationist economists. Friedman and Phelps showed that there should be no long run trade-off between inflation rate and unemployment rate. The standard long run vertical Phillips curve plays an important role in mainstream economics, and it is supported by the latest fad in neoclassical macroeconomics, the New Consensus.

However, in recent decades, low inflation and low unemployment have made questionable the claims of accelerationist economists. Their Phillips curve would no longer depict the current relationship between inflation rates and unemployment (or

any other measure of demand pressure). Post-Keynesians propose a new argument to describe the Phillips curve. In their view, there would only be a trade-off between inflation and unemployment at very low and very high levels of capacity utilization. Inflation will not change for levels within an intermediate range of capacity utilization.

Using time series data, I analyze the relationship between the inflation rate and capacity utilization rates in the United States. I find that from 1970 to 2003, there exists a cointegration relationship between these two variables. If $U < 77$, and $U > 82$, the capacity utilization rate positively and significantly impacts on the inflation rates; if $82 \geq U \geq 77$, the capacity utilization rate does not have any effect on the inflation rate.

In addition, from 1990 to 2003, there is no cointegration relationship any more between inflation rates and capacity utilization rates. In other words, there is no long run relationship between the two variables in the recent years.

There are still some limitations to my study. A major drawback is that I cannot provide sophisticated statistical measures of the low level (U_m) and the high level (U_h) capacity utilization rates. What I have done is to simulate the two values by means of a succession of experiments, which may lead to some uncertainties in the true statistical significance of my tests. Whereas there is no appropriate way to estimate these two values, trial and error remains a convenient way to determine them.

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Figure 5. Series data

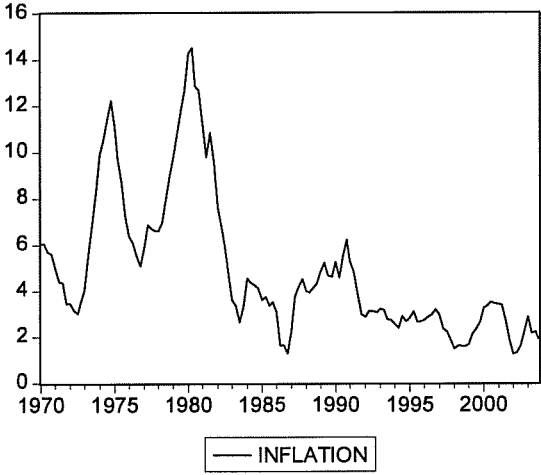
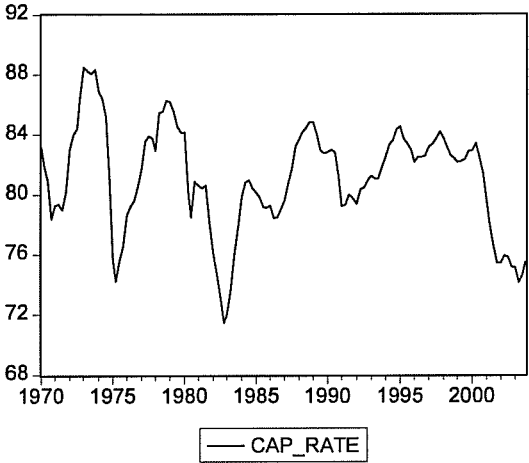


Figure 6. The co-movement between the inflation rate and the capacity utilization rate

(1970-2003).

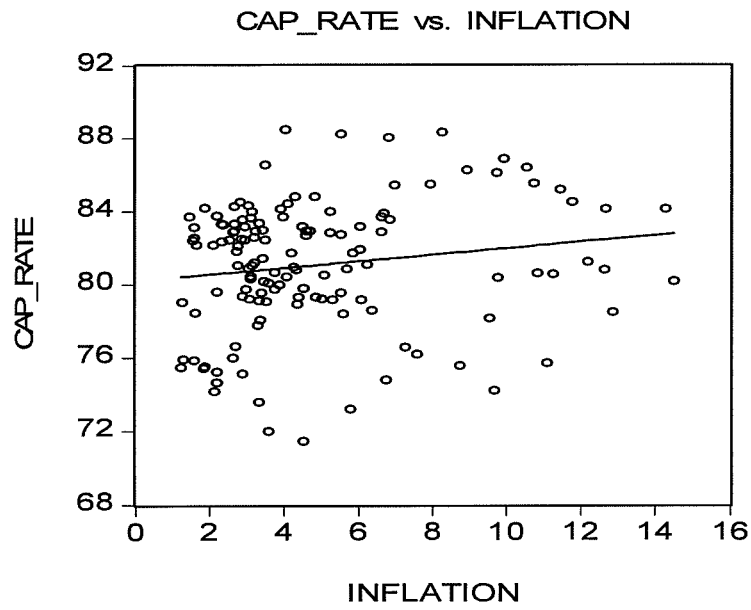


Figure 7. The scatter graph between the inflation rate and the capacity utilization rate

(1990-2003).

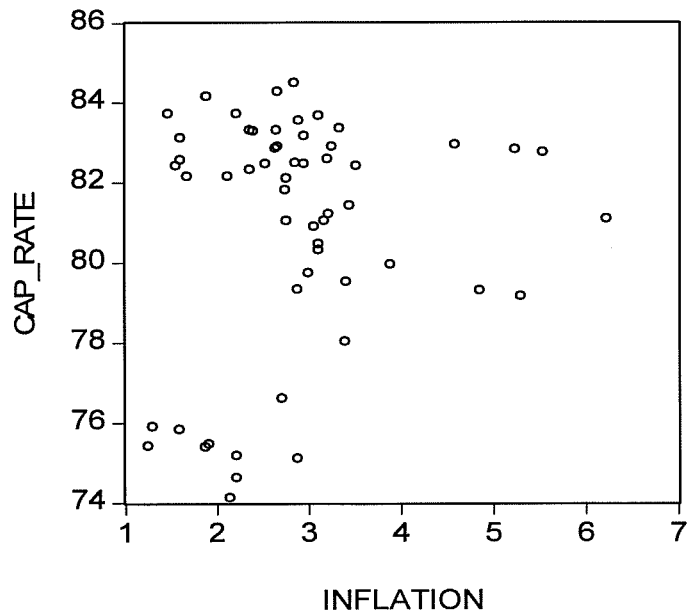


Table 1. Augmented Dickey Fuller (ADF) Unit Root Test Results with data from 1970 to 2003

Variables	Lag Length	ADF Test statistic	Critical value
Inflation rate	4	-1.871793	-2.5783(10%)
Capacity utilization rate	4	-3.547857*	-3.4811(1%)

Notes:

1 * indicates statistically significant at the 1 percent level, ** indicates statistically significant at the 5 percent level, *** indicates statistically significant at the 10 percent level;

2 Maximum lag lengths are 13.

3 The critical values are reported by Mackinnon (1996);

4 The appropriate lag length is selected based on the SICs.

Table 2. Johansen Cointegration test

Hypothesized	H1	Trace Statistics	5% Critical value	1% Critical Value
No. of CE				
$r=0^*$	$r \geq 0$	22.39390	19.96	24.60

$r \leq 1$	$r > 1$	3.948934	9.24	12.97
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Notes:

- 1 The number of observation is 131.
- 2 Lag length in cointegration test is 4.
- 3 The critical values are reported by Osterwald Lenum(1992).
- 4* (**) denotes rejection of the hypothesis at the 5%(1%) level.
- 5 Trace test indicates 1 cointegrating equation(s) at the 5% level, and no cointegration at the 1% level.

Table 3. OLS test for the whole period, 1970-2003 simple regression model.

F-statistic is 1340.546.

Variable	Coefficient	t-Statistic	P-value
constant	-6.871565	-5.364483	0.0000
U	0.086639	5.517018	0.0000
$\Pi(-1)$	1.271585	16.37977	0.0000
$\Pi(-2)$	-0.306784	-3.925573	0.0001

Notes:

- 1 The number of observation is 134.
- 2 The significance level is 5 percent.

Table 4.1 OLS test for $U > U_{fc}$

F-statistic is 1184.902

Variable	Coefficient	t-Statistic	P-value
constant	-0.049672	-0.427455	0.6698
D1*U	0.004637	3.520401	0.0006

$\Pi(-1)$	1.389453	18.17963	0.0000
$\Pi(-2)$	-0.419876	-5.416443	0.0000

Table 4.2 OLS test for $U_{fc} > U > U_m$

F-statistic is 1087.997

Variable	Coefficient	t-Statistic	P-value
constant	0.211877	2.005861	0.0469
D2*U	-0.001493	-1.076414	0.2837
$\Pi(-1)$	1.474417	19.63628	0.0000
$\Pi(-2)$	-0.511583	-6.772883	0.0000

Table 4.3 OLS test for $U < U_m$

F-statistic is 1152.799

Variable	Coefficient	t-Statistic	P-value
constant	0.232369	2.331130	0.0213
D3*U	0.005865	2.944714	0.0038
$\Pi(-1)$	1.416404	18.62321	0.0000
$\Pi(-2)$	-0.453313	-5.927294	0.0000

Table 5 Augmented Dickey Fuller (ADF) Unit Root Test Results with data from 1990 to 2003.

Variables	Lag Length	ADF Test statistic	Critical value
Inflation rate	4	-2.243594	-2.5953(10%)
Capacity utilization rate	4	-1.490480	-2.5953(10%)

Notes:

1 * indicates statistically significant at the 1 percent level, ** indicates statistically significant at the 5 percent level, *** indicates statistically significant at the 10 percent level;

2 Maximum lag lengths are 13.

3 The critical values are reported by Mackinnon (1996);

4 The appropriate lag length is selected based on the SICs.

Table 6 Johansen Cointegration test for period 1990-2003

Hypothesized	H1	Trace Statistics	5% Critical value	1% Critical Value
$r=0$	$r \geq 0$	11.98400	19.96	24.60
$r \leq 1$	$r > 1$	1.415201	9.24	12.97

Notes:

- 1 The number of observation is 51.
- 2 Lag length in cointegration test is 4.
- 3 The critical values are reported by Osterwald Lenum(1992).
- 4 Trace test indicates no cointegration at both 5% and 1% levels.