The Phillips Curve Through Time

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March 20, 2023

1 Introduction

In 1958, New Zealand economist Alban William Phillips published a groundbreaking paper denoting the inverse relationship between unemployment and wage growth within the United Kingdom according to observations recorded from 1861 to 1957. The research became supported by the literature with economists Paul Samuelson and Robert Solow coining the relationship observed as the "Phillips Curve." However, these economists adapted the original concept and compared a more relevant indicator, inflation, against unemployment with US data. The Phillips curve in essence would suggest that low inflation would entail a surge in unemployment, and vice versa, with both phenomena acting as opposing forces. This adaption would lead to the Phillips Curve becoming the indicator of choice when guiding monetary policy in the US and beyond (Dorn 2020). Therefore, the rise of the Phillips Curve within the toolbox of central banks would lead to the strong sense that there was a permanent tradeoff between inflation and unemployment. This fact endured despite Samuelson and Solow stating that their findings pertained primarily to the short run (Samuelson and Solow 1960).

This tradeoff shaped the Federal Reserve's dual mandate, which prioritizes maximum sustainable employment, and price stability, which is another way of saying that the institution targets an inflation rate of around 2 percent. The separation of these two aspects indicates that they are in conflict with each other, as was usually observed. The mechanism for this phenomenon here being that a falling unemployment rate signals an increase in the demand for labor, which puts upward pressure on wages and aggregate demand. As a result of this rise in demand and wages, profit-maximizing firms are forced to then raise prices to accommodate this change (Engemann 2020). However, there has been a shift in the stance within the literature, as more and more findings show that the relationship that Phillips once observed does not hold anymore. Since 1970, policymakers and researchers have noted that the Phillips curve has become flatter, with the inverse relationship of unemployment and inflation seemingly having disappeared (Kuttner and Robinson 2010).

The reason behind this is that the inflation rate has exhibited a fading sensitivity to labor market tightness, as periods of low unemployment and low inflation have been observed. Specifically, the US sustained one of the most extended recoveries in the economy's history in the period after the Great Recession up to 2020, where the inflation rate oscillated around an average of 1.665 percent (Guirguis and Suen 2022). Further research has posited that this goes beyond a US context, as the Phillips Curve relationship does not hold in the long run for other countries (Reichel 2004). The literature often suggests that a decline in sticky prices, that is, firms being able to respond to price changes more quickly, as well as the fact that monetary policy worldwide has begun to respond more aggressively to changes in economic factors, are some of the reasons why the Phillips curve relationship has faded away (Occhino 2019). As a result, a wave of opposition against the Phillips

curve has risen in recency, with many suggesting that it should stop being a guide for monetary policy.

Nonetheless, recent trends originating from the Covid Pandemic have brought the debate about the validity of the Phillips curve back to the forefront. Starting in 2020, the trends predicted by the Phillips curve became pronounced within the American economy as unemployment soared due to lockdowns while inflation plummeted to zero percent. In the subsequent two years, unemployment continued to decrease, while inflation began to soar to a peak of around 9 percent in May of 2022 ("Unemployment Rate — FRED — St. Louis Fed" n.d.). Thus, the inverse relationship once proposed by A.W. Phillips in the 50s reappeared in the last three years, bringing up the question of whether or not the Phillips curve is truly dead. This paper will try to answer this question by analyzing the latest data on unemployment and inflation, building upon the previous literature to arrive at a conclusion. Specifically, this paper will look at the analysis of Guirguis and Suen in their advances in estimating the Phillips curve to determine whether or not the inverse relationship is represented within the data.

2 Theory Review

The way that policy would usually work is through the belief that when the economy operates above its potential level, that is, growth is accelerating at an unexpected pace, the inflation rate is expected to rise as well. This signals to central bankers that a need for monetary contraction is necessary, entailing a rise in unemployment. However, as mentioned above, this relationship has weakened in recent decades with long spans of low unemployment and low inflation having been observed in the US. Thus, before analyzing the data and developing an economic model that can better predict and determine whether or not the predictions of the Phillips curve are correct, it is important to look at the mechanisms that the current literature suggests may have led to the flattening of the Phillips curve.

A common explanation for the flattening of the Phillips curve within the literature is structural changes in price-setting behavior. Specifically, the literature often cites sticky prices and wages as a culprit behind the flattening of the Phillips curve. Kuttner and Robinson suggest that the Calvo Parameter, the probability that a firm will be unable to change its price in any given period, appears to have increased, meaning that the duration between price changes has increased (2010). Furthermore, it appears that firms do not adjust their prices when negative shocks affect the economy, due to the belief that these will be corrected at the predetermined price adjustment. Sticky wages also play a role, as wage adjustments have stagnated since the US economy has shifted towards lower inflation. This is because there is high downward wage rigidity during recessions, where workers do not accept lower wages triggered by these downturns, which leads to lower wage inflation

during recoveries (Guirguis and Suen 2022).

Other explanations are better inflation expectations and better monetary policy administration. Better inflation expectations refer to the fact that a strong prioritization of the Fed's 2 percent inflation target makes the economy less responsive to inflation surprises as, in the long term, it is believed that inflation will eventually get back to the Fed target. Thus, since inflation expectations have become better anchored towards the long-term goal of 2%, individuals have become less responsive to exogenous and endogenous shocks, which might explain the flattening of the Phillips curve (Guirguis and Suen 2022). Others suggest that more aggressive monetary policy responses to economic activity might have led to a flattening of the Phillips curve with the aim of achieving 2 percent inflation. This is because if monetary policy is more aggressive and responsive to changes in economic activity, the output gap, that is, the difference between the natural level of output of the economy and its actual level, becomes smaller and less volatile. If the level of output remains closer to its natural level and becomes less volatile, then the economy will not experience stretches of high inflation, weakening the curvature of the Phillips curve (Occhino 2019).

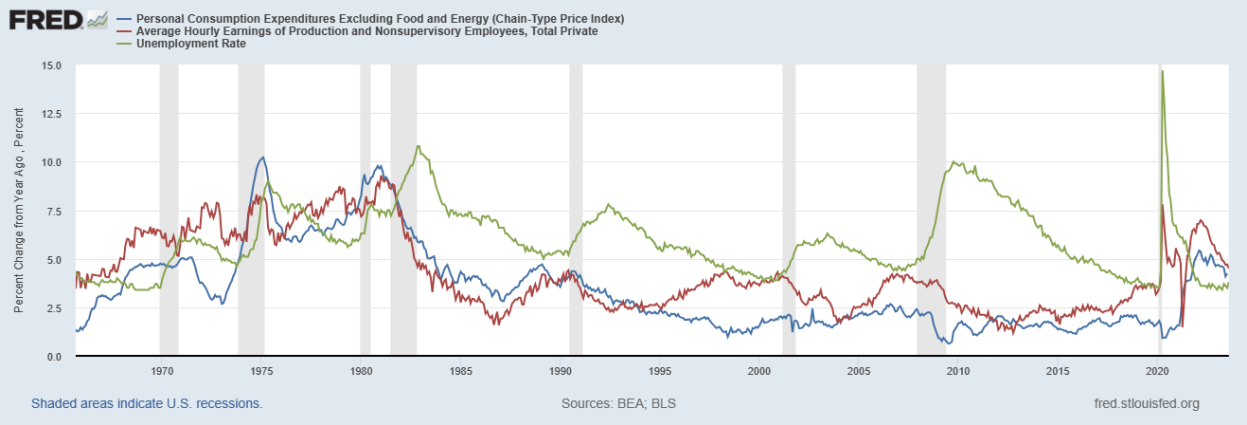
Finally, the literature suggests that data problems and globalization lead to the flattening of the curve. In terms of data problems, the idea is that the current methods of measuring the Phillips curve are flawed. Some researchers suggest that using PCE inflation is limited in that it focuses on the price components of inflation, excluding signals of structural changes in the economy and the driving forces that affect inflation and lead to its fluctuations. In exchange, some suggest the Underlying inflation Gauge or wage growth as alternatives to use when measuring the Phillips curve (Guirguis and Suen 2022). In terms of globalization, the argument is that it weakens the link between unemployment and PCE inflations. Firstly, global supply chains and competition have reduced the power of firms to adjust prices to changes in marginal cost. Secondly, an increase in imports to the US since 1995 means that inflation is not affected as much by domestic unemployment, instead being affected more by international prices and shocks. For example, factors such as oil prices, exchange rates, and international commodity prices have become more relevant in determining inflation in the US, something that could have weakened the link between labor slack and inflation (Forbes 2019).

3 Analysis

3.1 Exploratory Data Analysis

A common theme in our analysis is comparing core PCE vs wage growth to measure inflation. We were inspired to compare the two by the origins of the Phillips Curve, which used wage growth to measure inflation. Now, core PCE is commonly used by the Federal Reserve to measure infla-

Figure 1: Inflation and Unemployment



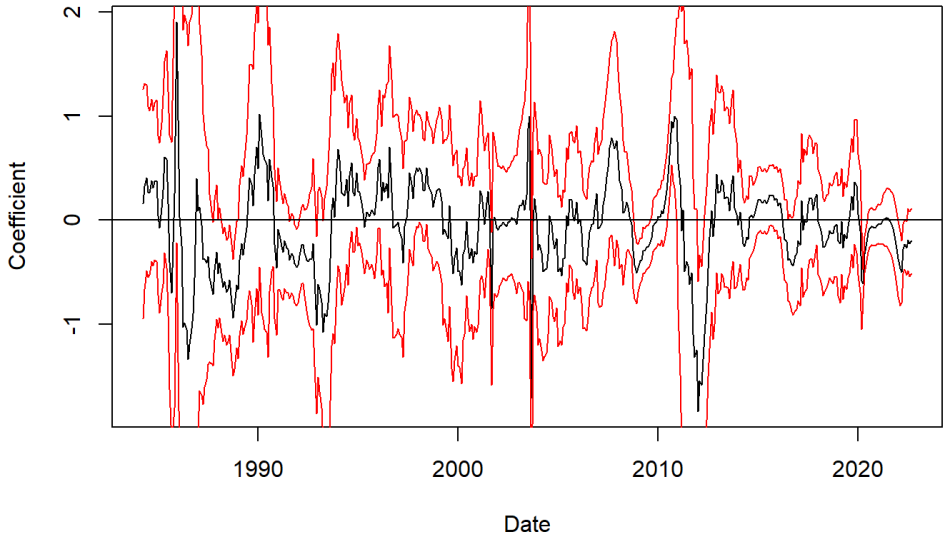
Notes: This figure displays time series data of wage growth, core PCE, and unemployment taken from FRED. Recessions are shaded.

tion and set targets. Figure 1 displays time series of core PCE, wage growth, and unemployment together. Visually, it's easy to identify periods where inflation and unemployment are moving in opposite directions, but we can just as easily find periods where they move similarly.

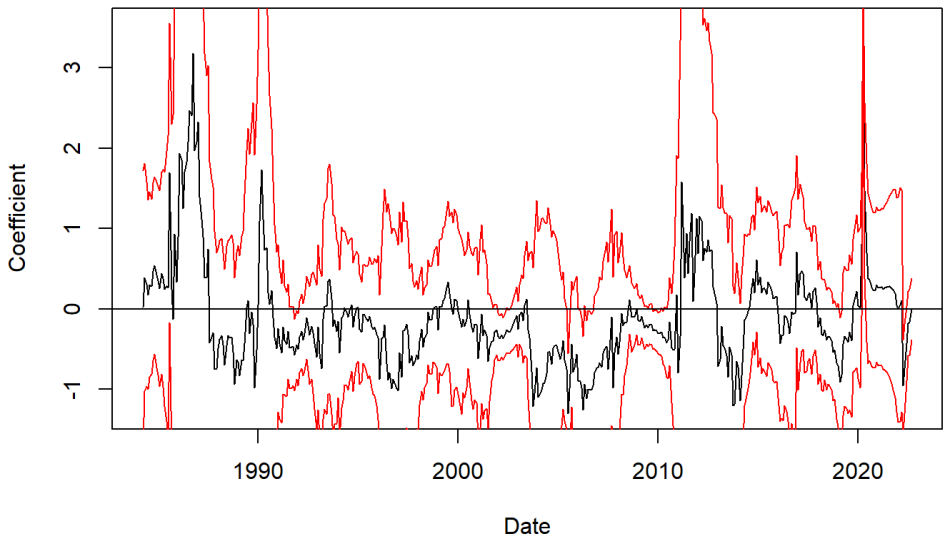
We pull most of our data from FRED and the Bureau of Labor Statistics. One of our first approaches was to simply regress inflation against unemployment at different points in time using a rolling regression. Our rolling regression uses a two year window on monthly data, for 24 observations per window, going back until 1982. We also plot the 95% confidence interval to examine significance. The results are shown in Figure 2. For core PCE, the coefficient is usually insignificant. There are brief periods of significance in the late 1980s, near 2008, and 2020. At each of these points, the coefficient is significantly negative, which would support the inverse relationship that the Phillips Curve describes. There is one small period near 2011 at which the coefficient is significantly positive. For wage growth, the coefficient is only ever significantly positive in 2020. There are some very small periods of a significant negative coefficient, and these are different from those displayed in the core PCE graph. This portion of our exploratory analysis offers two main takeaways: first, the Phillips Curve might be more prevalent around times of economic crisis, such as recessions. This is show by the graph for core PCE. Second, core PCE and wage growth give different results. This suggests that they might have different stories to tell.

We take another initial approach of a simple regression of inflation against unemployment, again using both core PCE and wage growth. This time, we include numerous control variables such as lagged inflation, expected inflation, nominal GDP, and the federal funds rate. A key difference with this regression is the use of cyclical unemployment as our measure of unemployment. We find this by subtracting the estimated natural rate of unemployment from the rate of unemployment. We also examine the change in cyclical unemployment. The results are displayed in Table 1,

Figure 2: Rolling Regression, Inflation vs Unemployment



(a) Core PCE



(b) Wage Growth

Notes: This figure displays unemployment coefficient for a rolling regression with a two year window. Core PCE and Wage Growth are compared in the two panels as different measurements for inflation. There are no other terms in the regression. The black lines show the estimated coefficient, while the red lines show the 95% confidence interval. The data spans from May 1982 to September 2022.

and the equation is as below:

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1}^{Wage} + \beta_2 \pi_{t-1}^{CPCE} + \beta_3 \pi_{t-1}^{e} + \beta_4 u_t + \beta_5 \Delta u_t + \beta_6 G_t + \beta_7 FR_t + \beta_8 \Delta FR_t$$

Where π^e is expected inflation, u is cyclical unemployment, G is nominal GDP, and FR is the federal funds rate.

The two coefficients of most interest are those for unemployment and its change. Both measures of inflation yield a significant estimate for both coefficients. For cyclical unemployment, the coefficient is negative only for wage growth. For the change in cyclical unemployment, however, the change is negative only for core PCE. Again, a negative coefficient supports the Phillips Curve. These results suggest an inverse relationship between inflation and unemployment for wage growth, but an inverse relationship between inflation and the change in unemployment for core PCE.

3.2 Event Study

Our primary analysis follows from Guirguis and Suen (2022), who estimate the following equation

$$\pi_t = \alpha + \beta \left(\frac{u_t - u_t^*}{u_t} \right) + \delta \pi_{t-1}^{e} + \sum_{i=1}^{6} \gamma_i \pi_{t-i} + \theta_1 \pi_{import,t-1} + \delta_1 \pi_{NP,t-1} + \delta_1 EX_{t-1} + D_{NBER} + \epsilon_t$$

where u is the rate of unemployment, u^* is the natural rate of unemployment, π^e is the expected inflation, π is inflation, and $\pi_i mport$ is the quarterly annualized log change in the ratio of prices of imported goods to domestic goods. π_{NP} is the price change in non-petroleum goods, EX is the broad effective exchange rate for the United States, and D_{NBER} indicates a recession.

Having seen some evidence in our exploratory analysis that the relationship between inflation and unemployment might change during a period of economic crisis, we expand this equation as an event study around recessions. We add indicators for the time relative to the recession in years and interact them with relative unemployment. The data is now quarterly, and the included variables only go back as far as 1995. This severely limits our data, and we can only use a few recessions. Aside from comparing different measures of inflation, we also compare our analysis with all variables from the paper's equation to a slightly simplified equation that drops a couple of variables in favor of an extended time period that includes more recessions. Specifically, we drop the variables for exchange rates and relative imports. This yields four different regressions, displayed in Table 2.

An important result to notice is that the estimates using wage growth as the measure for inflation are robust to the inclusion and exclusion of exchange rates and relative imports. Dropping these

Table 1: Regression: Inflation against Unemployment with Controls

	Core PCE	Wage Growth
	(1)	(2)
Core PCE, Lag	0.209^{***}	0.164^{*}
	(0.044)	(0.068)
Wage Growth, Lag	0.065^{**}	-0.040
	(0.022)	(0.035)
Cyclical Unemployment	0.007^{*}	-0.017^{**}
	(0.003)	(0.005)
Cyclical Unemployment, Change	-0.035^{**}	0.332^{***}
	(0.011)	(0.017)
Expected Inflation, Lag	0.052^{***}	-0.006
	(0.011)	(0.017)
Nominal GDP	0.025^{***}	0.021^{**}
	(0.005)	(0.008)
Fed Funds Rate	-0.005	0.002
	(0.004)	(0.006)
Fed Funds Rate, Change	0.027	-0.026
	(0.021)	(0.033)
Constant	-0.021	0.238^{***}
	(0.019)	(0.030)
N	485	485
R^2	0.369	0.477
Adjusted R^2	0.358	0.468
Residual Std. Error (df = 476)	0.113	0.176
F Statistic (df = 8; 476)	34.786^{***}	54.294^{***}

Notes: This table displays estimates for a regression of inflation against unemployment and several other control variables. Each column uses a different measure of inflation, one being core PCE, the other being wage growth.

variables to include more recessions has little effect on the estimates. Within the wage growth models, the only significant coefficients are during a recession and in the ”other” category of time, which is anything outside of two years before and three years after a recession. The time period during a recession yields significantly positive estimates, suggesting a direct relationship between inflation and unemployment. This goes against what we expected from our exploratory analysis of core PCE, which showed a negative relationship near recessions. The estimate for ”other” times is negative. Overall, these results suggest that inflation usually has an inverse relationship with unemployment until a recession. However, we would expect that there is an inverse relationship up until a recession, but this is not shown in the other estimates.

The estimates for core PCE differ between the original and extended time-period regressions. When time is prioritized, only the coefficient for unemployment 1 year after a recession is statistically significant, and even then it isn't economically significant. When staying true to Guirguis and Suen (2022), the only statistically significant coefficient (besides controls) is that during a recession. This is negative, supporting our previous theory that the Phillips Curve with respect to core PCE holds during recessions, but the magnitude of the coefficient is small, implying little economic significance. The magnitude in the models using wage growth is much larger during a recession, suggesting a stronger relationship.

4 Conclusion

While our estimates do not provide robust evidence for the relevance of the Phillips Curve, we show the importance of considering different measurements of inflation. In addition, our results suggest that economic crises play an important role in the Phillips Curve. Even though the statistically significant estimates aren't all economically significant, they give reasons to further explore these ideas in the future with new approaches. Finally, the robustness of our results using wage growth as a measure for inflation indicate that it might be wise to include wage growth in future analyses.

Table 2: Modified Regression

	Core PCE	Wages	Core PCE	Wages
	Controls Prioritized		Time Prioritized	
	(1)	(2)	(3)	(4)
All Other Time	0.001	-0.010^{**}	0.0004	-0.010^{***}
	(0.002)	(0.004)	(0.002)	(0.004)
2yr Before Recession	0.004	-0.007	0.0001	-0.009
	(0.006)	(0.013)	(0.004)	(0.011)
1yr Before Recession	0.001	0.005	0.002	0.004
	(0.006)	(0.011)	(0.003)	(0.009)
During Recession	-0.004^{**}	0.026^{***}	-0.001	0.023^{***}
	(0.002)	(0.004)	(0.002)	(0.003)
1yr After Recession	0.005	-0.0004	0.003^{*}	0.001
	(0.004)	(0.007)	(0.002)	(0.005)
2yr After Recession	-0.001	-0.001	-0.001	-0.001
	(0.003)	(0.007)	(0.002)	(0.005)
3yr After Recession	0.004	-0.002	0.0003	-0.004
	(0.003)	(0.007)	(0.002)	(0.005)
N	113	113	163	163
R^2	0.598	0.675	0.702	0.599
Adjusted R^2	0.482	0.582	0.664	0.532

Notes: This table displays estimates for an event study regressing inflation against unemployment and numerous control variables. The models in the first two columns prioritize the controls presented in the paper. The third and fourth columns prioritize a larger time period, dropping variables for exchange rates and relative imports.

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