An Econometric Analysis of Inflation and Unemployment in Ireland

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The continued relevance of the Phillips Curve is explored in this essay. Orson Francescone contributes to the debate by investigating the unemployment inflation relationship in Ireland, since the 1980s. He concludes that the original Phillips Curve relationship exists in Ireland over the period investigated and that inflation is negatively related to unemployment.

'Since 1970 the Phillips curve has become an unidentified flying object and has eluded all econometric efforts to nail it down'
Arthur M. Okun

Introduction

More than forty years have passed since Professor Phillips outlined the relationship between inflation and unemployment and to this day, the dust lifted from the huge debate sparked by his paper has not settled. It is not an exaggeration to say that most of the post-Keynesian macroeconomics has the critique, or reappraisal, of the Phillips curve, embedded in its genetic structure. It is for these reasons that I found the topic particularly interesting and it is why I have decided to conduct an econometric analysis of the relationship with regards to Ireland and specifically during the period from 1983 to 2001.

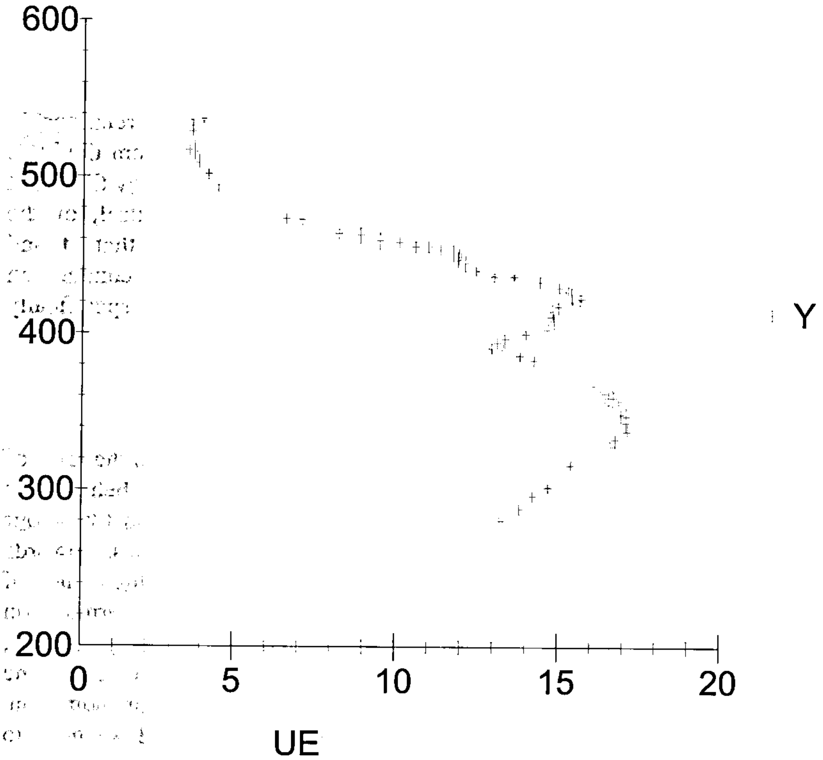
Theoretical background

In his original paper, Phillips discovered a negative relationship between the level of growth of money wages and the unemployment rate. The reasoning behind this relationship being that, similarly to the goods market, when the demand for labour increases (decrease in unemployment), its price (money wages), increases. Towards the end of the 1960s high levels of unemployment accompanied by high rates of inflation, led to the demise and downfall of the relationship, and to the formulation of the "Expectations-augmented" Phillips curve by Friedman and Phelps (1968), through the introduction of the concept of inflation expectations, implying that the trade-off between inflation and unemployment is only a short run phenomenon. Because my econometric model is a relatively simple one, this is all we need to know about the theoretical advances that have been made in this topic. However, one must bear in mind that many more important studies on this issue have been published since, particularly important the one by Lucas and Rapping(1970), in which the relationship is actually inverted.

The evidence

Before I introduce my model, I think it is useful to look at a scatter plot of the quarterly observations of the Consumer Price Index (CPI), on unemployment from 1983 to 2001.

Fig. 1.



From a quick visual inspection, it emerges that for most observations the negative relationship between inflation and unemployment holds in a striking way, although it is also quite clear that for the remaining observations the relationship is actually inverted from negative to positive. This inspection of the data would lead me to state that it is reasonable to try and fit a curve relating inflation and unemployment but that caution must be taken when deciding a functional form for the relationship.

The Model

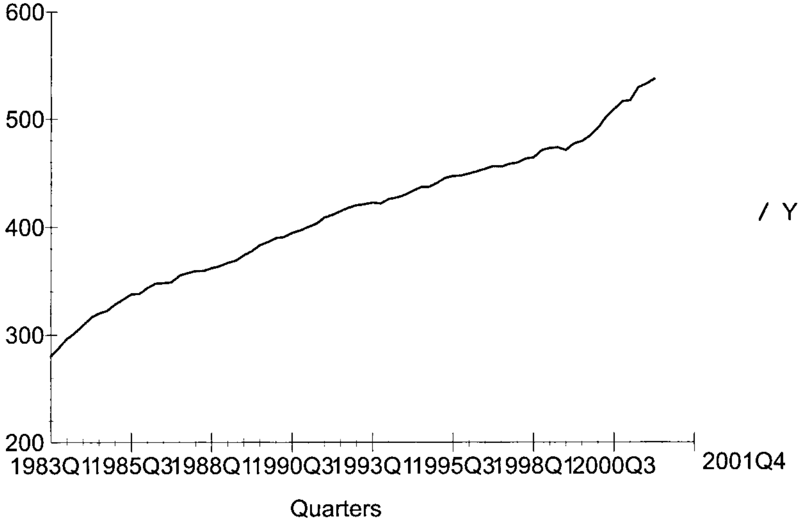
My econometric model will take the following form:

$$Y=\alpha+\beta_1X_1+\beta_2X_2+\beta_3D_1+u$$

Dependent Variable

Y: Consumer price index
My dependent variable is the CPI, which is designed to measure the change in the average level of prices paid for consumer goods and services by all private households in the country. I am using a quarterly series to base November 1975. There are two reasons behind my decision to use the level of goods inflation rather than wage inflation. Firstly, it has become a widely accepted practice in the study of the relationship between inflation and unemployment to use wage inflation and goods inflation interchangeably. This is based on the observed behaviour of wages' and goods' price level, which move closely together. Secondly, quarterly data on wages in Ireland has only become available recently, and in order to get a better insight into the possible inflation-unemployment relationship, I deemed quarterly data to be more appropriate than annual, thus opting for goods inflation rather than wage inflation. Figure 2. is a plot of the CPI against time and it is not surprising to observe a constant steadily increase in the index through the years.

Fig. 2.



Explanatory variables

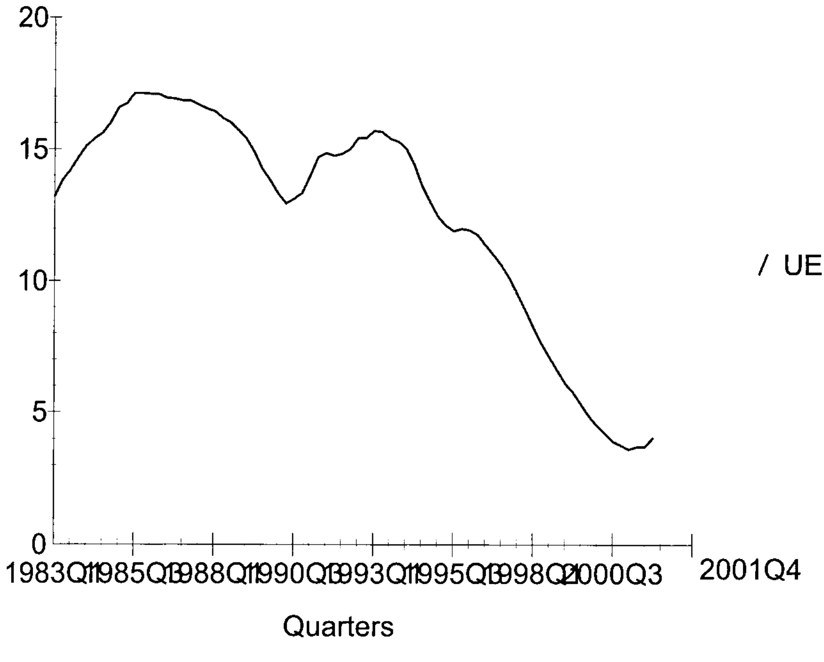
X_1: Standardised Unemployment Rate

The Standardised Unemployment Rate (SUR) is based on the estimated number of people unemployed expressed as a percentage of the total economically active population (i.e. the labour force), using internationally comparable definitions of employment and unemployment, as recommended by the International Labour Organisation (ILO).

I have expressed this variable in a reciprocal form, X^{-1}. This is because the relationship between inflation and unemployment has been previously found to be highly non-linear. The theoretical backing to the non-linearity assumption has taken several forms. Lipsey (1960), stated that, because unemployment can never become less than zero, it must approach zero as excess demand approaches infinity thus implying a smooth asymptotic curve. Santomero and Seater (1978), proposed that if it is assumed that increases in excess demand for labour have diminishing marginal returns in reducing unemployment, then a non-linear Phillips curve emerges.

Because of the evidence of Fig 1, in which we can see clear patterns of negative linearity followed by swings to patterns of positive linearity, I suspect a highly non-linear relationship, and this belief strengthens the case for using a reciprocal function of the unemployment rate. Fig. 3 is a plot of the SUR over time.

Fig.3.



X_2: Inflation expectations

This is a proxy for inflation expectations constructed as follows:

$X_2 = \{Y - Y_{-1}\}_{-1}$ where Y denotes the CPI.

This variable has been constructed by taking the difference between the CPI at time t and the CPI at time t-1 and lagging this difference by one period. The theoretical justification of including expectations into the Phillips curve model is important and was forwarded by Friedman and Phelps. It is crucial we understand why this variable is included and a brief explanation will follow. Let us assume that the economy is at a level in which there is full equilibrium in the labour market. The government decides it wants to boost aggregate demand further thus causing unexpected inflation. Employers will "trick" workers by offering the same (but now lower real wage) or a slightly higher wage (but still lower real wage). This will cause people to enter the labour market and unemployment to fall. We thus have a short-run Phillips curve. But workers will eventually realise that real wages have fallen and demand higher money wage rates. How much higher money wage rates will depend on expected inflation. If workers expect the new rate to be equal to that just experienced, and if this is realised, the "tricking" will cease and the unemployed will no longer prematurely abandon their job search leading to a rise in unemployment. So the only way to decrease unemployment is to surprise workers by increasing inflation again, this process will eventually lead to an inflationary spiral. Thus Friedman asserted that movements along the curve reflect only surprise inflation and that a different short-run Phillips curve relations exists for different rates of expected inflation. It follows that the coefficient β_2 should be equal to one so that to each different rate of expected inflation corresponds a separate short-run Phillips curve.

D : Incomes policies dummy variable
This is a binary qualitative variable used to take account of the effect of incomes policies on the inflation level. It takes the form:

D=0 Incomes policies not in place.

D=1 Incomes policies in place.

Incomes policies are government policies aimed at directly influencing wage rate growth as an attempt to reduce high rates of inflation. Theoretically one would expect that, if incomes policies fulfil their purpose, lower rates of inflation should be observed during "policy on" periods than during "policy off" period. In Ireland, from 1983 to the first quarter of 1987 there were no incomes policies in place. There have been incomes policies in place under several forms and guises for every subsequent year up to today.

Regression

Multiple Regression results

Throughout this paper I am performing Ordinary Least Squares estimations of the regression coefficients

Ordinary Least Squares Estimation
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Dependent variable is Y
74 observations used for estimation from 1983Q3 to 2001Q4
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
X1	672.6057	49.1502	13.6847[.000]
X2	3.6477	1.1799	3.0916[.003]
D	68.2795	7.4195	9.2027[.000]
C	304.7401	7.6336	39.9210[.000]

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R-Squared	.86751	R-Bar-Squared	.86183
S.E. of Regression	22.6928	F-stat. F(3,70)	152.7767[.000]
Mean of Dependent Variable	414.2835	S.D. of Dependent Variable	61.0490
Residual Sum of Squares	36047.3	Equation Log-likelihood	333.9768
Akaike Info. Criterion	337.9768	Schwarz Bayesian Criterion	342.5849
DW-statistic	.29039		

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Diagnostic Tests
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Test Statistic	LM Version	F Version
A:Serial Correlation	CHSQ(4)=56.8424[.000]	F(4,66)=54.6639[.000]
B:Functional Form	CHSQ(1)=10.8592[.001]	F(1, 69)= 11.8668[.001]
C:Normality	CHSQ(2)=4.5428[.103]	Not applicable
D:Heteroscedasticity	CHSQ(1)=.15775[.691]	F(1,72)=.15381[.696]

My estimated line of best fit is

$$Y=304.7401+672.6057X_1^{-1}-3.6477X_2+68.2795D$$

Analysis of multiple regression results

Statistical significance of regression coefficients

Under the null hypothesis that the regression coefficients are equal to zero, that is to say:

$H_0: \beta_1 = \beta_2 = \beta_3 = 0$

The critical t value for n-k (70) degrees of freedom and a 5% level of significance is approximately equal to 2. We thus have two cut off regions (this is a two tailed test), the limits of which are+ 2 and –2. As we can see from the regression output table, all the t-ratios of our regression coefficients fall in one of the rejection regions. We can thus reject the null hypothesis and state that, at the 5% significance level, all our regression coefficients are different from zero.

This result could be inferred by looking at the p-values associated with the coefficients. In fact there is a 0% probability of committing a type I error in relation to C, X_1 and D, and only a 0.3% in relation to X_2

Analysis of individual coefficients

The coefficient of the unemployment variable,β_1 is quite a large positive number. This indicates a strong negative relationship between inflation and unemployment as we have been using the reciprocal of the standardised unemployment rate in our model for reasons outlined above. Thus inflation and unemployment seem to move in opposite directions as proposed by Phillips.

We will now turn to the coefficient of the expected rates of inflation β_2 . From the negative coefficient there would seem to be a negative relationship between inflation and its expectations. The negative sign is consistent with the belief of inflation following a mean reverting pattern. In fact, if inflation deviates from its mean either upwards or downwards, we will expect it to move in the opposite direction in the next time period so as to return to its original trend, hence the term "mean reverting". It is interesting now to test whether the coefficient is statistically different from 1. This is the coefficient consistent with Friedman's expectations augmented Phillips curve theory. Let:

$H_0: \beta_2 = 1$

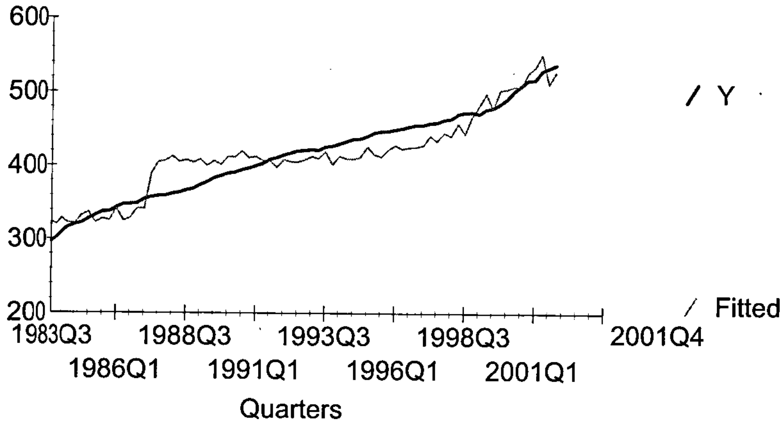
Then: $t = (-3.6477-1)/1.1799 \sim t$ 70df $t=-3.9390$
and we know that: $t_{70,0.025} \cong 2$
Clearly our test statistic falls in the rejection region on the left hand tail of the t distribution, so we reject the null hypothesis that β_2 is equal to one and it appears we can refute Friedman's theoretical findings.

Looking at β_3 , the coefficient on the incomes policies dummy variable, we can see, quite surprisingly, that it is a positive number. This means that when D takes on a value of 1(policy on), the intercept term shifts up by 68.2. It appears that incomes policies are having the opposite effect of what they were designed to do (decrease inflation). There is in fact an increase in inflation when they are in effect. Although surprising, this is not inconsistent with other findings. In one of their studies, Lipsey and Parkin(1970) noted that 'the data are not inconsistent with the view that wage and price restraints have usually been ineffective in restraining inflation, and also that the restraints have sometimes actually had the effect of raising the rate of inflation above what it would otherwise have been'

R^2: Coefficient of determination

The coefficient of determination is a measure of goodness of fit. In our model R^2=.86751 which is quite a high value. This means that 86% of the changes in Y can be explained by changes in our independent variables. An important property of R^2 is that it is a non-decreasing function of the number of explanatory variables. A more exact measure of goodness of fit, which takes into account the number of explanatory variables, is the adjusted R^2. In our case it is still high, standing at .86183.The level of goodness of fit can also be deduced by looking at the plot of the actual and fitted lines in Fig 4.

Fig. 4.



F-statistic

The F-statistic, which tests the overall significance of the sample regression, is F=152.7767

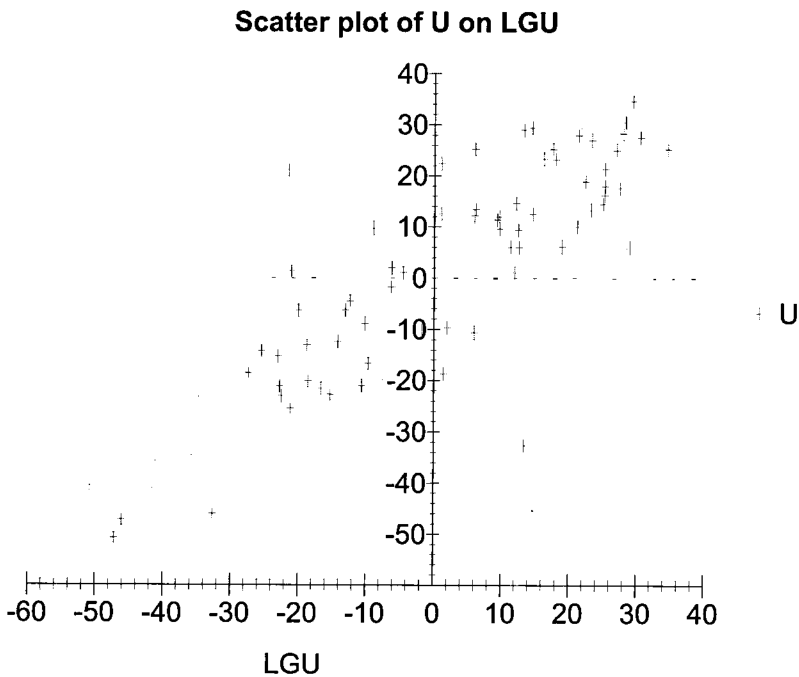
If we use the 5% level of significance, $F_{(3,70)} \cong 2.76$. Thus our F-statistics falls well into the rejection region and we can reject the null hypothesis of the model having no overall significance.

DW-statistic

The Durbin-Watson statistic gives us an indication of whether autocorrelation is present in our model or not.

In our model DW=.29039. For 74 observations and 3 explanatory variables d_L=1.395 and d_U=1.557.As 0 <.29318<1.395, we should reject the null hypothesis of no positive autocorrelation and should accept that our model has positively correlated disturbance terms. It must be noted, however, that the Durbin-Watson d test is inappropriate in this case as the regression model includes lagged values of the dependent variable in one of the explanatory variables, namely in X_2. In such cases the Durbin h test is appropriate. To detect the presence of autocorrelation it is useful to look at the plot of the residuals at time t against their value at t-1. Figure 5 reveals to us the classical pattern of positively correlated disturbances. It is important to note that, although the OLS estimation remains unbiased in the presence of autocorrelation, it is not efficient. This is a serious problem in that the t and F tests of significance we have performed are less legitimate.

Fig. 5.



Regression diagnostics

The *Lagrange multiplier* test for residual serial correlation confirms our findings. With a χ^2=56.8424 well beyond the critical value of $\chi^2(4)$=14.8602 at the 5% level of significance we reject the null hypothesis of no serial correlation.

Ramsey's RESET test for correct functional form produces aχ^2=10.8592. Unfortunately, this value is also beyond the critical value of $\chi^2(1)$=7.87944 and we must reject the null hypothesis of correct functional form.

The *Jarque-Bera* test of normality of residuals returned a χ^2=4.5428. This figure is below the critical value of $\chi^2(2)$=10.5966. We thus fail to reject the null hypothesis of normally distributed residuals and can conclude that the disturbances in the model follow a Normal distribution.

The test for *heteroscedasticity* based on the regression of squared residuals on squared fitted values returned a χ^2=0.15775, this is well below the critical value of $\chi^2(1)$=7.87944. We thus fail to reject the null hypothesis of homoscedasticity and can conclude that our residuals have constant conditional variances.

95% Confidence interval for X_1
This will take the form: $\beta_1 \pm t_{\alpha/2}\, se\,(\beta_1)$
Where α=5%. Then $t_{(70,0.025)} \cong 2$.
Thus 672.6057±2(49.1502)= 672.6057±98.3004
This means that $574.3053 \leq \beta_1 \leq 770.9061$
Thus we can see that, due to the large standard error associated with the coefficient, β_1 stands in quite a large confidence interval.

Forecast

I will test the forecasting capabilities of this model by substituting values for September 2001's Standardised Unemployment Rate and expected rates of inflation and letting D=1(incomes policy in place) into the estimated line of best fit and comparing the result with September 2001's CPI index.

If we substitute the values relating to September into our line of best fit we obtain:

Y=304.7401+672.6057*(1/3.7)-3.6477(1.799)+68.2795

Y=548.2425 which is our forecast value of the CPI for September 01.

Now, the actual value of the CPI for that period was 534.8. Our model has overestimated the CPI by approximately 2.5%. Considering that our model does not explain 100% of the changes in the CPI, I believe this to be a reasonably good forecast. I also regressed my model up to the first quarter of 2001 and forecast the remaining four quarters, obtaining reasonably good results with a mean prediction error of 4.29. Also the Chow predictive failure F test failed to reject the null hypothesis of correct forecasting properties of the model.

Single Equation Static Forecasts
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Based on OLS regression of Y on:
X1 X2 D C
71 observations used for estimation from 1983Q3 to 2001Q1
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Observation	Actual	Prediction	Error	S.D.of Error
2001Q2	529.1000	552.5828	23.4828	25.5039
2001Q3	532.6000	506.0560	26.5440	25.7845
2001Q4	537.2000	527.3792	9.8208	24.4403

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Summary statistics for single equation static forecasts
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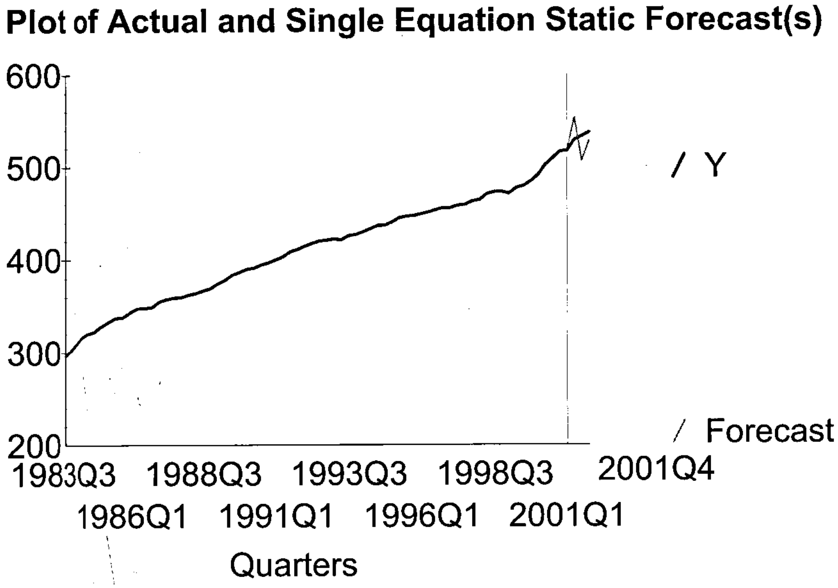
Based on 3 observations from 2001Q2 to 2001Q4			
Mean Prediction Errors	4.2940	Mean Sum Abs Pred Errors	19.9492
Sum Squares Pred Errors	450.8246	Root Mean Sumsq Pred Errors	21.2326
Predictive failure test	F(3,67)=.74751[.528]		

Fig. 6.



Conclusion

The model I have estimated returned all statistically significant coefficients at the 5% significance level and a relatively high value of R^2. Theoretically I can assert that Phillips' original finding is supported by this model in that there is a clear negative relationship between inflation and unemployment. With regards to Friedman's proposition, I rejected the hypothesis of a unit coefficient on the expected inflation variable thus rejecting the expectations augmented version of the Phillips curve, but the negative sign on the same variable supports the belief in inflation following a mean reverting pattern. This model supports the view that incomes policies are ineffective in reducing inflation, we can actually observe an increase in inflation during the years an incomes policies was in place. The overall forecasting properties of the model also seemed to be quite good.

However, having stated these findings we must not forget that this model has failed to pass a test for functional form implying there might be a specification error in the current formulation of the model. Wanting to speculate on the nature of this incorrect functional form, the non-linear relationship between inflation and unemployment is probably more complex than the one presented in this paper. More importantly though, another of the assumptions of the Classical Linear Regression Model has been violated, namely that of the absence of serially correlated errors. Strong positive autocorrelation has emerged from this regression. This is a serious problem in that in the presence of autocorrelation the residual variance is likely to underestimate the true variance and as a result we are likely to overestimate R^2. More importantly the coefficient variances may be underestimated, therefore the t and F tests of significance are no longer valid, and if applied, are likely to give misleading conclusions. Autocorrelation is not an insurmountable problem and there are several ways of taking remedial action against it. It would be interesting to see if our t and F statistics are still significant after correction for autocorrelation. This, unfortunately, would take us beyond the scope of this paper.

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