Temporal Ordering of Inflation and Inflation Uncertainty: Evidence from the United Kingdom

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The positive relationship between inflation and inflation uncertainty is well supported by empirical evidence in the literature. However, this does not answer the question of whether the inflation *causes* the inflation uncertainty and vice versa or both in the Granger sense. The empirical evidence provided from the United Kingdom suggests that inflation and inflation uncertainty cause each other for the monthly data from 1962:02 to 2002:09.

Key words: Inflation, Inflation uncertainty and ARCH.
JEL codes: E31, C32 and E37.

I. Introduction

Okun (1971) and Friedman (1977) argue that inflation is positively associated with inflation uncertainty. Okun claims that the reason for this positive relationship is that during periods of high inflation monetary policy becomes more unpredictable and this makes inflation more uncertain. Friedman (1977) defends his reason as the stop-and-go monetary policy that accompanies inflationary periods. Froyen and Waud (1987), Ball and Cecchetti (1990), Evans (1991) and Evans and Wachtel (1993) provide empirical evidence concerning this positive relationship. However, these studies did not examine whether the inflation rate *causes* inflation uncertainty or vice versa or both. Ball (1992) argues that higher inflation creates greater uncertainty about future inflation. He also presents a model in which there are two types of policy makers; one of these policy makers is willing to tolerate a recession to reduce inflation, but the other is not. When expected inflation is high, policymakers face a dilemma: they would like to decrease the inflation, but fear the recession that would result. The public does not know the preferences of future policymakers, and thus cannot know whether disinflation will occur. Hence, inflation causes inflation uncertainty in his model, Cukierman and Meltzer (1986), on the other hand, claim that the causality runs in the other direction as the central bank dislikes inflation but values the higher employment from monetary surprises. Cukierman and Meltzer's model predicts that if there is a lack of commitment and monetary policy is discretionary, then an inflationary bias occurs during periods of increased uncertainty. As a result, there is an increased incentive for the central bank to act opportunistically and create inflation surprises during periods of increased inflation uncertainty, as it is harder to assess policymaking when there is a high uncertainty.

Holland (1995) assesses this direction of causality and finds that inflation *causes* inflation uncertainty in the United States and that higher inflation uncertainty leads to lower average inflation because of the stabilization motives of policymakers. Grier and Perry (1998) showed that inflation significantly raises inflation uncertainty in all G-7 countries, but that increased inflation uncertainty raises inflation only in Japan and France.

This paper estimates the temporal ordering of inflation and inflation uncertainty for the UK. Using the UK data has certain advantages. Firstly, the UK has had a considerable variation in its inflation rate. This makes it easier to detect a possible relationship between inflation uncertainty and inflation that cannot be detected for countries with low inflation variability. Second, the earlier literature on inflation uncertainty provides a benchmark for comparing results. The empirical evidence provided here suggests that inflation and inflation uncertainty cause each other for the monthly data from 1962:02 to 2002:09. In particular, an increase in inflation increases inflation uncertainty, and increased inflation uncertainty increases inflation. Moreover, the empirical evidence for the post-1973 era suggests that this result is also robust. This is not parallel to what Grier and Perry (1998) find for the UK. They claim that an increase in inflation increases inflation uncertainty, but an increase in inflation uncertainty may not *cause* the inflation; and even if it does, inflation uncertainty decreases inflation. There are two possible reasons for this difference. (i) We are using different time periods than what they used; their sample size is 1948:1 to 1993:12, and ours is 1962:02 to 2002:09, and even more probable. (ii) We are using different specifications for inflation and inflation uncertainty from the ones they used. We incorporate inflation in the inflation uncertainty and inflation uncertainty in the inflation specifications simultaneously when we assess the temporal ordering. However, they adopt a two-step procedure. In the first step, they model the inflation with its own lags and conditional variance with various conditional variance specifications which do not incorporate the inflation itself. In the second stage, they perform the temporal ordering between the inflation and inflation uncertainty measures that they gathered from the first stage.

In order to assess whether the inflation and inflation uncertainty *cause* each other, we used the analogue of the Granger causality test, where inflation uncertainty is measured as a class of Autoregressive Conditional Heteroscedastic (ARCH) models parallel to Holland (1995), and Grier and Perry (1998). The Granger causality test is not the true causality test, but rather a test to see if one variable precedes the other. Hence, in this paper, we assess whether inflation or inflation uncertainty comes first for the United Kingdom but call it the *causality* test.

The class of ARCH models is not the only way to measure uncertainty. Using the variation in the survey forecast or Kalman filters might be other alternatives. Bomberger (1995) claims that using the variation of the survey data gives the measure of disagreement not the uncertainty.[1] Moreover, the forecast value of inflation might be biased because forecasters may try to avoid deviating too much from each others in their forecasts. However, ARCH specification assumes that the parameter in the inflation equation is constant. We could allow the coefficients to be changed. Evans (1991) defines two types of inflation uncertainty: Uncertainty on the short term prospect of inflation – measured with the conditional variance of inflation equation residuals; and uncertainty on the long term of prospect of inflation – measured with the changing coefficients of the inflation equation. Evans finds that there is a relationship between long-term inflation uncertainty and the level of inflation. He also finds that there is evidence for the US that uncertainty due to changing coefficients could be important. Nevertheless, since the main interest here is in the relationship

[1] He argues that ARCH models answer the question "What confidence could an observer have in a randomly selected individual forecast if he or she were familiar with the pattern of errors generated by such a forecast?" On the other hand, survey data answers "What confidence would an observer have in current mean forecasts if he or she were familiar with the pattern of errors generated by the forecasters?"

between inflation and the short-term uncertainty prospect of inflation, the assessment of the relationship between inflation and inflation uncertainty due to changing coefficient was left for future research. The plan of this paper is as follows. The next section develops and outlines the methodology. The model is then estimated using the United Kingdom consumer price index monthly data. Then the findings of the paper are summarized in the final section.

2. Model

In this study, inflation uncertainty is estimated with the class of ARCH models. The first step is to specify the inflation equation. Following Berument (1999) and Grier and Perry (1998), the inflation equation is specified as an autoregressive process:

$$\pi_t = \alpha_0 + \sum_{i=1}^{r} \alpha_i \pi_{t-i} + \varepsilon_t \tag{1}$$

Where π_t is the inflation rate, ε_t is a mean zero i.i.d. disturbance, at time *t* and *r* is the lag order. Least Square estimates assume that ε_t has a constant variance. However, ARCH specification allows the variance to be time dependent. Here, it is assumed that ε_t is a discrete-time dependent process with a *t*-distribution in order to account for the excess kurtosis as given by:

$\varepsilon_t \sim t(0,h_t)$

Note that the conditional variance of ε_t given by the information set at time *t-1* (h_t) is not assumed to be a constant. Engle (1982) shows that it is possible to simultaneously model the mean, π_t, and variance, h_t, of a series. Following Engle (1982) and Bollerslev (1986), the conditional variance of ε_t (h_t) is modeled with the given information set at time *t-1* as the Generalized ARCH(p,q): that is

$$h_t = \beta_0 + \sum_{i=1}^{q} \beta_{1i} \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_{2i} h_{t-i} \tag{2}$$

To avoid the non-negativity of conditional variance, β_0, β_{1i}, β_{2i} must be non-negative. Moreover, to guarantee non-explosiveness of conditional variance $\sum_{i=1}^{q} \beta_{1i} + \sum_{i=1}^{p} \beta_{2i}$ should be less than one.

Okun (1971) and Friedman (1977) argue the presence of a positive relationship between inflation and inflation uncertainty. In order to assess the direction of causality, it is necessary to incorporate the uncertainty measure in the inflation equation and incorporate inflation in the inflation uncertainty specification.

Grier and Perry (1998) estimated equations (1) and (2) jointly to gather the uncertainty measure (h_t), then perform the temporal ordering between inflation and h_t. However, for the incorporation of uncertainty or inflation equation, we used the method suggested by Engle, Lilien, and Robins (1987). They extend the ARCH specification to allow the conditional variance (or conditional standard errors) to affect the mean equation. To be specific, the inflation equation is specified as

$$p_t = a_0 + \sum_{i=1}^{n} a_i p_{t-i} + \sum_{i=0}^{m} a_{mi}\sqrt{h_{t-i}} \qquad (3)$$

Moreover, for the incorporation of the inflation variable to variance specification, the following equation is estimated:

$$h_t = b_0 + \sum_{i=1}^{q} b_i e_{t-i}^2 + \sum_{i=1}^{p} b_i h_{t-i}^2 + \sum_{i=1}^{l} b_{li} p_{t-i} \qquad (4)$$

Then whether inflation or inflation uncertainty leads to the other can be tasted.[2]

3. Empirical Evidence:

First, the inflation and conditional variance equations are estimated jointly by using the *Full Information Maximum Likelihood* method as suggested by Pagan and Ullah (1988). We use the UK's monthly inflation data covering the period from 1962:02 to 2002:09. Data was taken from the *International Monetary Fund – International Financial Statistics* tape. The inflation is measured using the logarithmic first difference of the consumer price index. The Final Prediction Error Criteria suggests that the lag order of the inflation equation is twelve.[3] First, we estimate the inflation equation by using the ordinary least square method. The Q-statistics for the residual terms of this equation are 2.24 and 20.59 for the first 12 and 24 lags; none of the Q-statistics is statistically significant.[4] Thus, the Q-statistics suggest that the residuals are not autocorrelated. Next, we performed the ARCH-LM test that Engle (1982) proposes on those residuals for the constancy of the residual variances. The ARCH-LM statistics are 21.08 and 24.05 for the first 12 and 24 lags. Even if the ARCH-LM test does not reject the null hypothesis on the constancy of the residual variances for 24 lags, it does for the 12 lags. Thus, the ARCH-LM tests suggest the presence of the ARCH effect in the inflation equation.

$$p_t = \underset{(1.99)}{0.45}\sqrt{h_t} + e_t \qquad (5a)$$

$$h_t = \underset{(1.06)}{0.004} + \underset{(3.20)}{0.154}\, e_{t-1}^2 + \underset{(13.54)}{0.78}\, h_{t-1} + \underset{(1.50)}{0.016}\, p_{t-1} \qquad (5b)$$

Log likelihood = 67.793

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[2] Grier and Perry (1998) used h_t as a measure of uncertainty but we used $\sqrt{h_t}$ instead. The reason for this choice is to match the moments with the inflation. However, the basic results of this paper are robust when h_t is used as a measure of uncertainty.

[3] The Final Prediction error criteria determine the lag order such that error terms of the inflation equation are no longer autocorrelated. This is important because Cosimano and Jansen (1988) show that autocorrelated errors make the ARCH-LM test suggest the presence of the ARCH effect even if the ARCH effect is not present.

[4] The level of significance is at the 5% level, unless otherwise stated.

Parallel to Grier and Perry (1998), the conditional variation is estimated with the Generalized ARCH (1, 1) specification. The estimates of equations 3 and 4 are reported in equations 5a and 5b, respectively, and the *t-statistics* for each estimated coefficient are reported under the corresponding estimated coefficients. In order to save space, we did not report the estimates of coefficients for 11 monthly dummies or for 12 lag values of inflation in the inflation equation. Note that the estimated coefficients of the ARCH specification are all positive. This satisfies the non-negativity of the conditional variances. Moreover, the sum of the estimated coefficients of the squared lag residual and lagged conditional variance is less than one. This satisfies the non-explosiveness of the conditional variances. The estimated coefficient of the lag value of inflation in the conditional variance equation is positive but not statistically significant. However, the estimated coefficient of the conditional variance (standard error here) in the inflation equation is positive and statistically significant. This suggests that inflation uncertainty *causes* inflation, but not vice versa. Thus, one can argue that inflation uncertainty does precede inflation, but not vice versa. This is not parallel to what Grier and Perry (1998) found for the UK.[5]

The estimates reported in equations 5a and 5b only include h_t and p_{t-1} for inflation and conditional variance specifications. However, these assumptions might be too restrictive. We also estimate the specification by using additional lags. Among all these estimates, the Bayesian Information Criteria suggests that the best estimate is

$$p_t = \underset{(2.19)}{0.370}\sqrt{h_t} + e_t \qquad (6a)$$

$$h_t = \underset{(0.79)}{0.035} + \underset{(4.10)}{0.26}\, e^2_{t-1} + \underset{(10.42)}{0.67}\, h_{t-1} - \underset{(-2.75)}{0.038}\, p_{t-1} + \underset{(3.66)}{0.069}\, p_{t-2} \qquad (6b)$$

Log likelihood = 71.774

The estimated coefficient of the conditional standard error in the inflation equation is positive and statistically significant. Moreover, except for the constant term, the estimated coefficients of the conditional variance equations are also statistically significant. These suggest that inflation and inflation variability *cause* each other.[6] The first lagged value of inflation is negative, but the second one is positive in the conditional variance equation. Thus, since the sum of these coefficients is positive, it can be concluded that while inflation

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[5] We also performed Q and ARCH-LM tests as specification tests for our model by using the standardized residuals (i.e., $e_t / \sqrt{h_t}$). The Q-statistics are 10.43 and 30.83, and ARCH-LM statistics are 19.83 and 30.48 for 12 and 24 lags. None of these test statistics is statistically significant. These statistics support the validity of our specification.

[6] The Q-statistics are 12.08 and 30.11, and the ARCH-LM statistics are 16.63 and 31.67 for 12 and 24 lags for the standardized residuals. None of these test statistics is statistically significant, either.

uncertainty increases inflation, higher inflation increases inflation uncertainty.[7] As robustness tests, we incorporate (i) the conditional variance of the inflation rather than the squareroot of the conditional standard errors, (ii) different lag orders of inflation equations and (iii) different lag orders of Generalized ARCH specifications. The basic results of the paper are robust.

4. Conclusion

A number of models imply a positive relationship between the rate of inflation and inflation uncertainty. In this paper, the classes of ARCH models are used to construct measures of monthly inflation uncertainty in the UK for the period from 1962:02 to 2002:09. Then the relationship between inflation and inflation uncertainty is examined. The empirical evidence suggests that inflation and inflation uncertainty cause each other in the Granger sense.

[7] The negative coefficient in the conditional variance equation for the lagged value of inflation violates the sufficient condition for the non-negativity of the conditional variance. However, simulations show that estimated conditional variances were never negative.

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