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Rational Expectations and The Role of Monetary Policy: Some Tests Based on the Fisher Equation

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INTRODUCTION

In the past, the focus of attention in the context of the policy debate was largely on the short versus the long-run real impact of stabilization policy. In recent years, however, most of the debate has been directed at whether such policies have any real short-run effects. The shift of attention was prompted by the rational expectations models of Lucas [31, 32], and Sargent and Wallace [39, 40], among others. These models profoundly imply that systematic policy, working through the inflationary channel, has no real effects even in the short-run—what is now commonly known as the policy ineffectiveness proposition.

Clearly, this implication is at odds with the traditional (Keynesian and monetarist) view that monetary policy, in particular, has a significant short-run expansionary impact upon real output. Consequently, the policy ineffectiveness proposition has attracted a lot of attention in recent years. At the theoretical level, some economists have advanced counter plausible models implying that systematic monetary policy can still have short-run real effects (for example, Taylor [46] employing the notion of incomplete information within a transition period following a chnage in the monetary rule; Fischer [22] and Canzoneri [12] using the contract theory; Blinder [10] utilizing price rigidity; and Flood and Hodrick [24] drawing on the inventory theory).

The present paper reexamines the evidence relating to the policy ineffectiveness proposition. The analysis builds on previous work in at least three dimensions. First, the most crucial and difficult issue in testing rational expectations models is how to generate appropriate measures of unobserved expected and unexpected inflation. A number of previous studies have relied on some forms of econometric models to estimate the public's expectations of inflation. That is, inflation was regressed on lagged values of some predictors, and the fitted values from the regression were used as a proxy for expected inflation, while the residuals were employed as the unexpected component of actual inflation. Examples of such studies are Sargent [38], Fair [19] and Darrat [14].

These studies, have produced mixed results. For example, while Sargent and Darrat found only the unexpected inflation to exert real effects, Fair claimed that both unexpected and expected inflation have important effects. As Amihud [1] pointed out, part of the problem is that there is no assurance that the estimated proxies of expected and unexpected inflation do, in fact, reflect the expectations of rational economic agents. Based on the Fisher effect, the expected and unexpected inflation effects at issue in this paper are those inferred from actual

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market interest rates. As Fama [18] demonstrated, market interest rates embody rational estimates of future inflation rates. However, contrary to Fama's analysis, due allowance is also made for possible variations in real interest rates.

The present study further undertakes to extend previous work by testing the validity of the policy ineffectiveness proposition in the case of the United Kingdom. It is interesting to note that most studies in this area have confined their attention to the United States' experience with comparatively less work being devoted to other countries.[1] In this paper, we used the United Kingdom as the case study to gain some insight into the robustness of the underlying hypothesis.[2] Finally, the real output testing equation is also modified to take account of the potential real effects of fiscal and foreign variables in the British open economy. Failure to incorporate these two variables are found to lead to serious misspecification.

The rest of the paper is organized as follows. The procedure used to generate series of expected and unexpected inflation is discussed and the estimates obtained are presented below. Next, the policy ineffectiveness proposition is examined and the empirical results obtained are tested. Some concluding remarks follow.

GENERATING EXPECTED INFLATION SERIES

Drawing on the work of Fisher [23], many researchers have decomposed the nominal rate of interest into the ex ante real rate of interest and the expected inflation rate. Fama [18] has suggested that, in the context of an efficient market, the nominal interest rates comprise rational estimates of expected inflation. His argument is that in an efficient market, there is a reliable relationship between the one-period nominal interest rates observed at any point in time and the subsequent one-period rate of inflation. Of course, he presupposes that the real interest rate is constant, an assumption that will be relaxed below due to its questionability particularly for the U.K.[3]

At time t, actual inflation $\dot{p}$ can be decomposed into expected and unexpected elements, or:

$$(1) \qquad \dot{p}_t^u = \dot{p}_t - (\dot{p}_t^e \mid I_{t-1})$$

where $\dot{p}_t^u$ is unexpected inflation at time t, and $\dot{p}_t^e$ is inflation expected for time t based on the information set I available at time $t - 1$. Amihud showed that the one-period nominal interest rate observed at time $t - 1$, denoted by i_{t-1}, can be set equal to[4]:

$$(2) \qquad i_{t-1} = (r_{t-1} \mid I_{t-1}) + (\dot{p}_t^e \mid I_{t-1})$$

where r_{t-1} is the ex ante real interest rate expected at the beginning of period $t - 1$.

Substituting (2) into (1) yhields:

$$(3) \qquad \dot{p}_t^u = \dot{p}_t - [i_{t-1} - (r_{t-1} \mid I_{t-1})]$$

As mentioned above, the ex ante real interest rate r_{t-1} should be treated as a variable rather than a constant especially for the U.K. Thus, r_{t-1} is treated as a function of some lagged variables V_{t-1}:

$$(4) \qquad r_{t-1} \mid I_{t-1} = aV_{t-1}$$

Substituting (4) into (3), we get:

$$\dot{p}_t^u = \dot{p}_t - [i_{t-1} - aV_{t-1}]$$

Rearranging terms, we obtain:

$$(5) \qquad (\dot{p}_t - i_{t-1}) = aV_{t-1} + \dot{p}_t^u$$

or,

$$(\dot{p}_t - i_{t-1}) = aV_{t-1} + E_t$$

where E_t is the vector of residuals representing unexpected inflation. Therefore, rational (market-based) estimates of expected and unexpected inflation may be measured respectively as the predicted values and residuals from regressing $(\dot{p}_t - i_{t-1})$ on the set of the lagged variables V_{t-1}. In other words, expected inflation is measured here by the difference between the nominal and the (expected) real interest rates. The distinction between this measure and the measure used in many previous studies lies in the fact that the former is extracted from the actual market interest rates which has been shown by Fama to closely reflect rational inflationary forecasts. By contrast, there is no assurance that measures obtained from assumed inflationary-generating processes would provide rational inflationary forecasts.

It is clear from equation (5) that appropriate measures of expected inflation depend critically on the selection of variables for inclusion in the vector V_{t-1}. Several authors (e.g., Amihud [1] and Mishkin [34]) have suggested the use of lagged inflation and lagged dependent variables for the U.S. as the only elements of V_{t-1}. Nevertheless, on purely theoretical grounds, it could be argued that monetary growth and budget deficits, in particular, can also exert important effects on real interest rates (see, for example, Motley [37] and Webster [47]). If, in fact, they do, then Amihud-Mishkin's approach would result in misspecification bias. To avoid this problem, the list of variables used here in V_{t-1} includes lagged inflation, lagged dependent variables *and* lagged values of budget deficits and money growth (defined narrowly as currency plus demand deposits). As to money growth, three quarterly lags were found appropriate.[5] Budget deficits, however, did not significantly influence interest rates and thus were omitted from the equation. Similar findings for the United States have been reported, for example, by Evans [16, 17]. One explanation of this result is that budget deficits in open economies could be financed, partly or fully, by an inflow of capital from abroad. Such foreign financing could then weaken any effect that budget deficits might have on domestic interested rates.[6]

Based on the foregoing discussion, the resulting interest rate equation is:

$$(6) \qquad (\dot{P}_t - i_{t-1}) = b_0 + b_1(\dot{P}_{t-1} - i_{t-2}) + b_2\dot{P}_{t-1} + b_3DM_{t-1} + b_4DM_{t-2} + b_5DM_{t-3} + E_t$$

where DM represents money growth.

Ordinary least-squares estimates of equation (6) are given in Table 1 using the British data over the period 1963:1 through 1982:4.[7]

As Demery, Duck and Musgrave [15] pointed out, at least four criteria must be satisfied by equation (6) in order to generate appropriate estimates of rational inflationary expectations. First, the contemporaneous values of the explanatory variables must be omitted from the equation since only information at time $t - 1$ is available when inflationary expectations are formed at time t. This requirement is met by equation (6). Second, the variables employed as predictors of inflation should explain a sizable proportion of the variation in inflation to make the decomposition into expected and unexpected inflation empirically possible. As Table 1 shows, equation (6) fits the data quite well as about 69 percent of the variation in the dependent variable is explained.

Third, equation (6) should also exhibit temporal stability in order to postulate that economic agents had sufficient knowledge about the structure of inflation throughout the

TABLE 1
Estimates of Equation (6)

b_0	b_1	b_2	b_3	b_4	b_5	$\bar{R}^2$	F	SE	DW	Dh	BG
−0.590	0.757 (11.43)	−0.455 (4.03)	0.213 (3.33)	−0.154 (2.25)	−0.023 (0.71)	0.69	34.37	1.586	1.99	0.05	15.86

Notes: The estimation period is 1963:1 – 1982:4; $\bar{R}^2$ is the coefficient of multiple determination adjusted for degrees of freedom; F is the F-value to test the hypothesis that all the right-hand side variables as a group except for the constant term have zero coefficients; SE is the standard-error of the regression; DW is the Durbin-Watson statistic; Dh is the Durbin-h statistic; BG is the Breusch Godfrey χ^2-statistic with 10 degrees of freedom; and absolute values of t-statistics are in parenthesis beneath the coefficient estimates.

period. On the basis of the Chow [13] test, two alternative breaking dates were examined, namely 1971:4 and 1972:2. The first breaking date was selected because Boughton [11], for example, argued that the British financial system may have undergone a structural change due to the introduction of the competition and credit control reforms of 1971. On the other hand, in 1972:2, the U.K. abandoned the fixed exchange rate system which may have resulted in a structural change in equation (6), particularly since the equation does not incorporate an exchange rate variable. For both breaking dates, however, results from the Chow test could not reject the stability hypothesis at the 5 percent level of significance. To check on the robustness of these stability results, an alternative procedure, namely the Farley-Hinich [20] test, was also applied. In contrast to a single-point structural shift examined by the Chow test, the Farley-Hinich procedure investigates whether there is a continuous drift in the equation throughout the period (see Farley, Hinich and McGuire [21] for details). The Farley-Hinich test too could not reject the stability hypothesis at the 5 percent level.[8]

Finally, the errors of equation (6), which are used as a measure of unexpected inflation, must be serially uncorrelated in order to truly reflect the mistakes of rational forecasters. The Durbin-h test indicates the absence of first-order serial correlation among the residuals of equation (6). Of course, serial correlation other than of the first-order type may instead be present. Thus, the Breusch-Godfrey test was also applied. As Johnston [26] noted, the Breusch-Godfrey procedure is a valid test against general autoregressive *and* moving-average processes. The Breusch-Godfrey test confirms the absence of significant serial correlation in equation (6) [the calculated BG = 15.86, and the critical χ^2 (10) = 18.31 at the 5 percent level].

Having provided some evidence on the adequacy of the estimates of expected inflation from equation (6), I now turn to testing the policy ineffectiveness proposition for the British economy.

EXPECTED VERSUS UNEXPECTED INFLATION AND REAL OUTPUT: THE TEST RESULTS

In the second stage of the testing procedure, the following equation of real output is usually estimated and tested for the relative statistical significance of the coefficients on expected and unexpected inflation:

$$(7) \qquad RY_t = C_0 + C_1 RY^* + \sum_{i=0}^{n_1} C_{2,i}\dot{P}^e_{t-i} + \sum_{i=0}^{n_2} C_{3,i}\dot{P}^u_{t-i} + \epsilon_t$$

Where RY is the logarithm of real output (real GNP), RY* is the natural level of real output,[9]

$\dot{P}^e$ and $\dot{P}^u$ are respectively the expected and unexpected inflation measures derived from equation (6),[10] and ϵ is a white noise disturbance term.

Although commonly employed in the literature relating to this area, the above output equation (7) appears *a priori* misspecified for two main reasons. First, the equation presupposes that fiscal policy (budget deficits) has no real effects on the economy. Yet, recent theorizing has shown otherwise (Stephens [44]). Even Laumas and McMillin [30] have found empirical grounds for arguing that fiscal policy exerts significant effects on real output in the United States. Interestingly, this implies that several widely cited studies in this area, in particular, Barro [6, 7] and Mishkin [35, 36] may be biased in the sense that only monetary policy variables are included in their regressions. Indeed, any study [including Laumas and McMillin's] that ignores either fiscal or monetary policy in the real output equation could be seriously biased.

Another source of possible misspecification in the above real output equation is that it implicitly assumes that the economy is "closed" to the rest of the world. While this may adequately characterize the United States' economy historically, it certainly does not reflect the structure of the British economy. In open economies international influences must be taken into account in equations explaining real output behavior.

Preliminary results from the common specification of equation (7) suggests that both unexpected and expected inflation have significant and positive effects upon real output. However, both the Durbin-Watson and the Breusch-Godfrey tests also show that the equation is plagued with significant serial correlation. This finding indicates the seriousness of omitting variables reflecting fiscal and international influences from the real output equation. With significant serial correlation, it is well-known that the usual t and F statistics calculated for equation (7) are no longer valid and thus could lead to erroneous conclusions regarding the policy ineffectiveness proposition.

Therefore, equation (7) was expanded to include the potential positive effects of fiscal policy and exports on real output in the U.K. Equation (7) is then rewritten as:

$$(8) \qquad RY_t = d_0 + d_1 RY^*_t + \sum_{i=0}^{n_1} d_{2,i}DEF_{t-i} + \sum_{i=0}^{n_2} d_{3,i}S_{t-i} + \sum_{i=0}^{n_3} d_{4,i}\dot{P}^e_{t-i} + \sum_{i=0}^{n_4} d_{5,i}\dot{P}^u_{t-i} + \mu_t$$

where DEF represents changes in budget deficits, S represents changes in exports, and μ is a white noise error term.

Following Mishkin [35, 36] among others, the distributed lags in equation (8) were estimated by Almon polynomials. However, in order to avoid the estimation bias problem discussed in Schmidt and Waud [41], I did not impose, a la Mishkin, end point constraints. As recommended by Schmidt and Waud, the degree of polynomials and the length of the lags on the four explanatory variables were determined on the basis of Theil's residual-variance criterion. Table 2 reports the empirical results of equation (8). According to Theil's criterion, a third-degree polynomial with a ten-quarter lag on all explanatory variables was found empirically superior.[11]

The obtained results confirm the prior theoretical considerations and that international influences (proxied by exports) and fiscal policy (proxied by budget deficits) *do* play an important role in determining real output in the U.K. Both variables have the correct positive signs with some statistically significant individual coefficients, though among the two variables only the budget deficit variable has a significant summed coefficient. Another evidence for the importance of including the fiscal policy and foreign variables in equation (8) is that serial correlation is no longer present according to the Durbin-Watson and the Breusch-Godfrey tests.

TABLE 2

Effects of Expected and Unexpected Inflation on Real Output (equation 8)
Dependent Variable = Log (real GNP)

Constant	Time Trend	Budget Deficits	Exports	Expected Inflation	Unexpected Inflation
4.967	0.007	0.002	0.127	0.023	−0.008
	(5.74)	(1.02)	(4.69)	(1.64)	(0.70)
		0.005	0.029	0.007	−0.008
		(2.70)	(2.50)	(0.60)	(0.89)
		0.008	−0.026	−0.002	−0.001
		(3.14)	(1.97)	(0.17)	(0.05)
		0.009	−0.045	−0.006	0.012
		(3.24)	(3.10)	(0.46)	(0.98)
		0.009	−0.040	−0.005	0.026
		(3.18)	(3.10)	(0.49)	(1.95)
		0.009	−0.020	−0.002	0.039
		(2.99)	(1.80)	(0.18)	(2.68)
		0.008	0.004	−0.004	0.050
		(2.70)	(0.34)	(0.55)	(3.15)
		0.006	0.023	0.011	0.055
		(2.34)	(1.63)	(1.41)	(3.41)
		0.004	0.027	0.017	0.052
		(1.96)	(2.00)	(2.47)	(3.49)
		0.003	0.006	0.022	0.038
		(1.46)	(0.48)	(3.26)	(2.99)
		0.001	−0.051	0.023	0.012
		(0.55)	(1.95)	(1.60)	(0.77)
		Sum = 0.064	Sum = 0.034	Sum = 0.084	Sum = 0.267
		(2.73)	(1.30)	(1.57)	(2.75)

$\bar{R}^2 = 0.97$
SE = 0.0107
DW = 2.10
BG = 8.30

See notes to Table 1.

As mentioned earlier, the Lucas/Sargent and Wallace policy ineffectiveness proposition predicts no effect from expected inflation on real output but does predict a significant positive effect from *unexpected* inflation. The empirical results shown in Table 2 do not contradict such a proposition for the U.K.: only the unexpected component of inflation exerts a positive and statistically significant effect on real output. Specifically, the cumulative effect of expected inflation on real output, although positive, is insignificantly different from zero. The sum coefficient on this variable is 0.084 with an insignificant t-statistic of only 1.57. In marked contrast, the sum coefficient on the unexpected inflation variable is substantially larger; 0.267, with a t-statistic of 2.75 that is highly significant at better than the 1 percent level. These results imply that a ten percentage increase in unexpected inflation would, over a period of 2½ years, induce about a three percentage increase in real output. Perhaps more critically, the empirical results further imply that a sharp unanticipated reduction in inflation in any quarter could induce a recession in the British economy starting about three quarters after the initial shock, and lasting for about two years. On the other hand, expected reductions in inflation (perhaps

due to announced monetary decelerations) would have little negative impact upon real economic activity.

CONCLUSION

This study has investigated the empirical validity for the U.K. of the Lucas/Sargent and Wallace policy ineffectiveness proposition that inflation affects real output only if it is unexpected. To derive estimates of unexpected and expected inflation, I employed the Fisher/Fama hypothesis concerning the relationship between nominal interest rates and rational estimates of expected inflation. However, the model incorporates, as the Fisher/Fama hypothesis does not, the assumption that real interest rates are not constant but rather a function of a number of important macro variables. A plot of the expected real interest rates (not reported here to conserve on space) did show significant variation over time as did some previous empirical studies for the U.K. (e.g., Symons [35]). The real output equation tested here also incorporates the potential real effects of fiscal policy and foreign variables in the context of the British economy.

The empirical results indicate that real economic activity in the U.K. is significantly influenced by the openness of the economy and by movements in budget deficits. The results also suggest that only the unexpected component of inflation can have a significant positive impact upon real output in the U.K. The expected component of inflation, by contrast, does not have significant real economic effects. Considering the potential sensitivity of any regression results to measurement errors, model misspecifications and other estimation problems, the results of this paper should be interpreted with caution. At the very least, though, these results suggest that the British experience does not contradict the Lucas/Sargent and Wallace hypothesis. Such evidence, if valid, casts doubt on the usefulness of systematic inflationary (monetary) policy for stabilizing the real side of the British economy even in the short-run.

FOOTNOTES

1. For some cross-country studies, see [5] and [28].
2. Reference should be made here to Attfield, Demery and Duck [3, 4] who tested for the U.K. the related proposition that real output is invariant to anticipated money growth.
3. For example, see [27], [29] and [45].
4. Note that the Fisher equation as written in (2) abstracts from any potential interest-tax effects due primarily to the lack of consistent data.
5. Although insignificant with t = 0.71, the third quarter lag on money growth was kept because it seems to enhance the white noise property of the residuals.
6. Note, however, the actual budget deficits used in this and many other studies (including Evans') are not a good indicator of fiscal policy. This is because changes in these deficit figues can be in part the result of the automatic stabilizing aspect of fiscal policy rather than due to conscious fiscal policy moves. A better indicator is of course to use cyclically-adjusted (high-employment) budget deficits. However, data on this latter measure is not available for the United Kingdom on a quarterly basis. Only annual data on cyclically-adjusted budget deficit figures is published by the OECD, *Economic Outlook*.
7. Inflation, $\dot{p}$, is the rate of change in the GNP deflator; the nominal interest rate, i, is the 91-day Treasury Bill rate; and the money growth variable, DM, is the annual rate of change in M1 (currency plus demand deposits). Data on M1 are the quarterly averages of monthly figures. The nominal interest rate series was derived from the Bank of England, *Quarterly bulletin*. The remaining data were compiled from various issues of *International Economic Conditions* and *OECD Main Economic Indicators*.
8. The calculated F-statistics for the Chow test are 1.62 and 1.45 for the 1971:4 and the 1972:2 breaking

dates respectively. At the 5 percent level, the critical F-value = 2.24. As to the Farley-Hinich test, the calculated F-value = 2.34 and the corresponding 5 percent critical F-value = 2.36.

9. It is assumed that RY* follows a simple time trend path. Such an assumption is commonly made in the literature in the absence of any explicit model to explain the long-run development of the natural rate of output. See, for example, Barro [6] and Mishkin [35, 36].
10. Because the inflation variables could have important delayed effects on the real economy, lags on these variables are introduced in equation (8). For a theoretical rationale, see Blinder [9].
11. The results, however, are robust to alternative lag specifications. Further, equation (8) was also estimated using unconstrained OLS in order to gain insight into the robustness of the results to the details of the estimation procedures. The OLS procedure yielded results that are very similar to the Almon results reported in Table 2.

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