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Authors	K. Alec Chrystal, and David Peel
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Money and Activity in the U.K. 1961-1983: Surprise? Surprise!

K. Alec Chrystal* and David Peel**
Federal Reserve Bank of St. Louis
84-011

*Federal Reserve Bank of St. Louis and University of Sheffield
**University of Liverpool

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ABSTRACT

This is a study of the impact of money growth and money growth surprises on U.K. real activity (GDP and unemployment). We find no support for the 'only surprises have real effects' story except in the 1960s when the fixed exchange rate regime makes exogeneity of money questionable. Some support is found for the older monetarist view that lagged actual money growth has real effects. Our most surprising result is that U.S. M1 growth outperforms both U.K. M1 and sterling M3 as a determinant of U.K. real activity in the floating exchange rate period.

The relationship between changes in the money stock and real economic activity has always been of central concern in macroeconomics. A standard view amongst economists (for example, Friedman, 1968) is that changes in the money stock have real effects in the short run but are essentially neutral in the long run.[1/] More recently Lucas (1973) and Sargent and Wallace (1975) have shown that in an economy where agents have identical information sets, where expectations are formed rationally and there is an 'augmented Phillips curve' or 'surprises supply curve' only unanticipated changes, rather than anticipated changes, in the money stock will have real effects.

Empirical support for this model of the economy has been provided in a variety of papers (see Barro (1977, 1978) for the U.S., Wogin (1980) for Canada, and Attfield, Demery and Duck (1981) for the U.K., among others). Subsequent work has raised doubts about the claims of the above literature. For example, Gordon (1982) achieves a superior statistical fit from a model with sticky prices as compared to the money surprises approach. Mishkin (1983) rejects the hypothesis that only surprises have real effects when long lags of actual money growth are included. Driscoll, Ford, Mullineaux and Sen (1983) reject the restrictions implied by the surprises model. Theoretical problems with the approach have also been pointed out. The identification problem first noted by Sargent (1976) is important but not insurmountable (see McCallum 1979). More important is the problem of possible endogeneity of the money stock

(Buiter 1983). The money "surprises" may themselves be an endogenous response to some 'real' disturbance.

The present study offers some new results using quarterly data for the U.K. The principal novelty of the study arises from the following features

1. The model is fitted separately to periods of fixed and floating exchange rates.
2. We test for the presence of spillovers from U.S. money onto the U.K. economy.
3. Money surprises are generated from one period ahead forecasts of a moving regressions as well as from full period regression residuals.
4. We use both M1 and sterling M3 as measures of the money stock. Previous studies have used only the latter for the U.K.
5. We investigate the role of political factors in the monetary reaction function.

The principal results of our study are that:

1. The surprise model works best for the period of fixed exchange rates. However, during this period exogeneity of U.K. money is questionable. Under the floating regime monetary surprises appear to have little statistical significance.

2. Some spillovers are clearly evident from U.S. money. U.S. money surprises have an ambiguous effect, however, actual U.S. money clearly effects U.K. actively with a lag, post 1972. Indeed, we found that U.S. money alone provided a better statistical fit in U.K. output and unemployment equations than either measure of U.K. money.
3. While the results are not in general favorable to the surprise framework, M1 generally out performs £M3 in this regard. The exception is the 1962-72 period.
4. Using one period ahead forecasts does generate different results as compared to full period regression residuals.

The organization of the paper is as follows. Section I presents the results for the U.K. where only domestic money is considered. Section II compares our results with previous results for the U.K. Section III discusses the impact of U.S. money on the U.K. Section IV summarizes and concludes.

I. Theory

The theoretical framework is the, by now, standard 'rational expectations' market clearing reduced form approach to the business cycle. The reduced form consists of two equations.

$$(1) \quad y_t = \lambda_o (L)\, y_{t-i} + \alpha_1 (m_t - E(m_t | I_{t-1}) + e_t$$

$$(2) \quad m_t = \beta_o + \gamma_i(L)\, m_{t-i} + \sum_{i=1}^{n} \beta_j\, \theta_i(L)\, x_{jt-i} + \mu_t$$

Equation 1 is the reduced form implied by the structural Lucas (1973) or Sargent-Wallace (1975) supply curve. y_t is the deviation of the log of output (GDP) from its natural or normal level. L is the lag operator. The lagged output terms represent the influence of real costs of adjusting the labour or capital stock. Innovations in the rate of change of the money stock occur in the specification since it is assumed that surprise changes in the rate of price inflation, which would be an independent variable in the structural specification, are a linear function of innovations in the money stock.

Equation (2) is the reaction function or monetary change forecasting equation. It includes an autoregressive process on monetary change, and any other predetermined variables, x_{jt-i}, systematically related to monetary changes. e_t and μ_t are white noise errors which are assumed to be uncorrelated.

The specification of the aggregate supply curve is different from those previously used in empirical work in the U.K. economy. Both Attfield, Demery and Duck (1981)(ADD), and Driscoll, Ford, Mullineaux and Sen (1983)(DFMS) treat y as being at its natural or trend level except when perturbed by surprises. However unlike in our formulation, a finite polynomial on monetary innovations is employed rather than restricting the impact of monetary innovations to the current one.

DFMS defend their procedure by noting that (1) can be written as

$$(3)\ y_t = (1-\lambda_i(L))^{-1}\alpha_1(m_t-E(m_t|I_{t-1}) + (1-\beta_i(L))^{-1}e_t$$

In empirical work they approximate the infinite polynomial on the monetary innovation by a finite polynomial. This procedure also implies that the error term is a moving average process, which if e_t is assumed white noise, is of the same order as the monetary innovation term. In fact the disturbance term is assumed to be white noise in both ADD and DFMS empirical work. This implies misspecification. [Also see, Peseran (1982) on this point].

The econometric methodology of the present study is based upon the Barro (1977, 1978) two stage procedure. While the limitations of this procedure are well known, it has advantages which are important in the present study. It is computationally cheap and permits the testing of a wide range of alternative specifications. Comparison is also possible with other studies which used the same approach. Two modifications are incorporated in the present study which also reduce the identification problem present in other work. First, following McCallum (1979) we focus on the impact of contemporaneous surprises only (in any event lagged surprises were consistently insignificant). Second we incorporate 'political' factors in the quasi-reaction function, (2). Electoral dummies were tested but found insignificant. Shift dummies pick up the effect of the Barber 'dash for growth' in 1971 IV to 1973 III and Mrs. Thatcher's 'monetarism' 1979 III to 1983 I (end of period).

The Quasi-Reaction Functions

The quasi-reaction function (2) relates money growth to its own past history and to any predetermined variables which have a systematic influence on money growth. It is important that μ_t be a white noise error, otherwise systematic determinants of money growth are being ignored. The equation is a 'quasi'-reaction function because coefficient estimates reflect not just the behavior of the monetary authorities but also endogenous or structural relationships in the economy.

Targets of policy (inflation, unemployment, balance of payments) were tried, as well as related variables (budget deficit, interest rates). Lags up to 12 were investigated - the autoregressions of money growth was first determined to be no higher than fourth order (typically second order) other variables were then tested sequentially. Variables were excluded on the basis of t statistics and joint F tests (on the hypothesis that the sum of coefficients is zero, where variables were tested in sets of four lags, as in Mishkin, 1983).

While diagnostic tests indicated absence of autocorrelation in our final quasi-reaction function, estimation of the autoregressive error process was conducted. This revealed highly significant negative autocorrelation. By use of the Cochrane-Orcutt method autocorrelation of errors up to 4th order was investigated. It was found that the second order process was best determined. The final form was estimated by maximum likelihood methods on the SHAZAM program.

Two quasi-reaction functions were estimated, one for M1 and one for sterling M3.

The £M3 equation is:

$$(4)\quad M3 = CONST + SEASONALS + \underset{(5.3)}{5.7}\ BARBER + \underset{(10.1)}{0.94}\ M3_{t-1} - \underset{(2.4)}{0.32}\ M3_{t-2}$$

$$- \underset{(.07)}{0.009}M3_{t-3} + \underset{(.64)}{.05}\ M3_{t-4} - \underset{(1.95)}{8.1}\ U_{t-1} + \underset{(2.5)}{28.3}\ U_{t-2} - \underset{(2.9)}{34.8}\ U_{t-3} + \underset{(3.4)}{15.2}\ U_{t-4}$$

$$\bar{R}^2 = .74 \qquad \rho_1 = \underset{(11.4)}{-1.0} \qquad \rho_2 = \underset{(6.4)}{-.56}$$

M3 is $(\log M3_t - \log M3_{t-1}) \times 400$. U is percent unemployment. BARBER as a shift dummy 1971 III to 1973 III. Figures in parentheses are absolute values of t ratios. Those associated with ρ_1 and ρ_2 are asymptotic.

This is notable for the strong negative autocorrelation of residuals. Negative first order autocorrelation of unity suggests that it may be appropriate to estimate on overlapping semi-annual data.

The M1 equation is:

$$(5)\quad M1 = CONST + SEASONALS \underset{(-2.5)}{- 5.7}\ THATCHER \underset{(3.8)}{+ 0.37}\ M1_{t-1} \underset{(1.3)}{+ 0.13}\ M1_{t-2}$$

$$\underset{(.34)}{- 0.037}\ M1_{t-3} \underset{(1.6)}{+ 0.15}\ M1_{t-4} \underset{(1.4)}{- 9.25}\ U_{t-1} \underset{(1.7)}{+ 28.8}\ U_{t-2} \underset{(1.8)}{- 29.7}\ U_{t-3} \underset{(1.7)}{+ 10.7}\ U_{t-4}$$

$$\underset{(3.7)}{- 2.5}\ R_{t-1} \underset{(3.9)}{+ 3.0}\ R_{t-2}$$

$$\bar{R}^2 = 0.56 \qquad \rho_1 = \underset{(8.8)}{-.85} \qquad \rho_2 = \underset{(4.4)}{-.42}$$

The new variables are: THATCHER is a shift dummy 1979 III - end period (1983 I); M1 is as above replacing £M3 with M1; R is the U.K. Treasury Bill Rate. The unemployment terms are jointly significant in the M1 equation at the 5 percent level. The inclusion of THATCHER and BARBER dummies seems justified on the grounds that the associated policy changes were both announced in advance and sustained over some period.

A test of structural stability was performed on both 3 and 4. The data were divided into two periods - 1961 I - 1972 II and 1972 III - 1983 I. Both were subjected to the Chow test. The hypothesis of no structural change between the two periods could not be rejected in either case at the 5% level. It should be noted that the division corresponds closely to the switch from fixed to floating exchange rates.

The residuals from these two equations were taken as the basic measure of money growth surprises. An alternative measure for the period post 1972 II will be discussed below.

Money Surprises and Aggregate Output

The approach we adopt to testing for the impact of money surprises is slightly different from previous work. (A replication of ADD (1981) is presented below, and is a total failure). We test for the significance of the contemporaneous money surprise in the presence of the forecast value of contemporaneous money and lagged values of actual money.[2/] This approach is closely related to that suggested by McCallum (1979). Because variables are included in the reaction function (2) which do not appear in (1) we are able, in principle, to discriminate between the impacts of unanticipated and anticipated money on real output. Of course it is necessary to assume that the two error terms in the equations (1) and (2) are uncorrelated and that output or innovations in output (as might occur from micro responses of the banking system to changes in demand for money due themselves to anticipated and unanticipated changes in output) do not enter the reaction function. If these assumptions are not met then, in general, we will not be able to discriminate between the impacts of anticipated and unanticipated money in real activity since our equations will not be identified. This, of course, is the problem of observational equivalence. (See Sargent (1976), Buiter (1983)). These latter assumptions are also required in order to interpret previous empirical work.

Following Barro (1977, 1978) we estimate equations for both output (the aggregate supply curve, 1), and unemployment. We also offer estimates for our full data period 1961 III to 1983 I and two subperiods (1961 III - 1972 II; 1972 III - 1983 I). The subperiods appear to be very different. This might be expected as they correspond to periods of fixed and floating exchange rates. We shall present a sample of our results explicitly and summarize the rest in table form.

The following is our estimate of the output equation for the full period using M1.

$$(6)\quad y_t = \text{CONST} + \underset{(6.6)}{.74}\, y_{t-1} + \underset{(1.95)}{.21}\, y_{t-2} + \underset{(1.2)}{.05}\, M1R - \underset{(.6)}{.01}\, \hat{M1} + \underset{(1.8)}{.02}\, M1_{t-1}$$

$$+ \underset{(1.6)}{.02}\, M1_{t-2} + \underset{(1.7)}{.02}\, M1_{t-3} + \underset{(1.4)}{.02}\, M1_{t-4}$$

$$R^2 = .99 \qquad \text{D.W.} = 2.0 \qquad F^1_{78} = 8.3$$

where y is the log of real GDP; M1R is the residual from 4, above; $\hat{M1}$ is the fitted value from 4; $M1_{t-i}$ are lagged values of actual M1. The F statistic is a test of the hypothesis that all variables except lagged dependent sum to zero. In this equation the natural level of output is assumed to be constant over our sample period. We did, in fact, experiment with the usual time trend (insignificant) and also a constrained version in which the natural level of output was assumed to grow at 2-1/2% per annum. There were no significant differences in results which are worth reporting. We can reject the hypothesis of a zero coefficient sum at both 5 and 1 percent levels. Notice, however, that the money surprise on its own is not significantly different from zero. The M3 equation is not reported because only lagged dependent variables were significant, no other t-ratio exceeded 0.8, and the same joint F test could not be rejected.

The following is the full period unemployment equation using M3.

$$(7)\ U_t = \text{CONST} + \underset{(20.5)}{1.69}\ U_{t-1} - \underset{(8.1)}{0.7}\ U_{t-2} + \underset{(1.5)}{0.3}\ M3R - \underset{(2.1)}{0.2}\ \hat{M3} - \underset{(0.6)}{.04}\ M3_{t-1}$$

$$+ \underset{(0.3)}{.02}\ M3_{t-2} + \underset{(0.2)}{.01}\ M3_{t-3} + \underset{(1.8)}{.13}\ M3_{t-4}$$

$R^2 = .99$ D.W. = 2.0 $F^1_{78} = 1.39$

Here the money surprise is insignificant, and has the wrong sign. Predicted money is significant and has the right sign - money growth reduces unemployment. The money variables are, however, jointly insignificant at any reasonable probability level.[3/] This result is clearly inconsistent with the "surprises only matter" approach. The equivalent equation using M1 does a little better (the surprise has the right sign and $\hat{M1}$ has the wrong sign) but all money variables are both jointly and individually insignificant.

Table 1 summarizes other results for the full period and the two sub-periods. Two additional variables are included which have been used in other studies. Var P is the squared inflation rate. This is a proxy for the variance of inflation justified in Minford and Hilliard (1978). As it turns out this is either a bad proxy or an inappropriate variable to include. A time trend, T, is also included to pick up trend output growth due to technical change. This contributes to explaining unemployment in the full period and 1970s and to output in the 1960s, but not otherwise. Two lagged dependent variables were included (in all but output 1972-83 where only one was required) but these are not reported.

A 0 is recorded where coefficients are not significantly different from zero at the 5 percent level. The sign of significant coefficients is entered. For lagged money significant coefficients were of the same sign. In most cases this was only one of the 4 lagged money coefficients. This is the sign reported. The F test is a test of joint significance (zero sum) of all but lagged dependent variables. A ✓ indicates that we can reject the hypothesis that the sum of coefficients is zero at the 5 percent level.

The pattern of the results is fairly clear. For the full period neither the money surprise nor fitted money has any significant effect on either output or unemployment (same as discussed above). However, lagged M1 does have a significant real effect with the correct sign. The effect of M1 on unemployment is significant in the presence of a time trend but not without. No M3 variable has an influence on either output or unemployment.

The sub-periods chosen divide the full-period data in half. There is no sub-period re-estimation of the quasi-reaction function. The 1961-72 estimates stick out from the rest. This is the period when money surprises work best, but only in the output equation. No variable significantly influences unemployment. Both M3 and M1 significantly influence output. The surprise has the correct sign and fitted money has a negative coefficient. The M3 equation is slightly more robust - it is better determined and the M1 coefficients are weakened by the inclusion of a time trend. In all cases (of output) lagged money has significant explanatory power. The problem with these results is that this is a period of fixed exchange rates. In such regimes money is normally argued to be an endogenous variable. So the interpretation of these results is open to question. Nonetheless, this is the only period when the money surprises perform at all well.

In the 1972-83 sub-period all money variables are jointly insignificant in terms of the F test. However, the M3 surprise is positively related to unemployment while fitted money reduces unemployment. Notice, though, that even this effect disappears in the presence of a time trend. Lagged M1 does continue to have a significant effect in the period. While in 1961-72 money lags peaked at about 4 quarters (no evidence is presented here beyond 4, lags 5-8 were jointly rejected by F tests but lags up to 6 are reported in Section III) in the output equation, in the post-1972 period the lag to output is shorter. Typically only the first quarter lag is significant. The lag to unemployment is larger -- 4 quarters post-1972. This may explain the absence of effects on unemployment in the earlier period. Unemployment lags output so the effect of money on unemployment would be after more than a year. Such effects may be detected by PDL methods but none was discovered by adding longer lags on money in the present framework.

However, the clear message of these results is that the support for the only money surprises matter story is weak. Money surprises only matter in the 1960s, when their interpretation must be in doubt. Lagged actual money (especially M1) consistently influences real output and post-1972 also influences unemployment.

One Period Ahead Forecasts

One of the problems with taking full period regression residuals as a measure of "surprises" is that the sample includes information not available to actors at the time they make forecasts. Accordingly we generated one period ahead forecasts from a moving regression. We take the same quasi-reaction function as 3 and 4 except THATCHER and BARBER dummies were dropped. Parameters were re-estimated each time adding a new observation and dropping the last one. This regression was moved through the data. The one period ahead forecasts were recorded. The difference between this and the out-turn was recorded as the money surprise. The moving regression was of length 10 years (40 observations) so the first forecast was for 1971II. This method generated a measure of surprises for 47 observations.

For M3 the correlation between these new surprises and the full period residuals (for 1971II - 1983I) was 0.75 and for M1 it was 0.79. Not surprisingly the variance of these forecast errors was in both cases more than double that of the in sample residuals for the same period (M3:29.9 and 84.5; M1:41.8 and 89.0).

For comparison the new surprise measures were used in regressions for the floating exchange rate period 1972III to 1983I. For M3 there was a marginal improvement in the output equation - overall fit improved and the coefficient on the money surprise was better determined, however, the significance of coefficients was unchanged. In the unemployment equation both surprise and fitted money became significant (though with wrong signs, surprise +, fitted -) but only in the absence of a time trend. In none of the M3 equations were money variables jointly significant.

The M1 equations were noticeably improved. The following is the output equation.

$$(8)\quad y = \text{CONST} + \underset{(16.0)}{0.9}\, y_{t-1} + \underset{(1.7)}{.08}\, M1E - \underset{(.96)}{.03}\, \bar{M}1 + \underset{(2.6)}{.06}\, M1_{t-1} + \underset{(.46)}{.01}\, M1_{t-2}$$

$$+ \underset{(0.2)}{.005}\, M1_{t-3} + \underset{(0.8)}{.02}\, M1_{t-4}$$

$$R^2 = .88 \qquad D.W. = 1.9 \qquad h = 0.37 \qquad F^1_{35} = 5.19$$

where M1E denotes the one period ahead forecast error and $\bar{M}1$ denotes the forecast value of money growth. While not significant, the coefficient on M1E is better determined than that obtained using in sample residuals. More importantly we can now accept the hypothesis that the money variables jointly influence real output. This result and the significance of $M1_{t-1}$ is unaffected by the inclusion of a time trend. M1 forecast errors do not significantly affect unemployment but the effect of lagged actual money growth is more robust in the presence of this variable than the other. $M1_{t-4}$ is significant in the unemployment equation with or without a time trend. Though the set of money variables is only jointly significant in the absence of T.

Thus the one period ahead forecasts do marginally better than the full period regression residuals in explaining output and unemployment variation. However, the only differences which affect the acceptance or rejection of hypotheses arise in the M1 equation. The determination of the impact of lagged M1 is improved. The surprises, themselves, however have no significant impact.

II

For completeness we now test the impact of money surprises in the functional form used in a previous quarterly study of U.K. money surprises by Attfield, Demery and Duck (1981)(ADD). There are a number of differences between our study and theirs:

1. Our data period is 1961III-1983I; theirs is 1963I-1978IV, though they appear to drop at least 6 observations owing to use of lagged variables. We actually estimated from 1961III, our lagged values are from earlier periods.
2. They only use £M3. We use £M3 and M1. Our definition of £M3 excludes government deposits but this is only 1 or 2 percent of the aggregate and should have no effect on results.
3. Our surprise variables are only entered contemporaneously and in the presence of other money variables. Their surprises are reported contemporaneously and lagged with no other money variables present. As we argued below this can cause a problem with the error term.
4. We include lagged dependent variables they do not.
5. The generation of our surprise series is considerably different from theirs. In particular, we corrected for highly significant negative autocorrelation of the residuals in our quasi-reaction function.

The two major explanations of the major differences in results appear to be the absence of lagged dependent variables in ADD and the measure of surprise, though the data period contributes a little. The ADD output equation (OLS) was

$$(9) \quad y = \underset{(1141.85)}{9.874} + \text{SEASONALS} + \underset{(27.9)}{.0059T} - \underset{(4.63)}{.034}\ \text{Var P} + \underset{(1.74)}{.304}\ \text{M3R}_t$$

$$+ \underset{(.91)}{.158}\ \text{M3R}_{t-1} + \underset{(2.32)}{.413}\ \text{M3R}_{t-2} + \underset{(2.05)}{.37}\ \text{M3R}_{t-3} + \underset{(.18)}{.548}\ \text{M3R}_{t-4}$$

$$+ \underset{(4.17)}{.741}\ M3R_{t-5} + \underset{(2.29)}{.405}\ M3R_{t-6}$$

$R^2 = .98$ D.W. = 1.48 1963-1978

Using our full period surprises (residuals) and our different measure of Var P but an equation of similar structure we obtained.

$$(10)\ y = \underset{(454)}{5.04} + \text{SEASONALS} + \underset{(25.0)}{.0049T} + \underset{(1.5)}{.00004}\ \text{Var P} + \underset{(.5)}{.04}\ M3R_t$$

$$+ \underset{(.78)}{.06}\ M3R_{t-1} + \underset{(.49)}{.04}\ M3R_{t-2} + \underset{(.36)}{.03}\ M3R_{t-3} + \underset{(.67)}{.05}\ M3R_{t-4} + \underset{(.32)}{.02}\ M3R_{t-5}$$

$$+ \underset{(.14)}{.01}\ M3R_{t-6}$$

$R^2 = .94$ D.W. = .23 1961III-1983I

It should be noted that our money figures were annualized growth rates but reported $x10^2$ so there is still a multiple of 4 difference in our coefficients on money growth. However, scaling does not affect significance. We found a similar result for M1. We found no significant coefficients on surprises for the full period with either M1 or M3. For our subperiod 1961-72 we did find the coefficient on the money surprise significant at lag 4 both for M3 and M1. However, there were no significant coefficients for either aggregate in the 1972-83 sub-period. Indeed with M3 surprises the coefficients beyond lag 1 were all negative (but not significantly so). Notice also the high level of autocorrelation, especially in (10).

We then tested equations of the form of 9 and 10 against the alternative which has the same structure but where the current surprise is replaced by the predicted (fitted) level of money growth and the lagged surprises are replaced by lagged actual money. An F test was performed on the joint significance of the set of surprises in one case and the set of fitted and lagged actual money in the other. The F ratios, R^2 and mean squared error are compared for the two different equations, two different money aggregates, and full period as well as subperiods and reported in Table 2.

For the full period none of the surprises is significant up to 6 lags. M1 does slightly better than M3 but neither set of surprises is jointly significant at anything close to the .05 percent level. In contrast, fitted and lagged actual money are jointly significant at the .001 percent level for both M3 and M1. The M1 coefficients are best determined, with peak lag at 5 quarters (and significant 4-6).

For 1962-1972 both surprises and actual money are jointly significant when M3 is used, though surprises do marginally better. While neither M1 surprises nor actual M1 are jointly significant in this period, the overall goodness of fit of the M1 equations is marginally better. Remarkably both money aggregates in both equations (surprises and actual) are significant (by the t-test) at lag 4 and at no other lag in this period. The coefficients on the 4th lag are almost identical for the comparable money aggregate irrespective of whether the surprise or actual money is used.

Post 1972III the surprise model does very badly indeed. It does especially poorly when the one period ahead forecast errors are used as a measure of surprises. In this period fitted and lagged actual M1 are jointly significant at the .01 percent level. The peak lag here is in the 5th quarter (only 5 and 6 are significant). Money surprises in this period, by way of contrast, are nowhere near to being individually of jointly significant. These results could hardly be in greater contrast to those reported by ADD.

In two related respects, however, the results in Table 2 are too favorable to both alternatives. In all equations reported except (9) the Durbin-Watson statistic is of the order 0.2. Thus the hypothesis tests may be biased in favor of acceptance. This results from the second problem which is that there is good reason to expect an autoregressive cycle in output. It is, after all, the business cycle we are trying to explain. Accordingly two lags of the dependent variable were added to these equations. All surprise effects now become jointly insignificant. Even for M3 surprises in the 1962-1972 period the F statistic now becomes 0.49 this is nowhere near significant. Only fitted and lagged M1 retains joint significance for the full period (F = 7.2**) and for the 1972-1983 period (F = 5.3*).

II

So far we have treated the U.K. as a closed economy except for testing for the impact of the balance of payments on the quasi-reaction function. In reality the U.K. is an open economy. It may be expected that foreign influences would impact upon domestic activity. In particular we are interested to test for an impact of U.S. money growth and U.S. money growth surprises on U.K. activity. If only unanticipated monetary change has implications for real activity then the omission of unanticipate changes in the foreign money stock on domestic real activity will, given the normal assumptions, not have any implications for OLS estimation of (1). However, if lagged or current anticipated money are important then clearly ignoring the open economy aspects of the U.K.

economy may result in empirical results which suffer from a serious omitted variable problem.

Theory

It is clear from a consideration of the theoretical literature (see Marstons (1983) survey) that a floating exchange rate, will not, insulate the domestic economy from foreign shocks in a variety of different models. For example a simple extension of the Lucas, Sargent, Wallace supply curve in the open economy will recognize the distinction between the traded and non-traded goods sectors of the economy.

Consider the U.K. economy to be made up of two sectors. Each may contain many firms producing a variety of products all sold in competitive markets. However, one sector sells all its output in the U.K. (non-traded goods sector) and the other sells all its output in the U.S. (traded goods sector). There is complete separability between the sectors both on the demand side and on the supply side. The supply decision for the domestic sector is presumed to be modeled as above. Domestic money surprises will impact upon them as before. Complications due to the inclusion of export prices in the price level are ignored.

For those selling in the U.S. we assume that purchasing power parity is expected to hold and that, in fact, it does hold subject to a random error. Thus the signal extraction problem faced by a U.K. exporter to the U.S. is exactly the same as would be faced by a U.S. producer selling on the home market. Does a change in market price reflect an increase in demand or merely a change in the value of money?

Money surprises will increase the real supply of output whereas anticipated money growth will not.

Accordingly we augment the output and unemployment equations above with U.S. monetary variables. Surprises were generated, as above, taking residuals from a quasi-reaction function. The money supply process in the U.K. and U.S. were assumed to be independent. [For more formal derivations of the structural supply curve in the open economy see Leiderman (1980)].

The U.S. Quasi-Reaction Function

The monetary aggregate used for the U.S. was M1. The estimated equation was

$$\text{(11)}\quad USM1 = CONST \underset{(0.9)}{-\ .09}\ USM1_{t-1} \underset{(2.3)}{+\ .23}\ USM1_{t-2} \underset{(1.87)}{+\ .18}\ USM1_{t-3}$$

$$\underset{(3.3)}{+\ .32}\ USM1_{t-4} \underset{(.46)}{-\ .02}\ B_{t-1} \underset{(.4)}{-\ .02}\ B_{t-2} \underset{(.3)}{+\ .02}\ B_{t-3} \underset{(.7)}{-\ .03}\ B_{t-4}$$

$$\underset{(4.5)}{-1.7}\ RUS_{t-1} \underset{(4.3)}{+\ 1.6}\ RUS_{t-2}$$

$$\bar{R}^2 = .75 \qquad D.W. = 2.0 \qquad \rho_1 = \underset{(2.9)}{0.28} \qquad \rho_2 = \underset{(-4.6)}{-0.44}$$

where B_i is the lagged value of the Federal budget surplus and RUS is the three month Treasury Bill rate. The terms in the U.S. budget surplus were not individually significant but they were jointly so at the 5 percent level.

Table 3 summarizes the effect of adding U.S. money variables. USMR is the surprise; $\hat{USM}$ is the fitted value; USM_{t-i} is the lagged actual value - this is one lag in the output equation and four lags in the unemployment equation. U.S. data are for M1 only. The bottom quarter of the table reports the effect of using one period ahead forecasts for surprises in both the U.K. and U.S. Again 0 indicates the absence of a significant coefficient or set of coefficients (for lagged money). The time trend and inflation variance were excluded in the tests reported.

It is even more clear from Table 3 than from Table 1 that the two sub-periods generate very different results. Accordingly we offer no discussion of the full period results. For the 1961-72 period U.S. money has no impact on output. The presence of U.S. money variables does lower the significance of $\hat{M3}$ and $M3_{t-i}$. The −+ sign on $M1_{t-i}$ indicates that the first lag on M1 is negative and significant while the third and fourth lags are positive and significant. The big change in this period is that we now have significant coefficients in the unemployment equation. The sign of the M3 surprise is incorrect and the fitted value of M3 has a significant negative effect. U.S. money surprises here appear to reduce U.K. unemployment. The M1 equation is more reasonable from the surprises point of view. U.K. M1 surprises reduce unemployment, fitted M1 increases unemployment and lagged money first increases then reduces it. Fitted U.S. money reduces U.K. unemployment.

The 1972-83 period is a marked contrast. Apart from an effect of lagged M1 on unemployment, the only variable to be significant is lagged U.S. money growth. This raises U.K. output (with a 1 quarter lag) and reduces U.K. unemployment (with a 2 or 3 quarter lag). The effect is well determined irrespective of the aggregate used for U.K. money. This result is altered somewhat by the use of forecast errors as measures of surprises for both the U.K. and U.S. The use of these measures weakens the effect of lagged U.S. money on U.K. output, though the impact on unemployment survives. The U.K. M1 surprise now has a significant impact on output.

U.S. Money versus U.K. Money

Finally we ask the question: Do U.S. money variables explain U.K. output and employment as well as U.K. money. On the evidence of the results in Table 3 this was not likely to be true for the fixed rate period. Accordingly we concentrate on the floating rate period, since 1972. Recall that it used to be common to presume that floating exchange rates insulate an economy from overseas monetary shocks, though this presumption relied on the assumption of purchasing power parity or the law of one price.

We estimated output equations of the form

$$(12)\quad y_t = \alpha_1 + \alpha_2 y_{t-1} + \alpha_3 MR + \alpha_4 \hat{M} + \sum_{i=1}^{4} \beta_i M_{t-i}$$

where y is the log of real GDP, MR is the money growth surprise, $\hat{M}$ is the fitted value of money growth, and M_{t-i} are (4 lags) of actual money growth. This equation was estimated for the period 1972 III to 1983I using three different money measures--U.K. M1, U.K. M3 and U.S. M1. Measures of goodness of fit are shown in Table 4. Reported there are the Mean Squared Error, R^2, and an F-statistic (degrees of freedom 1 and 35 for full period; 1 and 20 for up to 1979II). The F-statistic is a test of the hypothesis that $\alpha_3 + \alpha_4 + \sum_{i=1}^{4} \beta_i = 0$; that is that the sum of the impact of the money variables is zero. Large values of F imply rejection of the zero sum. Equation 12 was also estimated for the subperiod 1972III to 1979II as well as the full floating period, 1972III to 1983I.

In terms of goodness of fit U.S. money does best, though in no case can we reject the hypothesis that the sum of the money coefficients is zero. However, for U.S. M1 there is a significant positive coefficient on the first lag of actual money for both periods. There is a significant coefficient on the first lag of U.K. M1 for the full period but this is not present before 1979. Thus so far as the U.K. money variables are concerned the M1 fit improves after 1979 while the M3 fit deteriorates.

An equation similar to 12 was tested for unemployment. The differences were that a second lag on the dependent variable was included, as was a time trend (a time trend was insignificant and excluded from the output equation for the floating period). The results here are even more dramatic. U.S. M1 both wins the goodness of fit comparisons and has an F-statistic which clearly rejects the hypothesis of a zero sum on the money coefficients, in one case at the 5 percent level (1972 III - 1983 I) and in the other (1972 III - 1979 II) at the 1 percent level.

How these results should be interpreted is a question for lengthy discussions which space does not permit us to pursue at present. However, we would claim to have demonstrated one thing quite clearly. That is how weak the link is between U.K. money and U.K. economic activity for the period under study. For the period since floating U.S. money seems to be more important.

IV. CONCLUSIONS

Our empirical results may be summarized as follows:

1. We have found little support for the idea that "only money surprises have real effects." Apart from the 1961-72 period, out of 24 estimated coefficients on U.K. money surprises (tables 1 and 3; to this add the 4 discussed in the text and the 6 in equation (10)) only two were significant. One of these had the wrong sign. Significant coefficients are achieved in the 1961-72 period but this is a period of fixed exchange rates when the exogeneity of money must be seriously doubted.
2. The fitted value of U.K. money does not generally influence activity. Such effects as there are vary with the money aggregate chosen. For some estimates with M3, fitted money significantly reduced unemployment. Otherwise fitted money had a perverse effect on activity. However, as with surprises, there is no clear evidence of an impact in the floating period.
3. U.S. money growth does appear to have some influence on U.K. activity. The presence of U.S. money growth in the U.K. equation does influence the results (viz. unemployment 1961-72). The most persistent effect, however, is picked up in the 1972-83 period. Lagged U.S. money growth increases U.K. output with a one quarter lag and reduces U.K. unemployment with a two or three quarter lag. Remarkably, U.S. money provides a better explanation of U.K. activity in this period than does either of the U.K. monetary aggregates.

4. There is a substantial difference between periods of fixed and floating exchange rates. This result must raise serious doubt about the validity of studies of this kind for the U.K. which use data spanning both regimes. The problem is not in the quasi-reaction function since this appears to be a fairly stable (dominantly autoregressive) process. Rather it is a problem with the reduced form aggregate supply curve. Our conjecture is that this results from the endogeneity of money in fixed exchange rate periods. According to this interpretation the contemporaneous correlation of money surprises and activity results from common reactions to a disturbance in the IS curve rather than from unexpected and exogenous changes in money.
5. A test of the surprise model in which the surprises are compared to fitted current and lagged actual money is very unfavorable to the surprise model. Only in the 1962-72 period does the surprise model perform at all well. Even here the lagged money model performs almost as well.
6. One result we have which appears to have some robustness is that lagged U.K. M1 has some effect on real activity, though even this result is both weakened by the inclusion of U.S. money and seems strong only for the 1960s and the post 1979 period. A strong relationship over a short period should be regarded as tentative at best pending further evidence. Evidence that U.S. money influences U.K. activity is, if anything, the strongest positive result we have, though again

this evidence comes only from the post 1972 period. More time may be required before strong conclusions can reasonably be drawn.

Data Appendix

Data were taken from various data tapes as of September 1983. U.K. M1 (NSA) and £M3 (NSA) were taken from IFS. £M3 excludes government deposits. All money variables are calculated as log differences x 400 (though regression coefficients are reported x 100). Break adjustments were calculated using data made available by the Bank of England. GDP (NSA) is from IFS. Unemployment (SA) is from Chase Data Tapes. Other data are from the Federal Reserve Bank of St. Louis data files. All data are quarterly.

Table 1
Summary of U.K. Output and Unemployment Equations

	MR	$\hat{M}$	M_{t-i}	Var P	T	F test
Full Period						
y(M3)	0	0	0	0	0	0
y(M1)	0	0	+	0	0	✓
u(M3)	0	0	0	0	+	0
u(M1)	0	0	−	0	+	✓
1961–72						
y(M3)	+	−	+			✓
y(M1)	+	−	+			✓
u(M3)	0	0	0			0
u(M1)	0	0	0			0
y(M3)	+	−	+	0	+	✓
y(M1)	0	0	+	0	+	✓
u(M3)	0	0	0	0	0	0
u(M1)	0	0	0	0	0	0
1972–83						
y(M3)	0	0	0			0
y(M3)	0	0	+			0
u(M3)	+	−	0			0
u(M1)	0	0	0			0
y(M3)	0	0	0	0	0	0
y(M1)	0	0	+	0	0	0
u(M3)	0	0	0	0	+	0
u(M1)	0	0	−	+	+	0

Table 2
Output Equation: Test of Current and Lagged Surprises Versus Fitted Current and Lagged Actual Money

	Current and Lagged Surprises			Fitted Current and Lagged Actual Money		
	F	R^2	MSEX10^3	F	R^2	MSEX10^3
1962I-1983I						
M3	0.93	.9378	1.154	17.30***	.9505	0.919
M1	1.78	.9391	1.130	21.62***	.9541	0.853
1962I-1972II						
M3	5.59*	.9854	0.119	4.72*	.9838	0.131
M1	2.54	.9860	0.113	2.98	.9857	0.116
1972III-1983I						
M3	0.16	.6984	0.711	1.95	.7226	0.653
M1	1.02	.6967	0.714	12.79**	.7938	0.486
M3 forecast errors	0.01	.7259	0.492			
M1 forecast errors	0.01	.6795	0.575			

Note: The F test is a test that a set of coefficients adds to zero. Higher values of F indicate a rejection of the hypothesis. For our sample approximate critical F's at the .05 level are: full period = 4.0, 1962-1972 = 4.35, 1972-1983 = 4.17. * indicates significance at that level, ** indicates significance at .01 level and *** indicates significance at .001 level. Two observations are lost as compared to above results owing to the extra two lags.

Table 3
U.K. and U.S. Money and U.K. Activity

	MR	$\hat{M}$	M_{t-i}	USMR	$US\hat{M}$	USM_{t-i}
<u>1961-83</u>						
y(M3)	0	0	0	0	0	+
y(M1)	0	0	+	0	0	0
u(M3)	0	−	0	0	0	0
u(M1)	0	0	0	0	0	0
<u>1961-72</u>						
y(M3)	+	0	0	0	0	0
y(M1)	+	−	−+	0	0	0
u(M3)	+	−	0	−	+	0
u(M1)	−	+	+−	0	−	0
<u>1972-83</u>						
y(M3)	0	0	0	0	0	+
y(M1)	0	0	0	0	0	+
u(M3)	0	0	0	0	0	−
u(M1)	0	0	−	0	0	−
			<u>Forecast Errors for Surprises</u>			
<u>1972-83</u>						
y(M3)	0	0	0	0	0	0
y(M1)	+	0	0	0	0	0
u(M3)	0	0	0	0	0	−
u(M1)	0	0	0	0	0	−

Table 4
U.K. versus U.S. Money as Determinant of U.K. Activity

OUTPUT	MSE X10^2	R^2	F
1972III - 1983I			
U.K. M3	.0271	.866	0.91
U.K. M1	.026	.871	2.05
U.S. M1	.0248	.877	1.72
1972III - 1979II			
U.K. M3	.0386	.822	0.1
U.K. M1	.0366	.831	1.2
U.S. M1	.0296	.863	0.3
UNEMPLOYMENT			
1972III - 1983I			
U.K. M3	.1432	.995	0.22
U.K. M1	.1418	.995	1.4
U.S. M1	.1263	.996	7.17*
1972III - 1979II			
U.K. M3	.164	.99	3.3
U.K. M1	.225	.986	.005
U.S. M1	.147	.991	9.4**

FOOTNOTES

1/ Non neutrality in the long run could arise either from money and growth effects (see Burmeister and Dobell, 1970) or from a possible relationship between the variance of inflation, the rate of inflation and the equilibrium level of real output (see Taylor, 1981).

2/ We tested for the influence of lagged monetary innovations but they were insignificant both on their own and in the presence of lagged actual money.

3/ There is no evidence of significant autocorrelation of residuals. The DW statistic is not appropriate in the presence of lagged dependent variables. However the Durbin h statistic equals zero when DW = 2.0. h has a standard normal distribution and so it could not display less evidence of autocorrelation. Efforts to estimate up to 4th order autocorrelation were unsuccessful.

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