The demand for money in the United Kingdom: experience since 1971

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Introduction and summary

The Economic Section of the Bank has for some time been engaged in the econometric estimation of demand-for-money relationships in the United Kingdom. In a previous paper,[1] Goodhart and Crockett reviewed some published results, and presented their own estimates, based on quarterly data. In a further paper,[2] Price examined more closely the lag structures of the relationships, and presented for the first time equations for the demand for broadly-defined money by the company and personal sectors separately. He concluded from his results that 'equations of the types described provide a sufficiently accurate statistical explanation of past movements in the stock of money to be a useful guide for monetary policy.'

This paper re-examines the findings in the light of more recent experience.

The initial object is to examine the extent to which the behaviour of the money stock since 1971 has diverged from what might have been expected from equations estimated over the preceding period. Thus Section 2 below presents new equations, similar in structure to those previously published but estimated from revised data for the fourth quarter 1963 to the third quarter 1971 (1963 IV – 1971 III), and then compares the forecasts generated by them for 1971 IV – 1974 I with the corresponding actual movements of the money stock. It shows that the demand for money narrowly-defined (M_1) has in only a few quarters been significantly out of line with expectation, and that holdings of broadly-defined money (M_3) by the personal sector were also much as predicted until 1973 I. In contrast, however, companies' holdings and total holdings of M_3, as well as personal holdings after 1973 I, are shown to have grown persistently faster than predicted by the equations.

Section 3 seeks to provide an explanation. It is argued that the introduction during 1971 of the new arrangements for competition and credit control (the new approach) resulted in important changes in the behaviour of the deposit banks which have had the effect of increasing the attractiveness to asset-holders of interest-bearing money in relation to other financial assets. In particular, the deposit banks have for the first time been bidding competitively for large, 'wholesale' deposits in the parallel money markets, and have been issuing certificates of deposit in their own names. In these circumstances, the persistent underprediction of the demand equations for M_3, which appear to fit the preceding period quite well, is not too surprising.

An implication of the argument of Section 3 is that the rate of interest paid on wholesale time deposits and certificates of deposit may have become a significantly more important determinant of the demand for M_3 since 1971. Section 4 attempts to test this hypothesis. It presents a second set of equations, this time based on data taken to the end of 1972, and examines their forecasting performance from 1973 I to 1974 I. It shows that the behaviour of companies' holdings and of total holdings of M_3 since 1971 appears more explicable when, for this period, the interest rate on certificates of deposit (which is probably also representative of rates paid on large time deposits) is included among the explanatory variables of demand. This finding gives some support to the argument of Section 3. Even so, a number of reasons are given why the behaviour of these aggregates during 1972 and 1973 may provide an unreliable guide to their behaviour in the future. Whether the unexpectedly fast growth of personal

[1] C. A. E. Goodhart and A. D. Crockett, 'The importance of money', June 1970 *Bulletin*, page 159.

[2] L. D. D. Price, 'The demand for money in the United Kingdom: a further investigation', March 1972 *Bulletin*, page 43.

sector holdings of M_3 from 1973 I to 1974 I can also be explained by a similar new influence is not examined directly in this paper.

A reviewer of the empirical evidence on the demand for money could write in 1971 that 'there does seem to exist . . . a reasonably stable relationship between the demand for cash balances and a few other variables' and could claim that 'the actual quantitative values of the parameters of the functions implied by these observed relationships have remained reasonably steady over time. These parameters have not remained constant, of course, but changes in them have been slow rather than sudden.'[1] This study points to a recent significant, and somewhat sudden, though not surprising shift in certain demand-for-money relationships. At some time in the future there may be more reason for confidence that these relationships have restabilised than there can be at present. But meanwhile, at least, the results reported below encourage caution.

1 Model specification

This first section establishes the general form of the equations estimated. The basic model adopted is one in which – with all variables in natural logarithms – desired money balances in any quarter are a linear function of current and lagged values of appropriate explanatory variables; and in which actual money balances adjust towards desired balances with a lag such that a constant proportion (to be estimated) of any remaining adjustment towards equilibrium is accomplished in each quarter. A variety of possible determinants of desired money holdings is suggested by economic theory. For the purposes of this section, however, attention is restricted to a particular set of three explanatory variables: real income, the price level, and a representative interest rate. Ignoring for present purposes any lags in the desired money stock function the model may be written: [2]

$$\ln M_t^* = a_0+a_1 \ln Y_t+a_2 \ln P_t+a_3 \ln r_t \quad (1)$$

$$\ln M_t - \ln M_{t-1} = (1-\gamma)(\ln M_t^* - \ln M_{t-1}) \quad (2)$$

where

M^* is desired money stock

M is the actual money stock

Y is real income

P is the price level

r is a representative interest rate

t, $t-1$ are time subscripts

$(1-\gamma)$ is the coefficient of adjustment, $0 < \gamma < 1$.

This familiar partial adjustment model yields a single reduced-form equation to be estimated, one of whose arguments is the lagged dependent variable (in this case the lagged money stock):

$$\ln M_t = b_0+b_1 \ln Y_t+b_2 \ln P_t+b_3 \ln r_t+\gamma \ln M_{t-1} \quad (3)$$

where

$$b_i \equiv (1-\gamma)a_i, i = 1, 2, 3.$$

Because the variables in this equation are in logarithms, the short-run elasticities of the demand for money with respect to Y, P, and r are given by the respective coefficients b_1, b_2, and b_3, which are to be estimated. However, these coefficients show only the impact effects of changes in the independent variables. The presence of the lagged dependent variable in equation (3) means that the adjustment of the demand for money to a change in an explanatory variable will continue during quarters subsequent to that in which the change occurs. In fact, in the long term the elasticities with respect to Y, P, and r will approach $b_1/(1-\gamma)$, $b_2/(1-\gamma)$, and $b_3/(1-\gamma)$

[1] D. E. W. Laidler, introduction to the section on 'The Demand for Money', in *Readings in British Monetary Economics*, edited by H. G. Johnson (Clarendon Press, Oxford, 1972), page 121.

[2] To simplify presentation, stochastic error terms are omitted from equations in this section.

respectively; this is merely to say that after full adjustment, the elasticities are given by the coefficients a_1, a_2, and a_3 of the desired stock equation, (1).

Thus, the log-linear form of equation (3) constrains the elasticities (short-term and long-term) of the demand for money with respect to each explanatory variable to be constant, and in particular, to be independent of the level of the variable. This implicit assumption is convenient and, generally speaking, not implausible. In the case of the interest-rate variable, however, it is perhaps less likely that, for example, a doubling in the rate from 1% to 2% will have the same proportionate effect on the demand for money as will a doubling from 10% to 20%. Therefore equation (3) is amended by entering the interest rate by means of the variable $\ln(1+r)$, rather than by using $\ln r$. This constrains the interest-rate elasticity to vary directly with the rate, so that, for instance, a rise from 10% to only (about) 11·1% has the same proportionate effect on money demanded as a rise from, say, 1% to 2%.[1] Equation (3) is thus amended to:

$$\ln M_t = b_0 + b_1 \ln Y_t + b_2 \ln P_t + b_3 \ln(1+r_t) + \gamma \ln M_{t-1}. \qquad (4)$$

A further amendment of the basic model results from assuming that the long-run price elasticity is unity. This assumption may be justified on three counts. First, and most importantly, it reflects received doctrine: the prediction that real desired money balances will be unaffected by changes in the price level is one of the least disputed in monetary theory. Secondly, when the price elasticity has been freely estimated, in work performed in the Bank and elsewhere, the results have commonly been sufficiently close to unity to support the theory. Thirdly, the high degree of correlation between real income and price means that it is often difficult to know how much credibility can be attached to coefficients of the two variables when freely estimated separately, particularly when the estimated price elasticity is not close to unity. Thus the problem of multicollinearity provides a further rationale for constraining the coefficient of the price variable to its theoretically plausible value.[2]

By constraining the long-run price elasticity in equation (1) to unity, equation (4) becomes

$$\ln M_t = b_0 + b_1 \ln Y_t + (1-\gamma) \ln P_t + b_3 \ln(1+r_t) + \gamma \ln M_{t-1} \qquad (5)$$

which may be rearranged to give

$$\ln(M_t/P_t) = b_0 + b_1 \ln Y_t + b_3 \ln(1+r_t) + \gamma \ln(M_{t-1}/P_t). \qquad (6)$$

Equation (6) is the relationship as estimated; but the results will be presented in the form of equation (5), which makes explicit the value of the short-run price elasticity, $1-\gamma$, of nominal money balances.

The equations were estimated in first differences, using ordinary least squares, but applying the Cochrane-Orcutt transformation to adjust for serial correlation. Notes on the method of estimation are contained in Appendix 1.

2 Estimation period 1963 IV – 1971 III: estimates and forecasting performance

Estimates

Equations were estimated for four monetary aggregates: [3] M_1, M_3, personal sector holdings of M_3 (MP), and company sector holdings of M_3 (MC). (Apart from MP and MC, the remainder of M_3 – about 10% over the estimation period – is held by financial institutions other than banks and by the public sector.) In the case of each aggregate, the equations estimated were of the form of equation (6) above, except that more than

[1] This procedure is roughly equivalent to including r [rather than $\ln(r)$] in the equation, since $\ln(1+r) \doteqdot r$, for small r.

[2] See Appendix 3.

[3] For definitions of these and other data series, see Appendix 2, which also notes some imperfections of the money stock data.

one interest rate and lagged values of the exogenous variables were allowed to enter.[1]

The real-income (or expenditure) variable used for M_1, M_3, and MC was total final expenditure (TFE) at constant prices, and for MP it was personal disposable income (PDI) at constant prices. In each case, the price variable used was the deflator of the appropriate income series. The three-month local authority rate and the yield on 2½% Consolidated Stock (Consol rate) were used to represent, respectively, rates of interest on competing short-term and long-term financial assets; various alternative rates (including equity yields and a euro-dollar rate) were tried, but with less success. Also, for the broad (M_3) aggregates, equations were estimated containing the overnight inter-bank rate and the clearing banks' seven-day deposit rate, as representative of interest paid on time deposits; but the results were unsatisfactory. Thus, no significant 'own rate' influence was found.

For each monetary aggregate, therefore, a number of variant equations were fitted. One 'best' equation for each was then selected by the usual statistical criteria; these are presented in Table A. In Appendix 3 they are compared with the previously published estimates; but some other features of the results are worth noting here.

Table A

Demand-for-money equations 1963 IV – 1971 III[a]

All variables are in natural logarithms

Dependent variable	Constant	Coefficients: Short-run elasticities Y_t	P_t	$1+r^s_t$	$1+r^L_t$	$1+r^L_{t-1}$	M_{t-1}	Standard error of estimate (per cent)	$\bar{R}^2$	D-W[b]	ρ[b]	Long-run elasticities[c] Y	r^s	r^L
M_1	24·574	0·228 (0·158)	0·585	−0·736 (0·317)	−1·568 (0·753)		0·415 (0·134)	1·35	0·49	2·09	−0·6	0·391	−0·081	−0·184
MP	3·912	0·346 (0·086)	0·373			−0·382 (0·392)	0·627 (0·118)	0·78	0·70	2·38	−0·6	0·927		−0·069
MC	24·970	0·319 (0·270)	0·623	−0·657 (0·520)	−1·794 (1·266)		0·377 (0·156)	2·06	0·27	2·15	−0·4	0·511	−0·067	−0·197
M_3	6·725	0·162 (0·123)	0·359	−0·513 (0·199)			0·641 (0·138)	0·95	0·56	2·22	−0·6	0·450	−0·091	

[a] For definitions of the variables, see Appendix 2. Standard errors are shown in brackets beneath the appropriate coefficients.

[b] For the meaning of the Durbin-Watson statistic (D-W) and ρ see Appendix 1.

[c] The long-run price elasticity is constrained to unity in each equation. Long-run interest-rate elasticities are evaluated at the mean interest rates of the estimation period (see footnote [1] on page 288).

First, although all coefficients reported in Table A have the signs expected *a priori*, many are not significantly different from zero.[2] In three of the four equations (MP is the exception) the coefficient of real income in not significant; and neither the MP nor the MC equation contains a significant interest-rate coefficient. These results appear to contrast with many reported elsewhere. They stem essentially from the method of estimation, and in particular from the fact that the equations were estimated in first differences. Estimation in levels would tend to produce more significant coefficients, but it was considered that, owing to the nature of the data, such estimates might be seriously biased (see Appendix 1). The comparatively low coefficients of determination ($\bar{R}^2$) reported in Table A also reflect the method of estimation.[3]

In contrast to the real-income and interest-rate variables, the lagged money stock may be seen to have a coefficient significantly different from zero in each of the four equations. The size of each of these coefficients implies a speed of adjustment towards any desired change in

[1] Also, in recent work at the Bank, equations have been estimated containing variables other than the levels of real income, prices, and interest rates. These have included the rate of inflation, and a variable measuring the divergence of the current long-term interest rate from past rates (the latter representing an attempt to identify a Keynesian speculative influence on demand). The results obtained with these other variables were not, however, satisfactory, and are not reported here.

[2] Throughout the paper all significance tests refer to the 5% probability level.

[3] When the equations of Table A were estimated in levels, with no adjustment for serial correlation, all coefficients except one were significant at the 5% level; the exception – r^s in the MC equation – was significant at the 10% level. The lowest $\bar{R}^2$ was 0·71 (MC), the highest 0·98 (MP). The forecasts given by these estimates were, however, more inaccurate than those generated by the estimates reported in Table A, often markedly so, thus indicating that the coefficients estimated in this way were, indeed, biased.

money holdings, which may be seen to be faster for M_1 and MC than for MP and M_3. In fact, the coefficients in the former two equations imply that more than 95% of the desired adjustment to any exogenous change is accomplished after four quarters; the equivalent proportion in the latter two equations is slightly below 85%.

The long-run elasticities implied by the estimated coefficients are shown in the final three columns of the table.[1] While none of these are implausible, it is puzzling that the income elasticity for total M_3 falls below those for the two individual M_3 components, even though these do not account for quite the whole of M_3. It is also perhaps surprising that the income elasticity for M_3, which includes interest-bearing money, is so little greater than that for the more narrowly-defined M_1, with which the idea of economies of scale in the transactions demand for money would probably be more closely associated. Indeed, the fact that all four long-run income elasticities are below unity suggests that the demand for money both narrowly and broadly-defined may have been subject to such economies of scale over the observation period. However, the 95% confidence interval of each estimate includes values above unity, so that the alternative hypothesis that money is a 'luxury good' cannot be rejected on this evidence.

Finally, the standard errors of estimate of the equations are similar to those found generally in investigations of this type. They indicate that the MP and M_3 equations have the best overall fits, while the MC equation appears to be the least well determined.

Forecasting performance 1971 IV – 1974 I

An acid test of the estimated relationships is whether they forecast accurately outside the period over which they were estimated. This sub-section examines the *ex post* 'forecasts' of the equations set out above. Taking appropriate actual values of the exogenous and lagged endogenous variables, the equations were used to predict the quarter-to-quarter movements of each of the four aggregates from 1971 IV to 1974 I. If the equations remained valid, the actual values of the aggregates should lie within (for instance) two standard errors of the corresponding predicted values in (about) 95% of cases (assuming that the error terms are normally distributed).[2] The proportionate forecasting errors were therefore compared with the standard errors of the equations.

The proportionate forecasting error of one of these equations in any quarter is approximately the same as the difference between the actual rate of increase of the appropriate money aggregate and the rate of increase predicted by the equation.[3] Some indication of the results can therefore be obtained from Charts C, E, G, and J, (contained in Appendix 4), which compare actual and expected rates of increase in each quarter. The charts suggest that the results obtained were considerably worse for MC and total M_3 than for M_1 and MP; and a closer examination of the prediction errors quarter by quarter confirms this impression.

The equation for M_3 underpredicted its growth nine times during the ten-quarter forecast period. Each time, except 1973 II, the forecasting error exceeded twice the standard error. Thus in eight quarters out of the ten, there was significant underprediction. The only overprediction was in 1974 I, when the error was not significant, and was indeed the smallest of the period.

The pattern of errors produced by the MC equation was very similar. Thus, underprediction again occurred in nine quarters out of the ten. However, the underprediction in the first two forecast quarters was not significant, although greater than for the M_3 equation. (In fact, in all ten

[1] The interest-rate elasticities implied by the coefficients of $\ln(1+r)$ are calculated at the mean interest rates of the estimation period. That is, given that

$$\frac{\partial \ln M}{\partial \ln r} \equiv \frac{r}{1+r} \cdot \frac{\partial \ln M}{\partial \ln(1+r)}$$

the elasticity with respect to r was calculated by multiplying the elasticity with respect to $(1+r)$ by the ratio $r/(1+r)$, evaluated at the mean r of the estimation period.

[2] Owing to the method of estimation, this applies only to forecasts in which actual values of the lagged endogenous variables are used.

[3] The difference between actual and predicted growth rates in period t reduces to $(M_t - \hat{M}_t)/M_{t-1}$ (where $\hat{M}$ is the predicted value of M), whereas the proportionate forecasting error is given by $(M_t - \hat{M}_t)/\hat{M}_t$.

quarters, the prediction errors of the MC equation exceeded those of the M_3 equation; but the standard error of the former is considerably larger too.) As with M_3, the worst results were obtained for 1973 III and 1973 IV: in the first of these the error was over 11%, and was thus more than five times the standard error of the equation. And again, the best results were for 1973 II (a small overprediction) and for 1974 I (a small underprediction).

The equation for M_1 also tended to underpredict: it did so in seven out of the ten quarters. However, five of the seven errors were not significant, and nor were the three overpredictions (1971 IV, 1973 I, and 1973 III). Thus only two of the forecasting errors (1972 II and 1973 II) were over twice the standard error. The worst result was for 1973 II – over three times the standard error.

Over the first six quarters of the forecast period (1971 IV – 1973 I), the MP equation was the best. It too mostly underpredicted (five times out of the six), but only one of the six errors (1972 I) was significant. After 1973 I, however, the performance of the equation deteriorated markedly, with consistent, significant, and increasing underprediction; by 1974 I the prediction error was almost four times the standard error of the equation.

In sum, the success of the equations is evidently limited. The only results which could be called at all satisfactory are those for the M_1 equation, notably the successful prediction of the volatile movements of this aggregate during the last three quarters of the forecast period, and those for the MP equation between 1971 IV and 1973 I, when, with only one exception, the aggregate was each time within 0·75% of the prediction. In contrast, the results for MC and M_3 show quite clearly that the behaviour of these aggregates during 1972 and 1973 cannot be predicted by the demand-for-money relationships estimated from pre-1972 data.[1] The next section seeks to explain this failure.

3 Explaining the failures

There are three possible kinds of explanation for the poor predictions of the MC and M_3 equations: [2]

a the relationships may have been misspecified: for instance, important determining factors may have been omitted, or there may have been misspecification of the lag structures;

b the coefficients in the equations may have been inaccurately estimated or biased, owing to, say, multicollinearity or inadequate adjustment for serial correlation of errors;

c there may have been structural change since the estimation period, so that the behaviour of the relevant aggregates could not have been predicted accurately, even from correctly specified and unbiased estimates.

Each of these possibilities may well have something to offer. However, while various economic and econometric arguments might be put forward claiming the importance of the first two possibilities, the third seems particularly applicable.

Thus in May 1971, the Bank issued the consultative document, *Competition and credit control*,[3] and by September the new approach to monetary policy had begun to operate, its aim being to encourage the removal of certain rigidities which had developed in the banking system during the years of ceilings controls on lending and of other restraints on competition and innovation. In particular, the London and Scottish clearing banks' interest-rate agreements were given up; their cash and liquidity ratios were replaced by a 12½% reserve assets ratio applicable to all banks; the special deposits scheme became applicable to all banks; and quantitative ceilings on lending were abandoned. Not surprisingly, these reforms gave rise to important changes in financial markets and in the behaviour of the banks.

[1] Moreover, the forecasts calculated from the equations were 'one step ahead' forecasts only, i.e. the actual value of the lagged dependent variable was used in each period. This is probably a less stringent way of testing the forecasting ability of a model than the alternative method (not used in this paper) whereby the previous period's forecast of the dependent variable is entered.

[2] The subsequent failure of the MP equation will be considered later.

[3] Reprinted in the June 1971 *Bulletin*, page 189.

During the years before 1971, there had been a progressive loss of competitiveness by the clearing banks *vis-à-vis* other banks (owing primarily to the clearers' interest-rate cartel and to their asset-ratio requirements) and a corresponding expansion of the less restricted 'secondary' banking system[1] in relation to the 'deposit' banking system. (The clearing banks as business entities, however, had formed subsidiary companies which operated as secondary banks.) More particularly, with ceilings controls applying to all banks, there had been a loss of competitiveness by the banking system as a whole in relation to other channels of financial intermediation.

It was to be expected therefore that the freeing of the clearers' borrowing and lending rates from their rigid link with Bank rate, the changes in reserve requirements, and the removal of the ceilings on lending would together lead to a reversal of these trends, and thus to a growth in both sides of the banks' balance sheets: after the long spell of 'disintermediation', the new approach would encourage 'reintermediation'.

This is indeed what seems to have happened. The clearing banks were able to adopt more flexible policies for rates on time deposits. Before September 1971, they had paid a standard 2% below Bank rate on deposit accounts. Although this rule has survived in rather more flexible form in the rate still paid for deposits under £10,000,[2] since the advent of the new approach the deposit banks have generally been offering rather higher rates for deposits of medium size (over £10,000 or £25,000), and, more important, they have for the first time bid for large deposits in the parallel money markets. These markets, which had sprung up during the 1960s, and the 'wholesale' deposit business associated with them, thus ceased to be the sole preserve of the secondary banks. For example, soon after the new approach was instituted, the clearing banks for the first time began to issue negotiable certificates of deposit (CDs) in their own names, although a market in these instruments had existed since 1968.[3]

The reforms of 1971 thus, as intended, induced a new competitiveness in the borrowing behaviour of the banks; and it is more than plausible that the new competitiveness of the deposit banks' liabilities in the last three years will have increased the attractiveness of 'money' – if defined sufficiently broadly to include, as with M_3, wholesale time deposits and CDs – relative to other financial assets. Thus, the underprediction of the MC and M_3 equations reported in the previous section may be explicable in terms of this increased attractiveness of interest-earning money balances. This argument would imply that the interest rate on time deposits (and CDs) has become a more significant determinant of the demand for M_3 balances since September 1971. An attempt is made in Section 4 to examine this proposition directly. Meanwhile, it is perhaps worth indicating four pieces of evidence which support the importance in this context of the structural change which occurred with the new approach.

The first of these is the varying degrees of success of the four equations. The equation for M_1, which excludes all time deposits, performed best; the equation for MP, in which no certificates of deposits are included,[4] and in which wholesale time deposits probably form a less important constituent than in MC (or total M_3), came second; and the MC and M_3 equations very clearly came off worst. In fact, perhaps the only feature which is difficult to explain in the context of the structural change is the delay before any significant deterioration appeared in the MP forecasts (although it is in a sense consistent with results presented in Section 2, and elsewhere in this paper, which suggest that the personal sector tends to be relatively slow in adjusting to exogenous changes).

Secondly, the contrast between the growth rates of narrow (M_1) and broad (M_3) money over the period 1971 III and 1974 I, and particularly

[1] Namely, the 'accepting houses, overseas banks, and other UK banks' as in Table 11 of the statistical annex.

[2] The rates paid for deposits under £10,000 since September 1971 have, apart from short-term anomalies, been between 1½% and 2% below the banks' own base rates, subject, since September 1973, to a maximum of 9½%.

[3] See the article 'Sterling certificates of deposit' in the December 1972 *Bulletin*, page 487.

[4] This is not because CDs are not held in the personal sector, but because there is no better information. Sterling CDs issued by banks to the rest of the private sector are attributed to industrial and commercial companies or to other financial institutions.

the exceptionally large increase in companies' broad money holdings, support the proposition that there was an unusually large rise in 'idle', rather than 'active', money balances, attracted by competitive yields in relation to other assets. Seasonally adjusted, M_1 increased by about 20% between 1971 III and 1974 I; M_3 by about 75%; and MC by about 100%.

That there has been an increase in the 'idleness' of the broad money stock may be seen more clearly from Chart B, in which the income velocity of M_3 is plotted against the rate of interest (as represented by the Consol rate [1]) from 1963 I to 1974 I. An increase in interest rates, *ceteris paribus*, should encourage asset-holders to economise on their money balances and so cause the velocity of circulation to rise. Because, over time, movements in velocity will depend upon other factors as well, in particular upon the income elasticity of and time lags in the

Chart A
The income velocity of M_1 and the rate of interest, 1963 I–1974 I

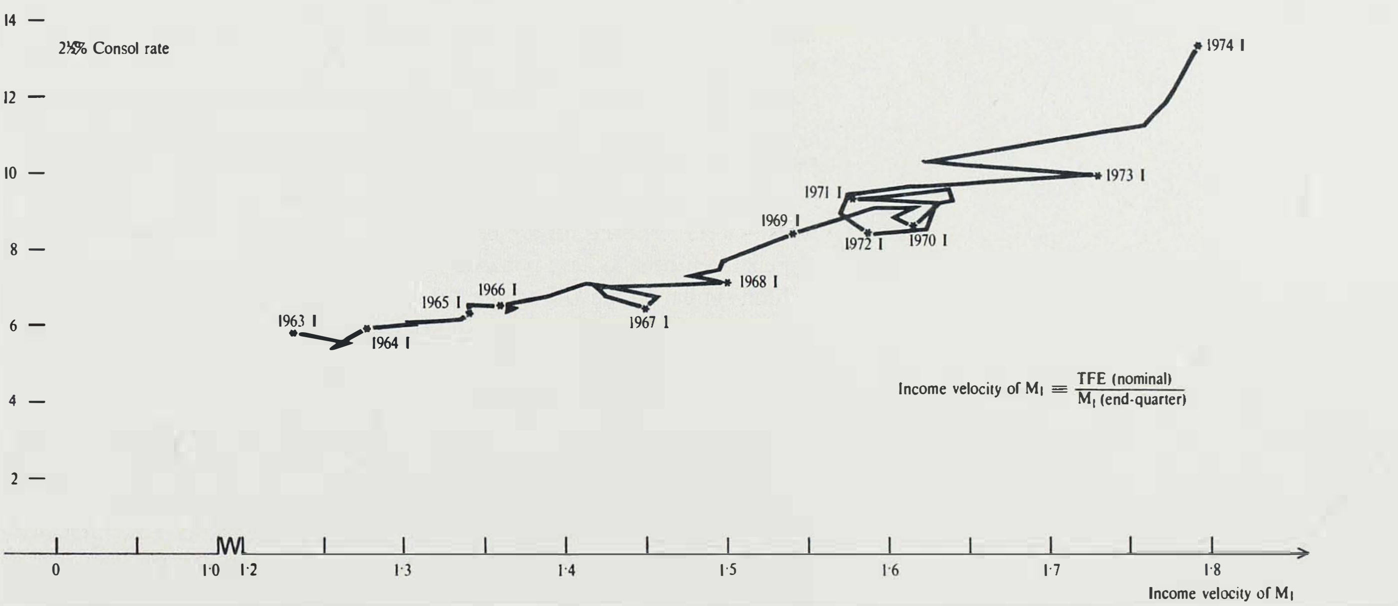
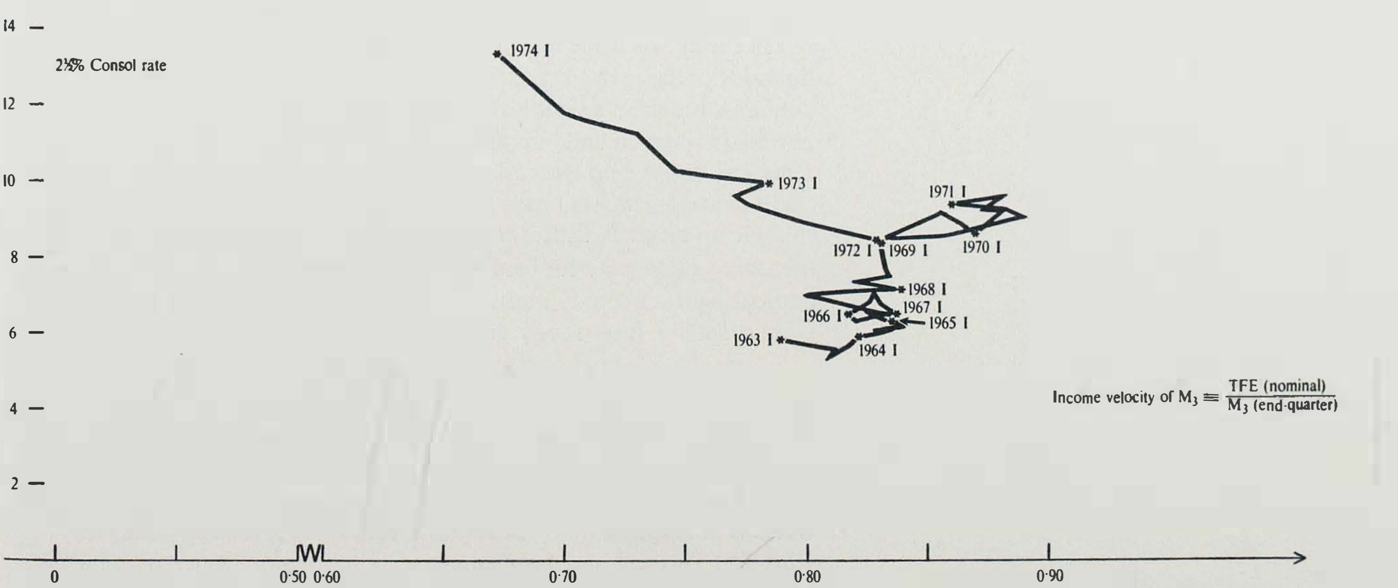


Chart B
The income velocity of M_3 and the rate of interest, 1963 I–1974 I



[1] A similar pattern was obtained when the local authority three-month rate was used instead.

demand-for-money function, the *ceteris paribus* qualification is important in the interpretation of Charts A and B.[1] Nevertheless, they show that whereas the income velocity of M_1 (Chart A) has, as would be expected, grown steadily with interest rates, the income velocity of M_3 (Chart B) has fallen markedly since 1971. Indeed, this fall is so different from the pre-1971 experience that the forecasting failure of the M_3 demand equation is hardly surprising. And it is perhaps difficult to see how, during this period of rising interest rates, such a marked increase in the demand for broad money in relation to nominal income could have occurred unless the own rate on money had acquired a new significance in its determination.

Thirdly, the figures of time deposits cannot be satisfactorily disaggregated by rate of interest earned and there is no precise information, therefore, on how much of the increase in time deposits since 1971 has been lodged at competitive money-market rates. However, and this is the third piece of evidence, data relating to banks' issues of CDs are more readily available, and they show the strong expansion in this source of funds to the banks after 1971. In fact, the estimated value of sterling CDs issued by all banks to the rest of the private sector, which was some £420 million, or about 2¼% of M_3, at the end of 1971 III, had risen to £1,470 million, or 5½% of M_3, by the end of 1972.

Fourthly, in Canada, the Bank Act of 1967 introduced reforms in the system of monetary control similar in many respects to the new approach. In particular, the bankers' interest-rate cartel was abolished, and certain restrictions on banks' behaviour – including limitations placed on interest rates – were removed. In the next two years the Canadian monetary aggregates appear to have behaved (in relation to previous experience) in a fashion similar to the UK aggregates since 1971, as the banks expanded more strongly than other financial intermediaries.

This section ends by considering certain ways in which the particular financial and economic environment of 1972 and1973 may, at various times, have contributed additionally to the rapid expansion of the demand for broad money, given the structural change already discussed.

One such influence, clearly evident on several occasions in these two years, arose from the comparative inflexibility of the banks' base rates in relation to the rates offered by them, in the money market, for deposits. Because of this, sharp increases in money-market rates narrowed the differential between banks' lending rates (determined in relation to base rates) and their (market-determined) borrowing rates; and the margin between 'prime' overdraft rates (1% above base rates) and money-market rates several times became negative. It then became profitable for some bank customers, particularly 'blue chip' companies borrowing at the finest rates, to borrow from the banks merely to redeposit with the banking system. Even when the margin was still positive, so that pure arbitrage or 'round tripping' was not possible, substantial narrowing of the differential doubtless provided a significant incentive to some bank customers to borrow in order to build up their balances of interest-bearing deposits. Thus, customers who feared a return to the pre-1971 system of direct credit controls may well have protected their access to credit by drawing on their overdraft facilities, and accumulated money balances. However, the extent of demand for bank credit and money balances arising from this particular precautionary motive, or indeed for precautionary purposes more generally, is obviously unknown.

At all events, arbitrage inflated the advances and deposits of the banks at various times during 1972 and 1973, and, although this probably had no long-term effect on the growth of the broad monetary aggregates, it certainly produced sharp movements in the short term. The fall in the rates of growth of M_3 and MC during the first quarter of 1974 (see Charts E and G in Appendix 4) probably reflects in part some unwinding of arbitrage. This will have been encouraged by the supplementary deposits

[1] Moreover, movements in current interest rates will tend to affect expectations of future rates, and if asset-holders' expectations are extrapolative, movements in the velocity of money may in the short term be 'perversely' related to interest-rate movements. If for example, an increase in interest rates leads to expectations of further increases, the velocity of circulation may fall as asset-holders move out of bonds into capital-certain money.

scheme announced by the Bank in December 1973,[1] and the concurrent announcement by the clearing banks of their intention to adjust their lending rates more rapidly to movements in market rates, specifically in order to curtail arbitrage (although this intention was not, in the event, realised until this July).

Furthermore, the significant rise in the demand for interest-bearing money since 1971 may also suggest an increase in the Keynesian speculative demand for money (already referred to above). Keynes drew attention to the fact that in a model in which money and bonds are the only two financial assets, the demand for money will tend to be high when interest rates are expected to rise. When the more complex array of actual financial assets is allowed for, Keynes' theory becomes a theory of speculative demand for capital-certain assets in general, including, for example, building society shares and deposits, national savings deposits, local authority debt, and so on. Thus, bondholders who expect interest rates to rise will not necessarily switch into 'money' as normally defined; and their choice among capital-certain assets will depend to a high degree upon their relative yields. But the above argument that yields on interest-bearing money have risen in relation to those on other financial assets implies that bondholders will have been more likely than hitherto to switch into assets included in M_3. Two inferences may be drawn from this. The first is that the demand for (broad) money may have become a more unstable function of any set of variables which does not take adequate account of interest-rate expectations (as opposed to existing rates). The second is that when, since 1971, there have been expectations of rising interest rates (and the period has been one of secularly rising nominal rates and growing inflation) then some part of the increases in money holdings may be accounted for by increases in speculative demand which the equations of Section 2 could not easily have predicted.

In sum, there are a number of reasons why the behaviour of the broad monetary aggregates since 1971 – MC and M_3 in particular – is badly predicted by the demand relationships estimated from the period before the new approach, and especially why their growth should have been underpredicted. In this light, the next section examines whether the equations can be improved by taking into account the structural change which is argued to have occurred.[2]

4 Estimation period 1963 IV – 1972 IV: estimates and forecasting performance

Estimates

An implication of this structural change is that the forecasting performance of the equations for broad money could be significantly improved only if the estimation period were extended to take post-1971 behaviour into account. A new observation period was therefore adopted, going to the end of 1972, and thus covering the first five quarters of the new approach, but still leaving five quarters over which to test forecasting performance. The results of the fresh estimations are reproduced in Table B.

[1] March *Bulletin*, page 37.

[2] An alternative 'structural change' explanation for the failure of pre-1971 demand-for-money equations has appealed to some commentators, including M. J. Artis and M. K. Lewis (see their article 'The demand for money: stable or unstable', *The Banker*, Volume 124 Number 577, March 1974, pages 239–47). They assert that the underprediction errors have been due to an excess supply of money in 1972–73: that is, demand equations have not been able to predict the behaviour of the money stock simply because 'we have been off the demand curve'. But this explanation, if closely examined, clearly runs into difficulties. In particular:

a Why did an excess supply apparently not appear for M_1?

b Why did an excess supply not appear for personal sector holdings of M_3 through 1972?

c Why, if there were involuntary holdings of money in the company sector in 1972–73, was companies' demand for bank borrowing so consistently high, and their capital expenditure so consistently less than generally expected?

d Most fundamentally, how did the excess supply arise? Although in recent years, and particularly with the new approach, the authorities have placed a greater emphasis on movements in the monetary aggregates as indicators helping in the formulation of policy, this does not imply that the authorities have used different instruments to achieve their objectives. They do not directly control the money stock, but rather try to influence its development through operations in financial markets which affect the level and structure of interest rates. In this case, it is not clear how an excess of supply over demand could have arisen.

For these and other reasons, a 'shift in the demand curve' appears to provide a more plausible explanation than an excess of supply over demand.

Table B

Demand-for-money equations 1963 IV – 1972 IV[a]

All variables are in natural logarithms

Dependent variable		Constant	Coefficients: Short-run elasticities Y_t	P_t	$1+r^s_t$	$1+r^L_t$	$1+r^L_{t-1}$	$1+r'_t$	M_{t-1}	Standard error of estimate (per cent)	$\bar{R}^2$	D-W[b]	ρ[b]	Long-run elasticities[c] Y	r^s	r^L	r'
M_1		17·504	0·315 (0·153)	0·452	−0·441 (0·293)	−1·324 (0·763)			0·548 (0·127)	1·42	0·48	1·96	−0·6	0·697	−0·062	−0·206	
MP		4·287	0·326 (0·083)	0·301			−0·475 (0·352)		0·699 (0·105)	0·80	0·79	2·43	−0·6	1·081		−0·110	
MC	(1)	12·980	0·334 (0·315)	0·151	−0·105 (0·580)	−1·497 (1·492)			0·849 (0·137)	2·55	0·58	2·21	−0·4	2·206	−0·044	−0·696	
	(2)	−9·303	0·449 (0·268)	0·447		−2·197 (1·100)		3·156 (0·931)	0·553 (0·144)	2·19	0·69	2·40	−0·4	1·003		−0·345	0·568
M_3	(1)	3·833	0·144 (0·137)	−0·013	−0·574 (0·207)				1·013 (0·103)	1·16	0·79	2·25	−0·6	∞	−∞		
	(2)	4·373	0·175 (0·127)	0·176	−0·693 (0·197)			1·173 (0·448)	0·824 (0·119)	1·07	0·82	2·48	−0·6	0·995	−0·248		0·537

[a] For definitions of the variables, see Appendix 2. Standard errors are shown in brackets beneath the appropriate coefficients.

[b] For the meaning of the Durbin-Watson statistic (D-W) and ρ see Appendix l.

[c] The long-run price elasticity is constrained to unity in each equation. For r^S and r^L, elasticities are evaluated at the mean interest rates of the estimation period; for r' they are evaluated at the end of the period.

Two equations are reported for both MC and total M_3. The first in each pair is a re-estimation of the 'best' equation which had been estimated over the shorter observation period (Table A). In each of these the standard error of estimate has risen, and several of the coefficients are less significant. More important, however, in each there has been a marked (and statistically significant) increase in the coefficient of the lagged dependent variable. For MC, this implies a considerably slower speed of adjustment and a marked increase in the long-run elasticities. The implied long-run elasticity with respect to real income, for example, has risen from 0·5 in the previous estimates to 2·2. For the M_3 equation, the results are even more striking, and clearly implausible, for the coefficient of the lagged money stock has risen above unity;[1] but the results for MC suggest that this equation too is misspecified.

None of this is surprising in the light of the argument of the previous section that the interest rate on wholesale money will have attracted certain asset-holders into M_3 balances since the inception of the new approach, and that therefore movements in M_3 could probably no longer be adequately described in terms of demand relationships which did not include an own rate. The next step was to thus estimate equations for MC and M_3 which included an own-rate variable. As noted in Section 2 above, equations containing the clearing banks' seven-day deposit rate and the overnight inter-bank rate had already been estimated over the period ending in 1971 III, without satisfactory results. These experiments were repeated over the new, longer estimation period; but again, the coefficients either had the wrong sign or were not significant, or both. However, the failure to identify a significant own rate over the whole observation period 1963 IV – 1972 IV clearly does not conflict with the hypothesis that the rate on wholesale money became an important influence on the demand for M_3 after the reforms of 1971. To test this hypothesis adequately, various alternative own-rate variables were constructed to reflect the shift in the competitiveness of interest-bearing money.

Four main alternatives were tried. Over the final five quarters, 1971 IV – 1972 IV, each was defined as the three-month CD rate,[2] so as to reflect movements in money-market interest rates (rates paid on large time deposits as well as on CDs) since the new approach. Over the previous period from 1963 II they were defined as follows. Variant A was the clearing banks' seven-day deposit rate (generally Bank rate minus 2%),

[1] This implies that the coefficients in the desired money-stock function, from which (together with the partial adjustment hypothesis) the estimating equation was derived (see above, Section 1), are opposite in sign to those of the equation estimated. That is, the M_3 (1) equation of Table B implies a dynamic adjustment process which is unstable, so that no finite long-run (equilibrium) elasticities can be defined.

[2] There is a slight exception in the case of variant C: see below.

Table C
Own-rate variants

	$r_t - r_{t-1}$		
Variant	1963 III – 1971 III	1971 IV	1972 I – 1972 IV
A	$(\text{deposit rate})_t - dr_{t-1}$	$CD_t - dr_{t-1}$	$CD_t - CD_{t-1}$
B	Zero	CD_t	$CD_t - CD_{t-1}$
C	Zero	Zero	$CD_t - CD_{t-1}$
D	Zero	$CD_t - dr_{t-1}$	$CD_t - CD_{t-1}$

even though this had not been found significant as a determinant of M_3 balances over this period. Variant B was zero. In this case, there was a danger that the estimates – obtained from first differences – might be biased by the consequent large jump in the first difference in 1971 IV. Variants C and D, therefore, comprised rather arbitrary expedients designed to guard against this danger; each differed from variant B only in the way its first difference in 1971 IV was defined: in variant C, zero was taken, and in variant D it was the CD rate minus the previous quarter's seven-day deposit rate.

The four variants may be compared in Table C, where the first differences of each throughout the period are given. Variants B, C, and D are based on the assumption that until the new approach no own rate was a statistically significant determinant of broad money balances, so that variations in any such own rate could for these purposes be ignored. But all four of the alternatives embody a discontinuity between 1971 III and 1972 I, which is designed to reflect the hypothesis that money-market interest rates became a significant determinant of M_3 balances for the first time towards the end of 1971.[1]

On the basis of the estimations and the forecasting results, variant D was selected.[2] The second MC and M_3 equations in Table B contain this variable (r'); they are the 'best' equations for these aggregates over the new estimation period.

In each of them, the coefficient of the r' variable has the appropriate positive sign, and is significantly different from zero. The long-run elasticity with respect to the own rate, calculated at the end of the estimation period, is in each case greater than 0·5, and therefore comparatively high. The table also shows that these equations have better overall fits than the equations which did not include an own rate. As compared with the earlier estimates, the implied speeds of adjustment in both MC (2) and M_3 (2) are slower, and the long-run income elasticities higher – for the latter, each is now close to 1, whereas previously each was close to 0·5. The long-run elasticities with respect to the competitive interest rates r^s and r^L have also risen quite markedly.

These results give some support to the hypothesis under test. However, the changes which have occurred in the coefficients of the real-income and competitive interest-rate variables imply that the inclusion of the own rate during the period of the new approach has not been sufficient to explain the forecasting errors revealed in Section 2.

Given the successful 'forecasting' performance up to the end of 1972 of the MP equation estimated over the shorter period, it is hardly surprising that the replication of the same equation over the longer estimation period gave satisfactory results (see Table B). Indeed, it again gave the best results of all equations fitted for this aggregate. As compared with the previous estimate, the overall fit is slightly worse; the long-run real-income elasticity has risen slightly from 0·9 to 1·1 (accounted for by an increase in the coefficient of the lagged dependent variable); and both short-run and long-run interest-rate elasticities have also increased slightly. However, none of these changes are statistically significant.

In Section 2, it was found that, taking the whole forecast period into account, the M_1 equation had performed fairly satisfactorily, and that there seemed little reason to conclude that there had been structural change in the determination of the narrow money stock. This inference was given some support when the previous 'best' equation again gave the most satisfactory results over the longer estimation period: this re-estimate is shown in Table B. Like the MP equation, compared with the original estimate, the overall fit is rather worse; and the coefficient of the lagged

[1] In earlier work at the Bank, an alternative method was tried of deriving an own-rate variable embodying a similar discontinuity. This variable was defined as the differential between the CD rate and banks' prime lending rates whenever this differential was positive, and zero elsewhere. The variable thus in effect identified when opportunities for pure arbitrage arose, and had the advantage of always taking a zero value naturally, rather than by 'imposition', before the new approach. Although equations were estimated in which this variable was statistically significant, the results imputed an implausibly large proportion of the increase in M_3 during 1972 to arbitrage, and were therefore rejected in favour of the approach reported in the text. However, further research in this direction is probably desirable.

[2] It may be of interest that the only variant whose coefficient was frequently not significant was variant A. It was also not always positive in sign.

money stock has risen, and accounts for an increase in the long-run real-income elasticity from 0·4 to 0·7. However, M_1 remained the least income elastic of the four aggregates.

Forecasting performance 1973 I – 1974 I

As before, the best equations were used to 'forecast' the movements of the four aggregates, this time over the five quarters 1973 I – 1974 I. Actual and predicted growth rates in each quarter are compared in Charts D, F, H, and K in Appendix 4.

Given the forecasting results of the original MP equation, and the similarity to it of the new equation, it is not surprising that little improvement resulted from the extension of the estimation period to the end of 1972. Closer examination confirms the impression obtained by comparing Charts J and K: although in each of the five 'forecast' quarters the error of the new equation was smaller than that of the old, in each of the final three quarters there was again significant underprediction.

The forecasting results of the new M_1 equation, also, were similar to those of the old. Although the extension of the estimation period succeeded in reducing the forecasting errors in three quarters out of the five, there was again significant underprediction in 1973 II. The other four errors were again not significant.

Chart H shows the results for MC. Although the contrast with the old equation (Chart G) is immediately apparent, the success of the new equation, MC (2) of Table B, is in fact rather limited. Overprediction occurred in four quarters out of the five (1973 III being the exception); and in two of these – 1973 I and 1974 I – the errors were significant.

Finally, Chart F, which shows the results for the M_3 (2) equation of Table B, again contrasts markedly with the charted performance of the old equation. In fact two quarters were underpredicted (1973 III and 1973 IV), neither significantly at the 5% level, and three were overpredicted, one significantly (1974 I).

Implications of the results for total M_3, MC and MP

Although the MC and M_3 equations estimated before the introduction of the new approach failed to forecast subsequent behaviour at all accurately, it has been found that equations which fit the data to the end of 1972 quite well may be obtained by inclusion of the CD rate over part of the period. This supports the argument that the own rate on money became a more significant and powerful determinant of the demand for M_3 from the end of 1971 onward.

However, these equations need to be interpreted with even more caution than is usually needed in the interpretation of demand-for-money equations. For the importance of the CD rate to the results may to a large extent be a reflection of the transition to the changed money-market environment, and in particular of adjustment to the growing market in CDs. Also, during the five quarters added in the new estimation period, the attraction of CDs may have been especially great for tax reasons. (The associated tax loophole was blocked by measures in the 1973 Budget.[1])

In short, the fact that the new MC and M_3 equations take into account only five quarters' experience of the new approach may mean that they describe behaviour much of which reflects transitional or other temporary influences. It would therefore be premature to conclude what the characteristics of the demand for broad money will be over any long period. This cautionary note is supported by the limited 'forecasting' success and tendency towards overprediction, especially of the MC equation. Furthermore, it is notable that both the MC and M_3 equations overpredicted in 1974 I, which was the first quarter in which the supplementary deposits scheme was in operation. Although the errors in this quarter cannot be attributed with any certainty to the effects of this

[1] However, 'forecasts' for 1973 II – 1974 I which were based on the hypothesis that the attraction of CDs diminished after 1973 I with the closing of the loophole, were not as good as those discussed above which took no account of a possible tax effect. This is not necessarily surprising, particularly as the CD rate was included to represent the own rate on wholesale money generally, and not only on CDs.

scheme,[1] the central results of this paper imply that it is unwise to be confident in the survival of stable demand-for-money relationships when there are changes in regulations affecting the banks.

Although the behaviour of MP until the beginning of 1973 is explicable in terms of the old relationship, this does not appear to be true for the remainder of the forecast period. An extension of the estimation period beyond the end of 1972 may throw some light on the extent to which the apparent shift in this relationship also can be explained by the addition of an own rate to the list of explanatory variables; but this has not yet been attempted.

[1] During this quarter there were exceptional influences at work, in particular short-time working in industry and the resulting pressures on company liquidity; and the income and price data used to produce the forecasts for the quarter were tentative preliminary estimates.

Appendix 1

Method of estimation

The addition of the disturbance term u_t to the right-hand side of equation (6), derived in Section 1 above, produces the stochastic equation

$$\ln(M_t/P_t) = b_0+b_1 \ln Y_t+b_3 \ln(1+r_t)+\gamma \ln(M_{t-1}/P_t)+u_t. \quad (7)$$

The method of ordinary least squares would provide unbiased estimates of (7) only if the following assumptions were satisfied:

a $E(u_t) = 0$ (mean of errors zero over time);

b $E(u_t u_s) = 0$ when $t \neq s$ (no autocorrelation),
$= \sigma^2$ when $t = s$ (variance constant over time); and

c no correlation between the error process and the set of predetermined variables.

An implication of these assumptions is that the error process should be stationary upon correct specification of the deterministic model. As the variables in levels were trended, it was considered that a first-difference transformation should be taken before estimation. Thus (7) is transformed to

$$\begin{aligned}\ln(M_t/P_t)-\ln(M_{t-1}/P_{t-1}) = {} & b_1(\ln Y_t-\ln Y_{t-1}) \\ & +b_3[\ln(1+r_t)-\ln(1+r_{t-1})] \\ & +\gamma[\ln(M_{t-1}/P_t)-\ln(M_{t-2}/P_{t-1})] \\ & +v_t\end{aligned}$$

where

$$v_t = u_t-u_{t-1}$$

i.e.

$$\Delta \ln(M_t/P_t) = b_1 \Delta \ln Y_t+b_3 \Delta \ln(1+r_t)+\gamma \Delta \ln(M_{t-1}/P_t)+v_t \quad (8)$$

where

Δ is the first-difference operator.

Although this transformation removes any linear trends that may be present in the variables expressed in logarithmic levels, it is still possible, for two reasons, that the residuals, v_t, may be autocorrelated. First, it may be that the appropriate model has been specified, but that this 'true' model exhibits autocorrelation: in this case, the best procedure would be to estimate the equation using an autoregressive least squares technique. Secondly, if, despite the presence of the lagged dependent variable, a Durbin-Watson statistic significantly different from 2 is found for equation (8), this may be evidence of misspecification. In this case, the structure of the equation should be modified until an appropriate value for the statistic is obtained.

The assumptions were adopted that equation (8) comprised the true model, and that an appropriate procedure to eliminate the residual autocorrelation was to use a Cochrane-Orcutt transformation.[1] The final equation estimated was thus of the form

$$\begin{aligned}\Delta \ln(M_t/P_t)-\rho \Delta \ln(M_{t-1}/P_{t-1}) = {} & b_1(\Delta \ln Y_t-\rho \Delta \ln Y_{t-1}) \\ & +b_3[\Delta \ln(1+r_t)-\rho \Delta \ln(1+r_{t-1})] \\ & +\gamma[\Delta \ln(M_{t-1}/P_t)-\rho \Delta \ln(M_{t-2}/P_{t-1})] \\ & +e_t \quad (9)\end{aligned}$$

where

$$e_t = v_t-\rho\, v_{t-1}$$

and

$$|\rho| < 1.$$

The value of ρ was varied between -1 and $+1$, at intervals of 0·2. This rough search procedure proved sufficient to determine the approximate optimal value of ρ (the criterion being the minimisation of the equation standard error); this value is shown in Tables A and B for each of the equations reported.

In order that the estimated equation could be expressed in the form of equation (7), a value for the constant term b_0 was derived by appropriate backward transformation. The error term u_t of the estimated equation expressed in this form is given by

$$(1-L)(1-\rho L)u_t = e_t$$

where

L is the lag operator

and

e_t is white noise.

[1] D. Cochrane and G. H. Orcutt, 'Application of Least Squares Regression to Relationships Containing Auto-Correlated Error Terms', *Journal of the American Statistical Association*, Volume 44 Number 245, March 1947, pages 32–61.

Although the Durbin-Watson statistics obtained from the estimation of equation (9) are shown in Tables A and B of the text they do not have their usual interpretation, owing to the presence of the lagged dependent variable.

Appendix 2

Data

The variables represented by the symbols used in the reporting of the empirical results are as follows:

M_1, M_3 — as defined in the additional notes to Table 12 of the statistical annex; £ millions, seasonally adjusted, end-quarter.

MP — holdings of M_3 of the personal sector (as defined for the flow of funds accounts); £ millions, seasonally adjusted, end-quarter.

MC — holdings of M_3 of industrial and commercial companies (as defined for the flow of funds accounts); £ millions, seasonally adjusted, end-quarter.

Y — a in connection with M_1, M_3 and MC: total final expenditure at 1970 prices; £ millions, seasonally adjusted, quarterly;

b in connection with MP: personal disposable income at 1970 prices; £ millions, seasonally adjusted, quarterly.

P — a in connection with M_1, M_3 and MC: the implicit deflator of total final expenditure; $1970 \equiv 1$;

b in connection with MP: the deflator of personal disposable income; $1970 \equiv 1$.

r^S — interest rate on three-month deposits with local authorities; quarterly averages of working days.

r^L — yield on 2½% Consolidated Stock; quarterly averages of working days.

r' — a before 1971 IV: zero;

b from 1971 IV onwards: interest rate on three-month sterling certificates of deposit (but see text and Table C); quarterly averages of working days.

The data used in the reported work may be obtained on application to the Economic Section, Bank of England, London, EC2R 8AH.

Reliability of the money stock data

M_1 and M_3, and even more MC and MP, are quantities which cannot be measured direct and have to be estimated with the help of certain rules of thumb, most particularly in order to deal with transit items. An odd result might sometimes easily be explained by misallocation of transit items. These errors would, as it happens, particularly affect MC and M_3; and it is interesting that 1973 I and 1974 I, which sometimes produced bad results in this exercise, are each quarters where there was a particularly large rise in transit items (which would depress MC and M_3). Thus the money stock data are not very secure; moreover, this work has had to be done with the inherently more erratic quarterly series, and not with the steadier monthly figures.

Appendix 3

A review of three sets of results; stability and instability

In this appendix, some salient features of the equations estimated over the period 1963 IV – 1971 III, and reported in Section 2 above are compared with the estimates published previously in this *Bulletin* in the papers by Goodhart and Crockett, and Price.[1] The point estimates of the long-run interest-rate, real-income, and price elasticities implied by each of the three sets of estimates are brought together in Table D.

There appear to be a number of contrasts. However, owing to differences in the data, the comparisons are not straightforward. Thus the M_1 series currently in use and adopted in this paper differs significantly from the series used in the previous papers, most notably in that the latter included accounts with the London clearing banks only, while the former includes accounts with all UK banks. Also, all money-stock series used for this paper relate to end-calendar quarter data, while the previous M_1 series comprised averages of mid-monthly figures. All told, the old 'M_1' series represents a quite different variable from the current series and so the new and old results are not really comparable. A further, but less significant difference between the new and old data is that in this paper the income (or expenditure) variables used are TFE (for M_1, M_3 and MC) and PDI (for MP), whereas previously gross domestic product at factor cost was used throughout.

It is, however, apparent from Table D that there are discrepancies in the results which are unrelated to these differences in the data, and which raise the question of the stability of the relationships: that is, the question of whether the characteristics of the estimates are reliable, or whether they vary significantly as the data period or the specification of the relationships is altered, even when this is done in only a minor way.

Table D

1 Long-run interest-rate elasticities compared

	M_1	MP	MC	M_3
This paper (Table A)	–0·26 [a]	–0·07(r^L)	–0·26 [a]	–0·09(r^S)
Price [b] (r^S)	–9·52	..	–0·36	–0·12
Price [b] (r^L)	–0·79	–0·30	..	–0·18
Goodhart and Crockett [c] (r^S)	–1·05	..	..	–0·21
Goodhart and Crockett [c] (r^L)	–0·80	..	..	–0·51

2 Long-run real-income and price elasticities compared

Price elasticities shown in brackets where freely estimated

	M_1	MP	MC	M_3
This paper (Table A)	0·39	0·93	0·51	0·45
Price [b] (r^S)	–2·38(17·33)	..	2·77(0·41)	2·47(0·51)
Price [b] (r^L)	0·79(1·36)	2·29(0·90)	..	1·81(1·02)
Goodhart and Crockett [c] (r^S)	1 (–3·5)	..	..	0·47(1·95)
Goodhart and Crockett [c] (r^L)	1 (2·0)	..	..	–0·29(2·71)

.. not available.

[a] The sum of r^S and r^L elasticities.

[b] Price, estimation periods:
M_1 1956 I – 1969 IV
M_3, MP, MC 1964 I – 1970 IV.
In all equations, long-run price elasticity was unconstrained.

[c] Goodhart and Crockett, estimation periods:
M_1 1955 IV – 1969 III
M_3 1963 II – 1969 III.
The elasticities in part 1 of the table are from equations in which nominal income is treated as one variable; in part 2, the equations referred to were estimated *per capita*, with price and real income entered separately, and price elasticity unconstrained.

A problem which will clearly tend to give rise to instability of coefficients is that of multicollinearity; and the danger of this arising in demand-for-money relationships is considerable, as the independent variables all tend to be strongly trended, and hence intercorrelated, even in logarithmic form. This danger can, however, be reduced by various means. For example, it is argued in Section 1 of the text that the high correlation between real income and price provides a justification for constraining the coefficient of the price variable to its theoretically plausible value. In this connection, it is notable that in the results reported in Table D part 2, freely-estimated price

[1] For references, see the footnotes on page 284.

Table E

Correlation matrix; M_3, income, and interest rates; 1963 IV – 1971 III

		1	2	3	4
1	$\Delta \ln Y_t$	1·00			
2	$\Delta \ln (1+r_t^S)$	–0·09	1·00		
3	$\Delta \ln (1+r_t^L)$	0·23	0·32	1·00	
4	$\Delta \ln (M_{3_{t-1}}/P_t)$	0·25	0·08	0·16	1·00

elasticities differing substantially from unity were frequently associated with real-income elasticities which might be regarded as dubious: see in particular Price's r^S results; and Goodhart and Crockett's M_3 results.

But the problem arises in a similar way because of correlation among real income, the lagged money stock, and interest rates. In each case, comparatively small changes in the data threaten to alter the coefficients estimated. However, the first differencing of the data, which was performed before all equations reported in this paper were estimated, reduced considerably the intercorrelation among these variables. Table E is the correlation matrix for the first differences of these variables over the period 1963 IV – 1971 III. The coefficients of correlation shown here can reasonably be regarded as acceptably low. None of the previously published equations were estimated in first differences; the danger of multicollinearity was therefore greater than in the work reported in this paper.

The stability of estimated coefficients can be tested by comparing estimates from different sample periods; and by examining the success of relationships in forecasting beyond their estimation period. The results of some such tests are reported in the main body of this paper.

Despite the disparities, the latest estimates support certain interesting inferences drawn by Price from his results (as well as, in some cases, by other investigators from theirs). These inferences include the following:

a the long-run real-income elasticity of the demand for narrow money has been less than that for broad money;

b the interest elasticity of the demand for narrow money has been numerically greater than that for broad money;

c short-term interest rates (at least as represented by the LA rate) have not been significant in explaining MP, and the Consol rate lagged one period appears to have had greater significance than the current rate in its determination;

d MC has been more interest elastic than MP;

e MC has appeared to adjust faster than MP to exogenous changes.

Appendix 4

Charts of predicted and actual changes in the monetary aggregates

Chart C
M_1: Estimation period 1963 IV—1971 III

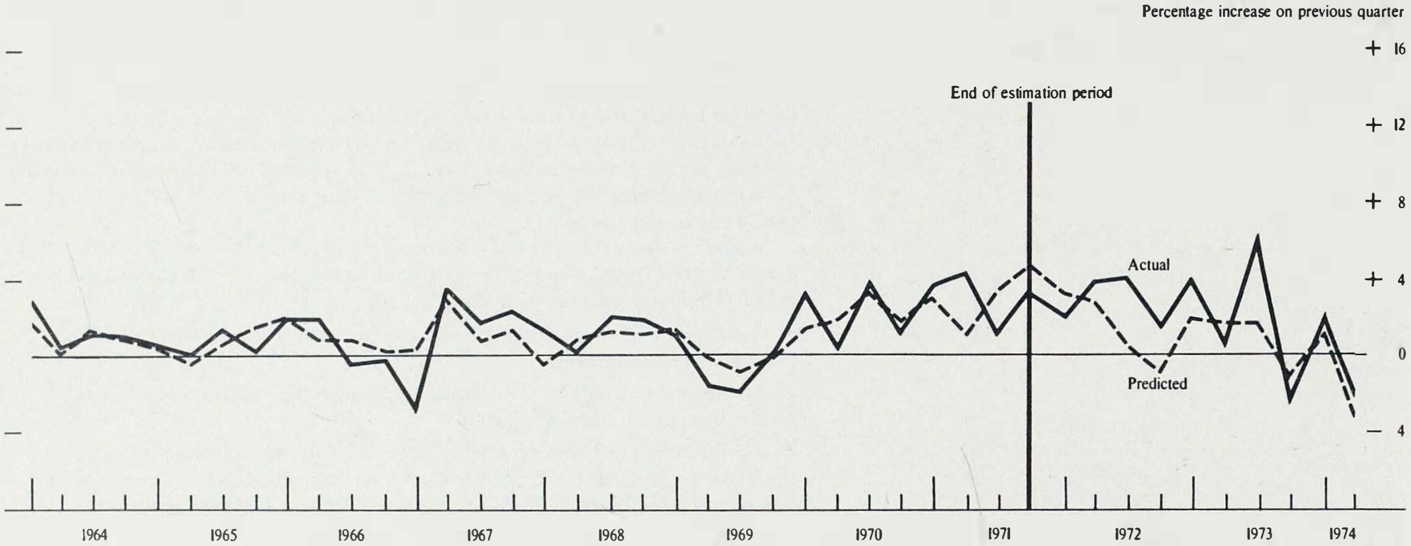


Chart D
M_1: Estimation period 1963 IV—1972 IV

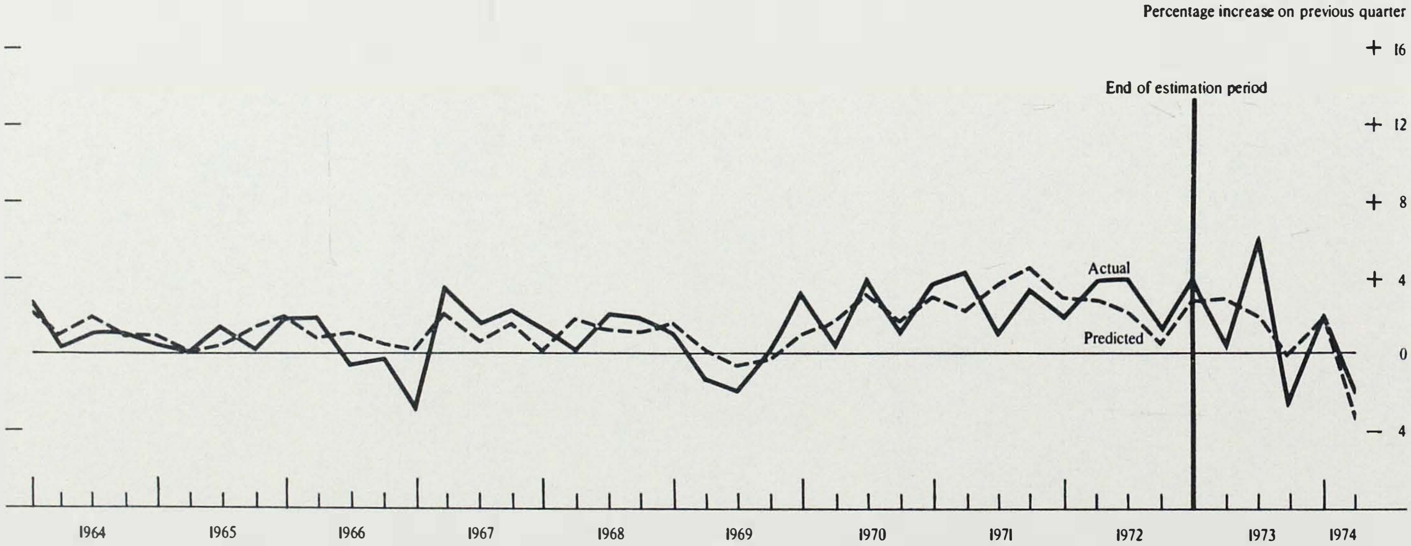


Chart E
M_3: Estimation period 1963 IV—1971 III

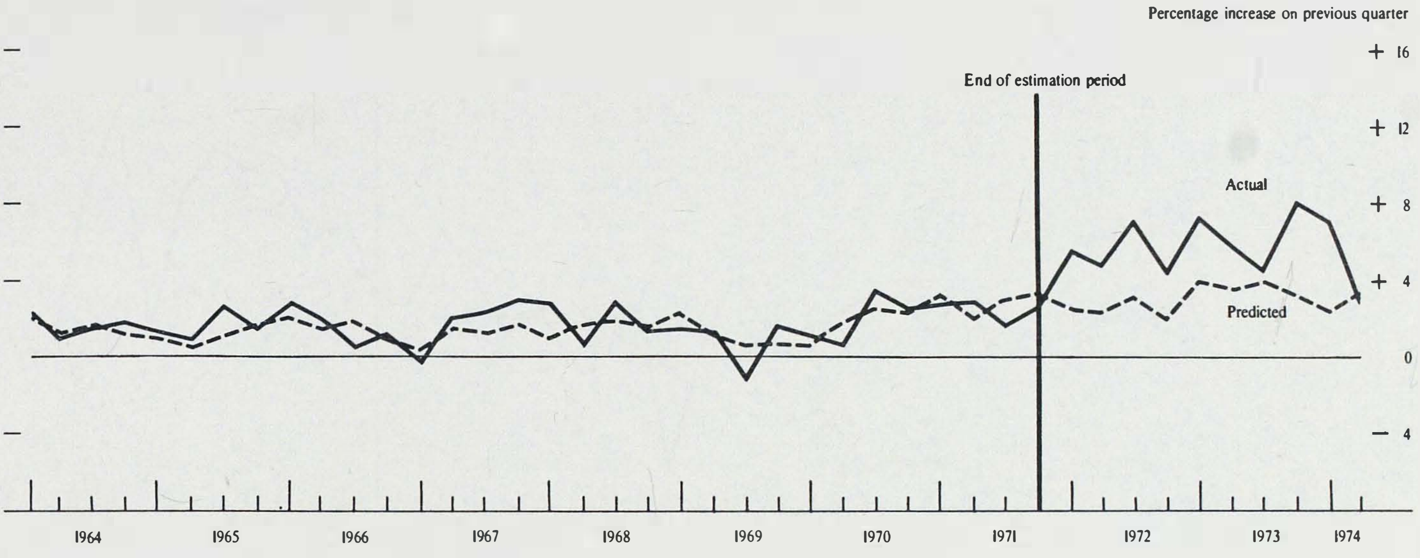


Chart F
M_3: Estimation period 1963 IV—1972 IV

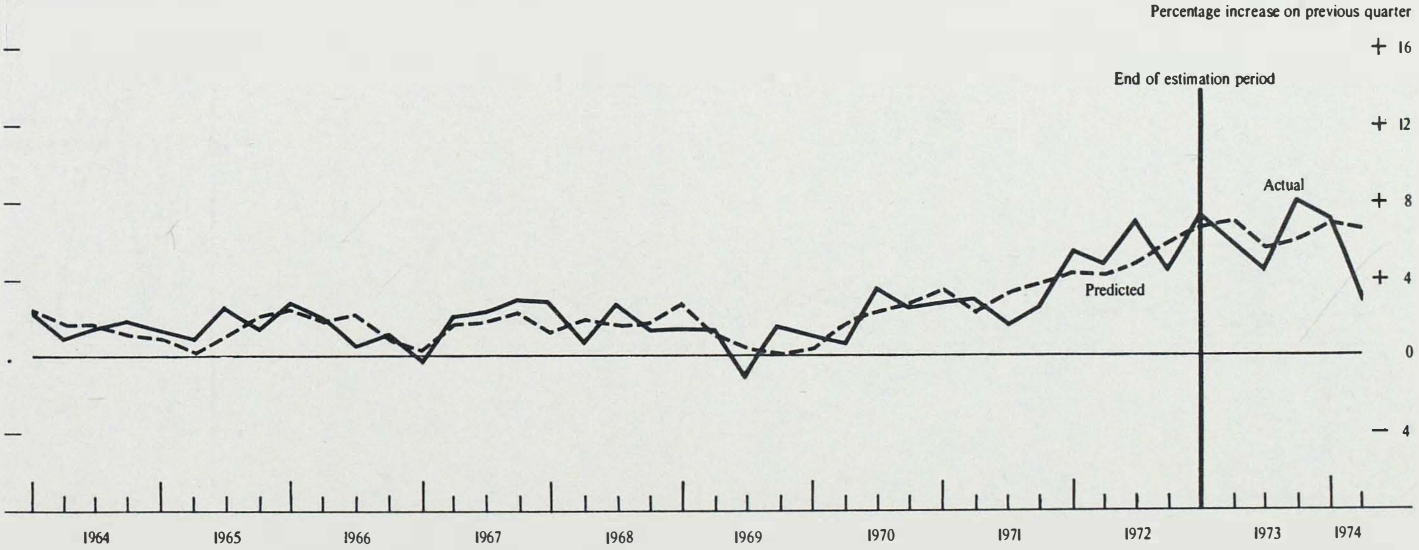


Chart G
MC: Estimation period 1963 IV—1971 III

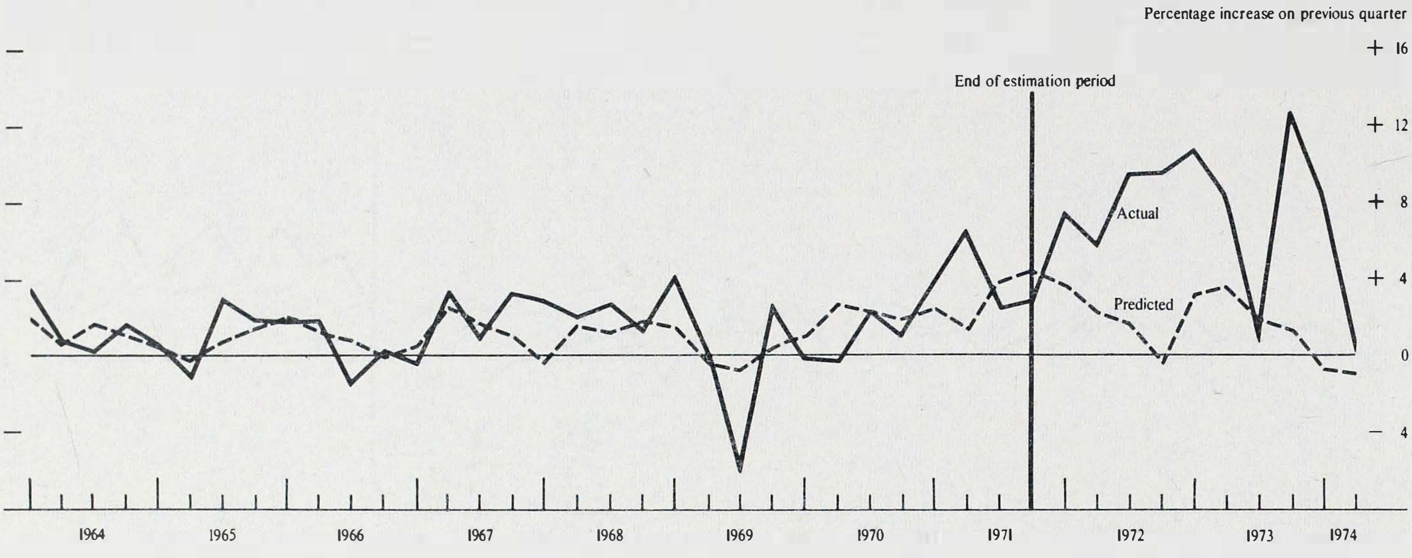


Chart H
MC: Estimation period 1963 IV—1972 IV

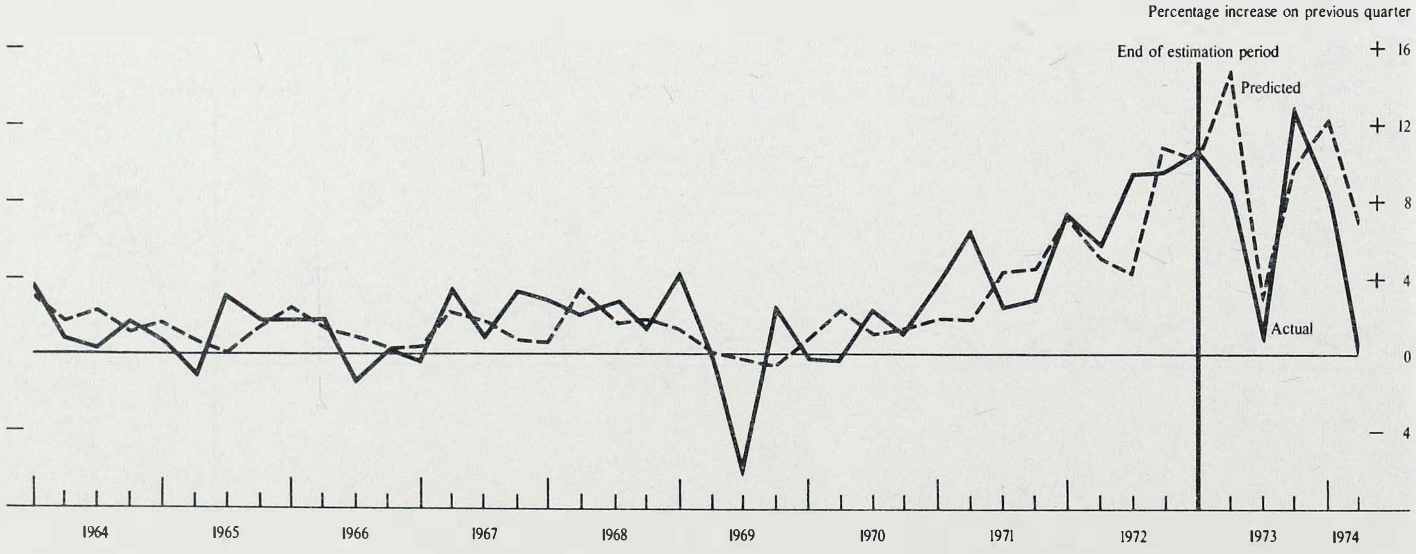


Chart J
MP: Estimation period 1963 IV—1971 III

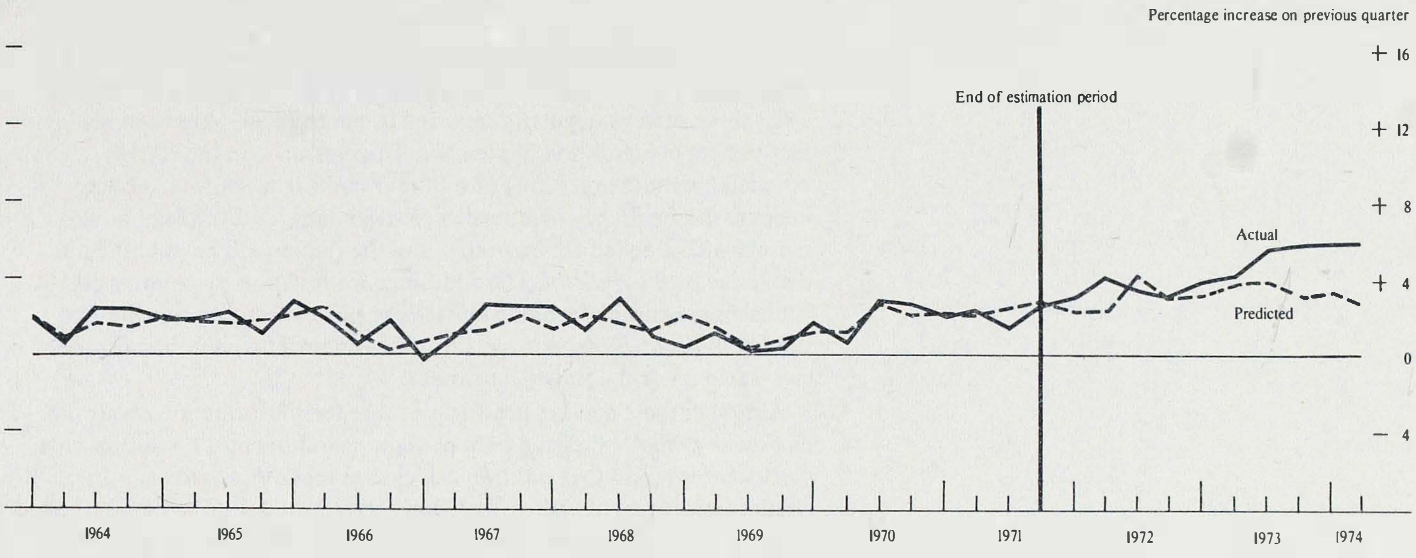


Chart K
MP: Estimation period 1963 IV—1972 IV