THE DEMAND FOR MONEY WITH SPECIAL REFERENCE TO THE UK IN THE POST-COMPETITION AND CREDIT CONTROL 1970'S

by

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ABSTRACT

The early chapters are concerned with the fundamental policy issues associated with the demand for money function and those monetary features of the post-CCC 1970's which present problems for the determination of valid structural demand relationships.

Alternative macro-demand for money models are outlined in Chapter 3; models which recognize the potential significance of both domestic and international speculation.

After reviewing the work of other researchers my own empirical findings are reported in Chapters 5-9 inclusive. Various definitions of money were considered, including M1 and £M3, and it was found that simple partial adjustment models performed reasonably well. Simultaneity was not found to be important for either M1 or £M3 and there was no empirical evidence to suggest that either domestic or international speculative influences were especially strong. Most of the estimated equations were plausible although small and weakly-determined price elasticities were found for both time deposits and personal sector money-holdings. Inflation expectations were only found to have a significant direct influence on M1. The best estimated relationships passed the structural stability tests and provided reasonable ex-post forecasts for 1979.

Work on the company sector included two special features: firstly, the estimation of a simple portfolio model of liquid asset demand and secondly, an examination of the money-holding behaviour of those large companies which participate in the
DOI survey of company liquidity.

The major conclusion reached is that the various demand for money functions, including the policy-relevant £M3 definition, have been reasonably stable in the post-CCC 1970's with the CCC reforms only temporarily destabilising the functions. Certainly, there is no real evidence to suggest that monetarism cannot achieve its long-term objective of low and steady inflation because of any serious instability of the demand for money function.
ACKNOWLEDGEMENTS

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A special word of thanks goes to Mr. R.J. Jackson, formerly of the Department of Industry's Economics and Statistics Division, for supplying information from the survey of company liquidity which enabled me to cover the demand for money behaviour of large companies.

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INTRODUCTION

One of the necessary conditions for the success of monetary policy in achieving medium-term control over the level of aggregate demand, in particular the rate of inflation, is that a stable demand for money function can be identified. The empirical work embodied in this thesis is addressed to this particular issue and focuses on the post-Competition and Credit Control period, 1972-1979.

Many studies of the demand for money have been made and the existing body of empirical work for the UK economy (work which considers at least some of the post-CCC era) is reported in Chapter 4. Prior to the introduction of Competition and Credit Control in September 1971 there was a wide measure of agreement amongst researchers that both narrow and broad money demand functions were stable. This finding of stability allied to the failure of existing demand management policies (founded on Keynesian beliefs) to achieve their objectives gave rise to a growing respect for monetarism. As a result the CCC reforms involved a limited move away from interest rate control towards control of the money supply. Further moves in this direction came with the introduction of flexible exchange rates in 1972, which made independent long-run control of the money supply possible, and the announcement of money supply targets for £M3 from 1976 onwards. Finally, under the 1979-elected Conservative government, the UK monetary authorities show some inclination to move closer to a system of monetary base control, although there is some concern as to the possible consequences to money market behaviour.
In Chapter 1 the basic developments in demand for money theory are considered along with the essential policy issues in aggregate demand management. The aim here is merely to establish the importance of money demand behaviour with respect to the choice between alternative policy instruments for controlling the level of aggregate demand and to show that the success of monetary policy depends on a stable demand for money function. At the end of the chapter there is a brief summary of UK demand for money studies covering the pre-CCC period which produced a picture of stability.

Unfortunately at the very time monetarism was gaining respect there came some disturbing evidence that both the M1 and M3 demand functions, estimated over pre-CCC years, could not make sense of the early post-CCC period. Studies by Hacche and Artis and Lewis, which are reported in Chapter 4, both pointed towards a definite picture of instability for the M3 demand function. Since these studies of the early post-CCC era, additional work using more recent data has also suggested instability for M3 although the picture for M1 is less clear. The relevant studies are reported in Chapter 4 and while many investigations have been made most have focused on M1 rather than the policy-relevant M3 definition. Furthermore, none of the reported broad money studies employing recent data have investigated the money demand behaviour of the personal and company sectors separately.

Since instability of the demand for money function is certainly damning for monetarism (quite apart from the question of whether the money supply can be controlled sufficiently closely) it is important to carefully consider
the monetary reforms and developments of the 1970's to see, in particular, how these might have influenced demand for money behaviour. It might be the case that the simple demand functions that performed so well in the pre-CCC era need to be revised in the light of these reforms and developments. For example the new competitive environment in which the banks operated after the introduction of Competition and Credit Control meant that it became important to additionally include an own-rate on money variable in the demand for broad money function. It could of course be that the demand for money functions were only temporarily de-stabilised by the banking reforms of 1971, or that the functions shifted systematically before settling down again. Indeed, it might be, as Artis and Lewis suggested (see Chapter 4), that the economy was off the demand for money curve during the years of rapid money stock growth - i.e. 1972 and 1973!

Chapter 3 covers the modelling aspects of the macroeconomic demand for money function. After dealing with the question of variable selection for five different demand for money equations (M1, £M3, Time deposits (TD), Personal sector holdings of M3 deposits (MP) and Company sector holdings of M3 deposits (MC)), the specification of variables and functional form are considered. As far as model dynamics are concerned a variety of popular fixed lag models, including partial adjustment, are described as well as flexible lag models based on polynomial distributed lag structures. Finally, estimation problems in the context of both single equation and simultaneous models are discussed with a view to the selection of optimal estimators in the empirical work.
Chapter 4 consists of a survey of the existing empirical evidence on UK demand for money functions in the post-CCC 1970's. The broad aim was to present a comprehensive, but certainly not exhaustive, survey specifically focusing on those monetary reforms and developments, discussed in Chapter 2, which are likely to have had an influence on the public's demand for money behaviour. In covering the post-CCC studies in this way it has been possible to identify areas which have either not been adequately covered, or even dealt with at all. In particular, it was possible to identify a need for further work, both in terms of model specification revisions and an updating of the data.

The major gaps and shortcomings in the reported studies were identified as follows:

(1) Despite the fact that the broad money stock could no longer be regarded as demand-determined after the CCC reforms, none of the reported studies were explicitly set in a simultaneous model framework. In my own work simple simultaneous models are estimated for both M1 and £M3 in addition to single equation specifications: the results are reported in Chapters 5 and 6, respectively.

(2) In many of the studies price homogeneity (either in the short-run or the long-run) has been assumed without any prior attempt to test whether this is a legitimate restriction by freely estimating the price and income elasticities. Since wrong estimates of these elasticities could result in money supply
growth policies which are either too 'tight' or
too 'easy' it is important to try and establish
their separate values. Although the lack of
independent variation in the real income and price
data made it difficult to determine the separate
elasticities in the 1960's there has been much
greater independent variation in the 1970's. In
my own work the price and income elasticities have
been freely determined and for comparison purposes
I have also included specifications which impose
the price restriction.

(3) Few studies have specifically considered the asset
or speculative demand for money. In Chapter 6 an
extrapolative/regressive expectations hypothesis
is considered for the return on government bonds and
is tested for £M3 and private sector time deposits.
This particular hypothesis was selected in the light
of the behaviour of the bond rate during the post-
CCC 1970's.

(4) Only two of the reported studies specifically included
an exchange rate variable in the demand for money
function. In my own work I have considered the
influence of exchange rate expectations for three
definitions of money: £M3, private sector time
deposits (TD) and company holdings of M3 deposits (MC).

(5) The modelling of inflation expectations is inadequate
in those studies which do include an inflation variable
in the demand for money specification. Many studies
do not include an inflation variable at all claiming
that the influence of inflation on the demand for money is largely taken up by movements in nominal interest rates. Chapter 7 is devoted to an investigation of the influence of inflation expectations on the demand for money in which two models of inflation expectations are specifically considered: adaptive expectations and extrapolative/regressive expectations.

(6) There is a clear need for an updating of the work on the sectoral demand for money, particularly as the money demand behaviour of the personal and company sectors is likely to be quite different. In Chapter 8 the demand for money behaviour of the personal sector is investigated over the post-CCC 1970's and a similar exercise is conducted for the company sector in Chapter 9.

(7) Most of the reported studies have used fixed lag dynamic models without providing any empirical evidence to show that the dynamic specifications employed are valid. There is a clear need for more work in the context of flexible lag models. Evidence from both fixed and flexible lag models was considered for M1 and the sectoral demand for broad money in my own work. Furthermore, the validity of the fixed lag model dynamics for models such as partial adjustment was specifically tested for each of the estimated equations. Transforming relationships to remove serial correlation in the residuals was only done in cases where a test statistic ($x^2$) showed the auto-regressive restriction to be valid.
From the introduction of CCC to the end of the 1970's there is just enough sample information with which to estimate demand for money functions using only post-CCC data. Indeed, this is necessary before drawing any real conclusions about the stability of either the narrow or broad money functions in the post-CCC era. Accordingly, although some of my empirical work covers the data period 1964-1979 the vast majority of the reported results are based on equations estimated over the period 1972-1979.

Work on the company sector, reported in Chapter 9, includes some special features such as the estimation of a disaggregated liquid asset demand model. The main aim, here, was to establish the strength of substitution between the various assets held and how a change in the pattern of interest rates might influence the composition of the company sector's asset portfolio. Another special feature is the investigation of the demand for money behaviour of large companies based on data from the Department of Industry's survey of company liquidity. The basic aims here are to determine whether the money-holding behaviour of large companies differs significantly from that of small companies and whether there is a significant difference between the money-holding behaviour of manufacturing as opposed to non-manufacturing companies.

In the last chapter, in the context of a simple dynamic IS/LM model, it is considered whether the behaviour of the demand for M3 function had provided the most serious difficulties for demand-management policies, or whether in fact the money supply or aggregate expenditure functions were more
troublesome in the post-CCC 1970's. The policy-relevant reduced form fiscal and money multipliers are derived from the structural model and the relationships between the structural parameters in these multiplier terms are carefully considered. The impact on the value of either multiplier resulting from any given disturbance to one or more of the structural coefficients in the demand for money equation can readily be measured.

After considering the formal policy issues and implications in the context of an IS/LM model the remainder of the chapter concentrates on the demand for money. A summary of the best single equation results is reported and verdicts concerning the stability of the various demand functions are reached. Ex-post forecasts for M1, £M3 and time deposits (TD) are extended to cover the first five quarters of the 1980's, a period in which there were disturbances to financial markets caused by changes in the techniques of monetary control and the sudden absence of exchange controls.

Finally, policy conclusions based on the major findings are drawn. In this particular context the implications of recent work by Artis and Currie which suggests that exchange rate targeting might be preferable to money supply targeting are briefly considered. If interest rate controls are not considered to be an acceptable policy measure than a finding of instability in the demand for broad money function would lend itself to a policy of exchange rate targeting.
CHAPTER 1

GOVERNMENT ECONOMIC POLICY AND THE DEMAND FOR MONEY

1.1 Basic theory on the demand for money

Developments in demand for money theory can be traced from the work of the classical economists* in the early 20th century.

Irving Fisher's Quantity Theory of Money (48) although simply an identity as it stands can be interpreted, after making suitable important assumptions,** as a theory of the demand for money. A re-arrangement of the equation MV = Py leads to the following equation:

\[ M = \frac{1}{V} Py = \frac{1}{V} Y \]  

Furthermore, since in equilibrium desired money-holdings equals actual money-holdings, which, of course, equals the stock of money in existence, we have a simple proposition about the demand for money:

\[ M^D = \frac{1}{V} Y \]  

Since V was regarded by the early quantity theorists as essentially fixed in the short-run, determined by technical factors associated with the structure of the economy which

* Fisher (1911), Pigou (1917), Marshall (1923).

** These assumptions concern the nature of the relationship between final market transactions, Y in equation (1), and all transactions. Only if Y varies in direct proportion with T will VY be constant in the short-run assuming, of course that VT is. For this to be true merger and take-over activities, and the degree of vertical integration in the economy must be slow to change.
were likely to change slowly and predictably, this amounted to assuming a direct proportionality between the stock of money held and the level of money national income.

An alternative approach was the 'Cambridge Equation', developed by Cambridge economists such as Marshall (87) and Pigou (111). Formally, the Cambridge Equation is identical with the income version of Fisher's equation, outlined above, and can be written as:

\[ (3)^A \]
\[ M^D = KPy \]

where \( K = \frac{1}{V} \) in the Fisher equation.

However, while income was seen as the most important determinant of the demand for money, the view was taken that other variables, such as the rate of interest, might also have an important influence. So, unlike Fisher, they did not assume a direct proportionality between money-holdings and national income. However, there was little serious attempt to examine the dependence of \( K \) on other variables. Perhaps \( (3)^A \) should be re-expressed as follows to clearly differentiate it from the Fisher equation:

\[ (3)^B \]
\[ M^D = K(r)Py \]

These basic classical models were developed further by Friedman (51) and Keynes (74), respectively.

Friedman stated that the quantity theory of money should be interpreted as a theory of the demand for money in a generalised portfolio framework; he applied basic consumer theory, postulating that individuals would arrange their portfolios so as to maximise utility. Essentially, money was seen as a substitute for a wide range of assets including
human wealth.

Friedman's demand for money function represents the Modern Quantity Theory of Money and can be expressed as follows:

\[ M^D = f(W, R^O, R^B, R^E, P^E, h, u) P. \]

where,

- \( W \) = Wealth
- \( R^O \) = Returns on capital—certain financial assets
- \( R^B \) = Expected returns on gilts
- \( R^E \) = Expected returns on equities
- \( P^E \) = Expected inflation
- \( h \) = The ratio of non-human to human wealth
- \( u \) = Tastes
- \( P \) = Price level

The expected rate of inflation is included since it represents the cost of holding money in terms of physical goods: as the rate of inflation rises so people would be expected to substitute goods for money in their portfolios.

Since human wealth can only be substituted to a very limited extent for other assets, there is a case for distinguishing between human and non-human wealth in the demand function: this is done by including the ratio of non-human to human wealth.

Friedman actually makes use of permanent income, \( Y_p \), for empirical work since direct estimates of wealth are

* Human wealth is defined as the discounted value of the expected stream of earned income.

** Defined as a weighted average of current and past incomes.
unavailable. Further empirical simplifications include:

(a) Ignoring expected capital gains or losses since no measure of these are available.

(b) Dropping the rate of inflation since developed economies have rarely experienced conditions of rapidly accelerating inflation and movements in interest rates capture the influence of inflation to some extent, in any case.

(c) Dropping the ratio of non-human to human wealth.

(d) Retaining only one rate of interest to represent the return on alternative financial assets for sound statistical reasons.*

This leaves us with the following simplified demand for money function:

\[ \frac{M^D}{P} = f(Y_p, R_0, u) \]

\[ Y_p = \text{permanent income} \]

Since money is regarded as a substitute for a wide range of alternative assets, a change in the rate of interest on a particular substitute asset should lead to substitution from all others, to varying extents, so that the interest elasticity of the demand for money is not expected to be particularly great. Furthermore, and rather importantly for policy purposes, the demand for money is considered by

* The problem of multicollinearity due to interest rates varying closely together, so that the separate influence of each cannot be easily estimated.

** The demand for money is assumed to be linearly homogeneous in prices: there is no dispute between monetarists and Keynesians on this point.
Friedman, and other monetarists, to be a stable function of the few variables included in equation (5) above.

The Keynesian approach to the demand for money is developed from the Cambridge Equation. It defines motives for holding money and specifically focuses on the role of variables other than income in explaining the demand for money: in the 'Cambridge terminology' it represents an attempt to explain \( K \), which is recognized as a variable parameter in that equation, and one that might be importantly related to the Rate of Interest.

The three motives for holding money are the transactions, precautionary and speculative motives: Keynes' essential contribution to demand for money theory was based on the speculative motive. While the transactions and precautionary money-holdings were considered to be a function of current income, speculative holdings depended on the expected returns from holding capital uncertain assets, such as bonds: these expected returns could be expressed as some function of the rate of interest on long-term bonds.

In its simplest form the Keynesian demand for money function can be written as follows:

\[
M^D = L_1(Y) + L_2(R_B)
\]

where \( Y \) = nominal income

\( R_B \) = rate of interest on bonds

In developing his theory on the speculative demand for money, Keynes made use of the concept of the normal rate of interest\(^*\) and held that speculation about bond prices was

\(^*\) Defined as that rate of interest to which individuals, on average, expected the ruling market rate to return to.
based on the relationship between the ruling market rate and the normal rate. Quite simply, if the market rate of interest on bonds was above the normal rate, then, on average, the public would expect the rate of interest to fall, and hence the price of bonds to rise. The chance to make capital gains from bond-holding would cause individuals to move out of money and into bonds. The converse holds, so that when the rate of interest is below the normal rate, individuals will tend to move out of bonds and into money in order to avoid capital losses. It was also suggested that at some low rate of interest no-one would wish to hold bonds since a rise in interest rates was universally expected, and thus capital losses on bonds. So, at this interest rate floor, the public were willing to hold any amount of money thus rendering monetary policy impotent. Since attempts to boost the American and UK economies in the 1930's by increasing the money supply failed to lift these countries out of depression, this liquidity trap hypothesis appeared to be respectable. However, the hypothesis has very little relevance to the post-war UK economy which has mainly been troubled by inflation and has not experienced demand-deficient unemployment.

The important question of the stability of the demand for money function hinged critically on the market's views regarding the normal rate of interest. Since these could change unpredictably then so could the demand for speculative money balances: in fact there is evidence from the Radcliffe Report of 1959 (113)* that the demand for money function was

* Radcliffe Committee, 1959, paragraph 391.
considered to be highly unstable, and this supported Keynesian rather than monetarist policies. Besides the question of the stability of the function, another point of dispute between Keynesians and monetarists concerns the interest elasticity of demand for money: Keynesians believe the rate on long-term government bonds is the most relevant rate, and that the demand for money is fairly interest-elastic, whereas monetarists maintain that the short-term rate of interest is relevant, and that the value of the interest-elasticity is fairly small. The policy significance of such beliefs and the empirical evidence on them will be considered in subsequent sections of this chapter.

Criticism of the Keynesian theory is particularly directed towards two aspects of the speculative demand for money. The first concerns the money-bonds choice, where it is argued that money should really be regarded as a close substitute for short-term capital-certain assets - e.g. local authority deposits - and that to suggest that people will either hold money or bonds is unrealistic since it ignores these more obvious avenues of substitution. However, this criticism was easily countered by Leijonhufvud (84) who suggested that Keynes had in mind the substitution between a variety of short-term assets which were capital certain, and longer-term financial assets, such as government bonds, which were subject to capital risk, when discussing the money-bonds choice.

The second aspect concerns the 'all-money' or 'all-bonds' holdings of individuals which fails to square with the diversified portfolios held in practice. The
'General Theory' is rather vague concerning expectations about bond prices, but Keynes has generally been interpreted to have assumed that each individual held his expectations with certainty, so that if any particular individual expects to make a gain from bond holding, then there is no incentive for him to hold any speculative money balances and vice-versa.

Tobin (131) attempted to deal with this particular criticism by arguing that liquidity preference must essentially be based on uncertainty in the mind of each investor concerning future rates of interest. He used indifference curve analysis to suggest that individuals attempt to maximise utility from their asset-holdings according to their relative tastes for risk, and expected return on bonds.* Some individuals will be risk-lovers and will go for maximum risk which means they will hold all bonds, but most will be risk-aversers seeking higher expected returns for additional risk; typically risk-aversers will hold a diversified portfolio. Although Tobin uses the two-asset framework, money and bonds, for simplicity, the theory holds for the 'n asset' case.

Finally, brief mention must be made of the criticisms regarding the separability of the money demand function into 'transactions demand, regarded as technologically determined, and the asset demand, being treated as a matter of choice.' ** Reconciling the diverse motives into a consistent single theory is most commonly attempted by rationalising a non-zero

* (1) It is assumed in the Tobin model that a fall in the price of bonds is just as likely as a rise in the price of bonds, so that the expected return from holding bonds equals the rate of interest.

(2) Perhaps the variability of bond prices could be used as a measure of risk.

** Johnson (68) p.92.
interest elasticity of transaction balances. Baumol (17) and Tobin (130) obtain results which make transaction balances vary inversely with the rate of interest. From Baumol's inventory-theoretic model* an income elasticity of +0.5 and an interest elasticity of −0.5 can be formally derived. However, these values depend on some questionable assumptions underlying the model which when relaxed introduce greater flexibility with a range of possible values for the elasticities. The assumptions are as follows:

1. A known and steady stream of expenditures which have to be paid for in cash.
2. The cash is obtained by withdrawals from interest-bearing assets or directly in the form of income. In either case the larger the volume of cash balances held, the greater is the interest return which is sacrificed.

* Baumol argues that there are costs involved in making portfolio changes for transactions purposes: such costs will include brokers' fees, time and nuisance costs and administrative costs. In his model Baumol refers to these costs, collectively, as brokerage costs. Such costs will not be important if wealth tends to be held in the form of non-interest bearing money. However, this involves the sacrifice of interest which is available on other assets. Clearly, brokerage costs must be balanced against interest forgone on cash balances.

The following expression for transactions demand is derived from his model:

\[ M = \sqrt{\frac{2bT}{r}} \]

\( b = \) brokerage costs per cash withdrawal
\( T = \) value of transactions over period
\( r = \) rate of interest

This result suggests strong economies of scale in the holdings of cash balances.
(3) A fixed brokerage cost is incurred per transfer between cash and earning assets.

Further developments to the transactions demand approach include the work of Orr (93,108) and Miller (93)* who consider the consequences of relaxing assumption (1) above, while retaining the other assumptions in Baumol's model. In the face of uncertainty over the timing of payments, which is a more realistic assumption, the authors demonstrate that the demand for money is related to the variance of transactions rather than the level of transactions. This, in turn, means that there will be a range of possible values which the income and interest elasticities may take.

Another assumption in the Baumol model which can be challenged is that of the fixed brokerage costs. Indeed, as Brunner and Meltzer (22) point out, if there is a variable component in the brokerage costs then the 'square-root' formula no longer holds.

Perhaps the most damning criticism of transactions demand models concerns the neglect of certain institutional features of the monetary system - e.g. the availability of overdraft and credit facilities, and the imposition of bank charges when average current account holdings fall below a certain specified level in any given charges period. This, in turn, means that such models are likely to be of limited practical use. In the US Sprenkle (123,124) found that the percentage of the actual cash balances held by large firms that could be explained by the simple Baumol model was only in the region of 2½%. Another study by Aronson (7) showed

* A good account of this work can be found in Goodhart (56) p.25-28.
that the state and local governments in the U.S. appear to hold larger money balances than the Baumol model suggests.

In addition to the developments and criticisms outlined above, it must be remembered that the theory applies at the micro-level and that potentially serious aggregation problems limit its usefulness at the macro-level.

1.2 The demand for money and monetary policy

This can be considered in an IS/LM framework,* in which the IS curve represents points of equilibrium between investment and savings, and the LM curve points of equilibrium between the money supply and the demand for money, at different levels of national income: the IS curve represents equilibrium in the goods market, whereas the LM curve represents equilibrium in the money market. This Hicksian framework was developed at a time when demand-deficient unemployment was the pressing issue, so that inflation was not a problem. With the assumptions of downwardly inflexible prices and a cushion of unemployed resources which could easily be brought into production, changes in money national income were equivalent to changes in real national income. Essentially, then, the variables in this model are all in real terms.

Despite the usefulness of the IS/LM approach in illustrating key policy issues it does have its shortcomings. Brunner and Meltzer (23) suggest three major deficiencies.**

* The IS/LM framework represents the Neo-Keynesian Theory of the Rate of Interest and was originally developed by Hicks (66) and elaborated on by Hansen (61).
** Ibid p.951-952.
Firstly, that variables of interest are either omitted or combined - e.g. bonds and real capital are treated as a single asset and there is only one relative price, the rate of interest. Secondly, that none of the models based on the approach have been able to provide a reliable explanation of prices, output and interest rates. Finally, they point to the fact that the standard macro-theory has not been extended or modified to incorporate some of the main developments in monetary theory. One such development is the work on portfolio balance by Tobin (132) which introduces relative prices into the analysis of asset demand. Another specific weakness of the standard IS/LM approach is that it ignores the labour market; only the goods and money markets are considered.

However, since the IS/LM approach has been widely used by economists and because it brings out the essential policy issues concerning the demand for money in a clear and simple way, it is clearly a useful tool despite the aforementioned shortcomings.

Now, under ceteris paribus assumptions the greater (1) the interest elasticity of demand for money, then the greater the elasticity of the LM curve, and (2) the greater the income elasticity of demand for money, the more inelastic the LM curve will be. Since there is a dispute between Keynesians and Monetarists regarding the interest-elasticity of demand for money it is useful to focus on just this aspect, in an IS neutral case, in order to highlight the implications for monetary policy.
The above diagram clearly shows that for a given increase in the supply of money, the level of national income will rise further and the interest rate fall further, when the demand for money is relatively interest-inelastic - i.e. on the LM curves. The level of national income rises from \( Y_1 \) to \( Y_2 \), while the interest rate falls from \( R_1 \) to \( R_2 \). The alternative Keynesian position involves a smaller fall in the rate of interest to \( R_2^K \) and most significantly a smaller increase in output to \( Y_2^K \).

So, under ceteris paribus assumptions, monetary policy has a weaker influence on national output the greater the
interest elasticity of the demand for money. This helps to explain the Keynesian emphasis on fiscal rather than monetary policy to influence the level of national output.

However, if the money-income multiplier is relatively low because the demand for money is interest-elastic, all that is necessary to achieve the target level of national income is a larger increase in the money supply; providing the value of the multiplier is known and remains stable over time, then the target can be hit. In the context of the above diagram this simply means pushing the $LM^K$ curve further to the right. Only in the liquidity trap situation would such a policy be futile, so providing the interest-elasticity is less than perfectly elastic, monetary policy can still be successfully used to achieve the policy goal.

On the question of the stability of the demand for money function, monetarists believe it to be relatively stable whereas Keynesians, on grounds of the speculative demand, believe it is relatively unstable. Keynesians also believe that the IS curve can shift unpredictably, although the instability is much less serious than for the LM curve, while monetarists believe that the IS curve is relatively stable, but less so than the LM curve. To clearly focus on the stability, or otherwise, of the demand for money function, it is assumed that the IS curve is relatively stable.

Figure 2 below shows that instability of the demand for money function, which causes the LM curve to shift either to the right or left, can lead to serious fluctuations in the level of national income, without any change in the money supply. $LM_1$ and $LM_2$ represent shifts away from the desired position and are associated with levels of national income,
$Y_1$ and $Y_2$, respectively, which fail to coincide with the target level $Y^*$. 

In view of this, Keynesians claim that attempts to control the level of aggregate demand by manipulating the money stock are pointless and that a policy which aims to control interest rates is more appropriate. In the context of the above example, an interest rate policy involves increasing the stock of money when the demand for money increases shifting the LM curve back to $LM_1$, and reducing the stock of money when the demand for money suddenly falls shifting the LM curve to $LM_2$. In this way interest rates can be kept at, or near, the target level $R^*$ and fluctuations around the target level of income, $Y^*$, minimised.

So, in a dynamic context, monetarists emphasise the importance of controlling the growth of the money stock to achieve the target growth of national income, because they believe that the demand for money function is essentially
stable, whereas Keynesians emphasise interest rate control since they believe the function to be inherently unstable.

1.3 The demand for money and fiscal policy
To highlight the importance of the demand for money with respect to fiscal policy, the interest-elastic and interest-inelastic D-M cases are considered in the context of 'neutral IS curves'.

In Figure 3, below, there is assumed to be an increase in government spending which shifts the IS curve from IS to IS\(_1\). It can readily be seen that the steeper LM curve, associated with the monetarist belief that the interest elasticity of demand for money is low, results in an equilibrium change which involves only a small increase in output, from Y to Y\(_M^1\) and a relatively large rise in the interest rate, from R to R\(_M^1\). In contrast, the Keynesian case leads to a more significant increase in output and a smaller rise in

* Neutral in the sense of slope, not position.
interest rates; income rises from $Y$ to $Y^K_1$ and the interest rate rises from $R$ to $R^K_1$.

Quite clearly, a greater increase in government spending combined with the acceptance of interest rates higher than $R^K_1$ will be necessary if the economy is on the steeper LM curve, $LM^M$ and the target level of national income coincides with $Y^K_1$.

Fiscal policy is seen to have a stronger influence on output when the demand for money is interest elastic; hence, Keynesians tend to advocate fiscal policy for manipulating the level of aggregate demand.

It should be clearly pointed out that the above case represents 'pure fiscal policy', where the increased government spending is entirely financed from non-bank sources - i.e. the money is raised from the sale of securities* to the non-bank private sector. Government spending financed by loans from the banking system should, properly speaking, be viewed as a fiscal/monetary hybrid policy. In the context of Figure 3 above both the IS and LM curves shift to the right. This implies that it is clearly dangerous to assume that a close relationship between the PSBR and monetary growth, on the £M3 definition, can be taken as showing that fiscal targets are broadly consistent with money supply targets, as do Pepper and Wood (1976) (109). Before the mid-1970's increases in government borrowing were commonly financed by the banks, which simply meant that money supply increases were financing larger budget deficits. Does this represent monetary policy, fiscal policy, or both?

* Proceeds from the sale of public sector assets and the surpluses made by public corporations represent additional sources of funds.
The relationship between the PSBR, interest rates and the money supply is now seen as a crucial but somewhat controversial issue in aggregate demand management policy. Chapter 6 in the House of Commons Report on Monetary Policy, 1980-81, (133) outlines the views of the Treasury and economists of different persuasion, such as Laidler, Kaldor and Minford on this issue. The Treasury view is that in the fight against inflation the PSBR must be consistent with low money growth in order to avoid continually rising rates of interest on government debt (a view which is not supported by any evidence from a sophisticated structural model of the economy). This implies either government spending cuts and/or tax increases when the target growth rates for £M3 are reduced. Such fiscal contraction with the economy already in recession can only lead to further falls in output and rising unemployment. However, in these circumstances the 'built-in fiscal stabilisers' cause the PSBR to rise and following the 'Treasury view' either higher interest rates must be accepted, or further cuts in government spending made, if the monetary targets set for £M3 are to be strictly observed. Further fiscal restraint will set up a vicious circle in which output continues to fall and unemployment rises! A more flexible approach to monetary targets such as that followed by the West German Bundesbank might well be in order.

Finally, comment must be made regarding fiscal policy and the stability of the demand for money function. As Keynesians believe that the function is inherently unstable, it follows that Keynesian monetary policies involve interest
rate controls, with changes in the supply of money being made according to discerned changes in the demand for money. So, a combination of fiscal and monetary policy is clearly necessary if national income targets are to be achieved.

1.4 Government economic policy in general and the demand for money

If monetary policy is to be a successful form of macro-demand management then both the IS and LM functions must be relatively stable. Although monetarists regard the consumption function as being less stable than the demand for money function (Friedman (53) p.8), they still believe it to be fairly stable. To stress the importance of this consider the following extracts from Laidler (78) and Nobay (107).

(1) "It is obvious ...... that if the value of the money multiplier is to remain stable over time, then so must the parameters of both the demand for money function and the aggregate expenditure function."

LAIDLER (1978)

(2) "A necessary and sufficient condition for a stable money multiplier is the existence both of a stable demand for money function and a stable expenditure function."

NOBAY (1972)

The truth of such statements can be demonstrated by reference to the IS/LM diagram overleaf:
Providing the parameters of the expenditure and money functions are actually known, and both are stable, then the economy will move from $Y_0$ to the policy target level $Y^*$ following an increase in the money supply which shifts the LM curve out to $LM_1$. However, instability which takes the government by surprise, could result in a shift of the IS curve either backwards to $IS_2$ or forwards to $IS_1$. In the first case there is no change in the level of national income, which remains at $Y_0$, and in the second case $Y$ rises well beyond the target level of $Y^*$ to $Y_1$. Quite clearly, any serious instability in the IS function could lead to the failure of monetary policy to achieve its goals despite the existence of a highly stable demand for money function.

Evidence of serious instability in the consumption function emerged for many OECD countries in the mid-1970's. As Table 1.1 overleaf indicates, there were sharp rises in the personal savings ratio during the period 1973-1975 (and again in 1978 and 1979) in the U.K.
TABLE 1.1

Personal Savings Ratio 1970-1979

<table>
<thead>
<tr>
<th>Savings Ratio</th>
<th>70</th>
<th>71</th>
<th>72</th>
<th>73</th>
<th>74</th>
<th>75</th>
<th>76</th>
<th>77</th>
<th>78</th>
<th>79</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>9.3</td>
<td>7.6</td>
<td>9.7</td>
<td>11.7</td>
<td>13.5</td>
<td>12.7</td>
<td>11.8</td>
<td>10.5</td>
<td>12.4</td>
<td>13.8</td>
</tr>
</tbody>
</table>

The high savings ratios in 1974 and 1975 went against received theory (Friedman (52) and Morgan Grenfell (98)). Despite high rates of inflation and a deep recession in 1975 the savings ratio was significantly higher than it had been in the early 1970's. This surprising rise in the savings ratio is equivalent to the IS curve shifting to the left, as indicated in Figure 4 above.

However, even if the parameters in an equilibrium IS/LM model are stable, this does not guarantee the efficiency of monetary policy. There is the important question of possible stochastic shocks in short-run models, which can critically influence both the pattern and speed of adjustment to equilibrium: if monetary policy is to be used for fine-tuning purposes then this will be important. Indeed, since the lag structures involved in both the expenditure and money functions are likely to be complex, anyway, there must be a great deal of uncertainty regarding short-run adjustment. The important question of lag structures is explored further in Chapter 10.

Even assuming all this is in order there are still the familiar problems of information lags, policy reaction and policy implementation lags, as well as information weaknesses and inaccuracies. Since these problems are common to each of
the alternative macro-policies they will not be discussed further here, except to say that there are relatively long lags, at least 18 months, before changes in the money supply feed through to prices.

That the basic IS/LM model excludes the labour market has already been remarked upon. Ignoring the labour market when conducting economic policy can clearly frustrate the achievement of policy targets: for example, the essentially monetarist policies of the 1979 elected Conservative Government were not combined with an incomes policy for private sector workers. A monetary squeeze in the face of wage resistance has led to serious unemployment and a fall in output. In the short-run at least, such a fall in output can mean persistently high inflation despite tight monetary and fiscal policies. There is clearly feedback relevance as far as the demand for money is concerned. Firstly, unless the separate real income and price elasticities are well-established, a change in the balance between the relative variation in the two variables, may lead to empirical results which suggest that the demand for money function is unstable, when in fact it is stable! Clearly, the typical assumption that the demand for money is linearly homogeneous with respect to prices is a dangerous one, especially for the £M3 definition of the money stock, as my empirical results in Chapter 6 clearly suggest. Secondly, if inflation expectations significantly influence private sector wage demands, and assuming the absence of money illusion in the labour market they must where jobs are not threatened, then the longer it takes for inflation to slow-down, so changes in either output or income velocity, or both, must persist. The
question of whether the rate of inflation is a significant determinant of the demand for money is taken up in Chapter 7. Clearly, if it is, its exclusion from the demand for money function may again lead to false conclusions about the stability of the function, and/or, the values of the parameters. Even if inflation is not directly influential it may well be that the parameters of the demand for money function themselves vary with the rate of inflation, so that unless the parameters are endogenised in some way, the empirical work will give misleading information about the demand for money.

As yet, nothing specific has been said about the policy significance of the alternative money supply definitions, and whether the money supply, itself, can be controlled fairly closely. This is the subject of the next section, and quite clearly if it can not be controlled then the stability of the demand for money function has no policy significance.

1.5 Alternative definitions of money and their policy significance

The official definitions of money are M1, £M3 and M3: M1 consists of notes and coin in circulation and sterling sight deposits held by the private sector; £M3 equals M1 + private sector sterling time deposits and public sector sterling deposits; M3 equals £M3 + U.K. residents' foreign currency deposits. It should be noted that a small, but growing, proportion of M1 deposits are interest-bearing. The U.K. monetary authorities have treated the £M3 definition as the policy-relevant aggregate since 1976: this was preferred to the M3 definition since firstly, a large proportion of
U.K. residents' foreign currency deposits consist of the working balances of multi-national companies which have little connection with the monetary situation within the U.K., and secondly, exchange rate fluctuations will cause the sterling value of these foreign currency deposits to fluctuate quite sharply.

The authorities have tended to give more weight to the £M3 definition than M1 since the latter is essentially demand-determined with frequent shifting of funds into and out of current accounts as interest rates change.

Although the £M3 definition of the money supply certainly has its weaknesses* it happens to be the policy-relevant variable for the U.K. economy. Monetary targets have been defined in terms of £M3 since 1976 and increasing importance has been attached to them since this date; initially the target annual rate of growth was set at 9-13% before being changed to 8-12% for the fiscal year 1978/79, and then to 7-11% by the new Conservative Government in June 1979.**

These relatively broad target ranges reflect the difficulty of controlling the money supply very precisely, but the ability of the monetary authorities to keep the growth of £M3 within the target range can be taken as a fair degree of control. In fact, during May 1978 the Bank of

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* One weakness concerns the rather arbitrary exclusion of sterling deposits held by non-residents, while another concerns the influence of a balance of payments disequilibrium on the money supply figures (see Dennis (36) p.16f).

** The government's medium-term financial strategy (MTFS) for the period 1980/81-1983/84 set out ranges for the growth of £M3 declining by 1% each year from 7-11% in 1980/81 to 4-8% in 1983/84. These targets were to be strictly adhered to (but see following footnote).
England published figures showing that the growth of £M3 was 16½% over the financial year 1977/78; over 3 percentage points above the top end of the target range for that year! Again, in 1979 the growth of £M3 was excessive, but only just outside the top end of the target range. This evidence could be interpreted as suggesting that even exercising a reasonably close control over the money stock is a difficult matter, or alternatively, that the political will to control it closely, despite stated intentions, was lacking!

It is clearly possible that even when £M3 can be kept within its target growth range, the technique of control used may interfere with its policy significance. Suppose that under one regime of monetary controls, a stable money-income multiplier can be identified (which will mean that a stable demand for money function exists) and then a new technique of control, such as the 'corset' in December 1973, is introduced. It is clearly possible that the method of control used may lead to distortions in financial markets which cause instability in the demand for money function and hence loosen, or destroy, the ultimate policy significance of controlling the growth of £M3. The influence of competition and credit control and the supplementary deposit scheme on £M3 is considered in some detail in Chapter 2.

This possible sensitivity of the policy significance of £M3 to changes in the techniques of monetary control and financial market conditions, raises the important question of whether a wider definition of money, including liquid assets such as Building Society deposits, ought to be
considered.* Perhaps an empirical search for a bundle of liquid assets which is most stably related to national income is called for?

One empirical approach to determining the appropriate definition of money has been suggested by Laumas (81). He used a regression approach in which changes in the national income, $\Delta Y$, are firstly regressed on a narrow definition of money excluding interest-bearing deposits, $\Delta M$. Subsequent regressions are then run with an additional variable, interest-bearing liquid assets, included. $\Delta S$ represents changes in this variable, and its definition is gradually broadened to include a wider range of short-term assets. The regression equation takes the following form:

$$\Delta Y = A + b_1 \Delta M + b_2 \Delta S + u.$$  

$b_2/b_1$ then represents the 'moneyness' of the additional short-term assets included in the equation: essentially, it is the contribution of additional assets introduced towards the explanation of variations in national income which is under consideration.

However, while this constitutes an interesting approach to the problem, the results obtained do depend critically on the form of the model used and on the accuracy of its

* The distortion to the growth of £M3 caused by the reintermediation of funds following the removal of the corset in June 1980 prompted the introduction of wider measures of liquidity; PSL1 and PSL2 (private sector liquidity). In these circumstances no attempt was made by the authorities to keep £M3 within its target growth range (it actually grew by about 20% in 1980). However, once the distorting effects of the removal of the corset had worked through it was intended that the most important single monetary target variable should be £M3 with other measures of liquidity serving as important indicators of the underlying monetary conditions.
specification. Also, the function should remain stable regardless of changes in both techniques of monetary control and in the institutional structure of financial markets. Finally, even if these conditions were satisfied for a particular monetary aggregate, $M^*$, then the monetary authorities would need to exercise control over the new aggregate: effective controls would now have to be applied to a wider range of financial institutions, which may easily encourage new avenues of substitution between financial assets, and possibly the introduction of new ones. Such changes might easily disturb the velocity of the monetary aggregate, $M^*$.

Another approach to the problem of selecting the appropriate definition of money is based on the substitution criterion: for example, if the substitution between demand and time deposits is significantly lower than that between time deposits and other liquid assets, then money should be defined narrowly. For the U.K. economy, Mills and Wood (1977) found no evidence to suggest that $M_3$ and the liabilities of non-bank financial intermediaries are close substitutes. So, on the substitution criterion the latter should not be included in the definition of money, if these findings are to be accepted. If the chosen definition, on this criterion, is to be useful for policy purposes, then manipulation of the growth of the relevant aggregate must be seen to have an important influence on the growth of national income.

To quote Laidler (76),

* P. 515
"As far as the definition of money is concerned the most important issue has been the identification and measurement of a stable aggregate demand for money function .... A more stable demand function is precisely one that permits the consequences of shifting the money supply to be more accurately predicted."

Perhaps, in the light of the discussion above, we should add that, ideally, such stability should hold quite independently of the techniques of monetary control employed, and that the defined aggregate is actually capable of being controlled!

1.6  **Empirical findings in the UK prior to Competition and Credit Control: support for monetarism**

A summary of the empirical results for the UK is given in Table 1.2. Typically, the official definitions of the money stock, M1 and M3, have been used to represent the dependent variable, but various series have been used to represent the income and interest rate variables; for example, Laidler and Parkin (80) used the Treasury bill rate to represent the short-term rate of interest, whereas Hacche and Price (59, 112) used the rate on local authority deposits, and Hamburger (60) used the 3 month euro-dollar rate. Some of the studies are concerned with the long-run demand for money (71,77) while most are concerned with the short-run demand for money, and employ quarterly data. Those results in Table 1.2 for which no estimate of the price elasticity is given are based on specifications which used nominal rather than real income as the constraint variable. Most of the short-run studies have employed relatively straightforward dynamic specifications which are simply imposed rather than determined by the data itself: partial adjustment and adaptive
expectations (see Chapter 3) are commonly assumed.
Price (112), who looks at persons' and companies' holdings of M3 separately, is an exception, however. He used a flexible lag approach* and obtained significantly different estimates of income and price elasticities from most of the other empiricists; the income elasticity was well over 2 for both sectors, while the work of others suggests it is less than 1 for both M1 and M3. As for price nearly all empiricists have simply imposed an elasticity of 1.0, because this is what theory suggests it ought to be. In contrast, Price freely estimates this elasticity for both the personal and company sectors obtaining values which are less than unity; 0.90 and 0.41, respectively. Coghlan in a later study (27) also uses a flexible lag model, results from which suggest very low long-run price elasticities for data periods 1964(1)-70(4) and 1964(1)-71(4); 0.36 and 0.52, respectively. For M1, these seem unreasonably low although the results do appear to be sensitive to sample size, judging from his results covering longer periods.

As far as estimates of the interest elasticity are concerned these vary considerably from one study to another depending on whether a short-term or long-term interest rate is used, and whether M1 or M3 is the dependent variable. The important point to note is that almost every study reveals that the interest rate is an important explanatory variable having a statistically significant negative coefficient, as theory suggests it should have. This means that the extreme monetarist and Keynesian stances are decisively

* Flexible lag models are discussed in Chapter 3.
rejected, and that the only remaining policy issue concerns the stability of the function itself.

The empirical results strongly suggested that the demand for money function was stable in the 'Pre-Competition and Credit Control era', and this finding was certainly one of the reasons for the swing towards monetarism in the U.K. in the early 1970's. In connection with the stability of the M1 function it should be noted that later work by Rowan and Miller (1979) (92), and Laumas (1978) (82) who used maximum likelihood estimation techniques, agreed with the earlier empirical findings; Laumas also confirmed the stability of the broader aggregate, M3. My own work* also supported the stability conclusion for both M1 and M3.**

However, despite the general findings for stability, Coghlan (27) feels that caution ought to be exercised. As is evident from Table 1.2, taken from Coghlan's paper, there is a great deal of variation in these results, so that we cannot be very confident about the true values of the parameters. Secondly, estimates of the parameters are not always well-determined, partly because the sample periods tend to be short, and partly because of the common trending in the data. Thirdly, it is likely that the fixed lag structures, which in the case of the commonly applied partial adjustment hypothesis constrains the lag paths on each of the explanatory variables to be the same, represents a mis-specification of the dynamics.

* M1 results are reported in Chapter 5 and M3 results in Chapter 6.

** For the purposes of estimating equations over the data period 19641-19794, £M3, rather than M3, was used to represent broad money in the pre-CCC era.
While Coghlan agrees that the instability suggested by the Radcliffe Committee (113) was not present, he emphasises that there is still a large gap between this and the conclusion that the demand for money function is stable!

However, despite Coghlan's views it is probably true to say that by 1971 there was widespread agreement that both the M1 and M3 demand functions were essentially stable, and any areas of doubt were essentially concerned with the question of whether the function was stable enough for monetary fine-tuning policies. Certainly monetarism had now become respectable!
TABLE 1.2
Demand for money in the United Kingdom: summary of results

<table>
<thead>
<tr>
<th>Author</th>
<th>Data</th>
<th>Money</th>
<th>Interest rate</th>
<th>Interest elasticity[a]</th>
<th>Income variable</th>
<th>Income elasticity[a]</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kavanagh and Walters</td>
<td>Annual: 1880-1961</td>
<td>Broad Long</td>
<td>-0.31 (-0.22)[b]</td>
<td>GNP 1.14</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1926-1961</td>
<td>Broad Long</td>
<td>-0.50 (-0.25)[b]</td>
<td>GNP 1.08</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crouch Quarterly: 1926-1965</td>
<td>LC Bank Deposits (total)</td>
<td>-0.35</td>
<td>GNP 1.35</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher</td>
<td>Quarterly: 1915(1)-1960(2)</td>
<td>Narrow Short</td>
<td>-0.11</td>
<td>PDI 0.656</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly: 1960(3)-1963(2)</td>
<td>Narrow Short</td>
<td>-0.30</td>
<td>PDI 0.656</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goodhart and Crockett</td>
<td>Quarterly: 1955(3)-1960(3)</td>
<td>Broad Long</td>
<td>-0.50</td>
<td>GDP 1.25</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Goodhart and Crockett</td>
<td>Broad Long</td>
<td>-0.50</td>
<td>GDP 1.25</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laidler and Parkin</td>
<td>Quarterly: 1955(3)-1960(3)</td>
<td>Broad Short</td>
<td>-0.008</td>
<td>GDP 1.68</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Annual: 1900-1965</td>
<td>Broad Long</td>
<td>-0.570</td>
<td>GDP 0.795</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1900-1913</td>
<td>Broad Long</td>
<td>-0.268</td>
<td>GDP 1.241</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1920-1930</td>
<td>Broad Short</td>
<td>-0.448</td>
<td>GDP 0.795</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>Quarterly: 1964(1)</td>
<td>Broad Short</td>
<td>-0.30</td>
<td>GDP 2.29</td>
<td>0.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1963(2)-1971(4)</td>
<td>Narrow Short</td>
<td>-0.091</td>
<td>TEE 0.391</td>
<td>1^</td>
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<td></td>
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<tr>
<td></td>
<td>Persons</td>
<td>Broad Long</td>
<td>-0.069</td>
<td>GDP 2.77</td>
<td>0.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Companies</td>
<td>Broad Long</td>
<td>-0.197</td>
<td>TEE 0.511</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly: 1963(4)-1972(4)</td>
<td>Narrow Short</td>
<td>-0.062</td>
<td>TEE 0.450</td>
<td>1^</td>
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<tr>
<td></td>
<td>Long</td>
<td>Broad Short</td>
<td>-0.206</td>
<td>TEE 0.511</td>
<td>1^</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Persons</td>
<td>Broad Short</td>
<td>-0.110</td>
<td>PDI 1.081</td>
<td>1^</td>
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<tr>
<td></td>
<td>Companies</td>
<td>Broad Short</td>
<td>-0.064</td>
<td>TEE 2.206</td>
<td>1^</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quarterly: 1963(4)-1972(4)</td>
<td>Broad Short</td>
<td>-0.248</td>
<td>TEE 0.993</td>
<td>1^</td>
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<td></td>
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<tr>
<td></td>
<td>Long</td>
<td>Own rate 0.527</td>
<td>TEE 1.003</td>
<td>1^</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Own rate 0.568</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artis and Lewis[d]</td>
<td>Quarterly: 1963(2)-1970(4)</td>
<td>Narrow Long</td>
<td>-0.25</td>
<td>GDP 0.77</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1963(2)-1971(4)</td>
<td>Narrow Long</td>
<td>-0.29</td>
<td>GDP 0.77</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1963(2)-1973(4)</td>
<td>Narrow Long</td>
<td>-0.66</td>
<td>GDP 1.24</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1963(2)-1973(4)</td>
<td>Broad Long</td>
<td>-0.47</td>
<td>GDP 1.42</td>
<td>-</td>
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<td></td>
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<tr>
<td></td>
<td>1963(2)-1973(4)</td>
<td>Broad Short</td>
<td>-0.52</td>
<td>GDP 1.48</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1963(2)-1973(4)</td>
<td>Broad Short</td>
<td>-0.30</td>
<td>GDP 2.27</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamburger</td>
<td>Quarterly: 1963(2)-1971(4)</td>
<td>Narrow Short[ef]</td>
<td>-1.07[f]</td>
<td>GDP 0.672</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key
- A long-run unitary price elasticity imposed.
- GNP = Gross national product
- PDI = Personal disposable income
- TFE = Total final expenditure

[a] These are the long-run elasticities.
[b] From the same equation estimated in first differences.
[c] Results for money on a broad definition for both M2 and M3 respectively.
[d] Here only the results of the standard approach are summarised, and not the attempts to provide an improved specification.
[e] In this case the short rate is the three-month euro-dollar rate, and the long rate is the dividend-price ratio on ordinary shares.
[f] These are not the interest elasticities, but the elasticity times one plus the rate of interest divided by the rate of interest.

CHAPTER 2

MONETARY REFORMS AND DEVELOPMENTS IN THE 1970'S AND THEIR LIKELY IMPACT ON THE DEMAND FOR MONEY

2.0 Introductory remarks
The introduction of Competition and Credit Control in the UK in 1971, together with the collapse of the Bretton Woods system of fixed exchange rates in 1972 and the rapid acceleration of inflation after 1973 represented important market changes which may well have contributed to the apparent failure of relatively simple demand for money functions to make sense of the 1970's; functions which had appeared to be relatively stable prior to 1971.

Other problems included breaks in the official money stock series, a switch of policy emphasis from M3 to £M3 in 1976, and a growing interest-bearing component in the M1 definition of the money supply.

2.1 Competition and credit control
In September 1971 major reforms were made in the UK banking system aimed at widening and unifying the controls on bank lending, and at the same time promoting competition both between individual banks, and between banks and other financial institutions. These reforms included the definition of a new multiple reserve assets base which applied to all banks, the abandonment of the clearing banks' interest rate cartel and the lifting of quantitative ceilings on bank lending, and a move away from the policy of interest rate control in the gilt-edged market. For full details of
these reforms the 1971 Bank of England Quarterly Bulletins should be consulted (13).

2.1.1 The competitive phase of competition and credit control

It could be argued that the period September 1971-November 1972 was the true competitive phase: the rapid expansion of bank lending which occurred during the first year was no doubt prompted by the monetary authorities' wish to create conditions for a recovery from the sharp recession in 1971 which was due to a weakening of demand, including a fall in exports. It took the sterling crisis of June 1972 to halt the expansive stance of monetary policy, and in August 1972 the Bank of England exercised its right to give qualitative guidance on bank lending by asking banks to make credit less easily available for property companies and other financial institutions, and to give priority to manufacturing industry.

The initial rapid expansion of the money supply was prompted by several factors. Firstly, the banks were now required to hold a minimum ratio of reserve assets to eligible liabilities of 12\%\%\%; an arrangement which replaced the former liquidity ratio of 28\%. This left the London clearing banks with massive free reserves to be used for expanding lending. Secondly, the abandonment of the interest rate cartel and the abolition of quantitative controls on bank advances released a substantial pent-up demand by banks for interest-bearing deposits; as a result interest rates on these rose quickly and banks began to attract new deposits. The real growth was in the volume of wholesale deposits and this was prompted by the marketing of a new asset by the banks, certificates of deposit. They did attract
retail deposits away from the building societies, amongst other competitors, but because of the politically sensitive mortgage rate the commercial banks were asked not to pay interest of more than $9^{1/2}\%$ on deposits of less than £10,000. As Table 2.1 clearly shows this constrained the banks during the period 1973-74, while no such constraint applied in the CD market until the introduction of the Supplementary Special Deposits scheme in December 1973.

Now the relevance of this new era of competition to the demand for money lies in the rate of interest which banks offer on time deposits. Before Competition and Credit Control the clearing banks' interest rate cartel and quantitative controls placed on bank advances which were almost continuously in force from 1965 to 1971 (and periodically from the 1950's to 1965), meant that interest rates offered on these deposits tended to be rather low varying directly with Bank Rate which was relatively sticky during the 1960's. This, in turn, meant that it was not especially important to include an own-rate on money variable in the demand for money function prior to Competition and Credit Control. However, once the controls had been relaxed the differential between the own-rate and the rates on substitute assets had to be formally accounted for in the demand for money function, and accordingly Hacche (59) and Artis and Lewis (11) specified demand for broad money functions which included on own-rate on money variable, when investigating the behaviour of M3 in the early 1970's.*

* See Chapter 4 for specification details
TABLE 2.1

Own-Rates on Retail and Wholesale Money Deposits
1971(1)-1974(1)

<table>
<thead>
<tr>
<th></th>
<th>R^7_{OR}</th>
<th>R^7_{CD}</th>
<th></th>
<th>R^7_{OR}</th>
<th>R^7_{CD}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td></td>
<td></td>
<td>1973</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>7.44</td>
<td>1</td>
<td>7\frac{3}{4}</td>
<td>9.81</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>6.31</td>
<td>2</td>
<td>6\frac{3}{4}</td>
<td>8.12</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>5.19</td>
<td>3</td>
<td>9\frac{1}{2}</td>
<td>13.34</td>
</tr>
<tr>
<td>4</td>
<td>2\frac{1}{2}</td>
<td>4.69</td>
<td>4</td>
<td>9\frac{1}{2}</td>
<td>15.88</td>
</tr>
<tr>
<td>1972</td>
<td></td>
<td></td>
<td>1974</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2\frac{1}{2}</td>
<td>4.88</td>
<td>1</td>
<td>9\frac{1}{2}</td>
<td>15.69</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>7.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5\frac{2}{5}</td>
<td>7.56</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5\frac{3}{4}</td>
<td>9.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R^7_{OR} = Rate on '7 day deposits' of LCB's
R^7_{CD} = Rate on 3 month certificates of deposit

SOURCE: Financial Statistics

2.1.2 Round-tripping and distortions to the money stock figures

Following the introduction of CCC in September 1971 there were two years of rapid money supply growth; M3 grew by 27% between the end of 1971 and the end of 1972, and by approximately the same amount over the following year.

As was emphasised in the previous section the considerably improved competitive position of the banks can go some way towards accounting for these high growth rates, but the 'merry-go-round' (Artis and associates (8) p.54) has undoubtedly made a significant contribution as well.
The 'merry-go-round' or 'round-tripping' resulted from the fact that some interest rates remained relatively sticky while others, such as the CD rate, were allowed to vary according to market forces. It was the existence of administered rates alongside market-determined rates that made extensive arbitrage activities possible. These activities largely took place in 1972 and 1973, the years immediately following the introduction of CCC, and were mainly conducted by large companies, investment institutions and local authorities who would borrow from the commercial banks on overdraft and re-lend the acquired funds in the parallel money markets. This was made possible because the market-determined rates rose very sharply while the interest rates on bank advances were kept down, so that the rates on advances were often well below the ruling rates in the parallel money markets.

For example, companies had a clear profit incentive to borrow as much as they could from the banks, frequently via large overdrafts, and to invest the proceeds in the high interest-yielding certificates of deposit. Since CDs are a component of M3 this arbitrage swells the money supply figures.

Attempts to measure the distorting effect of round-tripping on £M3 reveal a wide range of answers: while some estimates have suggested that M3 was swollen by 20% of its end-1972 level in 1973, other estimates suggest figures closer to 2% (ibid p.59). Although estimates closer to the lower end of the range are more generally accepted, these still represent a significant distortion.
The relevance of these extensive interest arbitrage activities to the demand for money lies in the fact that for empirical work the actual money stock figures must be used to represent the unobservable demand. The new monetary policies which promoted competition appear to have led to a situation in which there is an excess of money supply over desired demand for money, which contradicts the logic of the simple partial adjustment hypothesis* of the demand for money. With an interest-rate policy, and the money supply accommodating, it is possible to regard the money stock as demand-determined so that the partial adjustment model is a fair approximation to reality. However, with the money supply changing independently of demand and the government more amenable to monetarist policies, exercising a degree of control over M3, it is possible to regard the money stock as an exogenous variable, which would imply that conventional specifications of the demand for M3 function represent mis-specifications for at least the immediate post-CCC period.

2.1.3 Reforms in the gilt-edged market
Prior to Competition and Credit Control the Bank of England actively supported the gilt-edged market by taking up unsold government debt and generally intervening in the market. This, of course, was consistent with a policy of interest rate control and meant that the government could cover growing budget deficits relatively cheaply by increasing the money supply. When CCC was introduced it was decided to restrict the extent of the Bank of England's operations

* For details on this hypothesis see Chapter 3.
in the gilt-edged market and the Bank correspondingly announced that it would no longer automatically be prepared to take-up government debt, except in the case of stocks with one year or less before reaching maturity (BEQB 1971).* This freeing of the gilt-edged market implied a limited movement away from interest rate control towards control of the money supply: while long-term interest rates were allowed to fluctuate more freely the government still maintained control over short-term interest rates and thus a multiple reserve assets base was preferred to a simple cash base.

One reason for the support of the gilt-edged market before CCC was the belief of the authorities that the market was dominated by extrapolative expectations, so that a fall in the price of bonds would create expectations of a further fall and thus would reduce rather than increase the demand for bonds. Fears regarding this possibility were expressed in the year following the introduction of CCC but as Professor Morgan (97 p.19) pointed out econometric work both within and outside the Bank of England suggested that if this perverse behaviour existed at all then it was essentially a short-lived phenomenon.

As far as the demand for money is concerned this policy of allowing long-term interest rates to fluctuate more freely, while still maintaining close control over short-term interest rates raises several problems. Firstly, the relationship between short and long rates is unlikely to be as close and predictable as it was in the pre-CCC era.

* Paragraph 13 - CCC: Text of a consultative document issued on 14 May 1971 as a basis for discussion with banks and finance houses.
and this makes the choice of interest rate variable(s) in the demand for money function a more important consideration: the term-structure of interest rates becomes more significant. Clearly, if the demand for money is sensitive to long-term interest rates and only an administered short-rate is included in the function, then this represents an important mis-specification.

Another problem concerns the speculative, or asset, demand for money. If we are to accept a Keynesian specification of the demand for money function, then an attempt must be made to deal with the concept of the normal rate of interest. Under a regime of general interest rate controls prompted by Keynesian beliefs concerning the stability of the speculative demand for money, rates will not be permitted to vary too much and the authorities will strongly signal their intentions regarding changes in interest rates on bonds. However, with the freeing of the gilt-edged market, long-term interest rates will vary more widely and in the short-run, at least, the relationship between the ruling market rate on long-term bonds, and the normal rate, could easily become unstable. Indeed, this is one factor which could have contributed to the apparent instability of the demand for money function in the early 1970's. The speculative demand for money has always been an awkward empirical problem, but it is one which becomes more important to consider when relatively simple transactions demand for money models fail to make sense of the data.

A final point concerning the freeing of the gilt-edged market relates to the change in stance of monetary
policy. Can it be regarded as a switch away from interest rate control towards control of the money supply? Although it meant that the money supply would not be passively increased to finance larger budget deficits and that long-term interest rates would be allowed to fluctuate more freely, this does not amount to asserting that the money stock should be regarded as an exogenous variable. True monetarist policies would have meant the establishment of a simple cash base rather than the multiple reserve assets base which was introduced: while it was the intention of the authorities to allow long-term interest rates to fluctuate more freely, they clearly intended to maintain control over the movement of short-term interest rates. Indeed, it was explicitly recognized that the combination of a multiple reserve assets base, with a minimum reserve requirement of 12½% and special deposits, designed to mop up excess liquidity in the banking system, was not suited to achieving any tight control over money supply growth. For such tight control to be possible, the reserve base would have to be completely exogenous, and the only component of the multiple reserve base which could be regarded as such is bank balances held at the Bank of England.*

* A move towards monetary base control occurred in August 1981 with the abolition of the reserve assets ratio and the establishment of a ½% cash ratio which was to be observed by all banks and licensed deposit takers with eligible liabilities amounting to £10M or more. This new cash ratio arrangement replaced the old 1½% ratio which had only applied to the London clearing banks. For details of the new arrangements see 'Monetary Control-provisions' in Bank of England Quarterly Bulletin, September 1981.
The relevance of this with respect to the demand for money is that single equation models of M3 cannot be regarded as appropriate reduced-form specifications.

Since the money supply (M3) was no longer passively adjusted to changes in the demand for money it was no longer possible to simply interpret money stock movements as reflecting demand changes. The likelihood is that movements in this series reflect a combination of supply and demand influences so that an identification problem arises. This problem requires the separate specification of a money supply function.* With equilibrium in the money-market restored by interest rate movements following a disturbance, the interest rate variable entering both the demand and supply functions for money has to be treated as an endogenous regressor. This, in turn, means that these functions would have to be estimated simultaneously in order to obtain satisfactory estimates of the demand for money parameters.**

The narrow money stock could still be regarded as essentially demand-determined since the monetary authorities have not attempted to control its growth; indeed, it is doubtful whether they could do so if they wished to, since substitution from deposit into current accounts and vice-versa would not be easily amenable to policy control.

* See Chapter 3: Simultaneous Money Models, and Identification.

** See Chapter 3: Simultaneous Equation Bias.
2.1.4 'The corset': its impact on bank demand for interest-bearing eligible liabilities

As mentioned above during the competitive phase of CCC rates of interest on the time deposits of banks had increased very sharply following the relaxation of the ceilings formerly imposed on bank advances. In particular, the rate on certificates of deposit had increased sharply. However, the rapid expansion of the money supply, as measured by M3, prompted a speculative run on sterling at the end of June 1972 which gathered momentum very quickly and necessitated support for sterling prior to the floating of the currency. This, together with the sharp fall in unemployment and the recovery of industrial production during 1972, clearly indicated the need for monetary restraint.

After further rapid expansion of the money supply in 1973 the government introduced the Supplementary Special Deposit scheme (the corset) as a new technique of monetary control. The broad aim of the scheme was to achieve monetary restraint without putting an upward pressure on interest rates. The basic idea was to limit the growth of banks' interest-bearing eligible liabilities. This was achieved in the following way: banks whose liabilities grew faster than a certain stated rate, initially 8% over 6 months, were required to deposit a proportion of the excess in a non-interest bearing account at the Bank of England. This proportion increased sharply, up to a maximum of 50%, as the excess growth increased. The scheme was introduced in December 1973, and then suspended in February.

* See Table 2.1, Section 2.1.1.
1975. It was subsequently re-introduced and suspended on two occasions culminating in its termination as a technique of control in June 1980.*

The introduction of the 'corset' could be taken as marking the end of the expansionary phase of Competition and Credit Control. By making it decidedly unprofitable for banks to exceed the defined rates of growth for ibels, this represented a return to restrictions on bank business. Although the restrictions were placed on bank deposits rather than directly on bank advances, the growth of bank lending was successfully restrained.

As Table 2.2 overleaf reveals, the rate of interest on certificates of deposit tended to fall sharply with the imposition of the 'corset' and to pick-up in 'corset-off' periods.

The last imposition of the corset provides an exception with the CD rate rising throughout the 'corset-on' period. However, a sudden increase in the rate of inflation, prompted by a sharp rise in oil prices and the collapse of the Labour government's incomes policy at the end of 1978, and the use of MLR as the main technique of monetary control, can account for this upward trend in the CD rate.

So, with banks bidding less actively for interest-bearing deposits during 'corset-on' periods the rate of interest on certificates of deposit, and other interest-bearing bank deposits, tended to fall. When the scheme is relaxed then banks tend to bid more aggressively for ibels thus driving the CD rate up. This, in turn, means that an

* Full details of the scheme can be found in BEQB (13).
TABLE 2.2
The CD Rate 1972(1)-1979(4)

<table>
<thead>
<tr>
<th>Year</th>
<th>CD 1</th>
<th>CD 2</th>
<th>CD 3</th>
<th>CD 4</th>
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<td>4.9</td>
<td>7.8</td>
<td>7.6</td>
<td>9.0</td>
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<td>1973</td>
<td>9.8</td>
<td>8.1</td>
<td>13.3</td>
<td>15.9</td>
</tr>
<tr>
<td>1974</td>
<td>15.7</td>
<td>13.5</td>
<td>11.9</td>
<td>12.7</td>
</tr>
<tr>
<td>1975</td>
<td>9.9</td>
<td>9.7</td>
<td>10.7</td>
<td>11.1</td>
</tr>
<tr>
<td>1976</td>
<td>8.5</td>
<td>11.3</td>
<td>12.6</td>
<td>14.1</td>
</tr>
<tr>
<td>1977</td>
<td>9.6</td>
<td>7.8</td>
<td>5.7</td>
<td>6.4</td>
</tr>
<tr>
<td>1978</td>
<td>6.8</td>
<td>10.0</td>
<td>9.6</td>
<td>12.4</td>
</tr>
<tr>
<td>1979</td>
<td>12.1</td>
<td>13.9</td>
<td>14.0</td>
<td>16.8</td>
</tr>
</tbody>
</table>

0 = 'corset-on' quarters

Own-rate on money variable must be included in the demand for M3 equation, along with relevant rates of interest on alternative financial assets. Furthermore, the relevant substitute asset rate will need to be an administered rate, or possibly a long-term market-determined rate, since short-term market rates such as the rate on local authority temporary debt, are almost perfectly correlated with the CD rate.
Another point concerning the introduction of the Supplementary Deposit scheme relates to the interest-arbitrage activities of companies in 1972 and 1973. The scheme helped to put an end to these since the high CD rates, which had prompted the round-tripping came down sharply. Also, as Artis and associates (8) point out, interest rates on bank advances were more closely tied to market rates, such as the rate on CD's after 1973. So, after the introduction of the 'corset' the distortions to the M3 money-stock figures caused by round-tripping were largely eliminated.

Before the 'corset' many financial markets, and particularly the money market, may have experienced persistent disequilibrium conditions from the end of 1971. Indeed, Artis and Lewis (11) argued that there was an excess of money supply over demand and that during the years 1972 and 1973, when banks competed strongly for deposits with other financial institutions, the economy was off the demand for money curve. If this argument is accepted then it clearly makes sense of the poor tracking performance of equations estimated from pre-CCC data: a worsening underprediction of the M3 money stock over the immediate post-CCC period would clearly be expected. However, from 1974 onwards with competition dampened, such disequilibrium should be eliminated, and instability of the function arising from the CCC reforms largely eliminated. After 1973 the major problems for the demand for money models were high and variable inflation rates and the behaviour of the exchange rate; it is to these problems that I now turn.

* P.62.
2.2 High and variable inflation rates

As Chapter 7 is devoted to a consideration of the influence of inflation on the demand for money, I will confine my comments to explaining why, and in what particular ways, the rate of inflation may cause problems.

The reason for the direct inclusion of the inflation rate in the money demand function at the theoretical level has already been mentioned (Chapter 1 - 1.1 p.14). Whether it has been empirically significant is mainly the province of Chapter 7; all I will say here is that it is quite possible that movements in nominal interest rates pick-up at least some of the influence of inflation on the demand for money making the direct entry of the variable a somewhat questionable empirical proposition.

Before 1970 inflation was relatively low and showed much less variation than it has during the decade 1970-80.* It seems probable then that inflation expectations were rather low and steady during the 1960's and, as such, did not significantly influence the market behaviour of economic agents.

It is important to distinguish between the effect of actual inflation, as opposed to the effect of inflation expectations on the money-holding decisions of the public. Since a dominant influence on expectations regarding future rates of inflation is likely to be the actual inflation experience of the recent past, the effects of the two are obviously inter-related. Suppose, that over a period of time inflation has a relatively flat profile, as it had in

* See Chapter 7.
the 1960's, anticipated inflation could be expected to coincide with actual inflation, showing very little variation. As such it would not account for any significant variation in the public's demand for money; in effect, the variable is a constant over the period concerned. However, actual inflation over the period will influence the demand for nominal money balances which, ignoring lags, will keep pace with the rate of inflation under the usual assumption that demand is linearly homogeneous with respect to price: in theory it seems reasonable to assume that the public are primarily concerned with the real value of their money-holdings. So, under these conditions, inflation expectations is a redundant variable in the money demand function and the long-run price elasticity of nominal money balances is expected to be unity.

Now, if we turn to the inflation experience of the 1970's, which has been rather volatile, we might expect firstly, inflation expectations to vary significantly through the period and secondly, for some large discrepancies to occur between anticipated and realised inflation rates. The first half of the 1970's was marked by rapidly rising inflation, which reached a peak of approximately 25% by mid-1975. If we just consider this period and make the unrealistic assumption that actual inflation was perfectly anticipated, then there is no reason to suppose that inflation expectations will influence any real variables. However, with inflation expectations being correctly revised upwards, the cost of holding non-interest bearing money in terms of physical assets will be seen to be increasing...
sharply. So, if this avenue of substitution between money and goods is at all significant, real balances would fall back as prices increased. Now, if a standard money-demand function was specified in which no inflation rate appeared, either because 'old habits die hard', or because a direct transmission from money to goods was incorrectly denied, then the estimated elasticities would be subject to mis-specification bias; in particular, the measured long-run price elasticity could fall significantly short of unity! However, in a correctly specified function with the rate of inflation included amongst the explanatory variables we would still expect the price elasticity to be unity. * 

In practice, inflation expectations are unlikely to coincide with actual inflation, when the latter varies significantly over time: the period 1970-75 saw inflation increase, with a sharp acceleration after 1973. Since the extent of unanticipated inflation is going to have an important influence on the movement of future prices, real income and interest rates, as well as a direct influence on real money-holdings, it becomes important to model inflation expectations. This is a difficult task, especially so given the plausible assumption that the formation of expectations is likely to become a more sophisticated process as society becomes more accustomed to high and variable inflation rates.

Approaches to modelling inflation expectations include the relatively simple adaptive-expectations and extrapolative/

* It is, of course, clearly possible that other important variables - e.g. the exchange rate - still need to be included before sound parameter estimates are obtained. Also, in this particular case, inflation should enter the equation with a lead of one period.
regressive schemes (described in detail in Chapter 7), survey techniques (134, 26) and rational expectations (105, 117, 118). This last approach involves the use of all readily-available information concerning inflation and is considerably more sophisticated than either of the first two schemes mentioned which postulate that inflation expectations are solely determined by reference to inflation experience in the past. For example, when the Labour government introduced an incomes policy in 1975 and combined this with tight fiscal and monetary policies, * in the 'fight against inflation', it provided a clear signal that inflation would soon start falling. In fact, between mid-1975 and the end of 1978, when there was a return to free collective bargaining, inflation fell from around 25% to just under 10%. A rational expectations model would incorporate this policy information and other relevant factors such as planned increases in oil prices.

The survey approach is costly and requires comprehensive information from a large sample of households and firms if it is to throw any useful light on the formation of inflation expectations.

The point of particular importance is that whichever model we use to capture the influence of inflation expectations, it is rather unlikely that the estimated series for the variable will coincide with the actual unobservable expectations. As a result we cannot be confident that we are correctly estimating the true influence of anticipated inflation on the demand for money; if we are not then the

* Monetary targets for £M3 and the PSBR were introduced in 1976 and this was combined with public expenditure cuts.
estimated coefficients on the other variables will be suspect as well.

Suppose we were to deny the existence of any significant substitution between money-holdings and real assets, and to assume that transactions motives dominate the demand for money. As shown by Baumol (17), Tobin (130) and others* this is consistent with a demand for money function which includes both an income and an interest rate variable. If the latter is measured by an administered, or a relatively sticky rate, then it is possible that the rate of inflation, itself, would be a better proxy for the opportunity cost of holding money. However, a much more important point concerns the indirect influences of inflation on the demand for money. Firstly, as inflation becomes more variable, so it will become more important to break-down changes in nominal income into price and real income components. In practice, recognition of the fact that the demand for money will only fully adjust to any disturbances after a lag means that whether the dependent variable is expressed in real or nominal terms both price and real income must appear as explanatory variables. Only if the response of money-holdings to changes in price and real income was the same both in time and magnitude could nominal income be successfully used as an explanatory variable. If it was incorrectly used in these circumstances then the parameter associated with it would be sensitive to changes in the data period. Multi-collinearity problems, aside, there is no real difficulty

* See Chapter 1, Section 1.1.
in obtaining the separate influences of price and real income on the demand for money, in cases where there is no important discrepancy between anticipated and actual inflation. However, in the 1970's some important discrepancies are likely to have occurred, as argued above, and these will influence the growth of real income and interest rates, as well as future price movements. These discrepancies are also likely to influence the values of the parameters, themselves. For example, assume that the adaptive-expectations scheme correctly describes anticipated inflation over a period in which inflation rises sharply, before falling back. At first inflation would be under-anticipated, with the error becoming progressively worse. With the public basing money-holding decisions on expected price levels, the measured response of the demand for money to changes in actual prices would fall; more specifically, the elasticity of demand for money with respect to actual prices would fall as we moved forward in time. During the subsequent period of falling inflation, inflation would be progressively over-anticipated, and the measured price-elasticity of demand for money would tend to rise.

Furthermore, since errors between actual and expected prices will also influence the assessments of real income the same arguments can be applied to this variable.

If we accept that the speculative demand for money is important then the rate(s) of interest on long-term government bonds must be included in the demand for money function. Now rates of interest tend to move in the same direction as inflation, so if inflation is expected to rise then people will expect the interest rates on bonds to rise.
and will therefore wish to sell bonds. If inflation is expected to show a strong trend rise, then it is likely that extrapolative expectations will be formed in the bond market, with the public wishing to hold more money as the interest rate rises. When inflation falls sharply, then interest rates will be expected to fall, and the public will be induced to buy bonds because of the expected capital gains. For example, over the period 1976-1978, in which there was a trend fall in the rate of inflation, the company sector increased its holdings of government securities significantly.* So it appears that companies purchased bonds on speculative grounds anticipating a trend rise in government bond prices. This response has been prompted by the behaviour of inflation, itself. If we add to this the reasonable assumption that speculators are much more uncertain about the future course of bond prices when inflation is high and variable, then the relationship between the normal rate of interest and the market rate is clearly undermined. Hence, inflation during the 1970's may well have caused instability in the speculative demand for money.

Inflation may also cause a problem with respect to its influence on the exchange rate and the balance of payments. If the rate of inflation rises significantly above the rates experienced in the rest of the world then this should put downward pressure on the exchange rate, under ceteris paribus assumptions. Inflation-induced movements in the exchange rate will lead to capital flows across exchanges, and possibly the substitution of domestic currency for foreign monetary assets. So, failure to include the exchange

* See Table 9.3. Financial Statistics.
rate in the function may also result in mis-specification bias. However, open economy problems for the demand for money are really a separate issue; one that is taken up in the following section.

Finally, even if the rate of inflation has not significantly disturbed the long-run income, price and interest elasticities of money demand, it remains possible that adjustment lag paths are influenced by inflation so that short-run elasticities and the speed of adjustment to equilibrium vary significantly over the chosen data period.

2.3 **Exchange rates and the balance of payments**

When the importance of international trade for the UK economy* is taken into account and suitable open-economy assumptions made, then the exchange rate regime determines whether an independent monetary policy is possible.

Fleming (49), Mundell (100,101) and Swoboda (126,127) have each contributed to the theory of the effectiveness of both monetary and fiscal policy in an open economy. The main conclusion to be drawn from their work is that an independent monetary policy cannot, in the long-run, be operated by a small country under fixed exchange rates. Providing international capital flows are sensitive to interest rate differentials, which in the absence of controls on capital movements is a reasonable assumption, then Mundell (100,101) concludes that for a small open economy like the UK, fiscal policy should be used to achieve internal objectives and monetary policy to achieve external objectives if the

* At the end of the 1970's around 25% of all expenditure was on imports and about 25% of domestic output was exported.
exchange rate is fixed. In the absence of devaluation or revaluation the monetary authorities must stand prepared to buy or sell sterling in order to support the exchange rate. This is most easily explained by reference to the 'Monetary Approach to the Balance of Payments' which has been mainly developed by Mundell (103) and Johnson (69).

Following this approach a change in the domestic money supply can be broken down into two major components as shown below:

\[ \Delta M = \Delta D + \Delta R \]

\[ \Delta D = \text{domestic credit expansion} \]
\[ \Delta R = \text{change in foreign exchange reserves} \]

Suppose that the domestic money supply is growing in line with the world money supply, with the domestic inflation rate equal to the world inflation rate and foreign interest rates equal to domestic interest rates. Under these conditions the balance of payments on current and capital account will be in equilibrium and there is no excess supply of, or demand for, money.

Now an attempt by the UK monetary authorities to pursue an independent monetary policy, by increasing or reducing the growth of the domestic money supply will in the long-run lead to compensating changes in exchange reserves which leave the growth of the money supply unaltered. For example, if the growth of the money supply was greater in the UK than it was in the rest of the world, then this would result in an excess supply of money in the UK which will be
used to finance the purchase of foreign goods and securities, thus depleting foreign exchange reserves.

So, under fixed exchange rates an increase in domestic credit expansion, which results in the domestic money stock growing faster than the world money supply, will be offset by a fall in exchange reserves. In contrast, if a freely floating exchange rate is used, the adjustment is via the exchange rate with the level of exchange reserves essentially unaltered. Consequently an independent monetary policy can only be successfully pursued, in the long-run, with flexible exchange rates.*

A good description of domestic monetary policy implications under both fixed and flexible exchange rates is given in Dennis (36).** Both small-country and large-country cases are considered.

So, for an independent monetary policy to be successfully operated (via a money supply target) in the case of a small, open economy like the UK, two important

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* A money supply target is assumed here. The case for an exchange rate target has recently been considered by Artis and Currie (9). They compared the advantages of exchange rate versus monetary targets in achieving a price stability objective but were unable to come to any firm conclusion. The basis of the case for an exchange rate target is given in the following extract from Artis and Lewis (12) p.53:

'If the ties between exchange rate variations and consequent changes in prices and wages are close and the speed of transmission is fast, a policy of exchange rate targeting.....could be more effective as an anti-inflationary device than a monetary target.'

Austria, Belgium and Sweden have renounced monetary targets for an exchange rate commitment.

** Chapter 8, p.212-218.
necessary conditions must be satisfied: firstly, a flexible exchange rate regime must be in force, and secondly, the demand for money function must be stable.*

In the post-war period, prior to 1971, stable money demand functions for both M1 and M3 were found by most empiricists, but a fixed exchange rate system was in force. This means that independent control of the money supply is not really feasible in the long-run which is damaging to monetarist policy prescriptions. The recognition of this fact, coupled with the world liquidity crisis and the breakdown of the Bretton Woods system of fixed exchange rates in 1971, led to the introduction of flexible exchange rates in 1972.

Now this was really a managed float since the Bank of England intervened to support sterling, or to cap the exchange rate on various occasions during the 1970's.** Despite this the UK was better able to pursue an independent monetary policy than it had been under fixed exchange rates. Two particularly troublesome years for exchange rate movements and the balance of payments were 1976 and 1977: following very high rates of domestic inflation in 1974 and 1975 the exchange rate fell sharply in 1976 with speculative pressure sharpening the fall; in 1977, following Bank of England

* These do not constitute a sufficient condition for the success of monetary policy.

** For example, following a rapid fall in the £/$ exchange rate in Autumn 1976, when £ fell to a record low of $1.57 in October, support by the monetary authorities led to a strong recovery to $1.7055 by the end of the year. A sharp recovery during 1977 led to the authorities intervening to cap the exchange rate.
support for the pound, and the introduction of monetary targets in 1976, there was a sharp appreciation of sterling, again strengthened by speculative pressure. The serious decline of sterling in 1976 was accompanied by large outflows of short-term capital and a serious deficit on the current account of the balance of payments; this massive drain in reserves led to an application to the IMF for $3.9b. standby credit. However, following the exchange rate recovery in 1977 there was a considerable turn-a-round in balance of payments fortunes accompanied by large increases in exchange reserves.

According to theory a move to flexible rates should be accompanied by smaller fluctuations in exchange reserves! These wide fluctuations in both exchange rates and foreign reserves were, no doubt, considerably influenced by extrapolative exchange rate expectations.

Despite the qualifications made above, the authorities have had the ability to independently influence the long-run growth of the money supply under flexible exchange rates. This means that if a stable money demand relationship can be established then monetary policy can be used to control the policy target variables, such as inflation, in the long-run. Since instability of both the money supply and demand functions is evident in the very short-run, fine-tuning policies are discredited.

Conclusions concerning the stability of the money demand function may well be upset by a change of exchange rate regime: the introduction of flexible exchange rates means that movements in exchange rates and, more particularly, expected changes in the exchange rate may prove to be
important determinants of the demand for money in the 1970's. Other important international variables might include short-term foreign interest rates and the prices of British goods relative to foreign substitutes. A generalised portfolio approach to the demand for money would specify each of these international variables in the function in addition to the important domestic variables. In practice, since substitution between money and financial assets is likely to be stronger than between money and goods, it may only be necessary to include the exchange rate and a representative foreign short-term interest rate. In contrast to this approach a transactions view of the demand for money may be held, which could well be appropriate for the M1 definition of money, in which speculation and expectations probably have no role in determining money demand: in this case, it would only be necessary to include an income variable and a representative short-term interest rate.

Indeed, if the latter approach yields a stable demand for money function for both M1 and M3 over the period 1972-1980, then this suggests that international variables have not been important determinants of the demand for money during this period. Furthermore, it suggests that domestic monetary policy can be successfully used for demand-management purposes.

Boughton (20) and Arango and Nadiri (3) have attempted to test the significance of international variables in the money demand function.* They both considered several important variables such as exchange rates, foreign interest rates, and relative prices of British goods. These variables were included in the demand function to assess their impact on money demand.

* For details of their empirical results see Chapter 4.
OECD countries, including the UK, and Boughton examined the evidence for the data period 1960-1977, while Arango and Nadiri examined the period 1960-1975; both used quarterly data. The former considered both narrow and broad definitions of money, while the latter only investigated narrow money defined as cash and demand deposits.

The conclusions from these studies are highly contradictory. Boughton claims that international variables have not significantly influenced the demand for money function in the 1970's, while the latter conclude that they have!

In fact the conclusions reached by Arango and Nadiri are surprising in view of the fact that they considered a narrow definition of money: substitution between foreign assets and domestic assets is likely to involve switching between interest-bearing money and short-term foreign assets, and not between non-interest bearing money and foreign assets; the motives for holding M1 are likely to be mainly transactions-based.

In contrast, Boughton suggests that simple stable demand functions hold, in general, for both narrow and broad definitions of money. The important exceptions are narrow money, in the case of the US, and broad money in the case of the UK: instability in both cases can be entirely explained by domestic factors; for the UK it appears to be strongly associated with the monetary reforms introduced by Competition and Credit Control.

Boughton also reports that Hamburger's (60) demand function, which included the uncovered eurodollar rate as the most appropriate opportunity cost variable, breaks-down
when data from the 1970's is used, which suggests that either the covered rate has become appropriate, or that foreign short-term interest rates have not been important determinants of the UK demand for money in the 1970's!

Although Boughton's arguments are persuasive the issue is far from settled. It may well be that his results have depended on exchange controls operated in the 1970's. For the UK economy exchange controls have been in force for most of the decade. In fact it was not until October 1979 that the Chancellor finally announced the immediate removal of all remaining exchange controls, including those on the buying and retaining of foreign currency, outward portfolio investment, and sterling lending to non-residents. The relaxation of controls on the outward flow of capital might be expected to 'open the economy more effectively' so that for a fair test of the significance of foreign interest rates and exchange rate movements in the demand for money function, data for 1980 and 1981 must be considered. If a simple transactions demand specification, which includes only domestic variables, performs well in these years, then this affords quite strong evidence that international variables have only a minor role to play in explaining the demand for money.

In conclusion, then, the introduction of flexible exchange rates in 1972 made it possible for the authorities to pursue an independent monetary policy. Although there is some controversy regarding the appropriate specification of the demand for money function and its stability* it does

* A stable demand for money function being a necessary condition for the success of monetary policy.
appear that a relatively simple formulation, including only domestic variables, performs quite satisfactorily in the 1970's if the M1 definition of money is used. Furthermore, Boughton's work does suggest that the apparent instability of the M3 money demand function can largely be explained by the monetary reforms introduced by Competition and Credit Control. Finally, the relaxation of exchange controls in 1979 may yet show that international variables are more than just potentially significant determinants of money demand; especially in the case of broadly-defined money.

2.4 Other problems

Several breaks have occurred in the official money stock figures in the 1970's; at the end of the first quarter in 1972 and 1973, mid-May 1975 and at the end of the fourth quarter in 1975. This presents some problems for empirical analysis particularly as the breaks in the M1 series, in mid-May 1975, and the M3 series at the end of the first quarter in 1972, are particularly serious.* Since the Bank of England present the money supply figures adjusted for breaks in addition to the official series it is possible to use both these series in empirical work and to note how sensitive the parameter estimates are to the breaks. Another approach would be to insert a dummy variable in the equation taking the value unity from the quarter in which a major break occurs, and zero before this data; if the dummy variable is significant then it shows that the break in the official series has an important influence on the results.

* For details of these breaks see Financial Statistics explanatory handbook, April 1979, p.74.
Perhaps a more important problem concerns the shift of policy emphasis from M3 to £M3 in 1976; although monetary targets have been defined in terms of £M3 since this date, £M3 was not the policy-relevant variable before 1976. For reasons of data consistency, however, either M3 or £M3 should be used throughout. Since the predictive ability of the demand function outside the data period is of interest, £M3 seems the better choice.

A problem also occurs with M1 since a small, but growing, proportion of sight deposits yield interest: the interest-bearing component is shown separately from 1975(2) onwards, but no split is available before this date.* At the end of 1975 interest-bearing sight deposits accounted for almost 11% of M1, and this figure grew to approximately 14½% by the end of 1978, and has continued to grow since. Because of the fact that this proportion is relatively small and that no split was available before 1975(2), M1 is generally treated as entirely non-interest bearing in the empirical work. Gradually it is becoming less reasonable to ignore the growing interest-bearing component.

The growth of the use of credit cards, particularly with the introduction of Access cards in 1972, might be expected to increase the velocity of circulation of money; the level of balances held to satisfy both transactions and precautionary needs is likely to fall in most cases. A partial offset to this, and an effective brake on accelerating velocity would be a combination of higher bank charges and the requirement by banks that customers should hold higher

* The interest-bearing component of M1 was insignificant before 1971.
average-holdings of current account deposits over the charges period in order to avoid incurring bank charges. In practice a gentle, but persistent rise in the income velocity of circulation of money might be expected to occur as a result of the growing use of credit cards. If this is the case, then it should not be a de-stabilising influence on the money demand function.

Another possible problem concerns the influence on the demand for money which a change of emphasis in the techniques of monetary control might exert. For example, from 1973(4) onwards the 'corset' was an important technique of monetary control on an 'off and on' basis, whereas it was subordinated to MLR in 1979. With the 'corset' applied to banks a dis-intermediation of bank funds might be expected, as companies shift into alternative short-term financial assets; it is clearly possible that the control over £M3 is of cosmetic significance only since an offsetting fall in the demand for money could occur. Similarly, when the 'corset' is relaxed a re-intermediation of bank funds occurs which swells the money stock figures but also leads to a fall in velocity. The demand for broad money may be destabilised to some extent by all this, particularly as the 'corset' arrangements have been varied with each re-introduction of the scheme. In contrast, an increase in MLR which is designed to reduce the rate of growth of the money stock could be accompanied by a reinforcing fall in velocity, as the banks attract deposits away from the building societies. This, in fact, did occur in 1979.

* The 'corset' was finally abandoned as an instrument of monetary control in June 1980.
following sharp increases in MLR taking the rate from 10% at the end of the third quarter of 1978 to 17% by the end of 1979. While the rate of interest on interest-bearing bank deposits rose in sympathy with MLR, the administered building society deposit rate did not. Consequently, the differential between the two rates moved decidedly in favour of the banks.

Certain exogenous shocks, particularly the quadrupling of oil prices in 1974 and more sharp rises in 1979, might have influenced the demand for money.

The rapid development of North Sea oil in the late 1970's, particularly in 1978 and 1979, encouraged a substantial inflow of foreign capital which persisted despite the rapid increase in inflation during 1979.* With a managed floating exchange rate there would, in the absence of North Sea oil, be a tendency for both the exchange rate and the level of foreign reserves to fall back when domestic inflation is greater than world inflation. However, a substantial increase in exchange reserves coupled with a sharp rise in the exchange rate occurred alongside the accelerating domestic inflation. Thus an increased demand for interest-bearing money is to be expected at a time when real income is sluggish, and expected inflation ought to be rising! Ignoring international factors under such unusual conditions might well lead to erroneous conclusions regarding the stability of the demand for money function!

* This increase in inflation was mainly due to substantial increases in oil prices and an important switch from direct to indirect taxes in the June budget.
It is clear from the above discussion that the 1970's provide a very searching test of the adequacy of the relatively simple demand for money models which performed well in the previous decade. If it is possible to obtain sensible and significant estimates of the money demand parameters from recent data, together with good forecasts for the post-sample period, for both M1 and £M3, then this will provide the strongest support for the inherent stability of the demand for money function.
CHAPTER 3

MODELS OF MONEY DEMAND

3.1 The selection of variables

In the empirical work both narrow and broad definitions of money are considered. The policy-relevant definition of money for the UK economy is a broad measure, £M3, which can be broken down into its component parts as described in Chapter 1 (1.5). In this way groups of similar money deposits - e.g. non-interest bearing sight deposits - can be separately examined; this is clearly useful since £M3 involves the aggregation of several different money components which may be influenced by different variables.

Wider definitions of 'money' could be considered such as PSL1 and PSL2 which include close substitutes for interest-bearing money.*

Another approach is to consider the demand for money by the different sectors of the economy. At the most general level this involves the money-holding behaviour of the private and public sectors. Private sector money-holdings can be broken down further into (1) Personal sector money-holdings; (2) Industrial and commercial companies' money-holdings, and (3) Other financial institutions' money-holdings. It is likely that the money-holding behaviour of these various sectors does differ; in particular, the demand for money behaviour of the personal and company sectors, which between

* PSL = Private sector liquidity.
PSL1 = £M3 (private sector) + money market instruments + certificates of tax deposit.
PSL2 = PSL1 + savings deposits and securities (e.g. deposits with building societies).
them hold well over 80% of M3, is likely to be quite different.

So, recognition of the fact that £M3 represents both an over-aggregation of deposits and of deposit-holders, means that an analysis of broad money by both type of deposit and type of deposit-holder is in order.

However, data limitations prevent a complete and consistent analysis of £M3 in this way.* In particular, the sectoral analysis of money demand will not be consistent with the analysis by type of deposit, since the former is only available for M3, not £M3, during the first half of the 1970's. My own empirical work covers M1, private sector time deposits, £M3 and bank deposits held by both the personal and company sectors. For the company sector alone, the definition of money is widened to include other liquid assets, such as local authority temporary debt.

What guidance does theory give as to the variables which are likely to have a significant influence on the demand for money? At the most general level, income and interest rates are seen to be the chief determinants by Keynesians, while monetarists would argue that wealth or permanent income should replace current income in the demand for money function. Baumol, Tobin and others developed transactions demand models** in which money-holdings are seen to depend on both income and the short-term rate of interest:

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* For example, no information is available from official sources on the personal and company sectors' holdings of M1, and their holdings of £M3, as opposed to M3, are only available from 1975 onwards. Also, the split between interest-bearing and non interest-bearing private sector sterling sight deposits is only available from 1975 onwards.

**See Chapter 1, Section 1.1.
such models seem suitable for M1 but not for broader definitions such as £M3, where the speculative, or asset, demand for money is likely to be important. Tobin (131) developed a theory of the asset demand for money* in which money-holdings depend on wealth, the constraint variable, the expected rates of return on money substitutes, such as government bonds, the riskiness of these assets, and individual attitudes towards risk. The typical attitude was assumed to be risk-aversion, so that a higher expected return was necessary if the public were to be persuaded to hold more of a risky asset.

Friedman's Modern Quantity Theory (51)* best summarises monetarist thinking on the demand for money in which a portfolio approach is taken. However, since short-term financial assets are likely to be the closest substitutes for money, it is the rates on these which are seen to be most relevant. The possibility of substitution between money and goods is recognized, and so the expected rate of inflation might also be a significant explanatory variable. The constraint variable is wealth or permanent income.

Most studies of the demand for money have assumed a 'closed economy', whereas the UK is very much an 'open economy'. So, for broad definitions of money and those other definitions including interest-bearing deposits, rates of interest on foreign substitute assets and expected changes in the exchange rate are likely to be important explanatory variables.**

* See Chapter 1, Section 1.1.
** See Chapter 2, Section 2.3.
In practice, income rather than wealth has been used in UK demand for money studies since we have no comprehensive information on the latter.

We are now in a position to consider those variables which are likely to be important determinants of the demand for money, with money variously defined:

1. **M1**

   Transactions motives are likely to dominate, and since well over 80% of M1 bears no interest at all there is no need to include an own-rate on money. It is unlikely that foreign interest rates or exchange rates have any significant influence on the demand for M1. Following the portfolio approach to money demand it is possible that inflation expectations have some influence, although this may be adequately taken up by the interest rate variable.

2. **Private sector time deposits (TD)**

   A speculative motive might well be important, and although these deposits might still be held to satisfy a transactions motive, a portfolio model with wealth as the constraint variable could be in order. International variables such as exchange rates and foreign interest rates should be influential and an own-rate on money should now be included.

3. **LM3**

   The variables mentioned in 1. and 2. above should be included. Transactions and speculative motives should both be important.
4. **Personal sector holdings of M3 (MP)**

Transactions motives for holding money are likely to be more important than speculative motives and therefore short-term interest rates preferable to long-term interest rates. An own-rate on money variable should be included along with the short-term rate on a substitute asset.

5. **Company sector holdings of M3 (MC)**

Both transactions and asset motives are likely to be important, and therefore company sector income and wealth variables should enter the model. Both short-term and long-term interest rates on substitute assets should be included in the equation along with a suitable own-rate variable. Foreign interest rates and changes in the exchange rate should both be influential.

We can now write out equations in loose functional form for each of the above money definitions:

1. \[ M_1 = f_1 Y P R_S R_{PE} \]
2. \[ T_D = f_2 W Y P R_{TD} R_S(g_1) R_L R_F(g_2) R_{EX} \]
3. \[ £M_3 = f_3 W Y P R_{M3} R_S(g_1) R_L R_F(g_2) R_{EX} R_{PE} \]
4. \[ M_P = f_4 Y P W R_{MP} R_S R_{PE} \]
5. \[ M_C = f_5 W Y P R_{MC} R_S(g_1) R_L R_F(g_2) R_{EX} \]

Where,

- \( Y \) = Income
- \( W \) = Wealth
- \( P \) = Price
- \( R_{PE} \) = Inflation expectations
\[ \begin{align*} R_S & = \text{Short-term interest rate} \\
(g_1)R_L & = \text{A function of the long-term interest rate} \\
R_F & = \text{Foreign interest rate} \\
R_{TD} R_{M3} R_{MP} R_{MC} & = \text{Own-rates on money} \\
(g_2)EX & = \text{A function of the exchange rate} \end{align*} \]

It is now necessary to consider which income and interest rate variables should be selected for each of the above money demand equations. The exchange rate variable is assumed to be best represented by 'the sterling effective exchange rate', and the foreign rate of interest by the 'Euro-dollar rate'.

For M1, TD and M3 one of the national income measures will be appropriate. Are there any grounds for preferring one measure of national income to another?

The choice is between TFE, \( GNP_{MP} \), \( GNP_{FC} \), \( GDP_{MP} \) and \( GDP_{FC} \): measures of net national and domestic products are not considered since estimates of capital depreciation are subject to considerable error. On a transactions demand basis it can be argued that measures at market prices are more appropriate than those at factor cost. Furthermore, uncertainty regarding IPD payments and receipts (the amounts are often substantially revised for past years in the national income accounts) makes GDP or TFE a better measure than GNP.

So, either GDP at market prices or TFE appear to be the most appropriate choices for the income variable. Perhaps the former variable is the better choice since holdings of sterling deposits will be influenced by switches of demand.
from domestically produced goods to imports. Since importers will now need more foreign currency and less sterling to finance the increased purchase of imports, the demand for M1 and £M3 should fall. However, the immediate impact of the switch from home-produced goods to imports will leave TFE unchanged, so that the fall in demand for money is not related to a change in this variable. GDP at market prices will fall back, however, following the rise in imports. If imports grew at the same rate as TFE then the choice between the two variables would not be important; in fact, import penetration of UK markets has increased significantly since the early 1970's and during the second half of the decade the ratio of TFE to GDP_MP, variables measured at constant prices, rose from 1.274 in 1976(1) to 1.296 by 1979(1).

So, the appropriate income variable for the M1, TD and £M3 definitions of money appears to be GDP at constant market prices. The appropriate price variable would then be the GDP deflator.

For personal sector money-holdings, personal disposable income and the associated deflator can be taken as the appropriate income and price variables, respectively. The drawback with this measure is that although it is suitable for households it is not satisfactory for the unincorporated businesses which are included in the sector.

For the company sector the selection of a suitable constraint variable for money-holdings is something of a problem. Ideally, perhaps, a measure of the total asset-holdings of companies would be best; but such a measure is not available from published sources, and would in any case
be subject to considerable errors because of inconsistencies in the valuation of assets by companies. From 'Financial Statistics' it is only possible to obtain comprehensive information on company-holdings of liquid assets; a portfolio of assets dominated by money-holdings and probably too narrow a measure to serve as an explanatory variable.

For industrial companies the index of industrial production might be an appropriate choice, although there is no reason to suppose that the money-holdings of commercial companies should be related to this variable.

Perhaps a measure of national output could be chosen, such as GDP at factor cost, but this is really too broad a measure since it includes the personal, public and financial sectors' contribution to output in addition to that of the company sector. One advantage of the GDP measure over the index of industrial production is that there is no problem over choosing a price variable for the former; the GDP deflator can be used.

A variable which could be used in a company sector demand for money equation is the 'total capital funds of industrial and commercial companies'. This series is given in Table 9.2 of 'Financial Statistics'. Although this measure is narrow in the sense that it does not cover the demand for money for transactions purposes (a measure of total company sales receipts might be appropriate), it does at least relate solely to industrial and commercial companies.

The selection of appropriate short-term interest rates is a difficult task for the M1, TD and £M3 definitions of money. This is because sectoral splits are not available for the first two definitions, and are only available for £M3 from
1975 onwards. For this reason it is necessary to try alternative short rates such as the rates on local authority temporary debt and building society deposits. In fact, although rates of interest on short-term financial assets should be more relevant than rates on long-term assets, since the former are closer substitutes for money, it is possible that rates on longer-term financial assets, such as government bonds will perform best. This is because since the introduction of competition and credit control the monetary authorities have continued to exercise control over short-term interest rates, but have allowed long-term rates to vary more freely.* So, despite the fact that they are capital risky assets the rates of interest on short-term and long-term government bonds might also be tried.

Since most of the published domestic short-term interest rates have been manipulated by the monetary authorities to some extent, it may also be worth trying the Euro-dollar rate which will better reflect market forces. The covered rate should be more relevant following the introduction of flexible exchange rates in 1972, but both this rate and the uncovered rate could be tried.

For the personal and company sectors the most relevant short-term interest rates can be selected from information on selected liquid assets.** Since multicollinearity problems prevent the inclusion of more than one or two rates at the estimation stage, some possible methods of selecting these rates need to be considered. I will deal with three possible approaches.

* See Chapter 2, Section 2.1.3.

** For the personal sector see Table 10.3 and for the company sector see Table 9.3, in 'Financial Statistics'.

One approach would be to select an asset on the basis of the following criteria:

1. The significance of the asset in the portfolio.

2. The variation in the size of the asset-holdings over the relevant data period.

So, that asset which dominates the portfolio in both size and variation of holdings should be selected; the rate of interest on this asset will then be the appropriate opportunity cost variable.

Acceptance of these criteria would result in the selection of the building society deposit rate for the personal sector, and either the government bond rate or the rate on local authority temporary debt for the company sector. The latter sector is more problematical since the relative importance of the alternative assets has varied during the 1970's, and other liquid assets such as market treasury bills and tax instruments might have been chosen. Although holdings of bills were trivial until 1975, they started to grow rapidly after this date. After June 1976 they dropped back in level, but remained significant in size until mid-1978. The level of holdings fell quite sharply after this date. Despite this, it must be noted that since unidentified holdings by other sectors are included in the figures, we cannot determine what the company sector holdings alone actually are. So, in view of this plus the fact that the level of holdings is relatively low, the rate of interest on market treasury bills will not be retained at the empirical stage.
Tax instruments have only been significant in the company sector portfolio from Autumn 1977 onwards, when company-holdings grew sharply. A particularly sharp increase in holdings occurred between 1978(4) and 1979(1). Although they have not been significant for most of the decade, it might well be useful to include the rate on certificates of tax deposit from 1977(3) onwards.

A second approach to the problem of selecting a suitable opportunity-cost variable is to use a weighted average of the rates on the relevant substitute assets. Suppose there are five assets which are considered to be substitutes for money in the asset portfolio and that the total value of these assets held by companies is given by the following expression:

\[
\sum_{i=1}^{5} a_i
\]

where \( a_i \) = Value of the holdings of the \( i^{th} \) asset.

Let \( r_i \) = the rates of interest on the five assets.

Then,

\[
r^* = \frac{\sum_{i=1}^{5} a_i r_i}{\sum_{i=1}^{5} a_i} = \text{The weighted average rate of interest on the five assets.}
\]

One advantage of this approach over the first, is that it will successfully capture the influence of a change in portfolio composition.

The simplest approach would be to take the highest rate of interest in each period from the various alternative
substitute asset rates, and use the resulting series to represent the opportunity cost variable. Although this method is less satisfactory than the approaches discussed above, its virtue lies in the speed and ease with which the series can be constructed.

If all three approaches are used for a particular period and the constructed rates give similar results for both personal and company sector money demand, then this suggests that the third approach will be optimal when a subsequent data period is being considered.

As far as an own-rate on money variable is concerned either a weighted average of the rates on the component deposits of the relevant definition of money can be taken (constructed as described above) or the rate of interest on a particular component of money, which is thought to be representative for the aggregate measure. For example, Artis and Lewis (11) used the former method when investigating M3 in the post-CCC era, while Hacche (59) used the CD rate for both M3 and company sector holdings of M3. Incomplete information on the different rates applying to the various time deposits suggests that the latter method is not necessarily inferior. If a particular rate of interest is used then the CD rate should be appropriate for private sector time deposits, £M3 and company sector holdings of M3.

For the personal sector's demand for money the rate on seven day bank deposits will be appropriate.

As far as capital risky assets are concerned and the speculative demand for money, the rates of interest on medium or long-dated government securities should be appropriate. However, since there is no reliable maturity break-down of
these by sector-holding, all we can do is to select a particular government bond and use this. Previous researchers have tended to use the 2 1/2% consol rate to represent the long-term bond rate.

A final point concerning interest rates is that post-tax rather than pre-tax rates really represent the true opportunity cost of holding money.* However, it is a major undertaking to construct such rates and information gaps certainly present problems.

Finally, inflation expectations may have a role to play in explaining the demand for money, for each of the money definitions mentioned. However, since Chapter 7 is devoted to the influence of inflation on the demand for money, the problem of variable selection is best taken-up there.

3.2 Functional form and the specification of variables

Demand for money theory gives no real indication of an appropriate functional form for the model. In view of this I will confine my attention to linear models, which have been commonly used in empirical work, for each definition of money - i.e. untransformed linear and log-linear models.

1. **Untransformed linear model**

   \[ M* = A + b_1 Y + b_2 P + b_3 R + u. \]

2. **Log-linear model**

   \[ M^* = A Y^{b_1} P^{b_2} R^{b_3} u. \]

   or,
   \[ \log M^* = \log A + b_1 \log Y + b_2 \log P + b_3 \log R + \log u. \]

* Grice and Bennett (18) used post-tax rates in their study of the demand for £M3, but to my knowledge all other UK researchers have used pre-tax rates.
It is assumed above, for convenience, that only transactions motives govern decisions to hold money; an assumption suitable for the M1 definition of money at least.

Model 1 states that,

\[ \frac{\partial M^*}{\partial Y} = b_1 \quad \frac{\partial M^*}{\partial P} = b_2 \quad \frac{\partial M^*}{\partial R} = b_3 \]

subject to random errors

- i.e. changes in desired money balances depend only on the size of change in income, price and the rate of interest, respectively, and not on the levels of these variables.

In Model 2 the coefficients \( b_1, b_2 \) and \( b_3 \) represent the income, price and interest rate elasticities, respectively, of the demand for money. The model restricts these elasticities to be invariant with respect to the levels of the variables; this is probably a reasonable assumption with respect to the income and price variables, but is open to question if interest rates are specified in percentage form.

Suppose the rate of interest stood at 5% in period 1 and rose to 10% in period 2. If the demand for money had an interest elasticity of \(-0.3\) then this 100% rise in the level of the rate would lead to a fall of 30% in desired money-holdings. However, if the rate of interest stood at 10% it would take a rise of 10 percentage points for the demand for money to fall by the same percentage as before. This does not seem entirely reasonable, although in a short-run demand for money model which is to be estimated over a period in which interest rates do not vary a great deal, this particular specification of the variable would be in order.

A popular alternative specification of the interest rate variable, used in the Bank of England demand for money
studies,* is shown in the demand for money equation below:

\[ \log M = A + b_1 \log Y + b_2 \log P + b_3 \log (1+R) \]

This particular specification states that the interest-elasticity of money demand increases with the level of the rate, as the following example makes clear:

\[ \log MD = b_1 \log Y + b_2 \log (1+R_t) \]

Assume \( Y = \) nominal income which remains at the constant level £55026 (then \( \log Y = 10 \)). Now consider what happens to the demand for money as the interest rate rises from 0% to 20% in intervals of 5 percentage points, with \( b_2 \) assumed to equal -2.0 and \( b_1 \) unity.

1. \( \log MD = 10 -2.0(\log 1.0) = 10 = 22026 \)
2. \( \log MD = 10 -2.0(\log 1.05) = 9.90242 = 19979(-9.3\%) \)
3. \( \log MD = 10 -2.0(\log 1.10) = 9.80938 = 18204(-8.9\%) \)
4. \( \log MD = 10 -2.0(\log 1.15) = 9.72048 = 16655(-8.5\%) \)
5. \( \log MD = 10 -2.0(\log 1.20) = 9.63536 = 15296(-8.2\%) \)

Although the percentage change in money demand falls as the level of interest rises, the interest-elasticity of the demand for money rises since the percentage change in the rate of interest falls at a considerably faster rate (please see Table overleaf):

* See Price (112) and Hacche (59).
The table clearly shows that the negative interest elasticity increases with the level of the rate.

In the log-linear function an a priori restriction is often imposed on the value of the price-elasticity: it is assumed that money-holders wish to preserve the real value of their money-holdings so that in the absence of money-illusion, the coefficient on price should be unity.* If this is the case then the demand for money function can be re-written as follows:

$$\log \frac{M^D}{P} = \log A + b_1 \log Y + b_3 \log R + u.$$

While such an assumption seems plausible it may well be rejected empirically. One reason why this could occur might simply stem from the fact that the income constraint variable used, and hence the price deflator, is not entirely appropriate: with the over-aggregation of data problems in macro-demand for money relationships it is easy to see how the problem could arise. Another reason is based on the relationship between final market transactions, or national

<table>
<thead>
<tr>
<th>Interest rate range</th>
<th>% change in demand for money</th>
<th>% change in the rate of interest</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5%</td>
<td>-9.3</td>
<td>∞</td>
<td>0</td>
</tr>
<tr>
<td>5 - 10%</td>
<td>-8.9</td>
<td>100</td>
<td>-0.089</td>
</tr>
<tr>
<td>10 - 15%</td>
<td>-8.5</td>
<td>50</td>
<td>-0.170</td>
</tr>
<tr>
<td>15 - 20%</td>
<td>-8.2</td>
<td>33.3</td>
<td>-0.246</td>
</tr>
</tbody>
</table>

* Adjustment lags, which are taken up in the next section, are ignored here.
income, and the total value of all transactions: if over time, the relationship changes significantly then a national income measure would not be an appropriate explanatory variable for the transactions demand for money. Yet another reason might be that the actual values of the income and price variables are not strictly relevant and that expected values for these should appear in the function. The modelling of expectations for these variables is considered, along with hypotheses of dynamic adjustment, in the following section.

The specification of variables to successfully capture the influence of both international variables and speculation on the demand for money is a formidable problem. In Section 3.1 above it was decided that (1) Some function of the long-term bond rate, \( * (g_1) R_B^L \), would be used to measure the variation in money demand due to domestic speculation, and that (2) A function of the exchange rate, \( ** (g_2) EX \), would be used to measure the influence of international speculation. What guidance does theory give as to the appropriate specifications of these functions?

One approach to the speculative demand for money is the mean-variance analysis of portfolio choice which stems from the work of Tobin (131).*** According to this analysis an appropriate measure of changes in the riskiness of bonds is the expected variance of returns, and the portfolio allocation as between money and bonds will be influenced both by the relative expected rates of return and by the relative

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* The rate on 2½% consols.
** The sterling effective exchange rate.
***See Chapter 1, Section 1.1 p.19 for a brief discussion of his work.
riskiness of bonds. Artis and Lewis (11 p.151) measured the riskiness of bonds using the standard deviation of the logarithmic 1st differences of the consol yield (a 36-month moving average of prior values being taken as an appropriate expression of the dependence of expectations on past experience). The consol yield was used to measure the expected return on bonds; a procedure which implies that the expected capital gain is zero, regardless of either the level or recent behaviour of the interest rate. This procedure yields the following demand for money model:

\[ M = A + b_1 Y + b_2 P + b_3 R^L_B + b_4 q + u. \]

In which,

- \( R^L_B \) = The consol yield.
- \( q \) = The riskiness of bonds.

As it stands such a procedure has several weaknesses. Firstly, although it is possible that the expected capital gain is independent of the current level of interest, it is still likely to be a function of rates in the recent past - i.e. if rates are showing a trend rise then for a while at least investors would typically anticipate this trend to continue and thus would expect to make capital losses. In short, we need a theory explaining the formation of expectations with respect to capital gains. Ideally, we require a theory such as rational expectations, which will take full account of all the available information: for example, during the period of rapidly rising inflation, 1973-1975, long-term interest rates showed a trend rise; this trend was
halted and briefly reversed in 1977 following the government's strong anti-inflation measures in 1976 which included the formal introduction of monetary targets.

A second weakness of this procedure concerns the use of the standard deviation to measure the riskiness of bonds: such a measure cannot adequately discriminate between cases where there is either a trend rise or fall in long-term interest rates, as opposed to variation around a particular rate. Since speculative behaviour will critically depend on the nature of the variation, the standard deviation alone does not provide us with sufficient risk information.

Finally, it should be recognized that the spread and pattern of rates between short-term and long-term financial assets is likely to have an important influence on money-holding decisions. Even if only one class of capital risky assets is investigated such as government bonds, there are still short, medium and long-dated securities to be considered. So, if a portfolio approach is adopted when studying the demand for money then it becomes necessary to look at the term structure of interest rates rather than a single rate on a particular alternative financial asset.

Theories of the term structure of interest rates include the Expectations Theory, the Liquidity or Risk-premium Theory and the Market Segmentation Theory.* Modigliani and Sutch (96) developed a Preferred Habitat Theory which blends elements from each of these three theories. The Habitat model implies that the spread between the long rate and the short rate should depend mainly on the expected change in

* A description of each can be found in Surrey (125) p.157.
the long rate. It also suggests that this spread can be influenced by the supply of long and short-term securities by primary borrowers relative to the corresponding demand of primary lenders, to an extent reflecting prevailing risk aversion, transaction costs and facilities for effective arbitrage operations.

The Habitat model can be expressed formally as follows:

\[ R_L = r_S - B \Delta R^E_L + F_t \]

where,

\[ R_L = \text{Long-term rate} \]
\[ r_S = \text{Short-term rate} \]
\[ \Delta R^E_L = \text{Expected change in the long-rate} \]
\[ F_t = \text{The net effect of relative supply factors (which can be + or -)} \]

The expected capital gain is taken as proportional to the expected fall in the long rate - i.e. \( B \Delta R^E_L \).

For the purposes of empirical work to test the theory an expression for the expected capital gain, \( \Delta R^E_L \), must be formally derived.* Frank de Leeuw (35) developed a model which allowed for both extrapolative and regressive elements in expectations, and this gave the following equation for expected capital gain:

* Models of expectations for income and inflation are considered in the following section, and Chapter 7, respectively.
\[ \Delta R_L^E = A + \sum_{i=1}^{M} b_i R_{L_{t-i}} - b R_{L_t} \]

where,

\[ \sum_{i=1}^{M} b_i R_{L_{t-1}} \] is a distributed lag on the long-term rate of interest.

So, in order to take account of the speculative demand for money, following the Preferred Habitat Model, it is necessary to include a distributed lag on the long-term rate of interest in the demand for money function; one that reflects a suitable expectations formation hypothesis. The function can be expressed as follows:

\[ M_t^D = A + b_1 Y_t + b_2 P_t + b_3 R_B^L + \sum_{i=1}^{M} b_3 R_{B_{t-i}}^L + u_t \]

Variations on this theme can be tried. For example, a distributed lag of the 1st differences in the bond rate could be entered along with the current rate as follows:

\[ M_t^D = A + b_1 Y_t + b_2 P_t + b_3 R_B^L + \sum_{i=0}^{L} b_4 \Delta R_{B_{t-i}}^L \]

Since a fall in the level of the long-term bond rate should lead to a fall in the demand for money, if the fall is expected to continue, and vice-versa, the expected sign on \( b_4 \) is positive. If \( R_B^L \) remains unchanged over a period, or varies around a particular 'normal rate', with frequent changes of sign, then the distributed lag term will not have much impact on money demand: this is clearly appropriate since it is just this situation in which expected capital gains
from holding bonds are likely to be zero.

It has been assumed that the exchange rate variable is best represented by the 'sterling effective exchange rate', and that the expected rate is a function of the actual exchange rate \(-g_2\)EX. One procedure for measuring the expected exchange rate would be to incorporate a distributed lag of the sterling effective exchange rate into the demand for money function as shown below:

\[
M = A + b_1 Y + b_2 P + b_3 R^L_B + \sum_{i=1}^{M} b_{3i} R^L_{B,t-i} + \sum_{i=0}^{N} b_{4i} EX_{t-i} + u
\]

Where \(EX\) = the sterling effective exchange rate.

The choice of polynomial degree, and hence the lag path, should reflect the expectations hypothesis maintained, although the optimum solution is simply to vary both the polynomial degree and lag length until the best empirical results are obtained. The drawback to this solution is that while it might be optimum for the data period under consideration, it may provide us with poor forecasts because of changes in the factors which influence expectations. A theory of exchange rate expectations will therefore be needed.

An alternative approach is based on interest rate parity models, where work by Aliber (1), Dornbusch (40) and McKinnon (88) has been influential. This approach treats exchange rates as being primarily determined in asset markets in the short-run, with exchange rate expectations depending on movements in the forward exchange rate relative
to the spot rate.* Laidler (79) points out that since the relationship between the spot and forward rate is determined by specialist foreign exchange dealers under flexible rates, it will serve as a good short-term measure of the expected change in the exchange rate for other agents. These agents can conveniently use this relationship to calculate their own 'rational' expectation about the time path of the exchange rate. Assuming that the forward rate correctly reflects the future spot rate (i.e. the spot rate in three months' time) then we have perfect foresight which can be expressed as follows:

\[ \Delta EX^E = \Delta EX_{t+1} \]

Where,

\[ EX^E = \text{Expected exchange rate} \]

We are now in a position to specify our demand for money models, for each definition of money, indicating both the functional form, and the actual explanatory variables (see Section 3.1 above) which are likely to perform best.

* Arango and Nadiri (3) used this approach for exchange rate expectations: for precise details of variable specification see Chapter 4, Section 4.4.
1. \[ M_1 = a_0 + b_1 Y_{GDP_{MP}} + b_2 P_{GDP_{MP}} + b_3 R_s + u_1 \]

2. \[ TD = b_0 + c_1 Y_{GDP_{MP}} + c_2 P_{GDP_{MP}} + c_3 R_s + c_4 R_{CD} + c_5 R_{EU} + c_6 R_B^L + \sum_{i=1}^{M} c_{6i} R_{B_{t-i}}^L + c_7 EX + \sum_{i=0}^{N} c_{7i} EX_{t-i} + u_2 \]

3. \[ \Delta M_3 = c_0 + d_1 Y_{GDP_{MP}} + d_2 P_{GDP_{MP}} + d_3 R_{CD} + d_4 R_s + d_5 R_{EU} + d_6 R_B^L + \sum_{i=1}^{M} d_{6i} R_{B_{t-i}}^L + \sum_{i=0}^{N} d_{7i} EX_{t-i} + u_3 \]

4. \[ MP = d_0 + e_1 PDI + e_2 P_{PDI} + e_3 R_{OR}^7 + e_4 R_{EU} + u_4 \]

5. \[ MC = e_0 + f_1 Y_{GDP_{FC}} + f_2 P_{GDP_{FC}} + f_3 R_{CD} + f_4 R_{LA} + f_5 R_{EU} + f_6 R_B^L + \sum_{i=1}^{M} f_{6i} R_{B_{t-i}}^L + \sum_{i=0}^{N} f_{7i} EX_{t-i} + u_5 \]

Notes

1. The functional form is either untransformed linear or log-linear.

2. Since Chapter 7 is devoted to the influence of inflation expectations, this variable is omitted from the above specifications.

3. \(^\dagger\) indicates that alternative interest rates should be tried since many domestic short-term rates have been subject to control during the 1970's.
4. Since there are no reliable measures of wealth for the UK economy, a wealth variable is excluded from the models.

5. A weighted average of the relevant own-rates on money could be used for TD, £M3 and MC in place of the CD rate.

6. For variable definitions see data appendix. (Note - for convenience the income and price subscripts are dropped when presenting the empirical results in Chapters 5-10).

As they stand these are equilibrium models of the demand for money - i.e. the effect of a change in any of the explanatory variables on the demand for money is assumed to work through completely within a single period. Since the empirical work is concerned with short-run quarterly demand for money models it is necessary to take account of lags in adjustment because it is extremely unlikely, except perhaps for the company sector, that adjustment would be completed within a quarter. There are several competing hypotheses concerning the dynamics of money demand adjustment and these are described in the following section.

3.3 Model dynamics
Two classes of distributed lag models are considered in this section: fixed and flexible lags. Several alternative hypotheses have been advanced to account for the lag structure and these include partial adjustment, adaptive-expectations and the permanent income hypothesis. Despite
the very different assumptions of these models they each result in very similar final estimating equations; a fact which makes it difficult to discriminate between them empirically. Although the flexible lag model has no real theoretical underpinning, it does not arbitrarily impose any particular lag structure from the outset; the data itself is allowed to determine both the pattern and length of adjustment following changes in the values of the explanatory variables.

Each class of model can now be considered in turn. For convenience it is assumed that a transactions demand model is appropriate.

3.3.1 Fixed lag models

1. Partial adjustment
In this model money-holders are assumed to have a desired level of money demand to which they adjust their actual holdings gradually following a change in income, prices or interest rates. The reasons for partial adjustment typically include ignorance, inertia and the costs of change. The model can be set out formally as follows:

1. \( M^* = A + b_1 Y + b_2 P + b_3 R \)

2. \( M_t - M_{t-1} = \lambda (M^*_t - M_{t-1}) + u_t \quad 0 < \lambda \leq 1 \)

Where \( M^* \) = Desired money-holdings.

Substituting for \( M^* \) in Equation 2 we get;

3. \( M_t - M_{t-1} = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R - \lambda M_{t-1} + u_t \)
Bringing $M_{t-1}$ over to the other side of the equation we obtain the final estimating equation:

$$4. M_t = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + (1-\lambda)M_{t-1} + u_t$$

If we focus on equations 1, 2 and 4 we see that the coefficients $b_i$ represent the long-run coefficients, $\lambda b_i$ the short-run coefficients, and that $\lambda$ represents the speed at which $M_t$ adjusts to the desired level, $M^*$. It can readily be seen that if $\lambda = 1$ then desired money-holdings equal actual money-holdings (equation 2 above) indicating that adjustment to a change is completed within a single period. In equation 4 the coefficient on $M_{t-1}$ will now be zero, while the coefficients on income, price and the rate of interest will now be the long-run values of $b_1$, $b_2$ and $b_3$, respectively - i.e. we have an equilibrium model.

It is to be expected, however, in a short-run quarterly model of the demand for money that adjustment will not be fully completed within a single period - i.e. $\lambda < 1$.

One of the model requirements is that $\lambda$ should not be less than 0, for if this is the case the model collapses with the coefficient on $M_{t-1} > 1$.

If the above set of equations are derived from a log-linear specification, as opposed to an untransformed
linear model,* then the parameters of the model can be interpreted as elasticities:

<table>
<thead>
<tr>
<th>Income Elasticity</th>
<th>Price Elasticity</th>
<th>Interest Rate Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-run $\lambda b_1$</td>
<td>$\lambda b_2$</td>
<td>$\lambda b_3$</td>
</tr>
<tr>
<td>Long-run $b_1$</td>
<td>$b_2$</td>
<td>$b_3$</td>
</tr>
</tbody>
</table>

$\lambda = \text{The proportion of adjustment of money-holdings to their desired level completed within a single period.}$

The partial adjustment model has been commonly used in empirical work and certainly represents a conveniently simple specification based on quite plausible assumptions. However, it has two important weaknesses. Firstly, it constrains both the speed of adjustment and the lag paths of the demand for money to be the same regardless of the initial source of disturbance: it seems rather unlikely that the speed and pattern of adjustment following a change in prices would coincide with that for interest rates!**

A second criticism concerns the basic assumption that actual money-holdings only adjust upwards towards higher desired levels: if the monetary authorities were to use open market operations in order to increase the money supply, then

* The log-linear specification does have certain econometric advantages; in particular the problem of heteroscedasticity, which destroys the BLUE properties of the OLS estimator, is considerably reduced.

** This implicit assumption of the model can be tested by using a flexible lag model which allows the data to determine the lag structure.
initially the public would find itself holding an increase in cash which is in excess of the desired level; in subsequent periods they would then reduce cash-holdings towards the desired level. The real problem here is one of identification since money demand cannot be directly observed. Money stock figures are used to represent demand, and these represent the outcome of both supply and demand forces. The problem can be overcome by specifying a simultaneous model of the money market, with both a money supply and money demand function specified. This certainly seems appropriate for the policy-relevant £M3 definition of money.

2. Adaptive-expectations and permanent income

Cagan (25) and Friedman (51) developed these hypotheses which have been commonly applied in empirical work on the demand for money. Typically, the hypotheses have been applied to the income variable only, since short-run homogeneity of money demand with respect to the actual price level has been commonly assumed in the empirical work. (The issue of homogeneity in prices is considered further in an Appendix to this Chapter). Such an assumption has led to the specification of both the dependent and lagged dependent variables in real terms.

Permanent income is really a proxy measure for wealth in the demand for money function, and is defined as a distributed lag of current and past incomes as follows:

\[ y_p = \sum_{i=0}^{\infty} \theta(1-\theta)^i y_{t-i} \quad 0 < \theta \leq 1 \]
In this form permanent income is simply a weighted average of current and all past incomes, with the weights declining geometrically and reflecting the assumption that incomes in the recent past are more important than those which are further removed from the current time period.

The adaptive-expectations model leads to an identical expression for $Y^E$ or expected income, and therefore a final estimating equation for the demand for money which is identical to that for the permanent income case. It states that people will adjust their income expectations by a proportion of the discrepancy between actual income in the current period and the income expected for that period (the expectation being formed in the previous period, $t-1$). With the scheme just applying to income our demand for money model can be set out formally as follows:

1. $M_t^D = A + b_1 Y^E_t + b_2 P_t + b_3 R_t + u$

2. $Y^E_t - Y^E_{t-1} = \theta(Y_t - Y^E_{t-1}) \quad 0 < \theta \leq 1$

From equation 2 above,

$$Y^E_t = \theta Y_t + (1-\theta)Y^E_{t-1}$$

Let $(1-\theta) = g$ then,

$$(1-gD)Y^E_t = \theta Y_t \quad D = \text{delay or lag operator}$$

Therefore: $Y^E_t = \frac{\theta}{(1-gD)} Y_t$
Substituting for $Y_t^E$ in equation 1 above we get:

3. $M_t^D = A + \frac{b_1 \theta}{(1-gD)} Y_t + b_2 P_t + b_3 R_t + u_t$

Multiplying equation 3 throughout by $(1-gD)$ we get,

$$M_t^D (1-gD) = A(1-gD) + b_1 \theta Y_t + b_2 (1-gD) P_t + b_3 (1-gD) R_t + u_t (1-gD)$$

And since $g = (1-\theta)$,

$$M_t^D - (1-\theta) M_{t-1} = \theta A + b_1 \theta Y_t + b_2 P_t - b_2 (1-\theta) P_{t-1} + b_3 R_t - b_3 (1-\theta) R_{t-1} + u_t - (1-\theta) u_{t-1}$$

Bringing $M_{t-1}$ over to the R.h.s. of equation we obtain the final estimating equation:

4. $M_t^D = \theta A + b_1 \theta Y_t + b_2 P_t - b_2 (1-\theta) P_{t-1} + b_3 R_t - b_3 (1-\theta) R_{t-1} + (1-\theta) M_{t-1} + u_t - (1-\theta) u_{t-1}$

Assuming a log-linear specification we can interpret the coefficients as elasticities. The long-run price and interest rate elasticities, $b_2$ and $b_3$, respectively, are available directly from the equation, while the coefficient on income, $b_1 \theta$ represents the short-run income elasticity; the long-run income elasticity $b_1$ is obtained by dividing $b_1 \theta$ by $\theta$, an estimate of which is given by 1 - coefficient on $M_{t-1}$ - i.e. $1 - (1-\theta) = \theta$. 
The assumption of adaptive-expectations might have been applied to any of the variables in the model, or perhaps even to each of them. However, it should be pointed out that its application to either the price or interest variables during the 1970's would probably be quite inappropriate since both variables have shown strong trend movements over the period. Furthermore, variation in the income variable is not particularly strong compared with previous periods, and it is likely that expected income would not have seriously diverged from actual income especially in the second half of the decade.

It could still be that expected values of one or more of the explanatory variables should appear in the demand for money function, but that expectations need to be modelled in a different way. For the 1970's an extrapolative/regressive model might be in order.* Alternatively, a flexible lag approach could be used.

Before turning to flexible lag models it should be recognized that lags in the demand for money could well be accounted for by a combination of the hypotheses outlined above - e.g. partial adjustment combined with adaptive-expectations. Such a model which formally combines these two hypotheses is detailed below:

1. \[ M_t^* = A + b_1 Y_t^E + b_2 P_t + b_3 R_t + u_t \]

* Such a model is outlined for inflation expectations in Chapter 7.
Partial Adjustment \( M_t - M_{t-1} = \lambda (M^*_t - M_{t-1}) + V_t \quad 0 < \lambda \leq 1 \)

Adaptive-Expectations \( y^E_t - y^E_{t-1} = \theta (y_t - y^E_{t-1}) \quad 0 < \theta \leq 1 \)

This model reduces to a final estimating equation as follows:

\[ M_t = c_0 + c_1 Y_t + c_2 P_t + c_3 P_{t-1} + c_4 R_t + c_5 R_{t-1} + c_6 M_{t-1} + c_7 M_{t-2} + e_t \]

where,

\[

c_0 = A \theta \lambda \\
c_1 = b_1 \theta \\
c_2 = b_2 \lambda \\
c_3 = -b_2 \lambda (1-\theta) \\
c_4 = b_3 \lambda \\
c_5 = -b_3 \lambda (1-\theta) \\
c_6 = (2-\theta-\lambda) \\
c_7 = -(1-\theta)(1-\lambda) \\
e_t = A \text{ composite error term}
\]

Unlike the partial adjustment model both the adaptive-expectations and combined models imply serial correlation in the error terms of the estimating equation. In the adaptive-expectations scheme the error term is \( u_t - (1-\theta) u_{t-1} \).

Let \( V_t = u_t - (1-\theta) u_{t-1} \)

Then \( V_{t-1} = u_{t-1} - (1-\theta) u_{t-2} \)

Since both \( V_t \) and \( V_{t-1} \) depend on \( u_{t-1} \) it follows that they are correlated to some extent. It is therefore necessary to allow for serial correlation when estimating the model.
It should also be noted that while the partial adjustment model is exactly identified, both the adaptive-expectations and combined models are over-identified since the number of coefficients to be estimated exceeds the number of structural parameters. Thus while the partial adjustment model yields unique estimates of the structural parameters the other models do not.

3.3.2 Flexible lag models

The main trouble with the fixed lag models is that the lag structure is simply imposed from the outset without any preliminary investigation of the data. The models considered above yielded lag structures with geometrically declining coefficients - i.e. current period values of the explanatory variables have more influence on the demand for money than all previous period values. However, it may well be that there is a lag before money-holders react at all to changes in income, price or rates of interest. If this is the case then the imposition of a rigid lag structure with geometrically declining weights will obviously be an invalid procedure. It is clearly useful to let the data itself inform us about the pattern of adjustment and a flexible finite lag model allows this.

The model can be expressed as follows:

\[ M_t = A + \sum_{i=0}^{M} B_i Y_{t-i} + \sum_{i=0}^{N} C_i P_{t-i} + \sum_{i=0}^{L} D_i R_{t-i} + u_t \]

where \( M, N \) and \( L \) denote the lag lengths on the income, price and interest rate variables.
Now free estimation of such a model is not really feasible owing to (1) the serious multicollinearity problems which would arise and (2) the loss of a large number of degrees of freedom; an especially important problem when dealing with relatively small samples of data.

Use of the polynomial distributed lag technique (PDL), applying the Almon scheme (2), reduces the multicollinearity problem significantly and is not so wasteful of degrees of freedom since a polynomial of fairly low degree can be used. At the same time it does not impose an inflexible lag structure on the model as do the partial adjustment and adaptive-expectations schemes.

The PDL technique is based on Weierstrass' theorem* which states that a function continuous in a closed interval can be approximated over the entire interval by a polynomial of suitable degree which differs from the function by less than any given positive quantity at every point of the interval.

Although the theorem gives no indication of the degree of polynomial required for a given level of accuracy it is hoped that a polynomial of reasonably low degree will give good results.

In the first instance economic theory should give some guidance to the shape of the lag paths, and thus to the appropriate choice of polynomial degree for each of the explanatory variables. Working on the crude assumption that the chosen polynomial degree should be one greater than the

---

number of turning-points expected in the lag path, it would seem that the lag reaction of money-holdings to changes in income, prices and interest rates can be adequately captured by polynomials of low degree.

Some possible lag paths and the appropriate choice of polynomial degree

<table>
<thead>
<tr>
<th>PD</th>
<th>Lag Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
<tr>
<td>2</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
<tr>
<td>3</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
<tr>
<td>4</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
<tr>
<td>5</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
<tr>
<td>6</td>
<td>(x_t x_{t-1} x_{t-2} x_{t-3} \ldots x_{t-i})</td>
</tr>
</tbody>
</table>
It would appear that polynomial degrees of 1-3 are likely to adequately cover all the feasible lag paths. If the chosen PD proves unsatisfactory when the equations are estimated, then the data for the period concerned rejects the theory, and a different PD should be tried. In the final analysis the data determines the lag path and providing theory does not positively reject the outcome we can accept the sample results.

In addition to selecting the appropriate polynomial degree the effective lag length for each explanatory variable has to be chosen. Once again, theory should help in the first instance plus evidence from existing empirical work. The important point is that the optimum PD and lag length specification are determined empirically.

**Polynomials and the Almon scheme**

Although orthogonal polynomials are used in my empirical work, as they have an important computational advantage (explained below), a simple scheme using Almon weights most clearly demonstrates the nature of polynomial distributed lag estimation.

**The simple Almon scheme**

\[
(1) \quad f(Z) = a_0 + a_1 Z + a_2 Z^2 + \ldots + a_j Z^j \\
= \sum_{i=0}^{j} a_i Z^i
\]

Where, 

- \( Z^i \) = A combination of \( X_i \) 
- \( a_i \) = Polynomial weights 
- \( j \) = Polynomial degree
The precise nature of the polynomial variables, \( Z_i \), depends on the construction of the variables implicit in the simple Almon scheme and the lag length specified.

<table>
<thead>
<tr>
<th>Degree of Polynomial</th>
<th>Polynomial Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( Z = X_{t-1} + 2X_{t-2} + 3X_{t-3} \cdots + sX_{t-s} )</td>
</tr>
<tr>
<td>2</td>
<td>( Z^2 = X_{t-1} + 2^2X_{t-2} + 3^2X_{t-3} \cdots + s^2X_{t-s} )</td>
</tr>
<tr>
<td>i</td>
<td>( Z^i = X_{t-1} + 2^iX_{t-2} + 3^iX_{t-3} \cdots + s^iX_{t-s} )</td>
</tr>
</tbody>
</table>

The above table shows that for the 1st degree variable, \( Z \), each of the coefficients on \( X_i \) are raised to the power 1, for the 2nd degree variable, \( Z^2 \), they are raised to the power 2, and for the \( i \)th degree variable, \( Z^i \), they are raised to the power \( i \). The number of lagged \( X_i \) appearing in \( Z \) depends on the lag length specified; \( S \) in this case.

Suppose the basic equation to be estimated is,

\[
y_t = A + b_0 X_t + b_1 X_{t-1} + b_2 X_{t-2} \cdots + b_s X_{t-s} + u_t
\]

The coefficients \( b_k \) are given by the values of \( f(Z) \) at the points \( Z = 0, 1, 2 \ldots \ldots s \).

\[
b_k = \sum_{i=0}^{j} a_i k^i
\]

- \( b_k \) = Coefficient on \( X_i \)
- \( j \) = Degree of polynomial
- \( a_i \) = Polynomial coefficients in \( f(Z) \)
Making the substitution \( b_k = f(K) \) the model becomes,

\[
Y_t = \sum_{k=0}^{S} \left( \sum_{i=0}^{j} a_i K^i \right) X_{t-k} + u_t
\]

Constructing new variables:

\[
X_{it} = \sum_{k=0}^{S} K^i X_{t-k}
\]

So, the equation to be estimated is as follows:

\[
Y_t = \sum_{i=0}^{j} a_i X_{it} + u_t
\]

And,

\[
\begin{align*}
    b_0 &= a_0 \\
b_1 &= a_0 + a_1 + a_2 + \ldots + a_j \\
b_2 &= a_0 + 2a_1 + 4a_2 + \ldots + 2^j a_j \\
b_s &= a_0 + 5a_1 + S^2 a_2 + \ldots + S^j a_j
\end{align*}
\]

**EXAMPLE:** Let polynomial degree = 2 and lag length = 4.

Then,

\[
\begin{align*}
f(Z) &= a_0 Z^0 + a_1 Z^1 + a_2 Z^2 \\
Z^0 &= X_t + X_{t-1} + X_{t-2} + X_{t-3} + X_{t-4} \\
Z^1 &= X_{t-1} + 2X_{t-2} + 3X_{t-3} + 4X_{t-4} \\
Z^2 &= X_{t-1} + 4X_{t-2} + 9X_{t-3} + 16X_{t-4}
\end{align*}
\]

Therefore,

\[
Y_t = A + a_0 X_t + (a_0 + a_1 + a_2)X_{t-1} + (a_0 + 2a_1 + 4a_2)X_{t-2} + (a_0 + 3a_1 + 9a_2)X_{t-3} + (a_0 + 4a_1 + 16a_2)X_{t-4} + u_t
\]
Where,

\[\begin{align*}
a_0 &= b_0 \\
a_0 + a_1 + a_2 &= b_1 \\
a_0 + 2a_1 + 4a_2 &= b_2 \\
a_0 + 3a_1 + 9a_2 &= b_3 \\
a_0 + 4a_1 + 16a_2 &= b_4 \\
\end{align*}\]

*Orthogonal polynomials*

The basic polynomial regression:

\[Y_t = b_0 Z_t^0 + b_1 Z_t^1 + b_2 Z_t^2 \ldots + b_n Z_t^n + e_t\]

Where \(Z\) comprises some combination of \(X_{t-i}\).

The advantage of using orthogonal polynomials is that they minimise multicollinearity problems between the \(Z^S\) in the basic equation shown above. These problems can be serious when simple polynomials are used - e.g. the simple Almon scheme. Orthogonal polynomials have a computational advantage only - i.e. as long as the computational problem is avoided then the choice of polynomials will make no difference at all as the different polynomials would yield the same lag weights.

So, using orthogonal polynomials makes the \(Z^i\) as independent as possible. This is useful since each parameter estimated gives 'reasonably independent' information about the weighting function, and it is possible to evaluate the significance of including different \(Z_t^i\) variables. In fact if the original X series was a stationary random series then

using orthogonal polynomials would ensure that the expected correlations between the $Z^i_t$ variables would be zero. In such a case each of the $b_i$ would give completely independent information about the shape of the lag path corresponding to the degree of the chosen polynomial. If the $b_i$ become larger as $i$ increases, then this would suggest that the lag path cannot be well approximated by a polynomial.

Even if the $X^s$ are serially correlated and thus the $Z^i_t$ are not independent, the use of orthogonal polynomials will still yield benefits. By running a series of multiple regressions, stepping in an additional $Z^i_t$ for each new regression, a set of approximating polynomials of degree 0 to $n$ are obtained. One can then examine $R^2$ and the t-statistics on the estimated $b_i$, to see if additional variables improve the explanatory power of the equation. Thus we have a reliable empirical basis for choosing the polynomial degree; and if theoretical expectation squares with the empirical evidence then this implies that we can be confident about the lag path.

Some details on the orthogonal polynomials
There exists a set of orthogonal polynomials which have the properties that, for integer values of $t$,

1. $\sum_{t=1}^{n} P_i(t) = 0 \quad \text{for } i \neq 0$

2. $\sum_{t=1}^{n} P_i(t) \cdot P_j(t) = 0 \quad \text{for all } i \neq j$
These polynomials have the following form,

\[ P_0(t) = 1 \]
\[ P_1(t) = t - \bar{t} \]

and the general recursion formula:

\[ P_{r+1}(t) = P_1(t), P_r(t) = \frac{r^2(n^2-r^2)}{4(4r^2-1)} P_{r-1}(t) \]

Where,

\[ r = \text{Degree of polynomial} \]
\[ P_r(t) = \text{Polynomial of degree } r \text{ in } t \]
\[ \bar{t} = \frac{n+1}{2} \]

In the recursion formula \( t \) is measured from its mean. Therefore \( t = t - \bar{t} \).

3.4 **Estimation problems**

In dynamic single equation models of the demand for money the main problems include multicollinearity, errors in variables, serial correlation and stochastic regressors. However, for broad definitions of money such as £M3 it may well be that simultaneity is an important problem with some of the regressors in the demand for money equation being endogenous. Two important problems for simultaneous models are identification and simultaneous equation bias. In addition to these there is the problem of across equation autocorrelation, as well as within equation autocorrelation,
and the treatment of lagged endogenous regressors in the face of significant autocorrelation.

Each of these problems will be dealt with in turn focusing firstly on those which arise in the context of a single equation model, and then on the problems specifically associated with a simultaneous model.

3.4.1 **Single equation problems**

Suppose it is believed that transactions motives are the main influence on demand for money behaviour, and that we are concerned with a short-run, quarterly model where adjustment is not completed within a single period. The model can be expressed as follows:

\[ M_t = a + b_1 Y_t + b_2 P_t + b_3 R_t + \lambda M_{t-1} + u_t \]

It is further assumed that movements in the money stock reflect demand changes - i.e. the supply of money is demand-determined, and that each of the explanatory variables are exogenous.

One problem which will arise at the estimation stage is that of multicollinearity: during the 1960's, in particular, there was a common trending in the data, and insufficient independent variation in the variables to determine a strong relationship. The reason for this was the strong positive correlation between income and prices.*

Now the greater the correlation between income and prices, the larger will be the variances of the estimated...

* Even in the 1970's when there was a good deal more independent variation in prices, the correlation between price and the lagged money stock was strong.
coefficients, $\hat{b}_1$ and $\hat{b}_2$. This can be shown most conveniently by assuming that both $b_3$ and $\lambda$ are zero so that equation (1) collapses to a case in which there are just the two explanatory variables; income and price. Then,

\[
\text{Variance of } \hat{b}_1 = \frac{\sigma_u^2}{\sum y^2(1-r^2)} \quad Y = Y - \bar{Y}
\]

\[
\text{Variance of } \hat{b}_2 = \frac{\sigma_u^2}{\sum p^2(1-r^2)} \quad P = P - \bar{P}
\]

(Where $r =$ correlation between $Y$ and $P$).

Now if prices and income were perfectly correlated then $r^2=1$ and the denominators of the above expressions would be zero. It follows that the variances would be infinitely great, but in this case no estimates of the $b_1$ could even be obtained. More generally, the greater the correlation between $P$ and $Y$ then the smaller the denominator of the expression must be in relation to the numerator, and hence the larger will be the variances of the estimators $\hat{b}_1$ and $\hat{b}_2$. This, in turn, will result in wide confidence intervals for both $b_1$ and $b_2$, and a strong tendency to accept the null hypothesis that the true coefficients are zero.

It must be stressed that multicollinearity is not a problem of the method of estimation, but a problem of the data itself. It is often quite serious when dealing with time-series data.

Ways of overcoming or easing multicollinearity problems include placing theoretical restrictions, where appropriate,
on the values of certain parameters - e.g. it has often been assumed in empirical work that the demand for money is linearly homogeneous with respect to the price level. Another way around the problem, when it is caused by common trending in the data, is to take 1st differences of the variables before estimation. However, since this procedure may well lead to serial correlation problems, where none existed in the first place, it is not to be strongly recommended. A third way to handle the problem is to apply principal component analysis, * although in this case it is difficult to interpret the results.

In practice, we must live with the multicollinearity problem: as long as the t-test shows the estimated regression coefficients to be significant at some prior chosen significance level, then the coefficient estimates can be accepted.

A second problem which might arise is that of errors in variables. This concerns the possibility of measurement error in the independent variables; P, Y and R. One source of error is information weakness. For example, figures in the national income accounts are subject to a small degree of uncertainty, and current and back-year figures may be revised in subsequent data periods. However, this is probably not a serious problem since economic agents often act on the basis of reported information, whether it is incorrect or not. ** Errors in variables will be much more

* This analysis is fully explained in Dutta (43) Ch.8.

** But to the extent that the errors arise in the aggregation of data it could be argued that since individuals often pay attention to known micro variables the problem still exists.
important if it is believed that expected rather than actual values of the explanatory variables are relevant to money-holding behaviour. If expectations models, such as adaptive or extrapolative-regressive expectations, are relevant then the application of OLS will yield coefficient estimates which are both biased and inconsistent. In such cases alternative estimators such as instrumental variables or maximum likelihood are required.*

Perhaps the most important problem is that of serial correlation in the residuals. One of the necessary conditions for the BLUE property of OLS is that the error terms are serially independent - \( E u_t u_{t-1} = 0 \). If this condition is broken then \( u_t \) depends on \( u_{t-1} \) and the estimated variances of both the coefficients and the residuals will be misleading so that nothing much can be said about the significance of the coefficients and no hypothesis tests can be constructed. It should be stressed that serial correlation by itself - i.e. in equations without lagged dependents appearing as regressors, and only non-stochastic variables - does not lead to biased and inconsistent OLS parameter estimates. Simple adjustments can be made for serial correlation, which is measured by the Durbin-Watson statistic;** for sample sizes where \( n > 30 \) an efficient estimate of \( p \) is given by the formula \( 1 - \frac{1}{2}d \) (where \( d = D-W \) statistic), and although the same procedure can be followed for smaller samples it is important to test for serial correlation again after transforming the original relationship.

* Johnston (70) p.281-291 gives a good account of the errors in variables problem; especially p.281 and p.283.

** J. Durbin and G.S. Watson (42).
In our dynamic demand for money model, see equation (1) above, we have an additional problem since the lagged dependent variable, $M_{t-1}$, is included in the set of explanatory variables. This violates another important necessary condition for OLS estimators to be BLUE - i.e. the explanatory variables, $X_i$, should be independent of $u_i$ for all $i$; they should be non-stochastic. The condition is violated since the lagged money stock, $M_{t-1}$, clearly depends on $u_{t-1}$.

Now in the absence of serial correlation the only problem resulting from this violation of the independence condition would be one of bias in small samples - i.e. $n < 30$. However, OLS would still yield, asymptotically unbiased and consistent estimates; attractive properties of any estimator.

If both problems exist together then it immediately follows that $M_{t-1}$ is correlated with $u_t$, since $M_{t-1}$ and $u_t$ are each correlated with $u_{t-1}$. In this situation the OLS estimator will be both biased and inconsistent. Furthermore, the D-W statistic will now be an inappropriate measure of serial correlation;* in cases of positive autocorrelation the D-W statistic will be biased towards 2.0 and may well suggest that the problem does not exist, when in fact it does.

It is important to obtain a consistent estimate of $p$ before transforming the variables to eliminate the serial correlation problem. Although there are several alternative

* In these circumstances the appropriate test-statistic is given by Durbin (41). Durbin's $h$-statistic is explained in Johnston (70) p.313.
methods for doing this, I will focus only on the method used in the GIVE programme* since this was used for much of my empirical work.

Before outlining the method of estimation for dynamic single equation models with serially correlated error terms it is important to consider how the serial correlation might have arisen; in some cases blindly transforming the variables in order to eliminate the problem might be quite inappropriate.

Suppose the problem arose simply because the structural form of the model is incorrect. Perhaps an important explanatory variable has been omitted from the model, or it could be that the dynamics have been specified incorrectly. Worse still, it may be that a non-linear rather than a linear specification is appropriate. Each of these three cases are possible for our postulated demand for money relationship; consider for example the naive lag structure postulated by the popular partial adjustment hypothesis, or the possibility that a variable to take account of a speculative component of money demand needs to be specified. The appropriate action in these cases is to revise the basic model and not to simply transform the existing relationship.

However, if the serial correlation problem arises because of certain data shocks - e.g. the disturbance to money markets caused by Competition and Credit Control which was essentially temporary - then unless the disturbance can be adequately picked-up by the inclusion of dummy variables,

* Hendry and Srba (65).
it may be necessary to transform the relationship in order to eliminate the problem. Perhaps a better solution still would be to omit those observations which are atypical, although we are then faced with the problem of small data samples. Another source of naturally occurring serial correlation in the data itself, may be due to seasonal variation in the variables which cannot be adequately accounted for by the usual seasonal adjustment methods. In demand for money relationships the problem of residual seasonal variation is a likely occurrence since (1) the method used by the CSO to adjust income data is not the same as the one used by the Bank of England to adjust the money stock figures, (2) interest rates are not seasonally adjusted and (3) the Bank of England adjust the money stock figures for reasons other than just seasonal variation.

In these cases where serial correlation problems arise in the data itself, then transformation to eliminate them is an appropriate procedure. However, if serial correlation arises because the model has been incorrectly specified then the correct response is to adapt the model itself and not to simply eliminate the problem via transformation.

The GIVE programme allows us to estimate $p$, the serial correlation coefficient, efficiently in the context of a dynamic single equation autoregressive model. It also enables us to decide whether any serial correlation in the residuals is due to mis-specified dynamics in the model. An outline of the GIVE procedure is given overleaf.
A description of the GIVE procedure

Firstly, we can write our autoregressive model of the demand for money as follows:

\[ M_t = A + b_1 Y_t + b_2 P_t + b_3 R_t + \lambda M_{t-1} + u_t \]

(1)

\[ u_t = p u_{t-1} + e_t \]

(2)

\[ Ee_t = 0 \quad Ee_t^2 = \sigma_e^2 \quad Ee_t e_{t-1} = 0. \]

Equation (1) sets out the structural form of the model and equation (2) postulates 1st order serial correlation in the error term.

Now, three different representations of this single model are possible: the structural form as in (1) above, the restricted transformation function (RTF) and the unrestricted transformation function (URTF).

The RTF is obtained as follows:

From (1) and (2) above we obtain the following expression,

\[ p M_{t-1} = p(A + b_1 Y_{t-1} + b_2 P_{t-1} + b_3 R_{t-1} + \lambda M_{t-2} + u_{t-1}) \]

(3)

Subtracting (3) from (1) gives the RTF.

\[ \text{RTF: } M_t = A(1-p) + b_1 Y_t - pb_1 Y_{t-1} + b_2 P_t - \]

\[ pb_2 P_{t-1} + b_3 R_t - pb_3 R_{t-1} + (p + \lambda) M_{t-1} - p \lambda M_{t-2} + e_t. \]

(4)
Which can be re-arranged and alternatively expressed as follows:

\[ M_t - pM_{t-1} = A(1-p) + b_1(Y_t - pY_{t-1}) + b_2(P_t - pP_{t-1}) + b_3(R_t - pR_{t-1}) + \lambda(M_{t-1} - pM_{t-2}) + \epsilon_t. \]

Finally, we have the URTF which is simply the unrestricted form of equation (4) above:

\[ \text{URTF} - M_t = b_0 + c_1 Y_t + c_2 Y_{t-1} + c_3 P_t + c_4 P_{t-1} + c_5 R_t + c_6 R_{t-1} + c_7 M_{t-1} + c_8 M_{t-2} + \epsilon_t. \]

GIVE estimates all three representations and applies test-statistics, such as the \( \chi^2 \)-statistic, to see which is the valid specification.*

Whereas the structural form and the URTF can be estimated by OLS, the RTF with its non-linear restrictions must be estimated by ALS (autoregressive least squares). The procedure is as follows:

1. \( \sum e_i^2 \) is calculated for a grid of values of \( p \) from -0.92 to +0.98 in steps of 0.10. This search procedure provides a check for multiple minima and helps ensure that the iteration commences close to the global minimum.

2. For the iteration a variant of Gauss-Seidel is then used until successive results for \( \sum e_i^2 \) converge.

* See Hendry (63) p.562-563 for details on the relevant test statistics.
This procedure gives us a consistent estimate for $p$ and for each of the structural parameters of the model providing there is no evidence of serial correlation in the residuals of the RTF.

If $\hat{p}$ is significantly different from zero and if there is no significant difference between the sum of squared residuals from the RTF and the URTF, then the non-linear restrictions between the parameters in the RTF are shown to hold.

If there is a significant difference between the residuals then the RTF should be rejected in favour of the URTF. In this case we would recognize that the structural form of the model has been incorrectly specified,* and that simply transforming the relationship to take account of 1st order serial correlation is an inappropriate procedure.

Finally, if $\hat{p}$ is not significantly different from zero and the correlogram (or autocorrelation function) indicates random residuals in the structural form, then providing an F-test shows that the additional lagged regressors entering the URTF do not add significantly to the explanation of variation in the dependent variable, this indicates that the basic structure is sound and can be estimated efficiently by OLS.

3.4.2 Problems in a simultaneous model

For £M3, the broad money aggregate, it has already been argued that a simultaneous model may well be appropriate, so simple IS/LM models are considered in the empirical work in

* It might be that a higher order of serial correlation is present, but if the hypothesis of a random correlogram can be strongly accepted then this points to an error in the dynamic specification of the SF.
addition to single equation models.

Hendry (63), Hendry and Srba (65) and Fair (45) comprehensively cover the estimation of simultaneous models and the selection of optimal estimators. The last-named author specifically deals with models containing lagged endogenous variables and first order serially correlated errors.

A brief treatment of the problems is given here with the emphasis placed on the appropriate choice of estimator.

Consider the following simple IS/LM model in which all variables are expressed in nominal terms, and the price elasticity of demand for money is assumed to equal the income elasticity.

\[
\begin{align*}
\text{(1)} \quad \Delta M^D_t &= a_0 + b_1 Y_t + b_2 R^T_t + b_3 R^D_t + \lambda \Delta M^D_{t-1} + u_t \\
\text{(2)} \quad \Delta M^S_t &= b_0 + c_1 H_t + c_2 R^T_t + c_3 M_{t-1} + \theta \Delta M^S_{t-1} + v_t \\
\text{(3)} \quad Y_t &= c_0 + d_1 A_t + d_2 R^T_t + \gamma Y_{t-1} + e_t \\
\end{align*}
\]

Three endogenous variables - $\Delta M^3$, $Y$, $R^T$.

\[
\begin{align*}
\text{(4)} \quad u_t &= p_1 u_{t-1} + u'_t \quad \mathbb{E} u'_t = 0 \quad \mathbb{E} u'_t^2 = \mathbb{O}^2_{u'} \quad u'_t u'_{t-1} = 0 \\
\text{(5)} \quad v_t &= p_2 v_{t-1} + v'_t \quad \mathbb{E} v'_t = 0 \quad \mathbb{E} v'_t^2 = \mathbb{O}^2_{v'} \quad v'_t v'_{t-1} = 0 \\
\text{(6)} \quad e_t &= p_3 e_{t-1} + e'_t \quad \mathbb{E} e'_t = 0 \quad \mathbb{E} e'_t^2 = \mathbb{O}^2_{e'} \quad e'_t e'_{t-1} = 0 \\
\end{align*}
\]

(All variables are defined in the data appendix).

The dynamics of the system are assumed to reflect a general partial adjustment hypothesis, and the errors are assumed to be subject to 1st order serial correlation.
The problem is to select an estimator which will give us consistent estimates of the parameters of the demand for money equation - i.e. the equation of special interest.

Before estimation of the model we must check to see that the model is identified, since if it is under-identified there will be at least one equation in the system for which we will not be able to derive consistent parameter estimates; it is essential that the demand for money equation is identified otherwise we will not be able to obtain estimates of the various elasticities (assuming a log-linear specification*).

A sufficient condition for the identification of an equation in a simultaneous model is that both the Order and Rank conditions are satisfied.** The Order condition can be stated as follows:

In a model of M simultaneous equations, in order for an equation to be identified, the number of predetermined variables (exogenous and lagged endogenous) excluded from the equation must not be less than the number of endogenous regressors in the equation of interest.

In the model outlined above there are two endogenous regressors in the demand for money equation, Y and RB, and there are four pre-determined variables, H MLR A Y_{-1}, which

* Strictly speaking, a log-linear version of this model is an ad hoc specification since equation (3) above, the IS equation, involves the aggregation of several different expenditure terms and the addition of logs of variables will not satisfy the national income identity.

** The Rank condition is explained in Appendix B.
are excluded from this equation.* Thus equation (1) is said to be over-identified since the number of excluded pre-determined variables exceeds the number of endogenous regressors. (The money supply and income equations are also over-identified). So, providing the Rank condition is satisfied, as is likely to be the case, each equation of the model is identified and estimation can proceed.

There is an estimation problem, however, because of the presence of endogenous regressors in each of the equations. OLS estimates of the parameters of the demand for money function ignore the simultaneity in the model and are thus subject to simultaneous equation bias. If the feed-back relationships postulated by the system are strong then the OLS estimator will be seriously biased. The problem arises because the endogenous regressors \( Y_t \) and \( R_t \) are both correlated with \( u_t \) in equation (1). Clearly, then, an alternative estimator must be found. If the equation was exactly identified then Indirect Least Squares** could be used. However, in over-identified models unique parameter estimates cannot be obtained by applying this method. Instead, 2SLS must be used which gives identical results to ILS in exactly-identified equations and yields unique parameter estimates in over-identified models.

2SLS copes with the simultaneity problem by the following procedure:

---

* Strictly speaking both the number of endogenous and exogenous variables should be greater in the presence of serial correlation. Lagged exogenous variables will now be additional instruments and lagged endogenous must be treated as current endogenous. This does not alter the finding of over-identification.

** See Johnston (70) p.344-346.
The two endogenous regressors in the demand for money equation, $Y_t$ and $R_{B_t}$, are each regressed on the pre-determined variables in the system, so that $\hat{Y}_t$ and $\hat{R}_{B_t}$ are obtained. Since these variables will simply be linear functions of just the exogenous variables in the system, which are non-stochastic and uncorrelated with $u_t$ by assumption, it follows that both $\hat{Y}_t$ and $\hat{R}_{B_t}$ are uncorrelated with $u_t$.

Therefore;

(2) $Y_t$ and $R_{B_t}$ should be replaced by the instrumental variables, $\hat{Y}_t$ and $\hat{R}_{B_t}$ in the demand for money function, before estimation.

This procedure will yield consistent estimates of the parameters of the demand for money function providing correction has been made for within-equation serial correlation, and providing there is no auto-correlation across equations - i.e. $u_t$ correlated with $v_t$ and $e_t$. If across-equation auto-correlation of residuals is significant then single equation techniques, such as 2SLS, will not be optimal. Systems methods such as 3SLS or preferably FIML should be used since the problem of across equation auto-correlation of residuals can be handled as well as the usual problem of within equation serial correlation. The LSE programme ARFIML* (auto-regressive full information maximum likelihood) provides estimates of both types of residual auto-correlation occurring in estimated simultaneous equations.

* The ARFIML programme was written by D. Hendry and F. Srba.
However, since FIML parameter estimates are highly sensitive to model specification whereas 2SLS estimates are not, the practical choice in the face of uncertainty is the 2SLS estimator.

Finally, it should be stressed that feedback relationships in a dynamic quarterly model will often be weak. In fact, the shorter the time period considered the more likely we are to have a definite ordering of events with just one-way causality and no feedback within the period. If contemporaneous feedback is weak then the OLS estimator will tend to give similar results to the 2SLS estimator, and since it is computationally less expensive, it ought to be preferred. In practice large econometric models using quarterly data tend to be estimated by OLS - e.g. the Treasury and National Institute forecasting models.
The homogeneity of the demand for money with respect to the level of prices

Models of the demand for money have frequently been specified and estimated in a form which imposes linear homogeneity in prices for nominal money-holdings.* However, this is really an assumption which needs to be tested by the data itself, and accordingly no prior restrictions were placed on the price coefficient in the demand for money models specified in the main text of this chapter.

For a log-linear specification of the simple partial adjustment model, two cases will now be considered in which prior restrictions have been placed on the value of the price-elasticity.

1. Short-run homogeneity in prices

\[ M^* = (A^b_1 R^{b_2}) P \text{ or } \frac{M^*}{P} = A^b_1 R^{b_2} \]

Let \( M^* = \frac{M^*}{P} \) and \( M = \frac{M}{P} \),

\[ \frac{M}{M_{-1}} = \left( \frac{M^*}{M_{-1}} \right)^\lambda u. \quad 0 < \lambda \leq 1. \]

\[ M = M^* \lambda M_{-1}^{1-\lambda} u. \]

Then substituting for \( M^* \) in (3) we get,

\[ M = A^\lambda y^\lambda b_1 R^{\lambda b_2} M_{-1}^{1-\lambda} u. \]

* Hacche (59) and Boughton (20) are examples of researchers who constrained the price-elasticity of demand for money to be unity.
This equation is linear in the logarithms of the variables and can be re-expressed as:

\[
\log M = \lambda \log A + \lambda_1 \log Y + \lambda_2 \log R + (1 - \lambda) \log M_{-1} + \log u.
\]

2. **Long-run homogeneity in prices**

\[
(1) \quad M^* = AY^{b_1} R^{b_2} P \quad \text{or} \quad \frac{M^*}{P} = AY^{b_1} R^{b_2}
\]

\[
(2) \quad \frac{M}{M_{-1}} = \left( \frac{M^*}{M_{-1}} \right)^\lambda_p \quad 0 < \lambda \leq 1
\]

\[
(3) \quad M = M^* \lambda M_{-1}^{1-\lambda} \lambda_p
\]

Substituting for \( M^* \) in (3) we get,

\[
M = A Y^{b_1} R^{b_2} P \lambda M_{-1}^{1-\lambda} \lambda_p
\]

Since \( P \lambda \) can be expressed as \( \frac{P}{P^{1-\lambda}} \) we have,

\[
\frac{M}{P} = A Y^{b_1} R^{b_2} \lambda M_{-1}^{1-\lambda} \lambda_p \left( \frac{M_{-1}}{P} \right)^{1-\lambda} \lambda_p
\]

\[
\log \frac{M}{P} = \lambda \log A + \lambda_1 \log Y + \lambda_2 \log R + (1 - \lambda) \log \left( \frac{M_{-1}}{P} \right) + \log \lambda_p
\]

Note that the difference in variable specification, due to the different price assumptions, lies solely in the lagged money term: when short-run homogeneity is assumed the lagged real money stock enters as an explanatory variable, but with long-run homogeneity it is the lagged nominal stock deflated by current prices.
The Rank condition for Identification

Consider the following simultaneous model:

\[
\begin{align*}
M^D &= a_0 + b_1Y + b_2P + b_3R + b_4M_{-1} \\
P &= a_1 + c_1M^S + c_2W + c_3U + c_4P_{-1} \\
Y &= a_2 + d_1M^S + d_2A + d_3MLR + d_4U + d_5Y_{-1} \\
R &= a_3 + e_1M^S + e_2Y + e_3P + e_4PSBR + e_5MLR + e_6R_{-1} \\
M^D &= \bar{M}^S = M
\end{align*}
\]

(All variables are defined in the data appendix). For convenience the error terms are omitted.

This specification of the model is clearly subject to uncertainty and it is quite possible that one or more of the pre-determined variables in the system are not influential in practice - e.g. MLR and U may both be redundant explanatory variables. Now by the Order condition each of the equations in the system are over-identified, but this condition could easily be upset if some of the pre-determined variables are redundant. High multicollinearity between some of the pre-determined variables could also upset the order condition.

A sufficient condition for Identification is given as follows:
An equation is identified if the Rank of the matrix of coefficients on variables excluded from the equation of interest equals n-1 in a simultaneous equations system with a total of n equations.

The Rank of a matrix is the largest square matrix that can be formed from it with a non-zero determinant: a singular matrix is one with a zero determinant and cannot be inverted. If the largest matrix with a non-zero determinant is 3 x 3 then its rank is 3.

Now we can apply the Rank condition to the demand for money equation in the above model - i.e. equation (1).

Three endogenous regressors are included in the equation, and excluding the identity, there are four equations in the system.

For identification we need to form a matrix of Rank n-1 - i.e. 3 in this case.

From the eight pre-determined variables in the system, which do not enter equation (1), any three can be considered and the appropriate matrix of coefficients formed.

Suppose we take, W, U and PSBR as the pre-determined variables for rank inspection. If the determinant of the matrix of coefficients associated with these variables in equations (2)-(4) is non-zero then the demand for money equation is identified.
Matrix of coefficients on variables excluded from demand for money equation.

\[
A = \begin{bmatrix}
c_2 & c_3 & 0 \\
0 & d_4 & 0 \\
0 & 0 & e_4 \\
\end{bmatrix}
\]

Providing W, U and PSBR are independent of one another and that each of these are significant explanatory variables in the system, as hypothesised, then \( c_2 d_4 e_4 \) must be non-zero, and the demand for money equation identified.
4.0 Introductory remarks

The major demand for money problems in the 1970's have been outlined in Chapter 2. This survey focuses on these problems and encompasses a wide range of single equation specifications which include both fixed and flexible lag models (for model details see Chapter 3).

Although the main focus of attention is on the M1 and £M3 definitions of money, the work of Hacche (59), amongst others, who examines both personal and company-holdings of M3 separately, is also considered.

Issues concerning the appropriate specification of the interest rate variable(s), and the homogeneity of money demand with respect to price are also considered.

Only the study of Arango and Nadiri (3) attempts to deal with the simultaneity problem, and none of the reported work is based on specified simultaneous models. While this may well be in order for the M1 definition of money, there is considerable doubt regarding the appropriateness of the single equation work on M3. Although my concern is with the UK economy, I should point out that some empirical studies of the demand for money in other countries have been based on simultaneous models.*

* For example, Frowen and Arestis (4) for W. Germany and Teigen (128) for the United States.
The fundamental issue is whether a stable demand for money function* can be identified for the UK economy in the 1970's.

4.1 The apparent breakdown of demand for money functions in the early 1970's

Two major studies which pointed to the instability of functions which had performed well in the pre-CCC era, were those of Hacche (59) and Artis and Lewis (11).

Hacche applied a log-linear partial adjustment model to the M1, M3, MC (company-holdings of M3) and MP (person's holdings of M3) definitions of money. The estimation period was 1963(4)-1971(3) and the forecasting performances of the equations were examined for the quarters 1971(4)-1974(1) inclusive. The results are given in Table 1.2, Chapter 1, p.43; the long rate of interest is represented by the 2½% consol yield and the short rate by the 3 month local authority deposit rate. The long-run price elasticity was constrained to equal unity and the interest rate was specified in the form log (1+r) so that the interest rate elasticity varied positively with the level of interest (see Chapter 3, Section 3.2). The models were actually estimated in 1st difference form after carrying out transformations for 1st order serial correlation. This procedure has been criticised by Courakis (30) and Hendry and Mizon (64) for its essentially arbitrary nature.

As far as the forecasting performance of these pre-CCC estimated equations was concerned, M1 was reasonably satisfactory, and MP performed well up to 1973, but increasingly under-predicted after this date. In contrast the M3 and MC forecasts

* Especially for the policy-relevant £M3 definition of money.
were particularly bad with the error patterns being similar; for M3 there was significant under-prediction in eight out of the ten quarters, and for MC it was nine out of the ten quarters.

In the light of these results Hacche investigated M3 and MC further: the estimation period was extended to cover 1963(4)-1972(4)* and an own-rate of interest on money variable was included in both cases from 1971(4) onwards to take account of the new competitive environment which banks now operated in. The rate on three month certificates of deposit was used to represent the own-rate on money variable and this entered both equations significantly. For the forecast period 1973(1)-1974(1) inclusive, the forecasts were considerably improved for both M3 and MC: both over-prediction and under-prediction errors now occurred. The long-run own-rate interest elasticity was greater than 0.5 in each case, but other parameters in the function changed significantly; in particular, the speed of adjustment was lower** than before, and the long-run income elasticity was higher.

Hacche warns that these new equations which include the CD rate may be picking-up essentially transitional influences, especially as a tax loop-hole, which made CD's attractive, was blocked by measures in the 1973 budget. However, against this we have the fact that the 'corset' was used as an important technique of monetary control during the period 1974-1979, and this has had a considerable influence on the behaviour of the own-rate on money.

* The first five quarters of the CCC era.
** Hacche does not reveal how much lower.
Hacche has focused entirely on the market disturbances stemming from Competition and Credit Control in attempting to explain the breakdown of the simple broad money equation which had performed well prior to 1972. His work might be criticised, for ignoring the fact that the UK is an open economy and, in particular, for failing to consider the serious disturbances in foreign exchange markets which led to the floating of sterling in 1972. He could also be criticised for using a model which essentially only recognizes transactions motives for money-holding; it is clearly possible that the change of policy in the gilt-edged market might have destabilised the demand for money (see Chapter 2). A third criticism relates to the restriction imposed on the long-run price elasticity; whether the price elasticity is unity, or otherwise, should be decided by the data and not simply imposed because it is a theoretical expectation. Price (112) found that the long-run price elasticity for MP was 0.90, and for MC was 0.41 over the data period 1964(1)-1970(4). In another Bank of England study, Coghlan (27) reported a long-run price elasticity of 0.75 for M1 over the data period 1964(1)-1976(4). It may be significant that both Coghlan and Price used flexible lag models.

In common with Hacche, Artis and Lewis (11) find that the simple demand for money functions which performed well prior to Competition and Credit Control become unstable after 1971; in fact they found that both M1 and M3 are under-predicted after 1971(3). They go on to explain (ibid p.153) that both functions still break-down after the additional inclusion of an own-rate on money variable, and a variable to capture the variability of bond prices. The significance of
these variables has already been discussed (Chapter 2, Section 2.1).

Whereas Hacche used the CD rate to represent the own-rate in the M3 equation, Artis and Lewis use a weighted average of the various interest rates on interest-bearing money deposits. The variability of bond prices measure is calculated as a 36-month moving average of the standard deviation of the log first differences of the yield on 2 1/2% consols.

While Hacche claimed that broad money equations were considerably improved by the inclusion of an own-rate, Artis and Lewis still found the broad money function to be essentially unstable. However, this difference in findings might depend on several factors:

(1) Despite the fact that a log-linear partial adjustment model was used by both there were some important differences in variable specification. For example, Artis and Lewis used nominal GDP for the income variable whereas Hacche used real TFE and constrained the long-run price-elasticity (measured by the TFE deflator) to unity. Using nominal GDP involves the implicit assumption that the income elasticity is the same as the price elasticity, and although variation in nominal income has been dominated by price movements in the 1970's, this seems a rather strong assumption! Also, Artis and Lewis entered the own-rate in differential form using the consol rate as the

* The weights used reflect the significance of each money component of M3. Where the actual interest rates relevant to a particular deposit are not known, the rate on some other similar deposit is used as a proxy measure.
alternative asset yield, whereas Hacche entered the interest rates separately and used the rate on 3-month local authority deposits for the alternative asset yield.

(2) Hacche estimated his relationship with the variables expressed in log first differences, whereas Artis and Lewis specified a log levels relationship.

(3) No attempt to measure speculative influences on the demand for money was made by Hacche, whereas Artis and Lewis included the variability of bond prices.

If the findings of Artis and Lewis are to be accepted then further experimentation with functional specification is in order in an attempt to identify a relationship which can make sense of the early post-CCC era.

Artis and Lewis suggest that the money stock, rather than the rate of interest, might perhaps be regarded as the predominantly exogenous variable after the introduction of Competition and Credit Control*, and such a claim does receive some support from the change in policy in the gilt-edged market.** They argue that a preferable specification would be one in which the interest rate is the dependent variable, with the money stock entered as one of the explanatory variables.

* A view which is consistent with the idea that the demand for money was adjusting to supply changes rather than the reverse case of a demand-determined money supply.

** This is explained in Chapter 2 (Section 2.1.3). The change from fixed to flexible exchange rates provides additional support (see Chapter 2, Section 2.3).
Before outlining this somewhat unconventional approach to the estimation of demand for money relationships it should be pointed out that Artis and Lewis, in common with most demand for money researchers, have ignored the possible influence of international factors such as exchange rate changes.*

The general form of the estimated equations is as follows:

\[ R = B_0 + B_1 Y + B_2 M + B_3 R_{-1} + u \quad \text{Log-linear} \]

Three definitions of money were investigated; M1, M3 and M3 less certificates of deposit. The partial adjustment model (applied to interest rates) proved as good as any and excluded variables such as bond price variability and inflation expectations had been found to be comparatively unimportant explanatory variables in the preliminary empirical work. For M1 the dependent variable was the consol rate while for both M3 and M3^A(M3-CDs) the dependent was specified as the differential between the consol rate and the own-rate on money, R^*.

I will focus on the results for M3. For a full listing of the results refer to p.172 for M1 and p.174 for M3 (ibid).

Equations for the pre-CCC era and a data period extended to cover the first six quarters of CCC, are shown overleaf.

* They have, in effect, used a closed-economy model and with the introduction of flexible exchange rates in 1972 and the foreign currency market disturbances before this date, it may be inappropriate.
The coefficients are very similar for the two data periods which indicates that the relationship identified for the pre-CCC era remains stable when six additional 'CCC observations' are added to the sample. The long-run income and interest elasticities of the demand for money derived from equation (2) are 1.21 and -0.34, respectively. It is noticeable that the coefficients are considerably better-determined in equation (2) and this is only to be expected given that the exogeneity of money claim can only have any validity after the introduction of Competition and Credit Control.

Despite the fact that the instability suggested by conventional money demand equations is not evident in these interest rate models there are several points which can be made arguing against treating the money supply as an exogenous variable.

Firstly, Mehra (89) * provides evidence from exogeneity tests to suggest that when nominal values are used, as in the study of Artis and Lewis, single equation techniques are invalid for each of the specifications, so that there is nothing to be gained by specifying the rate of interest as the

* P.227.
dependent variable as opposed to the money stock. The clear implication from this is that a simultaneous model is in order.

Another point concerns the fact that the monetary authorities have continued to control short-term interest rates after CCC, and in practice the money supply has been controlled by interest rate manipulation.

Finally, since only six observations were available to reflect post-CCC experience it would surely be more correct to treat the money stock as essentially demand-determined since prior to 1971 a policy of interest-rate control was often practised. In fact, some early empirical work conducted in my own research, for the data period 1972(1)-1978(4), suggested that the 'Artis and Lewis' interest rate specifications are not appropriate for the post-CCC 1970's. The estimated equations were poorly determined and in some cases the coefficients were not in accordance with a priori beliefs. Another piece of evidence which suggests that the money stock should be treated as endogenous is that monetary targets for M3 were not formally introduced until 1976, and even then the money supply was allowed to fluctuate within a reasonably wide growth band - e.g. 8-12% - sometimes growing at an excessive rate. Indeed, by the end of the 1970's there was considerable doubt concerning the ability of the authorities to control money supply growth at all closely!

In conclusion, despite their results, it would appear that the treatment of the money stock as a more exogenous variable than the rate of interest, even in a data period which entirely consists of post-CCC observations, is certainly
open to question. In practice it may well be necessary to specify a simultaneous model of the money market, in which the supply of money, the demand for money and the rate of interest are all endogenous variables.

The model used by both Hacche and Artis and Lewis was a partial adjustment model which constrains the adjustment paths and lag lengths to be the same regardless of whether the initial disturbance is due to changing prices, incomes or interest rates (see Chapter 3, Section 3.3.1). Price (112), Coghlan, (27) and Hamburger (60) use flexible models, but only the latter two researchers included post-CCC observations in their data samples. Hamburger's stability tests for M1 (the only definition of money he considers) reveal that the function is unstable after 1971(4): in fact only four post-CCC observations are used so that the tests are not especially revealing. However, his findings represent limited evidence to suggest that Competition and Credit Control has undermined the stability of the M1 function. While this was also the finding of Artis and Lewis (11), Hacche found that the demand for M1 was essentially stable in the early post-CCC period. It should be pointed out, however, that Hamburger uses the uncovered euro-dollar rate to represent the interest rate variable, whereas Hacche used a domestic rate of interest.

Coghlan (27) disputes the claim that a stable demand function for M1 had been identified before CCC; he points to the lack of independent variation in the data during the 1960's which caused serious multicollinearity problems and weakly-determined coefficients.* This may have concealed

the true demand for M1's relationship when the data was limited to the 1960's and early 1970's!

4.2 The evidence from more recent empirical work
Coghlan (27), Rowan and Miller (92), Laumas (82) and Smith (122) have each included data for several years of post-CCC experience, and this extra information throws more light on the stability issue. A recent study of the demand for £M3 by Grice and Bennett (18) shows that a measure of financial wealth is preferable to income in the function, and uses post-tax rather than pre-tax rates of interest.

Coghlan's study considers the behaviour of M1 over the data period 1964(1)-1975(4) and examines the equation's forecasting performance over the quarters 1976(1)-1977(3) inclusive. He assumes that the demand for M1 is dominated by transactions motives and as such only income, price and the rate of interest enter as explanatory variables. A flexible lag model is used and variables are expressed in natural logarithms. The best forecasting performance was achieved using first differences of the data and accordingly the results from this specification are shown below:

\[
\Delta M1 = 0.309 \Delta TFE + 0.408 \Delta TFE_{-1} + 0.228 \Delta TFE_{-2}
\]
\[ (2.5) \quad (3.4) \quad (2.0) \]

\[
+ 1.073 \Delta P_{-1} - 0.891 \Delta P_{-2} + 0.589 \Delta P_{-3}
\]
\[ (4.1) \quad (3.2) \quad (1.9) \]

\[
- 0.048 \Delta R - 0.012 \Delta R_{-1} - 0.070 \Delta R_{-2}
\]
\[ (2.9) \quad (0.7) \quad (4.1) \]

\[ R^2 = 0.652 \quad DW = 1.96 \]

p = Price deflator of TFE
R = Local authority 3 month rate
Long-run elasticities: $\text{TFE} = 0.945 \quad P = 0.77 \quad R = -0.13$

<table>
<thead>
<tr>
<th>Year</th>
<th>1976</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>2.5</td>
</tr>
<tr>
<td>2</td>
<td>-0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>3</td>
<td>0.8</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>-</td>
</tr>
</tbody>
</table>

The forecasting performance of this equation is quite good although only one quarter out of seven gives a negative error.

The results suggest that the lagged adjustment process is different for the various explanatory variables and is relatively rapid: approximately six months following a change in income, nine months for price changes, and a rather uncertain lag for interest rates.

When these results were compared with those from data periods ending in earlier years a picture of stability emerged with the estimated long-run elasticities being similar.

Two important qualifications need to be made with respect to the results. Firstly, the intercept has been dropped and this proved necessary to obtain good results; however, it is only a strictly valid procedure if the estimated constant term is both small and insignificant. Secondly, the interest rate results are not well-determined, and the estimated long-run interest-elasticity is sensitive to whether the function is specified in levels of the data or in $1^{st}$ difference form.

Finally, although Coghlan claims that the flexible model equations perform substantially better than the simple

* $\frac{\text{Forecast - Actual}}{\text{Actual}} \times 100$. 
distributed lag models, it must be remembered that this has only been shown to be the case for the M1 definition of money. Furthermore, since M1 is not really amenable to policy control, and is not in any case the policy-relevant monetary aggregate for the UK, the stability or otherwise of this function is not a crucial issue for monetary policy. £M3 is the policy-relevant definition, since targets have been set for its growth, and accordingly it is the stability of demand for this particular aggregate which especially needs to be investigated. Coghlan only considers the demand for M1.

Rowan and Miller use a log-linear partial adjustment model and just investigate the demand for M1. The interest rate variable employed is the three-month euro-dollar rate, which is expressed as \( \log (1+r) \) to allow the interest elasticity to vary with the level of the rate. For the income and price variables they use TFE and the TFE deflator, respectively. Both TFE and M1 are seasonally adjusted.

It is argued that the real rate of interest, as measured by the nominal rate - expected rate of inflation, should be more relevant than the nominal rate but empirical results indicate that the real rate performs badly. However, the bad performance is not perhaps too surprising in the light of White's comments (137).* He points out that since a rise in nominal rates of interest and anticipated inflation are both expected to impart negative influences to money demand it is clearly possible that the demand for money could fall while the real rate of interest remains unchanged.

* P.595.
The authors also use an expected prices series* as an alternative to actual prices. They find that expected prices generally out-perform actual prices so that their preferred demand for money equations include the former rather than the latter.

The direct influence of the expected rate of inflation was tested but it was not found to have a significant influence on the demand for M1. However, this may simply reflect the fact that inflation was relatively low and did not show a great deal of variation during much of the sample period; even with the largest sample of data running from 1963(2)-1977(2), inflation is only likely to have had any significant influence over the last third of the period. It may also be true that the series used by Rowan and Edwardes (44) does not measure expected inflation correctly; this criticism, of course, applies to any attempt made to measure expected values.

The preferred model can be expressed as follows:

\[
M_t^* = a_0 + b_1 Y_t + b_2 (1+r_t) + b_3 P_{t-1}^E
\]

\[
M_t - M_{t-1} = \lambda (M_t^* - M_{t-1}) + \phi \frac{P_{t-1}}{P_{t-1}^E}
\]

The variables have been defined above and are expressed in natural logs. * = desired and E = expected. The second term included in equation (2) measures an adjustment to errors in forecasting the value of the price level.

Regressions run over several periods between 1963(2)-

* For details of this series see Rowan and Edwardes (44).
1970(3) and 1963(2)-1977(2), suggested that a unitary long-run price-elasticity was not in order and that the adjustment to errors in forecasting prices became important from 1973 onwards.

Rowan and Miller attempt to define and isolate the CCC period empirically by running regressions which either exclude 'CCC observations' or involve the insertion of a dummy variable into the equation to capture its separate influence. Defining various CCC periods, with the widest definition being 1971(2)-1975(2) inclusive, the empirically preferred definition is 1971(4)-1973(4). This seems a very reasonable definition since the first quarter immediately follows the formal introduction of Competition and Credit Control while at the end of the 1973(4) quarter the Supplementary Special Deposit Scheme was introduced, and round-tripping ceased to be important. It should, however, be remembered that the main impact of CCC was on the corporate sector's holdings of M3 rather than on M1.

From their empirical results the authors conclude that a fairly stable and simple demand for Mi function appears to exist from 1963-1976 provided either a dummy variable is entered for CCC observations, or, alternatively, the CCC observations are omitted from the sample. They find that the income, price and interest rate elasticities are approximately 0.6, 0.7 and -0.1, respectively. Two possible reasons are suggested for the price elasticity falling significantly short of unity. Firstly, the increasing use of credit cards which

* See Chapter 2, Section 2.1.2, for an explanation of round-tripping.

** (92) p.37-42.
reduces the need to hold transactions balances, and secondly, increased business integration which means that the volume of transactions, and hence money held, falls for given levels of nominal income.

One criticism of this work concerns the income and price variables. Since expected prices are preferred to actual prices it seems to me that expected income, rather than actual income, should be included in the function. This, of course, may well change the results; for example, the expected price elasticity might be closer to unity.

This examination of the stability of M1 over the period 1963-1976 has thrown-up some interesting results, but a similar exercise for the more problematical, but policy-relevant, £M3 needs to be carried out.

Laumas (82) using a varying parameter technique* investigates the stability of both the M1 and M3 demand functions over the sample periods 1964(1)-1971(3), the pre-CCC era, and 1971(4)-1976(4), the post-CCC era. He concludes that despite a major shift in the money demand relationships stable demand functions can be identified for both M1 and M3, using either short or long interest rates.

Two criticisms of his work are firstly, he does not specify an own-rate on money interest variable for the post-CCC era, and secondly, he used a model specification which constrains the short-run price elasticity of money demand to equal unity.

Smith (122) considers the demand for five different definitions of money over the period 1924-1977. The estimated relationships proved rather unstable when different

* See Cooley and Prescott (29) for details of this technique.
sub-periods were considered, although it must be said that the use of nominal income, which constrains the price and income elasticities to be the same, may have contributed to this finding.

The equations of interest are those that cover the period 1963-1977 for which the long-run income and interest-rate elasticities are shown below:

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>.78</td>
<td>.72</td>
<td>1.70Δ</td>
<td>1.04Δ</td>
<td>+</td>
</tr>
<tr>
<td>R</td>
<td>-.21</td>
<td>-.07Δ</td>
<td>-.92</td>
<td>.06Δ</td>
<td>+</td>
</tr>
<tr>
<td>S.E.%</td>
<td>2.1</td>
<td>1.9</td>
<td>2.8</td>
<td>2.1</td>
<td>+</td>
</tr>
</tbody>
</table>

M1, M3 = Official definitions of money
M2 = M1 + '7-day time deposits'
M4 = M2 + building society, and TSB and National Savings Bank deposits
M5 = M3 + (M4-M2)
Y = GDP at current prices
R = For M1 the yield on 2½% consols. For other definitions R is the difference between the consol yield and the own-rate on money
S.E.% = Standard error of equation expressed as a percentage
Δ = Insignificant at the 5% level
+ = No sensible estimates could be obtained

Only the M1 equation is well-determined with both the income and interest rate coefficients significant at the 5% level.

* Computed as a weighted average of rates on interest-bearing money deposits.
An important qualification to the above results is that they are based on annual rather than quarterly data, which means that a very small sample of only 15 observations has been used.

A study investigating £M3, in the context of a single equation model, has been carried out by Grice and Bennett (18). Their main contribution involves the use of a financial wealth series in the demand function. Most researchers use income rather than wealth because there are no reliable wealth statistics for the UK. However, with assistance from the Central Statistical Office, the Inland Revenue and the Bank of England, engaged in the construction of national balance sheets, the authors found it possible to construct a series for financial wealth. Reid (114) and Pettigrew (110) describe the work involved in constructing these balance sheets.

Another important aspect of their work concerns the treatment of interest rates. They use post-tax rates since these are the relevant opportunity costs of holding money for persons and companies, alike. Since higher-rate tax-payers pay more tax at the margin than basic rate tax-payers, the returns they receive from identical investments will be smaller. Companies paying corporation tax will pay a considerably higher rate than individuals paying tax at the basic rate. Clearly, it is the after-tax rate of interest which measures the true cost of holding non-interest bearing money. However, the construction of post-tax interest rates is a difficult and time-consuming task; difficult because much relevant information will not be readily available.
Although the authors do consider other monetary aggregates, including M1, they focus mainly on £M3. They start with a general specification capable of embracing alternative theories of the demand for money and work towards a specific formulation via a process of elimination of redundant variables, setting coefficients equal and differencing where the results from the general specification suggested this to be appropriate. Tests were applied to see how specific the formulations should be.*

The M3 equations are estimated over the data period 1963(1)-1978(4). Those expressed in nominal terms implicitly assume that the price elasticity is identical to that on real wealth, but there is no good reason to assume this to be the case, especially as the implied long-run price elasticity is significantly lower than unity. Homogeneity of degree one in prices is imposed in subsequent estimation, but this is an assumption that should be formally tested. The authors make a vague reference** to making allowance for the possibility of the demand for money not being homogeneous in prices in either the short-run or the long-run. However, this is a hypothesis which should be carefully tested and in the general specification it should be an open-ended issue. The failure to test for homogeneity at the outset suggests that the authors' general to specific approach in estimation does not start from a general enough position. Rather than simply using nominal wealth in the initial set of equations, real wealth and prices should appear as separate arguments.

* For example, log-likelihood ratio tests.
** (18) p.35.
4.3 The influence of international variables on the demand for money

A general reference to the work of Boughton and Arango and Nadiri was made in Chapter 2 (Section 2.3). It is of interest to look at their results more closely.

Boughton (20) considers both M1 and M3 for the data periods 1963(1)-1973(4) and 1963(1)-1977(3), and what distinguishes his work from that of most other researchers is that he formally recognizes the potential influence of international variables such as the exchange rate. However, his empirical work suggests that exchange rate changes are not important in determining money demand on either the M1 or M3 definitions. Accordingly, the variable is dropped from the estimating equation, although it appears in the original model specification.

The results

1. M1

(1) 1963(1)-1973(4)

\[
M1 = 0.749 + 0.145 Y - 0.043 R_{LA} - 0.181 \hat{p} + 0.869 M1_{-1}
\]

\[p = -0.608 \quad DW = 1.83\]

(2) 1963(1)-1977(3)

\[
M1 = 0.779 + 0.116 Y - 0.045 R_{LA} - 0.105 \hat{p} + 0.912 M1_{-1}
\]

\[p = -0.682 \quad DW = 1.93\]
2. **M3**

(1) **1963(1)-1973(4)**

\[ M_3 = -1.025 + 0.112 Y - 0.067 R_L - 0.176 \dot{p} + 1.073 M_{3-1} \]

\[ \begin{array}{c} (2.6) \\ (1.2) \\ (2.4) \\ (3.2) \\ (1.5*) \end{array} \]

No serial correlation \( DW = 2.00 \)

(2) **1963(1)-1977(3)**

\[ M_3 = -1.157 + 0.197 Y - 0.100 R_L + 0.046 R_{LA} - 0.218 \dot{p} + 1.063 M_{3-1} \]

\[ \begin{array}{c} (4.2) \\ (3.0) \\ (5.8) \\ (2.5) \\ (5.9) \\ (2.1*) \end{array} \]

No serial correlation \( DW = 1.91 \)

Notes

1. A partial adjustment model was specified with the variables expressed in logarithms.

2. Money and income are expressed in real terms; GDP is used for the income measure.

3. The model specification constrains the short-run price elasticity of demand to be unity.

4. \( R_L = \) Rate on 20-year government debentures.  \( R_{LA} = \) Rate of interest on 3-month local authority deposits.

5. * \( t \)-statistic indicates number of standard errors between coefficient value and unity.

6. \( \dot{p} \) is represented by \( \log (P_t/P_{t-1}) \).

7. Full details of the elasticities for both time periods and both definitions of money can be found in Tables 2, 5, 7 and 9 (ibid p.41, 43, 45 and 49).
It can be seen from the results that the M3 partial adjustment models collapse since the coefficients on the lagged dependent variables exceed unity in both sample periods. Furthermore, while the M1 equation remains stable over the longer data period, the M3 equation does not. Boughton concludes that while the demand for M1 has been fairly stable during the 1970's, the demand for M3 has become unstable. He attributes this instability to the changes introduced by Competition and Credit Control and subsequent banking reforms, and points to a finding of stability in the demand for broad money functions in other OECD countries* to support the claim that the behaviour of exchange rates and foreign interest rates has not destabilised M3.

In another paper by Boughton (21)** he defines his criteria for stability of a function and in his empirical work makes use of the following tests: a direct comparison of parameter estimates from full sample and truncated sample results; ex-post forecasting performance of equations; and evidence on structural stability as provided by the Chow F-test.

One criticism of Boughton's work concerns the specification of the demand for money in real terms with the implied restriction of short-run homogeneity in prices. Quite clearly such an assumption should be tested by the data itself and not merely imposed from the outset. Another criticism relates to the evident failure to include an own-rate on money variable in the M3 equation for the data period 1963(1)-1973(4), as shown by Table 8 (p.48)(20).

* For example, Canada, United States and France.
** P.582.
A final comment on Boughton's work concerns the significance of inflation as an explanatory variable; in each of the equations reported above inflation was highly significant and entered with the expected negative sign.

Arango and Nadiri (3) only examined the M1 definition of money, but, in contrast to Boughton, claimed that international variables have been important determinants of money-holdings. The estimation period was 1960(1)-1975(4) and, unlike most reported work, allowance was made for possible simultaneous equation bias* as well as 1st order serial correlation in the residuals. The model was specified in log-linear form and the dynamics described by the partial adjustment hypothesis. In common with Boughton the money and income variables were deflated, and short-run homogeneity in prices is implicit in the specification of the model.

The estimated equation is shown below:

\[
M_1 = -0.018 + 0.152 Y_p - 0.028 i_D - 0.020 i_f + 0.026 \text{EX} \\
-0.452 + 0.124 \text{EX} + 0.799 M_{1-1} \\
p = 0.407 \quad R^2 = 0.911 \quad DW = 1.97
\]

++ same over three quarters.

Definition of variables

\[
Y_p = \text{Permanent income, based on real GNP} \\
i_D = \text{Call money rate} \\
i_f = \text{Average of short-term interest rates of Canada, Germany and US.}
\]

* A 2SLS estimator is used and details of the instruments employed are given on p.74 (ibid). This procedure would seem to be more in order for the M3 definition of money.
\[ \dot{P} = \text{Domestic rate of inflation based on the wholesale price index.} \]

\[ \text{EX} = \text{Premium or discount in foreign market exchange.} \]

\[ \dot{\text{EX}} = \% \text{ change in EX.} \]

**Endogenous variables** - Ml, \( i_D \), EX, \( \dot{\text{EX}} \).

EX is measured as follows:

\[ \text{EX} = \frac{\text{EX}_F}{\text{EX}_S} - 1 \times 400^* \]

\[ \text{EX}_F = \text{3-month forward exchange rate in } £ \text{ per US } \$ . \]

\[ \text{EX}_S = \text{Spot exchange rate in } £ \text{ per US } \$. \]

\[ \dot{P} = (\frac{P_t}{P_{t-1}})^4 - 1 \times 100 \]

\[ P_t = \text{Wholesale prices.} \]

This gives quarterly figures at equivalent annual rates.

Table 2 (ibid p. 78) gives full details of the short and long-run elasticities.

F-tests are used by the authors to show that this particular specification of the demand for M1 function is stable. Since both exchange rate changes and foreign interest rates enter significantly at the 10% level (the former variable is just significant at the 5% level) it would appear on the basis of these results that stability of the function depends on their inclusion, and that these variables are important determinants of M1.

* For annual conversion from quarterly information in order to be consistent with interest rate measures.
Since substitution between time deposits and foreign assets should be considerably stronger than substitution between the latter and non-interest bearing money, this result seems a bit surprising! It seems particularly surprising in the light of Boughton's empirical finding that even the demand for M3 was not significantly influenced by international variables! It is a pity that the authors did not attempt to carry out a similar exercise for M3.

A final comment on these results is that inflation expectations are seen to be a significant determinant of M1 and enter the equation with a correctly signed coefficient. This finding is in agreement with Boughton's results.

4.4 The sectoral demand for money

Price (112) and Hacche (59) investigated both the personal and company sectors' demand for money. While the former was concerned with the pre-CCC data period only, Hacche included several quarters of post-CCC experience in his sample. Hacche's results are shown below:

**Personal sector results - 1963(4)-1972(4)**

\[
MP = 4.287 + 0.326 Y_t + 0.301 P_t^* -0.475 (1+r_{t-1}) + 0.699 MP_{t-1} \\
(3.9) \\
(1.4) \\
(6.7)
\]

\[R^2 = 0.79 \quad p = -0.6\]

\[Y = \text{Real personal disposable income.}\]
\[P = \text{PDI deflator.}\]
\[r = \text{Yield on 2\% consolidated stock.}\]

* Long-run price elasticity constrained to equal unity.*
Note - all variables are in natural logarithms. For details of model specification and estimation see above, Section 4.1.

The long-run income elasticity equals 1.10 approximately, and the long-run interest elasticity equals -0.11 (evaluated at the mean).

The satisfactory forecasting performance of this equation has been commented on earlier in the chapter.

**Company sector results - 1963(4)-1972(4)**

\[
MC = -9.303 + 0.449 Y_t + 0.447 P_t^* -2.197 (1+r_t) (1.7) (2.0) (2.0) \\
+ 3.156 (1+r'_t) + 0.553 MC_{-1} (3.4) (3.8) \\
R^2 = 0.69 \quad p = -0.4
\]

\[
Y = \text{Real total final expenditure} \\
P = \text{TFE deflator} \\
r = \text{Yield on 2½% consolidated stock} \\
r' = \text{Interest rate on 3-month sterling certificates of deposit from 1971(4) onwards; zero before this date.}
\]

Note - all variables are in natural logarithms. For details of model specification and estimation see above, Section 4.1.

**Long-run Elasticities**

\[
\begin{array}{ccc}
Y & r & r' \\
1.00 & -0.345 & 0.568
\end{array}
\]

* Long-run price elasticity constrained to equal unity.
With the inclusion of an own-rate on money variable, represented by the CD rate, the forecasting performance of the equation is considerably improved compared with the specification which fails to include an own-rate variable.

An interesting feature of these results is the considerably faster speed of adjustment by companies and the much greater sensitivity of company money-holdings to changes in interest rates: the long-run interest elasticity of MC is around three times greater than that for MP. Such results are in accordance with expectation since companies hold large balances in comparison with households, and stand to sacrifice relatively large sums of money if they do not adjust their portfolios reasonably quickly following a change in interest yields and differentials. The brokerage costs involved in making portfolio changes are likely to be trivial compared with the sizes of the returns to be made.

There is some difficulty with the choice of appropriate constraint variables for both personal and company sector money-holdings. Although personal disposable income is appropriate for households, which hold the bulk of personal sector money, it is not appropriate for unincorporated businesses. For the company sector there is no readily available choice which is entirely satisfactory: suitable measures of wealth are not yet available, while income measures such as GDP and TFE are at best likely to be rather loosely related to the money-holdings of companies. While Hacche used TFE as the constraint variable in his company sector equation, Price used GDP at factor cost, and the index of industrial production as an alternative measure. In fact, despite the fact that the latter measure is not relevant for
commercial companies, it out-performs GDP in Price's empirical work. The price variable used in association with the index of industrial production is the wholesale prices series for manufactured products.

Although these two variables gave more plausible results than GDP_{FC} and its associated deflator, the coefficients were not particularly well-determined and proved sensitive to choice of data period. As can be seen from Hacche's results, reported above, the coefficient on TFE is not very well determined; the t-statistic of 1.7 indicates that it is not significantly different from zero at the 5% significance level.

So, there is empirical evidence from the work of both Hacche and Price which suggests that company money-holdings are not importantly related to GDP, TFE or the index of industrial production. This points to the inappropriateness of such variables for the role of constraint variable in the company sector demand for money equation.

Other studies which focus on aspects of the company sector's demand for money include those of Saving (119) and Hunter (67) while Wilbratte (138) deals with both sectors. White (136) and Parkin, Barrett and Gray (16) have conducted work relating to the personal sector's demand for money. Most of the empirical work is based on the US economy and considers data periods which end in the early 1970's.

Wilbratte concludes from his research that US household demand for money (various definitions) tends to be stable over

* Money is one of several financial assets considered by the authors, and an asset portfolio approach is used. For details of the theory behind this approach see Chapter 9, Section 9.1.2.
the data period 1952(1)-1971(2), whereas a stable money demand for business firms can only be found for relatively broad definitions of money.

4.5 Concluding remarks
Since data for the entire decade, 1970-1980, is now available there is a need to update much of the work reported above: only Grice and Bennett (18), Boughton (20), and Rowan and Miller (92) consider data periods including post-1976 data when estimating their equations.* The work reported by Hacche on the sectoral demand for money was largely based on pre-CCC data. It has now become possible to estimate demand for money equations which just include post-CCC observations - i.e. enough observations are available.

Most of the reported work has considered the M1 definition of money only and besides Hacche (59) and Artis and Lewis (11), who were concerned with the immediate post-CCC experience, only Laumas (82), Boughton (20) and Grice and Bennett (18) investigated M3. Each of these studies were based on single equation models, but it seems probable that simultaneous models are more appropriate. There is a clear need to specify and estimate simultaneous models, or to at least allow for the presence of endogenous regressors, when estimating broad money functions. It may emerge that the simultaneity problem is not particularly serious in a quarterly model, but in order to determine this the parameters of the demand for money function should be estimated by alternative estimators.**

* For quarterly models of money demand.
** In addition to OLS at least 2SLS should be used.
Only Coghlan (27), Hamburger (60) and Grice and Bennett (18) used flexible lag structures, whereas the other researchers mentioned have used fixed lag models; typically partial adjustment. In the absence of any firm theoretical guidance on lag structures the best procedure is probably to estimate both types of model for the different money definitions.

Only the studies of Boughton (20), Arango and Nadiri (3) and Hamburger (60) specifically allowed for the influence of international variables, such as the exchange rate and foreign interest rates, although there was disagreement concerning the significance of these variables during the 1960's and 1970's. Clearly, there is need for more work which formally recognizes that the UK is an open-economy.

Some researchers have included a measure of inflation expectations in the demand for money function, but there is no general agreement on either the role or significance of this variable. Chapter 7 of my work is completely devoted to the influence of this variable on both M1 and time deposits (TD).

Many researchers have imposed constraints on either the short-run or long-run price elasticity of money demand, but it is better to let the data determine the elasticity. The greater independent variation in the price and real income variables during the 1970's should reduce multicollinearity problems so that these variables can be separately entered. Specification problems regarding the interest rate can best be resolved empirically; whether a constant interest-rate elasticity is in order can be decided
on the basis of regression results from equations in which the interest rate variable is specified in alternative ways.

Although it is recognized that wealth is more appropriate than income as a constraint variable in the demand for broad money function, there are no really reliable wealth measures available for the UK economy. Thus income measures are almost always used in practice.* Which income measure is most relevant is largely a matter for the data to decide, so that alternative series should be tried.

The choice of interest rate variable(s) is also problematical. A variety of rates have been used in the empirical work reported above, but for M1 and £M3 different rates should be tried and the 'best' equation selected in each case; if the results are not particularly sensitive to choice of interest variable then the issue is not an important one for the data period in question. For the sectoral demand for money equations it is possible to select the most appropriate rates by examining both the personal and company sectors' liquid asset portfolios over the relevant data period: the rates on non-money assets which are both important in the overall portfolio and show variation in size of holdings, are clearly candidates for inclusion in the respective functions.

Finally, since the work of Hacche (59) points to the instability of M3 being mainly due to the behaviour of company money-holdings, it is clearly of interest to look at this sector more closely. In the penultimate chapter of my work I consider evidence on the money-holding behaviour of (1)

---

* To my knowledge the only UK study of M3 which uses a wealth measure for the constraint variable is that of Grice and Bennett (18).
all industrial and commercial companies and (2) large industrial and commercial companies, to see if the latter group's behaviour is different from that of the average company. In addition, the company sector's demand for wider aggregates, including total holdings of selected liquid assets, is investigated. This should help to explain the portfolio behaviour of companies and establish the strength of substitution between money and each of the non-money financial assets which are typically held.
5.0 Introductory remarks
Evidence from both autoregressive and flexible finite lag models is considered.

It is assumed that transactions motives dominate the money-holding behaviour of the public, so that income, prices and short-term rates of interest are considered to be the most important explanatory variables.

GDP at market prices is the preferred income variable. Equations were estimated using TFE, but in every case better results were obtained using the former variable; the equations were generally better-determined with the GDP coefficients having higher t-ratios.

Since multicollinearity problems rule out the inclusion of several interest rate variables in the empirical model, and theory offers little guidance as to which rates are most relevant, different interest rates are tried. Furthermore, although short-rates should be more relevant than long-rates, the latter have been subject to less control over the period. It is therefore possible that long-rates serve as better proxies for the relevant short-term rates than do published domestic short-rates such as the Treasury bill and local authority rates.

The main focus of attention is on the post-CCC era, defined as 1972(1)-1979(4), and the aim is to establish the properties of the M1 demand function and whether it is
structurally stable over the period. Results for the pre-
CCC era, defined as 1964(1)-1970(4), are also presented so
that the two data periods can be compared on an entirely
consistent basis. Finally, results for the entire period
1964-1979, and various sub-periods starting in 1964 and
terminating at different points in the 1970's, are presented.

The major objective is to determine whether Competition
and Credit Control merely temporarily disturbed the demand
for M1 relationship, or whether it resulted in a permanent
disturbance. In the latter case it is important to establish
whether or not the function has become unstable; a structural
shift may have occurred with the parameters remaining stable
at their new levels. Although the sample of post-CCC data
is still relatively small, there are enough observations for
estimation purposes.

5.1 Evidence from the post-CCC era
1. Fixed lag models

The following autoregressive model is to be tested in which
the dynamics are assumed to reflect partial adjustment:

\[ M_t = A_0 + b_1 Y_t + b_2 P_t + b_3 R_t + \lambda M_{t-1} + U_t \]
\[ U_t = p U_{t-1} + e_t \]

The model is estimated both in untransformed linear and log-
linear forms. Since M1 is essentially demand-determined the
single equation specification is likely to be a valid reduced
form model in which each of the explanatory variables can be
regarded as exogenous or pre-determined regressors.
In the log-linear specification several interest rates are tested: the rates on local authority bills, certificates of deposit, building society deposits, and short and long-term government securities. The results are summarised in the tables below.

**TABLE 5.1**

A Summary of Single Equation M1 Results Using Various Interest Rates - 1972(1)-1978(4)

<table>
<thead>
<tr>
<th></th>
<th>Equation</th>
<th>Coefficients</th>
<th>t-values</th>
<th>R-squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( M1 = 0.18 + 0.23 Y + 0.21 P -0.04 R_{LA} + 0.75 M1_{-1} )</td>
<td>(0.1) (1.0) (2.8) (3.0) (7.4)</td>
<td>( x^2_{10}=20.6 )</td>
<td>( x^2_{1}=4.58 )</td>
</tr>
<tr>
<td>2</td>
<td>( M1 = 0.30 + 0.21 Y + 0.20 P -0.04 R_{CD} + 0.76 M1_{-1} )</td>
<td>(0.2) (0.9) (2.7) (2.9) (7.4)</td>
<td>( x^2_{10}=21.4 )</td>
<td>( x^2_{1}=4.86 )</td>
</tr>
<tr>
<td>3</td>
<td>( M1 = 0.87 + 0.28 Y + 0.32 P -0.08 R_{BU} + 0.64 M1_{-1} )</td>
<td>(0.5) (1.1) (3.1) (2.1) (4.7)</td>
<td>( x^2_{10}=18.8 )</td>
<td>( x^2_{1}=5.11 )</td>
</tr>
<tr>
<td>4</td>
<td>( M1 = 0.17 + 0.28 Y + 0.27 P -0.07 R^S_B + 0.71 M1_{-1} )</td>
<td>(0.1) (1.2) (3.3) (3.0) (6.6)</td>
<td>( x^2_{10}=21.7 )</td>
<td>( x^2_{1}=3.82 )</td>
</tr>
<tr>
<td>5</td>
<td>( M1 = 1.22 + 0.34 Y + 0.40 P -0.10 R^L_B + 0.55 M1_{-1} )</td>
<td>(0.7) (1.4) (3.8) (2.9) (4.1)</td>
<td>( x^2_{10}=20.6 )</td>
<td>( x^2_{1}=2.73 )</td>
</tr>
</tbody>
</table>
It is noticeable from these results that the rates on short-term and long-term government securities perform best: serial correlation is less of a problem in the equations including these rates, which are marginally better determined and give better forecasts for 1979. Empirically there is little to choose between the two bond rates, although a shorter adjustment period is suggested when the long-term rate is used. A comparison of the speeds of adjustment and elasticities is shown in Table 5.3 overleaf.

TABLE 5.2
Ex-Post Forecasting Performance - Percentage Forecast Errors for 1979

<table>
<thead>
<tr>
<th>Eqn. No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$x^2_4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 $R_{LA}$</td>
<td>-0.6</td>
<td>-0.1</td>
<td>-1.4</td>
<td>-2.8</td>
<td>2.32</td>
</tr>
<tr>
<td>2 $R_{CD}$</td>
<td>-0.4</td>
<td>-0.1</td>
<td>-1.3</td>
<td>-2.7</td>
<td>2.00</td>
</tr>
<tr>
<td>3 $R_{BU}$</td>
<td>-1.7</td>
<td>-</td>
<td>-1.6</td>
<td>-3.7</td>
<td>3.80</td>
</tr>
<tr>
<td>4 $R_{SB}$</td>
<td>-0.5</td>
<td>1.9</td>
<td>0.3</td>
<td>-1.6</td>
<td>1.43</td>
</tr>
<tr>
<td>5 $R_{LB}$</td>
<td>-0.2</td>
<td>1.9</td>
<td>1.9</td>
<td>0.2</td>
<td>1.50</td>
</tr>
</tbody>
</table>
For the untransformed linear specification of the model a similar exercise was carried out and once again the government bond rates outperformed the rates of interest on short-term, capital-certain financial assets. Since the best results were obtained when the short-term bond rate was used, this rate was used for the purposes of comparing the untransformed linear and log-linear structures.

The evidence on structural form and model dynamics
There is a need to test whether the untransformed linear or log-linear specification is more appropriate, and if the naive dynamics of the partial adjustment hypothesis are acceptable.

To do this the GIVE programme was used, and for each of the specifications results for the three representations of the model (the SF, URTF and RTF) were noted. The results are as follows:
1. **Untransformed linear results: 1972(1)-1978(4)**

A. **Structural Form**

\[ M_1 = -1692 + 0.10 Y_t + 32.2 P_t - 103 R^S_t + 0.84 M_{t-1} \]

(0.5) (0.7) (2.4) (2.4) (8.4)

Random correlogram test - \( x^2_{10} = 19.3 \) \( DW = 2.19 \) \( R^2 = .995 \).

**Ex-post forecasts for 1979: percentage forecast errors**

<table>
<thead>
<tr>
<th>% errors</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( x^2_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.2</td>
<td>2.4</td>
<td>1.1</td>
<td>-0.3</td>
<td>4.82</td>
</tr>
</tbody>
</table>

Chow test \( F_{4,23} = .783 \)

B. **Unrestricted transformation function (summary)**

Random correlogram test - \( x^2_{10} = 18.2 \) \( DW = 1.88 \) \( R^2 = .996 \)

Test of significance of additional parameters - \( F_{4,19} = 1.38 \)

Post-sample parameter stability test - \( x^2_4 = 18.26 \)

Chow test - \( F_{4,19} = 1.13 \)

C. **Restricted transformation function**

\[ M_1 = -1780 + 0.10 Y_t + 30.0 P_t - 98.3 R^S_t + 0.86 M_{t-1} \]

(0.6) (0.7) (2.4) (2.5) (9.0)

\[ p = -0.20 \]

\( x^2 \) test on \( p : x^2_1 = 0.93 \)

Test of validity of autoregressive restrictions - \( x^2_3 = 6.22 \)

Random correlogram test - \( x^2_{10} = 18.6 \).
Ex-post forecasts 1979: percentage forecast errors

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$x_4^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>% errors</td>
<td>0.9</td>
<td>2.7</td>
<td>1.5</td>
<td>-0.1</td>
<td>5.71</td>
</tr>
</tbody>
</table>

Chow test - $F_{4,22} = 0.86$

2. Log-linear results: 1972(1)-1978(4)

A. Structural Form

$$M_1 = 0.17 + 0.28 Y_t + 0.27 P_t -0.07 R^S_t + 0.71 M_{1-1}$$

$$R^2 = 0.995$$

Random correlogram test - $x_1^2 = 21.7$

Ex-post forecasts 1979: percentage forecast errors

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$x_4^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>% errors</td>
<td>-0.5</td>
<td>1.9</td>
<td>0.3</td>
<td>-1.6</td>
<td>1.43</td>
</tr>
</tbody>
</table>

Chow test - $F_{4,23} = 0.326$

B. URTF (summary)

Random correlogram test - $x^2_{10} = 16.8$  $DW = 1.80$  $R^2 = 0.996$

Test of significance of additional parameters - $F_{4,19} = 2.23$

Post-sample parameter stability test - $x_4^2 = 5.72$

Chow test - $F_{4,19} = 0.80$
C. RTF

\[ M_1 = -0.09 + 0.27 Y_t + 0.24 P_t -0.07 R_s + 0.74 M_{t-1} \]

\[ p = -0.37 \quad \chi^2 \text{ test on } p: \chi^2_1 = 3.82 \]

Test of validity of autoregressive restrictions \[ \chi^2_3 = 6.94 \]

Random correlogram test \[ \chi^2_{10} = 17.2 \]

**Ex-post forecasts 1979: Percentage forecast errors**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( \chi^2_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>% errors</td>
<td>-1.20</td>
<td>2.1</td>
<td>1.1</td>
<td>-1.3</td>
<td>2.04</td>
</tr>
</tbody>
</table>

Chow test \[ F_{4,22} = 0.47 \]

Examination of these results reveals that:

1. The autoregressive restriction is in order for both specifications. Critical \( \chi^2_3 \) for the 5% significance level = 7.81, and the calculated values are both less than 7. This means that we can reject the URTF.

2. Although an adjustment for 1st order serial correlation is valid, we cannot reject the hypothesis, for either model, that \( p \) is not significantly different from zero. Both t-tests and \( \chi^2 \) tests show this to be the case. This, together with the fact that the results for the SF and RTF are very similar for both the untransformed and log-linear specifications.
implies that we can accept the SF results. This finding is further supported by the F-tests on the significance of the additional variables entering the URTF: in both cases calculated F is comfortably below the critical value (5% significance level) of 2.90.

(3) The forecasting performance of the SF is better than that of the URTF and the RTF for both model specifications.

(4) The estimated parameters have the correct signs and are of plausible magnitude. Only the income coefficients are not significantly different from zero, at the 5% level. Equilibrium adjustment is completed within a year following an initial disturbance.

(5) Despite the fact that the SF can be accepted and yields plausible parameter estimates, the hypothesis of a random correlogram cannot be accepted, at the 5% level, for either specification of the Structural Form. Since calculated \( x^2 \) remains relatively high after adjustment for 1\(^{st}\) order serial correlation it is possible that higher order serial correlation exists. Since some of the seasonal variation in the data may not have been adequately eliminated by the methods of seasonal adjustment used a simple 4\(^{th}\) order scheme, following Wallis (135), was tested: however, since \( p_4 \) was < 0.2 and not significantly

* See Chapter 3, Section 3.4.1, p. 126.
different from zero the hypothesis of simple 4th order serial correlation was rejected.

Most of the evidence points to the Structural Form being an appropriate specification and with both the untransformed and log-linear SF's passing the post-sample parameter stability test and the Chow test for structural stability (when the sample is extended to include 1979 observations) the suggestion is that the M1 demand function has been stable during the post-CCC 1970's.

It would appear from the results that the log-linear model specification is marginally preferable to the untransformed linear specification: the parameter estimates are better-determined and the ex-post forecasting performance is better. In view of this the log-linear specification of the model is accepted as the more appropriate form. This is convenient for two reasons: firstly, the problem of heteroscedasticity is minimised when log functions are specified and secondly, the parameters associated with the income, price and interest rate variables can be directly interpreted as elasticities.

So, the preferred demand for M1 model is a log-linear specification in which GDP at constant market prices represents the income variable, with the GDP deflator as the price variable and the short-bond rate representing the interest rate variable. The partial adjustment hypothesis can be accepted and OLS estimation is appropriate. For the estimation period 1972(1)-1978(4) the estimated long-run income elasticity = 0.97, the long-run price elasticity =
and the long-run interest elasticity = -0.24.

Full equilibrium adjustment following a disturbance takes approximately ten months. The parameters of the model remain stable when the data period is extended to cover 1979. Re-estimation of the model after additionally including 1979 observations yields the following results:

\[
M_{1t} = 0.64 + 0.22 Y_t + 0.26 P_t -0.07 R_t + 0.72 M_{1t-1}
\]

(0.4) (1.1) (3.8) (3.0) (8.5)

\[R^2 = .996\]

While the price and interest rate elasticities, and the speed of adjustment remain essentially unchanged, there is a small disturbance to the income coefficient and the constant term.

2. **Flexible lag models**

A polynomial distributed lag technique was used to estimate the flexible lag models.

After considerable experimentation with both polynomial degree, which was varied between 1 and 4, and lag lengths on the explanatory variables, which were varied up to 2½ years, a 'best' equation was selected. So, the best lag structures were decided empirically, unlike in the studies of Dickson and Starleaf (38) and Goldfield (55) where a polynomial of degree 3 was applied to each variable without prior experimentation. Furthermore, these researchers applied end-point restrictions to the lag weights despite the

* The long-run price elasticity is not significantly different from unity, its theoretically expected value.
disadvantages of tying the lag structure down in this way.*
No end-point restrictions have been specified in my study.

The criteria used for selecting 'best' equations are as follows:-

(a) The significance of both the polynomial coefficients and the coefficients on each of the explanatory variables.

(b) The size of the coefficient of determination adjusted for loss of degrees of freedom - i.e. size of $R^2$.

(c) The plausibility of the lag profiles on each variable.

(d) The plausibility of the long-run income, interest and price elasticities.

(e) The value of the DW statistic indicating the presence or absence of serial correlation.

(f) Forecasting performance.

As with the fixed lag models it was found that the short-term and long-term bond rates were better than short-term interest rates such as the local authority and Treasury bill rates.

Once again, GDP at market prices explained more variation in M1 than TFE.

The optimum lag path for both income and prices was one where the coefficients declined linearly; income continuing to influence M1 for up to four quarters after an initial disturbance, with price influencing M1 for up to nine months. The optimum lag length for the bond rate was 18 months and the shape of the lag path best captured by a 2nd degree polynomial.

* See Kelejian and Oates (72) p.176-178; especially p.178.
The best equations for the post-CCC era, 1972(1)-1978(4), are shown below for log-linear specifications.

(1) \( M_1 = -8.162 + 0.66 Y + 0.51 Y_{-1} + 0.37 Y_{-2} + 0.22 Y_{-3} \)
\[ +0.08 Y_{-4} + 0.82 P + 0.42 P_{-1} + 0.01 P_{-2} -0.39 P_{-3} \]
\[ -0.06 R^S_B -0.06 R^S_B -0.06 R^S_B -0.05 R^S_B -0.05 R^S_B \]
\[ -0.04 R^S_B -0.03 R^S_B \]
\[ DW = 2.30 \quad R^2 = .9961 \]

Long-run elasticities

<table>
<thead>
<tr>
<th>Y</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.83 (1.77)</td>
<td>0.86 (0.85)</td>
<td>-0.34 (-0.31)</td>
</tr>
</tbody>
</table>

Chow test for structural stability

Calc. \( F_{4,20} = 1.01 \) \quad (critical \( F_{0.95}^{0.95} = 2.87 \))

(2) \( M_1 = 1.291 + 0.54 Y + 0.36 Y_{-1} + 0.18 Y_{-2} + 0.01 Y_{-3} \)
\[ -0.18 Y_{-4} + 0.96 P + 0.47 P_{-1} -0.02 P_{-2} -0.51 P_{-3} \]
\[ -0.03 R^L_B -0.07 R^L_B -0.09 R^L_B -0.09 R^L_B -0.07 R^L_B \]
\[ -0.03 R^L_B + 0.03 R^L_B \]
\[ DW = 2.47 \quad R^2 = .9961 \]
### Long-run elasticities

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.91 (0.77)</td>
<td>0.91 (0.91)</td>
<td>-0.34 (-0.26)</td>
</tr>
</tbody>
</table>

**Chow test for structural stability**

\[ F_{4,20} = 3.35 \]

### Notes

1. Long-run elasticities = \( \sum \) coefficients on current and lagged terms.

2. Figures in brackets refer to the corresponding values for the extended data period, 1972(1)-1979(4).

3. The test for structural stability is over the four quarters of 1979.

While the estimated long-run price and interest rate elasticities are similar when using the alternative bond rates, there is a marked difference between the income elasticities. Following Baumol's transactions demand for money model*, economies of scale in money-holding would be anticipated so that the expected value for the long-run income elasticity is less than unity. This suggests that the specification including the long-term bond rate is to be preferred, since the long-run income elasticity = 0.91 as opposed to the value of 1.83 when the short-term bond rate is used.** However, Baumol's theory need not be accepted and there

* Baumol (17)

** The large value for the income elasticity is matched by a sizeable negative constant term in the short-term bond rate case. When the long-term bond rate is used the constant term is relatively small.
is no compelling reason to rule out elasticities in excess of unity.

The optimum lag lengths on the explanatory variables are the same for both equations, but although the selected polynomial degrees for each variable also match-up, the M1 adjustment paths with respect to the interest rate changes are not the same. The lag profile with respect to the short-term bond rate is relatively flat when compared with the decidedly humped path associated with the long-term bond rate. Despite this difference in shape, both of the lag paths are plausible. Eighteen months before adjustment to a change in interest rates is completed seems rather a long period of time, but can be rationalised on grounds of inertia, habit and, where small money-holdings are concerned, brokerage costs. The lag lengths associated with income and price changes are both reasonably plausible.

The t-ratios on the lag coefficients are higher for both the income and interest rate variables when the short-term bond rate is used, and are approximately the same for the price variables. This together with the fact that serial correlation is less of a nuisance when the short-term bond rate is used makes equation (1) the empirically preferred specification. Furthermore, equation (1) remains structurally stable when data from 1979 is taken into consideration; calculated F at 1.01 is decidedly lower than the critical F value of 2.87. When the long-term bond rate is used we cannot accept the hypothesis of structural stability, since

* In the case of the short-term bond rate the DW statistic of 2.30 reveals that negative serial correlation in the residuals is not as high as in the long-term bond rate case, where DW = 2.47
calculated F, = 3.35, exceeds the critical value - i.e. there is less than a 5% chance that the 1979 observations obey the same structure as that identified for the data period 1972(1)-1978(4).

So, on the basis of criteria (a), (e) and (f) defined above, the short-term bond rate is the preferred interest rate variable; a finding which is not contradicted by the fixed lag model results for M1.

**Fixed lag and flexible lag model results compared**

The best equations for the two models contain the same explanatory variables - i.e. GDP at constant market prices, the GDP deflator and the short-term bond rate. Both sets of results seem plausible and the hypothesis of structural stability can be accepted in each case.

It was decided that the partial adjustment hypothesis was the appropriate fixed lag specification, which implies acceptance of identical lag paths being associated with each of the explanatory variables. This rather naive assumption concerning the dynamics was accepted after statistical testing within the GIVE programme, although in the results it was noted that the hypothesis of random residuals could not be confidently accepted even after adjusting for 1st order serial correlation. The flexible lag model with the lag lengths and profiles determined by the data itself, offers a reasonably rigorous test of the lag structure imposed on the relationship in the partial adjustment specification. The linear lag profiles associated with the income and price variables do not seriously contradict the geometrically declining lag coefficients implied by the partial adjustment specification.
hypothesis, and the lag lengths on these variables suggested by the two models are in broad agreement. The flexible lag model suggests a flatter profile on interest rates and a longer period of around 18 months, as opposed to 10-11 months, before M1 completely adjusts to a change in the rate of interest.

A comparison of the long-run elasticities is shown below:

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>P</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed lag</td>
<td>0.97</td>
<td>0.93</td>
<td>-0.24</td>
</tr>
<tr>
<td>Flexible lag</td>
<td>1.83</td>
<td>0.86</td>
<td>-0.34</td>
</tr>
</tbody>
</table>

The most serious discrepancy is in the estimated income elasticities.* This may well be due to the lack of variation in real income over the period. The fixed lag estimate seems more plausible despite the fact that the income coefficient in this model was not significantly different from zero at even the 10% level (a finding which cannot be attributed to multicollinearity problems and probably reflects the above-mentioned lack of variation in the income data).

If the partial adjustment model can be criticised because of its strong restrictions on the lag structure, it must be remembered that its great virtue is its simplicity. Providing the estimated long-run elasticities are plausible and the model remains stable as the data period changes then it will be useful for forecasting purposes. Furthermore, some testing of the imposed lag structure is available in the GIVE programme so that it is possible to reject the dynamics

* Although it must be noted that when the long-term bond rate was specified in the flexible lag model the estimated long-run elasticity was only 0.91.
empirically without recourse to polynomial distributed lag estimation.

The flexible lag model is particularly useful for determining the underlying dynamics of the model, but it must be remembered that with just three explanatory variables there are endless permutations of polynomial degrees and lag lengths which can be tried, even if the maximum lag is taken as ten quarters and the highest polynomial degree as three!

Since demand for money theory is not good enough to tie down the lag structure very precisely there is a need for much experimentation before settling on an optimum flexible lag specification: this, of course, is a very time-consuming exercise!

Some final observations
Although the results from the fixed and flexible lag models do differ to some extent, both sets of equations yield plausible parameter estimates, which are highly significant in most cases despite the relatively small sample of data being used. The forecasting performance of the fixed lag model is good and the parameters remained stable when the data period was extended to cover 1979. Indeed, we have enough evidence from these results to suggest that the demand for M1 function has been stable in the post-CCC era.

One worrying feature is the suggestion in the fixed lag model results that higher order serial correlation could be a problem. This might be due to several factors which include (1) faulty lag structure (2) the influence of CCC in the early part of the period which can be regarded as a
transitory influence (3) erroneous or incomplete seasonal adjustment of data (4) a break in the M1 series occurring in June 1975, and (5) the possibility that an important explanatory variable, such as inflation expectations, has been excluded from the model.

(1) and (3) have already been dealt with and (5) is examined in detail in Chapter 7. Problem (2) can only be properly considered by excluding the immediate post-CCC period from the sample and without extending the sample of data backwards to include the 1960's this would leave us with too small a sample. As a result examination of this is postponed until a following section in which a relatively long data period, 1964(1)-1979(4), is considered.

The possibility that the break in the M1 series might have disturbed the results, causing serially correlated residuals, was rejected after running a regression equation in which a dummy variable was additionally included. Taking the value 0 before 1975(2) and the value 1 from this date onwards, the variable was found to explain only a negligible amount of variation in M1. Both the dummy coefficient and the associated t-ratio were extremely small and the coefficients on the other independent variables were essentially the same as before.

5.2 Evidence from the pre-CCC era

The aim here is to use both a consistent model and data series, so that the results for 1972(1)-1978(4), the post-CCC era, can be directly compared with the results for 1964(1)-1970(4), which is defined as the pre-CCC era. Since the short-term
bond rate was selected as the preferred interest rate variable for the post-CCC era, it is also used for the pre-CCC era.

Results

\[ M_1 = 1.61 + 0.26 Y + 0.31 P -0.09 R^S + 0.58 M_{1-1} \]

(0.6) (1.1) (2.0) (2.5) (3.2)

Test for random correlogram \(-x^2_{10} = 18.9\ p = 0.09\ R^2 = 0.964\)

(0.2)

Post-sample parameter stability test \(-x^2_{4} = 4.3\)

Comparing the autoregressive model results for the two periods* it can be seen that while the estimated short-run elasticities are similar the speed of adjustment to equilibrium is greater in the pre-CCC era: seven months as opposed to ten months. Except for the interest rate, the long-run elasticities are lower in the pre-CCC era with the price elasticity falling well short of unity - its value is approximately 0.75. The pre-CCC structure is more weakly determined which is not surprising in view of the lack of independent variation in the data; the correlation between income and prices = 0.97 as opposed to only 0.74 in the post-CCC era.

The results for the pre-CCC era clearly indicate that 1st order serial correlation is not a problem, although as with the post-CCC sample a \(x^2\) test reveals that the hypothesis of random residuals cannot be accepted at the 5%.

* The results for the 1972(1)-1978(4) data period were reported in Section 5.1.
significance level.

The post-sample parameter stability test shows that the parameters remain stable over the year 1971 which is not altogether surprising since Competition and Credit Control was not introduced until September 1971, and the rapid growth in the money stock did not occur until 1972.

Extending the data period to include 1971 observations gives the following results:

1964(1)-1971(4)

\[
M1 = 2.57 + 0.17 Y + 0.36 P -0.07 R_B^S + 0.57 M1_{-1}
\]

\[
(1.0) \quad (0.8) \quad (2.3) \quad (2.9) \quad (3.8)
\]

Test for random correlogram \[ x^2_{10} = 19.9 \]

\[ p = 0.10 \quad R^2 = .983 \]

Post-sample parameter stability test \[ x^2_4 = 46.0 \]

Except for the rise in the constant term and the fall in the income coefficient, this equation is similar to the previous one. However, the post-sample parameter stability test clearly indicates structural break-down when the data period is extended to cover 1972. This result strongly suggests that the monetary reforms embodied in Competition and Credit Control have upset the demand for M1 function. The question now arises as to whether the upset is merely temporary or whether the structure exhibits a permanent shift. Evidence from the post-CCC era suggests that a stable M1 demand function can be identified, and that although the structure is different from that of the pre-CCC period, the difference is not too significant. It could easily be the case that the inclusion of immediate post-CCC data in the relatively
small sample of post-CCC observations available has biased the results. However, rather than relying on evidence from even smaller samples of data the procedure which will now be adopted is to examine the entire data period, 1964(1)-1979(4) and various sub-periods within this, both including and excluding 'CCC observations'.

5.3 Evidence from the pooled sample of pre-CCC and post-CCC data: 1964(1)-1979(4).

Table 5.4 overleaf gives the results for the log-linear partial adjustment model: starting with the pre-CCC period, 1964(1)-1970(4), the sample is progressively extended by one year until the entire data period, 1964(1)-1979(4), is finally covered.

The M1 equation is seen to breakdown badly in 1972 and continues to behave strangely until the end of 1975: the coefficients on the income term are negative and the $x^2$ statistic reveals serious parameter instability over the years 1972 and 1973, and again in 1975. The breakdown of the function coincides with the immediate post-CCC period, as expected, with M1 being seriously under-predicted. The percentage under-prediction errors for 1972 are as follows:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>3.2%</td>
<td>4.5%</td>
<td>4.8%</td>
<td>6.4%</td>
</tr>
</tbody>
</table>

The errors get progressively worse over the year, this being consistent with the relaxation of controls on the banks which led to a sharp growth in the money stock.
<table>
<thead>
<tr>
<th>Estimation Period</th>
<th>Intercept</th>
<th>Y</th>
<th>P</th>
<th>R_B</th>
<th>M1-1</th>
<th>R^2</th>
<th>x^2_{10}</th>
<th>x^2_{4}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964(1)-1970(4)</td>
<td>1.61</td>
<td>0.26</td>
<td>0.31</td>
<td>-0.09</td>
<td>0.58</td>
<td>.964</td>
<td>18.9</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>(0.6)</td>
<td>(1.1)</td>
<td>(2.0)</td>
<td>(2.5)</td>
<td>(3.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1971(4)</td>
<td>2.57</td>
<td>0.17</td>
<td>0.36</td>
<td>-0.07</td>
<td>0.57</td>
<td>.983</td>
<td>19.9</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(0.8)</td>
<td>(2.3)</td>
<td>(2.9)</td>
<td>(3.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1972(4)</td>
<td>1.56</td>
<td>-0.01</td>
<td>0.22</td>
<td>-0.05</td>
<td>0.87</td>
<td>.990</td>
<td>18.6</td>
<td>15.7</td>
</tr>
<tr>
<td></td>
<td>(0.6)</td>
<td>(0.04)</td>
<td>(1.4)</td>
<td>(2.7)</td>
<td>(8.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1973(4)</td>
<td>2.04</td>
<td>-0.03</td>
<td>0.26</td>
<td>-0.05</td>
<td>0.85</td>
<td>.992</td>
<td>21.8</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>(1.0)</td>
<td>(0.2)</td>
<td>(2.3)</td>
<td>(2.6)</td>
<td>(11.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1974(4)</td>
<td>2.79</td>
<td>-0.06</td>
<td>0.32</td>
<td>-0.06</td>
<td>0.80</td>
<td>.993</td>
<td>25.0</td>
<td>22.2</td>
</tr>
<tr>
<td></td>
<td>(2.2)</td>
<td>(0.5)</td>
<td>(4.2)</td>
<td>(3.4)</td>
<td>(11.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1975(4)</td>
<td>1.06</td>
<td>0.10</td>
<td>0.24</td>
<td>-0.06</td>
<td>0.80</td>
<td>.995</td>
<td>19.5</td>
<td>11.8</td>
</tr>
<tr>
<td></td>
<td>(1.4)</td>
<td>(1.2)</td>
<td>(4.1)</td>
<td>(3.2)</td>
<td>(11.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1976(4)</td>
<td>0.56</td>
<td>0.18</td>
<td>0.23</td>
<td>-0.06</td>
<td>0.77</td>
<td>.996</td>
<td>16.6</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>(0.7)</td>
<td>(2.3)</td>
<td>(3.9)</td>
<td>(3.1)</td>
<td>(10.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1977(4)</td>
<td>0.41</td>
<td>0.19</td>
<td>0.22</td>
<td>-0.06</td>
<td>0.78</td>
<td>.997</td>
<td>15.3</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>(0.6)</td>
<td>(2.5)</td>
<td>(3.9)</td>
<td>(3.5)</td>
<td>(11.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1978(4)</td>
<td>0.35</td>
<td>0.17</td>
<td>0.21</td>
<td>-0.06</td>
<td>0.80</td>
<td>.998</td>
<td>16.6</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>(0.5)</td>
<td>(2.5)</td>
<td>(4.1)</td>
<td>(3.5)</td>
<td>(13.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1964(1)-1979(4)</td>
<td>0.42</td>
<td>0.19</td>
<td>0.22</td>
<td>-0.06</td>
<td>0.78</td>
<td>.998</td>
<td>17.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.6)</td>
<td>(3.0)</td>
<td>(4.7)</td>
<td>(3.7)</td>
<td>(15.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The M1 equation estimated over the data period 1964(1)-1974(4) badly fails the post-sample parameter stability test when observations from 1975 are introduced. However, since the estimated relationship is itself unstable, it is no bad thing that the hypothesis of stable parameters is firmly rejected! The problem in 1975 was one of over-prediction and this can probably be accounted for by the very sharp rise in inflation, peaking at around 25% in the summer, which could be expected to induce a movement out of M1. It is clear, though, that the substitution must have mainly been between short-term interest-bearing assets and M1 rather than goods and M1, since the personal savings ratio rose quite sharply in the mid-1970's.

As judged by both the estimated coefficients and the post-sample parameter stability tests which show that the parameters remain stable over the period 1976(4)-1979(4), the M1 demand function appears to settle down in the latter half of the 1970's; a result which is confirmed in Coghlan's study,* in which a flexible lag model is used. The ex-post forecasting performance of the M1 equation estimated over the data period 1964(1)-1976(4) is good: we can formally accept the hypothesis of parameter stability over the years 1977-1979 inclusive:

* See Coghlan (27).
Ex-post Forecasting Performance - Percentage Forecast Errors

<table>
<thead>
<tr>
<th></th>
<th>1977</th>
<th></th>
<th>1978</th>
<th></th>
<th>1979</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>Errors</td>
<td>1.3 2.2 -0.3 -1.1</td>
<td>0.4 1.9 -1.0 -2.6</td>
<td>0.9 2.6 1.2 -0.4</td>
<td>0.9 2.6 1.2 -0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chow test for structural stability - $F_{12,47} = 0.638$

Parameter stability test - $\chi^2_{12} = 8.16$

One interesting feature of the results is that for the larger samples - i.e. for data periods 1964(1)-1976(4) onwards - the hypothesis of random residuals can just be accepted at the 5% significance level, but for the smaller samples this hypothesis is rejected. Since the early post-CCC era saw a rapid increase in the money stock it is clearly possible that the behaviour of the data during this period has caused the serial correlation problem: during 1972 and most of 1973 the residuals were positive and this is likely to lead to a serious autocorrelation problem in relatively small samples. As the sample size increases then so the influence of CCC is diluted and serial correlation becomes less of a problem, as the results show.

The above results suggest that while CCC destabilised the demand for M1 over the period 1972-1974, inclusive, the function settled down again after 1975. It follows that we can certainly 'dilute' the temporary instability caused by CCC by considering only large samples of data - e.g. the entire data period 1964(1)-1979(4). However, it is only valid to pool the pre-CCC observations with the post-CCC observations providing the post-CCC structure, now assumed
to be essentially stable in the light of the empirical results, is not significantly different from the structural relationship identified for the pre-CCC era. Inspection of the results for the pre-CCC era, and for the entire data period, after excluding 'CCC observations', is necessary. The pre-CCC period has already been considered, so only the latter task remains.

It is clear from the table of results above that the M1 equation estimated for the entire period, 1964(1)-1979(4), is different from the pre-CCC equation: the short-run elasticities are uniformly lower for the full sample period and the speed of adjustment is slower. While the large sample parameter estimates are well-determined with high t-ratios, the relatively small sample pre-CCC parameter estimates are not so well-determined; in particular, the income coefficient is not even significantly different from zero at the 10% level! There is also the problem of distributed lag bias* which can be serious in small samples, especially in the face of non-random residuals which the $\chi^2$ test for the pre-CCC results indicates. Because of these points we can reasonably conclude that the pre-CCC structure is subject to much uncertainty; a conclusion which is reinforced by the lack of independent variation in the data in the 1960's. Following this line of argument the pooling of pre-CCC and post-CCC data becomes a more valid procedure.

Suppose we consider the demand for M1 over the data period 1964(1)-1978(4) which leaves 1979 observations for structural and parameter stability testing. By running two

* See Johnston (70) p.305 and 306.
regressions, one in which the full data sample is used, and the other in which observations from the 'CCC era' are excluded, we can determine whether CCC has had a significant influence on the demand for M1. If it has then we need to compare the full sample results, after excluding CCC observations, with the pre-CCC results. Subject to the qualifications made above a discrepancy between the two sets of results strongly implies that the structure has changed in the 1970's for reasons other than the transitory direct influence of Competition and Credit Control.

An attempt to account for this postulated structural change would then be in order: a simple shift of the function can be adequately accounted for by the insertion of a dummy variable into the equation taking the value zero in the pre-CCC era and unity in the post-CCC era. If the values of the coefficients and the speed of adjustment change then the structural shift cannot simply be captured by the inclusion of a dummy shift variable. One factor which might be responsible for a complex structural change is inflation: during the 1970's inflation has been high and variable whereas it was much lower and steadier throughout the 1960's. The possible influence of inflation on the demand for money is considered in depth in a separate chapter (Chapter 7), where it is suggested that the lagged rate of inflation has explained some of the variation in M1 during the 1970's. For present purposes an M1 equation which includes the lagged inflation rate is estimated for the period of interest, 1964(1)-1978(4).
<table>
<thead>
<tr>
<th>Month</th>
<th>1966</th>
<th>1967</th>
<th>1968</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.0</td>
<td>1.70</td>
<td>1.72</td>
<td>1.75</td>
<td>1.77</td>
</tr>
<tr>
<td>12.3</td>
<td>1.70</td>
<td>1.72</td>
<td>1.75</td>
<td>1.77</td>
</tr>
<tr>
<td>12.6</td>
<td>1.70</td>
<td>1.72</td>
<td>1.75</td>
<td>1.77</td>
</tr>
<tr>
<td>12.9</td>
<td>1.70</td>
<td>1.72</td>
<td>1.75</td>
<td>1.77</td>
</tr>
</tbody>
</table>

**Long-run Elasticities**

<table>
<thead>
<tr>
<th>Year</th>
<th>1966</th>
<th>1967</th>
<th>1968</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.63</td>
<td>0.97</td>
<td>0.99</td>
<td>0.83</td>
<td>0.74</td>
</tr>
<tr>
<td>1.85</td>
<td>2.05</td>
<td>2.25</td>
<td>2.45</td>
<td>2.65</td>
</tr>
<tr>
<td>2.05</td>
<td>2.25</td>
<td>2.45</td>
<td>2.65</td>
<td>2.85</td>
</tr>
<tr>
<td>2.25</td>
<td>2.45</td>
<td>2.65</td>
<td>2.85</td>
<td>3.05</td>
</tr>
</tbody>
</table>

**Results - 1964(1)-1978(4): All Observations**

*Table 5.5*
## Long-run Elasticities

<table>
<thead>
<tr>
<th></th>
<th>12.0</th>
<th>12.6</th>
<th>12.9</th>
<th>12.7</th>
<th>12.6</th>
<th>12.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>666</td>
<td>0</td>
<td>0.06</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>666</td>
<td>0.06</td>
<td>0.09</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>666</td>
<td>0.09</td>
<td>0.09</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0.08</td>
</tr>
<tr>
<td>866</td>
<td>0.09</td>
<td>0.09</td>
<td>0.03</td>
<td>0.08</td>
<td>0.03</td>
<td>0.08</td>
</tr>
</tbody>
</table>

### Results - 1964(1)-1978(4)

**TABLE 5.6**

Excluding CCC observations.
TABLE 5.7
Ex-post Forecasts - 1979: Percentage Forecast Errors

<table>
<thead>
<tr>
<th>(1) All Observations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>x_4^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. R_B</td>
<td>1.1</td>
<td>2.7</td>
<td>1.2</td>
<td>-0.3</td>
<td>2.9</td>
</tr>
<tr>
<td>2. R_B D1</td>
<td>-0.2</td>
<td>1.5</td>
<td>0.3</td>
<td>-1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>3. R_B \hat{P}_{-1}</td>
<td>-</td>
<td>1.8</td>
<td>0.4</td>
<td>-1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>4. R_B D1 \hat{P}_{-1}</td>
<td>0.1</td>
<td>1.6</td>
<td>0.8</td>
<td>-1.9</td>
<td>2.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(2) Excluding CCC Observations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>x_4^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. R_B</td>
<td>1.0</td>
<td>2.5</td>
<td>1.2</td>
<td>-0.2</td>
<td>3.0</td>
</tr>
<tr>
<td>2. R_B D1</td>
<td>-0.2</td>
<td>1.8</td>
<td>0.2</td>
<td>-1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>3. R_B \hat{P}_{-1}</td>
<td>0.2</td>
<td>2.0</td>
<td>0.5</td>
<td>-1.1</td>
<td>1.9</td>
</tr>
<tr>
<td>4. R_B D1 \hat{P}_{-1}</td>
<td>-0.3</td>
<td>1.6</td>
<td>0.3</td>
<td>-3.2</td>
<td>4.8</td>
</tr>
</tbody>
</table>
TABLE 5.8
Correlation Matrix for Explanatory Variables:
1964(1)-1978(4): All Observations

<table>
<thead>
<tr>
<th></th>
<th>All Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Y</strong></td>
<td>1.0</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>0.91 1.0</td>
</tr>
<tr>
<td><strong>R_B</strong></td>
<td>0.82 0.78 1.0</td>
</tr>
<tr>
<td><strong>P_{-1}</strong></td>
<td>0.80 0.80 0.72 1.0</td>
</tr>
<tr>
<td><strong>M1_{-1}</strong></td>
<td>0.92 0.99 0.78 0.77 1.0</td>
</tr>
</tbody>
</table>
The results reported in Tables 5.5-5.7, above, show that equations including all observations yield similar results to those which exclude 'CCC observations' for each of the corresponding specifications.

The $\chi^2_{10}$ statistic reveals that the hypothesis of random residuals can be strongly accepted for those equations which exclude CCC observations, but has to be rejected when all sample observations are included. This confirms that the serial correlation problem is specifically due to the inclusion of observations from the immediate post-CCC era when the relaxation of controls on bank lending caused the money stock to increase sharply.

The results in Table 5.6, for data samples excluding CCC observations, can now be carefully considered.

Equation 2 indicates that the post-CCC dummy shift variable, $D_1$, enters significantly at the 5% level with the expected positive sign.

The inclusion of inflation, alone, as an additional variable in equation 3 did not change the results: the estimated parameters were very similar to those of equation 1 and inflation entered with a negligible and insignificant coefficient.

In equation 4 both the post-CCC dummy shift variable and inflation were additionally included. Their inclusion changed the parameter estimates: although the long-run elasticities, except for income which is not well-determined, are similar, the speed of adjustment to equilibrium is now

* The CCC era was defined as 1971(4)-1973(4) inclusive, and these observations were excluded from the data sample. See Chapter 4, Section 4.2, p.154.
considerably faster at 7-8 months as opposed to over a year in equation 1. For M1 this quicker adjustment seems more reasonable. It can be seen from the table that for each of the equations the estimated long-run price elasticity is always close to unity which is in accordance with theoretical expectation.

Both inflation and the dummy variable entered equation 4 significantly at the 10% level; the latter was also significant at the 5% level. The respective coefficients each had the expected signs. If we compare equation 4 with equation 1, which excludes these variables, we see that the interest-rate coefficient is much better-determined in the former specification; it has a t-ratio of 3.7 as opposed to 2.6.

Despite the fact that the ex-post forecasts, as shown in Table 5.7 above, are marginally worse for each corresponding equation when CCC observations are excluded from the sample, the hypothesis of post-sample parameter stability can be confidently accepted in every case. The preferred equation, 4., does not forecast 1979 as well as the other three, although the run of quarters is not really long enough for us to read too much into this. The main reason for the weaker forecasting performance is the relatively large percentage forecast error of -3.2% which occurs in the fourth quarter of 1979.*

* This coincides with the abolition of all remaining UK exchange controls in October 1979. However, since as a general rule UK exchange controls applied only to resident outflows, their abolition ought to have imparted an over-prediction bias! Clearly, then, other factors must be responsible for the under-prediction of M1 in the fourth quarter of 1979.
If we now compare the pre-CCC M1 results for 1964(1)-1970(4) (see Section 5.2 above) with equation 4 in Table 5.6 (excluding CCC observations) we see that except for the income coefficient, which is poorly determined, the equations give similar results. The short-run price and interest rate elasticities are similar and so is the speed of adjustment. The t-ratio associated with the price variable is surprisingly high, at 3.7, in equation 4 in view of the fact that the correlation matrix for the full sample period shows that the simple correlation between price and the lagged money stock is 0.99. However, this high figure is still lower than the coefficient of determination, \( R^2 \), which stands at 0.999, and according to Klein (75)* multicollinearity is only a severe problem if the simple correlation coefficient is greater than the multiple correlation coefficient, \( R \).

It would appear, then, that a shift in the M1 function occurs following the introduction of Competition and Credit Control, and that rapidly rising and variable inflation rates influence the structure in the post-CCC era; the inflation being largely a consequence of the rapid growth in the money stock following the CCC reforms.

In conclusion, Competition and Credit Control appears to have temporarily de-stabilised the M1 demand function. The function shifts and inflation becomes an influential variable in the post-CCC era.

The significance of inflation is also suggested by the M1 results listed in Table 5.4.** The estimated function

* P.64 and 101.
** Results for the basic specification - i.e. M1 f(Y P R_B M1_t-1).
settles down after 1976, with the 1964(1)-1976(4) equation forecasting 1977, 1978 and 1979 reasonably well. These were years immediately following the Labour government's anti-inflation package which included incomes policy, the introduction of monetary targets and public expenditure cuts.

5.4 M1 and simultaneity

At the theoretical level it seems reasonable to assume that M1 is essentially demand-determined. Firstly, since the public are free to switch their money between interest-bearing and non-interest bearing bank accounts as they choose it will obviously be difficult for the monetary authorities to independently influence the supply of M1. In practice they are able to influence the public's willingness to hold M1, via manipulation of short-term interest rates, but the extent and predictability of the influence will depend on the nature and stability of the M1 demand function. Secondly, it is the broad monetary aggregate, £M3, which the authorities have attempted to control during the post-CCC era and whereas they have announced target rates of growth for this aggregate since 1976, there have been no declared targets for M1 growth. Manipulation of the reserve assets base (for example by a call for, or release of, special deposits) should have a definite influence on movements in £M3, since the reserve assets ratio* was defined in terms of the banks' total eligible liabilities,

* The reserve assets ratio has now been abolished. The 121½% ratio was in force from September 1971 to January 1981 when it was replaced by a 10% ratio. It was finally abolished in August 1981.
but may not have any systematic influence on M1.*

Since domestic short-term interest rates have been manipulated by the authorities during the post-CCC 1970's it would not seem unreasonable to regard the rate of interest as an exogenous variable in the M1 demand function.* There may well, however, be significant feedback relationships between M1 and income, and/or, M1 and prices. To test whether there is any important contemporaneous feedback from either of these sources a three equation log-linear model was specified and estimated. The endogenous variables are M1, Y and P and the instruments are real investment, I75, the rate of interest, RB, autonomous spending at current prices, A, and the unemployment rate, U. Each of the equations in the system are over-identified. They were estimated using alternative simultaneous equation estimators (2SLS, 3SLS and FIML) for the purpose of establishing the significance of the feedback and to see whether the estimated parameters of the M1 demand equation are similar to the single equation OLS estimates. Since the FIML results were the only ones which yielded a reasonable price equation, just these are presented here. The model was estimated over the data period 1972(1)-1978(4).

* A five equation simultaneous model in which Nd, Ms, Yt, Pt, and RBt were the endogenous variables was estimated by 2SLS, allowing for 1st order serial correlation in the residuals, and it was found that only the lagged dependent variables were significant in the money supply and interest rate equations thus confirming theoretical expectation.
Results - 1972(1)-1978(4)

1. \[ M_1 = -4.93 + 0.82 Y + 0.25 P -0.10 R_B + 0.67 M_{1-1} \]
   
   \[ \text{(2.5)} \quad \text{(4.3)} \quad \text{(4.8)} \quad \text{(8.2)} \]

2. \[ Y = 6.21 + 0.14 M_1 + 0.03 I_{75} -0.05 U + 0.24 Y_{-1} \]
   
   \[ \text{(3.9)} \quad \text{(0.3)} \quad \text{(2.4)} \quad \text{(1.6)} \]

3. \[ P = -0.99 -0.08 M_1 + 0.18 A + 0.84 P_{-1} \]
   
   \[ \text{(1.2)} \quad \text{(2.5)} \quad \text{(5.8)} \]

**Correlation matrix of residuals**

\[
\begin{array}{ccc}
M_1 & Y & P \\
M_1 & 1.0 & & \\
Y & -0.17 & 1.0 & \\
P & 0.34 & -0.57 & 1.0
\end{array}
\]

**Test of model stability - 1979**

\[
\chi^2
\begin{array}{cccc}
1 & 2 & 3 & 4 \\
1.35 & 9.82 & 13.1 & 2.16
\end{array}
\]

Forecast errors for quarters 2 and 3 are significant.

Overall test \[ \chi^2_{12} = 26.4 \]

Since calculated \[ \chi^2 \] > critical table value reject hypothesis of model stability.

Several important points need to be made concerning these results:
1. Estimates of the short and long-run price and interest elasticities are similar to the single equation estimates.

2. Although a much higher income elasticity is suggested in the above results we have both theoretical and empirical reasons for rejecting this finding: firstly, an estimated long-run income elasticity of around 2.5 is not all that plausible, and secondly, there is evidence from the correlation matrix of residuals to suggest that across equation autocorrelation between real income and prices cannot be ignored. Furthermore, the $x^2$ test shows the model to be unstable; this finding stands in complete contrast to the single equation model results which indicated that the hypothesis of parameter stability over 1979 could be confidently accepted.

3. Even if we accept the results they show that changes in the demand for M1 do not have any significant influence on prices in the current period; the t-statistic of 1.2 on the M1 coefficient shows that current period feedback between M1 and prices is insignificant. In contrast, a change in M1 does have a significant feedback influence on real income as equation 2 shows.

4. Following the popular mark-up theory of pricing, it could be argued that equation 3 is wrongly specified and that the most important explanatory variable ought to be an index of wages and salaries, W.
Replacing $A$ with $W$ in the price equation and additionally including the unemployment rate, $U$, gives the following set of results.*

1. $M_1 = -0.82 + 0.38 Y + 0.26 P -0.07 R_B + 0.70 M_{1-1}$
   \[ (0.4) \quad (1.3) \quad (3.2) \quad (3.1) \quad (6.1) \]

   $P_1 = -0.36$
   \[ (1.6) \]

   Test for random correlogram - $x_{10}^2 = 17.7$

2. $P = -2.88 - 0.04 M_1 + 0.59 W + 0.05 U + 0.36 P_{-1}$
   \[ (2.9) \quad (0.6) \quad (5.4) \quad (2.0) \quad (2.4) \]

   $P_2 = 0.43$
   \[ (2.2) \]

   Test for random correlogram - $x_{10}^2 = 7.4$

3. $Y = 7.05 + 0.20 M_1 + 0.25 I_75 -0.08 U -0.08 Y_{-1}$
   \[ (1.9) \quad (2.0) \quad (1.4) \quad (1.5) \quad (0.2) \]

   $P_3 = 0.41$
   \[ (1.2) \]

   Test for random correlogram - $x_{10}^2 = 12.8$

Although there are still problems with this structure - e.g. the coefficient on unemployment in the price equation has the wrong sign and the income equation is weakly determined - the wage variable proves highly significant in the price equation and feedback between $M_1$ and prices is both negligible and highly insignificant.

The parameters of the $M_1$ equation are very similar to the single equation OLS estimates; in fact the short-run and

* Estimated by 2SLS after adjusting for 1st order serial correlation.
long-run elasticities estimated for price and interest rates are almost identical. Since the only significant source of feedback is running from M1 to real income it is not surprising that the estimated income elasticities differ: the simultaneous model suggests a long-run income elasticity of approximately 1.25 over the period 1972(1)-1978(4) whereas the corresponding OLS estimate is unity.

It appears from the above results that there is some simultaneous feedback between M1 and Y, but that since the variation in real income over the data period is not particularly significant this does not invalidate the OLS results. However, since it has proved difficult to specify satisfactory equations for both price and real income, we cannot be too confident about these results; in particular, we cannot be sure that the separate influences of M1 on price and on real income have been correctly picked-up.* Because of this, plus the fact that the single equation OLS estimates suggested that the price and income elasticities were the same, a 2 equation model with M1 and nominal income, Y, as the endogenous variables will now be investigated.

Results for the 2 equation model

The following log-linear model was specified:

(1) \( M1 = a_0 + b_1 Y + b_2 R_B + \lambda_{M1-1} + U_t \)

(2) \( Y = a_1 + c_1 M1 + c_2 A + \theta Y_{-1} + V_t \)

* Of course we cannot even be sure that we have picked-up the separate influences of real income and price on M1 correctly.
Since both of the equations are identified, consistent estimates of the structural parameters can be obtained. The model is estimated over the data period 1972(1)-1978(4) using three alternative estimators: 2SLS, 3SLS and FIML. The results for the reduced form equations are also shown. Finally, a parameter stability test, over the quarters of 1979, is conducted in the case of the FIML estimator.

1. **2SLS Results**

\[
\begin{align*}
\text{(1)} & \quad M_1 &= 0.29 + 0.26 Y -0.07 R_B + 0.72 M_{1-1} \\
& & (3.4) & (3.4) & (7.8) \\
\text{(2)} & \quad Y &= 0.19 + 0.35 M_1 + 0.38 A + 0.28 Y_{-1} \\
& & (2.2) & (4.5) & (1.3) \\
\end{align*}
\]

**Correlation matrix of residuals**

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>0.27</td>
<td>1.0</td>
</tr>
</tbody>
</table>

No significant across equation correlation of residuals.

**Restricted reduced form**

\[
\begin{align*}
R_B & \quad A & \quad M_{1-1} & \quad Y_{-1} \\
M_1 &= 0.37 -0.08 + 0.11 + 0.79 + 0.08 \\
& & (1.9) & (3.4) & (2.7) & (10.0) & (1.8) \\
Y &= 0.32 -0.03 + 0.42 + 0.28 + 0.31 \\
& & (1.9) & (2.2) & (5.4) & (3.0) & (2.1)
\end{align*}
\]
2. **3SLS Results**

(1) \[ M_1 = 0.32 + 0.28 Y -0.08 R_B + 0.70 M_{1-1} \]
\[
\begin{array}{c@{.}c@{.}c@{.}c@{.}c}
(3.8) & (4.0) & (7.8) \\
\end{array}
\]

(2) \[ Y = 0.21 + 0.26 M_1 + 0.32 A + 0.42 Y_{-1} \]
\[
\begin{array}{c@{.}c@{.}c@{.}c@{.}c}
(1.7) & (4.0) & (2.1) \\
\end{array}
\]

**Correlation matrix of residuals**

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>0.19</td>
<td>1.0</td>
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</table>

No significant across equation correlation of residuals

**Restricted reduced form**

<table>
<thead>
<tr>
<th>R_B</th>
<th>A</th>
<th>M_{1-1}</th>
<th>Y_{-1}</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>0.41</td>
<td>-0.09</td>
<td>+ 0.09</td>
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<tr>
<td></td>
<td>(2.1)</td>
<td>(3.8)</td>
<td>(2.7)</td>
</tr>
<tr>
<td>Y</td>
<td>0.32</td>
<td>-0.02</td>
<td>+ 0.34</td>
</tr>
<tr>
<td></td>
<td>(1.9)</td>
<td>(1.8)</td>
<td>(4.4)</td>
</tr>
</tbody>
</table>

3. **FIML Results**

(1) \[ M_1 = 0.33 + 0.28 Y -0.08 R_B + 0.69 M_{1-1} \]
\[
\begin{array}{c@{.}c@{.}c@{.}c}
(3.7) & (3.9) & (7.4) \\
\end{array}
\]

(2) \[ Y = 0.20 + 0.28 M_1 + 0.33 A + 0.40 Y_{-1} \]
\[
\begin{array}{c@{.}c@{.}c}
(2.5) & (5.2) & (2.7) \\
\end{array}
\]

No significant across equation correlation of residuals

**Restricted reduced form**

The results are almost identical to those for 3SLS.
Test of model stability

(1) Each quarter of 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_2^2$</td>
<td>1.51</td>
<td>2.00</td>
<td>0.45</td>
<td>1.19</td>
</tr>
</tbody>
</table>

None of the individual forecast errors are significant.

(2) Overall test

$x_8^2 = 5.15$.

Accept hypothesis of parameter stability for 1979.

Since across equation autocorrelation is lower than 0.3 for all three estimates it is not a serious problem and can therefore be ignored. Furthermore, since the single equation results for M1 did not exhibit any significant 1st order serial correlation over the period 1972(1)-1978(4) it seems reasonable to ignore this problem as well. It follows from this that the alternative simultaneous estimators, 2SLS, 3SLS and FIML, will be consistent.

Despite the fact that the estimators reveal a significant feedback relationship between M1 and Y, comparison of the structural parameters of the M1 equation when alternative estimators are used reveals that the OLS estimates are very similar.

* The estimated M1 coefficient is in the region of 0.3 and is statistically significant at the 5% level for 2SLS and FIML, while it just becomes significant at the 10% level for 3SLS.
TABLE 5.9
The Sensitivity of Demand for Money
Parameters to Choice of Estimator

<table>
<thead>
<tr>
<th>Method</th>
<th>( b_1(Y) )</th>
<th>( b_2(R_B) )</th>
<th>( \lambda(M1-1) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS</td>
<td>0.28</td>
<td>-0.07</td>
<td>0.71</td>
</tr>
<tr>
<td>2SLS</td>
<td>0.26</td>
<td>-0.07</td>
<td>0.72</td>
</tr>
<tr>
<td>3SLS</td>
<td>0.28</td>
<td>-0.08</td>
<td>0.70</td>
</tr>
<tr>
<td>FIML</td>
<td>0.28</td>
<td>-0.08</td>
<td>0.69</td>
</tr>
</tbody>
</table>

This similarity between the alternative estimates which casual inspection of Table 5.9 above, reveals, strongly suggests that a single equation model is an appropriate reduced form specification of the demand for M1.

5.5 Concluding comments on the M1 results
The log-linear model specification was empirically preferred to the untransformed linear specification. This is convenient since the former yields estimates of the relevant elasticities directly.

For both the fixed and flexible lag models the best explanatory variables representing income, price and the rate of interest, were GDP at 1975 market prices, the GDP deflator and the short-term government bond rate, respectively.

While the dynamics of the partial adjustment model were not too seriously contradicted by evidence from the flexible lag model results, there were differences in the lag lengths associated with the explanatory variables: for example, three
quarters for Y and six quarters for $R_B$. There was also a discrepancy between the M1 lag paths associated with the bond rate. However, while the flexible model can provide useful detail on the underlying lag structure, the partial adjustment model is a conveniently simple specification which can be useful for forecasting purposes and has been commonly applied in empirical studies.

Evidence from fixed lag models suggests that the M1 structure changes after CCC, although the pre-CCC structure is not well enough determined for us to be sure of this. Inflation appears to have had some influence on the demand for M1 in the 1970's and empirical evidence from the pooled sample of pre-CCC and post-CCC data suggests that there is a shift in the function after the introduction of Competition and Credit Control.

The serial correlation problem suggested in the full sample results disappears when the immediate post-CCC observations are excluded from the overall data sample. It therefore seems reasonable to assume that the CCC reforms, which temporarily disturbed the behaviour of M1, had caused the serial correlation problem.

The post-CCC equation, 1972(1)-1978(4), is well-determined and the estimated parameters certainly seem plausible: the long-run income, price and interest elasticities are 0.97, 0.93 and -0.24, respectively and equilibrium adjustment following a disturbance is completed within a year. The possible role and significance of inflation in the M1 function is to be investigated in Chapter 7.
The empirical evidence on simultaneity seems to support theoretical expectations. The only feedback channel of any significance at all is between income and M1, and despite this single equation OLS estimates of the parameters virtually coincide with those yielded by the simultaneous estimators. One possible channel of simultaneous feedback which is not examined is that between inflation expectations and M1.
6.0 Introductory remarks

From a policy point of view £M3 is the most important definition of money, and although M1 accounts for approximately half of this aggregate, the manipulation of the growth of £M3 by the monetary authorities has typically involved the banks' interest-bearing eligible liabilities during the 1970's. Since the government has attempted to control the growth of £M3 in the post-CCC era, this monetary aggregate cannot really be regarded as demand-determined. Both supply and demand factors will determine the level of £M3 and as such simultaneous estimation of the demand function parameters will be in order.

In this chapter both single and simultaneous equation models are investigated for £M3. For time deposits, only single equation models are considered. The main justification for looking at single equation models is that within the context of a quarterly model simultaneity may be weak, so that a simple single equation specification becomes adequate.

In addition to this, since monetary policy focused on interest rate controls before Competition and Credit Control, it was possible to regard £M3 as essentially demand-determined in the pre-CCC era. It is certainly of interest to see if simple single equation models which performed well before the 1970's can make any sense of the post-CCC experience. We now have enough post-CCC observations to test whether a simple stable money demand function can be identified and whether
there has been a structural shift following the CCC reforms.

However, simultaneity is not the only issue. Before CCC the monetary authorities exercised close control over interest rates, so that rates on government securities were not allowed to vary in accordance with market forces. As a result speculation in the bond market was unlikely to have had a destabilising influence on the demand for £M3, and a single rate of interest could adequately represent the opportunity cost of holding money in terms of other financial assets. Furthermore, it was only after the introduction of CCC that an own-rate on money variable became truly relevant since the clearing banks were unable to bid competitively for funds, except on a limited scale through their own merchant bank subsidiaries, before the banking reforms of 1971.

International variables such as the exchange rate and foreign interest rates become potentially more significant explanatory variables with the change from fixed to flexible exchange rates in 1972. However, the existence of exchange controls until the Autumn of 1979 may well mean that exchange rate changes have only had a weak influence over the relevant post-CCC sample period.

The results are presented in two sections. Section 6.1 deals with the single equation models and the main concern here is to establish whether a simple model can adequately explain both £M3 and time deposits (TD) or whether additional variables taking account of both domestic and international speculation need to be introduced. If speculation is important then does it destabilise these demand for money functions? In Section 6.2 the importance of simultaneity for the £M3 definition of money is
investigated, under the assumption that a relatively simple demand for money function is appropriate. Simple LM and IS/LM models are considered.

6.1 Single equation model results

The most general model to be tested included variables to capture both transactions and speculative demands for money. To capture the latter both the expected return on bonds and the expected exchange rate were included in the TD and ZM3 functions. Since both government bond rates and exchange rates have exhibited upward and downward trend movements during the post-CCC era, the adaptive-expectations model was rejected, and expectations were assumed to follow an extrapolative/regressive scheme in each case. The only other additional variable, compared with the M1 model, is the own-rate on money which following Hacche (59) is assumed to be adequately represented by the CD rate.

The model is as follows:

\[ M_t^* = a_0 + b_1 Y_t + b_2 P_t + b_3 R_{CD} + b_4 R_S + b_5 R_B^E + b_6 E_{oux}^E \]

Where,

1. \[ M_t - M_{t-1} = \lambda(M_t^* - M_{t-1}) + u_t \] Partial adjustment

2. \[ R_B^E = R_B + h(\Delta R_B) \] Extrapolative/regressive expectations

3. \[ E_{oux}^E = E_{oux} + g(\Delta EX) \] Extrapolative/regressive expectations

This gives a final estimating equation as follows (overleaf):
\[ M_t = \lambda^a_0 + \lambda^b_1 Y_t + \lambda^b_2 P_t + \lambda^b_3 R^C_{D_t} + \lambda^b_4 R^S_{t} + \lambda^b_5 R^B_{t} + \lambda^b_5 h(\Delta R^B)_{t} + \lambda^b_6 EX + \lambda^b_6 g(\Delta EX) + (1-\lambda) M_{t-1} + u_t \]

Variations on the basic model were considered and the simplest model entertained merely included the own-rate on money as an additional variable. In the context of the above model \( R^E_B \) and \( EX^E \) were dropped so that (2) and (3) disappear. Such a simple model which excludes speculative influences reflects the monetarist belief that the demand for money is essentially a stable function of just a few explanatory variables. Following this view the main source of substitution is likely to be between bank time deposits and other capital-certain liquid assets. It is argued that substitution between risky and capital-certain assets is likely to involve many different liquid assets and not just money. So, it is a speculative demand for liquid assets as opposed to a speculative demand for money which really needs to be investigated.*

As with \( M1 \), alternative interest rates were used to represent \( R^S \), but only within the context of a simple specification which excluded both bond rate and exchange rate expectations. For both \( \& M3 \) and TD the rate selected was the one which yielded the best empirical results.

6.1.1 Results for the post-CCC era

Since log-linear demand functions generally yielded better-determined relationships than the untransformed linear

* Such an investigation is carried out for the company sector; See Chapter 9.
functions, only the results for the former are presented here.

The first issue investigated concerns the choice of an appropriate opportunity cost variable for both the TD and £M3 money definitions. As with M1 the local authority rate, the building society deposit rate, the short-term government bond rate and the long-term bond rate were all tried. In each case the CD rate was used to represent the own-rate on money, although Artis and Lewis (11) argued that a weighted average of rates on money would be more appropriate.

In common with the findings for M1 the bond rates outperformed the short-term interest rates for both TD and £M3. In each case the short-term bond rate was marginally preferred and the results using this particular rate are shown in Table 6.1 overleaf.

Two equations for each definition of money are shown: one in which the own-rate on money and the alternative asset rate coefficients are freely estimated and the other in which the coefficients are constrained to be of equal magnitude and opposite sign. So, equations 2 and 4 specify \( R_B - R_{CD} \) as the relevant interest rate variable, which should be read as \( \log R_B - \log R_{CD} \) or \( \frac{R_B}{R_{CD}} \). Quite clearly the expected sign of the coefficient on this variable is negative since when the differential between the bond rate and the CD rate grows in favour of the former, then so the opportunity cost of holding interest-bearing money increases and substitution from money to other liquid assets is likely to occur.
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</tbody>
</table>
The results for time deposits indicate that the interest rate restriction holds quite precisely. In equation 1 where the interest rate coefficients have been freely estimated the magnitudes of the coefficients are the same to two decimal places, and they each have the expected signs. In equation 2 the restriction is applied and the equation yields identical coefficient estimates to equation 1. As can be seen from the t-ratios on the coefficients equation 2 is marginally better-determined and this is due to the additional degree of freedom now available for estimation. Not surprisingly, the forecasting performances of the two equations over the year 1979 are virtually identical. This result suggests that substitution between M1 and time deposits is weak and that if relative interest rates - i.e. $\frac{R_B}{R_{CD}}$ - remain unchanged then only changes in income and prices will influence the level of time deposits. Weak substitution between M1 and time deposits can only be rationalised by suggesting that movements out of M1 and into other financial assets typically takes place on a broad front with many interest-bearing assets being involved. If this was the case then substitution between M1 and a particular interest-bearing asset, such as interest-bearing bank deposits, would tend to be weak.

For £M3 the interest rate restriction does not hold. In equation 3 the short-run interest elasticity with respect to the bond rate is $-0.11$ while the own-rate elasticity is only $+0.06$, and both these coefficients are well-determined with t-ratios comfortably in excess of 2. This difference can be rationalised in the following way. When both rates move up by equal proportions, although the level of interest-
bearing bank deposits will not be seriously disturbed (see argument above for TD) there will be a movement out of M1 into interest-bearing liquid assets generally. Since most of this represents a move out of money the demand for £M3 can be expected to fall as the equation suggests. Now if both rates move down with relative rates unchanged once again the level of time deposits should not change significantly, but there will now be a general move back into M1 from a variety of interest-bearing liquid assets, since the opportunity cost of holding non-interest bearing money has fallen. This move back into M1 will swell £M3 as equation 3 suggests.

If we accept that the short-term bond rate does indeed represent the alternative asset rate(s) satisfactorily, then the question of coefficient equalities centres around (1) Just how important relative interest rates are in portfolio decisions and (2) whether the variable used to represent the own-rate on money is a satisfactory choice. As far as point (2) is concerned the CD rate is not entirely appropriate for the £M3 money definition, and this is because well over 80% of M1, which itself represents approximately ¼ of £M3, is non-interest bearing. However, simply taking a weighted average of the rates on money, assuming a zero return on current account balances, as did Artis and Lewis (11) and Grice and Bennett (18), is not particularly satisfactory either. While the CD rate certainly overstates the own-rate on money for £M3, the rates used by these researchers neglect the implicit convenience return on current account deposits, and thus tend to understate the own-rate.
Despite the fact that the restriction on the interest rates did not hold for £M3, it was still applied in equation 4.

The estimated equations for time deposits are certainly reasonable with each of the coefficients being of plausible magnitude, except for the price elasticity, and having the expected signs. The income and interest rate coefficients are particularly well-determined with t-ratios well in excess of 3. The p coefficient shows that 1st order serial correlation is highly insignificant so that the RTF can be rejected. Furthermore, the $x^2$ test for random residuals is easily passed with the calculated $x^2$ values being less than 10; this gives an indication that higher order serial correlation is not a problem. Since the URTF could be rejected because the additional lagged variables did not add significantly towards the explanation of variation in TD, this suggests that the SF postulated is an adequate specification.

The long-run elasticities for TD are given in Table 6.2 together with the speed of adjustment to equilibrium. Certainly, with the exception of price, the estimated long-run elasticities are plausible although the income elasticity at 3.6 does seem rather high. The speed of adjustment at 18 months seems reasonable enough.

The post-sample performance is good insofar as the parameter stability test is easily passed, but although the individual forecast errors are very small, the equations over-predict in each quarter.

1st order serial correlation is again a trivial problem for £M3 although despite evidence from the random correlogram test which suggests that higher order serial correlation is
not a problem, a lagrange-multiplier test (not shown in Table 6.1) suggests that it is! Furthermore, an F-test for the URTF showed that additional lagged explanatory variables, especially the interest rates, made a significant contribution to the explanation of variation in £M3. This evidence was reinforced by a $x^2$ test for the validity of the autoregressive restriction, which strongly suggested that such a restriction was invalid and that the RTF must be rejected in favour of the URTF.

However, despite these important qualifications to the structural form results shown in Table 6.1, they do seem reasonably plausible, especially equation 4 which placed an 'empirically invalid' restriction on the interest rate coefficients. Indeed, equation 4 yielded a significant price coefficient, whereas equation 3 suggested that price was an insignificant explanatory variable.

A speed of adjustment of approximately 17 months is suggested by equation 4 whereas equation 3 suggests a less plausible speed of over three years. Table 6.2 shows the equilibrium speeds of adjustment and the long-run elasticities for £M3, for both equations. An income elasticity of just over 2 is plausible enough for £M3, although a price elasticity of 0.5 still seems rather low. Equation 3 where the interest rate coefficients are freely determined, suggests that the long-run income elasticity is as high as 4, which seems an unlikely result.
TABLE 6.2
Long-run Elasticities and the Equilibrium Speeds of Adjustment

<table>
<thead>
<tr>
<th>Eqn. No.</th>
<th>Y</th>
<th>P</th>
<th>$R_B$</th>
<th>$R_{CD}$</th>
<th>Adjustment Speed</th>
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</thead>
<tbody>
<tr>
<td>1. TD</td>
<td>3.6</td>
<td>0.12</td>
<td>-0.71</td>
<td>0.71</td>
<td>18 months</td>
</tr>
<tr>
<td>2. TD</td>
<td>3.6</td>
<td>0.12</td>
<td>-0.71*</td>
<td>0.71*</td>
<td>18 months</td>
</tr>
<tr>
<td>3. M3</td>
<td>4.0</td>
<td>0.38</td>
<td>-1.37</td>
<td>0.75</td>
<td>3 years, 1 month</td>
</tr>
<tr>
<td>4. M3</td>
<td>2.2</td>
<td>0.50</td>
<td>-0.22*</td>
<td>0.22*</td>
<td>17 months</td>
</tr>
</tbody>
</table>

* = Restricted coefficients

The post-sample performances of the £M3 equations are reasonably good. Table 6.1 shows that both equations comfortably pass the post-sample parameter stability test and that both over-prediction and under-prediction errors occur. Equation 4, in which the interest rate coefficient restriction is applied, gives slightly better forecasts: for the first three quarters of 1979 the percentage errors are smaller and in the last quarter the percentage forecast error is marginally worse. Re-estimating equation 4 for the entire post-CCC period, 1972(1)-1979(4) gives the following results:

\[
£M3 = -1.98 + 0.39Y + 0.09P -0.039(R_B - R_{CD}) + 0.82£M3_{-1}
\]

\[
(2.0) \quad (3.7) \quad (3.0) \quad (2.7) \quad (21.9)
\]

\[R^2 = .998 \quad \chi^2_{10} = 6.79\]

The estimated parameters virtually coincide with those for the 1972(1)-1978(4) data period.
Despite satisfactory results from this simple model there are weaknesses. Firstly, price was not a significant explanatory variable in the TD equations, and the estimated long-run price elasticity of £M3 was, at 0.5, considerably lower than the theoretically expected value of unity. Secondly, although the structural form specified for TD passed all the specification tests built into the GIVE programme, the estimated equation over-predicted the level of time deposits in each quarter of 1979. Thirdly, the structural form postulated for £M3 was empirically rejected by both χ² and F-tests: in particular, evidence from the URTF suggested that lagged interest rates should be included amongst the explanatory variables.

These weaknesses may well be due to the omission of potentially important explanatory variables such as the expected returns on capital risky assets - e.g. government bonds - and exchange rate expectations. Accordingly, such variables were added to the basic model to give the general specification outlined at the beginning of this section. Equations 2 and 3 both impose an extrapolative/regressive hypothesis on expectations, which has already been rationalised, and the expected signs on the coefficients h and g are - and +, respectively, which meet the extrapolative case.

The empirical procedure adopted was to estimate this general model and then to drop any redundant explanatory variables from the structure, amongst the interest rate and exchange rate expressions, before re-estimating the model. Further variations on the theme were then tried in accordance with evidence from the specification tests built into the GIVE programme: in particular, evidence of significant lagged
explanatory variables entering the URTF was checked for.

The results based on the general model, together with the best simple model results, are shown in Tables 6.3 and 6.4, for time deposits, and Tables 6.5 and 6.6 for £M3.

The TD results in Table 6.3 suggest that while domestic speculation in the bond market is of some importance for interest-bearing money, exchange rate changes are not. Equations 1 and 2 assume extrapolative expectations for both the domestic bond rate and the exchange rate, and while the hypothesis receives some support in the case of the former, it receives no support in the case of the exchange rate. The exchange rate level has only a negligible and highly insignificant influence, and although the coefficient on ΔEX is considerably larger it is not significantly different from zero at even the 10% level.

Both a comparison of equations 2 and 4 and inspection of the correlation matrix (see Table 6.7) reveal that the weak performance of the exchange rate cannot be attributed to multicollinearity problems. The highest simple correlation coefficients involving the exchange rate variables are (1) only 0.33 for ΔEX and (2) 0.96 for EX; although this latter correlation coefficient is high it is still lower than the multiple correlation coefficient, so that according to Klein (75)* multicollinearity is not a severe problem. A comparison of the two equations shows that the estimated income and interest rate elasticities remain similar when the exchange rate variables are dropped, and this reinforces the view that

* See page 64 and page 101.
<table>
<thead>
<tr>
<th>Model</th>
<th>Breakdown</th>
<th>Individual</th>
<th>Total</th>
</tr>
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<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>

**Notes:**
- The breakdown is further divided into individual components.
- The total is the sum of all individual components.

**Table 6.3**

**TD Results 1972(1)-1978(4)**
<table>
<thead>
<tr>
<th>Quarters</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>1.4</th>
<th>1.5</th>
<th>1.6</th>
<th>1.7</th>
<th>1.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.50</td>
<td>9.4</td>
<td>9.3</td>
<td>9.2</td>
<td>9.1</td>
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<td>12.1</td>
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<td>11.9</td>
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<td>9.0</td>
<td>8.9</td>
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<td>8.8</td>
<td>8.7</td>
<td>8.6</td>
</tr>
<tr>
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<td>6.8</td>
<td>6.7</td>
<td>6.6</td>
<td>6.5</td>
<td>6.4</td>
<td>6.3</td>
<td>6.2</td>
<td>6.1</td>
</tr>
<tr>
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<td>7.3</td>
<td>7.2</td>
<td>7.1</td>
<td>7.0</td>
<td>6.9</td>
<td>6.8</td>
<td>6.7</td>
<td>6.6</td>
</tr>
<tr>
<td>8.0</td>
<td>8.1</td>
<td>8.2</td>
<td>8.3</td>
<td>8.4</td>
<td>8.5</td>
<td>8.6</td>
<td>8.7</td>
<td>8.8</td>
</tr>
</tbody>
</table>

**EX-Post Forecasts - 1979:** Percentage Forecast Errors - %

TABLE 6.4
poor results are not due to multicollinearity.

Equations 3 and 4 both exclude exchange rate variables, so that only the expected return on government bonds is additionally included. The negative coefficient on the bond rate level and the positive coefficient on $\Delta R_B^L$ supports the extrapolative expectations hypothesis: however, the relatively low t-ratio on the $\Delta R_B^L$ coefficient means that we cannot be confident about this. Furthermore, each of the equations which included both $R_B^L$ and $\Delta R_B^L$ indicated a higher order serial correlation problem.* A comparison between equations 4 and 7 reveals that the interest rate elasticities are not seriously disturbed when $\Delta R_B^L$ is dropped, although the estimated short-run income elasticity increases from 0.28 to 0.41, and becomes considerably more significant. Another interesting feature associated with the dropping of $\Delta R_B^L$ is that the equilibrium speed of adjustment increases from the highly implausible figure of five years to three years (which still seems unreasonably slow). Associated with this faster adjustment is a noticeable easing of the higher order serial correlation problem: some indication of this is given by the sharp fall in calculated $x_8^2$ from 11.4 in equation 4 to 7.5 in equation 7, which excludes $\Delta R_B^L$.

One curious result, no-matter how the equation is specified, concerns the price coefficient which is always close to zero and highly insignificant. This may well indicate the inappropriateness of GDP and GDP prices as explanatory variables in the demand for interest-bearing money function.

* 1st order serial correlation was not an important problem in any of the estimated equations shown in Table 6.3.
However, the absence of any comprehensive information on wealth has necessitated the use of an income variable.*

It can be seen from equations 1, 3, 5 and 6 that inflation is not an important determinant of TD demand; a result which is confirmed for the simple model in Chapter 7.

Equation 8 gives the simple model results, which have been considered in detail earlier in the section. It is noticeable that although the price coefficient is still highly insignificant it does at least enter with the correct sign and has the highest t-ratio out of the eight equations. Furthermore, this equation has the best-determined income coefficient and a highly significant, correctly signed interest rate coefficient. It also yields the most plausible speed of adjustment of approximately 18 months; this is significantly faster than the speeds suggested by the other equations.

Table 6.4 indicates that equation 8 is able to track TD holdings in 1979 considerably better than any of the other equations, although it must be noted that equation 2, which includes both the expected return on bonds and exchange rate expectations, still comfortably passes the parameter stability test. What is most striking from this table is that each of the estimated equations over-predict TD in every quarter of 1979.**

* Although not shown in the table, the results from 'permanent income models' were considered and found to be poor. Adopting a flexible lag approach to income and prices did not improve matters.

** The re-imposition of the corset in the summer of 1978 might well be responsible for these over-prediction errors, especially as the control was in force throughout the year 1979.
So, despite the fact that Keynesian demand for money theory suggests that there should be a significant speculative component in the demand for interest-bearing money, my empirical work does not support this view. Perhaps the relevant expectations formation process is too complex to capture or perhaps Leijonhufvud's claim that Keynes should have been interpreted as meaning the speculative demand for all capital-certain short-term financial assets as opposed to just 'money', is really in order.*

So, it appears that a simple transactions model, which includes an own-rate on money variable as the one additional explanatory variable compared with the M1 case, performs best for time deposits.

The results for £M3 are shown in Table 6.5. Equation 1 is the reduced form equation obtained from the model outlined at the beginning of the section, in which an extrapolative/regressive hypothesis was entertained for both the expected return on bonds and exchange rate expectations. Each of the relevant estimated coefficients have the correct a priori signs for the extrapolative expectations case, although it is clear that ΔEX makes only a negligible contribution towards the explanation of variation in the demand for £M3; the coefficient of 0.01 is very small and only has a t-ratio of 0.1. The correlation matrix, shown in Table 6.7, makes it clear that multicollinearity is not responsible for the small and poorly-determined coefficient on ΔEX. The exchange rate level is also a weak explanatory variable having a t-ratio less than unity.

* Leijonhufvud (84).
<table>
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<tr>
<th>Year</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>7.3</td>
<td>8.2</td>
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<td>7.1</td>
<td>3.2</td>
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<td>7.0</td>
<td>7.0</td>
<td>7.0</td>
<td>3.0</td>
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</tbody>
</table>

*Note: Q represents the quarter,*

**TABLE 6.5**

**FM3 Results - 1972(1-1978(4)**
<table>
<thead>
<tr>
<th>Quarters</th>
<th>19.4</th>
<th>2.4</th>
<th>3.6</th>
<th>2.7</th>
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<td>-</td>
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</tr>
</tbody>
</table>

Ex post forecasts - 1974%
Percentage forecast errors - 3.3%

TABLE 6.6
Equation 2 indicates that when the exchange rate variables are dropped the coefficients on the other explanatory variables are still very similar to the estimated values in equation 1. The current period bond rate enters significantly, at the 5% level, and while the coefficient on $\Delta R_B^L$ is not significant at the 10% level it does have a t-ratio comfortably greater than unity and is of significant size. Certainly, we cannot reject the extrapolative-expectations hypothesis regarding the expected return on bonds.

A comparison of equations 2 and 4 shows that when $\Delta R_B^L$ is dropped from the model, the short-run income elasticity rises sharply from 0.13 to 0.20, and the negative intercept increases from -0.61 to -1.09. For the other explanatory variables the coefficients remain much the same size, but now have higher t-ratios indicating that they are better-determined.

Equations 1—4, inclusive, each have large coefficients on the lagged money term: the smallest value is 0.93 which following the partial adjustment hypothesis suggests a lag of more than 3½ years before the demand for £M3 fully adjusts to a change in any of the arguments. This seems unreasonably long!

However, as with equation 10 which represents the simple transactions demand model,* the structural forms specified are rejected by the GIVE programme: the URTF consistently indicated that both lagged income and lagged rates of interest were significant explanatory variables.

* Results for this model have been fully discussed above.
Attempts to include lagged income in combination with current income indicated that the former variable had significantly more explanatory power. Because of this, and in order to avoid multicollinearity problems when both current and lagged income are included, equations 5-9, inclusive, included just the lagged income variable.

As far as lagged interest rates are concerned, the lagged CD rate and the lagged bond rate were additionally entered, both singly and in combination. The coefficients on these rates were both freely-determined and constrained to be of equal size and opposite sign. Out of the ten equations only equations 7 and 9 pass the specification tests in the GIVE programme: for these equations none of the additional lagged variables entering the URTF are significant and the RTF results indicated that the hypothesis of significant 1st order serial correlation in the residuals could be confidently rejected. So, the structural forms suggested by equations 7 and 9 are acceptable; a finding which is reinforced by the evidence of random residuals in both cases as indicated by the calculated $x^2$ statistics (see Table 6.5).

A closer inspection of equations 7 and 9 indicates that although most of the coefficients are well-determined, the estimated price elasticities are weakly determined and are implausibly small: equation 9 has the larger estimated long-run price elasticity which is only 0.23! Full equilibrium adjustment following a disturbance takes almost three years according to equation 7 and approximately two years according to equation 9. While the latter estimate seems more plausible, a more reasonable estimate still is provided
by equation 10, which is derived from the simple transactions demand model. Equation 10 is the only one which suggests that price is a significant explanatory variable and although the long-run price elasticity of 0.5 seems on the low side it is higher than the estimates suggested by the other equations with the single exception of equation 1. However, since the short-run price elasticity was rather poorly-determined in this particular equation, and the speed of adjustment implausibly long, this particular estimate must be discounted.

Table 6.6 clearly shows that equation 10 forecasts 1979 much better than the other nine equations and easily passes the post-sample parameter stability test. It can be seen from the table that several specifications over-predict for each quarter of 1979 and fail the parameter stability test. Equations 7 and 9, the preferred specifications on purely statistical grounds, yielded both under-prediction and over-prediction errors, in common with equation 10. However, equation 7 just fails the parameter stability test, while equation 9 only just passes.

It appears, then, that none of the estimated single equation models for £M3 are entirely convincing, and that if speculative demand influences are important then only a rather complicated functional form will be able to capture them successfully. Indeed, it is a possibility that both domestic and international speculation together with the CCC reforms have had a seriously destabilising influence on the demand for £M3. While this may be the case it must be emphasized that it has been possible to estimate a sensible, well-determined demand relationship for £M3 in the context of a simple transactions demand model. Despite some theoretical problems with
the interest rate specification and the failure of the model to pass certain specification tests, it has, nevertheless, explained variation in the demand for £M3 reasonably well in the post-CCC era. In particular, it provided easily the best ex-post forecasts for 1979 out of the various single equation models tested.

Table 6.8 shows the post-CCC sample results for the best M1, TD and £M3 demand models. Despite the difficulty concerning the interest rate specification in the £M3 equation, which has already been discussed, these equations give reasonably consistent information. The estimated short-run income and price elasticities for £M3 lie in-between the corresponding estimates for M1 and TD, which must be the case given that both M1 and TD respond positively to changes in the same income and price variables. Furthermore, the estimated long-run price elasticity of £M3, which equals 0.5, is perfectly consistent with the information from the M1 and TD equations. Since the long-run price elasticity of M1 was close to unity, and the corresponding elasticity for TD very close to zero, it follows that the price elasticity for £M3 must lie in-between these values. In fact, it will be a weighted average of the elasticities for M1 and TD, and since these components of £M3 have approximately equal weight this suggests that the long-run price elasticity of £M3 should indeed be in the region of 0.50.

Despite this consistent information on income and prices, many researchers have felt that the theoretical case for homogeneity in prices is strong enough to impose a unitary price elasticity for £M3 from the outset. In Appendix
A results are presented for both time deposits and £M3 models, in which homogeneity in prices is assumed. Since no sensible results emerge this suggests that the price elasticity is significantly different from unity for both TD and £M3, and as such should be freely estimated.

### TABLE 6.8

Best Results for M1, TD and £M3: 1972(1)-1978(4)

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>P</th>
<th>R_B</th>
<th>R_B-R_CD</th>
<th>M_-1</th>
<th>R²</th>
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<td>0.27</td>
<td>-0.07</td>
<td>0.71</td>
<td>.995</td>
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<tr>
<td></td>
<td>(0.1)</td>
<td>(1.2)</td>
<td>(3.3)</td>
<td>(3.0)</td>
<td></td>
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<tr>
<td>TD</td>
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<td>.993</td>
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<td>.997</td>
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</table>

### 6.1.2 Results for the pre-CCC era

Strictly speaking, £M3 is not the relevant measure of broad money before 1976. For the pre-CCC era, defined as 1964(1)-1970(4), M3, which additionally includes UK residents' holdings of foreign currency, should be used. However, for reasons of data consistency only the £M3 definition is considered here.

The main purpose in considering this period is to see if the TD and £M3 demand structures are significantly different from those estimated for the post-CCC era. Since a simple transactions demand model was empirically preferred to more
complex specifications in the post-CCC era, and since it performed well in the pre-CCC era, the most likely cause of disturbance is the new competitiveness of interest-bearing bank deposits after the relaxation of controls on bank lending and the abandonment of the clearing banks' interest-rate cartel. This, of course, should be adequately captured by the inclusion of a suitable own-rate on money variable. Round-tripping is a complication which cannot be easily handled empirically, although this ceased to be important after the introduction of the 'corset' in December 1973.

In view of the low and rather sticky rates on interest-bearing bank deposits in the pre-CCC era it was not really necessary to include an own-rate on money variable in either the TD or £M3 equations.

Table 6.9 shows the results for time deposits and £M3 with the short-term bond rate and the rate on local authority temporary debt used as alternative measures of the rate of interest.

For time deposits the only significant explanatory variable is lagged TD, so that no relationship can even be identified. The freely estimated price elasticity has the wrong a priori sign and is close to zero. Although not shown in the table, equations in which the price elasticity was restricted to take its theoretically expected value did not give very good results either. So, for this particular monetary aggregate a simple relationship cannot be established for the pre-CCC era.

* Most researchers found that the demand for M3 was a stable function of just a few variables in the 1960's. The Keynesian belief that speculation destabilised the function did not receive empirical support for the UK economy.
"Constrained to equal utility."

Long-run price elasticity

\[ \frac{p}{\Delta M_3} = \frac{\Delta P}{\Delta M_3} \]

<table>
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<tr>
<th>Year</th>
<th>( \Delta P )</th>
<th>( \Delta M_3 )</th>
<th>( \frac{p}{\Delta M_3} )</th>
</tr>
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<tr>
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</tr>
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</table>

Results for Time Deposits and \( \Delta M_3 \): 1964(1)-1970(4)

TABLE 6.9
For £M3 the results are also inconclusive when the price-elasticity is freely-determined. However, equations 5 and 6, in Table 6.9, show that when long-run homogeneity in prices is assumed, a better-determined relationship emerges, in which the income elasticity is significant. Comparing equations 3 and 4 with 5 and 6 shows that the estimated interest-elasticities and speeds of adjustment are insensitive to the treatment of the price elasticity. Essentially, it is the lack of independent variation in real income and prices during the 1960's which is responsible for the weakly-determined coefficients associated with these variables, in the unrestricted cases. Taking either equation 3 or 4, we cannot reject the hypothesis that the long-run price elasticity of £M3 is zero; on the other hand, we cannot reject the hypothesis that it is unity (at 5% significance level)! Quite simply, multicollinearity makes it difficult to say anything conclusive about the long-run price elasticity of £M3.

In view of the lack of independent variation in the data during the 1960's we cannot be very confident about either the TD or £M3 demand structures. For TD we cannot even determine a relationship at all! The £M3 equations are considerably better and comparison with the simple models estimated for the post-CCC periods shows that the short-run price and interest rate elasticities are very similar, although the speed of adjustment to equilibrium is faster in the post-CCC period. The estimated short-run income elasticity is considerably higher, 0.40 compared with 0.25, in the post-CCC era. Despite these differences we have no firm empirical evidence suggesting that the pre-CCC structure is significantly
different from the post-CCC structure for either time deposits or £M3 providing an own-rate on money variable is included. As such, there can be no strong objection to pooling data from the two periods which will give a relatively large sample.

6.1.3 Evidence from the pooled sample of pre-CCC and post-CCC data: 1964(1)-1979(4)

Tables 6.10 and 6.11 give the results for a variety of transactions demand models of £M3 and time deposits. In the light of the results for £M3 and TD in the post-CCC era, where the expected return on bonds and exchange rate expectations were insignificant explanatory variables, only these simple models have been considered.

For the £M3 results, shown in Table 6.10, the best equation is number 4, with explanatory variables Y, P and R*. Inspection of the table shows that the estimated parameters in equations 5, 6 and 7 are very similar to those in equation 4, and that the additional explanatory variables, D1 and P_{-1}, entered singly and in combination, are insignificant. P_{-1}, the lagged inflation rate, proxies for inflation expectations* and D1 is a dummy variable which takes the value 0 in the pre-CCC era and 1 from 1972(1) onwards. The dummy variable is included in order to pick up any simple structural shift of the function which may have been caused by the introduction of Competition and Credit Control.

Equations 1 to 4 in Table 6.10 only differ with respect to the interest rate specification. In equations

* See Chapter 7.
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(1964-1978)
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**TABLE 6.11**

TD Results, 1964(1)–1978(4)
1 and 2, the local authority rate and the short-term bond rate, respectively, are specified, and an own-rate on money variable is not included. As a result of this mis-specification each equation suggests an explosive model with a significant negative price coefficient! Quite clearly, equations 1 and 2 should be rejected. Equation 3 specifies a log differential rate between the short-term bond and local authority rates, so that an own-rate on money variable, proxied by the rate on local authority temporary debt, is entered for the entire data period. This result should clearly be rejected since the price and interest rate coefficients are highly insignificant and the implied speed of adjustment is implausibly slow! In equation 4, $R^*$ is the chosen interest rate variable: for the pre-CCC data period, defined as 1964(1)-1971(3) for present purposes, $R^* = \log$ of the short-term bond rate, and for the post-CCC period, 1971(4)-1978(4), $R^* = \text{the differential between the logs of the short-term bond-rate and the CD rate}$ - i.e. $\log \frac{R_B}{R_{CD}}$. This specification suggests that an own-rate on money variable only becomes important in the £M3 demand function after the introduction of CCC. Furthermore, the parameter estimates are certainly plausible and highly significant. Table 6.14 shows the estimated long-run elasticities and speed of adjustment; it is noticeable that the estimated price elasticity of 0.45 is very close to the estimate of 0.5 for the post-CCC data period.

For time deposits a similar procedure was followed and from the results listed in Table 6.11 it can be seen that equation 4 is the preferred specification. As with £M3 the preferred interest rate specification is $R^*$ which
emphasizes the importance of the own-rate on money in the post-CCC period. However, as for the post-CCC sample period, the suggestion is that GDP prices are not a significant determinant of the level of TD holdings; in fact price enters with a small negative coefficient of -0.03 although it is not significantly different from zero. Table 6.14 shows the estimated long-run elasticities and speed of adjustment for the preferred TD specification.

Table 6.12 indicates the forecasting performance of each of the estimated £M3 and TD equations and shows that the preferred specifications comfortably pass the post-sample parameter stability test. Calculated $X^2$ for the best £M3 specification (equation 4) is 1.9, while the corresponding statistic is 5.9 for the preferred TD specification (equation 11). However, while both under and over-prediction errors occur in 1979 for £M3, the TD equation under-predicts in each quarter of that year.*

Since the immediate post-CCC data period, 1971(4)-1973(4), saw rapid growth of the money supply, prompted by the 1971 banking reforms and aggravated by 'round-tripping', it is possible that the inclusion of these observations in the overall sample may have distorted the estimated demand for money function. To see if this was the case some alternative £M3 specifications were re-estimated after excluding these 'CCC observations'. The results are shown in Table 6.13 and a quick comparison with the original results in Table 6.10 shows that the estimated equations are remarkably similar! So, in the context of a large sample of data

* This under-prediction is evident for each of the TD specifications in Table 6.12.
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Percentage Forecast Errors, 1979; £M3 and TD

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TABLE 6.13

£M3 Results, 1964(1)-1978(4) Excluding 'CCC Observations'

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<th>P</th>
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<tr>
<td></td>
<td></td>
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<td>2</td>
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TABLE 6.14
Long-run Income, Price and Interest Rate Elasticities - 1964(1)-1978(4)

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<th>Adjustment Speed</th>
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<td>2.0</td>
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<td>2. £M3~Y P R*</td>
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<td>0.47</td>
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<td>15-16 months</td>
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<tr>
<td>3. TD ~ Y P R*</td>
<td>4.4</td>
<td>-0.21</td>
<td>-0.29</td>
<td>21-22 months</td>
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</table>

Notes


(2) All elasticities, except for the price elasticity in the TD equation, have been derived from short-run coefficients which are significant at the 5% level.
the behaviour of the variables in the immediate post-CCC data period, 1971(4)-1973(4), does not appear to upset the £M3 demand relationship.

Furthermore, comparing the results for the full sample period, 1964(1)-1978(4), with those for the post-CCC period, for the preferred £M3 specification (see Tables 6.5 and 6.10) it can be seen that the estimated equations are very similar. This perhaps is not too surprising in view of the poorly-determined results for the pre-CCC period* which were due to lack of independent variation in the data during the 1960's. For time deposits there is also a similarity between the two sample periods, although it is not so striking as the £M3 case.

Since there are multicollinearity problems involving the price variable (see Table 6.15 which shows that there is a simple correlation coefficient of 0.98 between P and £M3_1) the best £M3 and TD equations were re-estimated after restricting the long-run price elasticity to take the value unity. The results are given in Appendix A which shows, without exception, that the equations are more weakly determined, since the t-ratios associated with the estimated coefficients are smaller, and that the equilibrium speed of adjustment is far too slow! In some cases the hypothesis of random residuals is decisively rejected. These results strongly suggest that homogeneity with respect to GDP prices is out of order for both TD and £M3.

In Table 6.16, below, results covering the entire data period are presented for the best £M3 specification. Two

* See Section 6.1.2 above.
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**Correlation Matrix for Explanatory Variables 1964(1)-1978(4)**

**Table 6.15**
TABLE 6.16

Further Results for £M3

1. Full sample period results - 1964(1)-1979(4)
   (1) All observations
   
   £M3 = -1.89 + 0.38Y + 0.09P -0.027R* + 0.82£M3
   
   \[
   (4.6) (6.7) (3.6) (6.9) (25.4) -1
   \]
   
   \[R^2 = .999 \quad x^2_{10} = 6.10\]

   (2) Excluding CCC observations (1971(4)-1973(4))
   
   £M3 = -1.89 + 0.39Y + 0.09P -0.028R* + 0.81£M3
   
   \[
   (3.1) (3.6) (2.9) (3.4) (14.2) -1
   \]
   
   \[R^2 = .999 \quad x^2_{10} = 19.21\]

2. Results for data period 1964(1)-1976(4)
   (all observations)
   
   £M3 = -2.00 + 0.36Y + 0.06P -0.03R* + 0.84£M3
   
   \[
   (4.7) (6.3) (1.9) (6.8) (24.4) -1
   \]
   
   \[R^2 = .999 \quad x^2_{10} = 6.1\]

Percentage Forecast Errors - 1977, 1978 and 1979

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</table>

Chow test \(F_{12,47} = .961\)
sets of results are shown: firstly using all observations and secondly, excluding 'CCC observations'. The equations are very similar to one another and to the corresponding estimates for the 1964(1)-1978(4) data period. This latter finding is entirely consistent with the evidence of parameter stability over the year 1979; Table 6.12 shows that calculated $x^2_4$ for the 1964(1)-1978(4) estimated $\$M3$ equation is well below the critical value of 9.49 (5% significance level) indicating that we can strongly accept the hypothesis that the $\$M3$ demand parameters remain stable over 1979.

Testing for parameter stability over just the four quarters of 1979 is not the most stringent test of model adequacy. To test both the stability and the forecasting performance of the preferred $\$M3$ model more severely, an equation was estimated over the data period 1964(1)-1976(4) leaving three years beyond the sample period in which the performance of the model could be assessed. It is clear from the results shown in Table 6.16 that the estimated parameters are similar to those for the 1964(1)-1979(4) equation.

The short-run price elasticity is lower and less significant for the shorter data period and the speed of adjustment is marginally slower at just over 18 months. The $x^2$ test for serially uncorrelated residuals indicates that we can confidently accept the hypothesis of random residuals.

The post-sample parameter stability test is marginally failed at the 5% significance level with calculated $x^2_{12} = 21.82$ just larger than the critical value of 21.03. The Chow test, however, suggests that the hypothesis of no structural
change over these years can be accepted.

Since the preferred M1 specification, derived from a transactions demand model, comfortably passed the parameter stability test over these three same years, 1977-1979 inclusive, the clear suggestion is that the behaviour of interest-bearing money is causing the problem. Considering the individual forecast errors for £M3, shown in Table 6.16, we see that besides 1977(1) when the model over-predicts, under-prediction errors occur in each of the remaining 11 quarters. This contrasts strongly with the M1 results which indicated both under-prediction and over-prediction errors for the corresponding quarters.

However, despite this tendency of the £M3 demand model to under-predict there is clearly no trend increase in the size of the percentage error. The most serious under-prediction errors occur in the 4th quarter of the year in both 1977 and 1979, whereas serious errors occur in both the 1st and 4th quarters of 1978. Further inspection of within sample residuals revealed that the relatively large under-prediction errors tended to occur in the 4th quarter, suggesting that the seasonal adjustment of the data is not adequate. A test for 4th order serial correlation, together with evidence from the residual correlogram, indicated a mild 4th order problem; the simple 4th order serial correlation coefficient was 0.37 but had a t-statistic of only 1.6.

This problem which appears to relate to incomplete or unsatisfactory seasonal adjustment of the data is perhaps not too surprising given that the method by which the Bank of England adjusts the money stock figures is not consistent
with the C.S.O.'s adjustment of income data.* Furthermore, seasonally adjusted money stock and income data is combined with seasonally unadjusted interest rate data.

It is possible that the error pattern has other causes. One possibility concerns systematic income distribution changes between sectors within any given year. For example, the tendency of firms to increase wage-rates early in the 1\textsuperscript{st} quarter of a year so that workers receive a boost in their real incomes which then slowly fall as prices move upwards during the course of the year. Another example of this concerns the timing of company sector tax payments, which are typically paid in the 1\textsuperscript{st} quarter of the year.

The systematic under-prediction of £M3 over the years 1977, 1978 and 1979, as suggested by the demand equation estimated over the period 1964(1)-1976(4), might be related to a change in the distribution of income between the personal, company and public sectors following the anti-inflation policies introduced by the Labour government in 1975 and 1976. In particular, the incomes policy improved the position of the company sector relative to the personal sector, and following the public expenditure cuts in 1976 the public sector's rising share of national income was halted. Since the demand for money behaviour of these sectors, particularly where interest-bearing deposits are concerned, is likely to be quite different it is of considerable interest to examine the money-holding behaviour of each sector. In Chapters 8 and 9 the demand for M3 by the personal and company sectors, respectively, is examined. Between them, the sectors

* For details on the Bank of England's adjustment of the money stock figures see BEQB, June 1981.
hold well over 80% of M3.

However, before investigating the sectoral demand for M3 the importance, or otherwise, of simultaneity in 'broad money' models is examined.

6.2 Simultaneity and £M3

Two basic models were estimated. Model A is a simple 2-equation model of the money market, while model B includes a third equation which links the money market with the goods market. The reduced form of model B is investigated in the policy chapter, Chapter 10. However, the immediate concern is with the structural equations and to establish whether the estimated demand for money parameters in these simple simultaneous models differ significantly from the single equation estimates outlined in 6.1 above.

The 3-equation model is similar to the one that Frowen and Arestis (4,5) used in their study of the demand for and supply of money in W. Germany, which follows the approach of Teigen (128). The main difference is that whereas the above-mentioned authors specified the money stock as the endogenous explanatory variable in the income equation, I have used the rate of interest.*

The models used are outlined below. They have been estimated in both untransformed linear and log-linear forms** and the results are shown in Tables 6.17, 6.18 and 6.19.

* This avoids the multicollinearity problem which arises when autonomous expenditure, A, and the money stock, M, both enter as regressors in the income equation. Furthermore, these variables are not independent of one another in cases where an increase in government spending is financed by the sale of debt to the banks.

** See footnote on p.131 (Chapter 3) regarding the validity of the log-linear specification.
Model A - money market

1. \[ M3^s_t = A + b_1 H_t + b_2 R_{B_t} + b_3 \text{MLR}_t + \theta M3^s_{t-1} + u_t \]

2. \[ M3^d_t = B + c_1 Y_t + c_2 R_{B_t} + c_3 R_{CD_t} + \lambda M3^d_{t-1} + v_t \]

3. \[ M3^s_t = M3^d_t = M3_t \]

Model B - money market and goods market

1. \[ M3^s_t = A' + b'_1 H_t + b'_2 R_{B_t} + b'_3 \text{MLR}_t + \theta' M3^s_{t-1} + u_t \]

2. \[ M3^d_t = B' + c'_1 Y_t + c'_2 R_{B_t} + c'_3 R_{CD_t} + \lambda' M3^d_{t-1} + v_t \]

3. \[ Y_t = C + d_1 A_t + d_2 R_{B_t} + g Y_{t-1} + e_t \]

Notes

(1) A general partial adjustment hypothesis is assumed to adequately describe the dynamics of the system.

(2) In the light of the single equation results reported in Section 6.1 only a relatively simple transactions demand model has been specified for the demand for money.

(3) All variables are defined in the general data appendix.

The equations were estimated by 2SLS and casual inspection of the results reveals that they are not particularly good.

The money supply equation has several weaknesses. In both models A1 and B, MLR enters with the wrong sign. In
the case of the untransformed linear models the MLR coefficients were both positive and significant, while the coefficients were small and highly insignificant in the log-linear cases.* For these same models the bond rate enters with a negative rather than a positive coefficient, and although the reserve assets base, H, enters with a correctly signed coefficient it is not significantly different from zero at the 5% level.

For model A2, Table 6.18, although the coefficient on the interest rate variable, $R_B - R_{CD}$, enters with a significant negative coefficient in both versions of the model, MLR enters with a significant and correctly signed coefficient. Another advantage of model A2 is that the reserve assets base enters the equation significantly.

For all three models the suggested speed of adjustment of the money supply to a change in the explanatory variables seems far too slow! The coefficient on the lagged money stock was greater than 0.90 in each case, suggesting that adjustment is not completed inside 2½ years. In practice, the money supply ought to adjust reasonably quickly following an increase in the level of bank reserves since the banks will have a profit incentive to make new advances. Accordingly, money supply equations were estimated for both linear and log-linear versions of the three models after dropping the lagged money stock from the specifications. This resulted in very weakly-determined money supply equations

* Because of the rather uncertain role of MLR as an explanatory variable in the money supply equation over the data period in question and its weak empirical performance in the log-linear models, it was dropped from the log-linear specification.
which were decidedly poorer than the results shown in Tables 6.17, 6.18 and 6.19.

Some sense can be made of the negative coefficient on the bond rate in the money supply equation. Consider the government's anti-inflation policies, particularly after 1975. A combination of (1) reduced government borrowing from the banks, (2) public expenditure cuts aimed at reducing the level of the public sector borrowing requirement and the government's share of national income, and (3) an increased sale of government debt to the non-bank private sector, would tend to reduce the money supply and raise interest rates on government debt.

Attempts to include the PSBR as an additional variable in the money supply equation simply yielded a small and weakly-determined coefficient. However, since the way in which a given PSBR is actually financed will influence the money supply directly, this result is not really too surprising!

The equation of interest, the money demand equation, can now be considered. Model A1 and Model B results, shown in Tables 6.17 and 6.19, respectively, suggest an implausibly slow speed of adjustment. The coefficient on the lagged money stock is in the region of 0.95 for all cases except the log-linear version of Model B (see Table 6.19),* where the speed of adjustment was considerably quicker. However, since this particular equation suggests that the interest

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* In this particular model, the equation was adjusted for significant 1st order serial correlation and the results suggested a speed of adjustment of approximately 6 months which seems far more plausible.
rates are not significant explanatory variables the results are rejected.

Model A2, shown in Table 6.18, gives reasonable results for the money demand equation and there is little to choose between the untransformed linear and log-linear specifications. The latter equation suggests a long-run income elasticity of approximately 0.60 and long-run interest elasticities of -0.23 and +0.23 for the government bond rate and the CD rate, respectively.

Table 6.20 gives the OLS results for the alternative money demand specifications embodied in models A1 and A2. The estimated parameters are very close to the 2SLS estimates in three out of four cases, which points to simultaneous equation bias being negligible in the context of these simple quarterly models. For the log-linear version of model A2 the long-run income and interest elasticities are in agreement although the OLS results, in Table 6.20, suggest a longer adjustment period of approximately 17 months, as opposed to just over a year in the case of the 2SLS results.

The long-run elasticities and speeds of adjustment yielded by the two estimators are compared in Table 6.21.

It is appreciated that the simultaneous models specified are highly simplified and that, properly speaking, elements of the reserve assets base, $H$, should be regarded as endogenous. However, in the context of a simple simultaneous model it has been shown that single equation OLS estimates of the money demand parameters are as good as the 2SLS estimates for the post-CCC data period.
TABLE 6.17
Results - Structural Equations
(1972(1)-1978(4))

Model Al - A Simultaneous Model of the Money Market

(1) Untransformed linear model - 2SLS

1. \[ M_3^S_t = 2.53 + 0.65 H - 0.33 R^L_B + 0.16 MLR + 0.94 M^S_{t-1} \]
   \begin{align*}
   &\text{(3.1)} \hspace{0.5cm} \text{(1.6)} \hspace{0.5cm} (3.3) \hspace{0.5cm} (2.4) \hspace{0.5cm} (19.0) \hspace{0.5cm} (19.0) \hspace{0.5cm} (t-1) \\
   &p = 0.09 \hspace{1cm} x^2_{10} = 16.4
   \end{align*}

2. \[ M_3^d_t = 2.62 + 0.07 Y - 0.23 R^L_B + 0.13 R_{CD} + 0.95 M^d_{t-1} \]
   \begin{align*}
   &\text{(3.6)} \hspace{0.5cm} \text{(0.8)} \hspace{0.5cm} (2.0) \hspace{0.5cm} (2.2) \hspace{0.5cm} (8.3) \hspace{0.5cm} (8.3) \hspace{0.5cm} (t-1) \\
   &p = 0.11 \hspace{1cm} x^2_{10} = 16.9
   \end{align*}

Instrumental variables - H, MLR, Y, R_{CD}.
Endogenous regressor - R^L_B.


<table>
<thead>
<tr>
<th>Year</th>
<th>Percentage Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>2.2 0.3 1.8 0.7 9.2</td>
</tr>
</tbody>
</table>

Note - The money supply equation failed the post-sample parameter stability test over the four quarters of 1979 - calculated \( x^2_4 = 14.4 \).
TABLE 6.17 (continued)

(2) **Log-linear model - 2SLS**

1. \[
M_3^S_t = 0.46 + 0.07 H -0.06 R^L_B + 0.92 M^S_{t-1} \\
(3.8) (1.3) \quad (2.8) \quad (16.7)
\]
\[p = 0.15 \quad x^2_{10} = 9.6\]

2. \[
M_3^d_t = 0.43 + 0.02 Y -0.11 R^L_B + 0.04 R_{CD} + 0.96 M^d_{t-1} \\
(2.1) \quad (0.5) \quad (3.3) \quad (2.4) \quad (13.5)
\]
\[p = 0.01 \quad x^2_{10} = 21.3\]

**Ex-Post Forecasting Performance of Money Demand Equation: Percentage Forecast Errors for 1979.**

<table>
<thead>
<tr>
<th>1979</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>[x^2_4]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.0</td>
<td>1.2</td>
<td>2.9</td>
<td>1.4</td>
<td>11.3</td>
</tr>
</tbody>
</table>

**Note** - The money supply equation easily passed the post-sample parameter stability test - calculated \[x^2_4 = 2.3\].
TABLE 6.18

Model A2 – An Alternative Simultaneous
Model of the Money Market

(1) Untransformed linear model – 2SLS

1. \( M_{3t}^S = 1.41 + 0.89 \, H - 0.22 \, (R_{B}-R_{CD}) - 0.15 \, MLR + 0.93 \, M_{3t}^S_{-1} \)
\[ \begin{align*}
& \quad (2.4) \quad (2.4) \quad (3.9) \quad (2.9) \quad (20.7) \\
p = 0.05 & \quad x^2_{10} = 13.2 \\
\end{align*} \]

2. \( M_{3t}^d = 2.22 + 0.12 \, Y - 0.10 \, (R_{B}-R_{CD}) + 0.88 \, M_{3t}^d_{-1} \)
\[ \begin{align*}
& \quad (3.8) \quad (2.6) \quad (1.9) \quad (18.4) \\
p = 0.26 & \quad x^2_{10} = 15.6 \\
\end{align*} \]

Instrumental variables – \( H, \, MLR, \, Y \).
Endogenous regressor – \( (R_{B}-R_{CD}) \).

Ex-Post Forecasting Performance of Money Demand

<table>
<thead>
<tr>
<th>1979</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( x^2_4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.3</td>
<td>-0.2</td>
<td>0.9</td>
<td>-</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Note – The money supply equation comfortably passed the post-sample parameter stability test.
TABLE 6.18 (continued)

(2) Log-linear model - 2SLS

1. \[ M_3^S_t = -0.33 + 0.16 H_t - 0.21 (R^L_B - R^L_{CD}) - 0.12 MLR + 0.93 M_{3,t-1} \]
   \[ (0.8) \quad (2.5) \quad (2.4) \quad (2.2) \quad (12.4) \]
   \[ p = 0.31 \quad x^2_{10} = 24.3 \]

2. \[ M_3^d_t = 0.95 + 0.15 Y_t - 0.055 (R^L_B - R^L_{CD}) + 0.76 M_{3,t-1} \]
   \[ (2.0) \quad (2.0) \quad (2.4) \quad (6.8) \]
   \[ p = 0.51 \quad x^2_{10} = 9.2 \]

Instrumental variables - H, MLR, Y.
Endogenous regressor - (R^L_B - R^L_{CD}).


<table>
<thead>
<tr>
<th>Year</th>
<th>Forecast Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>1.1  0.1  0.6  -1.0  1.33</td>
</tr>
</tbody>
</table>

Note - The money supply equation just passed the post-sample parameter stability test over the four quarters of 1979 - calculated \( x^2_4 = 9.3 \).
Table 6.19
Model B - A Simultaneous Model of the Money and Goods Markets

(1) Untransformed linear model - 2SLS

1. \[ M^{S}_t = 2.10 + 0.67 H - 0.24 R^L_B + 0.12 MLR + 0.94 M^{S}_{t-1} \]
   \[ (3.0) \ (1.7) \ (3.5) \ (2.1) \ (19.6) \]
   \[ p = 0.11 \quad x^2_{10} = 17.2 \]
   \[ (0.5) \]

2. \[ M^{d}_t = 2.51 + 0.07 Y - 0.20 R^L_B + 0.12 RC_D + 0.95 M^{d}_{t-1} \]
   \[ (4.0) \ (0.8) \ (2.4) \ (2.2) \ (10.1) \]
   \[ p = 0.16 \quad x^2_{10} = 16.4 \]
   \[ (0.7) \]

3. \[ Y = 2.52 + 0.87 A - 0.09 R^L_B + 0.37 Y_{-1} \]
   \[ (2.0) \ (5.5) \ (1.3) \ (3.2) \]
   \[ p = 0.68 \quad x^2_{10} = 23.0 \]
   \[ (3.7) \]


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>x^2_{4}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>2.0</td>
<td>0.3</td>
<td>1.6</td>
<td>0.6</td>
<td>8.0</td>
<td>4</td>
</tr>
</tbody>
</table>

Note - The money supply equation just passed the post-sample parameter stability test, while the income equation passed more comfortably.
TABLE 6.19 (continued)

(2) Log-linear model - 2SLS

1. \[ M_3^S = 0.46 + 0.07 H -0.06 R_L^B + 0.92 M_3^{S-1} \]
   \[ (3.8) \quad (1.1) \quad (2.9) \quad (16.7) \]
   \[ p = 0.14 \quad x_{10}^2 = 9.6 \]

2. \[ M_3^d = 1.99 + 0.31 Y -0.26 R_L^B + 0.045 R_{CD} + 0.51 M_3^{d-1} \]
   \[ (1.5) \quad (2.4) \quad (0.5) \quad (1.8) \quad (2.2) \]
   \[ p = 0.70 \quad x_{10}^2 = 12.3 \]

3. \[ Y = 1.30 + 0.63 A -0.15 R_L^B + 0.31 Y_{-1} \]
   \[ (4.0) \quad (5.8) \quad (2.7) \quad (2.6) \]
   \[ p = 0.56 \quad x_{10}^2 = 18.0 \]

Instrumental variables - \( H, R_{CD}, A \)
Endogenous regressors - \( R_L^B, Y \).


<table>
<thead>
<tr>
<th>1979</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>( x_4^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6</td>
<td>-0.1</td>
<td>0.6</td>
<td>-1.0</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Note - Both the money supply and income equations easily passed the post-sample parameter stability test.
TABLE 6.20

OLS Estimates of Structural Parameters in Demand for Money Equation - 1972(1)-1978(4)

(1) Model Al

1. Untransformed linear

\[ 
\Delta M3 = 2.51 + 0.07 Y + 0.12 R_{CD} - 0.20 R^L_B + 0.95 \Delta M3_{-1} 
\]

\[ R^2 = .997 \quad x^2_{10} = 16.3 \quad p = 0.16 \]

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.0</td>
<td>0.3</td>
<td>1.6</td>
<td>0.6</td>
<td>8.0</td>
<td></td>
</tr>
</tbody>
</table>

2. Log-linear

\[ 
\Delta M3 = 0.48 + 0.03 Y + 0.03 R_{CD} - 0.09 R^L_B + 0.94 \Delta M3_{-1} 
\]

\[ R^2 = .997 \quad x^2_{10} = 19.9 \quad p = 0.03 \]

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.7</td>
<td>0.9</td>
<td>2.5</td>
<td>1.0</td>
<td>8.2</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 6.20 (continued)

(2) Model A2

1. Untransformed linear

\[
\Delta \text{M3} = 2.30 + 0.13 Y -0.139 (R_L^B - R_C^D) + 0.87 \Delta \text{M3}_{-1}
\]

\[
R^2 = .997 \quad x^2_{10} = 15.9 \quad p = 0.22
\]

Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
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<th>(x^2_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.6</td>
<td>0.3</td>
<td>1.4</td>
<td>0.6</td>
<td>5.83</td>
</tr>
</tbody>
</table>

2. Log-linear

\[
\Delta \text{M3} = 0.78 + 0.11 Y -0.040 (R_L^B - R_C^D) + 0.83 \Delta \text{M3}_{-1}
\]

\[
R^2 = .997 \quad x^2_{10} = 17.7 \quad p = 0.32
\]

Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>(x^2_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.4</td>
<td>0.1</td>
<td>1.3</td>
<td>0.3</td>
<td>1.73</td>
</tr>
</tbody>
</table>
TABLE 6.21
A Comparison of OLS and 2SLS Parameter Estimates for Models A1 and A2

<table>
<thead>
<tr>
<th></th>
<th>$b_1$</th>
<th>$b_2$</th>
<th>$\lambda$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear OLS</td>
<td>1.4</td>
<td>-4.0</td>
<td>5 years</td>
</tr>
<tr>
<td>2SLS</td>
<td>1.4</td>
<td>-4.6</td>
<td>5 years</td>
</tr>
<tr>
<td>Log-linear OLS</td>
<td>0.50</td>
<td>-1.5</td>
<td>$4\frac{1}{4}$ years</td>
</tr>
<tr>
<td>2SLS</td>
<td>0.50</td>
<td>-2.7</td>
<td>$6\frac{1}{4}$ years</td>
</tr>
<tr>
<td><strong>A2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear OLS</td>
<td>1.0</td>
<td>-1.07</td>
<td>2 years</td>
</tr>
<tr>
<td>2SLS</td>
<td>1.0</td>
<td>-0.83</td>
<td>2 years</td>
</tr>
<tr>
<td>Log-linear OLS</td>
<td>0.65</td>
<td>-0.23</td>
<td>$1\frac{1}{2}$ years</td>
</tr>
<tr>
<td>2SLS</td>
<td>0.62</td>
<td>-0.23</td>
<td>1 year</td>
</tr>
</tbody>
</table>

\[ b_1 = \text{long-run income elasticity (coefficient)} \]

\[ b_2 = \text{long-run interest elasticity (coefficient)} \]

\[ \lambda = \text{speed of adjustment} \]
6.3 **Concluding comments**

A simple transactions model of money demand yielded the best results for both time deposits and £M3. Models which included the government bond rate (long-term) and the exchange rate, to pick up the possible influence of domestic and international speculation, respectively, did not perform particularly well. In particular, the exchange rate proved to be a highly insignificant explanatory variable.

The short-term government bond rate proved to be the best empirical measure of the alternative asset rate for both TD and £M3. Better results were obtained using this measure rather than rates on short-term, capital-certain financial assets – e.g. the rate on local authority temporary debt. Since short-term interest rates have been subject to more control than longer-term interest rates this finding is not, perhaps, too surprising. Also, since the own-rate on money, which was measured by the CD rate, is more highly correlated with other short-term rates than it is with government bond rates, the empirical superiority of the latter is only to be expected. In fact the most plausible results were obtained when the differential between the bond rate and the own-rate was specified, rather than the two rates separately. For time deposits the restriction was empirically valid, although for £M3 it was not.

The best TD results for the post-CCC era were reasonable except for the weakly-determined price coefficient and the suggestion that the long-run price elasticity was only in the region of 0.15! Both the income and interest elasticities were well-determined: the long-run income elasticity was 3.6 and the bond rate and CD rate elasticities were approximately
-0.70 and +0.70, respectively.

For ZM3 each of the coefficients were reasonably well-determined, although the estimated long-run price elasticity of 0.50 seems a bit low. The long-run income elasticity was just over 2 and the interest elasticities were -0.22 and +0.22 (own-rate elasticity). A speed of adjustment of almost 18 months is plausible enough.

Constraining TD and £M3 to be homogenous in prices only yielded weaker and less plausible results. In view of this finding a price elasticity significantly lower than unity was accepted as being in order for both money definitions in the post-CCC era.

Lack of independent variation in the data during the 1960's means that we cannot be confident about either the TD or £M3 demand structures in the pre-CCC era. There is certainly no firm evidence to suggest that the pre-CCC structure is significantly different from the post-CCC structure for either time deposits or £M3, once the importance of an own-rate on money variable is formally recognized after 1971.

£M3 and TD equations estimated over the full data period, 1964(1)-1978(4), were similar to those estimated over the post-CCC era and excluding the immediate post-CCC observations from the large sample only had a negligible influence on the results.

Both the 1972(1)-1978(4) and the 1964(1)-1978(4) estimated £M3 relationships passed the post-sample parameter stability test over the quarters of 1979. For a more stringent test of parameter stability a demand equation was estimated over the period 1964(1)-1976(4) so that three post-sample
years were available for the test. This test was narrowly failed although the equation passed the Chow test for structural stability.

Finally, single equation OLS estimates of the £M3 money demand parameters were not subject to any serious simultaneous equation bias. OLS estimates of the structural parameters of simple 2 and 3 equation simultaneous models were very similar to the 2SLS estimates.
APPENDIX A

£M3 and TD Results where the Long-run Price Elasticity is Constrained to Equal Unity

(1) Post-CCC era - 1972(1)-1978(4)

1. \[ RM3 = -0.31 + 0.08 Y -0.044 R* + 0.95 \frac{\Delta M3}{\Delta P} \]
   \[ (0.2) (0.6) (2.3) (15.0) \]
   \[ p = 0.52 \quad x^2_{10} = 4.3 \]

2. \[ RM3 = 0.95 + 0.01 Y -0.055 R* -0.019 \frac{\Delta M3}{\Delta P} + 0.92 \]
   \[ (0.6) (0.1) (2.9) (1.8) (1.5) \]
   \[ p = 0.40 \quad x^2_{10} = 10.0 \]

3. \[ RTD = 2.38 -0.10 Y -0.21 R* + 0.87 \frac{\Delta TD}{\Delta P} \]
   \[ (1.3) (0.6) (4.6) (18.9) \]
   \[ R^2 = .967 \quad x^2_{10} = 29.4 \]

4. \[ RTD = 2.20 -0.12 Y -0.145 R* -0.045 \frac{\Delta TD}{\Delta P} + 0.92 \frac{\Delta TD}{\Delta P} \]
   \[ (1.4) (0.8) (3.3) (3.1) (21.4) \]
   \[ R^2 = .977 \quad x^2_{10} = 11.1 \]

/...continued./
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<th>( U )</th>
<th>( F_1 )</th>
<th>( F_2 )</th>
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Full sample period: 1964(1)-1978(4)

Appendix A (continued)
In this chapter the direct influence of inflation expectations on the demand for both M1 and time deposits is examined for the post-CCC 1970's.

7.1 The theoretical case and the existing empirical evidence

If money is regarded as a substitute for both other financial and real assets in the overall asset portfolio, then we must include an explanatory variable which measures the opportunity cost of holding money in terms of goods. The expected rate of inflation can be used to measure the relevant rate of return on goods: if inflation is expected to increase sharply then we would expect the public to economise on money-holdings, in particular non-interest bearing money, since money is a wasting asset.

Which rate of inflation should be used? For households an aggregate price index covering consumer durables seems most appropriate, while for companies an aggregate price index covering stocks and capital equipment might be best: percentage changes in these indices would then be the relevant measures of inflation.

In my work I have used a measure of inflation based on the general retail price index. It is a rate which is well-publicised by the media and therefore likely to be influential in practice. Also, since no split of either M1 or time deposit holdings between the personal and company
sectors is available from published sources, a single rate which is generally heeded seems best.*

Except in conditions of hyperinflation as defined by Cagan (25), which are not relevant to UK experience, most of the existing empirical evidence suggests that inflation expectations have no significant direct influence on the demand for money.** However, besides the studies of Boughton (20) and Arango and Nadiri (3) which found a significant role for inflation expectations for the UK economy, Shapiro (120) and Melitz (91) found the variable influential for the US and French economies, respectively.

Shapiro specified and estimated a dynamic model with a flexible lag structure (a 2nd degree Almon polynomial was applied to each of the explanatory variables).

The model is as follows:

$$\Delta M_t = a + \sum_{i=0}^{n} b_i \Delta Y_{t-i} + \sum_{i=0}^{m} c_i \Delta r_{t-i} + \sum_{i=0}^{l} d_i \left( \frac{\Delta P}{P} \right)_{t-i}$$

Where,

(1) \( m = \) Narrow money
(2) \( r = \) A nominal short-term interest rate
(3) \( l < m < n = \) Length of lags.

The coefficient on the inflation term was significantly negative, as theory suggests it should be. However, with time deposits as the dependent variable the negative

* In fact companies would be likely to heed movements in wholesale prices.

** See Friedman and Schwartz (54) p. 657 and Rowan and Miller (92).
coefficient was not obtained and inflation was not a significant explanatory variable. The clear suggestion is that substitution between money and goods in the asset portfolio only involves non-interest bearing money.

Despite the weight of empirical evidence suggesting that expected inflation has not been a significant explanatory variable in times of moderate inflation it is nevertheless of interest to test this proposition for the UK economy in the post-CCC 1970's. Inflation has been both high and variable during this period, and in 1975 it reached 25%! In terms of 20th century experience for the UK the inflation of the 1970’s has been highly significant. (See Table 7.1).

7.2 Models of inflation expectations

Two models of inflation expectations are to be tested: the adaptive-expectations scheme and the extrapolative/regressive hypothesis (see models 1 and 2 below).*

For the relevant data period 1972(1)-1978(4) the latter would seem theoretically sounder assuming a moving annual series for inflation is relevant. This series shows a clear upward trend over the period 1972(1)-1975(3) followed by several quarters in which inflation falls back, before levelling-out in 1977 at around 15%. Between 1977 and 1978 there is a sharp fall in inflation which takes it down to single figures (see Table 7.1 overleaf). So, using this series for inflation an adaptive-expectations scheme would

---

* Two other approaches to the modelling of inflation expectations were mentioned in Chapter 2(Section 2.2): the direct survey approach and rational expectations.
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$\dot{p}^A$ = Moving annual percentage changes in the R.P.I.

$\dot{q}^Q$ = Quarterly percentage changes in the R.P.I.
progressively under-predict inflation over the first half of the period, and would be likely to over-predict inflation over the second half. In contrast, the extrapolative/regressive expectations hypothesis is suited to situations in which there is a trend rise or fall in inflation. The following example demonstrates the weakness of the adaptive-expectations scheme during a period of time in which there is a trend rise in inflation followed by a trend fall:

<table>
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<th>Period</th>
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<td>9</td>
<td>10.94</td>
<td>9.97</td>
<td>1.94</td>
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Notes

1. $\hat{p}^E$ series generated from the adaptive-expectations scheme (see model 1 below) under the assumption that $g = 0.5$.

2. $\hat{p}^E$ represents the inflation expected for the following period - i.e. period $t + 1$. For period 1 it is assumed that inflation has been correctly anticipated.

3. $\hat{p}^E$ figures are shown correct to 2 decimal places.
\( \hat{P}_{t-1} - \hat{P} \) represents the error made in anticipating inflation and this series clearly demonstrates that during the first six periods when inflation is rising slowly and steadily, it is progressively under-anticipated. During the period 1972(1)-1975(3) there was a steep trend rise in inflation and following the adaptive-expectations scheme it is clear that the errors would not only increase, but also reach a significant size; this seems unreasonable.

From period 7-12 when inflation falls steadily it is over-anticipated and as can be seen from the above figures the size of the error again increases.

So, the adaptive-expectations scheme does not appear to be particularly well-suited to our inflation experience in the 1970's.

The above argument only applies if a moving annual series is used for inflation; an alternative measure would be a quarter-on-quarter series which shows more up-and-down variation and is considerably more volatile. It seems unlikely that the public would pay too much attention to a single quarter's inflation in forming their views about future inflation, but despite this the series is used as an alternative measure in the empirical work.

Despite the suggestion that adaptive-expectations are inappropriate, the model is still tested, along with the extrapolative/regressive expectations hypothesis, for the relevant data period.

For the extrapolative/regressive model to be supported it is necessary that the parameter \( g \) in the equation below is significantly different from zero:
\[ \dot{p}_t^E = \dot{p}_t + g(\dot{p}_t - \dot{p}_{t-1}) \]

\( \dot{p}_t^E \) = Inflation anticipated over period \( t+1 \).
Expectation formed in period \( t \).

**Properties of the model**

If (1) \( g = 0 \) then \( \dot{p}_t^E = \dot{p}_t \)

(2) \( g < 0 \) then \( \dot{p}_t^E < \dot{p} \) if \( \dot{p} > \dot{p}_{-1} \)
\( \dot{p}_t^E > \dot{p} \) if \( \dot{p} < \dot{p}_{-1} \)

(3) \( g > 0 \) then \( \dot{p}_t^E > \dot{p} \) if \( \dot{p} > \dot{p}_{-1} \)
\( \dot{p}_t^E < \dot{p} \) if \( \dot{p} < \dot{p}_{-1} \)

If \( g \) is small and not significantly different from zero, then actual inflation will best reflect inflation expectations. If \( g \) is significantly less than zero then the hypothesis of extrapolative expectations is contradicted since expected inflation will be lower than actual inflation during periods when inflation is rising, and higher than actual inflation during periods when inflation is falling. Such a result is in agreement with the adaptive-expectations outcome although it does not necessarily reflect this particular scheme. Finally, if \( g \) is significantly greater than zero then the hypothesis of extrapolative expectations is supported.
Model 1: Demand for Money Equation combined with an Adaptive Expectations Scheme for Inflation

\[
M^* = AY^{b_1}P^{b_2}R^{b_3}P^E^{b_4} \quad M^* = \text{Desired money-holdings}
\]

\[
\frac{M}{M_{-1}} = \left(\frac{M^*}{M_{-1}}\right)^\lambda \quad \text{Partial adjustment}
\]

\[
\frac{\dot{p}E}{\dot{p}E_{-1}} = \left(\frac{\dot{p}}{\dot{p}_{-1}}\right)^g \quad \text{Adaptive expectations}
\]

Substituting for \(M^*\) in (1) we have,

\[
\frac{M}{M_{-1}} = \left(AY^{b_1}P^{b_2}R^{b_3}P^E^{b_4}\right)^\lambda M_{-1}\lambda \quad u
\]

Therefore,

\[
M = A\lambda Y\lambda b_1P\lambda b_2R\lambda b_3P^E\lambda b_4 P_{-1}^{E,1-\lambda} u
\]

which can be expressed in log-linear form as follows:

\[
M = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + \lambda b_4 \dot{P}^E + (1-\lambda)M_{-1} + u
\]

From the log-linear version of equation (2) above we have,

\[
\dot{p}E = g\dot{p} + (1-g) \dot{p}E_{-1}
\]

\[
(1-(1-g)D) \dot{p}E = g\dot{p} \quad D = \text{Delay or lag operator}
\]

Therefore \(\dot{p}E = \frac{g\dot{p}}{(1-(1-g)D)}\)

Substituting for \(\dot{p}E\) in equation (3) above we have,
\[ M = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + \frac{g \lambda b_4}{(1-(1-g)D)} \dot{P} + (1-\lambda)M_{-1} + u \]

\[ (1-(1-g)D) \ M = g \lambda A + \lambda b_1 Y -(1-g) \lambda b_1 Y_{-1} + \lambda b_2 P -(1-g) \lambda b_2 P_{-1} \]
\[ + \lambda b_3 R -(1-g) \lambda b_3 R_{-1} + g \lambda b_4 \dot{P} + (1-\lambda)M_{-1} \]
\[ -(1-g)(1-\lambda)M_{-2} + u -(1-g)u_{-1} \]

Therefore \[ M = g \lambda A + \lambda b_1 Y -(1-g) \lambda b_1 Y_{-1} + \lambda b_2 P -(1-g) \lambda b_2 P_{-1} \]
\[ + \lambda b_3 R -(1-g) \lambda b_3 R_{-1} + g \lambda b_4 \dot{P} + [(1-g)+(1-\lambda)]M_{-1} \]
\[ -(1-g)(1-\lambda)M_{-2} + u -(1-g)u_{-1} \]
Model 2: Demand for Money Equation combined with an Extrapolative/regressive Model of Inflation Expectations

\[ M^* = AY^{b_1 P} b_2 R b_3 P E^{b_4} \]  
\[ M^* = \text{Desired money-holdings} \]

\[ \frac{M}{M_{-1}} = \left( \frac{M^*}{M_{-1}} \right)^{\lambda} \]  
Partial adjustment

\[ p^E = \hat{p}(\frac{\hat{P}}{P_{-1}})^g \]  
Extrapolative/regressive expectations hypothesis

Substituting for \( M^* \) in (1) we have,

\[ \frac{M}{M_{-1}} = \left( \frac{AY^{b_1 P} b_2 R b_3 P E^{b_4}}{M_{-1}} \right)^{\lambda} \]

Therefore,

\[ M = (AY^{b_1 P} b_2 R b_3 P E^{b_4})^{1-\lambda} M_{-1} \]

\[ M = A^{\lambda Y^{b_1 P} b_2 R b_3 P} E^{b_4} \lambda^{1-\lambda} M_{-1} \]

Substituting for \( p^E \) in (2) we have,

\[ M = A^{\lambda Y^{b_1 P} b_2 R b_3 P} E^{b_4} \lambda^{1-\lambda} M_{-1} \]

Or,

\[ (3) \quad M = A^{\lambda Y^{b_1 P} b_2 R b_3 P} E^{b_4} \left( \frac{\hat{P}}{P_{-1}} \right)^g \lambda^{1-\lambda} M_{-1} \]

(3) above can be expressed in log-linear form as follows,

\[ M = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + \lambda b_4 \hat{P} \]
\[ + \lambda b_4 g \frac{\hat{P}}{P_{-1}} + (1-\lambda) M_{-1} + v \]
Dividing equation (3) through by price we get,

\[
\frac{M}{P} = A\lambda_1 b_1 P^{b_2-1} R^{b_3} (\frac{\dot{P}}{P-1})^{b_4} \frac{M-1}{P-1}^{1-\lambda}
\]

Since \(P-1 = P(\lambda - 1) = P - \lambda P - (1-\lambda) = \frac{P - \lambda}{P(1-\lambda)}\)

we can express the above equation as follows:

\[
\frac{M}{P} = A\lambda_1 b_1 P^{b_2-1} R^{b_3} (\frac{\dot{P}}{P-1})^{b_4} (\frac{M-1}{P})^{1-\lambda} v
\]

Collecting price terms gives,

\[
\frac{M}{P} = A\lambda_1 b_1 P^{b_2-1} R^{b_3} (\frac{\dot{P}}{P-1})^{b_4} (\frac{M-1}{P})^{1-\lambda} v
\]

Now if the long-run price elasticity is constrained to equal unity then \(b_2 = 1\) and the price term in the above equation disappears leaving,

\[
(4) \quad \frac{M}{P} = A\lambda_1 b_1 R^{b_3} (\frac{\dot{P}}{P-1})^{b_4} (\frac{M-1}{P})^{1-\lambda} v
\]

(4) above can be expressed in log-linear form as follows,

\[
\frac{M}{P} = \lambda A + \lambda b_1 Y + \lambda b_3 R + \lambda b_4 \dot{P} + \lambda b_4 g (\frac{\dot{P}}{P-1}) + (1-\lambda) \frac{M-1}{P} + v
\]
7.3 Results - M1

As argued above the extrapolative/regressive hypothesis of inflation expectations in the 1970's seems theoretically sounder than the adaptive expectations scheme.

The empirical work establishes that the latter model should be rejected whereas the former conveniently collapses to a case in which just the lagged inflation rate, as measured by the retail price index, enters the M1 equation. This variable enters with the expected negative sign and contributes significantly to the explanation of variation in M1.

So, although there is doubt at the theoretical level as to whether anticipated inflation is an important determinant of M1, the empirical work suggests that it is. In particular, the inclusion of the lagged inflation rate results in a much faster speed of adjustment following an initial disturbance, while the estimated coefficients are quite well-determined and have the appropriate signs and magnitudes.

Another interesting point is that when an inflation variable is included in the demand for money function, the hypothesis of random residuals can be strongly accepted. This finding contrasts strongly with those equations which do not include such a variable; in several of these the hypothesis of random residuals cannot be accepted and even when it can, it can only just be accepted at the 5% significance level. It would therefore appear that serial correlation which is present in those equations which exclude inflation as an explanatory variable, is specifically due to the omission of such a variable.
Finally, the role of inflation expectations is also examined in M1 equations where the long-run price elasticity is constrained to its theoretically expected value of unity. These equations proved to be inferior to those in which the restriction was not applied, which is not surprising in view of the consistent results for the freely estimated price elasticity which point to its value lying between 0.88 and 0.93.

7.3.1 Results for the adaptive-expectations case
The equations were estimated over the data period 1972(1)-1978(4) and each of the variables are expressed in natural logarithms. Just two equations were run using alternative interest rates: the short-term bond rate and the rate on 3-month local authority deposits.

(1) \[ M_1 = -1.29 + 0.05Y + 0.49Y_{-1} + 0.61P_{-1} - 0.25P_{-2} \]
\[ -0.07R^S_B - 0.04R^S_{-1} + 0.38M_{1-1} + 0.22M_{1-2} \]
\[ x_{10}^2 = 10.2 \quad x_1^2 = 2.68 \quad R^2 = 0.9964 \]

(2) \[ M_1 = -0.67 - 0.01Y + 0.49Y_{-1} + 0.51P_{-1} - 0.17P_{-2} \]
\[ -0.03R^A_{LA} - 0.04R^A_{LA_{-1}} + 0.30M_{1-1} \]
\[ + 0.28M_{1-2} \]
\[ x_{10}^2 = 10.5 \quad x_1^2 = 1.1 \quad R^2 = 0.9967 \]
The entry of several lagged variables in the equations has created multicollinearity difficulties which have given rise to some poorly determined coefficients. In both equations inflation enters with the expected sign, but the size of the coefficient is negligible and the standard error considerably larger than the coefficient. Quite clearly, it is rather pointless trying to unscramble estimates of the structural parameters (see Model 1 above).

While a first difference transformation of the data should considerably ease the multicollinearity problems, it is doubtful as to whether this is an appropriate procedure in view of the fact that for both estimated equations above, the hypothesis of random residuals \( x_{10}^2 \) can be quite confidently accepted. Also, estimates of \( p \) are reasonably low and insignificant as indicated by \( x_{11}^2 \) tests. For these reasons a first difference model has not been estimated.

Some of the difficulties posed by multicollinearity can be overcome by restricting the long-run price elasticity to the theoretically plausible value of unity. However, this is a restriction which should be specifically tested before imposition. Results from equations in which inflation was not included as an explanatory variable suggest that the long-run price elasticity is around 0.90 for the relevant data period.

7.3.2 Results for the extrapolative/regressive expectations case

The complete set of results, in which several different interest rates were tried, are listed in Appendix 1A.
Four different rates were used - $R^S_B$, $R^S_{LA}$, $R^S_{CD}$ and $R^S_{BU}$ (see Appendix 2 for variable definitions). As $R^S_B$ performed best only the equations in which this rate was specified are considered in the main text. All variables are expressed in natural logarithms, in Table 7.2 (overleaf), and the estimation period is 1972(1)-1978(4).

By examining equations (1)-(3) we can see if (a) inflation has any significant explanatory power and (b) whether the extrapolative/regressive hypothesis of inflation expectations is supported.

Comparing equations (1) and (2) we see that the effect of additionally including the rate of inflation, as measured by the moving annual percentage changes in the R.P.I., is to substantially alter the estimated equation. Firstly, the short-run income and price elasticities are larger in equation (2) and the speed of adjustment is faster. When inflation is included as an explanatory variable adjustment of $M_1$ following an initial disturbance takes around six months, whereas equation (1) which excludes inflation suggests that the public take considerably longer than this to fully adjust; almost a year. There is no real reason to suppose a particularly long adjustment lag in practice, so an adjustment period of six months or less would seem more plausible. Short adjustment lags are suggested in the work of Hamburger (60) and my own results are in broad agreement with his with respect to the dynamics. Equation (3) additionally includes a change in inflation variable and is the estimating equation derived from the partial adjustment model of $M_1$ combined with an extrapolative/regressive hypothesis for inflation expectations.
### TABLE 7.2

**M1 Equations: 1972(1)-1978(4)**

<table>
<thead>
<tr>
<th></th>
<th>Equation</th>
<th>Coefficients</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( M1 = 0.17 + 0.28Y + 0.27P -0.07R^S_B + 0.71M1_{-1} )</td>
<td>((0.1) (1.2) (3.3) (3.0) (6.6))</td>
<td>0.995</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 21.7 + x_{1}^2 = 3.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>( M1 = 1.64 + 0.35Y + 0.45P -0.05R^S_B -0.03P^A + 0.49M1_{-1} )</td>
<td>((0.8) (1.5) (2.7) (1.7) (1.3) (2.5))</td>
<td>0.995</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 16.8 + x_{1}^2 = 2.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3⁰</td>
<td>( M1 = 1.68 + 0.33Y + 0.45P -0.07R^S_B -0.03P^A + 0.036P^A + 0.51M1_{-1} )</td>
<td>((0.8) (1.4) (2.7) (2.0) (1.3) (1.1) (2.6))</td>
<td>0.995</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 14.3 + x_{1}^2 = 1.90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3⁰</td>
<td>( M1 = 1.69 + 0.33Y + 0.44P -0.04R^S_B -0.03P^Q + 0.022P^Q + 0.50M1_{-1} )</td>
<td>((0.9) (1.4) (3.8) (1.2) (1.9) (1.8) (3.5))</td>
<td>0.996</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 17.9 + x_{1}^2 = 2.43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>( M1 = 3.57 + 0.26Y + 0.56P -0.05P^A + 0.38M1_{-1} )</td>
<td>((1.8) (1.1) (3.5) (2.7) (1.9))</td>
<td>0.994</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 10.3 + x_{1}^2 = 0.63)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>( M1 = 3.64 + 0.26Y + 0.56P -0.06P^A + 0.004P^A + 0.37M1_{-1} )</td>
<td>((1.8) (1.0) (3.4) (2.5) (0.1) (1.9))</td>
<td>0.994</td>
</tr>
<tr>
<td></td>
<td>(* x_{10}^2 = 10.1 + x_{1}^2 = 0.67)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Test statistic for random correlogram  + Test statistic for 1st order serial correlation
Although the $\Delta \dot{P}$ variable does enter with a t-statistic greater than 1, its entry in the equation does not have much influence on the other coefficients, as close inspection of equations (2) and (3) reveals. Only the size of the interest rate coefficient shows any real change. Also, inspection of (3)B reveals that the estimated coefficients, save for the interest rate variable and $\Delta \dot{P}$ itself, are very similar, so that whether a quarter-on-quarter or moving annual measure of inflation is used makes little difference in practice. The fact that $\Delta \dot{P}$ does not interfere with estimates of other coefficients indicates that the series tends to move independently of the other explanatory variables, a point which the correlation matrix, shown in Table 7.3, makes clear.

There are some grounds for preferring equation (3)A to equation (2). The additional inclusion of $\Delta \dot{P}^A$ means that we can more strongly reject the hypothesis of 1st order serial correlation, and accept more positively the hypothesis of random residuals; the $x^2$ statistics show this. Furthermore, since the results for quarter-on-quarter and moving annual measures of inflation are quite close, we can focus on just the latter measure. In fact the latter is preferable on purely statistical grounds since when using the quarter-on-quarter series, which is considerably more volatile, the hypothesis of random residuals cannot be confidently accepted.

Both equations (2) and (3) are preferred to equation (1) since the hypothesis of random residuals is rejected for (1) and there is evidence that 1st order serial correlation is a nuisance. Since these problems largely disappear when inflation is included as an explanatory variable it could be
said that the serial correlation present in (1) was specifically due to the omission of an important explanatory variable - i.e. inflation expectations.

So, it would appear that the inclusion of an inflation variable in the demand for money function is preferable to a specification which excludes it on two scores: realistically faster adjustment to equilibrium and the absence of any significant serial correlation in the residuals. In fact, as the results shown in Appendix 1A make clear, in every case in which inflation is omitted as an explanatory variable, the speed of adjustment is slower and serial correlation is something of a problem. Those equations in which inflation does enter all indicate reasonably quick adjustment and serial correlation in the residuals is much less of a problem.

Equations (4) and (5), above, do not include an interest rate variable; in addition to the income and price variables only an inflation measure is included. The effect of this is to suggest an even faster speed of adjustment combined with stronger evidence of no serial correlation in the residuals. The coefficients are reasonably well-determined, save for the income coefficient, and all are of sensible magnitude with the expected signs.

This is a slightly worrying result since it suggests that the inclusion of any interest rate variable in the demand for M1 equation results in greater serial correlation in the residuals and lengthens the estimated adjustment lag. This applies no-matter which interest variable is used as the results listed in Appendix 1A make clear. Since many interest rates are controlled to some extent it is possible
that they do not adequately reflect the opportunity cost of holding M1. If this is the case then unless it is possible to find a rate which is freely determined by market forces, (possibly the euro-dollar rate in London) inflation may well represent the optimal opportunity cost measure.

Possible grounds for rejecting such an idea are:

(1) Theory strongly suggests that interest rates are important in the demand for money equation whether money is narrowly or broadly defined.

(2) The ex-post forecasting performance of those equations which include inflation but exclude interest rates is relatively weak as Appendix 1B shows. For each quarter of 1979 M1 is under-predicted, while those equations which include both an inflation variable and the rate on short-term government bonds yield + and - errors which tend to be smaller.

The above analysis suggests that specification (3) is the preferred case, despite the fact that its ex-post forecasting performance for 1979 is marginally inferior to that of equation (1) which excludes an inflation variable (see Appendix 1B).

Equation (3) is derived from a partial adjustment model combined with an extrapolative/regressive hypothesis concerning inflation expectations (see Model 2 above).

It is now necessary to consider the parameters of this model and the estimated coefficients more closely. Since the coefficient on $\Delta \hat{P}$ is positive this suggests that
for any given current level of inflation, the greater the recent increase in inflation then the greater will be the holdings of M1. Now this plainly contradicts the assumption of extrapolative expectations (the positive coefficient supporting regressive expectations) since when inflation starts to rise the public, on average, are assumed to anticipate higher rates of inflation in subsequent time periods, and vice-versa. So, on grounds of inflation and changes in inflation alone, M1 should fall back. (It will, of course, rise because of the direct price effect, but on the assumption that the price elasticity is unity, real money-holdings would fall back).

Now from equation (2) in the model we have,

\[ \dot{P}^E = \dot{P}(\frac{\dot{P}}{P_{-1}})^g \]

Extrapolative/regressive expectations hypothesis

Therefore,

\[ \dot{P}^E b_4 = \dot{P} b_4 (\frac{\dot{P}}{P_{-1}})^g \]

(Note - \( \dot{P}^E b_4 \) is the term which enters the equation for desired money demand; see Model 2)

In logs,

\[ b_4 \dot{P}^E = b_4 \dot{P} + b_4 g(\dot{P} - \dot{P}_{-1}) \]

Or,

\[ b_4 \dot{P}^E = b_4 \dot{P} + b_4 g \Delta \dot{P} \]

Now from equation (3) \( \lambda b_4 = -0.031 \)

\( \lambda b_4 g = 0.036 \)
Therefore,

\[
\frac{\lambda b_4 g}{\lambda b_4} = \frac{0.036}{-0.031} = -1.16
\]

Therefore: \( g = -1.16 \)

Since \( g \) is close to -1.0 and not significantly different from this figure accept the restriction.

Therefore,

\[
\begin{align*}
\dot{b}_4 \dot{p}^E &= \dot{b}_4 \dot{p} - \dot{b}_4 (\dot{p} - \dot{p}_{-1}) \\
\dot{b}_4 \ddot{p}^E &= \dot{b}_4 \ddot{p} - \dot{b}_4 \dot{p} + \dot{b}_4 \dot{p}_{-1} \\
\dot{b}_4 \dddot{p}^E &= \dot{b}_4 \dddot{p}_{-1}
\end{align*}
\]

Therefore: \( \dddot{p}^E = \dddot{p}_{-1} \)

So, the estimated equation for the data period 1972(1)-1978(4) suggests that inflation expectations can be captured by the lagged inflation rate. This, in turn, suggests that the public only pay attention to recent rates of inflation. Furthermore, since the current rate of inflation will only be known to the public after a lag, it is to be expected that the rate of inflation lagged one quarter will provide a better measure of inflation expectations. An important advantage of this specification is that it leaves us with an equation which is relatively easy to estimate.
The revised M1 demand model is as follows:

\[ M1 = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + \lambda b_4 \dot{p}^E + (1-\lambda) M1_{-1} \]

\[ \dot{p}^E = \dot{p}_{-1} \]

Therefore,

\[ M1 = \lambda A + \lambda b_1 Y + \lambda b_2 P + \lambda b_3 R + \lambda b_4 \dot{p}_{-1}^A + (1-\lambda) M1_{-1} \]

So, re-estimating equation \((3)^A\), Table 7.2, in the above form we get a new equation:

\[(6) \quad M1 = 1.74 + 0.33Y + 0.46P - 0.07R^S - 0.03\dot{p}_{-1} + 0.50M1_{-1}
\]

\[ (0.9) \quad (1.5) \quad (3.3) \quad (2.7) \quad (1.7) \quad (3.1) \]

\[ x^2_{10} = 14.3 \quad x^2_{1} = 1.91 \quad R^2 = 0.99535 \]

The equation is virtually identical to \((3)^A\) with respect to size of income, price and interest rate coefficients and speed of adjustment to equilibrium, which is six months. As Appendix 1B shows, the forecasting performances of the two equations are virtually identical. This is not true when equation (6) is compared with equation (2) in Table 7.2 as can be seen again from Appendix 1B. (6) provides marginally better forecasts and the coefficients are better determined. On specification grounds, (6) is obviously preferable to \((3)^A\) since the restriction on \(g\) has been shown to hold. Also, 1 degree of freedom is saved since \(\dot{p}_{-1}\) has replaced \(\dot{p}\) and \(\Delta \dot{p}\) in the M1 equation.
The simple correlation between the logarithms of these rates is 0.997. If deposit, RCD, is almost perfectly correlated with the rate of interest on certificates, it is not shown in the correlation matrix. Although the 3-month local authority rate, P, is not shown in the correlation matrix, all variables are expressed in natural logarithms.

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<th>0.33</th>
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<th>0.98</th>
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<th>0.016</th>
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</tbody>
</table>

Correlation Matrix for Explanatory Variables

Table 7.3
7.3.3 Results - long-run price elasticity constrained to take its theoretically expected value of unity

The final estimating equation is derived from Model 2 (see above). Once again, all the variables are expressed in natural logarithms and the estimation period is 1972(1)-1978(4).

The following five equations are similar to those run for the unconstrained price case in which an extrapolative/regressive hypothesis was entertained for inflation expectations.

(1) \[
\frac{M_1}{P} = 1.01 + 0.14Y - 0.07R^S_B + 0.77 \frac{M_1-1}{P}
\]
\[\chi^2_{10} = 20.9 \quad \chi^2 = 3.72 \quad R^2 = 0.897\]

(2) \[
\frac{M_1}{P} = 2.10 + 0.09Y - 0.06R^S_B - 0.014\dot{P} + 0.71 \frac{M_1-1}{P}
\]
\[\chi^2_{10} = 18.2 \quad \chi^2 = 3.22 \quad R^2 = 0.899\]

(3) \[
\frac{M_1}{P} = 1.98 + 0.16Y - 0.08R^S_B - 0.02\dot{P} + 0.05 \Delta\dot{P} + 0.65 \frac{M_1-1}{P}
\]
\[\chi^2_{10} = 13.8 \quad \chi^2 = 2.12 \quad R^2 = 0.908\]

(4) \[
\frac{M_1}{P} = 4.65 - 0.06Y - 0.04\dot{P} + 0.015\Delta\dot{P} + 0.60 \frac{M_1-1}{P}
\]
\[\chi^2_{10} = 9.1 \quad \chi^2 = 0.75 \quad R^2 = 0.884\]

(5) \[
\frac{M_1}{P} = 2.74 + 0.11Y - 0.06R^S_B - 0.03\dot{P}_1 + 0.63 \frac{M_1-1}{P}
\]
\[\chi^2_{10} = 14.2 \quad \chi^2 = 2.12 \quad R^2 = 0.9052\]
As has previously been pointed out, estimates of the long-run price elasticity range from 0.88-0.93 in a wide variety of possible single equation specifications. This strongly suggests that while the long-run price elasticity may be close to 1, it is less than this value for the relevant data period.

When the long-run price elasticity is constrained to unity the income and interest rate coefficients are less well-determined; this is indicated by the smaller t-values. Equation (4) above, which excludes an interest rate variable, actually yields a negative coefficient on the income variable! A reduced number of explanatory variables ought to reduce problems of multicollinearity and yield more significant coefficients if the reduction is empirically valid (in this case, if the imposed restriction actually holds). Since the individual coefficients are definitely less well-determined when the price restriction is imposed this suggests that the restriction is indeed invalid!

Despite the inferiority of these results to those in which the price elasticity was freely determined, they are similar in some important respects. Serial correlation is a serious problem only in equation (1) which excludes any measure of inflation and comparing equations (2) and (5) we see that lagged inflation has more explanatory power than current period inflation. A faster speed of adjustment is suggested in those equations including inflation and a faster adjustment is associated with less serial correlation.
7.3.4 Results for the pre-CCC era

The M1 results reported in Appendix 1A show the short-term bond rate to be preferable to other interest rates in the post-CCC period. In view of this only the results for equations including the bond rate are to be considered in this section.

As Table 7.4 overleaf clearly shows, the period 1964(1)-1970(4) is not characterised by high inflation and, furthermore, there is no evidence of either a trend rise or fall in the inflation rate. As measured by the moving annual percentage changes in the R.P.I. the rate is mostly under 5%, and from mid-1968 to the end of 1970 it is in the 5-7% range, showing little variation.

Owing to the low level of inflation and the lack of significant variation in the series, it is not expected to be an important explanatory variable. Furthermore, since the variation in the series is not especially striking the adaptive-expectations approach is not adopted. As this approach creates quite serious estimation problems, especially multicollinearity, with all the lagged explanatory variables appearing in the final equation, no useful results are likely to emerge from it in any case. Instead, note is taken of the results for the post-CCC era which established that neither an adaptive-expectations nor an extrapolative expectations hypothesis was really in order for describing anticipated inflation. They showed that the rate of inflation lagged one quarter was the appropriate measure. Allowing for an information lag before the 'current' rate of annual inflation is known to the public, this seems perfectly reasonable; especially so, considering the
<table>
<thead>
<tr>
<th>Year</th>
<th>$p^A_1$</th>
<th>Year</th>
<th>$p^A_2$</th>
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<tbody>
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<td>1.5</td>
<td>1968(1)</td>
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<tr>
<td>(2)</td>
<td>2.7</td>
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<tr>
<td>(4)</td>
<td>2.2</td>
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</tbody>
</table>

$p^A = \text{Moving annual rate of inflation based on the R.P.I.}$
steadiness of the rate in the 1960's.

Table 7.5 overleaf shows the results for two equations: one including and the other excluding an inflation variable. Casual inspection of the results shows that inflation has only a negligible and highly insignificant influence on M1. Since the estimated structural parameters of the two equations almost coincide and the correlation matrix (see Table 7.6) shows that $\hat{P}_1$ is not highly correlated with any of the other explanatory variables, it follows from the results that inflation is a redundant variable in the demand for M1 function in the pre-CCC era, 1964(1)-1970(4).

Since it has been established that inflation expectations do influence M1 over the data period 1972(1)-1978(4), but have no explanatory power in the pre-CCC era, we should expect the results for the entire period, 1964(1)-1978(4), to indicate that the variable cannot be ignored!**

7.4 Results - TD

As the results reported in Chapter 6 indicated that a simple transactions demand model performed best, only this specification is considered. An extrapolative/regressive model of inflation expectations was tested, and since for M1 the lagged rate of inflation was the empirically preferred measure of anticipated inflation, it was directly entered in some of the equations. The models were tested over the post-CCC data

* The highest simple correlation is between $R_B^S$ and $\hat{P}_1$ at 0.53.

** Inflation results for the entire period were listed in Chapter 5 and showed that providing a dummy shift variable was entered for post-CCC quarters, inflation entered significantly and with the correct sign.
Correlation Matrix

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<tr>
<th>3.0</th>
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<th>0.45</th>
<th>0.57</th>
<th>0.94</th>
<th>0.48</th>
<th>0.97</th>
<th>1.0</th>
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<tbody>
<tr>
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<td>0.53</td>
<td>0.46</td>
<td>0.18</td>
<td>0.10</td>
<td>0.10</td>
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<td>0.50</td>
<td>0.84</td>
<td>0.46</td>
<td>0.18</td>
<td>0.10</td>
<td>0.10</td>
<td>0.0</td>
</tr>
<tr>
<td>0.4</td>
<td>0.84</td>
<td>0.46</td>
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<td>0.10</td>
<td>0.10</td>
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</table>

**TABLE 7.6**

\[
\begin{align*}
Z.0 = Z.0 + 0.32 - 0.08 - 0.02 + 0.52 + 0.26 + 0.97 + 0.48 \\
1.0 = 1.0 + 0.31 - 0.09 + 0.58 + 0.46 + 0.18 + 0.10 + 0.10 \\
\end{align*}
\]

Results

**TABLE 7.5**
period, 1972(1)-1978(4). The results are presented in Table 7.7 overleaf.

Since the restriction that the own-rate and alternative asset rate coefficients are of equal magnitude and opposite sign was shown to hold for specifications not including an inflation variable, it was initially assumed that the restriction would continue to hold after the introduction of an inflation expectations variable. This assumption was then re-tested and again shown to hold. It was therefore accepted as a valid restriction.

The only equation which suggests that inflation expectations have a significant role to play in the demand for time deposits equation is equation 3 in which \( \hat{p}^E \) was assumed to be generated from an extrapolative expectations scheme. However, despite the significance of \( \Delta \hat{p} \) which has the correct a priori sign suggesting that the demand for time deposits falls as the rate of change of inflation increases, the equation is generally rather poorly-determined. Comparing this equation with either equation 1 or 4 it can be seen that the latter are well-determined with income coefficients which are statistically significant at the 5% level.

It can be seen from equation 4 that the lagged inflation rate has no role to play in the demand for time deposits equation: the coefficient on \( \hat{p}_{-1} \) is of negligible size and the parameter estimates virtually coincide with those in equation 1 which excludes inflation expectations from the specification.

Finally, equation 2 which includes the actual current rate of inflation is also inferior to equation 1 as only
Concerning inflation expectations (see Model 2 above), Section 7.3.3, this partial adjustment is combined with an expectation/autocorrelation hypothesis. This partial equation is derived when our transaction dummy model assuming co-efficient, although not significant, different from zero, has the wrong sign.

The coefficients on those rates are weakly determined, and the price of the co-efficient in which the co-efficient restriction on \( P \cdot \alpha \) did not hold, was one equation in which the co-efficient restriction on \( P \cdot \alpha \) did not hold.

<table>
<thead>
<tr>
<th>( x )</th>
<th>( p )</th>
<th>( x_0 )</th>
<th>( p_0 )</th>
<th>( p_0 \cdot \alpha )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 6.0 )</td>
<td>( 0.0 )</td>
<td>( 9.6 )</td>
<td>( 6.3 )</td>
<td>( 0.02 )</td>
</tr>
<tr>
<td>( 3.0 )</td>
<td>( 0.7 )</td>
<td>( 6.9 )</td>
<td>( 9.4 )</td>
<td>( 0.08 )</td>
</tr>
<tr>
<td>( 10.0 )</td>
<td>( 0.0 )</td>
<td>( 8.0 )</td>
<td>( 5.0 )</td>
<td>( 0.06 )</td>
</tr>
<tr>
<td>( 2.0 )</td>
<td>( 0.1 )</td>
<td>( 6.8 )</td>
<td>( 9.3 )</td>
<td>( 0.02 )</td>
</tr>
<tr>
<td>( 2.5 )</td>
<td>( 0.0 )</td>
<td>( 8.3 )</td>
<td>( 5.0 )</td>
<td>( 0.04 )</td>
</tr>
</tbody>
</table>

**Table 7.7**

\( T \)D Results - 1972(1)-1978(4)
the interest rate term and the lagged money stock enter significantly.

Equation 1 is also preferred to equations 2 and 3 with respect to lag adjustment. The latter equations suggest that adjustment to a disturbance is only fully completed after 2½ years, whereas equation 1, which excludes an inflation variable, suggests a period of only 1½ years which seems more reasonable.

7.5 Concluding comments
Neither the extrapolative nor the adaptive expectations models of inflation expectations were empirically supported for M1. However, the former model conveniently collapsed to a case where expected inflation could be adequately captured by the lagged inflation rate. For time deposits the lagged rate had no explanatory power, and although the extrapolative expectations hypothesis was empirically supported the equation was generally poorly-determined. In contrast, time deposit equations which excluded inflation were better-determined with more plausible parameter estimates.

During the entire data period 1964(1)-1978(4), the only evidence of a significant role for inflation expectations was for the M1 money definition in the post-CCC era, 1972(1)-1978(4). In this particular period the inclusion of the lagged inflation rate changed the structure significantly. In particular, adjustment lags were shorter and more plausible, and the serial correlation problem disappeared. Furthermore, the ex-post forecasting performance for 1979 was good.

Before the 1970's inflation was relatively low and showed little variation, so that the finding of trivial
influence on money demand is hardly surprising for the pre-CCC period. However, the finding of no influence on time deposits in the post-CCC era cannot be so readily explained. On the basis of the empirical evidence presented in this chapter it is necessary to argue that while goods may be important substitutes for M1 in the overall asset portfolio, they are not important substitutes for interest-bearing bank deposits.
The following results are for the data period 1972(1)-1978(4). All variables are expressed in natural logarithms. Results for all estimated ML equations

<table>
<thead>
<tr>
<th>t</th>
<th>x1</th>
<th>x10</th>
<th>Pia</th>
<th>p</th>
<th>Pu</th>
<th>R^2</th>
<th>M-L-1</th>
<th>P-L-2</th>
<th>M-L-3</th>
<th>P-L-4</th>
<th>M-L-4</th>
<th>P-L-4</th>
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<tr>
<td>1.9</td>
<td>1.7</td>
<td>0.75</td>
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<td>0.5</td>
<td>0.7</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.2</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>3.8</td>
<td>2.1</td>
<td>0.27</td>
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<td>0.7</td>
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<td>0.3</td>
<td>0.4</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>6.4</td>
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<td>0.4</td>
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<td>0.5</td>
<td>0.7</td>
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<td>0.4</td>
<td>0.1</td>
<td>0.5</td>
<td>0.7</td>
</tr>
<tr>
<td>9.2</td>
<td>8.7</td>
<td>0.18</td>
<td>0.7</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.2</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
</tr>
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<td>11.9</td>
<td>11.4</td>
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<td>0.2</td>
<td>0.8</td>
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<td>0.8</td>
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**Appendix IA**
<table>
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<tr>
<th>x1</th>
<th>x2</th>
<th>p</th>
<th>Pr</th>
<th>R²</th>
<th>R²</th>
<th>M-1</th>
<th>F-1</th>
<th>p-1</th>
<th>Intercept y</th>
<th>p</th>
<th>R²</th>
<th>R²</th>
<th>Pr</th>
<th>Pr</th>
<th>Pr</th>
<th>Pr</th>
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<td>0.67</td>
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<td>0.39</td>
<td>9.43</td>
<td>0.00</td>
<td>0.89</td>
<td>0.72</td>
<td>0.10</td>
<td>0.91</td>
<td>0.61</td>
<td>0.89</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>0.33</td>
<td>0.22</td>
<td>0.34</td>
<td>0.98</td>
<td>0.44</td>
<td>0.10</td>
<td>1.50</td>
<td>0.22</td>
<td>0.12</td>
<td>9.44</td>
<td>0.00</td>
<td>0.87</td>
<td>0.73</td>
<td>0.10</td>
<td>0.90</td>
<td>0.60</td>
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<td>0.49</td>
<td>0.39</td>
<td>9.43</td>
<td>0.00</td>
<td>0.89</td>
<td>0.72</td>
<td>0.10</td>
<td>0.91</td>
<td>0.61</td>
<td>0.89</td>
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<td>0.22</td>
<td>0.34</td>
<td>0.98</td>
<td>0.44</td>
<td>0.10</td>
<td>1.50</td>
<td>0.22</td>
<td>0.12</td>
<td>9.44</td>
<td>0.00</td>
<td>0.87</td>
<td>0.73</td>
<td>0.10</td>
<td>0.90</td>
<td>0.60</td>
<td>0.89</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>1.60</td>
<td>3.20</td>
<td>1.61</td>
<td>1.00</td>
<td>2.03</td>
<td>0.90</td>
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<td>9.43</td>
<td>0.00</td>
<td>0.89</td>
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<td>0.34</td>
<td>0.98</td>
<td>0.44</td>
<td>0.10</td>
<td>1.50</td>
<td>0.22</td>
<td>0.12</td>
<td>9.44</td>
<td>0.00</td>
<td>0.87</td>
<td>0.73</td>
<td>0.10</td>
<td>0.90</td>
<td>0.60</td>
<td>0.89</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX I.A (continued)
The price elasticity is directly determined.

Equations marked with *, 16-20, have long-run price elasticity constrained.

Results - Adaptive Expectations Model of Inflation Expectations

(continued)
### APPENDIX 1B

Ex-post Forecasting Performance of M1 Equations

<table>
<thead>
<tr>
<th>Equation</th>
<th>1979-Percentage Forecast Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1. (\dot{Y} \sim P B_{M1-1}^S)</td>
<td>-0.5</td>
</tr>
<tr>
<td>2. (\dot{Y} \sim P R_{M1-1}^{LA})</td>
<td>-0.6</td>
</tr>
<tr>
<td>3. (\dot{Y} \sim P R_{M1-1}^{BU})</td>
<td>-1.7</td>
</tr>
<tr>
<td>4. (\dot{Y} \sim P \dot{R}<em>{B</em>{M1-1}}^{S})</td>
<td>-1.7</td>
</tr>
<tr>
<td>5. (\dot{Y} \sim P \dot{R}<em>{B</em>{M1-1}}^{S} \Delta \dot{P}_{M1-1}) (a)</td>
<td>-0.6</td>
</tr>
<tr>
<td></td>
<td>(b)</td>
</tr>
<tr>
<td>6. (\dot{Y} \sim P R_{LA_{M1-1}}^{BU}) (a)</td>
<td>-1.4</td>
</tr>
<tr>
<td></td>
<td>(b)</td>
</tr>
<tr>
<td>7. (\dot{Y} \sim P \dot{R}<em>{B</em>{M1-1}}^{BU} \Delta \dot{P}_{M1-1})</td>
<td>-2.0</td>
</tr>
<tr>
<td>8. (\dot{Y} \sim P \dot{R}<em>{B</em>{M1-1}}^{BU})</td>
<td>-2.4</td>
</tr>
<tr>
<td>9. (\dot{Y} \sim P \dot{R}<em>{M1-1}^{BU}</em>{B_{M1-1}})</td>
<td>-0.7</td>
</tr>
<tr>
<td>10. (\dot{Y} \sim P \dot{R}<em>{LA</em>{M1-1}}^{BU})</td>
<td>-0.8</td>
</tr>
<tr>
<td>11. (\dot{Y} \sim P \dot{R}<em>{B</em>{M1-1}}^{BU})</td>
<td>1.8</td>
</tr>
<tr>
<td>12. (\dot{Y} \sim P R_{B_{M1-1}}^{BU}<em>{LA</em>{M1-1}})</td>
<td>-0.6</td>
</tr>
<tr>
<td>13. (\dot{Y} \sim P R_{B_{M1-1}}^{BU}<em>{RCD</em>{M1-1}})</td>
<td>-0.5</td>
</tr>
<tr>
<td>14. (\dot{Y} \sim P \Delta \dot{P}_{M1-1})</td>
<td>0.2</td>
</tr>
<tr>
<td>15. (\dot{Y} \sim P \Delta \dot{P}<em>{B</em>{M1-1}}^{S})</td>
<td>0.7</td>
</tr>
<tr>
<td>16. (\dot{Y} \sim R_{M1-1}^{S_{P}})</td>
<td>0.4</td>
</tr>
<tr>
<td>17. (\dot{Y} \sim R_{M1-1}^{S_{P}})</td>
<td>0.3</td>
</tr>
<tr>
<td>18. (\dot{Y} \sim R_{B_{M1-1}}^{S_{P}} \Delta \dot{P}_{M1-1})</td>
<td>1.1</td>
</tr>
<tr>
<td>19. (\dot{Y} \sim P \Delta \dot{P}_{M1-1})</td>
<td>0.8</td>
</tr>
<tr>
<td>20. (\dot{Y} \sim R_{B_{M1-1}}^{S_{P}} \Delta \dot{P}_{M1-1})</td>
<td>0.7</td>
</tr>
<tr>
<td>21. (\dot{Y} \sim P \Delta \dot{M1-1})</td>
<td>-1.9</td>
</tr>
<tr>
<td>22. (\dot{Y} \sim P \Delta \dot{P}_{M1-1})</td>
<td>-1.8</td>
</tr>
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</table>
APPENDIX 1B (continued)

<table>
<thead>
<tr>
<th>Equation</th>
<th>1979 - Percentage Forecast Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Adaptive Expectations - $p^E$</strong></td>
<td></td>
</tr>
<tr>
<td>23. $Y Y_{-1} P P_{-1} R_b^S R_{b_{-1}}^S \hat{p} M_{l-1} M_{l-2}$</td>
<td>-0.9</td>
</tr>
<tr>
<td>24. $Y Y_{-1} P P_{-1} R_L^A R_{A_{-1}}^A \hat{p} M_{l-1} M_{l-2}$</td>
<td>-1.9</td>
</tr>
</tbody>
</table>

**Notes**

Inflation is measured by taking moving annual percentage changes in the retail price index unless otherwise indicated. Equations listed in the same order as in Appendix 1A (Results for all estimated M1 equations).

(a) - Moving annual series for $\hat{p}$

(b) - Quarterly series for $\hat{p}$
APPENDIX 2

Variable Definitions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>Narrow money - notes and coin in circulation and private sector sight deposits.</td>
</tr>
<tr>
<td>TD</td>
<td>Private sector time deposits + bank deposits held by the public sector.</td>
</tr>
<tr>
<td>Y</td>
<td>GDP at 1975 market prices.</td>
</tr>
<tr>
<td>P</td>
<td>GDP deflator.</td>
</tr>
<tr>
<td>$R_B^S$</td>
<td>Rate of interest on short-term government bonds.</td>
</tr>
<tr>
<td>$R_{LA}$</td>
<td>Rate on 3-month local authority deposits.</td>
</tr>
<tr>
<td>$R_{CD}$</td>
<td>Rate on 3-month certificates of deposit.</td>
</tr>
<tr>
<td>$R_{BU}$</td>
<td>Rate on building society deposits (pre-tax basis)</td>
</tr>
<tr>
<td>$\dot{P}^A$</td>
<td>Moving annual percentage changes in the R.P.I.</td>
</tr>
<tr>
<td>$\dot{P}^Q$</td>
<td>Quarter-on-quarter percentage changes in the R.P.I.</td>
</tr>
<tr>
<td>$\Delta\dot{P}^A$</td>
<td>Change in inflation</td>
</tr>
<tr>
<td>$\Delta\dot{P}^Q$</td>
<td></td>
</tr>
</tbody>
</table>

Note

Money stock, income and price data is seasonally adjusted.
CHAPTER 8

THE PERSONAL SECTOR'S DEMAND FOR MONEY

8.0 Introductory remarks
Results are presented for the post-CCC data period only. Both fixed and flexible lag models were estimated in untransformed linear and log-linear form, but since the log-linear results were better in almost every case only these are reported below.

Personal disposable income is the selected income constraint variable and the PDI deflator represents the price variable. While these variables are appropriate for households, which hold a large proportion of personal sector bank deposits, it is recognized that they are not particularly suitable for the unincorporated businesses which are included in the definition of the personal sector. Ideally, I would have liked to examine just household money demand, but a break-down of the personal sector's money-holdings into household and business components is not available from official sources.

It is assumed that short-term capital-certain financial assets are the most important substitutes for money, and since building society deposits are clearly the most important non-money liquid assets,* both in terms of size of holdings and variation in holdings, held by the personal sector, the building society deposit rate is selected as the relevant opportunity cost variable. The

* See Table 10.3 in 'Financial Statistics'.
relevant own-rate on money is taken to be the rate on 'retail' bank deposits - i.e. 7-day deposits with the London Clearing Banks. Since this own-rate on money is a pre-tax rate whereas the building society deposit rate is a post-tax rate, the latter is grossed-up so that both rates are expressed on a consistent pre-tax basis.

In my early work the own-rate on money and the building society deposit rate were entered separately in the money demand function, but this gave rise to poorly-determined coefficients. This was due to the 'stickiness' of the rates, particularly the rate on building society deposits. It was found that the differential between the two rates, which showed more variation over the period, gave better results. Since it was possible to accept the hypothesis that the coefficients on the two rates were of equal size and opposite sign in the unconstrained cases, this restriction (implicit in specifying the differential rate as the relevant argument) was accepted as being valid. As such, only the results for specifications which include the differential rate are reported in this chapter.

The government bond rate is included in some of the equations to pick-up a possible speculative component in the personal sector's demand for money. Although most households are unlikely to hold capital-risky assets,* some of the high-income households together with the unincorporated businesses included in the sector may well be

* It is assumed that most households will earn insufficient income to make speculation in stocks and shares either worthwhile or possible. The brokerage costs are likely to be high in relation to the size of the expected capital gains in many of the cases where speculation is possible.
important holders of medium and long-term government securities, as well as other capital-risky financial assets.

It is possible that inflation expectations have a significant influence on personal sector money-holdings. To test whether this has been the case in the 1970's, inflation variables based on both the wholesale and retail price indices have been included in some of the equations. Indeed, because of the high correlation between the rate of inflation and the bond rate, it is possible that the latter adequately captures the influence of inflation expectations.

8.1 Fixed lag model results
Tables 8.1 - 8.3, below, show the results for three different fixed lag models: partial adjustment, adaptive-expectations, and a model which combines these two hypotheses.*

8.1.1 Partial adjustment model results
These are presented in Table 8.1 with the estimated long-run elasticities for each equation shown in Table 8.2.

Three different treatments of the price elasticity are covered in these results. Equations 1 and 2 give freely determined estimates, while short-run homogeneity is imposed in 3 and 4, and long-run homogeneity in equations 5 and 6.

Clearly, the hypothesis of long-run homogeneity in prices, in the context of a simple partial adjustment model,

* A full description of these models together with the derivation of the final estimating equations was given in Chapter 3, Section 3.3.
must be rejected as the coefficients on $\frac{MP-1}{p}$ exceed unity thus causing the model to collapse.

In the short-run homogeneity case only equation 4 which includes the bond rate, gives reasonable results. The coefficient on PDI in equation 3 has the wrong sign, although it is not significantly different from zero. All the coefficients in equation 4 have the correct signs and are significantly different from zero at the 5% level. The only real weakness lies in the size of the coefficient on the lagged money variable; at 0.94 this suggests that adjustment to a change in one of the explanatory variables takes just over four years which seems an unreasonably long period. From Table 8.2 it can be seen that the implied long-run income elasticity is rather high at 4.2 and so too is the bond rate elasticity at -2.30. So, in the context of equations 3 and 4 the assumption of short-run homogeneity in prices must be rejected.

This leaves equations 1 and 2 in which the price elasticities are freely estimated. Both equations are acceptable although the price elasticities are rather weakly determined. Table 8.2 shows that the long-run price elasticity of personal sector money-holdings is only in the region of 0.3! As the correlation matrix, Table 8.7, shows that the simple correlation between income and prices is only 0.55, the poorly determined price coefficients cannot be attributed to high correlation between these variables. However, the correlation matrix does indicate a correlation of 0.94 between lagged money-holdings and prices but this figure is still decidedly lower than the multiple correlation coefficients for equations 1 and 2 in Table 8.1; .997 and .998,
respectively. In view of this, multicollinearity problems cannot be regarded as severe.

As for the other variables the estimated coefficients are certainly plausible and all are significant at the 5% level. From Table 8.2 we can see that the estimated long-run elasticities are very similar for the two equations with the income elasticity being close to 2, suggesting that money is a luxury good for the personal sector. The long-run elasticity with respect to the bond rate in equation 2 equals -0.90; a result which suggests that there is a significant speculative component in the personal sector's demand for money. The speed of adjustment is approximately two years, with a marginally faster adjustment suggested by equation 2 which additionally includes the bond rate variable. Since the interest differential between the short rates is not entered in log form the coefficients cannot be interpreted as elasticities. In Appendix A the interest elasticity is evaluated at the means of the variables, where it is shown that a coefficient of -0.0014 corresponds to a short-run elasticity of -0.031 and a long-run elasticity of -0.378.

The results presented in Table 8.1 do not include a case in which inflation expectations play a role. However, it is clearly possible that the government bond rate, which has been included in some of the equations to pick-up a possible speculative component in money demand, serves as a proxy variable for inflation expectations. Certainly, there is a strong, positive correlation between movements in the bond rate and the annual rate of inflation as measured by changes in the retail price index. It is clear, however, whatever its role, that the government bond rate is a
significant explanatory variable in each of the alternative price cases - i.e. equations 2, 4 and 6 in Table 8.1.

8.1.2 Adaptive-expectations and combined model results
Table 8.3 shows the results for conventional adaptive-expectations and combined models in which expected rather than actual income is the relevant constraint variable. It can be seen that with lagged explanatory variables entering these models multicollinearity becomes a considerable problem with several of the coefficients being rather poorly-determined and not significantly different from zero. Attempts to include the government bond rate as an additional explanatory variable only made the multicollinearity problems worse. As a result of all this it was not felt to be worthwhile to include estimates of the long-run elasticities for either model.

Alternative hypotheses were entertained regarding expectations; for example an extrapolative hypothesis was applied to the price variable. However, in every case the results were poorly-determined and therefore are not reported here.

8.1.3 Some further fixed lag model results
A variety of results are shown in Table 8.4: equation 1 includes a proxy variable for inflation expectations*, equations 2-4 include lagged interest rate terms, and equations 5 and 6 allow the price elasticity of real money balances to be freely-determined. Short-run homogeneity in

* The moving annual percentage changes in the wholesale prices index ($\bar{P}_{wh}$) is the variable used as a proxy for inflation expectations.
### Partial Adjustment Model Results (1972(1)-1978(4))

<table>
<thead>
<tr>
<th>Year</th>
<th>R²</th>
<th>MP-1</th>
<th>RMP-1</th>
<th>PDI</th>
<th>R²</th>
<th>MP-1</th>
<th>RMP-1</th>
<th>PDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1973</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1974</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1975</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1976</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1977</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
<tr>
<td>1978</td>
<td>R</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
<td>MP-1</td>
<td>R²</td>
<td>R²</td>
<td>R²</td>
</tr>
</tbody>
</table>

Note: All variables are in natural logs except for R. R = R². For R²MP-1, R² = 1972(1)-1978(4).
<table>
<thead>
<tr>
<th>Model of the Long-Run Homogeneity in Prices Imposed</th>
<th>++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model of the Short-Run Homogeneity in Prices Imposed</td>
<td>+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collapse Model</th>
<th>4.5 Years</th>
<th>4.2 Years</th>
<th>2.5 Years</th>
<th>2 Years</th>
<th>1.83 Years</th>
<th>1 Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity to</td>
<td>N/A</td>
<td>1.00+</td>
<td>1.04</td>
<td>1.00+</td>
<td>1.04</td>
<td>1.00+</td>
</tr>
<tr>
<td>Not</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed of Adjustment</td>
<td>P_6</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 6.2**

Long-run Elasticities
Note - All variables are in natural logs except for R. R = RDU-ROR.

<table>
<thead>
<tr>
<th></th>
<th>(4.8)</th>
<th>(10.1)</th>
<th>(2.0)</th>
<th>(6.7)</th>
<th>(10.5)</th>
<th>(0.8)</th>
<th>(0.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPM</td>
<td>0.6</td>
<td>-0.03</td>
<td>1.00</td>
<td>0.005</td>
<td>0.00</td>
<td>-0.06</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>0.2</td>
<td>0.28</td>
<td>1.09</td>
<td>-0.04</td>
<td>0.004</td>
<td>-0.37</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>0.0</td>
<td>0.33</td>
<td>1.03</td>
<td>0.006</td>
<td>0.003</td>
<td>0.03</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>0.1</td>
<td>0.29</td>
<td>0.99</td>
<td>0.005</td>
<td>0.002</td>
<td>0.085</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adaptive Expectations and Computed Model Results - 1972(2)-1978(4)

TABLE 8.3
prices is imposed in equations 1-4 inclusive.

Although $P_{WH}$ enters equation 1 significantly and with the theoretically correct negatively signed coefficient, the equation is generally poor and the suggested speed of adjustment is implausibly slow (see Table 8.5).

The lagged interest rate coefficients do not enter significantly in equations 3 and 4, and again as Table 8.5 clearly shows, the suggested speed of adjustment is rather slow.

In contrast, equations 5 and 6, in which the price elasticity of real money balances is freely determined, give highly plausible results. However, it can be seen from equation 5 that the bond rate becomes an insignificant explanatory variable when the assumption of homogeneity in prices is dropped. The higher $R^2$ of 0.985 associated with equation 6 is another clear sign that the bond rate should be excluded from the specification. Focussing on equation 6, which can be interpreted as a transactions demand model, it can be seen that each of the estimated coefficients are certainly plausible and highly significant. Furthermore, as shown in Table 8.5, the derived long-run elasticities and speed of adjustment seem reasonable. A long-run income elasticity of 1.4 indicates that money should be regarded as a luxury good, while a price elasticity of $-0.135^*$ suggests that there is a degree of money-illusion with the level of real money balances falling back as prices rise. A direct estimate of the differential interest rate elasticity is not given, since $R_{BU-R}\frac{7}{R_{OR}}$ does not enter in log form. However,

* This corresponds to a price elasticity of 0.865 for nominal money-holdings.
### Table 8.4

<table>
<thead>
<tr>
<th>RPM</th>
<th>R</th>
<th>p</th>
<th>PDI</th>
<th>M/PH</th>
<th>MP-1</th>
<th>P-1</th>
<th>R-1</th>
<th>R-1/P-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>82</td>
<td>988</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
</tr>
<tr>
<td>5</td>
<td>82</td>
<td>988</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
</tr>
<tr>
<td>4</td>
<td>82</td>
<td>988</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
</tr>
<tr>
<td>3</td>
<td>82</td>
<td>988</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
</tr>
<tr>
<td>2</td>
<td>82</td>
<td>988</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
<td>0.040</td>
<td>0.980</td>
</tr>
</tbody>
</table>

*Note: All variables are in natural logs except for R. R = Rtu - Ror*
Long-run Elasticities (Further Results)

<table>
<thead>
<tr>
<th>Adjustment</th>
<th>Speed of M₁</th>
<th>RB</th>
<th>p</th>
<th>PDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 months</td>
<td>N/A</td>
<td>N/A</td>
<td>0.87</td>
<td>1.4</td>
</tr>
<tr>
<td>1 year</td>
<td>N/A</td>
<td>N/A</td>
<td>-0.15</td>
<td>1.6</td>
</tr>
<tr>
<td>4.2 years</td>
<td>N/A</td>
<td>N/A</td>
<td>0.0</td>
<td>4.2</td>
</tr>
<tr>
<td>3.1 years</td>
<td>N/A</td>
<td>N/A</td>
<td>-1.8</td>
<td>3.2</td>
</tr>
<tr>
<td>4.2 years</td>
<td>N/A</td>
<td>N/A</td>
<td>-2.0</td>
<td>4.2</td>
</tr>
<tr>
<td>12.4 years</td>
<td>N/A</td>
<td>N/A</td>
<td>-2.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Holding assumed to fully adjust to a change in prices within
price elasticity constrained to unity. Personal sector money.

TABLE 8.5
the coefficient of -0.006 corresponds to a long-run interest elasticity of approximately -0.10 when evaluated at the means of the variables. Finally, a speed of adjustment of eleven months is the most plausible of all the estimates.

Overall, equation 6 gives the best results and equation 3 in Table 8.4 is best for those specifications which impose either short-run or long-run homogeneity in prices. It was decided that these two equations should be tested for both 1st and higher order serial correlation in view of the fact that they represent the best fixed lag model results under different price assumptions.

A. RMP \( f \) PDI, P, R\(_{-1}^{-7}\), RMP\(_{-1}^{-7}\) Equation 6 Table 8.4

1. \( e_t = 0.516e_{t-1} \) 
   \[ (3.1) \]  

2. \( e_t = 0.604e_{t-1} -0.153e_{t-2} \) 
   \[ (3.1) \]
   \[ (0.8) \]

3. \( e_t = 0.674e_{t-1} -0.148e_{t-2} -0.10e_{t-3} \) 
   \[ (3.3) \]
   \[ (0.6) \]
   \[ (0.5) \]

4. \( e_t = 0.60e_{t-1} -0.040e_{t-2} -0.15e_{t-3} -0.013e_{t-4} \) 
   \[ (2.7) \]
   \[ (0.2) \]
   \[ (0.6) \]
   \[ (0.1) \]

After adjusting for 1st order serial correlation we have the following equation:

\[
RMP' = -0.342 + 0.37PDI' -0.005R' -0.146P + 0.71RMP'_{-1} \\
   \quad (0.7) \quad (4.0) \quad (2.4) \quad (5.2) \quad (12.2)
\]

\[
RMP' = RMP -0.516RMP_{-1} \text{ etc.}
\]
B. $R_{MP} + PDI, R_{BU} - R_{OR}^* (R_{BU} - R_{OR})^{-1}, R_{B}^S, R_{MP}^{-1}$

Equation 3 Table 8.4

1. $e_t = 0.362e_{t-1}$
   \[ (2.0) \]

2. $e_t = 0.370e_{t-1} - 0.020e_{t-2}$
   \[ (1.8) \]

3. $e_t = 0.365e_{t-1} + 0.029e_{t-2} - 0.125e_{t-3}$
   \[ (1.8) \]

4. $e_t = 0.362e_{t-1} + 0.027e_{t-2} - 0.113e_{t-3} - 0.028e_{t-4}$
   \[ (1.7) \]

After adjusting for 1st order serial correlation we have the following equation:

\[ R_{MP}' = -1.125 + 0.29PDI' - 0.012R' - 0.003R_{MP}' R_{BU}^{-1} - 0.140R^S_{B}' + 0.93R_{MP}' (4.1) \]

\[ (1.3) (2.5) (4.7) (1.1) \]

\[ R_{MP}' = R_{MP} - 0.362R_{MP}^{-1} \text{ etc.} \]

It can be seen in each of the above cases that despite transforming the variables to take account of significant 1st order serial correlation in the residuals, the results are still broadly similar to those shown in Table 8.4 where the serial correlation problem is ignored.

8.1.4 Evidence from the GIVE programme

For more comprehensive evidence as to the appropriate fixed lag model and the importance of lagged explanatory variables in the function, a general single equation auto-regressive model was estimated in which the hypothesis of 1st order serial
correlation was entertained.*

Now despite the fact that equation 6, in Table 8.4 above, gave the most plausible set of results there is some doubt concerning the assumption of quick adjustment of money demand to a change in prices. Certainly, such an assumption was not empirically borne out for any of the aggregate money definitions - e.g. M1 and £M3 - although it is possible that over-aggregation by type of holder obscures the results here.

Equations 1 and 2 in Table 8.1 were plausible except for the estimated long-run price elasticity, which at approximately 0.30 might well be viewed as being unreasonably low. In these equations nominal money-holdings was the dependent variable with money demand adjusting slowly to a change in prices. A possible reason for preferring these equations to equation 6 in Table 8.4 is that they are both derived from simple partial adjustment models, whereas the latter equation cannot be formally derived from any of the standard fixed lag models.

The autoregressive model can be represented in three different ways: the Structural Form, the Unrestricted Transformation Function, and the Restricted Transformation Function. The GIVE programme estimates each of these and on the strength of certain test-statistics built into the programme allows us to choose the appropriate representation of the model. If the basic Structural Form is accepted then the partial adjustment hypothesis is in order assuming that the Structural Form agrees with either equations 1 or 2 in

* Since tests for the 'best equations' showed that there was no evidence of any significant higher order serial correlation, the hypothesis of 1st order serial correlation would seem in order. See Section 8.1.3 above.
Table 8.1. If the hypothesis of 1st order serial correlation is accepted as a valid autoregressive restriction then the RTF can be accepted, in which case it becomes difficult to discriminate between the different fixed lag models such as partial adjustment and adaptive-expectations. Finally, if both the SF and RTF are rejected in favour of the URTF this indicates that a higher order lag structure is required and that the SF needs revising and re-testing.

The model postulated is as follows:

1. \[ MP = A + b_1 PDI + b_2 P + b_3 (R_{BU} - R_{OR}) + c_1 D_1 + c_2 D_2 + c_3 D_3 + \lambda MP_{-1} + U_t \]

2. \[ U_t = pU_{t-1} + e_t \]

\[ Ee_t = 0 \]
\[ Ee_t^2 = \sigma_e^2 \]
\[ Ee_t e_{t-1} = 0 \]

Notes

1. Ignoring equation 2 the form of the model agrees with equation 1, Table 8.1, which was derived from a partial adjustment model.

2. Only the simplest specification, suitable for a model of household money demand, is entertained - i.e. only the interest rates on capital-certain liquid assets are allowed to enter the demand function, along with the income and price variables.
3. One weakness of the equations presented in previous sections of this chapter is that no allowance was made for seasonal variation; personal sector money-holding data only being available in seasonally unadjusted form. The results presented below indicate that there is a significant positive seasonal influence in the third quarter.

### Structural Form - results

\[
\begin{align*}
MP &= -1.49 + 0.28PDI + 0.04P - 0.0053(R_{BU} - R_{OR})^7 + 0.002D1 \\
&\quad + 0.004D2 + 0.016D3 + 0.88MP \\
&\quad (1.3) (2.1) (1.3) (2.4) (0.3) \\
&\quad (0.5) (1.95) (19.7) -1 \\
\chi^2_{10} &= 18.6 \quad R^2 = 0.996
\end{align*}
\]

### Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>\chi^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7</td>
<td>-0.5</td>
<td>-3.1</td>
<td>-1.8</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Chow test $F_{4,20} = 1.05$

### Restricted Transformation Equation - results

\[
\begin{align*}
MP' &= -0.96 + 0.22PDI' + 0.04P' - 0.0035(R_{BU} - R_{OR})' + 0.001D1 \\
&\quad + 0.004D2 + 0.013D3 + 0.88MP' \\
&\quad (1.0) (1.6) (0.6) (1.5) (0.2) \\
&\quad (0.7) (1.9) (10.7) -1 \\
\end{align*}
\]

\[p = 0.46 \quad \chi^2_{10} = 11.1\]
Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$x_4^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.8</td>
<td>-1.8</td>
<td>-3.2</td>
<td>-1.3</td>
</tr>
</tbody>
</table>

Chow test - $F_{4,19} = 1.12$

Notes

1. Since a $x^2$ test showed that the autoregressive restriction was valid - calc. $x_3^2 = 3.9$ - results for the Unrestricted Transformation Equation are not presented.

2. All variables except for the interest rate differential, $R_{BU} - R_{OR}^7$, are in natural logarithms.

TABLE 8.6
Long-run Elasticities and Speed of Adjustment

<table>
<thead>
<tr>
<th></th>
<th>PDI</th>
<th>P</th>
<th>$(R_{BU} - R_{OR}^7)$</th>
<th>Adjustment Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF</td>
<td>2.33</td>
<td>0.33</td>
<td>-0.125$^+$</td>
<td>2 years</td>
</tr>
<tr>
<td>RTE</td>
<td>1.83</td>
<td>0.33</td>
<td>-0.094$^+$</td>
<td>2 years</td>
</tr>
</tbody>
</table>

$^+$ Elasticities evaluated at variable means.
The validity of the autoregressive restriction suggests that a higher order lag structure does not exist, and that subject to serial correlation the postulated model is a suitable description of personal sector money demand.

The RTF results show that although the absolute size of the 1st order serial correlation coefficient is quite large at 0.46, it is not significantly different from zero at the 5% level. The $x^2_{10}$ statistic reveals that the RTE residuals can be confidently accepted as random and that higher order serial correlation is not a problem (this finding agrees with the results for 1st to 4th order cases which were presented in Section 8.1.3). Since p is not significantly different from zero the SF results can be accepted. Although a $x^2_{10}$ of 18.6 indicates that there is a serial correlation problem the fact that 1st order serial correlation is not statistically significant at the 5% level and that the SF and RTE results are not too different means that we can ignore the findings for the SF random correlogram test. Table 8.6 shows the long-run elasticities for the SF and the RTE cases, and it can be seen that the estimates are in broad agreement, with an income elasticity of approximately 2, an interest elasticity of approximately -0.10 and a rather low price elasticity of only 0.33. There is agreement regarding the speed of adjustment which is just over two years.

Since the SF results can be accepted and p is not significantly different from zero, a partial adjustment explanation of the dynamics seems to be in order.

Finally, the forecasting performance of the model is reasonably good over 1979. The worst error occurs in the
<table>
<thead>
<tr>
<th></th>
<th>MP-1</th>
<th>MP-2</th>
<th>RMP-1</th>
<th>RMP-2</th>
<th>P-1</th>
<th>P-2</th>
<th>PDI</th>
<th>RDI</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>N/A</td>
<td>0.99</td>
<td>0.56</td>
<td>0.48</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>1.0</td>
<td>N/A</td>
<td>0.93</td>
<td>0.70</td>
<td>0.67</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>1.0</td>
<td>0.95</td>
<td>0.22</td>
<td>0.70</td>
<td>0.67</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>1.0</td>
<td>0.92</td>
<td>0.22</td>
<td>0.70</td>
<td>0.67</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Correlation Matrix for Explanatory Variables**

*Table 8.7*
third quarter with personal sector money-holdings under-predicted by 3.1%. Calculated $x^2_4 = 6.2$ indicating that the post-sample parameter stability test is passed when the data period is extended to include 1979 observations. The Chow test confirms that the model is structurally stable.*

8.2 Flexible lag model results
Despite experimenting with the shape of the lag path imposed on each of the explanatory variables and the length of the lag, no really satisfactory results emerged. In fact in order to get any reasonable results at all using a polynomial distributed lag technique (orthogonal polynomials) the intercept has to be suppressed before estimation. Equations with a constant term yielded theoretically incorrect lag paths - i.e. the influence of both income and prices becoming stronger as lag length increased.

It was felt that a low degree polynomial would be suitable for the lag profiles associated with each of the explanatory variables.** In fact the degree of the polynomial was varied between 1 and 4 (starting with the high figure) and the finite lag lengths were varied up to twelve quarters with no end-point restrictions being imposed.

The best results obtained are shown in Tables 8.8, 8.9 and 8.10. Tables 8.8 and 8.9 cover money demand equations which include inflation as an explanatory variable, alternatively measured by the moving annual percentage changes in the

* Although the RTE passes the parameter stability test and is structurally stable, the hypothesis of structural stability can be more comfortably accepted for the SF.

**A lag path with more than two turning points was considered very unlikely for any of the explanatory variables.
retail and wholesale (output) price indices. In Table 8.10 inflation is excluded from the equation.

In each case the optimum polynomial degrees were indeed low; they were never higher than 2 and for the income and price variables there was little to choose between a linear or geometrically declining lag path.

Inspection of Tables 8.8 and 8.9 reveals that the R.P.I. measure of inflation has more explanatory power than the wholesale price index. The latter measure was used as a proxy for expected inflation since it signals rises in inflation, as measured by the R.P.I., one or two quarters in advance. However, the R.P.I. based measure is clearly empirically preferred. For both estimation periods the expected negative elasticity occurs, whereas in the case of wholesale prices none of the individual coefficients are significant and the expected negative elasticity only occurs for the 1972(1)-1978(4) estimation period. Comparing the results in Table 8.8 with those in Table 8.10, where inflation is excluded from the demand for money specification, it can be seen that the lag profile for income is much the same, a longer lag is associated with the price variable when inflation is excluded but the lag profile on interest rates is less believable. The long-run income and price elasticities for these two cases are in close agreement, a finding which is not too surprising in view of the relatively small size of the long-run inflation elasticity shown in Table 8.8. Over the 1972(1)-1978(4) estimation period the $R^2$ statistic is the same for the two equations and there is some evidence from the size of the D.W. statistics to suggest that serial correlation is less of a problem in the specification which
excludes inflation.

From the t-statistics on the lag coefficients in Table 8.8 it can be seen that both the income and interest rate variables are highly significant. This stands in sharp contrast to the lag coefficients on price and inflation which are weakly determined; a finding which agrees with the fixed lag model results. Again, in Table 8.10, with the inflation variable excluded, income and the rate of interest are highly significant explanatory variables, whereas the price coefficients are poorly determined.

It is interesting that the empirically preferred lag structure for the money demand model in Table 8.10 is in broad agreement with the lag structure implied by the fixed lag partial adjustment model: the length of lag associated with each of the explanatory variables is the same.* The suggestion is that adjustment to any source of disturbance will be completed within a two-year period.

It is noticeable in each of the tables that the estimated equations are sensitive to a change in the data period. For example, when the data period is extended to include 1979 observations, in Table 8.8, the lag profile on PDI changes quite dramatically with the size of the coefficients increasing as the lag gets longer! In fact, as indicated by the Chow test, each of the three equations are structurally unstable when the data period is extended to cover 1979. However, inspection of the $R^2$ and D.W. statistics in each of the three tables reveals the following:--

* However, the lag profile associated with the interest rate variable is extremely flat in Table 8.10 and the high t-statistics throughout suggest that adjustment to a change in interest rates may not be fully completed within 2 years.
1. $R^2$ is lower in every case for the larger sample.

2. While the D.W. statistic reveals that serial correlation is not an important problem for the 1972(1)-1978(4) data period there is evidence of significant serial correlation for the 1972(1)-1979(4) period.

Now in a relatively small sample of data, as we have here, the addition of just four new observations can upset the results if they are atypical. While certain events in 1979, such as the active use of MLR as an instrument of monetary control, a tax-switching policy in favour of indirect taxes, and the removal of exchange controls, might easily have upset the demand for money equation, the evidence from the fixed lag models did not suggest a structural breakdown.*

One interesting feature of the results is the value of the long-run income elasticity, which is always very close to unity. However, this result specifically depends on the suppression of the constant term; when the equation in Table 8.8 was re-estimated after including a constant the estimated long-run income elasticity was approximately 2.3, a result which is in broad agreement with the fixed lag model results.

The estimated long-run interest coefficients are higher in the flexible lag models than they are in the fixed lag models. This, however, is only true for cases in which

* Neither did the flexible lag models when a constant term appeared in the equations.
<table>
<thead>
<tr>
<th>Year</th>
<th>GDP</th>
<th>CPI</th>
<th>Unemployment</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>5%</td>
<td>2%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>2019</td>
<td>6%</td>
<td>3%</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>2020</td>
<td>7%</td>
<td>4%</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>2021</td>
<td>8%</td>
<td>5%</td>
<td>7%</td>
<td>6%</td>
</tr>
</tbody>
</table>

*Note: GDP and CPI data represent growth and price level, respectively.*

**Table 8.8**

**Flexible Price Model Results**

<table>
<thead>
<tr>
<th>Year</th>
<th>CPI</th>
<th>GDP</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>2%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>2019</td>
<td>3%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>2020</td>
<td>4%</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>2021</td>
<td>5%</td>
<td>8%</td>
<td>6%</td>
</tr>
</tbody>
</table>

*Note: CPI and GDP data represent growth and price level, respectively.*

**Table 8.9**

**Long-run Elasticity**

<table>
<thead>
<tr>
<th>Year</th>
<th>trade openness</th>
<th>GDP</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>0.5</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>2019</td>
<td>0.6</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>2020</td>
<td>0.7</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>2021</td>
<td>0.8</td>
<td>8%</td>
<td>6%</td>
</tr>
</tbody>
</table>

*Note: trade openness represents the degree of openness of the economy.*

**Table 8.10**

**Short-run Elasticity**

<table>
<thead>
<tr>
<th>Year</th>
<th>trade openness</th>
<th>GDP</th>
<th>Interest Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>0.4</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>2019</td>
<td>0.5</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>2020</td>
<td>0.6</td>
<td>7%</td>
<td>5%</td>
</tr>
<tr>
<td>2021</td>
<td>0.7</td>
<td>8%</td>
<td>6%</td>
</tr>
</tbody>
</table>

*Note: trade openness represents the degree of openness of the economy.*

**Table 8.11**

**Summary of Results**

- GDP growth is significantly influenced by trade openness and interest rates.
- CPI inflation is closely linked to interest rates and GDP growth.
- Interest rates show a clear upward trend, indicating monetary policy tightening over the years.

*Note: All data are subject to annual revisions.*
<table>
<thead>
<tr>
<th>D.W. S.F.</th>
<th>8' H</th>
<th>9' H</th>
<th>4' H</th>
<th>7' H</th>
<th>4' H</th>
<th>7' H</th>
<th>4' H</th>
<th>7' H</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972(1)-1979(4)</td>
<td>9.65</td>
<td>10.01</td>
<td>0.017</td>
<td>1.4</td>
<td>0.4</td>
<td>1.0</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>1972(1)-1979(4)</td>
<td>9.79</td>
<td>10.00</td>
<td>0.008</td>
<td>1.4</td>
<td>0.4</td>
<td>1.0</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>1972(1)-1979(4)</td>
<td>9.59</td>
<td>10.00</td>
<td>0.003</td>
<td>1.4</td>
<td>0.4</td>
<td>1.0</td>
<td>0.4</td>
<td>1.0</td>
</tr>
<tr>
<td>1972(1)-1979(4)</td>
<td>9.49</td>
<td>10.00</td>
<td>0.002</td>
<td>1.4</td>
<td>0.4</td>
<td>1.0</td>
<td>0.4</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Note**: The table above represents the Chow test for structural stability. The data points for each year are shown in the table, with each row indicating the stability of the relationship over the specified period.
In natural logarithms, F = 12.5

Except for R, the differential interest rate, rate PHI - PHI, all variables are expressed.

The figures in brackets shown under the explanatory variables in each of the three

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0000</td>
<td>0.0100</td>
<td>0.0200</td>
</tr>
<tr>
<td>0.0300</td>
<td>0.0400</td>
<td>0.0500</td>
</tr>
<tr>
<td>0.0600</td>
<td>0.0700</td>
<td>0.0800</td>
</tr>
</tbody>
</table>

Notes - Table 8.8 5.10
the intercept is suppressed and the long-run income elasticity relatively low at around unity. When a constant term is included in the equation then the long-run interest coefficient is close to the estimate suggested by the best fixed lag model results. *

8.3  Concluding comments
The fixed lag model results were generally superior to the flexible lag model results with the partial adjustment hypothesis providing an acceptable explanation of the dynamics.

Equations in which the price elasticity was freely determined gave more plausible results than cases in which either short-run or long-run homogeneity in prices was imposed. The best results were obtained when money demand was specified in real terms: a simple transactions model performed best with no significant explanatory role found for inflation expectations or the government bond rate. Each of the estimated coefficients were significant, had the correct signs and were of plausible magnitude. The long-run income and interest elasticities were 1.4 and -0.10, respectively, while the price elasticity of real money balances was -0.135. ** The speed of adjustment was approximately 1 year. The only trouble with this particular specification is that it cannot be formally derived from any of the conventional fixed lag models.

* Unfortunately the flexible lag model results cannot be accepted when a constant term is included.
** Equivalent to a price elasticity of 0.865 for nominal personal sector money balances.
For the partial adjustment model applied to nominal money balances the long-run income, price and interest rate elasticities were 2.33, 0.33 and -0.125, respectively, and the speed of adjustment was 2 years. The price elasticity seems unreasonably low at 0.33, although the income and interest rate elasticities are plausible enough and well-determined. Furthermore, when the data period was extended to cover 1979 the model proved structurally stable. The hypothesis of parameter stability could be accepted and the Chow test for structural stability was passed.

One result which clearly emerges for the personal sector is that money is a luxury good with the income velocity of money falling as income rises (at unchanged rates of interest). Another important result is that the price elasticity of personal sector nominal money-holdings is less than unity, although both its actual value and the associated adjustment period are in some doubt. There is some evidence from the best single equation results for £M3 to suppose that the 2 year adjustment lag, suggested in the nominal money equation, is more likely to be correct than the 1 year lag suggested in the equation for the personal sector's demand for real money balances. The suggested adjustment lag in the £M3 equation is 17 months, and given that company sector money demand adjustments are likely to be completed relatively quickly* - i.e. within 6 months - an estimate of 2 years for the personal sector would seem to be in order.

* For companies the size of returns to be made from portfolio adjustments will typically trivialise the brokerage costs involved thus encouraging quick adjustment following a change in relative interest rates.
APPENDIX A

The Personal Sector's Elasticity of Demand for Bank Deposits with respect to the Differential Interest Rate, $R_{BU} - R_{OR}$.

Since the best MP results were obtained from equations in which the interest differential entered directly, the coefficient on the variable cannot be interpreted as an elasticity. The elasticity will in fact vary with the size of the interest differential and the level of personal sector money-holdings. We can evaluate the value of the elasticity at the means of the variables as follows:

<table>
<thead>
<tr>
<th>Log RMP</th>
<th>$R_{BU} - R_{OR}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{x}$</td>
<td>9.8309</td>
</tr>
</tbody>
</table>

Now consider the impact of a percentage point increase in $R_{BU} - R_{OR}$ working from equation 3 in Table 8.4 - i.e. the best MP equation in which the price elasticity is restricted to unity. Since the estimated coefficient on $R_{BU} - R_{OR} = -0.014$ it follows that log RMP will fall by this amount following the increase.

<table>
<thead>
<tr>
<th>Natural log</th>
<th>(£M) Actual money-holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.8309</td>
<td>18600</td>
</tr>
<tr>
<td>- 0.0140</td>
<td>-</td>
</tr>
<tr>
<td>9.8169</td>
<td>18340</td>
</tr>
<tr>
<td></td>
<td>260</td>
</tr>
</tbody>
</table>
So, following a rise in \( R_{BU} - R_{OR} \) from 2.243 to 3.243, MP would fall by £260m which is a percentage change of \(-1.4\%\). A percentage point rise in the interest differential causes a fall in personal sector money-holdings of \(1.4\%\).

For the interest elasticity we require the percentage change in \( R_{BU} - R_{OR} \) from the mean value.

\[
\frac{3.243 - 2.243}{2.243} \times 100 = 44.6\%.
\]

Therefore the differential interest rate elasticity of MP as evaluated at the means of the variables is,

\[
\frac{-1.40\%}{44.6\%} = -0.031. \quad \text{Short-run elasticity}
\]

The long-run elasticity = \(-0.378\). (See equation 3, Table 8.4)
CHAPTER 9

THE COMPANY SECTOR'S DEMAND FOR MONEY

9.0 Introductory remarks

Although only short adjustment lags were anticipated for company money-holdings both fixed and flexible lag models were estimated. Since the former confirmed the expectation of quick adjustment and the latter failed to yield any sensible results for the post-CCC data period, only the fixed lag model results are presented in this chapter. In fact some of the estimated equations suggest that full adjustment to a market disturbance is completed within a single quarter.

In Section 9.1 the money demand behaviour of 'all industrial and commercial companies' is investigated. In the first instance a simple transactions demand model is considered in which no account is taken of possible domestic or international speculative influences. Factor cost GDP and the index of industrial production were used as alternative measures of the constraint variable, with the GDP deflator and the wholesale price index for manufactures alternatively representing the price variable. For the own-rate of interest on money variable the rate on 3-month certificates of deposit was used, and the rate on local authority temporary debt was

* In the circumstances the investigation of a monthly model would have been an interesting exercise. Unfortunately, however, neither the Bank of England nor the Department of Industry were able to supply a long series of monthly data for company sector money-holdings.

** It is recognized that the selected constraint variables are not entirely appropriate, but there is no reliable information on company sector wealth.
the preferred alternative asset rate. The local authority rate performed better than government bond rates, and, in terms of both volume of and variation in asset-holdings, local authority debt has been important in company portfolios over the relevant post-CCC data period.

Since other liquid assets are likely to be close substitutes for money with portfolio adjustment lags being reasonably short, the estimation of a dis-aggregated liquid assets demand model, for all industrial and commercial companies, was thought to be a worthwhile exercise. In section 9.1.3 a simple empirical model is estimated after first considering, in the context of a company sector liquid asset portfolio model, some of the theoretical properties of asset portfolio models. Before estimation some of the less important assets were dropped from the model, and there was some aggregation of assets. Multicollinearity problems made this aggregation and elimination of assets a necessary task. Since money and local authority temporary debt are very close substitutes for companies, the holdings of these were aggregated and called 'money'. Only two other assets were then included in the model, building society deposits and tax instruments: variation in asset-holdings was significant for each of these variables over at least part of the post-CCC data period.

Since money dominates the liquid assets portfolio, total holdings of selected liquid assets, LA, were not specified as the constraint variable in the model.* So, owing to the lack of any reliable data on the total asset-holdings

* It is, in any case, too narrow a measure of company sector financial wealth.
of companies, an income variable, GDP at current factor cost prices, was used. In addition to the relevant liquid asset rates of interest, the government long-term bond rate (2\(\frac{1}{2}\)\% consol rate) was included in the model in order to capture any significant speculative component in the company sector's demand for liquid assets.

Results for an aggregate company sector liquid assets demand model are reported in section 9.1.4. The constraint variable is nominal factor cost GDP, the own-rate of interest variable is variously specified,* and the long-term government bond rate and the exchange rate (in some of the equations) are included as additional explanatory variables.**

In section 9.2 the demand for money behaviour of large industrial and commercial companies is investigated. Data from the Department of Industry's survey of company liquidity is used: the survey covers a large, but non-random, sample of approximately 220 large companies. The income and price variables are represented by real factor cost GDP and the GDP deflator, respectively. While it is true that the money-holding behaviour of large companies need not be very closely associated with changes in domestic output, GDP is used in the absence of any comprehensive information on the total asset holdings of survey companies. For the own-rate on money

---

* Three alternative approaches to measuring a composite asset rate were discussed in section 3.1 of Chapter 3: (1) the best rate in each quarter on the various liquid assets held by companies; (2) a weighted average of the various relevant liquid asset rates; and (3) the rate on the most important asset in the portfolio in terms of both size of and variation in asset-holdings.

** These variables should pick-up any significant domestic or foreign speculative influences on company sector liquid asset demand.
variable the CD rate is specified, while the rates on local authority debt and long-term government bonds are specified as alternative measures of the substitute asset yield. The exchange rate, as measured by the 'sterling effective exchange rate', is included in some of the equations.

Equations are estimated for both aggregate survey company money-holdings and for holdings dis-aggregated by type of holder - i.e. manufacturing and non-manufacturing companies. Although it is recognized that the index of industrial production and the wholesale price index for manufactures are more appropriate explanatory variables for manufacturing companies, for reasons of consistency and ease of comparison with other results, factor cost GDP and its associated deflator are actually specified.

9.1 All industrial and commercial companies

In the first instance a simple transactions model was entertained with GDP at factor cost and the index of industrial production used as alternative income measures. The model was estimated in both untransformed linear and log-linear form.

In the work presented in this chapter on company sector money-holdings and other liquid assets, none of the equations include a variable to account for inflation expectations. However, uncertainty regarding (1) the appropriate choice of variable to successfully capture its influence, and (2) the significance of its role, provides some justification for omitting the variable from the empirical models. A further justification might be the suggestion that anticipated inflation is not a significant explanatory variable in either
the aggregate demand for time deposits or £M3 equations.*

In any case if inflation is important and has a systematic influence on company sector money-holdings this would cause a serial correlation problem in the context of a simple transactions demand model. If the RTE representation of the model is valid and yields plausible parameter estimates then this suggests that the model is in order and that inflation may have its main impact on adjustment speed without being of direct significance.

In an appendix to this chapter some of the ways in which anticipated inflation might be expected to influence the money-holding behaviour of companies are considered.

For the purposes of the empirical work holdings of M3 deposits by industrial and commercial companies represent company sector money demand. There are at least three reasons for defining the variable in this way:

(1) This is the closest one can get from published sources to a homogeneous group of companies.**

(2) No sectoral split is available from the Bank of England with regard to notes and coins in circulation; hence only company holdings of bank deposits can be considered.

(3) It has to be M3 deposits as opposed to £M3 or M1 deposits because the information is unavailable for the latter two series.***

* Although over-aggregation by type of holder and varying money demand adjustment speeds by the personal and company sectors could have led to this result.

** With the notable exception of DOI survey data on samples of (1) manufacturing and (2) non-manufacturing firms.

*** Information on company holdings of £M3 deposits is in fact available from 1975(2) onwards.
So, the definition of company money involves an unavoidable degree of aggregation in two dimensions:

(1) By holder since the aggregate deposits held by industrial and commercial companies cannot be broken down into (a) industrial and (b) commercial company-holdings.

(2) By type of money deposit held, since the definition employed, M3 deposits, comprises sight deposits, some of which pay interest, and time deposits which are various and include certificates of deposit.*

Before presenting the results it should be noted that over the data period 1972(1)-1979(4) there have been breaks in the series for company sector money-holdings. The only serious break occurs in 1975(2) when deposits were split into sterling and foreign currency deposits. The two estimates shown for this quarter differ by over £300 million with the larger figure being the new estimate. Initially a dummy variable was specified in the empirical model, taking the value 0 before 1975(2) and 1 from this quarter onwards, to account for the break in the series. However, since the dummy variable proved insignificant it was dropped from the empirical model and the break in the series was regarded as being of little consequence.

* In fact, company holdings of CD's can be separated from the other time deposits held, but no attempt is made to do this here, since these should be extremely close substitutes for most other forms of wholesale bank deposits which cannot be easily isolated in the company sector's portfolio of liquid assets.
9.1.1 Results - 1972(1)-1978(4): A simple transactions demand model

1. Untransformed linear model

(1) Structural Form

\[
MC = -4,888 + 49.0 \text{ IND} + 41.0 \text{ P}_{WH} + 72.3 \text{ R}_{CD} \\
-496.3 \text{ D}_1 -800.3 \text{ D}_2 -567.3 \text{ D}_3 + 0.51 \text{ MC}_{-1} \\
\text{ (2.1) (2.5) (1.5) (1.7) (3.3) (2.3) (2.7) } \\
\chi^2_{10} = 33.7 \quad R^2 = .988 \quad DW = 1.43
\]

(2) 
\[
MC = -7,634 + 0.33 \text{ Y} + 35.8 \text{ P} + 793.8 \text{ R}_{CD} -736.9 \text{ R}_{LA} \\
+ 0.56 \text{ MC}_{-1} \\
\text{ (3.9) (3.7) (3.3) (2.6) (2.5) (4.9) } \\
\chi^2_{10} = 5.66 \quad R^2 = .989 \quad DW = 2.08
\]

Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>\chi^2_4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>9.8</td>
<td>2.7</td>
<td>13.0</td>
<td>11.0</td>
<td>57.3</td>
</tr>
<tr>
<td>(2)</td>
<td>5.6</td>
<td>-2.7</td>
<td>7.3</td>
<td>6.8</td>
<td>24.36</td>
</tr>
</tbody>
</table>

Both equations failed the Chow test for structural stability.
(2) **Restricted Transformation Equation**

\[ \begin{align*}
(1) \quad MC &= -2774 + 62.6 \text{ IND} + 71.1 \text{ PWH} + 125.0 \text{ RCD} \\
& \quad -567.3 \text{ D1} -743.6 \text{ D2} -645.5 \text{ D3} + 0.15 \text{ MC}_{-1} \\
& \quad x^2_{10} = 29.7 \quad p = 0.58
\end{align*} \]

Test of validity of autoregressive restriction
\[-x^2_3 = 5.53\]

\[ \begin{align*}
(2) \quad MC &= -7757 + 0.34 \text{ Y} + 34.6 \text{ P} + 814.3 \text{ RCD} -759.8 \text{ RIA} \\
& \quad + 0.57 \text{ MC}_{-1} \\
& \quad x^2_{10} = 6.1 \quad p = -0.06
\end{align*} \]

Test of validity of autoregressive restriction
\[-x^2_4 = 8.35\]

**Percentage Forecast Errors - 1979**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>(x^2_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>10.1</td>
<td>1.4</td>
<td>11.9</td>
<td>8.1</td>
<td>51.45</td>
</tr>
<tr>
<td>(2)</td>
<td>5.6</td>
<td>-2.6</td>
<td>7.1</td>
<td>7.0</td>
<td>23.1</td>
</tr>
</tbody>
</table>

**Note** - since the autoregressive restriction is valid the results for the unrestricted transformation equation (URTE) are not shown.
2. Log-linear model

(1) Structural Form

\[ MC = -1.15 + 0.66 \text{IND} + 0.34 \text{WH} + 0.08 \text{CD} \]
\[ -0.07 \text{D}1 - 0.12 \text{D}2 - 0.08 \text{D}3 + 0.61 \text{MC}_{-1} \]
\[ x^{2}_{10} = 19.2 \quad R^{2} = .985 \quad \text{DW} = 1.39 \]

(2) Structural Form

\[ MC = -6.66 + 1.01 \text{Y} + 0.29 \text{P} + 0.90 \text{CD} - 0.84 \text{LA} \]
\[ + 0.61 \text{MC}_{-1} \]
\[ x^{2}_{10} = 7.7 \quad R^{2} = .985 \quad \text{DW} = 1.82 \]

Percentage Forecast Errors - 1979

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>(x^2_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>9.3</td>
<td>4.4</td>
<td>15.4</td>
<td>11.9</td>
<td>22.7</td>
</tr>
<tr>
<td>(2)</td>
<td>5.2</td>
<td>-2.7</td>
<td>9.0</td>
<td>10.5</td>
<td>9.33</td>
</tr>
</tbody>
</table>

Only equation (2) passed the Chow test for structural stability.
(2) **Restricted Transformation Equation**

\[
MC = 0.28 + 0.91 \text{IND} + 0.60 \text{P}_{WH} + 0.12 \text{R}_{CD} \\
-0.07 \text{D}_1 -0.10 \text{D}_2 -0.09 \text{D}_3 -0.04 \text{MC}_{-1} \\
\chi^2_{10} = 17.1 \quad p = 0.88 \\
(2.5) \quad (1.3) \quad (2.5) \quad (1.9) \quad (2.8) \quad (3.5) \quad (0.2)
\]

Test of validity of autoregressive restriction
\[-x^2_3 = 2.99\]

(2) \[
MC = 0.18 + 0.73 Y + 0.71 P + 0.57 \text{R}_{CD} -0.46 \text{R}_{LA} \\
+ 0.07 \text{MC}_{-1} \\
\chi^2_{10} = 13.3 \quad p = 0.79 \\
(0.3) \quad (2.9) \quad (3.4) \quad (1.6) \quad (1.3) \quad (0.4)
\]

Test of validity of autoregressive restriction
\[-x^2_4 = 3.1\]

**Percentage Forecast Errors - 1979**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>(x^2_4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>7.1</td>
<td>-1.3</td>
<td>9.7</td>
<td>2.6</td>
<td>7.0</td>
</tr>
<tr>
<td>(2)</td>
<td>1.4</td>
<td>-2.1</td>
<td>8.2</td>
<td>5.4</td>
<td>4.2</td>
</tr>
</tbody>
</table>

**Note** - Since the autoregressive restriction is valid the results for the URTE are not shown.
The post-sample parameter stability tests \( (x_4^2) \) covering the four quarters of 1979 reveal that the untransformed linear model is unstable for both representations of the model, whereas the parameters of the log-linear model are stable for the RTE.

For the specification in which the index of industrial production represents the income variable, instability might be due to erroneous seasonal adjustment of the data. In the untransformed linear model the seasonal shifts remain constant in value regardless of the upward trend in the values of the variables. If the adjustment is proportional rather than constant then only the dummies in the log-linear model will pick-up the seasonal influences correctly. However, when factor cost GDP was used to represent the income variable the seasonal dummies proved insignificant and were therefore dropped from the model. Despite their exclusion the untransformed linear model still clearly failed the post-sample parameter stability test: for the SF calculated \( x_4^2 = 24.4 \) and for the RTE \( x_4^2 = 23.1 \); values which are well above the critical \( x_4^2 \) value of 9.5 (5% significance level). In contrast, the log-linear results suggested that the parameters of the RTE were comfortably stable, and it was just possible, at the 5% significance level to accept the hypothesis of parameter stability for the SF.

It would appear, then, that the parameter instability suggested by the untransformed linear results is not caused by incorrectly specified seasonal dummies, so that the log-linear specifications are to be preferred on stability grounds.

---

* The method of seasonal adjustment most commonly applied is 'percentage of trend.'
Both classes of linear model yield sensible results with most of the estimated coefficients significantly different from zero at the 5% level. The adjustment speeds suggested by both representations of the model are quite rapid; in the case of the RTE, adjustment is particularly quick and is virtually completed within a single quarter. The SF and RTE results for the untransformed linear model suggest that GDP is the appropriate constraint variable. The random correlogram test \( \chi^2 \) shows that the hypothesis of random residuals is decisively rejected when the index of industrial production represents the income variable; calculated \( \chi^2 \) is in the region of 30 which is substantially higher than the critical value of 18.2. In contrast, the hypothesis of random residuals can be comfortably accepted when GDP represents the constraint variable. For the log-linear model the hypothesis of random residuals can once again be accepted in the GDP case, but it must be rejected for the SF and can only just be accepted for the RTE when the index of industrial production is used.

Since the log-linear models are clearly superior in terms of ex-post forecasting performance and post-sample parameter stability I will focus on just these.

Both the SF results are subject to significant positive 1\(^{st}\) order serial correlation and the RTE results indicate that \( p \) is very high; 0.88 and 0.79 for the index of industrial production and GDP cases, respectively. * Since

* Significant 1\(^{st}\) order serial correlation in the residuals is not inconsistent with the random residuals suggested by the \( \chi^2 \) test in the 'GDP equations' since the random correlogram test only indicates that high order serial correlation is not a problem.
a $x^2$ test showed the autoregressive restriction to be valid, adjusting for 1st order serial correlation is seen to be an empirically correct procedure, and as such the RTE is the appropriate representation of the model. In both the RTE equations the hypothesis of random residuals can be accepted according to the random correlogram test ($x^2_{10}$). Tests were conducted for higher order serial correlation up to the 4th order, but none of the $p_i$ were significantly different from zero.

Despite the size and significance of the 1st order serial correlation coefficient, and the validity of the non-linear parameter restrictions, it is still of interest to compare the long-run elasticities derived from the SF and RTE equations. The estimates are presented in Table 9.1 below together with the implied equilibrium adjustment speeds.

The SF results suggest that money is a luxury good as far as the company sector is concerned, with estimated income elasticities well in excess of unity. In contrast the income elasticities are lower than unity in the RTE cases. The SF results suggest much higher interest elasticities and a slower speed of adjustment; just over two quarters as opposed to three months.

It is of interest to compare these results with those of other researchers such as Hacche (59) and Price (112) who estimated demand-for-money equations for the company sector over the pre-CCC period. Their results are shown in Table 9.2. Although the variables used by the two researchers differ, and are different from the explanatory variables in my own model, some interesting comparisons can be made.
### TABLE 9.1
Long-run Elasticities and Speeds of Adjustment

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>P</th>
<th>R\text{CD}</th>
<th>R\text{LA}</th>
<th>Adjustment Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF (1) IND, P\text{WH}</td>
<td>1.69</td>
<td>0.87</td>
<td>0.21</td>
<td>-</td>
<td>7.7 months</td>
</tr>
<tr>
<td>RTE (2) IND, P\text{WH}</td>
<td>0.91</td>
<td>0.60</td>
<td>0.12</td>
<td>-</td>
<td>3 months</td>
</tr>
<tr>
<td>SF (3) Y, P</td>
<td>2.59</td>
<td>0.74</td>
<td>2.31</td>
<td>-2.15</td>
<td>7.7 months</td>
</tr>
<tr>
<td>RTE (4) Y, P</td>
<td>0.73</td>
<td>0.71</td>
<td>0.57</td>
<td>-0.46</td>
<td>3 months</td>
</tr>
</tbody>
</table>

Note - In both RTE equations, (2) and (4), the coefficient on the lagged money stock was very small \(<0.10\) and highly insignificant. Therefore adjustment was assumed to be completed within a single quarter so that the impact elasticities are the equilibrium long-run elasticities.

### TABLE 9.2
Company Sector Results for the Pre-CCC Period - Long-run Elasticities and Speeds of Adjustment

<table>
<thead>
<tr>
<th></th>
<th>Y</th>
<th>P</th>
<th>R\text{LA}</th>
<th>R\text{L}</th>
<th>Adjustment Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 PRICE 64(1)-70(4)</td>
<td>2.77</td>
<td>0.41</td>
<td>-0.36</td>
<td>-</td>
<td>Y - 2 quarters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P - 1 quarter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R - Most of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>adjustment in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1 quarter</td>
</tr>
<tr>
<td>2 HACCHE 63(4)-71(3)</td>
<td>0.51</td>
<td>1.0\text{+}</td>
<td>-0.07</td>
<td>-0.20</td>
<td>4.8 months</td>
</tr>
</tbody>
</table>

+ Long-run price elasticity constrained to unity.

Note - Whereas Price used an industrial output series for Y and wholesale prices for P, Hacche used TFE and TFE prices. R\text{LA} = 3 month local authority rate and R\text{L} = gross redemption yield on 2\% consols. Price used a flexible lag model whereas Hacche used a fixed lag model.
Firstly, adjustment speeds are certainly quick in both equations with an average adjustment speed of well under six months. Now in view of the higher and more variable rates of inflation during the 1970's one would anticipate even quicker adjustment by companies in the post-CCC era, so that the adjustment speeds of 3 months suggested by the RTE results, in Table 9.1 above, seem more realistic than those suggested by the SF results.

The issue regarding the size of the income elasticity is far from settled: Price's results suggest that money is a luxury good whereas Hacche's results suggest strong economies of scale in money-holding. If Hacche can be criticised for imposing long-run homogeneity in prices, then it must be said that the freely estimated price elasticity does, at 0.41, seem rather low in Price's equation.

In view of the fact that the RTE results for the post-CCC data period yielded the more realistic estimates for adjustment lags and that the empirically valid representation of the model was the RTE, the results for this particular specification are taken to correctly describe company sector money-holding behaviour within the context of a simple transactions demand model.

Another reason for preferring the RTE to the SF log-linear results is the superior ex-post forecasting performance of the former. Although the RTE results for both the index of industrial production and factor cost GDP equations are reasonable enough and pass all the relevant tests, GDP is the preferred explanatory variable in view of (1) the hypothesis of random residuals can be more confidently
accepted and (2) a marginally better ex-post forecasting performance over 1979.*

So, accepting the log-linear RTE as the appropriate representation of the model, with factor cost GDP as the constraint variable, the following conclusions can be drawn from the empirical results:

(1) There are economies of scale in company sector money-holding.

(2) Since the long-run price elasticity is only 0.71 real money-holdings have tended to fall with rising prices over the period.

(3) As expected, money-holdings are sensitive to changes in the own-rate on money, as measured by the CD rate, and the rates of interest on alternative liquid assets.

(4) The speed of adjustment is very fast with full adjustment to any market disturbances being completed within a single quarter. Anticipated inflation has probably influenced the speed at which companies adjust their asset portfolios.

In view of the fact that the 1st order serial correlation coefficient, was reasonably close to and not significantly different from unity, a first difference model was entertained and estimated. As can be seen from Table 9.3 overleaf the RTE and 1st difference results are similar.

* The weaker performance of the company money demand equations in which the index of industrial production is the constraint variable might well be due to the fact that an own-rate on money variable, RCDP, is the only interest rate in the equation. Severe multicollinearity problems ruled out the inclusion of any alternative rates.
TABLE 9.3
A Comparison of RTE and 1st Difference Elasticities

<table>
<thead>
<tr>
<th></th>
<th>Income</th>
<th>Price</th>
<th>Own-rate</th>
<th>LA rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RTE : IND</td>
<td>0.91</td>
<td>0.60</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>DIFF : IND</td>
<td>1.00</td>
<td>0.74</td>
<td>0.15</td>
</tr>
<tr>
<td>3</td>
<td>RTE : GDP</td>
<td>0.73</td>
<td>0.71</td>
<td>0.57</td>
</tr>
<tr>
<td>4</td>
<td>DIFF : GDP</td>
<td>0.63</td>
<td>0.76</td>
<td>0.61</td>
</tr>
</tbody>
</table>

9.1.2 An asset portfolio model for the company sector

This section focuses on the short-term, capital-certain financial assets which are held by companies, so that wealth effects arising on capital risky assets, when interest rates change, are not covered.*

The liquid assets held by industrial and commercial companies are shown in Table 9.3 of 'Financial Statistics': if we exclude government securities from the model then we are mainly left with capital-certain assets. A set of behavioural equations for these liquid assets is set out below in loose functional form:

\[
\begin{align*}
(1) \quad MC &= f_1 (LA, Y, R_{MC}, R_{BU}, R_{OFI}, R_{TB}, R_{TI}, R_{l1}, R_{l2}) \\
(2) \quad BU &= f_2 (\quad) \\
(3) \quad OFI &= f_3 (\quad) \\
(4) \quad TB &= f_4 (\quad) \\
(5) \quad TI &= f_5 (\quad) \\
(6) \quad l_1 &= f_6 (\quad) \\
(7) \quad l_2 &= f_7 (\quad) \\
LA &= MC + BU + OFI + TB + TI + l_1 + l_2
\end{align*}
\]

* For a discussion of the problems which capital-risky assets pose, including measurement of expected asset yields, uncertainty and the wealth effect see Goodhart (56); in particular p.59 and p.60.
Variable definitions

MC = Bank deposits
BU = Building society deposits
OFI = Deposits with other financial institutions
TB = Market treasury bills
TI = Tax instruments
la1 = Local authority temporary debt
la2 = Local authority longer-term debt

RMC = Own-rate on money
RBU = Building society deposit rate
LA = Total holdings of selected liquid assets excluding government bonds
Y = Total sales receipts

The explanatory variables include the interest rates on each of the liquid assets, a narrow measure of wealth covering the liquid assets included in the model and company sales receipts. Although wealth effects, arising from changing rates of interest, are absent in this dis-aggregated liquid assets model, income effects will arise - i.e. both income and substitution effects are relevant. In order to measure these separate effects total holdings of liquid assets can be split up as follows:

$$LA_t = LA_{t-1} + S_t$$

Where $S_t = \Delta LA_t = \text{addition to company sector wealth, held in the form of liquid assets, during the current time period.}$

A behavioural equation for $S_t$ can then be added to the model as follows:

$$S_t f(Y, R_i^S, R_B^F)$$
Where,

- \( Y \) = Total sales receipts
- \( R_i^S \) = Rates of interest on liquid assets
- \( R_i^E \) = Expected returns on capital risky assets.

Setting out the model in matrix form we have:

\[
\begin{array}{ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
Since,

$$LA = MC + BU + OFI + TB + TI + la_1 + la_2$$

(2) $$LA = LA_{t-1} + S_t$$

it follows that restriction (a) must hold.

However, since there is no particular reason for companies to hold newly-acquired wealth in the same way as they hold their existing wealth, in terms of portfolio balance, it follows that $$a_{iL}$$ need not equal $$a_{iS}$$. For example, the proportion of existing wealth, $$LA_{t-1}$$, held in the form of bank deposits could well differ from the proportion of company savings, $$S_t$$, held in this form.*

Now assuming we can successfully isolate the pure substitution effects from the income effects so that the matrix of $$b_i$$ coefficients measures substitution effects alone, we can impose further restrictions as follows:

$$\sum b_{ij} = 0$$

This says that the sum of interest rate coefficients along each row of the matrix must total zero. So, if all rates were to rise by the same amount and total holdings of liquid assets remained unchanged, then since there is no change in interest differentials companies would have no incentive to adjust their portfolios. Consequently, if the level of each type of liquid asset - e.g. bank deposits - is to remain unchanged the sum of the interest coefficients

* This might, of course, simply be due to portfolio adjustment lags although the simple transactions model results for company sector money demand suggested quick adjustment.
across the rows must be zero.*

(d) $b_{ij} = b_{ji}$

This says that the flow of funds into asset $i$ as the yield on asset $j$ falls by a given amount should be exactly the same as the flow out of asset $j$ as the yield on asset $i$ rises by the same given amount, once the adjustment process is fully completed. For example, if the rate on building society deposits falls by 1 percentage point, with other rates unchanged, and as a result £50m. of funds are lost to the banks, companies will switch precisely the same amount of funds from building society deposits to bank deposits following a 1 percentage point rise in the rate offered by banks (other rates unchanged). In standard price theory this is known as the slutsky effect.

Now with $b_{ij} = b_{ji}$ and $\sum b_{ij} = 0$ it immediately follows that $\sum b_{ji} = 0$. So, if the 'slutsky effect' holds then the sum of the interest rate coefficients will be zero both across rows and down columns.

The main diagonal of the sub-matrix of interest rate coefficients, $b_{11} - b_{77}$, shows the own-rates on each of the assets which companies hold, and these should all be positively signed. The off-diagonal parameters are the substitute asset rate coefficients which should all be negatively signed.** From the restrictions outlined above

---

* This rather suggests that for given levels of wealth companies will only pay attention to relative interest yields. Even if this is the case the rates used would need to be correctly measured post-tax rates.

** Complementary assets are not expected and if such cases are found in empirical work it may well indicate modelling errors or incorrect data.
it must be the case that the sum of positive own-rate coefficients along the main diagonal is exactly balanced by the sum of negative substitute asset rate coefficients in off-diagonal space, when dealing with the pure substitution effect.

A simple example using some figures to represent the interest rate coefficients is shown below.

**Example - a 3 asset model**

<table>
<thead>
<tr>
<th></th>
<th>( r_1 )</th>
<th>( r_2 )</th>
<th>( r_3 )</th>
<th>( \xi b_j )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_1 )</td>
<td>10</td>
<td>-4</td>
<td>-6</td>
<td>0</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>-4</td>
<td>6</td>
<td>-2</td>
<td>0</td>
</tr>
<tr>
<td>( A_3 )</td>
<td>-6</td>
<td>-2</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>( \xi b_i )</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Despite the attractions of an asset portfolio approach for an empirical study of the simultaneous determination of the company sector's demand for liquid assets, there are several serious difficulties in employing it.

Firstly, with all the interest rates and other explanatory variables which must be included the size of the matrix will be very large and many degrees of freedom will be lost in estimation.

Secondly, since many of the interest rates on the alternative company sector liquid assets move closely together, multicollinearity problems will make it difficult to clearly observe how the system responds to disturbances.

Perhaps the most serious difficulty concerns the data itself. The detailed balance sheet data required is not
fully available and some of the data which has been constructed is of questionable quality.

9.1.3 Results - 1972(1)-1978(4):
A dis-aggregated liquid assets demand model
In view of the above-mentioned empirical difficulties concerning the application of the asset portfolio model, as developed in the previous section, only a very simple empirical model, based on company sector data taken from 'Financial Statistics',* is considered here.

The size of the matrix is reduced by (1) omitting assets where company holdings have been small and have shown little variation over the relevant data period and (2) aggregating deposits where they are known to be very close substitutes - i.e. where the simple correlation between the rates of interest on two assets is close to unity. This procedure should help to minimise the multicollinearity problems which arise when all the relevant interest rate variables are included in the empirical model.

The basic model is as follows:-

(1) \[ MC^+ = a_0 + a_1 LA_{t-1} + a_2 \Delta LA_t + a_3 Y_t + b_{11} R_{CD} + b_{12} R_{BU} + b_{13} R_{TI} + \lambda_{1 MC^+} \]

(2) \[ BU = a_4 + a_5 LA_{t-1} + a_6 \Delta LA_t + a_7 Y_t + b_{21} R_{CD} + b_{22} R_{BU} + b_{23} R_{TI} + \lambda_{2 BU} \]

* The data is taken from Table 9.3: selected liquid assets of industrial and commercial companies.
(3) \[ .TI = a_8 + a_9 LLA_{t-1} + a_{10} \Delta LLA_t + a_{11} Y_t + b_{31} \lambda_{31} \]
\[ + b_{32} \lambda_{32} + b_{33} LTI_t + \lambda_{34} \lambda_{34} \]

(4) \[ \Delta LLA = a_{12} + a_{13} Y_t + b_{41} \lambda_{41} W + c_{42} E + \lambda_{43} \Delta LLA_{t-1} \]

**Identities**

\[ 1 \quad LLA_t = LLA_{t-1} + \Delta LLA_t = MC^+ + BU + TI \]

**Parameter restrictions**

1. \[ a_1 + a_5 + a_9 = 1 \]
2. \[ a_2 + a_6 + a_{10} = 1 \]
3. \[ \leq b_{ij} = 0 \]
4. \[ b_{ij} = b_{ji} \]

**Notes**

(1) All variables are as defined in section 9.1.2 except MC^+. Since the simple correlation between the rates of interest on local authority debt and certificates of deposit is 0.99 for the data period 1972-1979, bank deposits are combined with local authority debt and called money.

\[ MC^+ = MC + la_1 + la_2 \]

(2) Since holdings of market treasury bills, TB, and deposits held with non-bank financial institutions (excluding building societies), OFI, have not been particularly significant in company portfolios, they have been dropped from the model. This achieves two important advantages: firstly, the size of the data matrix is reduced so that more degrees of freedom are available for estimation; and secondly, the reduced
number of interest rate variables in the model will considerably ease multicollinearity problems. In fact as the correlation matrix in Table 9.4 shows, the highest simple correlation between interest rates is now only 0.82; this is for the building society deposit rate and the government bond rate. The correlation between $R_{CD}$ and $R_{BU}$ is only 0.64.

(3) Although not shown in the model specification above, allowance was made for serially correlated residuals; in particular, 1st order serial correlation.

(4) Ideally the lag structure should be empirically determined, but the size of the data matrix is already large enough. In view of this a naive general stock adjustment hypothesis is assumed to apply. Since the lags are likely to be short with most adjustments completed within a single period, the issue of lag structure is not, in any case, especially important.

(5) The model is assumed to be linear either in terms of the untransformed data, or after log transformation. Both versions are to be tested.

In fact, in view of the number of simplifications which have had to be made and the very narrow measure of wealth being considered, further changes were made before estimating the above model. Since money-holdings, $M_C$, represent a large percentage of the total selected liquid
assets held, a highly significant relationship between the two variables is inevitable, and as such the wealth measure was dropped in favour of an income measure. Furthermore, although the sales and investment receipts of industrial and commercial companies clearly represent the most appropriate income measure for empirical work, no such series can be obtained from published sources. As a result, nominal factor cost GDP was selected.

Dropping LA from the model means that $R_B^E$, the expected rate of return on bonds, must now be additionally included in equations (1)-(3) above. In the above model $R_B^E$ represented the opportunity cost of holding liquid assets (equation (4)). Finally, equations for both $Y_{CU}$ and $R_B^E$ are added to the model giving the following set of equations:

(1) $MC^+ = A_1 + a_1 Y_{CU} + b_{11} R_C + b_{12} R_B + b_{13} R_{TI} + c_{1}^L + \lambda_{1 MC}^+$

(2) $BU = A_2 + a_2 Y_{CU} + b_{21} R_C + b_{22} R_B + b_{23} R_{TI} + c_{2}^L + \lambda_{2 BU}^+$

(3) $TI = A_3 + a_3 Y_{CU} + b_{31} R_C + b_{32} R_B + b_{33} R_{TI} + c_{3}^L + \lambda_{3 TI}^+$

(4) $Y_{CU} = A_4 + d_1 A + d_{2}^L + \lambda_{4 Y}^+$

(5) $R_B^L = A_5 + e_1 Y_{CU} + e_{2}^W + \lambda_{5 R}^L$

Definitions of new variables

$R_B^L$ = Redemption yield on 2½% consols. It is assumed here that this yield reflects the expected return on bonds.

$Y_{CU}$ = GDP at current factor cost prices.

$A$ = Autonomous expenditure at current prices: investment + government consumption + exports.

$R_W^L$ = A weighted average of the short-term rates of interest on company sector liquid assets.
Notes

1. The parameter restrictions on the $a_i$ coefficients in the previous model are now irrelevant.

2. The theoretical restrictions placed on the interest rate coefficients are not imposed. Because of (1) aggregation and omission of variables and (2) the use of single asset interest rates to represent the returns on composite assets, it is rather unlikely that the theoretical restrictions would in fact hold. In view of this the parameters are freely estimated.

3. Simply using the redemption yield on consols to represent the expected return on bonds is only likely to be reasonable in the face of considerable uncertainty regarding future rates. Account should be taken of this risk or uncertainty but there is no really satisfactory way of doing this.*

The log-linear model specification yielded the most plausible set of results. As there was evidence of significant $1^{st}$ order serial correlation in the residuals the SF results were rejected. $x^2$ tests based on a comparison of the sums of squared residuals from the URTF and the RTF clearly indicated that the latter representation of the model was valid in each case. As such, only the RTF results are presented below.

Although the model includes equations for both $Y_{CU}$ and $R^L_B$, these variables are 'redundant' as endogenous regressors in the equations of interest, (1)-(3).** It can readily be seen

---

* Some possible measures of the riskiness of bonds together with criticisms of these were discussed in Chapter 3, Section 3.2

** Although this is true of the model as it stands it would not be the case in a fully specified portfolio model.
that while simultaneity is important in equations (4) and (5), there is no simultaneous feedback postulated between any of the liquid assets and either income or the long-term bond rate. So, as the model stands, it is quite legitimate to use single equation methods to estimate each of the liquid asset demand equations. The RTF is estimated by ALS and the results are as follows:

(1) \[ MC^* = 0.461 + 0.52Y_{CU} + 0.18R_{CD} -0.10R_{BU} -0.02R_{TI} \]
\[ -0.30R_{L} + 0.09MC^* \]
\[ p_1 = 0.88 \quad x_{10}^2 = 7.82 \quad x_4^2 = 7.44 \quad F_{4,20} = 1.32 \]

(2) \[ BU = 0.337 + 0.13Y_{CU} -0.25R_{CD} + 0.03R_{BU} + 0.02R_{TI} \]
\[ + 0.08R_{L} + 0.70BU \]
\[ p_2 = 0.49 \quad x_{10}^2 = 8.22 \quad x_4^2 = 0.16 \quad F_{4,20} = 0.05 \]

(3) \[ TI = -4.39 + 6.26Y_{CU} -1.64R_{CD} -0.71R_{BU} -0.05R_{TI} \]
\[ + 2.22R_{L} + 0.34TI \]
\[ p_3 = 0.93 \quad x_{10}^2 = 17.39 \quad x_4^2 = 2.77 \quad F_{4,20} = 0.55 \]

(4) \[ Y_{CU} = 0.812 + 0.90A -0.15R_{L} + 0.02Y_{CU} \]
\[ p_4 = 0.42 \quad x_{10}^2 = 35.2 \quad x_4^2 = 1.79 \quad F_{4,23} = 0.42 \]

(5) \[ R_{L} = 0.39 -0.035Y_{CU} + 0.24R_{LA} + 0.76R_{L} \]
\[ p_5 = -0.39 \quad x_{10}^2 = 5.02 \quad x_4^2 = 18.41 \quad F_{4,23} = 2.06 \]
Notes

\[ p_1 = \text{1st order serial correlation coefficients.} \]
\[ MC = MC - p_1 MC_{-1} \text{ etc.} \]
\[ x^2_{10} = \text{Random correlogram test} \]
\[ x^2_4 = \text{Post-sample parameter stability test} \]
\[ F_{4,20} = \text{Chow test for structural stability} \]

Since equations (4) and (5) are subject to simultaneous feedback relationships they were estimated by 2SLS allowing for 1st order serial correlation in the residuals.

For equation (1) above, the money demand equation, the ex-post forecast errors for 1979 are as follows:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>6.5</td>
<td>-0.6</td>
<td>6.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Despite the fact that the correlation between interest rates, as shown in Table 9.4, is not particularly high for any pair of interest variables, most of the interest coefficients are not significantly different from zero with some having t-statistics of less than unity.

Only the CD and government bond rates are significant in equation (1). For the building society deposits and tax instruments equations only the CD rate is significant. The relevant matrix of interest rate coefficients is shown overleaf.
The main diagonal relating to the three types of liquid assets held shows the own-rate interest elasticities while the off-diagonal elements show the cross-interest elasticities. The theoretical expectation is that the own-rate elasticities should be positive, while the cross-rate elasticities, including those associated with the bond rate, should all be negative. Ignoring the question of statistical significance it can be seen that each of the interest elasticities have the correct signs in the money demand equation. For building society deposits the CD rate enters with the expected negative sign and the own-rate coefficient although small and insignificant has the expected positive sign. The coefficient associated with the rate on tax instruments is negligible, which suggests that the two assets are not regarded as substitutes by companies. Finally, a positive elasticity of some significance is associated with the government bond rate and this contradicts theoretical expectation. However, since building societies are important purchasers of government debt, increased borrowing by the government from the non-bank private sector will raise the interest rates on government securities and attract funds from the building societies. The building societies, in turn, must bid for new funds to make these profitable loans and offer
The matrix covers each of the explanatory variables which appear in the VRTF representations. The matrix is as follows:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>RIA</th>
<th>MC-2</th>
<th>RII-1</th>
<th>Rd-1</th>
<th>RCD-1</th>
<th>YCU-1</th>
<th>YCU-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RIA</td>
<td>0</td>
<td>0.1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>MC-2</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RII-1</td>
<td>0.0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rd-1</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RCD-1</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>YCU-1</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>YCU-2</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: The table represents the correlation matrix for explanatory variables.
higher interest rates to investors. In this situation an increase in the government bond rate is associated with an increase in the rate of interest on building society deposits. The correlation matrix in Table 9.4 confirms the strong positive correlation between the two rates; $R = 0.82$, which, as indicated above, is the highest correlation between the alternative pairs of interest rate variables. In view of all this it is hardly surprising that an increase in company holdings of building society deposits is associated with an increase in the government bond rate. Indeed, the results suggest that the bond rate would serve as a better own-rate measure than the building society deposit rate, itself!

In the tax instruments equation only the CD and the building society deposit rate coefficients have the expected signs. The interest elasticities are relatively large compared with those for money and building society deposits. This is probably due to incorrect specification of the equation: during the last 18 months of the data period company holdings of tax instruments grew very sharply and a dummy plus time trend variable should have been included to take account of this sudden dramatic growth in asset holdings.

Focusing on the money demand equation it can be seen that if the rates of interest on each of the liquid assets were to rise by 10% while the bond rate remained unchanged, then the predicted response of company money-holdings is an increase of approximately 0.6% - i.e. $\leq$ short-rate elasticities $\times 10$. Furthermore, in view of the small and insignificant coefficient on lagged money-holdings which suggests quick adjustment, the increase of 0.6% represents the full response. Since each of the liquid assets held by companies have become
more attractive relative to government bonds this result is to be expected with companies shifting out of bonds and into a variety of capital-certain assets including money. If the CD rate rose by 10%, with all other rates remaining unchanged, then the equation suggests that company money-holdings would rise by 1.8%.

In contrast, if the government bond rate rose by 10% then company money-holdings are predicted to fall by 3%, which is clearly a more dramatic response than is predicted for equivalent rises on either building society deposits or tax instruments. This result clearly points to the importance of a speculative demand for money by companies.

Equation (5) suggests that following a 10% increase in short-term interest rates the long-term government bond rate will rise by 2.4% in the first quarter and will not finish adjusting until a year after the original change in short rates. After the adjustment is completed the bond rate also rises by 10%. According to this result a general rise in short rates indicates that capital losses can be expected on government bonds if companies intend to hold them for relatively short periods - i.e. less than a year.

In view of the fact that a broad measure of company sector wealth was not available from official sources an income variable, nominal factor cost GDP, was used to represent the constraint variable. For building society deposits held by companies the short-run income elasticity was 0.13 and the long-run elasticity was 0.43; full adjustment being completed after 10 months. In view of the fact

* The estimated short-run elasticity was not, however, significantly different from zero at the 5% or 10% levels.
that the tax instrument equation requires the addition of dummy and trend variables to capture the rapid growth towards the end of the data period, it is hardly surprising that the estimated income elasticity of 6 is unrealistically high! Finally, the income elasticity of company sector money-holdings was well-determined with a t-statistic of 3.1. The estimated elasticity was 0.52 with full adjustment to a change in income virtually completed after one quarter. This result is in agreement with the theoretically expected value in Baumol's 'inventory-theoretic' model.* It suggests important scale economies in money-holdings.

Since GDP is not really an appropriate constraint variable for company holdings of liquid assets it follows that the estimated interest elasticities must be treated with caution. Some explanation of the variation in company sector demand for liquid assets is perhaps being incorrectly attributed to the interest rate variables. As the empirical model stands it is not possible to impose theoretical restrictions on the interest rate coefficients and all that can really be done is to check that the own-rate and cross-rate coefficients are plausible - i.e. they have the expected signs and are of sensible size.

Equations (4) and (5) indicate that there is some simultaneous feedback between the income and government bond rate variables. Equation (4) suggests that a 10% rise in the government bond rate - e.g. a rise from 10 to 11% - will result in a 1.5% fall in GDP for a given level of autonomous expenditure. This fall in GDP feeds into the bond rate

* Baumol (17) p.550 and 551.
equation causing a small rise in the bond rate which feeds back into the income equation. So the feedback process continues becoming progressively weaker before eventually dying out. The importance of this feedback is, however, in some doubt since neither the interest coefficient in equation (4) nor the income coefficient in equation (5) are significantly different from zero at the 5% significance level.

Since the 1\textsuperscript{st} order serial correlation coefficients are not significantly different from unity in either the money or the tax instrument demand equations a 1\textsuperscript{st} difference model would be empirically valid. However, in the case of building society deposits the 1\textsuperscript{st} order serial correlation coefficient is only 0.49 and since the t-statistic associated with the coefficient is only 1.7 one could accept either the hypothesis that $p = 0$ or the hypothesis that $p = 1$, at the 5% significance level.

The hypothesis of random residuals ($x_{10}^2$) can be accepted for all equations except the income equation. Only the bond rate equation fails the post-sample parameter stability test ($x_4^2$) and all equations pass the Chow test for structural stability ($F_{4,20}$).

The forecast errors shown for the most important liquid asset held, money\(^*\), were very small in the 2nd and 4th quarters of 1979 - i.e. $<1\%$ - whereas relatively large over-prediction errors of over 6\% occurred in the 1\textsuperscript{st} and 3\textsuperscript{rd} quarters of that year. Since seasonally unadjusted data was used and no seasonal dummies specified it is possible that seasonal factors might account for the large percentage errors in the

\(^*\) 'Money' = Bank deposits + local authority debt.
1st and 3rd quarters of 1979. For the 1st quarter over-prediction might well be expected since companies will typically be re-stocking, awarding pay increases to labour and paying taxes. However, 'seasonal influences' cannot explain the large 3rd quarter error, which might be related to the late June budget of that year. Furthermore, since companies typically build-up money-holdings in the 4th quarter in readiness for the payments that must be made in the following quarter one might expect a significant under-prediction error on seasonal grounds; the forecast error for the 4th quarter of 1979 was, at less than 1%, negligible. Finally, since seasonal dummies were included in the transactions demand model and were found to be insignificant when GDP was specified as the constraint variable, this would appear to indicate that either seasonal influences are not especially important or that the seasonal pattern has changed over the relevant data period, 1972(1)-1979(4).

9.1.4 Results - 1972(1)-1978(4):
An aggregate liquid assets demand model

The empirical model entertained is as follows:

(1) \[ LA = A + b_1 Y_{CU} + b_2 R_{LA} + b_3 R_{RB} + (b_4 E_X) + b_5 LA_{-1} + u \]

(2) \[ u = p_1 u_{-1} + e \]

(all variables are expressed in natural logs.)

* Evidence from the DOI survey of large industrial and commercial companies suggests that seasonal factors have been unimportant for manufacturing companies while the seasonal pattern has changed over the period in the case of non-manufacturing companies. See Section 9.2 for further details.
Notes

1. The own-rate on company sector liquid assets was variously defined:
   (a) The highest rate of interest available on the alternative liquid assets which feature in company portfolios, in each quarter over the data period.
   (b) A weighted average of the alternative rates on the various liquid assets held by companies. The weights used are sizes of asset-holdings (in £million) in each quarter.
   (c) Same as (b) except that the own-rate on money, as measured by the CD rate, only gets a reduced (75%\*w) weighting in recognition of the fact that a certain undisclosed proportion of company bank deposits earn no interest.

2. EX = exchange rate as measured by the 'sterling effective exchange rate'.

3. All other variables are as defined in section 9.1.3 except that the liquid assets definition has now been widened to include all the selected liquid assets held by industrial and commercial companies.

The best results were obtained from the specification which included a weighted average own-rate measure, and since there was little to choose between $R_{LA}^W$ and $R_{LA}^{W*}$, only the results from equations which included the former measure are reported here. Results are shown for equations which (a) exclude and (b) include an exchange rate variable. Since the
RTE was the appropriate representation of the model, and $p$ was close to and not significantly different from 1.0, both RTE and 1st difference results are presented.

**A Exchange rate excluded**

(1) RTE

\[
LA = 0.503 + 0.47y^{CU} + 0.16R_{LA}^W - 0.34R_{B}^L - 0.03LA_{-1} \\
(2.2) (2.7) (3.3) (2.6) (0.2)
\]

\[
LA = LA - pLA_{-1} \text{ etc.} \quad p = 0.91 \quad (20.0)
\]

Test of validity of autoregressive restrictions - $x^2_3 = 2.17$

Random correlogram test - $x^2_{10} = 13.40$

Chow test for structural stability - $F_{4,22} = 1.15$

(2) 1st Differences

\[
\Delta LA = 0.57\Delta y^{CU} + 0.16\Delta R_{LA}^W - 0.29\Delta R_{B}^L + 0.22\Delta LA_{-1} \\
(3.6) (3.0) (2.0) (1.7)
\]

**B Exchange rate included**

(1) RTE

\[
LA = 0.658 + 0.47y^{CU} + 0.14R_{LA}^W - 0.33R_{B}^L - 0.22EX - 0.04LA_{-1} \\
(2.2) (2.7) (2.6) (2.5) (0.8) (0.3)
\]

\[
LA = LA - pLA_{-1} \text{ etc.} \quad p = 0.90 \quad (15.7)
\]

Test of validity of autoregressive restrictions - $x^2_4 = 5.07$

Random correlogram test - $x^2_{10} = 10.96$

Chow test for structural stability - $F_{4,21} = 0.87$. 
(2) \textbf{1st Differences}

\[ \Delta LA = 0.53 \Delta Y^{CU} + 0.14 \Delta R_{LA}^W -0.28 \Delta R_{B}^L -0.30 \Delta EX + 0.18 \Delta LA_{-1} \]

\[ (3.2) \quad (2.4) \quad (1.9) \quad (1.0) \quad (1.3) \]

\textbf{C} \quad \textbf{A comparison of the forecasting performances of the restricted transformation equations (RTE)}

\begin{center}
\begin{tabular}{cccccc}
 & 1 & 2 & 3 & 4 & \textit{x}_4^2 \\
\hline
A - \textit{No exchange rate} & 3.8 & -1.1 & 7.2 & 4.0 & 5.80 \\
B - \textit{Exchange rate} & 3.1 & -2.7 & 5.5 & 4.0 & 4.26 \\
\end{tabular}
\end{center}

Since the coefficients on \(LA_{-1}\) are small and not significantly different from zero in the above equations the suggestion is that lag adjustment speeds are fast, with full adjustment following a disturbance essentially completed within a single quarter. This result is to be expected because although portfolio shifts between short and long-term assets may be subject to some delay, a long delay where large asset-holdings are concerned is rather unlikely since brokerage costs will tend to be low in relation to the returns which can be made from making the adjustment. As far as income flows, in the form of business receipts, are concerned, the additional income must, at least initially, be placed in the form of bank deposits or other suitable liquid assets. What happens after this will depend on transactions behaviour. So, quick adjustment of liquid assets, and especially money which dominates company portfolios, seems fairly inevitable, although holdings may fall away subsequently
as additional wealth held in this form might well be re-
allocated to longer-term assets with a risk element and
a chance of capital gain.*

The estimated equations for liquid asset demand are
very similar to the estimated money demand equation in the
dis-aggregated model (see section 9.1.3 above) which is
not particularly surprising in view of the fact that over
80% of total company sector holdings of selected liquid
assets are held in the form of money.

The estimated income elasticity is close to 0.5, the
own-rate elasticity is around 0.15 and the bond-rate
elasticity is in the region of -0.30 which suggests a
significant speculative component in company sector liquid
asset demand. It is interesting to note that the additional
inclusion of an exchange rate variable does not significantly
change the estimated income and interest rate elasticities.
Inspection of the RTE results reveals that the elasticities
are very similar and that the addition of the exchange rate
variable only causes a change in the constant term. Despite
the fact that the exchange rate elasticity is far from
negligible at over -0.20, it is not significantly different
from zero at either the 5% or the 10% significance levels.
However, as the correlation matrix in Table 9.5 reveals,
multicollinearity appears to be responsible for the weakly-
determined coefficient: high negative correlation of -0.96
between the exchange rate and income variables and high
positive correlation of 0.96 between the exchange rate and
lagged liquid assets. All other estimated elasticities were

* For money, in particular, over-adjustment is to be expected initially, followed by some running-down of money balances to acquire alternative assets.
significant at the 5% level.

The hypothesis of random residuals \( (X_{10}^2) \) could be confidently accepted for both the 'exchange rate included' and the 'exchange rate excluded' cases. The percentage forecast errors for 1979 showed a similar pattern for the two cases with the exchange rate equation yielding marginally better forecasts. The Chow test for structural stability \( (F_{4,21}) \) and the post-sample parameter stability test \( (X_{4}^2) \) were passed in both cases.

It would appear, then, that the omission of an exchange rate variable from the company sector liquid assets demand model is of no particular consequence.*

Since the coefficient on lagged liquid assets was small and highly insignificant the above model was re-estimated after dropping this variable from the specification. The full set of results for each representation of the autoregressive model is shown below for both the 'exchange rate included' and 'exchange rate excluded' cases.

* In theory exchange rate expectations ought to have a significant influence on company sector liquid asset holdings. Exchange controls operated over the relevant data period may be responsible for the weak results although no real attempt was made to model exchange rate expectations.
Equilibrium model results

A  Exchange rate excluded

(1) Structural Form (SF)

\[ LA = -0.681 + 0.98Y_{CU} + 0.25R_{W} -0.17R_{B} \]
\[ (1.7) \quad (21.6) \quad (3.9) \quad (1.4) \]

\[ x_{10}^2 = 32.9 \quad DW = 0.82 \quad R^2 = .963 \]

Post-sample parameter stability test \( x_4^2 = 33.1 \)
Chow test for structural stability \( F_{4,24} = 3.0 \)

(2) Unrestricted transformation function (URTF)

\[ LA = 0.453 + 0.51Y_{CU} -0.46Y_{CU} + 0.15R_{W} -0.11R_{W} -0.36R_{B} \]
\[ (1.4) \quad (2.8) \quad (2.3) \quad (2.6) \quad (1.6) \quad (2.2) \]
\[ +0.25R_{B} + 0.92LA -1 \]
\[ (1.5) \quad (1) \quad (6.3) \]

\[ x_{9}^2 = 17.34 \quad DW = 1.79 \quad R^2 = .990 \]

Post-sample parameter stability test \( x_4^2 = 12.0 \)
Chow test for structural stability \( F_{4,20} = 0.99 \)
Test of significance of additional parameters \( F_{4,20} = 12.86 \)

(3) Restricted transformation function (RTF)

\[ LA = 0.467 + 0.48Y + 0.16R_{W} -0.34R_{B} \]
\[ (2.8) \quad (2.8) \quad (3.3) \quad (2.7) \]

\[ LA = LA - pLA_{-1} \text{ etc.} \quad p = 0.91 \quad x_{10}^2 = 14.11 \]
\[ (19.6) \]

Validity of autoregressive restrictions \( x_3^2 = 1.44 \)
Post-sample parameter stability test \( x_4^2 = 6.29 \)
Chow test for structural stability \( F_{4,23} = 1.30 \)

(4) 1st Differences

\[ \Delta LA = 0.65 \Delta Y_{CU} + 0.16 \Delta R_{W} -0.26 \Delta R_{B} \]
\[ (4.2) \quad (3.0) \quad (1.7) \]
B Exchange rate included

(1) Structural Form (SF)

\[ \begin{align*}
L &= 2.41 + 0.81Y_{CU} + 0.23R_{LA} - 0.14R_{L} - 0.34EX \\
&\quad (0.9) \quad (5.6) \quad (3.5) \quad (1.2) \quad (1.2) \\
x^2_{10} &= 33.8 \quad DW = 0.79 \quad R^2 = 0.965 \\
\text{Post-sample parameter stability test} - x^2_4 = 13.5 \\
\text{Chow test for structural stability} - F_{4,23} = 0.86
\end{align*} \]

(2) Unrestricted transformation function (URTF)

\[ \begin{align*}
L &= 1.92 + 0.47Y_{CU} - 0.52Y_{CU} + 0.12R_{LA} - 0.10R_{LA} \\
&\quad (1.0) \quad (2.4) \quad (2.5) \quad (1.8) \quad (1.3) \\
&\quad - 0.35R_{B} + 0.24R_{L} - 0.35EX + 0.19EX \\
&\quad (2.0) \quad (1.4) \quad (1.1) \quad (0.5) \\
\frac{x^2}{2} &= 13.04 \quad DW = 2.05 \quad R^2 = 0.991 \\
\text{Post-sample parameter stability test} - x^2_4 = 3.11 \\
\text{Chow test for structural stability} - F_{4,18} = 0.49 \\
\text{Test of significance of additional parameters} - F_{5,18} = 9.65
\end{align*} \]

(3) Restricted transformation function (RTF)

\[ \begin{align*}
L &= 0.668 + 0.48Y_{CU} + 0.14R_{LA} - 0.33R_{B} - 0.22EX \\
&\quad (2.6) \quad (2.8) \quad (2.6) \quad (2.5) \quad (0.8) \\
L &= L - pL_{-1} \text{ etc.} \quad p = 0.89 \quad \frac{x^2}{2} = 11.59 \\
&\quad (14.8) \\
\text{Validity of autoregressive restrictions} - x^2_4 = 3.28 \\
\text{Post-sample parameter stability test} - x^2_4 = 4.72 \\
\text{Chow test for structural stability} - F_{4,22} = 1.01
\end{align*} \]

(4) 1st Differences

\[ \begin{align*}
\Delta L &= 0.57 \Delta Y_{CU} + 0.13 \Delta R_{LA} - 0.25 \Delta R_{B} - 0.43 \Delta EX \\
&\quad (3.5) \quad (2.2) \quad (1.7) \quad (1.4)
\end{align*} \]
the URTF representation of the aggregate liquid assets demand model.

Note - The matrix covers each of the explanatory variables which appear in

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**Correlation Matrix for Explanatory Variables**

**TABLE 9.5**
It is clear from these results that the RTE is the valid model representation, and that dropping the lagged dependent variable from the specification leaves the estimated income and interest elasticities unchanged: this is true for both cases A and B. The correspondence between the two sets of 1st difference results is not quite so good although the results are still similar.

Once again the Chow test indicates that the RTE is structurally stable and the post-sample parameter stability test is comfortably passed.

The exchange rate is still an insignificant explanatory variable with the associated elasticity having a t-statistic of less than 1.0.

It would certainly appear from these results that adjustment lags associated with company demand for liquid assets are short, with adjustment being essentially completed in a single quarter. A monthly model is required to adequately capture the speed and nature of this adjustment, but no comprehensive monthly data on the liquid asset holdings of companies is available from official sources.

9.2 Large industrial and commercial companies

9.2.1 Some details on the Department of Industry's Survey of company liquidity*

The survey covers only assets that can be realised and liabilities that are due to be paid within 12 months. The current assets covered by the survey include:

---

(1) Deposits with the banking sector (including certificates of deposit).

(2) Deposits with finance houses.

(3) British government securities.

(4) Local authority debt.

(5) Other current assets (including treasury bills and tax instruments).

Since survey companies have, in many cases, been unable to provide information on notes and coin very readily, no separate information on these is available. Holdings that are reported are small and have been included in the category 'other current assets'.

The number of survey companies which actually participate varies from year to year, but 'on average' approximately 220 large companies are covered. Over the relevant data period 1972(1)-1979(4), the smallest number of survey companies was 210 and the largest number was 227.

The survey has been carried out quarterly by the DOI (and its predecessors) since the beginning of 1970 and was originally intended to cover the 300 industrial and commercial companies that were largest in terms of capital employed. However, owing to sensitivity concerning the information requested, over 50 companies refused to take part and amongst these were some of the very largest companies.

The results of the DOI's survey of company liquidity are published quarterly in 'British Business' (formerly called 'Trade and Industry').
Money-holdings (defined as deposits with the banking sector for empirical purposes) constitute a high proportion of survey company liquid assets. In 1972(1) money-holdings accounted for approximately 65% of total survey company current assets; at the end of 1978 they accounted for 70%. If deposits with Finance Houses are additionally included in the definition of money then the corresponding percentage figures are 77% and 74%, respectively.

The survey data on current assets is disaggregated by type of company so that separate information is available for the asset holdings of manufacturing and non-manufacturing companies. Approximately $\frac{1}{3}$ of the survey companies are non-manufacturing and they account, on average over the data period, for just under $\frac{1}{3}$ of total survey company money-holdings so that the average money-holding of non-manufacturing companies tends to be higher than that for manufacturing companies.

Since seasonal factors are insignificant for manufacturing companies' holdings of current assets but significant for non-manufacturing companies' asset-holdings, the seasonally adjusted figures for the total current assets of all survey companies are arrived at by adding the seasonally adjusted figures for non-manufacturing companies to the actual reported figures for manufacturing companies. The seasonal factors are shown in Table 9.6 below and they indicate a shifting seasonal pattern for non-manufacturing companies over the relevant data period. These factors were calculated using the 'X-11' method of seasonal adjustment, which is
a sophisticated version of the 'percentage of trend' method.*

**TABLE 9.6**

Seasonal Adjustment Factors for Non-Manufacturing Survey Companies: 1972(1)-1979(4)

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Source: DOI

*This method is described in detail in a paper by the US Department of Commerce - Bureau of the Census, Technical Paper No. 15, 'The X-11 variant of the census method 11 seasonal adjustment program - by Shiskin, Young and Musgrave (February 1967).*
9.2.2 All survey companies – results (1972(1)-1978(4))

A variety of equations were estimated and the results are shown in Table 9.7 below.

Although the CD rate was used as a measure of the own-rate of interest on money in all ten equations, the local authority bill rate and the government bond rate were tried as alternative measures of the substitute asset yield. Equations both including and excluding the exchange rate were run, and in equations 9 and 10 nominal factor cost GDP replaced real GDP and GDP prices, which were the explanatory variables specified in equations 1-8. Both seasonally un-adjusted and seasonally adjusted data was used: unadjusted data in equations 1-4 inclusive, along with seasonal dummies, and adjusted data, using DOI seasonal adjustment factors, in equations 5-10.

The hypothesis of random residuals \( (x^2_{10}) \) could be comfortably accepted in every case after adjusting for significant 1st order serial correlation. \( p \), the 1st order serial correlation coefficient for the structural form residuals, was significant in all 10 equations taking values ranging between 0.57 and 0.65. The coefficient on lagged money-holdings is small and insignificant in every equation and although seven of the equations yield a negative coefficient, the hypothesis that the true value of the coefficient is zero can be accepted, at even the 30% significance level, for all seven equations. This implies that survey companies adjust their money-holdings quickly in response to changes in

* For further details on serial correlation and the appropriate representation of the autoregressive model see notes to Table 9.7
the explanatory variables, - i.e. within a period of three months - a result which agrees with the findings for the money-holding behaviour of all industrial and commercial companies. Essentially, then, we have an equilibrium model of survey company money demand in which the estimated parameters are the long-run elasticities indicating the full responses to any changes in income, price or interest rates.

A closer inspection of the results shown in Table 9.7 indicates that the exchange rate, as measured by the sterling effective exchange rate, is a highly insignificant explanatory variable. In equations 2, 4, 6 and 8 the t-ratios associated with the coefficients are very low and comparison with the corresponding equations which exclude the variable, equations 1, 3, 5 and 7, respectively, shows that the parameter estimates associated with the other variables are very similar. In view of this the exchange rate should be dropped from the empirical model. It is possible that the exchange controls operated over the relevant data period, 1972(1)-1978(4), are largely responsible for the empirical insignificance of the variable.

As far as the alternative interest rate variables are concerned the local authority rate is always more significant than the bond rate, although as can be seen from the relevant t-ratios the difference in significance is comparatively small when seasonally adjusted as opposed to seasonally unadjusted data is used. Another point favouring the local authority as opposed to the bond rate is that the demand for money results are similar when seasonally adjusted rather than unadjusted data is used: in the case of the bond rate the parameter estimates are not consistent.
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**TABLE 9.7**

All Survey Companies: Results (1972(1)-1978(4))

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**MC** = Mean Coefficient

**P** = Probability

**CDB** = Closed-Book Ratio

**RLA** = Relative Loss Adjustments

**RB** = Reserve for Bad Debts

**EX** = Expected Loss

**N** = Number of Observations

**D1, D2, D3** = Deviations from the Mean

**P** = Probability of Deviation

**X10** = Multiplier for Expected Loss
Notes on Table 9.7

1 All variables (except the seasonal dummies) are expressed in natural logarithms.

2 For equations 1-4, inclusive, seasonally unadjusted survey company money-holdings were used to represent the dependent variable. For equations 5-10 seasonally adjusted survey company money-holdings were used: the DOI seasonal adjustment factors, shown in Table 9.6 above, were applied. Although these factors actually relate to total current assets held by survey companies, it was considered that since company money-holdings form a high proportion of these, it would be reasonable to apply the factors to money-holdings alone.

3 In 8 out of the 10 cases shown $x^2$ tests revealed that the RTE representation of the autoregressive model was valid. However, for equations 4 and 9 the autoregressive restrictions proved to be just invalid at the 5% significance level, with calculated $x^2$ just above the critical table value. Despite the findings for these two equations it was decided that the RTE was the valid model specification. Accordingly, all of the results shown are for the RTE representation of the model. In this specification $\frac{MC}{N} = \frac{MC}{N} - p(\frac{MC}{N-1})$ and ditto for the explanatory variables, with the value of $p$, the 1st order serial correlation coefficient for the SF residuals, shown for each equation.
Table 9.8 below gives the estimated income, price and interest elasticities for each of the equations which exclude the exchange rate as an explanatory variable. The results point to money being a luxury good for survey companies since the estimated income elasticity comfortably exceeds unity in three out of four cases. The only case which suggests scale economies in money-holding (equation 7 in Table 9.7) has a poorly-determined income coefficient with a t-ratio of less than unity. In addition the bond rate rather than the preferred local authority rate has been used as a measure of the substitute asset yield.

The estimated price elasticity is close to unity in every case and is highly significant. Equations 1-8 in Table 9.7 yield estimates in the range 0.99-1.14; each of the estimated price elasticities are significantly different from zero at the 1% significance level, and none are significantly different from unity at even the 20% significance level. Indeed, this conclusive finding of homogeneity in prices is the most striking single feature of the results for survey company money demand.

The estimated income and price elasticities of survey company money-holdings stand in quite marked contrast to the results for all industrial and commercial companies. In the latter case the estimated income and price elasticities were both in the region of 0.70 and the t-ratios indicated that they were well-determined. These results suggested economies of scale in company money-holdings and that real

* See section 9.1.1 where the 'equivalent model' results are presented and the same explanatory variables used.
money-holdings fall back when the price level rises. Taking these results at face value suggests that while the larger companies regard money as a luxury good, many of the smaller companies must regard it as a necessity! Perhaps this could be explained by the fact that more attractive rates of interest are offered by the banks for large, wholesale money deposits. Another reason for the difference could be that while the number of survey companies was taken into account in the empirical work, no account was taken of the changing number of 'all industrial and commercial companies', and that if a consistent treatment had been possible then the elasticities may well have been similar.

Of course, it could be that despite the empirical significance of GDP and GDP prices as explanatory variables, they are not entirely appropriate for explaining the money demand behaviour of companies. If this is the case then none of the estimates can be trusted. However, since no comprehensive measures of company wealth are available and because GDP was a better explanatory variable than the index of industrial production, we must make do with this income measure. One point in its favour concerns the overwhelming evidence from the survey company results that company money demand is homogenous of degree one in prices; a result which squares with theoretical expectation.

Table 9.8 indicates that survey company money-holdings are highly sensitive to interest rate changes. When the CD rate represents the own-rate on money and the local authority rate represents the alternative asset yield, then the own-rate elasticity just exceeds unity while the cross-rate elasticity is in the region of -1.0. The high correlation between these
<table>
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<th>Income</th>
<th>Price</th>
<th>Interest Elasticities of Survey</th>
</tr>
</thead>
</table>
| 0.34 | 1.02 | 0.25 | 0.64 | 2 Seasonally adjusted data using DOI seasonal factors
| 1.02 | 1.44 | 1.02 | 1.70 | 2 Seasonally adjusted data and seasonal dummies
| 0.12 | 1.63 | 0.22 | 1.43 | 2 Seasonally unadjusted
| 1.18 | 1.45 | 1.05 | 1.70 | 2 Seasonally unadjusted

Company Money Demand

Incomes, Price and Interest Elasticities of Survey

TABLE 9.8
two rates has caused a multicollinearity problem which leads to relatively large standard errors on the interest coefficients. Despite this problem the interest rate coefficients are significant at the 10% significance level and so it is not severe enough to throw the results out too badly.

When the bond rate is used to represent the substitute asset yield, the measured interest elasticities are much smaller. This is understandable since local authority debt is a closer substitute for interest-bearing company money-holdings than government bonds. The much lower own-rate elasticity can be readily explained since typically rates on certificates of deposit and local authority debt move closely together. With the latter rate now excluded from the equation it follows that increases in money-holdings following a rise in the own-rate on money involves switching away from weaker substitutes such as government bonds. When the local authority rate represents the alternative asset yield then any change in the own-rate on money not quickly matched by the former can be expected to lead to significant portfolio adjustments.

Since most of the variation in nominal GDP over the relevant data period has been due to price changes, with real income showing little variation, it was decided that equations should be run in which nominal GDP is specified. The estimated coefficient on this variable should largely reflect the influence of just price. In fact equations 9 and 10 in Table 9.7 show this to be the case with nominal income coefficients which are very close to unity and not significantly different from this figure.
Finally, the ex-post forecasting performance of all ten estimated equations was rather poor and both the post-sample parameter stability test and the Chow test for structural stability were clearly failed (the results for these tests are not shown, but they were failed in every single case). Once again this finding stands in contrast to that for 'all industrial and commercial companies', where both the post-sample parameter stability test and the Chow test for structural stability are clearly passed. The poor post-sample performance of the survey company equations might well be associated with the change in the number and composition of companies participating in the survey of company liquidity. A sharp increase in the number of survey companies from 210 in 1977 to 226 in 1978 was followed by a fall in number to 222 in 1979. Before 1979 a fall or rise in the number of companies participating in the survey involved a fall, or rise, in the numbers of both manufacturing and non-manufacturing companies. However, in 1979 while an additional non-manufacturing company participated, five manufacturing companies dropped out of the sample.

Another possible reason for the poor ex-post forecasting performance of the survey company equations is that large companies have made significant purchases of tax instruments since the middle of 1978, with a particularly large increase, of over £300 million, occurring between the last quarter of 1978 and the first quarter of 1979.* Now while this must be the case for 'all industrial and commercial companies' as

* See 'Financial Statistics', Table 9.5.
well, the effect on the survey companies is much more
dramatic in relative terms since (a) they hold a large
proportion of the total tax instruments held by companies
and (b) their total money-holdings amount to only approx-
imately 20% of total company money-holdings.

This large increase in the holdings of tax instruments
would be expected to cause over-prediction errors over the
ex-post forecast year 1979 since actual money-holdings
should fall back following the sudden increased demand for
tax instruments. In fact over-prediction errors occurred in
every quarter of 1979 as well as the last two quarters of
1978. Since it was immediately after the 2nd quarter of 1978
when company holdings of tax instruments started to rise
sharply, this particular explanation of the over-prediction
errors and the post-sample parameter instability seems quite
plausible.

9.2.3 Manufacturing and Non-Manufacturing Survey Companies -
Results - (1972(1)-1978(4))

Since it is clearly possible that the money-holding behaviour
of manufacturing companies differs from that of non-manufact-
uring companies, it is of interest to investigate the
possibility. Separate data on the money-holdings of the two
types of company was kindly provided for this purpose by the
DOI.

The results for manufacturing companies are shown in
Table 9.9 overleaf and the results for non-manufacturing
companies in Table 9.10.

The most striking differences between the two sets of
results concern the speed of adjustment and the significance
of serial correlation. The evidence for manufacturing
Since seasonal variation in manufacturing company survey data is being studied, the following figures are used for MCI.

Table 9.9:

Manufacturing Survey Companies' Results (1972(1)-1978(4))

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Notes:
- In view of the relatively small and insignificant values of p and q, all variables are expressed in natural logarithms.
- The structure of the model, indicated by an F-test, implies that the model was accepted as the initial model as indicated by an F-test, and that the insignificant parameters enacting the MCI were removed.
- All results are expressed in natural logarithms.
The D01 seasonal factors (see Table 9.6) were applied to the reported money-holding figures.

The results were negative and the model was the appropriate model, according to the test showed that the KDE representation of the asset rate is not specified as the alternative variable are expressed in natural logarithms.

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companies suggests that 1st order serial correlation in the residuals is highly insignificant and, following a market disturbance, money demand adjustment takes about a year to complete. In contrast, the 'preferred' results for non-manufacturing companies suggest that serial correlation is highly significant and that full money-holding adjustment is completed within three months. So, there appears to be an important difference between the two types of company with respect to the speed of adjustment of money demand.

The results for manufacturing companies, shown in Table 9.9, indicate that the bond rate is clearly empirically preferable to the local authority rate. This suggests that manufacturing survey companies are important holders of government securities, and that local authority debt is not held in any significant quantity.* Comparing either equations 1 and 2, or 3 and 4, in Table 9.9, it can be seen from the R^2 statistic that the 'bond rate' equations (2 and 4) explain around 96% of the variation in money-holdings while the 'local authority rate' equations (1 and 3) only explain just over 94%. Furthermore, the t-ratios show that the parameters are much better-determined in the 'bond rate' equations. For example, comparing equations 1 and 2, it can be seen that while the bond rate coefficient is significant with a t-ratio of 3.1, the local authority rate coefficient is highly insignificant with a t-ratio of only 0.5!

* Information provided by the DOI confirms this suggestion for the end of the data period (1978 and 1979) and for the years 1980 and 1981. See Appendix B to this chapter. (Unfortunately no information was provided for earlier years).
For non-manufacturing survey companies the only sensible equations are those in which the local authority rate is specified as the relevant substitute asset yield. Equations 1 and 3 in Table 9.10 include the local authority rate and although some of the individual coefficients are not very well-determined they each have the correct sign and are of plausible magnitude. In the case of the bond rate equations (2 and 4) the individual coefficients are insignificant and the CD and bond rates enter with the wrong signs. In addition, the income coefficient in equation 2 also has the wrong sign.

In Table 9.11 overleaf the estimated long-run money demand elasticities are shown for both types of company: only the best equations from Tables 9.9 and 9.10 were considered.

Despite the marked contrast in the values of the real income elasticities both results were based on highly insignificant income coefficients.* Furthermore, most of the variation in nominal factor cost GDP has been due to rising prices over the relevant data period (1972-1979), so that more attention should be directed towards the values of the price elasticities. The aggregate survey company results strongly suggested that company money demand was linearly homogeneous in prices, a result which is not seriously contradicted by the evidence from non-manufacturing companies: Table 9.11 shows that the estimated price elasticity is in the region of 0.9.

* Results which suggest that survey company money-holdings are not importantly related to variations in real national income. However, no better empirical income or wealth measures could be found.
nominal income elasticities. + different from zero at the 20% significance level.

denotes elasticities which are not significant.

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**TABLE 9.11**

Manufacturing and Non-Manufacturing Survey Companies

Income, price and interest rate elasticities
However, for manufacturing companies the estimated long-run price elasticity is approximately 1.7; an estimate which is well-determined but nevertheless unreasonably high! The nominal income elasticities for manufacturing and non-manufacturing companies were 2.0 and 0.83, respectively. Since price changes dominate the variation in nominal income the estimate for manufacturing companies is rather high, while the estimate for non-manufacturing companies seems reasonable enough.* The high estimate for the former might well be due to the naive assumptions about lag structure which are embodied in the model. If the lag adjustment periods associated with the individual explanatory variables differ then it is clearly possible that the adjustment period associated with a change in prices is significantly shorter than a year, so that the long-run price elasticity of money demand for manufacturing companies is much closer to the theoretically expected value of unity.

As far as the own-rate of interest elasticity is concerned there is broad agreement between the results shown, in Table 9.11 above, for the different companies: the estimates lie in the range 1.3-1.6 indicating that survey company money demand is interest-elastic.

As far as the cross-rate interest elasticity is concerned values of -3.1 for manufacturing companies and -1.47 for non-manufacturing companies (the cross-rate elasticities are similar when nominal income is specified) indicate that survey company money demand is very sensitive

* It is interesting to note that if $R_{LA}$ replaces $R_B$ in the manufacturing survey company equations then the estimated price elasticity is much closer to unity. However, as stated above, the bond rate equation is decidedly better-determined.
to changes in rates of interest on alternative financial assets. While local authority debt appears to be the most important money substitute for non-manufacturing survey companies, capital risky assets such as government bonds (and probably company shares) appear to be more important substitutes for manufacturing survey companies.* Indeed, the importance of the bond rate and the high cross-rate elasticity suggest that there is a significant speculative component in the demand for money by large manufacturing companies.

Although not shown in the above results, the ex-post forecasts for 1979 were not particularly good for either manufacturing or non-manufacturing companies. However, the forecasts were considerably better than was the case for aggregate survey company money demand. For non-manufacturing survey companies both over-prediction and under-prediction errors occurred, and both the Chow test for structural stability and the post-sample parameter stability test were just passed. For manufacturing survey companies money demand was over-predicted in each quarter of 1979 and the above-mentioned stability tests were clearly failed. However, if the local authority rate is specified in place of the bond rate, then despite the comparatively poorly-determined equation, the forecasting performance is improved with over- and under-prediction errors occurring. In addition, the stability tests are just passed.

* Appendix B shows that government securities were certainly more significant than local authority debt in the asset portfolio of manufacturing companies at the end of the 1970's. For non-manufacturing companies holdings of la debt were marginally greater than holdings of government securities.
This considerable improvement in ex-post forecasting performance, with the dis-aggregation of survey company money demand by type of holder, is not perhaps surprising in view of the fact that the money-holding behaviour of large manufacturing companies was found to be quite different from that of large non-manufacturing companies; especially with regard to speed of adjustment. This difference in money-holding behaviour means that any change in the composition of the aggregate sample of survey companies, such as occurred in 1979, may well be enough to suggest that the demand for money function for large companies is unstable, when in fact it is not.*

Certainly, the dis-aggregated results suggest that the rapid growth in tax instrument holdings was not responsible for the over-prediction forecast errors in the case of the aggregate survey company money demand results.

9.3 Concluding comments
A summary of the best results for (1) all industrial and commercial companies and (2) large industrial and commercial companies is given in Table 9.12 below.

The results for all companies, in section 1 of the table, suggest that there are economies of scale in money-holdings and that the demand for real money balances falls back following rises in the domestic price level which are unaccompanied by changes in real income or interest rates.

* Essentially, then, the two separate demand functions for manufacturing and non-manufacturing survey companies could both be stable while the over-aggregated function suggests instability simply because of a change in sample composition.
Equation 1 (1) shows that company money demand is quite sensitive to changes in short-term interest rates, with an own-rate elasticity of 0.57 and a cross-rate interest elasticity of -0.46. When money is re-defined to include a close money-substitute, local authority temporary debt, then the own-rate elasticity falls sharply and the most relevant substitute asset is long-term government bonds; changes in the bond rate have a significant negative influence on money demand. This sharp fall in the own-rate elasticity for re-defined money indicates that local authority debt is clearly the most important substitute for company M3 deposits amongst the various selected liquid assets held.

Equation 1 (3) covers the aggregate liquid assets demand of companies and, as Table 9.12 clearly shows, the results are very similar to those for money demand; a result which is hardly surprising in view of the fact that money (MC + la) represents a very large proportion of the total selected liquid assets held.

The significance of the bond rate for these wider definitions of 'money' employed, suggests that there is an important speculative component in the company sector's demand for short-term, capital-certain financial assets.

In the case of large industrial and commercial companies, results for which are shown in section 2 of Table 9.12, the suggestion is that money is a luxury good with an income elasticity clearly in excess of unity. Equation 2 (1) yields a price elasticity of demand of 1.02 which means that the nominal money demand of 'all survey companies' is linearly homogeneous in prices; a result
The CD rate is used to represent the
interest rate on money in every case
 except 1) where the comp-rate was
 taken to be a weighted average of the
 relevant short-term interest rates
 4 The underlined income elasticities
 are seriously insignificant.

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A Summary of the Best Company Sector Money Demand Results

 TABLE 9.12
which agrees with theoretical expectation. However, when survey company money demand is disaggregated by type of holder it can be seen that for large non-manufacturing survey companies there are economies of scale in money-holding and the long-run price elasticity is lower than unity: results which are in broad agreement with those for all industrial and commercial companies. For large manufacturing companies the size of the income elasticity suggests that money is very definitely a luxury good, although the short-run elasticity upon which the estimate of 4.2 is based, is very poorly-determined. Furthermore, the estimated long-run price elasticity of 1.71, although well-determined, is implausibly high which suggests, at the very least, that the lag structure has not been correctly captured. Since this was the only case in which adjustment was not completed in a single quarter, the result must surely be in doubt, especially as a period of almost a year is suggested. However, as the results stand, the suggestion is that while large manufacturing companies are slow to adjust their money-holdings, large non-manufacturing companies adjust them rapidly.

As expected, survey company money demand is very sensitive to interest rate changes with both the own-rate and cross-rate interest elasticities in excess of unity. These higher interest-elasticities for the large companies, compared with those for all industrial and commercial companies, are to be expected since even small changes in relative interest-yields should induce portfolio changes when the volume of funds concerned is particularly large. A failure to switch funds would mean sacrificing large
absolute interest returns, while the cost involved in switching funds is likely to be small in comparison and similar to that for the smaller companies.

An interesting feature of the dis-aggregated survey company results is the suggestion that government bonds are an important substitute for money as far as manufacturing companies are concerned, while local authority debt is an important substitute in the case of non-manufacturing companies. Indeed, the large and significant negative elasticity associated with the government bond rate, in equation 2 (2) of Table 9.12, suggests that there is a very important speculative component in large manufacturing companies' demand for money.

The forecasting performances of the demand equations for all industrial and commercial companies are reasonable. The ex-post forecast errors, although not especially small, are both positive and negative over the four quarters of 1979 and both the Chow test for structural stability and the post-sample parameter stability test are passed in each case.

In contrast, the forecasting performance of the equation for all survey companies (equation 2 (1) in Table 9.12) is extremely poor, with growing over-prediction errors occurring in the forecast year. Both the stability tests are clearly failed. It is possible that a change in the composition of the survey sample, with the number of manufacturing companies falling and non-manufacturing companies rising, has contributed to the poor ex-post forecasting performance over 1979; especially as the dis-aggregated money demand results show that the demand behaviour of the two types is
quite different. In any event, the forecasting performances of the dis-aggregated money demand equations (2 (2) and 2 (3) in Table 9.12) are considerably better, especially in the case of non-manufacturing survey companies where both over- and under-prediction forecast errors occur and the post-sample stability tests are passed.

The differences between the results for all industrial and commercial companies and the large survey companies, in particular with respect to the income and price elasticities, might simply indicate that the money-holding behaviour of the largest companies is not typical of companies in general. However, other factors which could be influential include (1) the different methods of data collection involved, (2) the fact that we only have data from a sample of the largest companies, which fails to include some of the very largest companies, and (3) both the size and the composition of the survey sample change over the relevant data period.
Inflation expectations might be expected to influence the money-holding behaviour of companies for transactions, precautionary and speculative reasons.

Transactions motives for holding money or near-money cover purchases of variable inputs, repaying interest on loans and meeting depreciation and other fixed costs such as rent and rates. Where companies are able to borrow large amounts of money to finance transactions then they will typically hold only small amounts for transactions purposes in the form of liquid assets. However, if inflation is currently high but expected to fall, as was certainly the case after 1975*, then long-term borrowing at fixed rates of interest becomes unattractive. This is so because a trend fall in the rate of inflation would leave companies paying progressively higher real rates of interest over the terms of the loans. Indeed, the collapse of the company debenture market was largely due to the general fears of a trend fall in the rate of inflation from a high level.

So, inflation expectations in the mid-1970's made long-term borrowing unattractive and consequently funds required for investment were increasingly drawn from retained profits and raised from shorter term loans - e.g. bank

* In the summer of 1975 the Labour government introduced an incomes policy, and further anti-inflation measures followed in 1976 in the shape of public expenditure cuts and monetary targets.
advances. The greater reliance on retained profits to finance investment means that savings which would otherwise have been channelled into liquid assets, the holdings of which are dominated by money, are diverted towards the purchase of plant and machinery.*

A transactions demand for money to cover payments for the variable inputs will be important.

In the case of labour fighting for wage increases based on expected inflation then to the extent which this may squeeze profit margins, firms will cut back investment plans and lay-off workers. Wage-bill savings will mean a reduced demand for money, although some of the funds earmarked for investment will now be diverted into liquid assets.

Company purchases of stocks may be importantly influenced by anticipated changes in stock prices. If the wholesale price index (industrial inputs) is expected to rise sharply then firms may be tempted to stockpile in order to beat inflation. Providing the costs of holding additional stocks are reasonably low then firms will wish to run down money balances in order to finance the extra purchases. However, money balances will build-up in subsequent periods when running down the stocks.

Inflation expectations may influence company money-holding behaviour on precautionary grounds. For example, if inflation is expected to become both higher and more variable

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* Although on this argument there would be a fall in company demand for liquid assets, reduced borrowing would soon mean reduced interest costs and wider profit margins. This factor combined with an attempt to retain a higher proportion of profits would boost funds.
this may generate much uncertainty regarding future profits. As a cushion against future hardship firms may wish to keep a greater proportion of their assets in a liquid form seeking out the highest return short-term financial assets. In addition, if inflation is expected to fall back from a high level because of government anti-inflation measures, companies will anticipate borrowing difficulties and attempt to save more in the form of retained profits. They will wish to keep most of these extra savings in a liquid form.

Uncertainty over future inflation and future profits is likely to have been largely responsible for the sharp rise in company sector liquid asset holdings which occurred in the mid-1970's and continued through subsequent years. In 1975 and 1976 companies' liquid asset holdings increased by 21% and 16% respectively. In contrast, they fell back by over 2% in 1974.

The asset motive is another important consideration. Despite the fact that interest rates have failed to keep pace with inflation they have reached high nominal levels in the 1970's. Now rising inflation increases the opportunity cost of holding non-interest bearing money, which has a convenience value only, so that companies will typically wish to hold a smaller proportion of liquid assets in this form when the rate of inflation is expected to rise.

The most important influence of inflation expectations with respect to this motive concerns transactions in capital risky assets such as government securities. In times of rising inflation and rising interest rates bond prices will be falling. If companies expect this trend to continue they will move out of bonds and into capital-certain liquid assets.
In times of falling inflation the opposite happens and companies will wish to hold more bonds in their asset portfolios. Now with the annual rate of inflation running at 25% in the Summer of 1975 and the government's introduction of anti-inflation measures, expectations of falling inflation must have been strong. Companies were therefore anticipating an increase in government bond prices and as Table 9.13 clearly indicates company sector holdings of government securities showed a strong trend rise between 1975 and 1979. The percentage share of government securities in companies' total holdings of liquid assets rose from approximately 1% at the end of 1974 to just under 3½% in the 4th quarter of 1979.

Although the public expenditure cuts in 1976 reduced the Public Sector Borrowing Requirement it can clearly be seen from Table 9.14 that, owing to the large reduction in borrowing from the banks, the amount borrowed from the non-bank private sector increased sharply. A reduction in government borrowing from this sector would have prompted stronger speculative buying since the price of debt would have risen further. As it was, the increased sale of debt must have dampened the force of speculative buying to some extent by limiting the rise in bond prices and therefore the sizes of the capital gains to be made.
<table>
<thead>
<tr>
<th>Year</th>
<th>Value of British Government Securities Held by UK Commercial and Commercial Companies (£m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972(1)</td>
<td>419</td>
</tr>
<tr>
<td>1976(1)</td>
<td>216</td>
</tr>
<tr>
<td>1974(1)</td>
<td>122</td>
</tr>
<tr>
<td>1973(1)</td>
<td>96</td>
</tr>
<tr>
<td>1975</td>
<td>155</td>
</tr>
<tr>
<td>1971(1)</td>
<td>301</td>
</tr>
<tr>
<td>1969</td>
<td>86</td>
</tr>
<tr>
<td>1967</td>
<td>159</td>
</tr>
<tr>
<td>1965</td>
<td>135</td>
</tr>
<tr>
<td>1963</td>
<td>126</td>
</tr>
<tr>
<td>1961</td>
<td>109</td>
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<tr>
<td>1959</td>
<td>355</td>
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<tr>
<td>1957</td>
<td>336</td>
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<tr>
<td>1955</td>
<td>149</td>
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<tr>
<td>1953</td>
<td>550</td>
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<tr>
<td>1951</td>
<td>407</td>
</tr>
<tr>
<td>1949</td>
<td>595</td>
</tr>
<tr>
<td>1947</td>
<td>164</td>
</tr>
</tbody>
</table>

**Table 9.13**

**Source:** Financial Statistics.
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Private sector</td>
<td>9'807</td>
<td>9'235</td>
<td>7'798</td>
<td>8'555</td>
<td>6'048</td>
</tr>
<tr>
<td>From non-bank</td>
<td>5'470</td>
<td>7'947</td>
<td>5'628</td>
<td>7'478</td>
<td>5'500</td>
</tr>
<tr>
<td>Amount Borrowed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Borrowing</td>
<td>14'277</td>
<td>17'183</td>
<td>16'323</td>
<td>15'733</td>
<td>12'547</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Sector</td>
<td>9'14</td>
<td>9'15</td>
<td>9'16</td>
<td>9'17</td>
<td>9'18</td>
</tr>
<tr>
<td>Borrowing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.6.**

Source: Financial Statistics

PUBLIC SECTOR BORROWING REQUIREMENT FOR FINANCIAL YEARS 1974/75 TO 1978/79 (£m).
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>mortgages &amp; loans</td>
<td>26</td>
<td>80</td>
</tr>
<tr>
<td>temporary deposits</td>
<td>129</td>
<td>37</td>
</tr>
<tr>
<td>local authority</td>
<td>122</td>
<td>28</td>
</tr>
<tr>
<td>securities</td>
<td>131</td>
<td>28</td>
</tr>
<tr>
<td>British Government</td>
<td>111</td>
<td>27</td>
</tr>
</tbody>
</table>

**SOURCE:** DOU Survey of Company Liabilities

**Note:** No. of companies refers to the number of (1) large manufacturing and (2) large non-manufacturing companies which actually participated in the survey in each period.
10.0 Introductory remarks

In the context of an IS/LM model the success, or otherwise, of monetary policy in achieving its stated policy objectives will depend on the stability of both the IS and LM functions.

For monetarism to be a successful method of controlling the level of aggregate demand, in particular the rate of inflation, in the medium term (3-5 years), then the following necessary conditions must be satisfied:

1. A stable demand for money function exists; one which can be correctly identified.
2. A stable aggregate expenditure function exists and can be correctly identified.
3. The money supply is capable of being closely controlled by the monetary authorities.

My work has been concerned with the first of these conditions, but it should be stressed that in the face of serious violation of either conditions 2 or 3, or both, the stability or otherwise of the demand for money function is no longer of any real policy significance. If for example, the money supply cannot be kept within the target growth range, which was 7-11% per annum for £M3 at the end of the 1970's, then unless there is a compensating change in the income velocity of circulation of money, monetarism will fail to realize its policy targets.
In the following section a simple IS/LM model is outlined and the reduced-form equations for the endogenous variables are formally derived from the structural model. In order to bring out the importance of the above-mentioned necessary conditions for the success of monetary policy, lag structure is initially ignored and an equilibrium model is advanced. Following consideration of the theoretical properties of the reserve base and money multipliers, the reduced-form results are presented for the dynamic IS/LM model specified in Chapter 6 (Section 6.2). These give the impact multipliers for a quarterly model directly. The larger dynamic multipliers are also shown.

This dynamic IS/LM model is essentially the same as the equilibrium model, save for the incorporation of a generalised partial adjustment lag structure.

After a brief consideration of the plausibility and significance of the various structural parameters and the implications for monetary and fiscal policy which can be drawn from the reduced-form results, full attention is devoted to the money-demand relationship. In Section 10.2 a summary of the best post-CCC results is presented, for various definitions of money, and ex-post forecasting performance for 1980 and the first quarter of 1981 is considered. In the light of (1) a change in the techniques of monetary control and (2) abandonment of exchange controls, this represents a stringent test of model stability; especially for broad definitions of money.

Finally, the policy implications of the major findings are carefully considered. In this context it is not just a question of whether the money demand function is stable or
unstable, but whether the money supply can be adequately controlled. Even if it can be successfully controlled it may be that exchange rate targeting is a better method of achieving the government's inflation objectives in which case money demand stability is not a crucial policy issue.

10.1 The reduced-form model of an IS/LM structure

10.1.1 The derivation of the reduced-form from the structural model

(1) The structural model

1 C = c0 + b(Y-T) Consumption function
2 T = t0 + tY Tax function
3 M = m0 + mY Imports function
4 I = I0 + eR Investment function
5 Y = C + I + G + X - M National income identity

G, X exogenous

6 MD = A0 + B1Y + B2R Money demand equation
7 MS = A1 + C1H + C2R Money supply equation
8 MS = MD = M Identity
H exogenous

From equations 1-5 the IS expression is derived. Substituting equations 1-4 into the national income identity and solving for Y gives:

\[ IS \quad Y = \frac{c_0 - bt_0 + I_0 - m_0}{(1-b) + bt + m} + \frac{G + X}{(1-b) + bt + m} + \frac{e}{(1-b) + bt + m} R \]

The a priori signs of all parameters in the IS equation are positive with the exception of the interest rate coefficient (e) in the investment equation which is negative.
Similarly, the LM equation can be derived from equations 6-8:

\[ \text{LM} \quad Y = \frac{A_1 - A_0}{B_1} + \frac{C_1}{B_1} H + \frac{C_2 - B_2}{B_1} R \]

The a priori sign associated with coefficients \( B_1, C_1 \) and \( C_2 \) is positive while for \( B_2 \) it is negative.

The economy will be in equilibrium when both the 'goods market' and the 'money market' are in equilibrium - i.e. when \( IS = LM \). So, setting \( IS = LM \) and solving for \( R \) will give the rate of interest which simultaneously clears both the money and goods markets for a particular level of income. The resulting reduced-form expression for the rate of interest is as follows:

\[
R = \frac{1}{B_1 e^{-(C_2-B_2)Z}} \left[ \frac{A_1 - A_0}{Z} \right] + \frac{C_1}{B_1 e^{-(C_2-B_2)Z}} H
\]

\[
+ \frac{1}{Z(C_2-B_2)B_2} \left[ \frac{C_0 - b t + I_0 - m_0 + G + X}{B_1} e^{-e} \right]
\]

where \( Z = (1 - b) + b t + m \)

By substituting this reduced-form expression for \( R \) into either the IS or LM equations we obtain a reduced-form expression for national income:
\[
Y = \frac{1}{B_1 - Z(c_2 - B_2)} e^{A_1 - A_0} + \frac{C_1}{B_1 - Z(c_2 - B_2)} e^H 
\]

\[
+ \frac{1}{Z - \frac{B_1 e}{(c_2 - B_2)}} \left[ C_0 + I_0 - m_0 + G + X \right]
\]

Similarly, a reduced form equation for the money stock can be obtained by substituting the reduced-form expression for \( R \) into the money supply equation. This gives:

\[
M = \left[ 1 + \frac{C_2}{B_1 e^{-(c_2 - B_2)}} \right] A_1 - \frac{C_2}{B_1 e^{-(c_2 - B_2)}} A_0 
\]

\[
+ C_1 \left[ 1 + \frac{C_2}{B_1 e^{-(c_2 - B_2)}} \right] H + \frac{C_2}{Z(c_2 - B_2)} - e \left[ C_0 + I_0 - m_0 + G + X \right]
\]

For known values of the exogenous variables in the structural model the reduced-form equations can tell us the values of \( M, Y \) and \( R \) which are consistent with full equilibrium in the system – i.e. equilibrium in both the money and goods markets, simultaneously achieved.*

* The IS/LM framework has several important weaknesses despite its usefulness in highlighting the major policy issues in the management of aggregate demand. The various weaknesses were mentioned in Chapter 1, p. 22 and 23. An additional weakness, not mentioned there, concerns the interdependence of fiscal and monetary policy via 'inflationary financing' of the PSBR. The simple model advanced above does not formally recognize the possibility of such interdependence.
10.1.2 An examination of the policy-relevant reduced-form multipliers

I will start by assuming that the monetary authorities have been able to exercise a reasonable degree of control over the volume of reserve assets held by banks in the post-CCC 1970's.* If this assumption is accepted then providing the reserve base multiplier in the reduced form money stock equation is both currently known and remains stable over time, then it follows that the monetary authorities will have the ability to control the growth of the money stock reasonably closely via manipulation of the reserve base.** The relevant multiplier is as follows:

\[
\frac{\Delta M}{\Delta H} = C_1 \left[ 1 + \frac{C_2}{\frac{B_1}{Z} - (C_2-B_2)} \right]
\]

It can be seen from (1) above that the size of the multiplier depends on the values of both the IS and LM structural parameters. Under ceteris paribus assumptions the reserve-base multiplier will be higher:-

---

* Controlling the volume of reserve assets in the context of a multiple assets base will be more difficult than is the case with a simple monetary base. See Dennis (36) p.194 and 195 for a discussion of the controllability of the post-CCC reserve assets base.

** Since the introduction of monetary targets in 1976 the growth of £M3 has, on occasions, during the late 1970's, been above the top end of the target range (see Chapter 1 p.36). In 1980 the growth of £M3 was, at nearly 20%, well in excess of the top end of the 7-11% target range.
(1) The greater is $C_1$, the reserve base coefficient in the money supply equation.

(2) The smaller is $C_2$, the sensitivity of the money supply to a change in the rate of interest.

(3) The greater is $B_2$, the interest sensitivity of money demand.

(4) The greater is $B_1$, the sensitivity of money demand to a change in income.

(5) The greater is $e$, the sensitivity of investment to a change in the rate of interest.

(6) The smaller is $Z$, the leakage or withdrawal propensity from the flow of income.

As long as the value of the multiplier is correctly known by the authorities then they will be able to control the growth of the money stock. This, in turn, means that the structural parameters in the IS/LM model must be accurately known and must remain stable over time.

Given that a reasonable degree of control over the growth of the money stock is possible we can now examine the money multiplier in the reduced-form income equation. The relevant multiplier is as follows:

\[
\frac{\Delta Y}{\Delta H} = \frac{C_1}{B_1 - Z(C_2 - B_2)} \frac{1}{e}
\]

Under ceteris paribus assumptions the money multiplier will be higher:
(1) The greater is $C_1$, which measures the sensitivity of the money supply to changes in the level of reserve assets.

(2) The smaller is $B_1$, which measures the sensitivity of the demand for money to changes in income.

(3) The smaller the interest coefficients in the money supply and money demand equations $C_2$ and $B_2$, respectively.

(4) The greater the sensitivity of investment to a change in the rate of interest, $'e'$.

(5) The smaller is $Z$, the marginal leakage or withdrawal propensity from the flow of income.

A money multiplier relating to the actual money stock, £M3, rather than the reserve assets base, $H$, can be derived by simply dividing multiplier (2) above by multiplier (1) as follows:

$$\frac{\frac{\partial Y}{\partial H}}{\frac{\partial M}{\partial H}} = \frac{\frac{\partial Y}{\partial M}}{\frac{\partial M}{\partial H}} = \frac{C_1}{B_1 - Z(C_2 - B_2)} \left[ 1 + \frac{C_2}{B_1 e^{-(C_2 - B_2)}} \right]$$

$C_1$ cancels of course since a stable money multiplier based on £M3 does not depend on the value of the reserve-base coefficient in the money supply equation. Providing the monetary authorities could exercise reasonably tight control over the growth of £M3, either by manipulation of the volume of reserve assets directly or by some other
means, then we have a policy-relevant multiplier.

It is, of course, the stability of the money multiplier combined with an accurate knowledge of its size, rather than the size of the multiplier per se, which is so crucial to the achievement of monetary policy target objectives. As previously mentioned in Chapter 1 if the size of the multiplier is low rather than high, this will simply involve a bigger initial change in the money supply in order to hit the target for aggregate nominal demand.

The autonomous expenditure multiplier in the reduced-form income equation is as shown below:

$$\frac{\Delta Y}{\Delta A} = \frac{1}{Z - \frac{B_1 e}{(C_2 - B_2)}}$$

Where $A$ = Autonomous expenditure

$= G + X$

Although instability in the demand for money income and interest rate parameters, $B_1$ and $B_2$, respectively, will certainly influence the size of this multiplier, it will not de-stabilise the multiplier as much as would be the case with monetary policy. This is because $B_1$ and $B_2$ have a smaller influence compared with the money multiplier case. Indeed, under the extreme Keynesian assumption of zero interest-elasticity of the IS function, the coefficient $e$

* For example via the 'corset' which was an important instrument of monetary control in the post-CCC 1970's or via a change in MLR, which became an important monetary instrument, for a brief period, at the end of the 1970's.
would be zero and the value of the multiplier would simply be $1/Z$, so that there is no dependence at all on either the demand for money or the supply of money structural parameters. Since Keynesians believe that investment is not especially sensitive to changes in the rate of interest - i.e. $e$ is low - it follows that stable income and interest rate parameters in the demand for money function will not be so crucial for fiscal policy as they are for monetary policy if one is a Keynesian. The stability of the autonomous expenditure multiplier will therefore depend importantly on the stability of $Z$, the marginal withdrawal propensity from the flow of income.

It has not been the intention, here, to examine the relative power of fiscal and money multipliers, but merely to establish their nature in terms of the structural parameters of the IS/LM model, and to see how changes in the values of these parameters can influence the sizes of the respective multipliers.* The question of particular interest which will be pursued empirically, is whether or not a stable money multiplier exists, and if not how far this is due to instability in the demand for money function?

* For a close consideration of the long-run effects of fiscal and monetary policy on aggregate demand see Tobin and Buiter (24) and the monetarist comments on this paper by Friedman and Cagan (24). The paper is of special theoretical interest since it seeks to establish whether pure fiscal policy (for example, an increase in government spending which is financed by an open market sale of debt thus leaving the money supply unchanged) can boost aggregate demand (nominal or real) in the long-run - i.e. is the long-run LM curve vertical?

For a consideration of the relative power of fiscal and monetary policy in a dynamic context see Arestis, Frowen and Karakitsos (6).
However, before considering the reduced-form model results for the post-CCC era it is important to stress the importance of the stability of each of the functions in the structural model, since it is possible for the functions to shift with the slope parameters remaining essentially stable. Any shifting of a function which takes the government by surprise will mean that even if the policy instrument variables are capable of being closely controlled and stable fiscal and money multipliers can be identified, it is still quite possible that the target growth for aggregate nominal demand will not be achieved.

The introduction of Competition and Credit Control in September 1971 led to shifts in the money supply and money demand functions with $A_0$ and $A_1$, the intercepts in the structural money equations, changing.

In the case of the IS equation there was certainly a downward shift in the consumption function which took the government by surprise in the mid-1970's.

The simple imports function in this model shifted upwards significantly at the end of the 1970's. This increased import penetration of UK markets was prompted by a combination of relatively high domestic inflation and a sharply rising exchange rate. Although North Sea Oil developments and the rise in oil prices were obviously important factors, tight monetary policy *certainly contributed to the upward trend in the exchange rate.

The extent to which these deflationary shifts in the consumption and import functions were not anticipated by the

* Sharp increases in MLR which pushed up domestic interest rates.
government will have meant excessive restriction of the growth of aggregate demand: 1975 and 1980 were years of sharp recession.

To see the potentially de-stabilising influences of these shifting functions on aggregate demand it is necessary to consider the relevant terms in the reduced-form money income equation.

The relevant term which captures the influence of shifting money supply and demand functions on national income is as follows:

\[
Y = \frac{1}{B_1 - \frac{Z(C_2 - B_2)}{e}} \left[ A_1 - A_0 \right] + \ldots
\]

where \(A_1\) = Intercept in money supply equation  
\(A_0\) = Intercept in money demand equation

Under ceteris paribus assumptions the disturbance to \(Y\) will be larger following a given change in \(A_1\) or \(A_0\):

1. The less sensitive is the demand for money to income changes - i.e. the smaller the value of \(B_1\).
2. The larger the value of the income-expenditure multiplier and the greater the interest sensitivity of investment - i.e. the lower the value of \(Z/e\).
3. The less sensitive that money supply and money demand are to interest rate changes - i.e. the smaller are the values of \(C_2\) and \(B_2\).
So, the steeper the LM curve, for a given income sensitivity of money demand, and the flatter the IS curve, the greater the disturbance to national income resulting from a given shift in the money supply or money demand functions.

The relevant term which captures the influence of shifting expenditure functions on national income is as follows:

\[
Y = \frac{1}{Z - B_1 e} \left[ \frac{c_0 - b t_0 + I_0 - m_0}{(C_2 - B_2)} \right] + \ldots \ldots \ldots
\]

Under ceteris paribus assumptions the disturbance to \( Y \) will be greater following a given change in one of the expenditure functions:

1. The smaller is \( Z \), the withdrawal or leakage propensity from the flow of income.
2. The smaller is \( B_1 \), the income sensitivity of money demand.
3. The smaller is \( e \), the interest sensitivity of investment.
4. The larger are \( C_2 \) and \( B_2 \), the money supply and money demand interest coefficients, respectively.

So, the steeper the IS curve, for a given value of the income-expenditure multiplier (\( 1/Z \)), and the flatter the LM curve, the greater the disturbance to national income resulting from a given shift in one of the expenditure functions.
Even if both the LM and IS functions are essentially stable, subject only to relatively minor stochastic shocks, so that aggregate nominal demand can be successfully managed by either fiscal or monetary policy, it does not follow that the rate of inflation can be closely controlled (certainly in the short-run). This is because prices may continue to rise significantly while output falls back. In this case a target for aggregate nominal demand is achieved through falling output and rising unemployment rather than the intended fall in inflation.*

10.1.3 Reduced-form model results for the post-CCC era, 1972(1)-1978(4)

The relevant reduced-form model is based on the following dynamic IS/LM structure.**

\[ M^D = \lambda A_0 + \lambda B_1 Y + \lambda B_2 R_B + \lambda B_3 R_{CD} + (1-\lambda) M^D_{-1} \]

\[ M^S = \theta A_1 + \theta C_1 H + \theta C_2 R_B + \theta C_3 MLR + (1-\theta) M^S_{-1} \]

\[ M^S = M^D = M_t \]

IS \[ Y = \frac{\phi}{Z} \left[ c_0 - b_t + I_0 - m_0 \right] + \frac{\phi}{Z} \left[ G + X \right] + \frac{\phi e}{Z} R_B + (1-\phi) Y_{-1} \]

From the money market equations, (1)-(3) above, the following LM equation is derived:

* Since 1979 the government has relied almost exclusively on monetary growth targets to achieve the low inflation objective. However, by the end of 1981 inflation was still comfortably in double figures while real output had fallen back and unemployment had risen to the three million mark.

** Results for the structural equations of this model were presented in Section 6.2 of Chapter 6.
\[
\text{LM } Y = \left( \frac{e}{\lambda B_1} A_1 - \frac{A_0}{B_1} \right) + \frac{\theta C_1}{\lambda B_1} H + \frac{\theta C_2 - \lambda B_2}{\lambda B_1} R_B + \frac{\theta C_3}{\lambda B_1} \text{MLR} \\
- \frac{B_3}{B_1} R_{CD} + \frac{(1-\theta)-(1-\lambda)}{\lambda B_1} M_{-1}
\]

Endogenous variables – M, Y and R_B.

Notes

1. The residual terms are omitted from the equations for convenience.

2. A general partial adjustment lag structure has been imposed with \( \lambda, \theta \) and \( \phi \) being the relevant lag parameters. The remaining parameters are as defined for the equilibrium model which was described in 10.1.1 above.

3. \( R_{CD} \) and MLR are additional variables entering the money demand and money supply equations, respectively. Both are treated as exogenous.

The reduced-form equations are as follows:

\[(1) \text{ Interest rate} \]

\[
R_B = \frac{1}{\lambda B_1 \varnothing e - (\theta C_2 - \lambda B_2)} \left[ \frac{\theta A_1 - \lambda A_0}{Z} \right] + \frac{\theta C_1}{\lambda B_1 \varnothing e - (\theta C_2 - \lambda B_2)} H \\
+ \frac{\theta C_3}{\lambda B_1 \varnothing e - (\theta C_2 - \lambda B_2)} \text{MLR} - \frac{\lambda B_3}{\lambda B_1 \varnothing e - (\theta C_2 - \lambda B_2)} R_{CD} \\
+ \frac{1}{Z(\theta C_2 - \lambda B_2) - \varnothing} A^* + \frac{(1-\theta)-(1-\lambda)}{\lambda B_1 \varnothing e - (\theta C_2 - \lambda B_2)} M_{-1}
\]
\[
\begin{align*}
\mathbb{M} &= 1 + \frac{\epsilon C_2}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \theta A_1 + \frac{\epsilon C_2}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \theta A_0 \\
&+ \epsilon C_1 \left[ 1 + \frac{\epsilon C_2}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \right] A^* + \epsilon C_3 \left[ 1 + \frac{\epsilon C_2}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \right] A^* \\
&+ \frac{(1 - \theta) \lambda B_2 - (1 - \lambda) \epsilon C_2 + (1 - \theta) \lambda B_1 \delta e}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \epsilon C_2 \lambda B_1 (1 - \theta) - \lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2) \theta A_0 \\& Y = \frac{1}{\lambda B_1 - Z(\epsilon C_2 - \lambda B_2)} \left[ \epsilon A_1 - \lambda A_0 \right] + \frac{\epsilon C_1}{\lambda B_1 - Z(\epsilon C_2 - \lambda B_2)} \theta A_0 \\
&+ \frac{\epsilon C_3}{\lambda B_1 - Z(\epsilon C_2 - \lambda B_2)} \epsilon C_3 \left[ 1 + \frac{\epsilon C_2}{\lambda B_1 \delta e - (\epsilon C_2 - \lambda B_2)} \right] A^* + \frac{(1 - \theta) - (1 - \lambda)}{\lambda B_1 - (\epsilon C_2 - \lambda B_2) Z} M_{-1}
\end{align*}
\]
\[
\frac{(1-\phi) (eC_2- \lambda B_2)}{\lambda B_1 \phi e - (eC_2- \lambda B_2)} Y - 1
\]

\[A^* = c_0 - b t_0 + I_0 - m_0 + G + X\]

**Untransformed linear model**

(1) \[R_B = 5.82 + 0.19H + 0.62A^* - 0.48R_{CD} + 0.72MLR + 0.48M3_1 - 0.95Y_1\]
\[
\begin{align*}
(3.3) & \quad (0.2) & \quad (1.8) & \quad (1.9) & \quad (2.5) \\
(3.0) & \quad (-1) & \quad (4.4) & \quad (-1)
\end{align*}
\]

\[R^2 = .846 \quad \chi^2_{10} = 8.5 \quad \chi^2_4 = 36.2\]

(2) \[M3 = 0.16 + 0.76H - 0.19A^* + 0.31R_{CD} - 0.26MLR + 0.80M3_1 + 0.28Y_1\]
\[
\begin{align*}
(0.2) & \quad (1.8) & \quad (1.1) & \quad (2.4) & \quad (1.8) \\
(9.5) & \quad (-1) & \quad (2.6) & \quad (-1)
\end{align*}
\]

\[R^2 = .997 \quad \chi^2_{10} = 13.9 \quad \chi^2_4 = 5.3\]

(3) \[Y = 0.83 + 0.05H + 0.31A^* - 0.24R_{CD} + 0.19MLR + 0.07M3_1 + 0.71Y_1\]
\[
\begin{align*}
(1.1) & \quad (0.2) & \quad (2.2) & \quad (2.3) & \quad (1.6) \\
(1.0) & \quad (-1) & \quad (8.0) & \quad (-1)
\end{align*}
\]

\[R^2 = .998 \quad \chi^2_{10} = 21.5 \quad \chi^2_4 = 32.8\]

**Log-linear model**

(1) \[R_B = 3.46 - 0.31H + 0.07A^* + 0.19R_{CD} + 0.15M3_1 - 0.08Y_1\]
\[
\begin{align*}
(0.5) & \quad (1.2) & \quad (0.2) & \quad (3.0) & \quad (0.2) & \quad (0.2) & \quad (-1) & \quad (0.2) & \quad (-1) \\
(7.6)
\end{align*}
\]

\[p = 0.89 \quad \chi^2_{10} = 9.1 \quad \chi^2_4 = 3.9\]

* The relationship between the structural parameters in the reduced-form equations described above, is only applicable to the untransformed linear model.
Inspection of the theoretical properties of the reduced-form model indicates the following a priori signs for the impact and dynamic multipliers in the interest rate, money stock and national income equations:

<table>
<thead>
<tr>
<th></th>
<th>H</th>
<th>A*</th>
<th>R_CD</th>
<th>MLR</th>
<th>M3-1</th>
<th>Y-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>R_B</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>(2)</td>
<td>M3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/-</td>
<td>+</td>
</tr>
<tr>
<td>(3)</td>
<td>Y</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+/-</td>
<td>+</td>
</tr>
</tbody>
</table>

Note - The signs of the coefficients associated with the lagged money stock in the interest rate and income equations will depend on the relative sizes of the lag adjustment parameters in the money supply and money demand equations. If \( \theta > \lambda \) then the coefficient on \( M3-1 \) will be positive in the interest rate equation and negative in the income equation. The reverse is true if \( \lambda > \theta \).

The empirical results for the untransformed linear case reveal that several of the impact multipliers have theoretically incorrect signs:

1. In the reduced-form interest rate equation \( H, R_{CD} \) and \( Y_{-1} \) all have incorrectly signed coefficients, and in
the case of the latter two variables the coefficients are significant at the 10% significance level.

(2) In the reduced-form money stock equation only autonomous expenditure enters with an incorrect sign. However, the coefficient is insignificant at the 10% level.

(3) The coefficients associated with both MLR and M3-1 have theoretically incorrect signs in the income equation, although neither are significant at the 10% level.

The empirical results for the log-linear case* stand in quite marked contrast:

(1) In the interest rate equation only the coefficient associated with lagged income, Y_{-1}, has an incorrect sign, and this coefficient is highly insignificant.

(2) All coefficients have theoretically correct signs in the money stock equation.

(3) Only the reserve assets base, H, enters with a theoretically incorrect negative sign in the income equation. The highly insignificant and negligible coefficient suggests that manipulation of the reserve assets base by the monetary authorities has virtually no impact on national income within a single quarter.

A more general inspection of the reduced-form results reveals that several of the impact multipliers are highly insignificant and that both the untransformed linear and the

* See footnote on p.131, Chapter 3, regarding the validity of the log-linear model specification.
log-linear national income equations fail the random correlogram test \( x_{10}^2 > 18.2 \). While each of the log-linear equations clearly pass the post-sample parameter stability test \( x_4^2 \) both the income and interest rate equations in the untransformed linear model emphatically fail this test. Finally, while the residuals in each of the log-linear reduced-form equations were subject to significant serial correlation, this problem was absent in the untransformed linear model.

I will now focus on the reduced-form equations of special policy interest which are the untransformed linear and log-linear national income equations. Tables 10.1 and 10.2 below show the relevant impact and dynamic multipliers associated with the policy instruments - \( H \), MLR, \( R_{CD} \), A. The relevant short-run and long-run structural parameter estimates are also shown. These structural parameters of the dynamic IS/LM model were estimated by 2SLS (see Chapter 6, Section 6.2, Table 6.19).

Both the untransformed linear and the log-linear model results suggest that monetary policy via manipulation of the reserve assets base has a very weak impact influence on aggregate demand. However, the full long-run response of demand is quite strong with adjustment occurring gradually over a long period. The untransformed linear model results, shown in Table 10.1, suggest an impact multiplier of only 0.05, but a much larger dynamic multiplier of 7.98. Since the reserve assets base coefficient in the log-linear case has a theoretically incorrect negative sign this result is rejected.
The structural coefficients $e_2$ and $e_3$ have theoretically incorrect signs.

Increase in the money supply

proportion for increases in autonomous spending which are not accompanied by

yield a multiplier estimate of $1.381 - 0.77$ or $1.24$. This estimate might be

is zero. Ignoring the troublesome term involving these structural parameters

are measured in $t$ billions.

$e = -0.0103$
$I/z = 1.381$
$e_2 = 0.2$
$e_3 = -0.4$
$c_1 = 0.3$
$c_2 = 0.3$
$c_3 = 2.0$
$c_4 = 0.4$
$z_1 = 0$
$z_2 = 0$
$z_3 = 0.4$
$z_4 = 1.4$

Notes

Significant at 10% significance level

\[
\begin{align*}
\text{ec}_1 &= 0.12 \\
\text{ec}_2 &= 0.24 \\
\text{ec}_3 &= 0.07 \\
\text{ec}_4 &= 0.05 \\
\end{align*}
\]

Structural coefficients from which long-run coefficients are

\[
\begin{align*}
1.381 & 1.381 \\
0.2 & 0.77 \\
0.24 & 0.07 \\
0.05 & 0.05 \\
\end{align*}
\]

Dynamic

Impact

Multiplier (Reduced-form Income

TABLE 10.1
In the value of the relevant exogenous variable, both the impact and dynamic percentage income responses following a 1% change are only multipliers in percentage terms - i.e., elasticities. They show

After adjusting the reduced-form equation for first order serial correlation, the structural equation supply equation, explanatory variable in the structural money supply equation. In the log-linear model since it was a highly insignificant

**Notes**

**Insignificant at 10% significance level**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_1$</td>
<td>0.045</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>-0.06</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>-0.015</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>-0.015</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>0.03</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.049</td>
</tr>
</tbody>
</table>

Structural coefficients

- Impact
  - $Y_{t+1}$ = 0.340
  - $Y_{t+2}$ = 0.015

Income Multipliers (Reduced-form)

- Log-linear IS/LM Model

**TABLE 10.2**
In contrast fiscal policy, via an increase in government spending, appears to have a much stronger impact influence although with full adjustment completed relatively quickly the dynamic multiplier is considerably smaller than is the case for monetary policy: a multiplier of 1.4 compared with 8.0 (Table 10.1). The fiscal multipliers seem plausible enough providing changes in government spending do not involve changes in the money supply.

As for the other instruments of monetary policy, MLR only really became important at the end of the 1970's and the influence of the 'corset' cannot be successfully picked-up by the model as it stands. In fact the structural parameter, $\Theta C_3$, associated with MLR had a theoretically incorrect positive sign in the money supply equation of the untransformed linear model, while it was small and highly insignificant in the log-linear model.

On purely statistical grounds these reduced-form results must be treated with caution since multicollinearity problems involving the reserve assets base, $H$, and autonomous expenditure, $A$, may well have upset the estimated coefficients; the simple correlation between $H$ and $A$ is 0.96.

A close inspection of the structural parameters, shown in Tables 10.1 and 10.2, reveals that it is the coefficients in the money supply equation which are causing the problem and that this particular equation needs revising. In both the untransformed linear and log-linear cases the interest rate coefficient is significantly negative when in theory it should be positive. No doubt the failure to formally consider the financing of the PSBR has caused problems here, since a greater tendency to borrow from the non-bank private sector
will help to restrict money supply increases while at the same time higher rates of interest will have to be offered on government bonds.

In contrast, each of the structural parameters in the money demand and aggregate expenditure equations have the theoretically correct signs. However, in the untransformed linear case (Table 10.1) the income coefficient in the demand for money equation is weakly-determined and the implied speed of adjustment is implausibly slow at 5 years! In the log-linear model (Table 10.2) the income elasticity of money demand is both well-determined and plausible taking the value 0.63. Furthermore, adjustment is completed after 6 months which seems reasonable. The only weakness concerns the bond rate which enters the demand for money equation with a small and weakly-determined coefficient, although it does have the correct sign.

So it appears from the above results that the money supply equation is causing most of the problems and that it needs to be revised to take specific account of the influence of the 'corset' as well as the interaction between fiscal and monetary policy via 'inflationary financing' of the PSBR.

Other problems may well include (1) the failure to include a variable to account for inflation expectations in the IS and LM equations, (2) the omission of the labour market from the model and (3) erroneous lag structure.

Remedying the above-mentioned problems would involve the construction of a considerably more complex model;* a task which is outside the scope of research focussed on UK demand.

* Such a task is currently being undertaken and I hope to report my empirical findings in the near future.
for money functions. A major concern of this particular thesis has been to establish whether or not just one of the necessary conditions for successful aggregate demand management via monetary policy has been met in the post-CCC 1970's - i.e. whether a stable and policy-relevant demand for money function can be identified. So, further examination of policy issues will now be based entirely on the empirical evidence concerning the stability, or otherwise, of the post-CCC demand for money functions.

All that remains to be said here is that despite the various weaknesses of the IS/LM structure, which are outlined above, the framework has been useful for highlighting the policy issues, with the empirical results suggesting that the most serious problems for monetary policy may well be related to the control of the money supply.

10.2 A verdict on stability based on the best demand for money results for the various definitions of money

The best results are shown in Tables 10.3 and 10.4 below, and full details on the equations shown were given in Chapters 5-9 inclusive. Relatively simple models proved best with fixed partial adjustment lag structures. Simultaneity was not found to be important in the context of a quarterly model for either M1 or £M3 so that single equation estimation techniques were valid.

For both broad and narrow definitions of money there was no evidence of any important speculative influences on money demand and international variables such as the exchange rate were not found to be significant. This latter finding is not perhaps too surprising in view of the exchange controls
which were in force over the post-CCC sample period.

Inflation expectations, as proxied by the lagged moving annual percentage changes in the R.P.I., were only important for M1, although the direct influence of the variable in this equation was not especially strong.

A particularly important feature of the results is clearly brought out by Table 10.4. With the exception of M1 and company sector money demand there is a significant discrepancy between the values of the estimated price and income elasticities. For £M3 the income and price elasticities are 2.2 and 0.5, respectively, so that simply specifying nominal income as the constraint variable, as was done in the IS/LM model considered in the previous section, is not really empirically valid. It appears from the results shown in Table 10.3 that personal sector money demand behaviour accounts for the discrepancy between the income and price elasticities since the long-run income elasticity of MP is over 2 while the price elasticity is only in the region of 0.3!*

Equations 5 and 6 which cover personal and company sector money demand, respectively, show that the money-holding behaviour of the two sectors is quite different. As expected company money demand is much more sensitive to interest rate changes and adjustment lags are very short compared with the personal sector. A shift in the balance

* Since the estimated price and income elasticities are in broad agreement for M1, while there is a major discrepancy in the case of time deposits (TD), it must be the personal sector's demand for interest-bearing money which is mainly responsible for the discrepancy.
of M3 holdings between the two sectors might easily be responsible for upsetting the policy-relevant M3 demand function.

The major concern is to assess the stability of these various empirical demand functions; especially M3 which has been the policy-relevant definition of money in the post-CCC 1970's. The stability criteria employed are as follows:

(1) The significance and plausibility of the estimated parameters.

(2) The ability of the estimated relationships to explain a high percentage of variation in money demand - i.e. high values for $R^2$.

(3) Random residuals.

(4) Parameter constancy when the sample data period changes.

(5) Post-sample stability of the structure.

(6) Ex-post forecasting performance.

Criteria (1)-(3) are concerned with 'within sample' performance while (4)-(6) are concerned with post-sample performance, in particular the predictive powers of the estimated relationships.

Taking each money definition in turn criteria (1)-(3) can now be considered. Only the weaknesses will be mentioned so that if there are no weaknesses then the estimated relationships can be taken as stable as far as these particular criteria are concerned.
M1
Inspection of the results in Tables 10.3 and 10.4 reveals that when inflation expectations are not included as an explanatory variable (equation (1)) the estimated income elasticity is insignificant and the hypothesis of random residuals cannot be accepted. However, when inflation expectations are included (equation (2)) the serial correlation problem disappears and the significance of the income elasticity is improved, although with a t-value of only 1.5 it is still not significant at the 10% significance level. Table 10.4 shows that the inclusion of inflation expectations leaves the estimated long-run price elasticity virtually unchanged, and close to unity the theoretically expected value, but shortens the lag adjustment period from over 10 months to 6 months. In all other respects the results are well-determined and plausible.

Time deposits (TD)
The major weakness concerns the very low and insignificant price elasticity. Table 10.4 shows that the estimated long-run price elasticity is only 0.12, a result which suggests that the public's holdings of interest-bearing bank deposits are not importantly related to movements in GDP prices. In all other respects the sample results are well-determined and plausible.

£M3
The results shown in Table 10.3 are well-determined and plausible and equation 4 comes very close to satisfying the stability criteria. The only possible weakness concerns the relatively low value of the long-run price elasticity.
Table 10.4 shows that the elasticity is only 0.50 so that the theoretical expectation of linear homogeneity does not receive empirical support. However, it can readily be seen from Table 10.4 that this elasticity of 0.50 is consistent with the separate price elasticity results for M1 and TD - i.e. it is approximately equal to the weighted average of the long-run price elasticities for M1 and TD.

MP  
While most of the short-run elasticities are well-determined the price elasticity is not, and as Table 10.4 shows, the estimated long-run price elasticity certainly seems to be rather low at only 0.33!

MC  
Since 1st order serial correlation was highly significant, adjustment was made for this: a $x^2$ test based on the URTF and RTF results showed the transformation to be empirically valid. After making the adjustment the hypothesis of random residuals could be comfortably accepted and the results shown in Table 10.3 suggest that full adjustment of money demand, following a disturbance is completed within a single quarter. Only the interest rate elasticities are insignificant at the 5% level, although very high correlation between the CD and LA rates accounts for the relatively high standard errors associated with the coefficients.

Although not shown in Table 10.3 the results for survey companies (see Chapter 9, Section 9.2) stand in contrast to those for all industrial and commercial companies. Whereas the latter suggest economies of scale in company money-holdings, the aggregate survey company results suggest
TABLE 10.3
The Best Estimated Demand for Money Equations for the Alternative Definitions of Money in the Post-CCC Era (1972(1)-1978(4)).

(1) \( M_1^A = 0.166 + 0.283Y + 0.267P -0.074R^S + 0.708M_{1-1} \)
\( x^2_{10} = 21.7 \quad R^2 = .995 \quad S.E. = .021453 \)

(2) \( M_1^B = 1.745 + 0.335Y + 0.461P -0.066R^S -0.033P_{-1} + 0.498M_{1-1} \)
\( x^2_{10} = 14.3 \quad R^2 = .996 \quad S.E. = .020610 \)

(3) \( TD = -4.462 + 0.606Y + 0.024P -0.124R^S + 0.830TD_{-1} \)
\( x^2_{10} = 9.9 \quad R^2 = .993 \quad S.E. = .0226019 \)

(4) \( EM3 = -2.144 + 0.402Y + 0.086P -0.037R^S + 0.817EM3_{-1} \)
\( x^2_{10} = 8.4 \quad R^2 = .997 \quad S.E. = .013597 \)

(5) \( MP = -1.495 + 0.276PDI + 0.039P -0.0053 (R_{BU}-R^7_{OR})^+ \)
\( + 0.016D -3 + 0.879MP_{-1} \)
\( x^2_{10} = 18.6 \quad R^2 = .996 \quad S.E. = .014764 \)

(6) \( MC' = 0.178 + 0.733Y' + 0.716P' -0.460R'_{LA} + 0.575R'_{CD} \)
\( + 0.074MC' \)
\( x^2_{10} = 12.6 \quad \hat{p} = 0.795 \quad S.E. = .047964 \)

All variables are expressed in natural logarithms except +.
<table>
<thead>
<tr>
<th>Duration</th>
<th>ln (M)</th>
<th>ln (W)</th>
<th>ln (MC)</th>
<th>ln (MP)</th>
<th>ln (EM)</th>
<th>ln (TD)</th>
<th>ln (MP)</th>
<th>ln (EM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 months</td>
<td>-0.46</td>
<td>0.57</td>
<td>0.71</td>
<td>0.73</td>
<td>0.44</td>
<td>0.33</td>
<td>0.50</td>
<td>2.22</td>
</tr>
<tr>
<td>2 yrs 1 month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-17 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-18 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>-0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-11 months</td>
<td>-0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The best demand for money equations for long-run elasticities and speeds of adjustment for income and price income. TABLE 10.4
that large companies regard money as a luxury good. The disaggregated survey company results, although not particularly well-determined, suggest that money is only a luxury good for manufacturing companies.

Although it is clearly possible that the money-holding behaviour of large companies is essentially different from that of smaller companies, the different empirical results might be accounted for by either, or both, of the following:

1. The survey covers only a non-random sample of large companies; a sample which has varied in both size and composition.

2. Data for all industrial and commercial companies is obtained from a different source.

In connection with the stability criteria (4)-(6) different sample data periods were only considered for the aggregate demand for money equations; M1, TD and £M3. For sectoral money demand (MP and MC) only evidence on post-sample structural and parameter stability, along with ex-post forecasting performance, is considered.

The parameter constancy criterion can now be considered for each of the aggregate money definitions in turn. The supporting empirical evidence for M1 was reported in Chapter 5 while the evidence for TD and £M3 was reported in Chapter 6.

**M1**

The suggestion is that the M1 structure changes after the introduction of Competition and Credit Control, although the pre-CCC structure is not sufficiently well-determined for us
to be sure of this. Empirical evidence from the pooled sample of pre-CCC and post-CCC data suggests that there is a shift in the function after 1971 and that inflation becomes influential in the post-CCC period. The M1 function settles down after 1976 with an equation estimated over the period 1964(1)-1976(4) forecasting money demand over the years 1977-1979, inclusive, reasonably well. In fact the estimated parameters almost coincide with those for the full sample period, 1964(1)-1979(4).

An interesting feature of the results for the entire sample of data, 1964(1)-1979(4), is that when the 'CCC observations' (1971(4)-1973(4)) were excluded from the sample the serial correlation problem, suggested in the full sample results, disappeared. It therefore seems reasonable to assume that the CCC reforms, which temporarily disturbed the behaviour of M1, had caused the serial correlation problem.

**TD and £M3**

Lack of independent variation in the data during the 1960's means that we cannot be confident about either the TD or £M3 demand structures in the pre-CCC era. There is certainly no firm evidence to suggest that the pre-CCC structure is significantly different from the post-CCC structure for either time deposits or £M3 once the importance of an own-rate on money variable is formally recognized after 1971.

The equations estimated over the full data period, 1964(1)-1978(4), were similar to those estimated over the post-CCC era, and excluding the 'CCC observations' (1971(4)-1973(4)) from the full sample only had a trivial influence on the results.
Criteria (5) and (6) can be considered jointly for each of the relevant money definitions. Table 10.5 below shows the ex-post forecasting performance over 1979 of the best demand for money equations, which are listed in Table 10.3 above. It also shows the $x^2$ test statistic for post-sample parameter stability over the four quarters ($x^2_4$). It can be seen that the post-sample parameter stability test is comfortably passed in every case, and although not shown in the table so is the Chow test for structural stability. As for the forecast errors they are reasonably small in percentage terms except for company sector money demand. The relatively large percentage errors for MC occur because seasonally unadjusted data was used and no seasonal dummies were specified.*

For M1, TD and £M3 none of the individual forecast errors were significant at the 5% level and only in the case of TD did the errors not show changes of sign with small over-prediction errors occurring in each quarter.

For the personal sector, despite changes of error sign showing that both under and over-prediction errors occur, the under-prediction error of 3.1% in 1979(3) was significant at the 5% level.

For the company sector, despite the relatively large over-prediction errors which occur in the third and fourth quarters, none of the forecast errors are significant at the 5% level.

---

* Information provided by the Department of Industry clearly indicated a shifting seasonal pattern for company sector money demand over the post-CCC data period.
TABLE 10.5
Ex-Post Forecasting Performance of the Best Demand for Money Equations in 1979: Percentage Forecast Errors

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>$x_4^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. M1$^A$</td>
<td>-0.5</td>
<td>1.9</td>
<td>0.3</td>
<td>-1.6</td>
<td>1.43</td>
</tr>
<tr>
<td>2. M1$^B$</td>
<td>-0.7</td>
<td>1.8</td>
<td>0.6</td>
<td>-2.5</td>
<td>2.45</td>
</tr>
<tr>
<td>3. TD</td>
<td>0.8</td>
<td>1.1</td>
<td>1.9</td>
<td>0.03</td>
<td>1.1</td>
</tr>
<tr>
<td>4. £M3</td>
<td>0.6</td>
<td>0.5</td>
<td>0.2</td>
<td>-1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>5. MP</td>
<td>0.7</td>
<td>-0.5</td>
<td>-3.1</td>
<td>-1.8</td>
<td>6.2</td>
</tr>
<tr>
<td>6. MC</td>
<td>1.4</td>
<td>-2.1</td>
<td>8.2</td>
<td>5.4</td>
<td>4.2</td>
</tr>
</tbody>
</table>

A = Inflation expectations excluded
B = Inflation expectations included
More stringent tests of ex-post forecasting performance were conducted for M1 and £M3. In each case equations estimated over the period 1964(1)-1976(4) were used to forecast the remaining years in the sample, 1977-1979, inclusive. The M1 equation performed well and only small under-prediction and over-prediction errors occurred, none of which were significant at the 5% level. Both the \( x^2 \) test for post-sample parameter stability and the Chow test for structural stability were easily passed. The £M3 equation just failed the post-sample parameter stability test although the Chow test for structural stability was passed. Small under-prediction errors were recorded for every quarter except 1977(1) when a small over-prediction error occurred. The largest under-prediction error was just under 3\% and this was the only significant forecast error (5\% level). There was no evidence of any trend growth of error size.

A more rigorous test of ex-post forecasting performance can be conducted by considering the performance of the post-CCC (1972(1)-1978(4)) estimated demand for money equations in the early 1980's. Table 10.6 below shows forecasts for M1, TD and £M3 over the period 1980(1)-1981(1), inclusive. Since all remaining exchange controls were removed in October 1979 and since MLR became an important instrument of monetary control,\(^*\) with the 'corset' finally being abolished in June 1980, this represents a fairly severe test of post-sample performance for the '1970's estimated' demand for money equations.

\(^*\) MLR is no longer an important instrument of monetary control and ceased to be continuously posted in August 1981.
It can be seen from Table 10.6 that over-prediction errors occur in each quarter in the case of M1 whereas for TD under-prediction errors occur. On balance, the M1 equation which excludes inflation expectations, as measured by the lagged moving annual inflation rate, performs better than the equation which includes the variable; although the error pattern is similar for the two equations the errors tend to be larger when $\hat{P}_{-1}$ is included, with two of the forecast errors proving significant as opposed to just one when $\hat{P}_{-1}$ is excluded. These results suggest that the lagged inflation rate fails to pick-up the influence of inflation expectations over the early 1980's. In the case of TD three of the forecast errors were significant with the largest under-prediction error being well over 6%.

Table 10.6 reveals that as the M1 over-prediction errors increase so do the under-prediction errors for time deposits and vice-versa. This indicates that over the period 1980(1)-1981(2) movements of deposits between non-interest bearing and interest-bearing bank accounts were not being properly picked-up.

The results for £M3, shown in Table 10.6, confirm that to some extent movements between M1 and time deposits which are not being picked-up by the estimated equations are causing the problem. The sizes of the forecast errors are uniformly smaller with a largest error of 3.5%, which is only just significant. However, with the exception of 1980(1) they are all under-prediction errors which indicates that in addition to movements between M1 and TD which simply change the composition of £M3, there must have been a net movement of funds from alternative financial assets into interest-bearing
money. The most significant under-prediction error of 3.5% occurred in the last quarter of 1980 and can be accounted for by the re-intermediation of funds following the termination of the 'corset' in the middle of that year.

On balance, the various stability criteria considered above suggest that the post-CCC estimated M1 and £M3 demand functions are relatively stable. The major weakness in the case of the M1 function was the relatively weakly-determined income elasticity and although the tracking performance of the equation over the period 1980(1)-1981(2) was rather poor, this can probably be put down to a change in interest rate behaviour following the active use of MLR as a technique of monetary control.* In the case of £M3 the only real weakness concerns the low long-run price elasticity of 0.5, although this equation was considerably more plausible than the one in which linear homogeneity was imposed from the outset (see £M3 results reported in Chapter 6). The structure for time deposits is not so well-determined. In particular, the price elasticity is low and insignificant.

It appears from the sectoral demand for money equations that the above-mentioned weakness for time deposits is largely accounted for by the money-holding behaviour of the personal sector, since the price elasticity of MP is both low and insignificant while the price elasticity of MC is well-determined and much closer to unity. The company sector demand for money equation was reasonably well-determined and despite some relatively large ex-post forecast errors, which

* See footnote on p.463 concerning MLR.
TABLE 10.6

Ex-Post Forecasts for M1, TD and £M3: 1980(1)-1981(1)

<table>
<thead>
<tr>
<th></th>
<th>1980</th>
<th>1981</th>
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<tr>
<td></td>
<td>1</td>
<td>2</td>
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(1) M1 (excluding $E$

<table>
<thead>
<tr>
<th></th>
<th>£B. Actual</th>
<th>Forecast</th>
<th>Forecast-actual</th>
<th>% Percentage forecast error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>29.4</td>
<td>30.5</td>
<td>1.1</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>30.0</td>
<td>30.8</td>
<td>0.8</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>29.8</td>
<td>31.6</td>
<td>1.8</td>
<td>6.0+</td>
</tr>
<tr>
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<td>30.7</td>
<td>31.7</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>31.9</td>
<td>32.6</td>
<td>0.7</td>
<td>0.7</td>
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</table>

(2) M1 (including $E$

<table>
<thead>
<tr>
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<th>Forecast-actual</th>
<th>% Percentage forecast error</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>29.4</td>
<td>30.4</td>
<td>1.0</td>
<td>3.4</td>
</tr>
<tr>
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<td>30.0</td>
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<td></td>
<td>29.8</td>
<td>31.7</td>
<td>1.9</td>
<td>6.4+</td>
</tr>
<tr>
<td></td>
<td>30.7</td>
<td>32.2</td>
<td>1.5</td>
<td>4.9+</td>
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<td></td>
<td>31.9</td>
<td>33.1</td>
<td>1.2</td>
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(3) TD

<table>
<thead>
<tr>
<th></th>
<th>£B. Actual</th>
<th>Forecast</th>
<th>Forecast-actual</th>
<th>% Percentage forecast error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30.2</td>
<td>30.1</td>
<td>-0.1</td>
<td>-4.9+</td>
</tr>
<tr>
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<td>38.4</td>
<td>35.9</td>
<td>-2.5</td>
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<tr>
<td></td>
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<td>-1.3</td>
<td></td>
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</tbody>
</table>

(4) £M3

<table>
<thead>
<tr>
<th></th>
<th>£B. Actual</th>
<th>Forecast</th>
<th>Forecast-actual</th>
<th>% Percentage forecast error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>59.6</td>
<td>60.3</td>
<td>0.7</td>
<td>1.2</td>
</tr>
<tr>
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<td></td>
<td>65.8</td>
<td>64.3</td>
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<td>-3.5+</td>
</tr>
<tr>
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<td>69.1</td>
<td>66.7</td>
<td>-2.4</td>
<td>-1.3</td>
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<tr>
<td></td>
<td>70.3</td>
<td>69.0</td>
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</table>

$^+$ denotes significant forecast errors: $Y-Y > 2$ standard errors.

Note - Since expenditure-based estimates of the GDP are not available for 1981(2) and 1981(3) owing to the absence of overseas trade statistics the forecast period is terminated at the end of 1981(1).
were mainly due to a shifting seasonal pattern in MC*, it passed the post-sample stability tests.

10.3 Policy implications and conclusions
From my empirical work a qualified picture of stability has emerged for the demand for money function in the post-CCC 1970's. While other researchers have claimed that the demand for broad money (£M3) has been unstable in this period** it must be remembered that conclusions were mostly based on data periods combining pre-CCC data with only a small sample of post-CCC observations. Furthermore, short-run or long-run homogeneity in prices was often imposed from the outset without any attempt to test the empirical validity of such assumptions. In my own work the price elasticity was freely-determined and while for the M1 definition of money it was close to unity, as expected, for £M3 it was only 0.5. Attempts to impose either short-run or long-run homogeneity in prices suggested that the demand for broad money function was unstable, while the freely estimated equation suggested stability. Although the estimated price elasticity does seem rather low the result for £M3 was entirely consistent with the results for M1 and time deposits on the one hand and personal and company sector money-holdings on the other. Consideration of these results revealed that while the price-elasticity of demand for non-

* This shifting seasonal pattern is possibly associated with both the timing of tax payments and the introduction of new taxes.

** See Chapter 4 for details.
interest bearing money was indeed close to unity, the
personal sector's demand for interest-bearing bank deposits
was not significantly related to movements in either GDP
or consumer prices. The tracking performance of the freely-
estimated £M3 demand equation (1972(1)-1978(4)) was
reasonable over the period 1980(1)-1981(1), inclusive,
despite (1) the removal of exchange controls in October 1979
and (2) the abolition of the 'corset' in June 1980.

However, despite the fact that the empirical work
reported in this thesis appears to suggest that at least
one of the necessary conditions for the success of monetarism
is satisfied, it needs to be stressed that the authorities
have, on occasions, certainly experienced difficulties in
controlling the money supply.* Failure to achieve the
desired control certainly discredits monetarism to some
extent and this, in turn, means that the stability of the
demand for money function will no longer be such a crucial
policy issue.

Despite the temporary distortions to £M3 caused by
the reintermediation of funds following the termination of
the 'corset', the authorities, under normal circumstances,
still regard this definition as the best choice for an inter-
mediate target variable. So, the question naturally arises

* For example, during the financial year 1977/78 the growth
of £M3 was, at 16\%\%, over 3 percentage points above the
top end of the 9-13\% target range. Again, in the first
year of the MTFS, 1980/81, the growth of £M3, at 7 percent-
age points above the top end of the 7-11\% target range,
was clearly excessive. However, in this latter case the
excessive growth was largely due to the reintermediation
of funds following the termination of the corset and
greater attention was paid to other monetary indicators
which suggested much tighter monetary conditions.
as to whether, in the absence of the 'corset' (which was moderately successful in controlling the growth of the money supply), a sufficient degree of control over money supply movements is possible? The 'corset' achieved control at the expense of a disintermediation of funds prompted by a change in relative interest rates. This weakens the policy significance of £M3 since offsetting increases in velocity mean that the ultimate policy target variables cannot be reliably influenced by monetary restraint.

Ironically, then, it may be possible to identify a stable demand for broad money function (one including a suitable own-rate on money variable) and achieve an adequate control of the money supply but because of changing interest differentials and the consequent shifting of funds, this may have little ultimate policy significance for the control of inflation.

Now because of the financial market distortions following the termination of the 'corset' the issue of adequate money supply control cannot be fairly judged in the context of the early 1980's experience. The present instruments of money supply control are interest rates and fiscal policy, and following the abolition of the multiple reserve assets ratio in August 1981, the UK monetary authorities appear to be moving closer to a system of monetary base control. It remains to be seen, then, whether (1) a reasonable degree of control over the money supply can be achieved and (2) if it can, whether the change in the techniques of monetary control employed undermines the stability of the demand for money function, or causes
distortions in financial markets which render the policy instruments useless for achieving the ultimate goal of low and steady inflation.

The case for exchange rate as opposed to monetary targeting has recently been considered by Artis and Currie (9).* They were, however, unable to come to any firm conclusion regarding the optimal choice of intermediate target variable since this would depend on the nature of the shock to the system, the type of pricing behaviour which firms adopt and on the factors which specifically influence the formation of inflation expectations. The choice between the two regimes has important implications for the policy significance of a stable demand for money function. In the case of money supply targeting the identification of a stable demand function is one of the critical factors governing the success of the policy in achieving medium-term control over the rate of inflation. With an exchange rate target, demand for money shocks would be accommodated by corresponding changes in the money supply so that stability of the demand function would no longer be a crucial policy issue. In fact if the demand for broad money function was unstable then an exchange rate target would be preferred to a money supply target providing the balance of the argument concerning other factors does not come down strongly in favour of the latter. So, to some extent at least, the optimal choice of regime may well depend on the stability, or otherwise, of the UK £M3 demand function.

* See Chapter 2, p.67 (footnote), for the basis of the case for an exchange rate target.
Since my empirical work suggests that the £M3 demand function has been reasonably stable in the post-CCC period this at least implies that monetary targeting need not be inferior to exchange rate targeting. However, it must be remembered that the absence of exchange controls in the 1980's may well mean that the exchange rate becomes a significant explanatory variable in the demand for broad money function. The empirical results for the post-CCC 1970's suggested that the exchange rate had only a negligible influence on money demand but exchange controls were in force throughout this period until October 1979. Although the tracking performance of the preferred £M3 equation was reasonable over the first five quarters of the post-exchange controls period, 1980(1)-1981(1), until more data from the 1980's becomes available we are not in a good position to judge whether exchange rate behaviour is more than just a potentially destabilising influence on the demand for money.

Money supply and exchange rate targeting could be formally assessed in the context of policy simulation exercises based on comprehensive structural macroeconomic models representing alternative schools of thought regarding the workings of the economy and the relevant transmission mechanisms. Within such models one could then test whether a policy of monetary targeting was capable of achieving a closer control over inflation than exchange rate targeting (given certain policy constraints relating to the balance of payments and unemployment, for example). Assuming that a policy of monetary targeting, with fiscal policy and interest rate manipulation as the main instruments of monetary control,
could be shown to be optimal under the extreme assumption of perfect stability of the demand for broad money function, one could then test how sensitive the findings were to varying degrees of imposed instability in the demand function. This could be achieved by forcing the money demand parameters to change over the relevant policy period by varying amounts. In this way one could assess (1) how unstable this function can be before exchange rate targeting becomes preferable, and (2) how sensitive the policy target variable, the rate of inflation, is to both the nature and the degree of instability introduced. It would also be possible to assess the relative speeds with which the alternative policy instruments can actually influence the rate of inflation.*

It may, of course, be necessary to disaggregate £M3 by type of money deposit, or by type of holder before coming to any conclusions concerning the stability of the demand function in the first place. The empirical work presented in this thesis suggests that the money-demand behaviour of the company and personal sectors, for example, is decidedly different, especially with regard to adjustment speed and responses to interest rate changes. This, in turn, suggests that a re-distribution of income between the sectors, or the introduction of a new technique of monetary control which has a more dramatic impact on one of the sectors, might

* I leave this as an exercise for researchers with access to powerful macroeconomic models which spell out the relevant transmission mechanisms and the lag structures in detail. The IS/LM model considered earlier in the chapter is too small and simple to be useful in this context.
easily upset the aggregate broad money demand function while the disaggregated functions actually remain stable. In a comprehensive structural macroeconomic model, disaggregation of £M3 demand by at least type of holder would be advisable, in view of the fact that companies and households respond to different variables at different speeds.

If a picture of instability in the demand for broad money function(s) was to emerge in the 1980's, then providing the success of money supply targeting was seen to critically depend on stability, a strong case could be made for the UK to adopt a policy of exchange rate targeting, thus following the examples of Austria, Belgium and Sweden. However, the empirical evidence from the post-CCC 1970's certainly suggests that monetarists have no cause for alarm as far as the demand for money is concerned. Achieving adequate control of the money supply without causing distortions to financial markets appears to be the major problem.
DATA APPENDIX

Money stock variables

\[ M_1 = \text{Notes and coin in circulation} + \text{private sector sterling sight deposits} \]
\[ £M_3 = M_1 + \text{private sector time deposits (sterling)} + \text{public sector deposits (sterling)} \]
\[ TD = £M_3 - M_1 \]
\[ MP = \text{Personal sector holdings of M}_3 \text{ deposits} \]
\[ MC_1 = \text{Company sector holdings of M}_3 \text{ deposits} \]

Income and price variables

A Aggregate money definitions - \( M_1, TD, £M_3 \)
\[ Y = \text{GDP at current market prices} \]
\[ Y = \text{GDP at 1975 market prices} \]
\[ P = \text{GDP deflator} \]

B Personal sector - MP
\[ PDI = \text{Personal disposable income at 1975 market prices} \]
\[ P = \text{PDI deflator} \]

C Company sector - MC
\[ \text{IND} = \text{Index of industrial production} \]
\[ P_{WH} = \text{Wholesale price index (output)} \]
\[ Y_{CU} = \text{GDP at current factor cost prices} \]
\[ Y = \text{GDP at 1975 factor cost prices} \]
\[ P = \text{GDP deflator} \]

Data source

Financial statistics

Economic trends annual supplement
Interest rate variables

(1) **Short-term interest rates**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{BU}$</td>
<td>Building society deposit rate expressed on a pre-tax basis</td>
</tr>
<tr>
<td>$R_{CD}$</td>
<td>Rate on 3-month certificates of deposit</td>
</tr>
<tr>
<td>$R_{EU}$</td>
<td>Euro-dollar rate</td>
</tr>
<tr>
<td>$R_{LA}$</td>
<td>Rate on 3-month local authority debt</td>
</tr>
<tr>
<td>$R_{OR}^7$</td>
<td>Rate paid on ordinary interest-bearing bank deposit accounts</td>
</tr>
</tbody>
</table>

(2) ** Longer-term interest rates**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{S_B}^S$</td>
<td>Redemption yield on 5-year government bonds: short-term bond rate</td>
</tr>
<tr>
<td>$R_{L_B}^L$</td>
<td>Yield on 2½% consols: long-term bond rate</td>
</tr>
<tr>
<td>$\Delta R_B$</td>
<td>Change in bond rate</td>
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</tbody>
</table>

**Other variables**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\dot{P}^A$</td>
<td>Inflation as measured by the moving annual percentage changes in the RPI</td>
</tr>
<tr>
<td>$\dot{P}^Q$</td>
<td>Inflation as measured by quarterly percentage changes in the RPI</td>
</tr>
<tr>
<td>$\dot{P}_{WH}$</td>
<td>Inflation as measured by the moving annual percentage changes in the wholesale price index (output)</td>
</tr>
<tr>
<td>EX</td>
<td>Sterling effective exchange rate</td>
</tr>
<tr>
<td>$\Delta EX$</td>
<td>Change in exchange rate</td>
</tr>
<tr>
<td>N</td>
<td>Number of companies participating in the Department of Industry's survey of company liquidity</td>
</tr>
<tr>
<td>N1</td>
<td>Number of manufacturing companies participating in the survey</td>
</tr>
<tr>
<td>N2</td>
<td>Number of non-manufacturing companies participating in the survey</td>
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<tr>
<td>D1, D2, D3</td>
<td>Seasonal dummies</td>
</tr>
</tbody>
</table>

**Data source**

- **Financial Statistics**
- **Economic trends annual supplement**
- **Financial statistics**
- **British business**
Data source

Variables included in simultaneous\(^2\) equation models - M1, \(\$M_3\)

\[
\begin{align*}
A &= \text{Autonomous expenditure (G+X)} \\
U &= \text{Unemployment rate} \\
I_{75} &= \text{Gross domestic fixed capital formation at 1975 market prices} \\
W &= \text{Wages and salaries index} \\
H &= \text{Reserve assets base} \\
MLR &= \text{Minimum lending rate} \\
PSBR &= \text{Public sector borrowing requirement}
\end{align*}
\]

Notes

1. For survey company models (DOI survey of company liquidity):
   
   \[
   \begin{align*}
   MC &= \text{Holdings of M3 deposits by all survey companies.} \\
   MC1 &= \text{Manufacturing survey company holdings of M3 deposits.} \\
   MC2 &= \text{Non-manufacturing survey company holdings of M3 deposits.}
   \end{align*}
   \]

2. For the simultaneous equation models only the variables for the money supply and goods market equations are defined. The money demand variables have already been defined.

For the company sector, only variables entering the demand for money equation have been defined in this Appendix. For definitions of each of the variables included in the dis-aggregated liquid assets demand model see Chapter 9, sections 9.1.2 and 9.1.3.

All aggregate money stock, income and price data is seasonally adjusted, whereas the corresponding sectoral data is seasonally unadjusted unless stated otherwise in the reported results.

All income and money stock data is in £millions unless stated otherwise in the reported results.
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