OPTIMAL CHOICE OF MONETARY POLICY INSTRUMENTS IN THE U.K.

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ABSTRACT

The purpose of this study is to examine which instrument or set of instruments of monetary policy is optimal in the case of the U.K. economy. A model of the U.K. economy is developed that includes both the 'real' sector and the 'monetary' sector. The emphasis is on the correct specification and estimation of the structural equations; we, thus, estimate this model with the help of three econometric techniques: ordinary least squares, two-stage least squares, and full information maximum likelihood. The stability of the parameters of the estimated relationships is tested, and also the stability of these relationships for prediction. Forecasts for a post sample period of one quarter is obtained practically in all cases, as well as forecasts of twelve quarters in one case. These forecasts are based on actual rather than forecasted values of the exogenous or predetermined variables.

The dynamic aspects of the model are carefully examined, and dynamic multipliers are derived. It is on these dynamic multipliers that our conclusions on the question of optimal monetary policy in the U.K. are based. This analysis suggests that an interest rate policy aiming at controlling the treasury bill rate, and through this rate the long-term bond rate, is the optimal policy; however, the money stock has a role to play too. The latter can be manipulated in such a way to help the monetary authorities to achieve the target interest rate.

Finally, some light is thrown on the question as to whether the setting of the instruments of monetary policy by the authorities is affected by the rest of the economic system. Clearly, if the answer to this question is positive then what is required is joint estimation of the relationships that explain the setting of the instruments with the rest of the basic model. Our conclusion is that we find no strong reasons for joint estimation. This analysis focuses also on the supply side of these assets, a problem that has been
neglected by the literature on the monetary problems of the U.K. economy as well as elsewhere.
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CHAPTER I

THE PROBLEM IN GENERAL:

1.1 Introduction:
The problem of optimal choice of monetary instruments arises as a result of the argument that monetary authorities may operate through either interest rate changes or money supply changes. They could either control the money supply and leave the interest rate to fluctuate according to demand conditions, or control the interest rate and thus make the money supply demand determined. They cannot operate through both instruments independently, and therefore must decide whether to use the interest rate or the money supply as the policy instrument. *

On the proper choice of monetary policy instruments three major positions in the debate may be identified:

Firstly, there are those, whom we might, perhaps unfairly, call Keynesians, who favour using an interest rate policy. Monetary authorities should push interest rates up in times of boom and down in times of recession, while letting the money supply to be an endogenous variable determined by purely demand conditions. This thesis is derived from the so-called "Keynesian Economics", on the ground that in the Keynesian system it is interest rates which transmit the impact of monetary changes to the real sector; in other words, monetary policy will not affect

* In the literature use is made, sometimes, of the concept "proximate" or "intermediate" targets instead of "policy" instruments. If the monetary authorities exercise perfect control over the money supply and the rate of interest, they are then "instruments" of monetary policy. In reality, however, such a perfect control is questionable; in that case the money supply and the rate of interest are more appropriately termed as the "proximate" targets (74, 107, 124); however, open market operations, Bank Rate and so on are in fact "policy" instruments. See also (19,20).
any "real" magnitudes in the economy (investment, national income etc.) unless interest rates are affected. Formally, this statement is not strictly correct for even in the Keynesian model there is a deterministic link between the rate of interest and the money supply, so that in general either can be used as the proper policy instrument. It is only when we make stronger assumptions, such as the existence of a liquidity trap, and more importantly that the demand for money is relatively unpredictable, that the Keynesian model favours an interest rate policy.

Even if, however, such assumptions were not made, Keynesian theorists would still favour an interest rate policy. The argument may be summarised as follows: to begin with, it is the conviction of Keynesian theorists that financial assets, particularly short-term liquid assets, are close substitutes for money, whereas goods and real assets are viewed as not being such close substitutes.* We assume that we are at equilibrium, and suddenly the monetary authorities increase the money stock by, say, open market operations. The increase in the money stock implies that the extra convenience which the increased money balances provide does not, other things being equal, match the opportunity cost represented by the return available on other assets. Purchases,

* A somewhat different approach has recently been revived by Leijonhufvud (92) who emphasises the distinctive characteristics of short and long-term assets, a distinction which he attributes to Keynes. Now, Keynes's model consists of only two financial assets, a non-interest bearing asset, i.e. money, and an interest bearing asset, i.e. bonds. Many economists understood Keynes to be differentiating between money as normally defined, i.e. currency and bank deposits, and all other financial assets. Leijonhufvud, however, argues that Keynes treated money as a paradigm for all short-term financial assets, and bonds as representing all long-term financial assets. One very important implication of this approach is that the "speculative demand for money" ceases to be an explanation of the holding of money, and becomes instead a theory about the determination of the yield curve, specifically whether changes in short rates of interest can induce sizeable changes in interest rates at the long end of the yield curve.
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therefore, of close substitutes for money which provide such a return ensues, and this raises the price and lowers the yield on such financial assets; this, in turn causes further purchases of somewhat less liquid assets, further along the liquidity spectrum. Eventually the price and yield of the long-end of the financial market are affected, thus bringing about a divergence between the cost of capital and the return on capital.

Those familiar cost-of-capital effects are not the only ones explicit in the Keynesian analysis. The impact of changes in interest rates upon expenditure includes also "availability" and "wealth" effects. Availability effects, in general, are present because of rigidities in certain interest rates and because of their divergence from the more freely determined market rates. Such a divergence may cause changes in the channels through which funds flow in which case credit may be severely rationed, and in markets, such as housing, where credit subject to such effects is of great importance, the impact of availability effects can be enormous. Wealth effects come about because changes in interest rates alter the present value of existing physical assets. For example, if interest rates rise, the present value of physical assets will fall, and the ultimate owners of such real assets will feel worse off; since no-one feels better off, one should expect these ultimate owners to change their expenditure behaviour.

It, thus, follows, that the effect of changes in the money supply upon expenditure decisions and income is regarded, by Keynesians, as taking place almost entirely by way of changes in interest rates on financial assets caused by the monetary disturbance; interest rates, therefore, provide more information than does the money stock. Suppose again, that the money stock increases but, due to an increase in the demand for money, or due to a very elastic liquidity preference curve, the interest rate changes very little. A Keynesian

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*A very good example of "stictly" rates are the Building Societies Association's recommended rates.*

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would predict that income will be very little changed. In other words, since changes in the stock of money can be offset by shifts in the liquidity preference curve, knowledge of changes in the stock of money has less information content than knowledge of changes in the long-term interest rate. This analysis, if true, has an immediate and obvious implication for monetary policy. It implies that monetary policy could be undertaken with greater certainty by acting directly to influence and to control interest rates than by seeking to control the money stock; the monetary authorities, in this case, have to provide however much money it takes to achieve their target interest rate.

The above analysis raises the very important empirical question of whether changes in interest rates have much effect on expenditure decisions. Surely this is the essence of the whole Keynesian argument. The empirical evidence on this question had appeared for long to suggest that it was very doubtful whether changes in interest rates had much effect on expenditure decisions. This, then, implied for the Keynesians that monetary policy had very little effect in influencing the level of expenditures; in fact, this body of empirical evidence (notably 7, 38, 75, 76, 77), has been influential in conditioning the conduct of monetary policy in recent decades. More recently, however, more detailed empirical investigation has suggested the existence of some noticeable interest rate effect, though most of the work has used U.S. data. The most important and carefully researched study is the one by de Leeuw and Gramlich (36), where it is shown that the interest rate effect is very important but with some lag.*

To be absolutely sure about the Keynesian argument, one has to distinguish between different degrees of substitutability between money and different financial assets. The smaller the degree of substitution between money and other financial liquid assets, the greater the required variation.

* See also the papers by M. Feldstein (43), Hines and Catephores (73) and Trivedi (120).
in interest rates on such assets need to be to restore equilibrium between the demand for and supply of money after initial disturbance caused by open market operations undertaken by the authorities; the larger, therefore, is the impact on expenditures via these changes in interest rates, with, of course, the climate of expectations in the economy remaining unchanged. The greater the degree of substitution between money and other financial assets, the less must be the expected effect from any given change in the money supply. The authorities' actions, though, could still have a considerable impact on the level of interest rates and thus on expenditure decisions, by adopting a policy of implementing very large changes in the money supply. This policy, however is found to be accompanied by severe difficulties; there are the difficulties in maintaining an efficient and flexible system of financial intermediation, and also such a policy does require a very stable relationship between changes in the money stock and interest rates.

The inevitable conclusion, then, is that if there were a high degree of substitution between money and other financial assets, and if this relationship was found to be stable at an empirical level, then a change in the money supply would have a small, but predictable effect on interest rates of substitute financial assets. In contrast, if there were a small degree of substitution between money and other financial assets, and if this relationship was empirically unstable, then a change in the money supply would have a powerful but erratic effect.

It therefore, follows that there is "a close relationship between the view taken of the degree of substitution between money and alternative financial assets, and the stability of that relationship, and the importance and reliance that should be attached to control over the quantity of money. At one pole there is the view expressed in a passage in the Radcliffe Report (75): 'In a highly developed financial system... there are many highly liquid assets which are close substitutes for money' so 'if there is less money to
go round. ... rates of interest will rise. But they will not, unaided, rise by much. ...' (para. 392). It is only logical that the Committee should then go on to conclude that control over the money supply was not 'a critical factor' (para. 397). At the opposite pole there is the monetarist view, of which Professor Friedman is the best known proponent". ** This brings me to the second position taken in the debate on the optimal choice of monetary policy instruments.

Secondly, there are those — with Milton Friedman the protagonist, the monetarists — who argue that monetary policy should set the money stock and let interest rates become an endogenous magnitude. One variant of this thesis is that the authorities should simply achieve a constant rate of growth of the money stock; another variant is that the authorities should adjust the growth in the money stock in response to the current state of economic activity as measured by the level of national income, causing the money stock to grow more rapidly in recession and less rapidly in boom.

It is not at all surprising that the proponents of this view believe in a money-stock policy. For one thing, the models used by this group assert that there is a strong relationship between current changes in income, and current and past changes in the money supply (53, 56). It is the apparent statistical success of these models in the U.S.A., in particular, which has produced the "monetarist revolution" there, though these results are open to criticisms and different interpretations. For another, it is the theoretical rationale of monetarists. The monetarist tradition views money as an asset with certain unique characteristics, and

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* The instrument of monetary policy suggested by the Radcliffe Committee was the level and structure of interest rates (75, para. 514 and Ch. VII).

** See Goodhart C. (62) p. 163. We note that our analysis of the Keynesian and the Monetarist views, relies heavily on Goodhart's (62) paper, especially pp. 161-166.
as such it can be thought of as a substitute not just for any one small group of assets, but for all assets, financial as well as real ones (49, 53). This conviction simply means that when people have excess money balances they will proceed to spend their excess money holdings not only on financial assets but on goods and services too. Similarly when they are short of money balances they will adjust to their equilibrium position - where the desired holdings of money balances are just equal to the actual money balances - by foregoing some planned expenditure on goods and services, as by selling some financial assets. This belief, then, implies that the interest - elasticity of the demand for money with respect to any one asset, or particular class of assets, is bound to be low, and it is low for the simple reason that money is not a substitute for that asset, or class of assets, but is an equally good substitute for all assets - financial and real. More formally, all goods and other assets which are not immediately consumed, are supposed to have what is termed the "own-rate of interest"; in other words all assets that are not used for immediate consumption are assumed to yield future services, and the relationship between the value of these services and the present cost of the asset is viewed as a rate of return. This rate of return is the "own-rate of interest". Equilibrium is reached where the services yielded by a stock of money (convenience, liquidity, etc.) are at the margin equal to the own-rate of interest on other assets. Keynesians and monetarists would be in agreement on this point; where, however, they do disagree is that Keynesians would argue that the relevant own-rate is that on some financial asset whereas monetarists would argue that it is the generality of own-rates on all assets. Keynesians, therefore, expect people to buy financial assets when there is an excess of money balances over their desired volume of money holdings, whereas monetarists expect people to spend the excess of their money balances on a wider range of assets including physical assets such as consumer durables as well as financial assets. The impact of changes in the quantity of money, therefore, will be
widely spread, according to the monetarists, rather than working through changes in particular interest rates. Thus relative own-rates of interest change, and expenditure on assets, real and financial, is supposed to respond quite sensitively to variations in relative own-rates of interest. The overall effect of monetary policy in influencing all own-rates of interest will, however, tend to be out-weighed in each individual case by factors special to that asset-changes in taste, supply/demand factors particular to that market etc. - so that no single interest rate can be taken as representing adequately, or indicating, the overall effect of monetary policy. As the effect of monetary changes is on relative "real" rates, it is useless to look for the rate of interest - particularly the rate on any financial asset - to represent the effect of monetary policy. Furthermore, since monetary policy impinges on a broad range of assets and a correspondingly broad range of associated expenditures, the Keynesian practise of looking only at recorded market rates, which are only part of a much broader spectrum of rates, makes one underestimate the actual impact of monetary policy. Also recorded market interest rates may not provide an appropriate measure of the cost of capital, since these interest rates are not real rates of interest that affect the basic forces of productivity but nominal rates that are influenced by the expected rate of inflation; moreover monetary influences may work through channels that we have not been able to identify. In fact, it may not be possible to trace through any particular channel, as monetary policy operates through an extremely complicated process of portfolio adjustments.

For all these reasons, monetarists consider that even the most complex structure of a general equilibrium model cannot be expected to capture actual monetary influences adequately. A more reliable empirical approach would be to pursue the methodology of positive economics, the essence of which is to select the crucial and simple theoretical relationships that allow one to predict something large (such as GNP)
from something small (for instance, the supply of money), regardless of the intervening chain of causation. One such relationship is claimed to be the velocity function - i.e. the relationship between money and nominal income - which has been shown, on average, to be very stable and consequently the key relationship in understanding macroeconomic developments (53). It thus follows that a very promising approach to monetary policy and its impact on the economy is to try to relate changes in income directly to changes in the quantity of money.

The crucial distinction between the above two schools of thought as to the best conduct of monetary policy seems to be their different assumptions about the degree of substitutability between alternative financial assets and money balances; and in particular whether there is a significantly greater degree of substitution between money balances and such financial assets than between money balances and real assets. The importance of this difference of view may be illustrated with an example. We assume that the monetary authorities undertake open-market sales of bonds. According to the extreme Keynesian view the open-market sales and the resulting shortage of cash in relation to the volume of transactions to be financed would increase interest rates, but, probably, not by much, because an increase in rates on financial assets which are very close substitutes for money would simply make people prepared to organize their affairs with smaller money balances. The money supply, then, has been reduced without much effect on financial markets. Expenditure decisions are effected, not directly by the fall in the quantity of money, but only by the second round effect of changes in conditions in financial markets; the impact, therefore, on expenditure decisions would be very small indeed, both because the interest rate changes are small and because of the apparent insensitivity of many forms of expenditure to much small changes in interest rates. The extreme monetarist would agree that interest rates on financial assets would increase as a result of the initial
open-market sales; this increase in rates, however, would not restore equilibrium by making people hold a lower ratio of money balances to total incomes. The initial sales of financial assets by the monetary authorities, resulting in higher interest rates, would only bring about a short-run partial equilibrium in financial markets; the desire to hold more of the cheaper financial assets would not, probably, be to hold smaller money balances, but rather to hold less of other goods. Full equilibrium would only be re-established when the desired ratio of money balances to incomes is restored, which would be achieved by a reduction in real expenditures.

In sum, monetary policy, by causing a reduction in the quantity of money, would bring about a nearly proportionate fall in aggregate expenditure. Interest rates, though, which were initially forced upwards by the authorities' open market sales of public debt, would fall back as a result of the deflationary impact of the restrictive monetary policy which would be restraining both the demand for capital and the rate of price inflation. The monetary policy instrument therefore, proposed by monetarists is that of money supply, which can register the thrust of monetary policy, unlike interest rates which although changing initially, they are expected to reverse back to their original position at the end of the day. Thus, using interest rates as the instrument of monetary policy would be giving the wrong information.

Thirdly, there are the fence-sitters, who argue that monetary authorities should use both the money stock and the rate of interest as instruments. It is, naturally, recognized that the money stock and the interest rate cannot be set independently, but a certain relationship between the two could be maintained. In other words the central bank could not possibly observe the rate of interest and then set the money stock since any change in the money stock will affect the rate of interest. Similarly, if a certain relationship between the money stock and the rate of interest is maintained, i.e. a supply of money function, then it is possible to choose a point on this function, thus establishing
a "combination" policy. The trouble with this thesis is that it is usually not explained satisfactorily how the instruments should be adjusted according to economic conditions. It has been shown, however, by Poole (107) that this thesis can be made precise within the context of a well defined model. The same author offers an explanation (108) as to how the instruments should be adjusted according to economic conditions. This explanation, which we may call "The Rule of Thumb Approach", suggests that in a recession interest rates should fall and the growth of the money stock should rise. Falling interest rates is not enough; as incomes decline interest rates fall in any case, so that even if we observe falling interest rates monetary policy might still be tight. But if the growth rate of the money stock rises as interest rates fall in a recession, then monetary policy must be easy, at least relative to the previous period. A rise in the money growth rate is also an insufficient criterion. Thus, if the demand for money increases during a recession and the money stock growth rate increases, but at a slower rate than the demand for money, then monetary policy is still too tight. Conversely, during an inflationary boom the money stock should grow at a slower rate and interest rates should be higher than before. Comparing actual U.S.A. monetary policy since 1951 with that called for by his rule, Poole finds that his rule would have been superior. This rule apart from being very general, it can also be criticised on the ground that it does not take into consideration the lag in the effects of monetary policy.

1.2 Monetary Policy Under Certainty:

The problem of optimal choice of monetary instruments may puzzle those who think of policy formulations in terms of deterministic macro-models. In such models, the policy prescriptions may be in terms of either the interest rate or the money stock; it makes no difference which instrument is selected. This point may be demonstrated within the context of a Hicksian LM-IS type model. The model consists of the following six equations:
where \( Y = \text{national income}, M^s = \text{money supply}, M^d = \text{demand for money}, r = \text{rate of interest}, I = \text{investment expenditure}, C = \text{consumption expenditure}, \) and all variables are in real terms for simplicity, with \( P(\text{Price level}) = \overline{P} = 1. \)

The usual substitutions give us the following two equations:

1. \( Y = a_0 + a_1 r \) the IS-curve with \( a_1 < 0, \)
2. \( M = d_0 + d_1 Y + d_2 r \) the LM-curve with \( d_0, d_1 > 0 \) and \( d_2 < 0. \)

There are then two equations and three unknowns, \( Y, M, r. \)

The monetary policy makers select either \( M \) or \( r \) as the policy instrument so that there are two endogenous variables and one exogenous (the policy instrument).

If, then, the rate of interest is the policy instrument, \( 3 \) and \( 4 \) are our reduced forms:

3. \( Y = a_0 + a_1 \overline{r} \)
4. \( M^s = (d_0 + d_1 a_0) + (d_1 a_1 + d_2) \overline{r}, \)

which we can express diagrammatically in figure 1.
Given now that $Y_f$ is the desired level of $Y$, say, the full-employment level of $Y$, we may obtain the optimal value for the instrument $r$, for from (3) we may have:

$$r^* = \frac{Y_f - a_0}{a_1}.$$  \hspace{1cm} (5)

In this case, the monetary authorities typically peg the rate of interest at $r$, letting the money supply to be determined by the forces which govern the IS curve, i.e. productivity and thrift. One immediately recognises that in fact this has been the case in the U.K. post-war II period - without forgetting, however, the implications of the D.C.E. concept and policy - as well as in the U.S.A. during and after the Second World War until 1947, and less firmly thereafter until 1951. There are some people, however, notably M. Friedman and his disciples (47, 48, 52) who argue that in fact monetary policy cannot peg interest rates for more than very limited periods; suppose that monetary authorities set out to keep interest rates down. They will try to do so by buying securities and the more rapid rate of monetary growth necessary to peg interest rates will stimulate spending thus increasing the desired cash balances which will raise the liquidity preference schedule and the demand for loans and it may also raise prices and reduce the real quantity of money. These effects, the argument goes, will reverse the initial downward pressure on interest rates fairly quickly, in something less than a year, and after a somewhat longer interval, say a year or two they will tend to return interest rates to the level they would otherwise have been.

If, on the other hand, $M^s$ is the policy instrument, (6) and (7) are our reduced - form equations.

$$Y = \frac{a_0 d_2 - d_0 a_1}{d_2 + a_1 d_1} + \frac{a_1}{a_1 d_1 + d_2} M^s$$  \hspace{1cm} (6)

$$r = \frac{-a_0 d_1 - d_0}{a_1 d_1 + d_2} + \frac{1}{a_1 d_1 + d_2} M^s$$  \hspace{1cm} (7)

19.
Given, as before, that \( Y_f \) is the desired level of \( Y \), we can obtain the optimal value for the instrument \( \bar{M}^s \); from (6):

\[
\bar{M}^s = \frac{a_1 d_0 - a_0 d_2}{a_1} + \frac{(d_2 + a_1 d_1)}{a_1} Y_f.
\]

It follows that the rate of interest, in this case, is demand determined. There is no agreement, however, amongst monetary economists as to whether the money supply is an exogenous quantity or endogenous. The argument runs along the following lines: the money stock at any moment in time is the result of portfolio decisions by the Central Bank, by the commercial banks, and by the public (including the non-bank financial intermediaries). The Central Bank determines the amount of High-Powered Money or Monetary Base (M.B.)—i.e., currency plus bank reserves—that it will supply (a clear exposition of M.B. is given by 2). The commercial banks determine the volume of loans and other assets that they will acquire, and the public determines how to allocate their holdings of monetary wealth among currency, demand, time, and savings deposits, intermediary claims and other financial assets. The money stock that emerges reflect all these decisions. The crucial question, then, is whether the Central Bank by controlling the M.B. can actually achieve a fairly precise grip over the money stock. This depends, obviously, on whether the link between M.B. and money stock is fairly tight and therefore predictable. If there is a
tight link the authorities can, in fact, formulate their policies and achieve any particular target for the money stock; on the other hand if there is a slippage and the Central Bank control over the money stock is not sufficiently precise to achieve a given target, it will necessarily have to formulate its policies in terms of other variables that it can control. In other words, the crucial question is whether the money stock is best viewed as an endogenous variable - determined by the interaction of the financial and real sectors - and outside the direct control of the Central Bank, or as an exogenous variable - as a policy instrument - that the authorities can control, and whose behaviour can be made to conform to the stabilisation guidelines.

Clearly the monetarists or Friedmanists, believe that the Central Bank can, and should, define its objective and implement its policies in terms of money stock; they assume then, that the Central Bank can engineer the desired behaviour of the money stock through control over the N.B., so that the money stock is, in fact, an exogenous quantity. This proposition, however, has been challenged by those who follow the "New View" approach to Monetary Economics (65, 118); they argue that the stock of money largely reflects the public's preferences for demand and time deposits, savings deposits, intermediary claims and other financial assets, and it cannot, therefore, be considered as an exogenous magnitude.

It is to be noted, however, that even if one decides that the money stock is largely endogenous, this does not rule out that the monetary authorities can control the money stock (39, 40, 41). They can do so, provided that they are prepared to permit the changes that such a policy may cause in the levels of prices and interest rates as well as in employment and in the trend of the level of economic activity in general.

The inevitable question now that arises from the above discussion is which one of the two instruments is the
optimal; the above deterministic model suggests that it makes no difference, the two instruments are equally optimal: for if the target is, say full employment Y, this target can be achieved either by setting that interest rate which is consistent with the target, given, the parameters and other exogenous variables in the system, or by setting a money stock which is consistent with the target. In other words, in this model the choice between the optimal interest rate and the optimal money stock is not an interesting one because one variable implies the other.

The monetarist, however, would argue that even within the context of this simple deterministic model, a money supply policy is still preferable to an interest rate policy. They argue that the rate of interest that is relevant for the IS curve is a real rate of interest while the authorities are at best able to fix a nominal rate. These two are equal if and only if the general public's expectations of inflation are zero. Otherwise they differ, and it becomes impossible for the authorities to set a particular value for the relevant real interest rate for the simple reason that it is impossible for them to know what the expected rate of inflation actually is, at any given point in time.

1.3 Monetary Policy Under Uncertainty:

The problem, however, becomes interesting when one drops the assumption that the values of the endogenous variables are known with certainty. Once one starts introducing stochastic disturbances either in the monetary or real sector it could be demonstrated, as several authors have done - chiefly 47, 48, 69, 74, 82, 96, 107, 110, 127 - that the interest rate and the money stock are no longer perfect substitutes; which of the two instruments is optimal depends crucially on the particular values of the structural parameters, on the variances and co-variances of the stochastic

* See also the following papers: 57, 67, 70, 80, 81, 83 and 111.
disturbances, and on the relative costs of stochastic move-
ments in the money stock and interest rates. In general
terms, if the source of instability lies in unpredictable
shifts in the IS-curve — which, of course, results from
instability in the underlying consumption and investment
functions — while retaining the unrealistic assumption that
the position of the LM-curve is known, it is better to pur-
sue a money stock than an interest rate policy. In figure
3 what is known about the IS function is that it will lie
between the extremes of IS₁ and IS₂; if the money stock is
set at some fixed level, then the LM-function will be LM₁,
and income therefore will be somewhere between the extremes
of Y₁ and Y₂.

On the other hand, if the policy-makers follow an interest
rate policy and set the interest rate at r₀, in which case
the LM-curve will be LM₂, income will be somewhere between
Y₁ and Y₂', a wider range than Y₁ to Y₂, and so the money
stock policy is superior to the interest rate policy. In
this case variations in the rate of interest with a fixed Mₙ
should reduce the impact of these shifts on income relative
to what they would be if the interest rate were set at its
optimal fixed value. In other words the fixing of the money
stock yields a smaller variance for Y. The reason being that
with the stock of money fixed, there is a kind of automatic
stabilisation; for any discrepancy between the expected and actual values of exogenous demand produces a stabilising change in interest rates, and thereby a stabilising change in the induced component of total demand. Whereas with interest rates pegged there is no stabilising change in the induced component of demand, whatever the discrepancy between the expected and actual values of the exogenous component, even if the actual stock of money may differ from the expected which case is of no consequence whatsoever.

If the primary source of instability is unpredictable shifts in the LN-curve, it is preferable to set the interest rate at its optimal value and simply accommodate the shifts in this curve. In figure 4 it is assumed that the position of the IS-curve is known with certainty, while the LM can be anywhere between $L_{M1}$ and $L_{M2}$ due to unpredictable shifts in the demand for money, if a money supply policy is pursued. In such a case income may end up anywhere between $Y_1$ and $Y_2$. But an interest rate policy can fix the LN-curve at $L_{M3}$ so that it cuts the IS function at the full employment level of income, $Y_f$. In this case the fixing of the stock of money yields the largest variance for $Y$; by pegging rates there can be no discrepancy between desired $Y$ and actual $Y$, because unpredictable shifts in the demand for money are not permitted to affect the interest rate. Policy-makers simply adjust the stock of money in response to the unpredictable shifts in the demand for money.

* It is to be noted that this case is perfectly consistent with the monetarists' policy prescriptions of controlling the money supply; for they believe that the volatility of investment behaviour is the main cause of the relatively unstable IS-curve. They regard, however, the demand for money function which determines the LN-curves as being stable over time.

** This policy prescription is obviously Keynesian; for it is the belief of this group of economists that the LM is unstable—chiefly the Radcliffe Report's claim of an extremely unstable velocity of circulation. The Keynesians would also argue that the IS-curve is unstable, for the very same reason of the monetarists' conviction on the instability of the IS-curve, but they would go on to suggest that the LN-curve is by far more unstable than the IS-curve. As it is shown below in this case an interest rate policy is preferable to a money supply policy.
The main criticism applicable to both a money supply policy or interest rate policy is that they are influenced greatly by feedbacks from the real to the financial sector, so that their position or direction of change at any time is a result of opposing influences. In addition, many of the important endogenous and exogenous variables are observable only after a considerable lag. Thus the monetary-policy-maker does not have complete knowledge of either the functions relating the policy instrument to the endogenous variables, or the non-policy variables amongst them. It is for all these reasons that optimum monetary policy is conceivable, which may be defined as the combination of those actions of the monetary-policy-maker to have the maximum possible impact on the targets chosen by him.

It then follows that a third case may emerge once one recognises that in general both the real and the monetary sectors are subject to stochastic disturbances which result in shifting the LM and IS curves; for example we may suppose that the main source of instability of the economy is in the instability of the investment function. We may also have disturbances in the monetary sector which could come about from mistakes by the monetary authorities, or perhaps shifts in the public's demand for money, or indeed shifts in the behaviour of the banking system which obviously affect the supply of money. In figure 5, it is assumed that the error terms shift the LM and IS curves within the area abcd.
It should then follow that in this case our conclusions are the same as above, in that depending on the random disturbances if the real sector's shifts tend to be more unsystematic than the ones in the monetary sector we should then choose the $N^s$ as our instrument, and the rate of interest if the monetary disturbances tend to be greater than the ones in the real sector. We illustrate these two cases in figure 6, where the unpredictable disturbances are larger in the expenditure sector, and in figure 7 where the unpredictable disturbances are larger in the monetary sector.
In the case of figure 6 variations in the level of income are smaller when the money stock is the instrument, whereas in the case of figure 7 variations in the level of income are smaller when the rate of interest is the instrument.

The above analysis concentrates entirely on the importance of the relative sizes of expenditure and monetary disturbances. We must, though, consider the slopes of the LM and IS curves and examine whether this makes any difference in the results. Consider figure 8: in this case we have two pairs of IS-curves with different slopes. It is easy to see that disturbances that shift LM to and forth which lead to income fluctuations greater than Y to Y2 - which fluctuations would occur under an interest rate policy - must suggest than an interest rate policy would be preferred regardless of whether we have the pair IS1 and IS2, or the pair IS3 and IS4. Similarly, a money supply policy would be preferred if the shifts in the LM lead to income fluctuations.
smaller than \( Y_1 \) to \( Y_2 \) regardless of the pair of IS-curves we might choose.

Next consider figure 9 where we have two pairs of LM-curves with different slopes:

![Diagram of LM-curves](image)

It is obvious that if the IS\(_1\)-shifts produce income fluctuations greater than \( Y_1 \) to \( Y_2 \), then a money supply policy is preferred regardless of the pair of LM-curves we would choose. Contrary if the income fluctuations arising from shifts in the IS\(_1\), are smaller than \( Y_1 \) to \( Y_2 \) an interest rate policy would be indicative regardless of which pair of LM-curves prevail.

The overall conclusion* then is that the crucial issue

* We note that in the case where the IS-curve slopes upwards - that is when higher income levels encourage investment more than savings via some form of accelerator type mechanism - and cuts the LM-curve from above (so that stability is ensured) the same conclusions hold. There is, however, one important exception: monetary policy appears to be more powerful the higher the elasticity of the demand for money - i.e. the flatter the LM-curve - which is contrary to the standard results demonstrated within the context of the traditional model which assumes a downward sloping IS-curve. See W. Silber "Monetary Policy Effectiveness: The Case of a Positively Sloped IS Curve", The Journal of Finance, December 1971. See also C.A.E. Goodhardt: Money, Information and Uncertainty, footnote 1, pp.233-234; Macmillan 1975.
for deciding upon whether an interest rate or money supply should be followed is the relative size of the disturbances in the expenditure and monetary sectors, and not the slopes of the IS and LM curves. To be absolutely sure with the argument, however, one has to add that once the choice between the two policies has been made, slopes, then, do play a vital role. If a money supply is superior, then the steeper the LM function is, the lower the range of income fluctuation, as can be seen from figure 9. It is also clear from figure 8 that under an interest rate policy an error in setting the interest rate will lead to a larger error in hitting the income target if the IS curve is relatively flat than if it is relatively steep. But these facts do not affect the choice between interest rate and money supply policies.

Another suggestion, that of Kareken and Pierce in (47 and 48), is the use of a "Proviso Clause", with either the stock of money or some index of interest rates as the proviso variable. Again depending on the variances of the error terms the monetary authorities may peg either the rate of interest or the stock of money and depending on the values of the uncontrolled variables from their target level, revise the target values of the policy variables. For example, the authorities may fix interest rates, until an initial observation of the stock of money is obtained; they then could change rates, perhaps in proportion to the discrepancy between the actual stock of money and the expected stock. Or they could fix the money stock at some predetermined value, and then depending on what interest rates have emerged change their target $M^s$ values. It follows that the choice of the appropriate policy instrument depends again on the relative disturbances of the real and monetary sectors.

It could, however, be shown (107) that by using a loss function of the type:

$$ L = E \left[ (Y_o - Y_f)^2 \right] $$

- giving the expected loss from failure of the level of income, $Y_o$, to equal the desired level i.e. target level - that there could be an optimum combination of the two
instruments in which the interest rate and money stock are maintained in a certain relationship to each other - the nature of the relationship depending on the values of the parameters - giving a level of income which is unique in the sense that its difference from the target level \((Y_f)\) is the minimum possible; and that this "combination policy" is superior to either a pure quantity of money policy or an interest rate policy. We may demonstrate this argument using the \(LN-IS\) schedules, as we have done above. In figure 10 the disturbances are assumed to prevail in the expenditure sector only; we know that in this case the appropriate policy is the one that fixes the money stock. We assume, however, that instead of fixing the money stock, the money stock is reduced every time the interest rate goes up and increased every time the interest rate goes down; if, now, the proper relationship between the money stock and the rate of interest can be established, then the \(LN\)-curve can be made to look like \(LM_o\) of figure 10:

![Diagram of LN-IS schedules](image)

It follows that income, in this case, can be pegged at \(Y_f\); this is so because the disturbances in the IS function produce changes in the rate of interest, which in turn cause spending changes sufficient to completely offset the effect on income of the initial disturbance.
We examine, now, the case where the money stock increases as the rate of interest rises and decreases as the rate of interest falls. We use figure 11 to examine this particular case:

LM₁ and LM₂ represent the leftmost positions of the LM function as a result of disturbances in the monetary sector; LM₁ prevails when the money stock is fixed, and LM₂ when the combination policy of introducing a positive money-interest relationship is followed. We ignore the rightmost positions of the LM-curve for simplicity, LM₃ is the position of the LM-curve when an interest rate policy is pursued. If either LM₁ or LM₂ prevails, the intersection with IS₁ produces the lowest income, which is below the Y₁ level obtained with LM₃. But since in the case of LM₂, the level of income associated with this policy i.e. Y₁ is only just lower than Y₁, whereas when IS₂ prevails Y₂ seems to be much lower than Y₂, it follows that on average the difference between Y₁ and Y₂ - i.e. the difference in income when a combination policy is pursued - is smaller than the difference between Y₁ and Y₂ - i.e. the difference in income when an interest rate policy is pursued. Therefore, it is better to adopt LM₂ than LM₃ although the extremes under LM₂ are slightly larger.
The empirical evidence on the problem of which instrument or combination of instruments is optimal, is practically non-existent. Poole (108), however, cites as some piece of evidence the Friedman-Meiselman debate (3, 37, 53, 54, 55, 72); this debate showed than one can predict income equally well from money as from autonomous expenditures. This suggests that the demand function for money and the expenditure function are, roughly speaking, equally unstable. What is important, however, is not stability, but predictability, and on this score to predict income using an autonomous expenditure approach is more difficult than to predict income using a money stock approach because autonomous expenditures themselves are more difficult to predict than is the money stock. Hence Poole suggests that the evidence supports a money stock target against an interest rate target.

The studies by Poole as well as the other ones referred to above, use as their main apparatus the LN-IS model. Such a model can be criticised on several grounds: (a) it assumes that expectations are known and unaffected by policy, (b) it assigns no role to the relative price of existing assets and newly produced assets, and (c) it ignores the distinctions between real and nominal, anticipated and actual interest rates. In addition all these studies and in particular the Poole's papers, deal only with one part of the problem, the minimisation of income fluctuations at a particular point of time, and not with the shift of the curves over time. Another criticism is that these studies ignore one very important aspect of monetary policy, namely that of the time lags. An important paper by D. Tucker (121) has shown that in fact lags in the money - demand function tend to counteract, rather than reinforce, the investment lags. This is an argument against those economists who believe that monetary policy is very slow in its impact; for slow lagged response of investment to interest rate and income changes does not provide a sufficient condition for monetary policy to work slowly. This study also provides an argument for using the money supply as a target. In the Tucker model the investment
lag is long, but monetary policy has only a short lag. This is so because an expansionary monetary policy may, if expenditures are slow to respond, result in a very large initial (but temporary) drop in the rate of interest. This, however, is only true if the interest rate is allowed to vary substantially; if the monetary authority changed the rate of interest by so much, and kept it there, then this initial overshooting of the interest rate would not occur. The lag in monetary policy is then long because it is determined by the slow response of expenditures. On the other hand if the monetary authority followed a money supply policy and allowed the interest rate to overshoot, then the Tucker analysis applies, and the lag is shorter.

Another criticism on the studies we have considered so far is on the assumption that the monetary authority can control the interest rate and/or the money supply without error; this amounts to assuming that the rate of interest and/or the money supply are instruments of monetary policy. Waud (124) has demonstrated that this assumption is fallacious for the interest rate and money supply cannot possibly be considered as instruments but only as proximate targets. Furthermore, he argues that one cannot determine the superiority of the two because the monetary authorities cannot distinguish between stochastic shifts in the system and shifts in structural parameters with their different implication for monetary policy. Shifts of the latter type change the values of the proximate targets which correspond to the desired target income level, while stochastic shifts do not. Inability, then, to distinguish between these two types of shifts means that the monetary authority may frequently be in the position of trying to maintain the proximate target variables at levels which no longer correspond to the desired target income level. Therefore, the monetary authority might be better advised to focus on ultimate target variables such as the employment and/or the income level, relying for purposes of policy implementation on the assumption that open market operations, say, will unambiguously push income and employment in the desired direction.
In view of the above analysis, one can argue that the choice between a money supply policy and an interest rate policy should be made on the basis of three criteria:

(a) the relative importance of unpredictable shifts in the demand for money and expenditure functions,

(b) the difficulties of measuring the rate of interest as well as the money supply, and

(c) the length of the lag of monetary policy.

We now move on to discuss the problem of optimal monetary policy within the context of the U.K. monetary environment.
CHAPTER 2

THE U.K. CASE:

2.1 Background Analysis:

It is the propositions put forward in the last paragraphs that we would like to apply in the case of the U.K. economy, and in particular under what assumption and values of the parameters of the structural equations the above criteria hold. It is then self-evident that this requires a systematic study of the British financial environment, say, since the 1950s, and naturally the monetary policies pursued. Analysis then of the structure of the various markets where the Bank of England operates in, and study of the Bank's strategies in the context of such market conditions allows one to make an estimate of the extent to which the authorities control the key variables within the monetary and financial system. One could in fact sketch the following picture for the British financial environment: the monetary authorities have absolute control over the Bank Rate which they set themselves, and through the network of banking conventions, also upon the related rates on bank deposits and advances (for the recent changes see below). They are in a position to influence the treasury bill rate given their power as lender of last resort, though for short periods the discount houses, if under pressure from the banks, may frustrate the authorities' control over this rate. The bank has no direct control over the other short-term money markets in London of which the most important is perhaps the Local Authority market although the Bank may indirectly influence the rates in this market via the treasury bill market.

The authorities' main concern has been, although with decreasing emphasis after 1968, the management of national debt with the objective of maximising the demand for gilt-edged securities, not only to provide for finance for current requirements but also for the refunding of a continuous flow of maturing debt. From this was derived a concern for the
stability of interest rates both short- and long-term, at a level which reduced the burden of debt finance. The Bank has, consequently, been seeking to obtain stability in both the treasury bill and gilt-edged markets. The Bank of England has generally been prepared to operate freely between cash, treasury bills and gilt-edge securities, so that neither the cash ratio nor the liquid assets ratio could provide a firm fulcrum for an effective monetary policy.*

In the gilt-edged market the authorities give priority to "maximising the long-term demand for debt" which has led them to pursue a policy which we may call as the "leaning into the wind" policy, (60, 103, 114). The result of this policy is that the authorities cannot control the total volume of sales of debt on the market, and in addition they have been unable to switch short-term debt from the banking system to the public. All this means that such a policy makes the authorities incapable to control the cash reserve base. They have, however, been able to reduce the total volume of central government created liquid assets available to the banking system i.e. treasury bills plus cash reserves, though they do not control the proportionate distribution between these which is determined by the banks themselves. The authorities have, furthermore, been able to control the total of treasury bills available to the banking sector in the short-run, despite their inability to use open market operations in the traditional manner, by employing the technique of calling for special deposits (1960). This has not, however, proved sufficient to restore control over the money supply, since the banking system has been able with considerable ease to engineer a substitution, after a very short lag, of private sector liquid assets for the withdrawn treasury bills. Since the money supply has not been under

* This question of controlling the money supply via a cash-asset ratio or a liquid-asset ratio has produced a very lively discussion and a number of important publications (25, 26, 27, 23, 31, 32, 33, 101, 113).
satisfactory control, the authorities have responded by resorting to an over wider use of direct controls, simply informing the banks - and a growing circle of non-bank financial intermediaries - during periods of squeeze what they may and may not do.

The empirical evidence on the effectiveness of special deposits and requests is rather discouraging. Goodhart (60) and Norton (103) provide results to show that the evidence suggests that the effect of such requests upon the granting of credits by the banks to the private sector and the calling of special deposits, was not very large. Norton concludes that: "It is tempting on the basis of the foregoing to argue that the authorities would be advised to abandon requests and deposits and rely instead on more flexible interest rates and possibly a stricter control of the money supply. The official argument against more flexible rates has asserted amongst other things that the market is unstable. But the finding of this paper suggest that this is essentially a short-term phenomenon and may well be due to the way the authorities operate in the market. If this is correct, then a large part of the case for official policy disappears".

All this has contrasted of course very strongly with textbook models that see the central bank achieving control over the quantity of bank credit through open market operations leaving the prices of credit in various channels to be set primarily by market forces.

It follows that although the post World War II British monetary policy - strictly since the return to a flexible monetary policy in 1951, when the level of the Bank Rate was raised from 2 to 2.1/2 percent* - has been the one we sketched in figure 1, there is a lot to be said about a kind of "combination policy" the authorities have tried to pursue in terms of controlling both the level of bank lending and the level and structure of interest rates. By setting the level

* Bank Rate was unchanged from the last quarter of 1939 to the last quarter of 1951.
of Bank Rate and pegging gilt-edged prices, the Bank has attempted to control the level and structure of interest rates. This policy has been facilitated because of the existence of various restrictive agreements between the clearing banks and the discount houses, which have resulted in a fixed relationship between the level of Bank Rate and certain important interest rates, such as the maximum rate paid on clearing bank deposit accounts, the rate on bank lending to borrowers of first class rating, the rate on basic call money and the spread of rates on fine bank bills. Given a change in the level of Bank Rate then, an immediate and direct impact on the level of these interest rates ensues; this means that the Bank Rate is not simply the rediscount rate of the central bank but also something similar to the American Regulation Q. The change in the level of Bank Rate and therefore the level of these other rates, is expected to affect the "liquidity" of the economy; at the same time limits on bank lending to the private sector are placed, in particular on the level of bank advances and on the terms of hire-purchase agreements for consumers. The aim of the latter has been to control the volume of credit and indirectly to impose some control over the money supply.

The mechanics, now, of monetary policy are in accordance with the Keynesian tradition of macroeconomic analysis, being set out in the Radcliffe Report of 1959 (75), and more recently in various research publications of the Bank of England (29, 62). Emphasis is placed on the role of credit and interest rates in influencing expenditure, subject to time lags; the stock of money has never been an explicit concern of the authorities. It is argued that the correlation that exists between changes in the stock of money and changes in money incomes greatly overestimates the importance of monetary policy because of the two-way relationship between money and income. This concern with credit has also been evident in the attempts of the monetary authorities to control the volume of certain types of credit referred to above.

This policy, however, has shown itself to be inadequate.
In the first place there is the empirical evidence* that seems to suggest that the official argument asserting that the market for government securities was unstable, may well be due to the way the authorities operated in this market. It is not perhaps surprising at all, then, that the authorities changed their tactics in that market towards the beginning of 1969 as it is clearly stated in the Bank of England Quarterly Bulletin (March 1969). Secondly, the emphasis on controlling the price and quantity of credit has increasingly, since 1961, led the authorities to use a battery of direct instruments of control - the imposition of specific ceilings on the growth of banks' sterling lending to the private sector of the domestic U.K. economy; during the fifties and early sixties the call for restrictions was in the form of "requests", but since May 1965 the authorities have imposed "specific ceilings". The effect of this policy has been the creation of new markets for credit not directly controlled by the authorities; and one should not forget the poor empirical evidence of these "requests" as we have already mentioned.

Thirdly, because of the growth of an integrated world capital market and the relative decline of sterling in the post-war period as the world's trading and reserve currency, the importance of Bank Rate in the world capital markets has been diminishing. It can be argued that it has been determined increasingly by monetary policy outside the U.K.; in the heyday of the Sterling Era when other currencies were pegged to sterling, monetary policy in the U.K. determined interest rates in the world economy as a whole. Now, however, with the Dollar Era, it is the U.S.A. monetary policy that is crucial to the determination of the level of nominal interest rates in world capital markets.

Fourthly, the importance of control of the money supply was impressed on the U.K. in 1968 by the I.M.F. After the devaluation of 1967, and the package of tight fiscal policies which accompanied it, the authorities in the U.K. pursued a

* Chiefly Norton (103).
relatively easy money policy. Domestic credit expansion in 1968 grew by 15% despite the fact that there were ceilings on bank lending and perhaps not surprisingly there was a substantial deficit on the U.K. balance of payments account in that year. Given the substantial and growing debit to the IMF, policy-makers faced no alternative in 1969 but to accept the IMF's diagnosis of the continued deficit. So in June 1969 the U.K. sent a letter of intent to the IMF stating that the level of domestic credit expansion was to be a variable which the Bank of England set out specifically to control. If one then thinks of the domestic credit expansion as an indicator of the money supply, it follows that the monetary authorities in the U.K. were proposing to put more emphasis on the Money Supply rather than on interest rates.

Finally, the collective interest rate agreements of the clearing banks which were allegedly an important facet in implementing the Bank of England's policy, have been under considerable criticism for some time now. The Prices and Incomes Board Report (99) was highly critical of the Bank's interest rate cartel as well as their effective agreements on charges; so was the Monopolies Commission (95). Furthermore, these agreements have helped towards the creation of new institutions and markets, not always under the control of the authorities.

As a result of these defects in the existing system there have been numerous proposals for reform. They range from the abandonment of all controls on the allocation of bank assets and the removal of all barriers which prohibit entry into banking (64) to the detailed control of all types of financial institutions by minimum capital, reserve and liquidity requirements as well as detailed supervision of the allocation of their assets (125), culminating to the proposals of the Bank of England (September 1971), which we

Domestic Credit Expansion (D.C.E.) may be defined as:
\[ \text{D.C.E.} = \Delta M^s + \Delta R \]
where \( \Delta M^s \) = changes in the Money Supply and \( \Delta R \) = changes in foreign reserves.

40.
may call as the "Competition and Credit Control" proposals. The proposals of the Bank of England and the particular form in which they are to be implemented are set out in three basic papers (9, 10, 11). In addition, an address by the Governor of the Bank of England (8) is also useful in understanding the new system as it constitutes an official statement of the economic thinking which underlies the changes.

2.2 The Competition and Credit Control Regime:

Let us trace these new proposals in their proper perspective. The letter of Intent of the Chancellor to the I.M.F. published on the 24th June 1969 and the Bank's publication (March 1969) constitute, perhaps, the starting point. The letter stated that the government's objectives and policies implied a Domestic Credit Expansion (D.C.E.) in the fiscal year 1969/70 of not more than £400 m.n. which obviously meant a shift in emphasis in monetary thinking in the U.K. towards putting more reliance in monetary control on the volume of money and credit and less on the level and structure of interest rates. This shift is clearly stated in the B.E.Q.B. (March 1969) where the authorities admit that they had already moved towards being concerned about the total change in money supply and less about the movement in gilt-edged prices, by changing their tactics in the gilt-edged market from previous concern, i.e. from a policy of pegging the interest rate on government stocks to allowing them to fluctuate. Rather than supporting the market where holders of securities want to sell - as the "leaning into the wind" policy would require - the Bank would allow, and in fact have allowed, the strain to be reflected in a change in prices, thereby avoiding pumping in additional cash into the economy. More recently (9, 10, 11) new techniques of monetary control have been introduced: to begin with, the existing liquidity and quantitative lending controls have been replaced by other means of influencing all bank, not simply deposit bank, lending in sterling; a minimum reserve (12.1/2%) has been implemented across the whole banking

41.
system with the London and Scottish clearing banks abandoning their collective agreements on interest rates.

All banks then, not only the deposit banks, have to maintain a fixed minimum ratio of 12.1/2 per cent of eligible reserve assets to eligible liabilities; the Finance Houses are obliged to maintain a ratio of 10% of eligible liabilities, while the discount houses must keep at least 50% of their funds in public sector debt, a ratio fixed in line with the average recent practice of the market. The range of eligible assets for the discount houses runs wider than that prescribed for the banks, to take in local authority bonds and government - guaranteed stocks with up to five years to run to maturity. The Bank continues to provide last resort lending facilities only to the discount houses, provided that the discount houses continue to cover the weekly treasury bill tender. The houses, however, since September 1972 have discontinued their long-standing practice of tendering at a common agreed bid.

The interpretation of the observance of the above mentioned ratios is more strict than that applied to the previous 28% ratio, as the institutions have to maintain these as minimum ratios on a day-to-day basis. The Bank suggested that a ratio of eligible assets to eligible liabilities of around 12.1/2% might be appropriate, this being close to the average held by the banking system as a whole for sometime during the years before the introduction of these proposals. Assets qualified to be included in the 12.1/2% ratio are: Balances with the Bank - other than special deposits; the London Clearing Banks have agreed to maintain a minimum of 1.1/2% of their eligible liabilities in the form of balances with the Bank of England and it is understood that such balances will be kept close to this minimum. The other banks do not hold any balances with the Bank of England other than trivial amounts. Treasury Bills, other Government and nationalised industries securities with a year or less to final maturity, local authority bills eligible for rediscount at the Bank of England, commercial
bills eligible for rediscount at the Bank up to a maximum of 2% of eligible liabilities, and money at call with the London money market - but not money at short notice and other call money or balances in the inter-bank or local authority markets. The money at call includes:

(a) members of the London Discount Market Association,
(b) discount brokers and money trading departments of certain banks,
(c) money brokers and jobbers on the London Stock Exchange.

Finally, company tax reserve certificates do qualify to be included in the 12.1/2% ratio. One should note that no new issues of these certificates are to be made, and all outstanding certificates should have been surrendered during the period up to the 31st December 1974.

The other new concept which has been introduced is that of 'eligible liabilities'; these are net sterling deposits of the banking system as a whole, excluding deposits originally made for over two years, which are more in the nature of longer-term transactions rather than short-term bank deposits. Eligible liabilities include sterling certificates of deposit - certificates which acknowledge the deposit of large sums of money and which can be readily bought and sold in a special market.

The main implication of these proposals is that the major institutions doing deposit - taking business on a wholesale level are to be controlled directly rather than indirectly through the banks; and this wide - extending reserve ratio is to be rendered variable by the retention of the Special Deposit System which might indeed be used to discriminate between various classes of deposit. Again the continued use of "quantitative guidance" is envisaged, at least unless and until powers of H.P. terms control are relinquished. Even more recently (9th October 1972) the Bank Rate was abolished and replaced by a floating "minimum lending rate", determined by market forces.

The inevitable conclusion is that these developments are in line with the spirit of the Radcliffe Report: certainly
the authorities' proposals for control of financial intermediaries reflect in part a subscription to the Radcliffe view on the role of non-bank intermediaries. Furthermore, these developments carry further the evolution of policy since 1968/69, representing a further limitation of the degree of market intervention and giving greater importance to the level of interest rates and the credit base of the banking system. What is less obvious is how the objective of managing the National Debt - previously given first priority - is now regarded. The only explicit official reference to this was the Governor's Munich speech (8) in which he said that the Bank would continue their normal operations of selling longer dated gilt-edged securities against purchases of short-dated stocks, but they would not buy stock outright. Thus they would not normally be prepared to facilitate movements out of gilt-edged by the banks, even if their sales should cause the market temporarily to weaken quite sharply.

In the same speech the Governor indicated that basically the new approach to monetary policy implicit in the proposals reflected a change in the official attitude towards two key questions: First, what monetary variable should the authorities attempt to influence; and second, by what means should they attempt to influence it. The answer to the first key question is that the emphasis is now towards broader monetary aggregates "We have increasingly shifted our emphasis towards the broader monetary aggregates - to use the inelegant but apparently unavoidable term; the money supply under one or more of its many definitions, for example, or domestic credit expansion" (10). It has not been made clear, however, how monetary aggregates are thought to influence the economy, nor whether the authorities regard any particular monetary aggregate as being of outstanding significance in this respect.

As far as the second key question is concerned the authorities would seek to influence their monetary aggregate via the structure of interest rates "In future the authorities would seek to influence the structure of interest rates through
a general control over the liquidity of the whole banking system" (8). The reserve ratio and special deposits would reinforce their power to influence the rate structure "The intention is to use our control over liquidity, which these instruments will reinforce, to influence the structure of interest rates" (8). The resulting changes in relative rates of return will then induce shifts in the asset portfolios of both the public and the banks.

The new policy will, it seems, be based upon open market operations supported, if necessary, by calls of special deposits. It will take effect by shifting the relative terms on the various assets which the banks may hold, thus inducing them to make changes, or to refrain from changes which they may have envisaged. For example, if interest rates are raised at a time when the banks as a whole have no excess reserve assets, they could then find that they have to sell investments on unfavourable terms if they wish to expand their advances. A single bank, however, would have other ways open to it of acquiring reserve assets, again perhaps on unfavourable terms. Again, it is intended that open market operations should affect the availability of reserve assets, and thus the credit base of the banks. These are the traditional ways in which open market operations were supposed to work; the mechanism of control and the objectives of open market policy have both been adjusted, in the light of previous shortcomings, in the hope of making the policy more effective.

Another interesting question is the significance of Bank Rate changes under these new arrangements. Apart from its effect on the treasury bill discount rate, the influence of Bank Rate in the past depended, to a large extent, on the fixed links maintained between it and clearing bank interest rates under the now abandoned agreements. It seems likely, therefore, that Bank Rate will in future exert a more tenuous influence. At the same time, however its influence may be diffused more widely through the financial system, reflecting the composition and uniform application of reserve assets and possibly special deposits requirements. It is no
surprise then that the Bank Rate was abolished in October 1972 and replaced by a floating "minimum lending rate".

All in all, then, under these new arrangements, the monetary authorities will exercise control through interest rate policy and its effect upon the asset preferences and reserve position of the banking system; the objective is to control the money supply or some similar "monetary aggregate" i.e. D.C.E., rather than bank lending as previously.

There is, however, an apparent inconsistency between the consultative document(s), and the Governor's speech referred to above. The speech starts from the assumption that monetary policy should seek to influence some monetary aggregate, the key issue being which one, and proceeds to explain that the Bank has been shifting from seeking to control bank lending to seeking to control the money supply or D.C.E. The speech, however, quickly returns to the assumption of the consultative document(s), that the objective of monetary policy is to influence or control the structure of interest rates. Nevertheless, there remains an inconsistency between theoretical approach and proposals, since reliance on a reserve ratio that can be varied by the authorities - which is broadly the centre-piece of the new proposals - assumes that the aim of policy is to control a monetary aggregate, and not to control either the structure of interest rates or the quantities of particular types of credit, which should, by implication, be left to come out of the wash; whereas both the document and the speech still emphasize interest rates and the amounts of particular types of credit as the objectives of policy control. Perhaps the answer to this inconsistency is that what the monetary authorities have in mind is perhaps a kind of "combination policy" referred to in the introduction. They may like to set the money supply schedule such that at different interest rates different quantities of money would be forthcoming. In other words they may neither pursue a pure Radcliffian policy that would make the money supply perfectly elastic in a specified set of interest rates i.e. the money supply would not be a perfectly elastic function of interest rates, nor a pure
Friedman extreme that would make the money supply function perfectly inelastic with respect to interest rates. They would, thus, make a certain stock of money available and only that stock at specified sets of interest rates.

Another interesting point in connection with the last paragraph is the problem of the appropriate indicator(s) of monetary policy that will be used to determine the direction and strength of change in policy. The authorities we are told, are concerned with control of "the broader monetary aggregates" which is interpreted as "the money supply under one or more of its many definitions for example, or domestic credit expansion" (8). This gives four alternatives, $M_1$, $M_2$, $M_3$ and D.C.E. It seems, however, that the level of interest rates is also to be some indicator of policy and again we are faced with alternatives: we can consider the inter-bank market rate, local authority market rate, Treasury bill rate and in general the yields on short-term gilt-edge stock. Yet a third type of indicator may be the composition of bank lending to the private sector of the economy. The fact that no particular indicator is specified is quite deliberate, as "it is seldom possible or desirable for the authorities to put their eggs in one monetary basket" and therefore "one must in practice take account of movements in many financial indicators, varying the relative importance attached to them as circumstances change" (8). However, we are neither told in a precise manner what the indicators are nor how the weights attached to them should vary as circumstances change.

Finally, there is the problem of whether, under the new arrangements, the banking sector could engineer a reshuffle of their assets so as to frustrate any policy of the authorities to change the reserve asset ratio. It appears that this is very possible, indeed: first, by purchasing eligible short-term bonds and bills from the uncontrolled private sector; there are substantial quantities of some reserve assets held outside the banking system and non-reserve assets can still be the new material from which reserve assets can be "manufactured". Secondly, by
increasing call loans to the discount market backed by non-reserve assets a possibility which, in the case of the latter is enhanced by the different definition of eligible reserve assets for the banks and discount houses. M. Parkin (104) argues strongly in favour of this possibility: "The main conclusions reached are that call money has provided and will continue to provide a means whereby the Banking System as a whole can substantially insulate itself from Bank of England policy and render the "Competition and Credit Control" regulations very imprecise".

Under such circumstances, credit creation is increased if assets are switched to those able to treat them as eligible reserves. The extension, though, of officially-required reserves to all banks and the finance houses effectively reduces the range of outside holders of official reserves able to supply the banks with additional reserves. The eligibility of gilts with under one year to maturity, however, may well enlarge the scope of shifts between bank and non-bank holdings of reserve assets beyond that feasible under the former liquidity ratio mechanism. In the case of the discount market, which can help the banks to expand reserve assets by increasing call money to the market whose members could then expand their holdings of one to five year gilts, the development of such a process on any scale will be affected by the cost to the discount market of further increasing their holdings of longer-term debt in periods of rising interest rates.

2.3 Optimal Monetary Policy in the U.K.

The question of optimal monetary policy has not been debated much in the U.K., the main reason being that given the pre-1971 uncompetitiveness of the financial system, stable relationships could not possibly be established. Since, therefore, there are some reasons for thinking that macro-economic relationships, especially the demand functions, are likely to be more stable, in terms of their usual arguments, in a competitive environment (109)—such as the one implied by the 1971 "Competition and Credit Control" proposals—
the question of optimal monetary policy becomes very important indeed. Laidler (91) calls for a money supply policy; his analysis is based on the Poole-model, and argues that since the LM-curve seems to be more stable than the IS, and given the complexity and instability of the time lags, a desirable framework of monetary policy should concentrate on regulating the quantity of money, and that the authorities should control the long-run growth path of the money supply and keep it reasonably steady. One, however, could disagree with Laidler's argument on the following grounds:

(a) The stability of the LM-curve is based on the stability of the demand for money function; and although there seems to be evidence of stable demand functions for money, the predictive reliability of these functions outside their sample period has not yet been established (62).

(b) The stability of money supply multipliers in British post-war experience is very doubtful; this is very true even if the money supply is treated as an exogenous (5,111) which in itself is again questionable.

(c) Finally, there is evidence that changes in aggregate demand are more closely related to changes in bank lending to the private sector than to changes in any of the traditional money supply concepts (61, 62).

The picture we have sketched, then, in this and in the last section should enable us to build up a model for the financial sector chiefly a model of the U.K. money supply determination which is so important especially for the "combination policy" model. Given certain assumptions about the real sector, a model could be set up resembling the LN-IS apparatus in appearance but in fact with more realistic assumptions and of more dynamic nature which would be the corner-stone of the whole analysis.

It is hard not to mention at this point the criticism on LN-IS framework, which is directed on its very static nature. However, there is no reason why this comparative static
framework should not be made dynamic as Noronoy and Nason show (98). So developed, this dynamic Hicks-Hanson model of the Keynesian system gathers substance for assessing the financial sector's role. The underlying structural equations are broadened and re-estimated to take account of price and credit rationing effects upon the slopes and positions of the pairs of schedules determined in each income period. Furthermore, because the under-lying structural equations are specified and estimated as an interdependent economic system, the approach becomes useful for deriving quantitative assess-ments of the effects of financial sector developments and for policy analysis. This type of dynamic interdependent format has been attempted in some small-scale and in most large-scale econometric models of the U.S. economy, as Fisher and Sheppard report in (46 chs. 2 and 3).

We may note at this point that one could not possibly ignore the real sector for in that case a specification bias is involved in the estimates of the structural coefficients (116, 117). Brainard and Tobin (17) also argue for the importance of explicit recognition of the interdependence of the financial and real sectors in both theoretical and empirical discussions of monetary problems and specificiations of related econometric models; failure to show clearly these interrelationships could easily lead to serious errors. Our relationships to be estimated should include behavioural functions in the real sector to which the monetary relation-ships are linked. There is also another important reason as to why one should want to set up a model in this way. Most of the studies undertaken to solve the problem of optimal monetary instrument use reduced - form equations with the money supply taken to be exogenous. If, however, the money supply is endogenous then it merely reflects fluctuations elsewhere in the system both in the real and financial sectors and the consequence of this for the "reduced form" approach is that one cannot talk in terms of one-way causality. Therefore, in these circumstances what is required is a model, specified and estimated within the context of a simultaneous equation framework, which reflects
and takes account of any two-way causation. In fact the empirical work on the British monetary affair has had a strong bias towards "reduced-form" approaches thus establishing the bias referred to above.

This argument is particularly applicable in the case of the monetarists position that the money stock influences money income. This criticism has led to the so-called "Reverse Causation Argument": the fact that money stock is well correlated with money income also means that money income is well correlated with money stock. Correlations do not establish much more than a suggestion of causal nexus, unless there is some extraneous evidence to suggest the direction of causation. Correlation in itself is not necessarily evidence of causation, and even were it, the direction of causation is not a question to which either correlation or regression theory can provide an answer. Further evidence is required to identify the direction of causation, and this must essentially come from outside the realm of statistical theory. The monetarists, however, have tried to shore up their position by producing studies and arguments which suggest that the direction of causation runs from money stock to money income.

Under the assumption then that this model is a satisfactory representation of the economy it should be possible to estimate how any set of variables that concern us behave if the monetary authorities pursue different policies or set of policies. This should enable us to say something about the stability of our structural parameters and the kind of optimum monetary policy to be suggested in terms of setting target values for the money supply and/or the rate of interest that should serve as connecting links between the actions of the monetary authorities and their objectives.

The next step, therefore, in the analysis should be the specification of the particular model we have in mind; before we embark on this task, though, we feel we must say something about the criteria for choosing the instruments of monetary policy.
2.4 Criteria for Choosing Instruments of Monetary Policy:

The problem of choosing an instrument, in a world of imperfect knowledge, may be considered in terms of a number of factors of which the most important ones can be: the choice of economic model; the problem of measurement; the goals of policy; and the extent of the monetary authorities' autonomy.*

Clearly, the choice of a particular instrument must depend on whether the monetary authorities can have a firm control over it (the autonomy problem). Related with this problem is the one of goals of policy; in connection with this problem we may think of a situation where there is a specialization of monetary instruments to particular goals, in which case the choice of instrument may reflect some priorities about goals. The problem of measurement arises as a result of the fact that data are not always speedily available and indeed are not always reliable; it also arises as a result of the question as to whether the statistically observed figures form good correlates of theoretical variables. The choice of economic model and in particular the assumed link between monetary and real variables, usually exert a considerable influence in favour of one instrument rather than another.

We begin our discussion of the criteria for choosing instruments of monetary policy with the choice of economic model factor.

We illustrate the point about models, with the help of some specific examples. We may take up as a starting-point the LM-IS model. As we have already seen in Chapter 1, this model in its deterministic form, it makes no difference which instrument is chosen, both are optimal. In a world of uncertainty the choice depends on the stability of the


52.
functions that determine the LM and IS functions. Adherence, therefore, to what can perhaps be described as a Keynesian model of this kind does not commit one to a preference for one or other instrument of policy without an evaluation of the relative stabilities of the schedules.

The models, now, which assert that,

\[ Y_t = (1/k)N_t, \]

or in more contemporary form:

\[ Y_t = f( M_t, M_{t-1}, \ldots, M_{t-i} ), \]

obviously favour a money supply policy. Money multiplier relationships assert a stable relationship between changes in money supply and changes in nominal income on the basis of an assumption about the exogeneity of money. These models are usually described as 'reduced forms' of some structural system and they are usually criticised on the grounds that different structural systems can give one, the same reduced-form. In the absence, therefore, of an explicit specification these 'reduced forms' should be better described as 'pseudo-reduced forms'.

The Wicksellian view of monetary phenomena would seem to suggest a money-supply policy, although in detail it would justify an interest rate policy. The form of the latter, though, is such that it must be treated in association with the 'natural' rate of interest which is not, really, an observable item. Harrington* argues that in certain circumstances the Wicksellian system does not indicate the money supply as an instrument. This argument is applicable when bank interest rates are constrained by monopolistic practices to a sub-equilibrium position, with the result that non-bank financial intermediation in effect accomplishes some of the work that would otherwise be done by increases in the money supply.

There are, finally, the models of the monetary process, which stress that the important links between financial and real variables occur at the level of stock market prices, rather than in the market for government bonds; furthermore, the architects of these models* take the view that relationships between the financial markets directly affected by monetary operations, and those markets where the significant link with real variables exists, are unstable and complicated. The obvious difficulty, however, with this approach is the autonomy problem.

The measurement problem is an important one in that unless it is resolved any model that claims to have established a particular instrument as the optimal one is likely to produce severe criticisms. There are two important questions related directly to this problem: firstly, there is the question of how far available data series provide information relevant to the theoretical variables; secondly there is the question of the speed of collection and reliability of the data themselves.

It seems that as far as the first question is concerned advocacy of an interest rate instrument encounters the most difficult measurement error. The relevant interest rate to expenditure decisions, it is argued, is the real rate of interest, whereas the directly observable data refer to nominal rates. In the unlikely event of price expectations not changing it can be argued that nominal rates are not a bad guide; otherwise nominal rates can be a misleading guide. Related problems of course are expectations about future levels of interest rates that can influence the timing of expenditures and there is also the problem as to which interest rates are the most relevant.

Advocacy of a money-supply policy does not preclude similar criticism; there is not a priori presumption that one definition of the money supply must be superior to

* See Tobin in (47, pp. 21-24; 78-82) for an example.
another. On this particular problem we shall have more to say in the next chapter.

On the second question of speed and reliability of collection and publication of the data, interest rates seem to be the victors. These data are instantly available whereas money supply data are available six months behind the event and, until recently quarterly. Beyond these factors, there is the problem of allowing for seasonality and as it is usually reported in the Quarterly Bulletin of the Bank of England this problem constrains any short-period 'monetary rule'.

Turning now to the goals of policy, we may note that, generally speaking, the implicit objectives have to do with stabilising the level of economic activity or with the level of prices or the balance of payments. A related problem is that of time-lags. Monetarists, for example, believe in long lags and that the long-run effect of money supply variations falls on prices rather than on real incomes. Studies, however, reported in the St. Louis Federal Reserve Bulletin tend to reverse sharply the monetarists' belief of 'long' lags, while Tucker (121) has shown that it is possible for monetary policy to have quick effects despite of long lags in investment functions. Hamburger* concludes that the measurement of policy lags depends to a great extent on the choice of policy instrument. There is therefore a lot of dispute and ambiguity as to when the effects of changes in the stance of policy could become apparent.

Finally, we have the autonomy problem. What we actually mean in this case is that the variable which is chosen as an instrument could be controlled by the monetary authorities. This means that it is no argument against, say, the choice of interest rates as an instrument, that the authorities chose not to control it, but instead to control something else, say, the money stock. Autonomy must not be confused with exogeneity.

Autonomy over a variable does not necessarily imply that this particular variable may be taken as statistically exogenous. Thus the authorities might be able to control the money supply via the monetary base of the system, although the money supply is an endogenous variable, say, a function of some rate of interest, income, and the monetary base. In this case we do have autonomy but, clearly, we do not have exogeneity.

The criterion of autonomy is most forceful in its application to the open economy; in particular, the British case may suggest that only D.C.E. can be regarded as an instrument. This follows from assumptions that interest rates and price levels are determined by the world, so that the authorities in this country have no option other than to apply that concept of the money supply that does take into consideration any movements in the Balance of Payments. Even then, the authorities would not be working in an environment of complete autonomy.

The inevitable conclusion is that once autonomy is taken into consideration accurate control is probably not feasible; instruments are subject to large random fluctuations.
CHAPTER 3

THE MODEL

In this chapter we discuss the basic features of the model referred to above. We begin with the monetary sector where we discuss the demand for money and the supply of money.

3.1 The Monetary Sector:

In any real economy where the monetary authorities can hope to influence behaviour in a predictable way via changes in the money supply, there are a number of preconditions that have to be fulfilled. Among the most important of these preconditions are that the monetary authorities should be able to control that set of assets which constitute the "money stock", and that the demand function for this stock must be stable enough so that the consequences of any changes in its volume would be predictable with a high degree of reliability. And as Professor Shackle notes*: "If the controlling of money is to provide a means of controlling the economy, money has to be something which passes two tests. It must itself have, or it must transmit, powerful effects on the economy; and it must itself be susceptible to control in appropriate respects". Whether these preconditions are met in the case of the U.K. economy has been the subject of a good deal of debate, and the problem has not been solved yet; and not surprisingly so: "These two requirements give us, perhaps, a sort of map-maker's fix on the definition of money. Neither requirement alone is sufficient, and, of course, there is no presumption that such a 'money' can be identified or shown to exist".** Central to the debate, though, is the question of a proper

* See Professor Shackle's comments on Professor Clover's paper at the Sheffield seminar on money in 1970, reported in Monetary Theory and Monetary Policy in the 1970s, Proceedings of the 1970 Sheffield Money Seminar, edited by Clayton G., Gilbert, J.C. and Sedgwick, p.32.

** Professor Shackle's "Discussion Paper" op. cit. p.32.
definition of the "money stock". In general, there are four approaches to defining "money":* The Conventional approach, the Chicago approach, the Gurley and Shaw approach, and the Central Bank approach.

The Conventional approach is really the oldest and probably the most accepted way of defining money, and views money by its distinguishing functional characteristic as a medium of exchange. According to this view,** then, the theory of the demand for money is a theory of the demand for an asset that is a generally acceptable means of exchange and also happens to be a store of value; it goes on to argue that a nation's money stock consists of currency (coins and legal tender paper money) as well as demand deposits (checking account money). Unlike demand deposits, then, which are readily transferable by cheque, time deposits, savings deposits and so forth are not means of exchange. Another argument*** which has been put forward to support this approach says that demand deposits, even though they are the liabilities of commercial banks whose owners are members of the economy, represent not wealth to the community, while time deposits and the liabilities of other financial institutions do not represent net wealth. It is argued that the principal means by which monetary policy works is the wealth effect and that the proper empirical definition of money is confined to currency plus demand deposits, since it is only changes in the real quantity of these assets that represent changes in the community's wealth. So, under this approach we have:

\[
N_1 = C_p + D_D
\]

* These four approaches have come to be recognised by a number of economists. For an example see Johnson, H.G. Monetary Theory and Policy "American Economic Review, June 1960, pp.351-354.


*** Due to Pesek and Saving (106).
where $C_p$ = currency held by the public, and $D_D$ = demand deposits.

The Chicago approach, associated with Professor Milton Friedman and other University of Chicago monetary theorists, defines the function of money more broadly as 'a temporary abode of purchasing power'; this approach, then, includes, in its definition of money not only currency and demand deposits, but time deposits ($D_T$) - interest-bearing deposits at commercial banks - as well (51)** This definition of money is, obviously, in conflict with the conventional definition because commercial bank time deposits are not directly spendable. They do not function as a medium of exchanges; the owner of a time deposit who wants to use it to buy a car, for example, must exchange this deposit for currency or demand deposits before he is able to make the payment for his purchase. One, however, could argue that although time deposits are not directly spendable, they should still be included in the definition of money given that commercial banks would always transfer money from a time deposit to a demand deposit. Professor Shackle's remarks on this point are very clear "... And so must time deposits. In Britain at least, the distinction of availability between demand and time deposits (current and deposits accounts) is practically negligible. A note to my bank will transfer money at any moment, at a loss of seven day's interest. I cannot write a cheque on my deposit account, but I can write one on my current account which, even if that account is empty, will be honoured if covered by my deposit balance. No holder of accounts in a British bank would make any distinction between the two sorts of account in regard to their readiness of availability, as opposed to the question of loss of interest"*** Is this the reason, perhaps of the

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** See also Selden, R.T. "Monetary Velocity in the United States" in Friedman, M., ed. Studies in the Quantity Theory of Money, Chicago 1956, pp.179-257.

*** Professor Shackle's "Discussion Paper", op. cit. p.33

59.
inclusion of time deposits in the Chicago definition? The answer is that the criteria upon which the Chicago definition is based are rather different. These are the following:

First, the Chicago theorists have shown that national income is more highly correlated with money as they have defined it than with money alternatively defined. Since changes in the money supply are hypothesized by the Chicago theorists to bring about predictable changes in national income, the Chicago definition is held by these theorists to come closest to meeting the empirical criterion of putting monetary theory in a good light (53).

Second, the approach is based on the theoretical criterion of defining as a single good those things which are perfect substitutes for each other. It is, then, argued that time deposits are indeed such close substitutes for currency and demand deposits, that it is more fruitful to treat them as if they were perfect substitutes than not. The relatively timeless and costless ease of transferring time deposits into demand deposits and currency, as well as the notion mainly held by the monetarists that a time deposit is actually "money in the bank", provide support to the close substitutability argument. One, however, could not possibly go as far as to argue that they are perfect substitutes, for if they were, one, then, would have to provide a satisfactory answer to the obviously awkward question as to why anyone would wish to hold non-interest-bearing demand deposits or currency when there is interest to be earned on time deposits.

The Gurley and Shaw Approach owes its name to a series of contributions* culminating in a major theoretical

work* by Gurley, J. G. and Shaw, E. S. where they argue that currency and demand deposits are not unique assets (except as a medium of exchange) but are instead just two amongst many in the family of claims against financial intermediaries. Furthermore, they particularly stress the close substitution relationships between currency, demand deposits, commercial bank time deposits, savings bank deposits, savings and loan association shares, and so on, all of which are viewed by the public as alternative liquid stores of value.

This approach seems to be very similar to the Chicago approach. They are in fact similar in their objective, for both attempt to define money to include all those assets that are means of payment plus those assets which are close substitutes for the means of payment. They differ, however, in their analysis; whereas the Chicago approach considers only time deposits to be close substitutes for the means of payment, Gurley and Shaw expand the number of substitutes to include deposits of and claims against, all types of financial intermediaries. The Gurley and Shaw analysis, though, raises the important question of how to account for the substitution relationships when defining the money stock. Gurley suggests that the money supply should be defined as a weighted sum of currency, demand deposits, and their substitutes, with the weights being assigned on the basis of the degree of substitutability.* According to this definition, weights of unity are assigned to currency, demand deposits, and their perfect substitutes, if any. Zero weights are given to assets which are totally unrelated to demand deposits and currency; and weights between zero and one are assigned to assets which are imperfect substitutes for demand deposits and currency. We illustrate this point with an example. Let us assume that the economy’s only assets are as follows: (1) £100 in currency, (2) £300 in demand deposits, (3) £200 in Building Societies share.

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accounts, and (4) £400 worth of bread. The economy's total assets are £1000. Now, we make the following assumptions on the substitutability relationships: the asset demands for currency and for demand deposits are independent of the demand for bread, whereas the degree of substitutability between Building Societies share accounts and currency—as well as demand deposits—is somehow determined to be 0.25. The weighted sum money supply would consequently be equal to £400, since currency and demand deposits would be assigned a weight of one, the Building Societies share accounts a weight of one-fourth, and bread a weight of zero. It is to be noted, however, that no attempt has been made to use the weighted sum money supply for testing monetary theory or for carrying out monetary policy. The practice has been to account for the Gurley and Shaw substitution relationships in ways other than how money is defined. So most researchers and policy-makers have tended to consider the substitution relationships by including rates of return on substitutes for currency and demand deposits explicitly in the analysis of currency and demand deposits. In so doing they have avoided the problem of having to make arbitrary assumptions about the degree of substitutability.

Finally, there is the Central Bank Approach, the approach to money taken by many monetary authorities. In this case the tendency is to view money in its widest possible concept to the point, in fact, that money is used as if it were synonymous with credit.* This is, actually, quite understandable once we note that the main interest of this approach is not monetary theory as such, but monetary policy. We, thus, have the notion of "total credit availability" in the U.S.A. as the key monetary policy variable for regulating the economy, and in the U.K. the notion of the "liquidity" of the economy.

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* Credit, here, is used as a general term meaning funds loaned to borrowers; not just credit extended by commercial banks, which gives rise to demand deposits, but credit extended by the widest variety of sources.
as it is exemplified by the Radcliffe Committee (75 ch. VI) and since clarified by R. Sayers. It follows, therefore, that unless money is defined very broadly as total credit, the term monetary policy would not have any meaning, for what the Central Bank has in fact followed is a credit availability (or liquidity) policy.

In terms of economic analysis and research three definitions for money are usually used:

1. \( M_1 = C_p + D_D \), what we have called the Conventional Approach,
2. \( M_2 = C_p + D_D + D_T \), the Chicago Approach, and
3. \( M_3 = C_p + D_D + D_T + D_{01} \)

where \( D_{01} \) = other savings deposits meaning those assets that are very close substitutes for time deposits, e.g. mutual savings bank's deposits etc.

All the above approaches to defining money include currency and demand deposits in their definitions. They all agree that those assets which serve as a medium of exchange are money. Where they disagree is on the question of whether other assets are so close to currency and demand deposits that one or more of these other assets should also be defined as money. At the heart of the controversy over what and what not to include as money are the substitution relationships between money, conventionally defined, and other assets.

The term "cross-elasticity of demand" is useful when measuring the substitution relationships. It is defined as:

\[
\varepsilon_{xy} = \frac{\Delta Q_x}{\Delta P_y} \cdot \frac{P_y}{Q_x}
\]

or, using derivatives:

\[
\varepsilon_{xy} = \frac{dQ_x}{dP_y} \cdot \frac{P_y}{Q_x}
\]

where $x$ and $y$ denote assets.

If $e_{xy} > 0$ then the assets are substitutes, and perfect substitutability means

$$e_{xy} = \infty$$

Imperfect substitutability means $0 < e_{xy} < \infty$.

If $e_{xy} = 0$ then the assets are completely independent.

If $e_{xy} < 0$ then they are complements.

While these propositions hold for the more general case in which prices are expressed in terms of costs, they must be reversed in sign for cases in which prices are expressed in terms of yields or rates of return. The following expression, then,

$$e_{xy} = \frac{dQ_x r_y}{dr_y Q_x},$$

where $r_y$ indicates the rate of interest on asset $y$, provides the rate-of-return cross elasticity. We may now generalise by saying that substitution relationships between financial assets, whose values are expressed as rates of return, are indicated by negative rate-of-return cross elasticities of demand. The greater the absolute size of the coefficient of cross-elasticity, the closer the degree of substitution.

Turning now to the empirical evidence, Feige* and Lee**, using U.S.A. data, have estimated cross-elasticity measures of the substitution relationships between commercial bank demand deposits, commercial bank time deposits, savings bank deposits, and savings and loan association shares.

Feige finds demand deposits and time deposits to be weak substitutes. Moreover, he finds savings and loan association shares and mutual savings bank deposits to be even weaker

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*** Although less work has been done using U.K. data, the study by Barrett, R.J., Gray, M.R. and Parkin, J.N. ("The Demand for Financial Assets by the Personal Sector of the U.K. Economy" in Renton, G. A. (ed.) *Modelling the Economy*, London, 1975) suggests that the U.K. is no different from the U.S.A. in this respect.
substitutes for demand deposits. On the basis of his evidence, Feige concludes that the substitution relationships are too weak to justify defining money broadly. Feige's study thus supports the conventional definition of money. Although Feige's study is the most careful study that has been carried out on the subject it seems that there are some crucial problems which might lead one to suspect these results. These problems arise because of the data used and the method of measuring the rate of return on demand deposits. A summary of these problems has been provided by Laidlor (88, pp. 520-522).

Lee's findings are rather different. In general, stronger substitution relationships are discovered. Savings and loan association share are found to be moderately close substitutes for demand deposits. Time deposits, on the other hand, are found to have no statistically significant substitution relationship to demand deposits, a result which leads Lee to reprove the Chicago approach to defining money.

While the Feige and Lee studies are enlightening, they provide no conclusive answer to the question of how to define money. Even if high cross-elasticities should be found, there would still be the problem of interpreting whether or not they are "high enough" to warrant a broad money supply definition. It seems, therefore that there can be no final answer to the question of defining the money supply on the basis of the evidence produced by Feige and Lee.

Another piece of empirical evidence, which is more indirect than the one provided by Feige and Lee referred to above, centres on the stability of the demand for money. Different definitions of money are used and the stability of the demand for money is then investigated; that definition of money which provides a more stable demand for money is preferred. This approach rests, of course, on the contention that a "more stable demand for money" is precisely one that allows the consequences of shifting the supply of money to be more easily and accurately predicted. A full
account of this kind of evidence is provided by Laidler (88, pp.515-520), who comes to the conclusion that the evidence suggests that a highly stable demand for money function can be identified whether the narrow or the broader definition of money is used; there seems, therefore, little, if not nothing, to choose between the alternatives considered in his paper. One, however, has to be very careful with these results, since they are contradicted by Feige's above mentioned important study. If the Laidler conclusions were to be accepted, there would then be an important conclusion to follow: as far as the exercise of monetary policy is concerned, and which particular aggregate of bank and non-bank liabilities the policy-maker would try to manipulate is a question which could only be settled by applying other criteria, for example, which aggregate it is easier to control than the criteria discussed above.

We move on, now, to discuss the demand for money and supply of money. We begin with the former.

3.1a The Demand for Money:

Whilst few people would dispute the existence of fundamental empirical arguments in the demand for money, there has been considerable dispute over which arguments are the most important and fundamental ones. This dispute has produced a massive empirical and theoretical work; Friedman's extension of the permanent income hypothesis to the demand for money suggests that wealth, or alternatively, the expected yield on wealth, which is approximated with permanent income, is the most important determining variable affecting the demand for cash balances (50, 51); other empirical findings have shown that it is also a function of some rate of interest. A summary of all these findings may be found in 62, 68, and 90.

The empirical work on the demand for money has been concerned with "testing" a demand for money. In general, regressions have been run on equations which treat "money" as the "dependent" variable, functionally related to various
"independent" arguments. The results have usually been judged according to the following criteria: goodness of fit ($R^2$), a test for significance of regression coefficients (e.g. the $t$-test), and the extent to which the signs of the regression coefficients agree with expectations. Such a procedure, however, raises the related general problems of identification, simultaneous equation bias (least square bias), and specification error. Those of course are not the only statistical problems that one encounters when undertaking empirical work on the demand for money function; there are many other problems that arise in interpreting results, but these other problems are not so general as the above mentioned ones, and are best dealt with in context as they arise.

We begin with the identification problem. The quantity of money demanded is not an observable variable; all that can be measured is the quantity of money supplied, and it is only by assuming equilibrium in the money market that the latter concept may be used to measure the former. There also exists a supply-of-money function, and questions must arise as to whether, in relating the money stock to various variables, one is not in fact measuring this supply function, or the combined effects of both the demand and supply functions, rather than the demand alone. It follows that those studies which estimate a demand equation without specifying a supply function cannot claim to identify the resulting equation as a demand function for the true supply function may be of a form which prevents identification.

Graphically speaking, we draw the demand for money as a negative function of the rate of interest and the supply function as a positive function of the rate of interest. This last assumption is justified on the grounds that as the rate of interest goes up then the banks reduce their excess reserves thus increasing the money supply; similarly if the rate of interest goes down the banks increase their excess reserves thus decreasing the money supply. We show both functions in the following figure (13):
Now, let the problem be to measure the relationship between the demand for money and the rate of interest from observations generated in this market. This will only be possible if it is always the money supply that shifts while the demand function remains stable, as it is shown in the following figure (14):

If only the demand function shifts, the supply curve will be what is observed as it is shown below (15):

If both curves shift, yielding a set of observations that, if regression analysis is applied to them will produce a curve such as \( FF \) or \( KK' \) that is neither a supply function nor a demand function (see figure 16).
Now the problem is presented here in a two-variable case, but it arises just as much where more than one variable is involved in explaining the demand for money. We may demonstrate this difficulty with the use of a linear demand for money function as well as a linear supply of money function. Suppose that our true demand and supply functions are:

(I) \[ \text{\( N^D = d_1 Y + d_2 r + d_3 W + u_1 \)} \]

(II) \[ \text{\( M^S = m_1 Y + m_2 r + u_2 \)} \]

where \( Y \) = national income, \( r \) = some rate of interest, and \( u_1 \) and \( u_2 \) are errors.

Next, multiply the \( N^D \) and \( M^S \) equations by the arbitrary constants \( \lambda_1 \) and \( \lambda_2 \) respectively. On the assumption that we are observing equilibrium positions (\( N^D = M^S \)), we can substitute \( N^D \) for \( M^S \) in equation (II). Having carried out these operations, we may add the two equations to get:

(III) \[ \text{\( N^D = \frac{\lambda_1 d_1 + \lambda_2 m_2}{\lambda_1 + \lambda_2} Y + \left( \frac{\lambda_1 d_2 + \lambda_2 m_2}{\lambda_1 + \lambda_2} \right) r + \frac{\lambda_1 d_3}{\lambda_1 + \lambda_2} W + \frac{\lambda_1 u_1 + \lambda_2 u_2}{\lambda_1 + \lambda_2} \)} \]

Suppose, now, that our econometric study establishes that a linear relationship between \( N^D, Y, r, \) and \( W \) exists. In this case there is no way of determining whether the regression coefficients of that linear relationship are the coefficients of the true demand equation (eq.(I)), or of the mongrel equation (eq. III). If however, the estimated equation had a zero regression coefficient on \( W \), it could be interpreted as an estimate of equation (II), for there is no way to form a mongrel equation which does not include \( W \). It, therefore, follows that whether a demand equation or a
supply equation can be identified from an estimated equation depends on which variables enter the true demand and supply functions and, without specifying the supply function, we cannot know whether an estimated equation represents a demand function or a mongrel equation.*

The above analysis suggests, then, that before one can take observations of the money supply, relate them to the level of income and the rate of interest, and call the result a demand-for-money function, one must be sure of two important matters: First, one must be sure that the \( N^S \)-function shifts independently of the \( N^D \)-function; that the \( N^S \) contains at least one variable that does not appear in the demand function. It is not difficult to establish that this is the case, for the level of reserves made available by the central bank to the commercial banking system, figures prominently in any theory of the money-supply and, does not appear in any theory of the demand-for-money. There is also ample evidence that this variable shifts around over time, permitting us to be sure that we can get observations taken at different points on the demand-for-money function. Second, such observations must lie on the same \( N^D \)-function. It is not sufficient to assume that \( N^S \) shifts independently of the demand-for-money function; it is necessary to assume that the latter stays put between observations.

Certain techniques have been developed by some econo-
mists when studying the money market, which overcome the identification difficulty by enabling supply and demand functions to be fitted simultaneously; we will examine this kind of developments when we come to testing our model.

The second problem is the simultaneous equation bias. This results from estimating a demand function by the technique of ordinary least-squares regression (OLS), for the coefficients estimated by OLS are unbiased only if the

* See, for example, Johnston, J. *Econometric Methods*. New York, 1963, Ch.9.
explanatory variables are uncorrelated with the random disturbance term. In general, this condition is not satisfied by the demand function for money. Explanatory variables are correlated with the random disturbance term because the explanatory variables are not truly exogenous but are themselves influenced by the dependent variable. The reason why the condition is not satisfied is that there is a two-way interaction between the dependent and independent variables, and this, in turn, arises because of the way "money" is treated as the dependent variable. Some studies have regressed a demand equation for money and have attempted to overcome the identification problem by asserting that the supply of money depends on none of the arguments in the demand function for money and that the supply of money is more volatile than the demand curve for money. But, if it were true that the supply of money depends on none of the same variables as the demand for money, then it is wrong to treat money as the dependent variable in the demand for money function. For each individual, the demand for money is a dependent variable, but in the community's aggregate demand function the stock of money is given and, for example, the rate of interest and Gross National Product are the dependent variables. The causal direction being wrongly specified in this way leads to biased estimates. In other words, if one begins with the $i^{th}$ individual, then the demand for money is represented by the following equation - omitting the disturbance term:

$$m_i = a_0 + b_1 y_i + b_2 r$$

The individual takes the rate of interest and the level of his nominal income as given and adjusts his nominal money balances. For the individual, therefore, nominal cash balances are the dependent variable. Very few studies, however, have used individual observations on households or firms. Most empirical works have used time series of aggregates, and there are obviously problems created with this aggregation. Clearly, for the economy as a whole the quantity of money cannot be considered as the dependent variable. If we ignore for the time the rate of interest,
then the normal aggregate monetary theory would argue that the aggregate quantity of money is determined by the monetary authorities and that the level of nominal aggregate income is the dependent variable. Formally, therefore, the aggregate relationship is derived as follows:

\[ \sum m_t = a_0 + b_1 \sum y_t \]

so that \( m = a_0 + b_1 y \),

with \( m = \sum m_t \), \( y = \sum y_t \), and writing the level of aggregate income as the dependent variable we have:

\[ y = - \frac{a_0}{b_1} + \frac{m}{b_1} \]

The regression analysis suggests that \( \frac{1}{b_1} \) is the money multiplier. One, however, could suggest that \( \frac{1}{b_1} \) simply measures the reaction of the monetary authorities to current income levels. The last equation assumes that the causal effect is from money to nominal income, not the other way around. If one were convinced, however, that money as such had little effect on income and that the authorities were passively supplying money for the "needs of trade", then the measure \( b_1 \) would give information only about the reactions of the Central Bank to current or expected economic conditions.

If, however, it is not true that the supply of money depends on different variables from those in the demand function, then failure to specify the supply function not only involves the identification problem, but it also leads to simultaneous-equation bias in the estimated regression coefficients of the demand for money equation. This is because the one-stage least squares procedure fails to take account of the whole model and the feedbacks that exist between the structural equations of the model. Simultaneous-equation estimation procedures are then required to meet this problem, e.g. two-stage least squares; this latter method and others have been used in the empirical work on the demand for money to avoid these problems (116 for example).
and this empirical procedure is followed in this study.

The Specification error arises when the structural equations of the model are incorrectly specified and therefore simultaneous estimation does not take full account of the "true" feedbacks between the structural equations. For example, suppose we specify a model where

\[ M^D = M^D(r, Y, \ldots), \quad \text{and} \]
\[ M^S = M^S(r, \ldots). \]

In this case, we should also specify a causal relationship between the rate of interest and income as a structural equation since otherwise we would have a specification bias, and also we would preclude using the model to analyse monetary policy. The rate of interest effect on money demand and supply does not record the effect of the money supply and the rate of interest on the level of money income.

An additional econometric problem, not mentioned above, is that of autocorrelation; in general, autocorrelation exists when the random errors of the demand for money function, to be estimated, are not independent of each other. The existence of autocorrelation is then, responsible for two kinds of problems: First, it leads to overestimates of the significance of the regression coefficients (see 24 for example). Second, where an attempt is made to estimate adjustment lags, the length of lag is likely to be wrongly estimated. The problem of autocorrelation is tackled in rather a detailed way, in this study; the computing programme we use for the estimation of the parameters of the demand for money and of the other structural relationships of the model tested in this piece of research, provide appropriate statistics which enables us to determine whether

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** See Chapter 4, below.
the autocorrelation problem is present or not.

The Empirical Evidence:

In the studies on the empirical evidence of the demand for money, the total of money balances is usually related to the level of money incomes and the rate of interest prevailing on some alternative financial asset, for example on Treasury bills. Alternatively, the ratio of money balances to money income that is to say, the inverse of the income velocity of money, may be used instead of the total of money balances as the variable to be explained. There is, however, considerable controversy as to the precise manner in which these equations are specified. There is, to begin with, dispute over the form of the income (or Wealth) variable which should be related to the demand for money. The evidence here clearly shows that permanent income performs consistently better than current real income \((49, 51, 89, 123)\). Controversy also exists over the relative merits of non-human wealth and permanent income in an aggregate demand for money. Friedman (51) demonstrates that permanent income performs better, whereas Metzler (94) finds that non-human wealth fits the data better than Friedman's permanent income. DeLeeuw's results** support a measure of non-human wealth as an explanatory variable in the demand function for demand deposits, but finds that a quarterly reconstruction of Friedman's permanent income data is a better explanatory variable for currency holdings, and that it is difficult to choose between the variables as affecting time deposits. Chow (22) finds that permanent income is preferable to non-human wealth (using the \(M_1\) definition), and Laidler (86) finds that, when money is

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** See DeLeeuw, F. "The Demand for Money - Speed of Adjustment, Interest Rates, and Wealth", op. cit.
defined as $N_2$, non-human wealth performs better, whereas with $N_1$ permanent income is better. A related problem is that of the extent of substitution between money balances and other financial assets. Evidence on this question is deduced from the coefficient of the interest-elasticity of the demand for money. This coefficient is calculated from the estimated demand for money equations, and it measures the percentage change in money balances associated with a percentage change in interest rates. Most of the econometric work on this question has been done using data from the U.S.A.; the results of similar studies using U.K. data tend to be quite confirmatory, although in some cases the estimated coefficient for the interest-elasticity of the demand for money is rather lower. A compressed selection of empirical work on the interest-elasticity of the demand for money which covers studies using both U.S.A. and U.K. data is provided by Goodhart (62, pp. 183-189).

Generally speaking, it seems that the empirical evidence has established that there is a significant negative relationship between movements in interest rates and money balances, that is to say, the higher the interest rate, the lower will

Whether the demand for money is interest-elastic or not is a more important question than appears at first sight, because it is fundamental to many issues in both monetary theory and monetary policy. Clearly the question of the interest-elasticity of the demand for money is crucial to the relevance of the Keynesian under-employment equilibrium trap. If it can be shown that the demand for money is not interest-elastic at all, then one is back with the classical quantity theory with a constant, or in Friedman's model a stable, velocity of circulation; and this implies that monetary policy must be tremendously effective, because by controlling the quantity of money the authorities are directly controlling money income - either real income and employment, or prices -. If, on the other hand, it can be demonstrated that the demand for money is very interest-elastic, expansion or contraction of the money supply may not cause enough changes in interest rates, thus having no significant influence on the level of income. Consequently, the results of the attempts to fit empirical demand functions for money raise some crucial issues about the effectiveness of monetary policy.
be the quantity of money balances associated with any given level of money incomes; and according to Laidler (90, p. 97): "whether one thinks of the demand for money function as being constrained by income, wealth, or expected income, whether one cares to define money to include time deposits or exclude them, whether one chooses to ignore the identification problem or deal with it, whether one uses a short rate of interest, a long one, the return on financial intermediaries' liabilities or the yield on corporate equities, there is an overwhelming body of evidence in favour of the proposition that the demand for money is stably and negatively related to the rate of interest. Of all the issues in monetary economics, this is the one that appears to have been settled most decisively". The interest-elasticity of the demand for money, however, appears to be quite low; it generally seems to lie within the range of -0.1 to -1.0 which is actually rather wide. This wide range, though, can be explained by the fact that different forms of demand for money relationships have been tested, and that the estimated interest elasticities tend to vary depending on the particular empirical form that the demand for money relationship takes. So if $N_2$ rather than $N_1$ is the variable to be explained, the interest-elasticity will be lower, because part of the effect of, say, rising interest rates will be to cause a shift from current to time deposits. If short-term rates rather than long-term rates are used, the estimated elasticity will also be lower because the variations in short-term rates are greater. If quarterly data are used rather than annual data, the estimated elasticity tends to be lower, the reason probably being that full adjustment of any changes in financial conditions will not be achieved in as short a period as one quarter. One, in fact, may generalise by saying that the econometric studies which use annual data with $N_1$ as the dependent variable and a long-term rate of interest as an explanatory variable does tend to give an estimate for the interest-elasticity of the demand for money nearer to the top end of the range of results, and those with $N_2$ and a short-term rate of interest
tend to give an estimate nearer to the bottom end. Although there are these differences in the results of various econometric studies, there is one important conclusion to be derived. The evidence on the elasticity of the demand for money provides conclusive contradiction to the extreme forms of both the Keynesian and monetarist theories. The strict monetarist form makes the assumption of a zero interest-elasticity of the demand for money; on purely empirical grounds this is clearly a very unsatisfactory assumption. Equally unsatisfactory is the Keynesian extreme assumption of an infinite interest-elasticity of the demand for money. The estimated coefficients for the interest-elasticity of the demand for money are far too low to support the extreme Keynesian view that even substantial changes in the money supply would merely cause a small and ineffectual variation in interest rates. At the same time the estimated coefficients for the interest-elasticity are definitely not zero and consequently full adjustment to a full equilibrium after a change in the money supply would not have to take place entirely and directly via changes in money incomes; one should expect, always according to the evidence, that some adjustment would take place by way of interest rates variation too, a result that contradicts the extreme monetarist view.

This conclusion, then, supports the proposition, mentioned earlier, that there is a significant negative relationship between some interest rate and money balances. This proposition, however, raises a further question, namely, which is the most appropriate interest rate that should be included in the demand for money function, some short-term rate or some long-term rate? One might indeed argue that it does not really matter which interest rate one might choose for the simple reason that time series data show that both rates move very closely together over time, and for the purposes of testing for the importance of the rate of interest in the demand for money function one rate is probably as good as the other rate. It is argued, however, that the long-rate is perhaps better because it is more representative of the
average rate of return on capital in the economy at any time, and hence it is a better indicator of the general opportunity cost of holding money than is the yield on short-term bills. On the other hand, it is also argued that the short-term rates, because of their short maturity, are closer substitutes for money than are longer bonds, so that the yield on them is particularly relevant among the alternatives that are foregone by holding cash. This, however, amounts to saying that the rate of return on short-term bills is subject to very little uncertainty, and it, therefore, follows that this tends to eliminate the importance of the short-term rate in the speculative demand for money. The issue, though, is an empirical one for there is no way of saying how much uncertainty constitutes a "little". On the empirical front, Metzler (91), and Chow (22), for example, use a long-term rate of interest, whilst Bronfenbrenner and Mayer (18); Laidler (86), and Teigen (116, 117), for example, use a short-term rate. In an attempt to solve this issue, Laidler (87), finds some evidence to support the theory that the demand for money is better related to short-term than to long-term interest rates. Laidler's test is based on the following proposition: if the demand for money is stable, the 'right' interest rate would be expected to show the same relationship to the demand for money in different time periods while the 'wrong' one need not. Laidler finds that using the wide definition of money the coefficient of determination is much greater for short-term rates than for long-term rates; he also finds that when the data are divided into sub-periods, the estimates for the coefficient of interest-elasticity are much more stable with respect to short-term rates than to longer-term rates. Heller (71) confirms Laidler's results; using quarterly data for the post-war period, he detects a significant coefficient of interest-elasticity for short-term interest rates but not for long-term rates. Lee(93), using differential rather than absolute rates, finds that the yield on savings and loan shares explains the demand for money, under either a narrow or broad definition, better
than the yield on longer-term assets. Tobin (119), however, derives a different set of conclusions. His results suggest that there is very little to choose between long-term and short-term rates, with long-term rates being marginally more successful in explaining the demand for 'narrow' money, whereas the demand for 'wide' money is slightly better explained by short-term rates. Goodhart (62) also reports that there is nothing to choose between long-term and short-term rates. Long-term rates are marginally more significant when the definition of money is restricted to currency plus clearing bank deposits, whereas the short-term rate appears slightly more significant when money is broadly defined - as in the Central Statistical Office's Financial Statistics. The short-term rate used in Goodhart's study is the local authority rate; he argues that the slightly better performance of this rate in the 'broad' demand for money may result from the deposits of the 'other' banks being more directly competitive with rates in the local authority market. These results are obtained when levels are used; when the same equations are estimated but with first differences, the short-term rate performed considerably better than the long-term rate.

The predictability of the demand for money function is another aspect of this function which has been debated and a number of empirical studies dealing with this problem has appeared in the literature. Keynes' work on this topic suggests that the demand for money is predictable enough, except, of course, at very low interest rates. In the post-war period, however, many Keynesians started questioning this contention, arguing that the availability of money substitutes would tend to weaken the predictability of this relationship and in particular it would make the money-income relationship very suspect and therefore it would not be of much practical use for economic management or forecasting.* This view has been challenged by the monetarists;

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* The extreme view on this question, is the one expressed in the Radcliffe Report (75, especially pages. 392 and 397).
Friedman and Schwartz, for example, in their study on the monetary history of the United States (56), have shown that there is a strong relationship between real income and real money balances, and that this relationship was reasonably predictable over the period 1867-1959. Since then, the studies by Metzler (911), Chow (22), Laidler (87), and Courchene and Shapiro (24), among others, have demonstrated that the demand for money in the United States is fairly well determined and predictable over the long period, with coefficients of determination in the range of 0.90 - 0.99 which is very high indeed. In the United Kingdom the study by Kavanagh and Walters (84) covering the period 1877-1961, produced the same results with a coefficient of determination equal to 0.98 in the demand for money function. These studies, however, suffer from a fundamental weakness in that the data used on both the dependent and independent variables to establish these relationships are trend-dominated; in this case it is easy to see that close relationships and high coefficients of determination are in fact inevitable, but these relationships are bound to be false because of the appearance of the time trend. One way to reduce this danger is to use changes in, rather than levels of, the data. This way is expected to eliminate the trend and consequently it can be considered as providing more reliable results in terms of the strength of the demand for money relationship in its predictability. When changes are used there occurs a dramatic reduction in the coefficient of determination. For example, in Laidler's study (87) the coefficient of determination in a typical equation is reduced from 0.99 to 0.51 when the data are transformed from levels into changes. Similarly, in the study by Kavanagh and Walters (84) the coefficient of determination is reduced from 0.98 to 0.49. In general all empirical studies that have reported results using both levels and first differences (i.e. changes) do come to the same conclusion, that is, there is always a significant reduction in the coefficient of determination when this transformation is employed. The use of lagged dependent variables as
explanatory variables is another way to reduce the danger of establishing false demand for money relationships when the variables are trend-dominated. Those studies that have introduced explicitly lagged dependent variables in their tests of the demand for money have established significant coefficients for the lagged variables while the explanatory power of other variables has been correspondingly lower. Possible explanations of these results can be the presence of time lags in the adjustment process of the dependent variable to its equilibrium position, and the existence of first or higher order autocorrelation in the residuals. We carefully examine these problems in our empirical analysis, where some important results are reported.

We may summarise the evidence on the predictability of the demand for money by quoting Goodhart (62, p.102): *"The empirical evidence suggests that the demand for money is more predictable than, say, the Radcliffe Committee would have imagined, but probably not predictable enough to be used as an instrument of short-term policy. Furthermore the predictability of the relationship in a period when control of the money supply was not a major feature of policy will not necessarily be a good guide to its predictability under conditions when it was more actively used".

The inevitable overall conclusion that emerges from the empirical investigations on the demand for money is that the range of possible disagreement has been reduced and consequently some movement towards consensus has been brought about. It is no longer possible to argue convincingly that the interest-elasticity of the demand for money is on the one hand, so large as to make monetary policy completely impotent, or on the other hand so small that it is necessary and sufficient to concentrate entirely on the direct relationship between movements in the money stock and in money incomes, while ignoring inter-relationships in the

* See Goodhart (62) for an example.
** See Feige (42)
*** We note that our analysis of the empirical evidence on the demand for money draws heavily on this study.
financial system. Instead, one can safely argue that there is some significant interest-elasticity in the demand for money relationship, and that the appropriate interest rate to be included in this relationship is the short-term rate of interest, although the evidence is not quite unanimous on the superiority of the short-term rate over the long-term rate. This conclusion, then, supports a demand for money function of the type:

\[ M_t^D = M^D(r_{st}, Y_t), \]

where \( r_{st} \) = some short-term rate of interest,

with \( \frac{\partial M_t^D}{\partial Y_t} > 0 \) and \( \frac{\partial M_t^D}{\partial r_{st}} < 0 \); writing this function in linear form we have:

\[ (i) \quad M_t^D = a_0 + a_1 Y_t + a_2 r_{st} + w_t \]

where \( M_t^D \) = desired (or equilibrium) money balances, and \( w_t \) = error term.

We note that current income is used in this equation than permanent income or wealth. This is justified on the grounds that although in a long-run context one of these latter variables is probably more useful, in short-run models there is some evidence that current income dominates either permanent income or wealth in explaining the demand for money.*

Following Feige (42), we assume that an individual, given his expected yield on wealth and the rate of interest, chooses a long-run desired level of cash balances (\( M_t^{D*} \)). A particular cash balance position (\( M_t^D \)) involves certain costs which can be broken down into two components: (a) the cost of being out of long-run equilibrium, and (b) the direct costs of portfolio change. The cost of being out of equilibrium is assumed to depend upon the gap between the individual's current cash position and his long-run desired position. If his current cash position exceeds his long-run desired position,

* See Chow (22, Table 2, p.122).
the individual suffers the cost of foregone income. Alternatively, if his current position falls short of his long-run desired position, he suffers the costs of increased risk and inconvenience. We can represent this cost by the expression:

\[ c_1 = a(N^D_t - N^{D*}_t)^2. \]

The second kind of cost incurred represents the brokerage charges and other transaction costs associated with changes in the portfolio, and these costs are assumed to depend upon the change in the current cash position. Thus,

\[ c_2 = b(N^D_t - N^D_{t-1})^2. \]

The total cost function, then, can be written as:

\[ c = c_1 + c_2 = a(M^D_t - N^{D*}_t)^2 + b(M^D_t - N^D_{t-1})^2. \]

The problem, now is to choose that cash position \( M^D_t \), which, given the long-run desired position \( N^{D*}_t \) and the previous cash position \( N^D_{t-1} \) minimises total cost. Differentiating \( c \) with respect to \( M^D_t \) and setting this derivative equal to zero we have:

\[ M^D_t = \frac{a}{a+b} N^{D*}_t + \frac{b}{a+b} N^D_{t-1}. \]

and if we let

\[ c_o = \frac{a}{a+b}, \]

then,

\[ M^D_t = c_o N^{D*}_t + (1-c_o) N^D_{t-1}. \]

or,

\[ M^D_t = N^D_{t-1} + c_o (N^{D*}_t - N^D_{t-1}). \]

Adding a disturbance term we have:

\[ (ii) \quad M^D_t = N^D_{t-1} + c_o (N^{D*}_t - N^D_{t-1}) + v_t. \]

This last equation relates current effective demand for real cash balances to the long-run desired stock. In its final form, it simply means that any discrepancy between \( M^D_t \) and \( N^{D*}_t \) is not made up instantaneously but only a fraction, \( c_o \), of the difference between the desired level \( N^{D*}_t \) and initial level \( N^D_{t-1} \).
Combining equation (i) and (ii) we get:

(iii) \[ M_t^D = c_0a_0 + c_0a_1Y_t + c_0a_2r_{st} + (1 - c_0)M_{t-1}^D + u_t \]

where \( u_t = c_0w_t + v_t \), a composite error term.

Equation (iii) is written as:

(iv) \[ M_t^D = d_o + d_1Y_t + d_2r_{st} + d_3M_{t-1}^D + u_t \]

where, \( d_o = c_0a_0 \), \( d_1 = c_0a_1 \), \( d_2 = c_0a_2 \), and \( d_3 = (1 - c_0) \).

3.1b The Supply of Money:

We now turn from the demand for money to the supply of money which is a major feature of this study. The problem of the formulation of the U.K. money supply is a very important one. For one thing, since the intention of the "Competition and Credit Control" new system of monetary techniques in the U.K. is to move away from control of bank lending, which was of major concern in the 1960's, to control of one of 'the broader money aggregates' such as the money supply, it follows that the precise process of the money supply determination becomes very crucial. For another, over the last twenty years or so the analysis of the U.K. money supply determination has been both neglected and confused. Neglected because of the belief that since the introduction of a flexible monetary policy in 1951, the price of government debt rather than the money supply has been the instrument of monetary policy; and confused because among those who have dealt with the problem of the determination of the U.K. money supply, there has been continuous disagreement as to whether the liquid assets ratio or the cash asset ratio has been the main determining factor (see for example, 25, 27, 33 and 101).

In a general sense, the usual analysis of the determination of the money stock is firmly based on a mechanical relationship. The rationale behind it may be put forward as follows:
The money stock (M) is defined as currency held by the public (Cp) plus the total of bank deposits (D). It is, therefore, possible to write the following identity:

(i) \( M = C_p + D \)

which must hold exactly by definition. Similarly it is possible to define the sum of currency held by the general public, and the cash reserves of the banking sector (R) as 'High powered money' or simply 'monetary base' (B). We thus have an additional identity:

(ii) \( B = C_p + R \)

It is also postulated that the public desire to hold currency as a constant proportion of the total money stock, so that

(iii) \( C_p = cM \)

where \( C_p \) is desired currency holdings and \( c \) is the desired currency to total money ratio; \( M \), of course, stands for the total money supply.

Furthermore, the total of bank reserves is a constant proportion of the total of deposits, so that:

(iv) \( R = rD \)

where \( r \) is the cash reserve ratio.

Substituting (iii) into (ii) and solving for \( R \) we have:

(v) \( R = B - cM \)

Next, substituting (v) into (iv) we have:

\( D - cM = rD \) or

(vi) \( D = \frac{B - cM}{r} \)

Substituting (vi) and (iii) into (i) we get:
\[ M = cM + \frac{B - cM}{r} \quad \text{or} \]
\[ rM = rcM + B - cM \quad \text{or} \]
\[ M(c + r - rc) = B \quad \text{or} \]
\[
(vii) \quad M = \frac{1}{c+r(1-c)} \cdot B
\]

The fraction by which the monetary base is being multiplied in equation (vii) is usually referred to as the monetary multiplier and denoted by the symbol \( m \). Thus we have:

\[
(viii) \quad M = m \cdot B.
\]

According to this explanation, then, the money supply depends on only three things: (1) the public's currency ratio, (2) the banks' cash ratio, and (3) the monetary base. By assuming that the two ratios are constant, changes in the money supply depend only on changes in the monetary base. If, then, the monetary base is under the control of the monetary authorities, then the authorities have control over the money supply, making it exogenously determined, if they want to.

This explanation of the money supply determination, therefore, depends crucially on a mechanical relationship summarised in the form of an identity (viii), which, it must be stressed, does not in any sense provide a behavioural theory of the money stock determination.* Not only does it not provide such a theory, but it also suffers from a serious weakness, in that the use of the above mentioned identity to show the definitional relationship that must hold between assets as the basis for analysis, tends to obscure the key role played by relative price (yield) changes in the adjust-

* We note that one does come across in the literature of studies that regress changes in the money supply on changes in 'high powered money', the banks' reserve-deposit ratio, and the public's currency-deposit ratio, and interpret the resulting statistically successful fit as providing enough evidence in favour of the money multiplier theory (31, 34 for example).
ment process. The latter, as it must be obvious from the analysis of the money multiplier, is supposed to be a purely mechanical process where the relative yield movements are completely ignored (59). This weakness is aggravated by a general failure to examine the factors determining the level of, and changes in, the monetary base. High powered money is assumed to be passed from hand to hand, and the portfolio adjustments of the banks play no role except in so far as they may seek to alter their reserve ratios. The public's asset preferences are also assumed to be irrelevant except in so far as they seek to alter their cash-deposit (or money stock) ratios. Such treatment is indeed a very incomplete way of describing the process of the determination of money stock. To be sure with the argument, though there are some studies which have taken into consideration the effect of relative price (yield) movements on the desired values of reserve-deposit ratio and currency-deposit (or money stock) ratio, but there still seems to be no study which treats the level of the monetary base as endogenous (with the exception of 59). The usual treatment of the monetary base is to take it as given, fixed by the monetary authorities, thus being completely exogenous, and no further attempt is made to examine the behavioural factors that can influence it. The study by Goodhart (59) provides a number of arguments against this common practice and goes on to develop a model which treats the monetary base, and the money supply as endogenous. The analysis by Goodhart is in line with a theory that might be labelled "The Portfolio Theory of Monetary Policy" developed in recent years, and has come to be widely accepted in the economics profession. Within this approach - whose architect is J. Tobin and the Yale School, see for example 118 - monetary theory is considered to be part of the broader theory of asset choice and portfolio management of economic units. A monetary disturbance such as an injection

of base money into the economic system is viewed as changing the existing conditions under which wealthholders are willing to hold current assets. A policy-induced change in the amount of the existing stock of any one asset - such as the amount of reserves that banks hold - lead to a behavioural reaction on the part of economic units as they attempt to readjust their stocks of both real and financial assets to the amounts desired under these new conditions. The attempt by individual economic units - households, commercial banks, nonbank financial institutions, other business firms, and government units - to reallocate their nonhuman wealth to a different set of assets appears in the real sector via a change in the quantity demanded of real assets - such as capital goods and consumer goods - and thus affects real output and prices.

One of the consequences of this approach has been to view the money stock as being determined both on the supply and demand sides by the behavioural actions of economic units. Money is considered as only one of many assets that economic units hold. The money stock is no longer considered to be completely exogenously determined, but is viewed as a quantity whose magnitude is partly determined by the policy actions of the central bank and partly endogenously determined within the economic system by rational portfolio decisions of the commercial banks and the public. The determination of the money stock, therefore, involves a process of general portfolio adjustment in response to relative interest rate changes, with the time path of the process depending on the various speeds of adjustment of the sectors to relative price changes. It is simply not true within the context of this approach that the only way in which the banks and the public affect the process of the determination of the money stock is when they alter their reserve ratio and their cash-deposit (or money stock) ratio respectively. The process is not mechanical and as J. Tobin (118, p. 9) strongly argues: "There is more to the determination of the volume of bank deposits than the arithmetic of reserve supplies and reserve ratios. The redundant reserves of the thirties
are a dramatic reminder that economic opportunities sometimes prevail over reserve calculations. The significance of that experience is not correctly appreciated if it is regarded simply as an aberration from a normal state of affairs in which banks are fully loaned up, and total deposits are tightly linked to the volume of reserves. The thirties exemplify in extreme form a phenomenon which is always in some degree present. The use to which the commercial banks put the reserves available to the system is an economic variable depending on lending opportunities and interest rates.

The central theme of this 'new' view may be illustrated with the aid of two simple diagrams, in which the extreme version of the 'traditional' view is contrasted with the 'new' view. In figure 17, the traditional view is presented in four stages. In 'Stage a' we plot different possible
values of the rate of interest \( (i) \), say the Keynesian long-term rate, and the banks' cash reserve ratio \( (r) \). Now, the relationship between \( r \) and \( i \) is depicted with a vertical line, expressing the view that \( r \) is not affected by the rate of interest. In 'Stage b' we plot different possible values for \( m \) - monetary multiplier - and \( r \); the relationship is inverse as one can easily deduce from equation (vii). 'Stage c' provides the relationship between \( m \) and \( M \) - money supply - which is of course positive - again from equation (vii), we can clearly see that with a given monetary base, greater values of \( m \) will give greater values for \( M \). The position of \( M \) - curve will of course depend upon the size of the monetary base; an increase in the monetary base will mean a greater \( M \) for given \( m \) and the \( M \) - curve will shift to the right. Finally, 'Stage d' shows the relationship between the rate of interest and the money supply. As the rate of interest has no effect on the size of the banks' cash reserve ratio it will have no effect on the values of the monetary multiplier and no effect on the total money supply. This lack of relationship between the rate of interest and the money is shown in 'Stage d' as a vertical straight line emanating from the horizontal axis at a point along that axis determined by the size of the monetary multiplier and the monetary base. Whatever the rate of interest the money may be regarded as being perfectly elastic until it reaches the limit determined by the monetary multiplier and the monetary base. Suppose for example that the rate of interest is \( i_1 \), then the money supply curve would be \( ABC \).

According to the extreme form of the traditional view, the money supply will always be at the absolute limit set by the banks' cash reserve ratio and the monetary base. If the authorities expand the monetary base then this will shift the \( M \)-curve in 'Stage c' and 'Stage d' to the right, and increase the money supply.

The new view is presented in figure 18, again in four stages. 'Stage a' shows the relationship between the rate of interest and the banks' cash reserve ratio, which is now inverse reflecting the new view's assumption that the higher
the i, the lower the r for the higher the i is the higher the opportunity cost of reserves. The section of the curve that slopes downwards from left to right shows that as the rate of interest rises to \( i_1 \) the banks depress their reserve ratio. However, when the interest rate reaches \( i_1 \) the banks are unprepared or unable to depress their reserve ratio any further. This may be because there is a legal minimum or a minimum which past experience has shown to be the appropriate level. Both 'Stage b' and 'Stage c'

![Diagram](image-url)
are the same as in figure 17. 'Stage d' is derived as follows: starting in 'Stage a' and reading down to 'Stage b' we see that at rates of interest of \( i_1 \) and above, the banks' reserve ratio is \( r_1 \). This gives a monetary multiplier of \( m_1 \). Reading across to 'Stage c' we see that with a monetary multiplier of \( m_1 \) and a given monetary base the money supply is \( M_1 \). In 'Stage d' then, at rates of interest of \( i_1 \) and above, the money supply curve is vertical at \( M_1 \).

Going back to 'Stage a' and 'Stage b' we can see that at a rate of interest \( i_2 \) the value of the banks' cash reserve ratio is \( r_2 \), which gives a value for the monetary multiplier of \( m_2 \). From 'Stage c' we see that given the monetary base the potential money supply is \( M_2 \). Doing the same exercise for all possible interest rates and cash reserve ratios we trace the supply of money curve ABC - as opposed to A'B'C - in 'Stage d'. The money-supply relationship is not a mechanical one anymore, and it does not ignore the impact of the rate of interest on the supply of money. So far we have been concerned with the supply of money relationship, but in the new view demand considerations are of equal importance. The demand for bank deposits is considered to be related to the rate of interest; to what extent the public is prepared to sell securities, say, in return for banks deposits, i.e. to what extent the demand for deposits can expand, should, surely, depend on the prevailing rate of interest. For example, the lower the rate of interest on government securities the more willing the non-bank public will be to sell securities to the banks in return for bank deposits. Thus it seems likely that the demand for bank deposits will be directly and negatively related to the rate of interest. The position of the demand curve at any given rate of interest will depend upon a number of other factors. One of the most important factors, which is particularly stressed by the new view, is the importance of competition from other non-bank financial intermediaries. In fact the new view places a great deal of emphasis on the similarity between banks and non-bank financial intermediaries and on the resulting competition that prevails between them both as issuers of indirect securities and purchasers of primary securities.

It is argued that the
existence and growth of the non-bank financial intermediaries implies the creation of liabilities highly substitutable for the liabilities of the banks, thus influencing the position of the demand for bank deposits relationship. It is also recognised that the position of this relationship does depend upon the economic climate. Given the rate of interest, the demand for bank deposits is expected to increase during a period of general prosperity; this is the result of the business sector being keen to expand and the consumers sector being keen to spend in anticipation of rising incomes thus stimulating the demand for bank loans. Similarly, given the rate of interest a reduction in the demand for bank deposits is expected to occur during a period of general depression. In 'Stage d' two possible positions of the demand curve for bank deposits are postulated. In the case where the curve is in the position $D_1$ the money supply will be $M_1$ at the absolute limit determined by the banks' minimum reserve ratio and the size of the monetary base. This is obviously a situation where the banks are fully loaned up. When the position of the demand curve is $D_2$ the supply of money will be $M_2$ implying excess reserves for the banks since they will be operating with a cash reserve ratio higher than the minimum necessary. Expansion of the money supply beyond $M_2$ would require the banks to be able to persuade the public to exchange loans and securities for bank deposits. This could only be achieved if the banks were prepared to lower the rate of interest charged on the loans they provide to the private sector and increase the price, i.e. lower the interest rate, they would have to pay on securities. But whether the banking sector would be prepared to do all these is questionable, for according to Tobin (118, pp.6-7):

"The marginal returns from lending and investing, account

---

For a detailed analysis of this proposition see Tobin, J. and Brainard, N. "Financial Intermediaries and the Effectiveness of Monetary Controls", American Economic Review, May 1963.
taken of the risks and administrative costs involved, will not exceed the marginal cost of the banks of attracting and holding additional deposits" thus making it unprofitable for the banking sector to undertake such an expansion of the money supply.

The main conclusion, then, of the new view which inevitably follows from the above analysis, is that "the quantity of money as conventionally defined is not an autonomous variable controlled by governmental authority but an endogenous or inside quantity reflecting the economic behaviour of banks and other private economic units", so that a complete theory of the money supply must start from the point that "Marshall's scissors of supply and demand apply to the output of the banking industry no less than to other financial and non-financial industries".

The empirical evidence on the money supply - practically nonexistent in the U.K., but not as thick, as one might expect, in the U.S.A. - has not, on the whole, been very impressive, especially when one compares it with the enormous number of published studies on the demand for money. One very interesting aspect of the money supply theory, from an empirical point of view, is the interest-elasticity of the money supply relationship. Any policy action of the monetary authorities to achieve a desired growth in the money stock affects both reserve aggregates and interest rates; changes in interest rates, in turn, influence the portfolio decisions of banks and of the public, which in its turn can be a complicating factor in the achievement of a desired money stock. Thus, the higher the numerical value of the interest-elasticity of the money supply function the more difficult it may be to implement monetary control through the control of reserve aggregates; the lower the interest-elasticity of the money supply function, then the easier it becomes for such a control.

* See J. Tobin (118), p.8.

** See J. Tobin (118), p.11.
For example, suppose that the Bank of England via open market operations try to reduce the volume of reserves available to the banking system; the Bank, in that case, would have to sell government securities, thus causing short-term interest rates to go up. If the amount of reserve-assets is very sensitive to changes in interest rates, then this interest rate movement would induce the banking sector to hold larger quantities of reserve-assets. This portfolio shift, then, frustrates the policy to decrease the money stock. To be sure with the argument, however, this does not mean that monetary control is absolutely impossible. The stronger the interest rate feedback, the larger the necessary magnitude of the open market operation required to achieve a given change in the money stock and the larger the associated variance in short-term interest rates; the monetary authorities, however, may not be prepared to allow these required changes as the case has been in the U.K. for most of the post World-War II era. The empirical investigations undertaken on the elasticity of the money supply function indicate that the interest sensitivity of this function is extremely low. This evidence, however, stems from studies undertaken in the U.S.A.; we know of no study that deals directly with this problem in the case of the U.K. monetary sector. The available evidence in the U.S.A. has been extensively reviewed by Rasche; * it seems from this review that the long-run elasticity is less than 0.5 while the impact elasticity (one quarter) is no greater than 0.10 to 0.15. The evidence, therefore, suggests that in the U.S.A. the policy-makers should have little difficulty in their actions to control the money stock. There is of course another crucial problem here, that of the random fluctuations in the money supply relationship which can be a major factor in the size of deviations of the money stock from its target-value.

In the U.K. Crouch (34) has tested the traditional money supply equation,
\[ M = m \cdot D \]
as well as two models of the U.K. monetary sector in a later study (35), one involving total bank deposits and the other involving demand deposits only. In both studies the results suggest a money supply curve that is perfectly inelastic with respect to the rate of interest, thus supporting the "traditional view" as it is explained above in figure 17.

**A Money Supply Theory:**

We now develop a Money Supply Theory; the resulting equation is empirically investigated within the context of a macro-economic model in the next chapter.

We begin by defining the money stock as:

\[ M^S = C_p + D \]

where \( C_p \) is the amount of currency held by the public, and \( D \) is the total amount of deposits. The \( C_p \) part of the money stock is a very small proportion of the total money supply, around 20\%, the rest 80\% constitutes of deposits. We investigate first the deposits component of the \( M^S \) and then the \( C_p \) component.

We start by looking at some identities:

\[ A = L \]

where \( A = \) assets and \( L = \) liabilities; equation (2) simply states the fact that in the banks' balance sheets, assets are always equal to liabilities.

\[ A = Q + P \]

where \( Q = \) claims on the government and \( P = \) claims on the private sector.

\[ L = D + K_o \]

where \( K_o = \) capital which is completely exogenous.

It then follows that:

\[ Q + P = D + K_o \]
Let us now examine $Q$ and $P$ more closely.

$$\text{(6) } Q = R + TB + B_s + B_L + (CN)_1$$

where

$R$ = reserves i.e. cash in hand plus deposits with the Bank of England.

$TB$ = treasury bills plus local authority bills.

$B_s$ = short-term bonds and short-term local authority bonds, eligible to be included in the 12.1/2\% reserve asset ratio.

$B_L$ = long-term bonds plus local authority long bonds.

$(CN)_1$ = money at call and short-notice with the discount market, backed by government bonds and treasury bills thus:

$$(CN)_1 = a(CN).$$

We may now develop the following assumptions for the R.H.S. variables:

$$\text{(Ga) } R = \lambda D \quad \text{or} \quad \lambda = \frac{R}{D}$$

The ratio $\lambda$ is called the desired reserve/deposit ratio.

One may suggest that for given values of interest rates and level of economic activity as measured by the level of national income, banks desire to hold $R$ and $D$ in relatively fixed proportions. If then $R$ and $D$ are held in fixed proportions it follows that the ratio of $R$ to $D$ is a constant i.e. $\lambda$ is a constant. According to Crouch (34), British banks never hold reserves over and above what they are required to hold. Their reserve ratio therefore is always kept at its minimum even when interest rates are very low. The probable reason for this is that the banks' liquid assets are virtually riskless and transactions costs of moving into and out of these assets are extremely low. This means that even when the yield on these assets is very small it will still outweigh the costs of acquiring them, and pay the banks to keep their reserve ratio at its minimum.

V. Argy (4) argues that the bank reserve ratio has normally two elements: one element, the legal reserve ratio which
is made up of the special deposit ratio, determined by the authorities; the other the excess reserve ratio, which is determined by the behaviour of the banking system, is conventionally set at 0.08. In fact, the banks have adhered closely to the 8 per cent cash convention, which means that this element of the excess reserve ratio for all practical purposes may be treated as a constant. For the whole banking system, however, there seems to be some variability in the cash reserve ratio (see for example 100).

The $\lambda$ ratio becomes very important under the new arrangements for previously the banks did in fact hold a fixed $\lambda$ whereas now this is questionable. It is arguable that the historical relative stability of the banks' cash ratio was only sustainable because the banks were confident that they could always trade or obtain cash, directly or indirectly, at fairly stable market rates or at rates bearing a systematic relationship to Bank rate, which itself remained stable over long periods. Now one of the implications of varying the cash base to control the money stock is a willingness on the part of the authorities to permit greater variability in interest rates, especially short-term rates. The question then becomes 'Would greater variability of interest rates cause the banks to adopt a more variable cash ratio? In particular would the ratio $\lambda$ be a variable and not a constant, and if the answer is positive, what are the most important determinants of $\lambda$? The studies by Anderson-Burger (1), Neigs* and Morrison** - all these studies use U.S.A. data - have shown that $\lambda$ varies inversely with interest rates which seems to be quite reasonable for it becomes more profitable at the margin for the banks to hold as low as possible $R$ as rates rise. As interest rates fall, it pays at the margin to hold more $R$ because the diminished return earned on those pounds, if left invested, is insuffi-


** See Morrison, G.: Liquidity Preference of Commercial Banks.
cient to cover the risks connected with investment. It thus follows that:
\[ \lambda = \lambda (r) \quad \text{with} \quad \frac{d\lambda}{dr} < 0, \]
so that
\[ R = \lambda (r). \]

We do feel, however, that even under the new arrangements for monetary control in the U.K., the constancy of \( \lambda \) will be preserved. The reason, surely, must be the opportunities provided by the organisation and functioning of the London Money Market. This market provides so many investment opportunities to banks in terms of short-term riskless assets - money at call and short notice is probably the best example - that the variability of interest rates implied by the new measures of monetary control will not induce the banks to hold excess reserves. We are, therefore, able to write the \( R \)-function as:

\[
(6a) \quad R = \lambda \cdot D
\]

Next, we write the \( TB \)-function as:

\[
(6b) \quad TB = (tb)_0 + t_{1} \tau_{b}
\]

where \( \tau_{b} \) = the treasury bill rate. This assumption tells us that there is a fixed amount of TBS the banks would like to hold in their portfolios to satisfy their reserve-asset ratio, and also a systematic part which depends on the going treasury bill rate.*

\[
(6c) \quad D_{s} = (bs)_0 + b_{1} r_{s}
\]

where \( r_{s} \) = the short-term bond rate. The rationale of equation (6c) is exactly the same as that of (6b).

\[
(6d) \quad D_{L} = (bL)_0 + b_{2} r_{L}
\]

where \( r_{L} \) = the long-term bond rate. The \( (bL)_0 \) part of this

* TB includes local authority bills also; these bills are of course eligible to be included in the 12.1/2% reserve ratio. In this case \( \tau_{b} \) is an index of both the treasury bill rate and the local authority bill rate.
equation is justified by the fact that banks would always hold a certain amount of bonds without paying much attention at the going \( r_L \), to satisfy their diversified portfolios. The systematic part depends obviously on the profitability of bonds.

The \((CN)_1\) function is postulated in a similar fashion as the function for TBs:

\[
(6c) \quad (CN)_1 = (cm)_o + d_1 r_c
\]

where \( r_c \) = the call money rate. The justification of \((6c)\) runs along the lines of the argument of equations \((6b)\) and \((6c)\).

We, now, turn our attention to the \(P\)-component:

\[
(7) \quad P = CB + OL + AD + (CN)_2
\]

where,

\(CB =\) commercial bills,

\(OL =\) other liquid assets, e.g. money at call with other financial institutions besides the discount houses,

\(AD =\) advances,

\((CN)_2 = (1-a), CN =\) money at call with the discount market backed by private sector claims.

Again we may develop the following assumptions for the R.H.S.:

\[
(7a) \quad CB = (cb)_o + h_1 r_c
\]

where \( r_c =\) commercial bill rate.

\[
(7b) \quad OL = (o1)_o + l_1 r_{ol}
\]

where \( r_{ol} =\) rate of interest on \(OL\).

The justification of equations \((7a)\) and \((7b)\) is the same with the one proposed for equation \((6b)\).

\[
(7c) \quad AD = (ad)_o + n_1 r_{ad} + n_2 Y
\]

where \( r_{ad} =\) interest rate on advances, and \( Y =\) national income. This equation may be justified as follows: the level
of advances would probably depend on the liquidity of the banks and on the rate of interest on advances. \( r_{ad} \) is, therefore, included in this equation as well as \( Y \) which we use as a good indicator for the liquidity of the banking sector.

The \((CM)_2\)-function is specified in a similar way as the \((CM)_1\)-function:

\[
(7d) \quad (CM)_2 = (cm)_{o} + d_{2} r_{c}
\]

Finally, the following relationship should always hold:

\[
(bs)_{o} + (tb)_{o} + (cm)_{o} + (cm)'_{o} + (cb)_{o} + (ol)_{o} = 0.125 \cdot D
\]

i.e. the 12.1/2% reserve ratio.

Making use of \( 5, 6, 6a, 6b, 6c, 6d, 6e, 7, 7a, 7b, 7c \) and \( 7d \), we have:

\[
\lambda \cdot D + (tb)_{o} + b_{1} r_{b} + (bs)_{o} + b_{1} r_{s} + (bl)_{o} + b_{2} r_{L} + (cm)_{o} +
+ d_{1} r_{c} + (cb)_{o} + h_{1} r_{c} + (ol)_{o} + l_{1} r_{ol} + (ad)_{o} + n_{1} r_{ad} +
+ n_{2} Y + (cm)'_{o} + d_{2} r_{c} = D + K_{o}
\]

or,

\[
\left[ 1 - \lambda \right] \cdot D = f(r, Y, B)
\]

i.e. we have taken \( r \) as representing an index of interest rates, and \( B \) as the sum of all constants, which we approximate with the monetary base of the system; we have also written the function in an implicit form. It, then, follows that

\[
(8) \quad D = \frac{f(r, Y, B)}{1-\lambda}
\]

We may, now, use (1) and (8) to get:

\[
(9) \quad M^{s} = C_{p} + \frac{f(r, Y, B)}{1-\lambda}
\]

and denoting \( 1-\lambda \) with \( k \) i.e. a constant, we have equation (9):

\[
(9) \quad M^{s} = C_{p} + \frac{f(r, Y, B)}{k}
\]

The question, now, is whether we can say anything about
C_p. It has been suggested by Gibson and Thom* that for given values of interest rates and the level of economic activity, the public desires to hold money in relatively fixed proportions as between C_p and M^S. If then C_p and M^S are demanded in fixed proportions it follows that the ratio C_p to M^S is a constant. We call this ratio the desired currency ratio and denote it as c, so that:

\[ c = \frac{C_p}{M^S} = \text{constant.} \]

The constancy of c, however, is based on the assumption of given values of interest rates and the level of income. If then income and interest rates are not constant, one would probably expect c to be a variable. Although there is not as yet conclusive evidence to suggest what factors are the most important determinants of this ratio, studies by Cagan** and Kaufman*** in the U.S.A. have shown that this ratio is inversely related to national income. The justification is that as income increases people demand more money, but they decrease the proportion of C_p relative to M^S because the increase in income is expected to lead to relatively more transactions requiring payment by cheque than payment in currency. Similar studies using U.K. data tend to support this argument. R. L. Crouch in his study of the U.K. monetary contraction of 1954-1956 (35), argues that the increase in the monetary base in that period would, ceteris paribus, have led to a 6.1/2% expansion in the money supply. However, the currency ratio changed to such an extent that the money supply decreased by 1.36%. Crouch also argues that changes in the currency ratio have dominated changes in the money supply on several other occasions. In 1946-1947, for example, the fall in the ratio more than offset


** See Cagan, P.: The Demand for Currency Relative to Total Money Supply.

a fall in the monetary base and the money supply increased. Again, in 1951-1952 an increase in the ratio offset an increase in the monetary base and the money supply stopped rising. Crouch's conclusion is that the authorities tend to ignore the c ratio "at their peril". N. J. Gibson (50) comparing series of the ratio of currency to time deposits with the interest on time deposits concludes that there does not appear to exist a systematic tendency to substitutes time deposits for currency as interest rates on the former rise. R. L. Crouch in a study of the U.K. monetary sector (34) estimated an equation for C_p, in which current and past levels of income are the explanatory variables. The main conclusion of these studies appears to be that currency is primarily related to an income variable than to an interest rate variable.

In view of the above analysis and results we may have:

(11) \( c = c(Y) \) with \( \frac{dc}{dY} < 0 \).

It follows that (9) can now be written as:

\[ N^s = c(Y)M^s + \frac{f(r, Y, B)}{k}, \]

or,

\[ N^s = \frac{f(r, Y, B)}{k[1-c(Y)]}. \]

This last expression for the \( N^s \)-function can be written in an explicit form as follows:

(12) \( N^s = N^s(r, Y, B) \).

This function states that a rise in income, other things being equal, will tend to increase the money supply as a result of the ratio \( C_p/M^s \) falling, and also as a result of the banks expanding their advances to the private sector; and the money supply decreases as the level of income is squeezed. It also states that as the monetary base and the rate of interest go up banks increase their holding of earning assets which is expansionary as far as the money supply is concerned; and contractionary as the monetary base and the rate of interest go down. This last result follows directly from our analysis of the determination of the money stock.
discussed above and needs no further explanation. We feel, however, that some more detailed explanation should be provided on the proposition that $\Delta N^g/\Delta Y > 0$. When income expands, ceteris paribus, the money supply will increase. The increase in the level of income is accompanied with expansion of investment, and the expansion in investment activity will require additional credit from the banks, which presumably will be provided mainly because of the upward pressure on interest rates and therefore the increased profitability of advances. The expansion of income which goes along with expansion of investment (through the operation of the multiplier) will lead to an increased desire to hold money for use in transactions. Thus there is not only an initial temporary demand on the banks in order to finance the additional investment, but also a lasting increase in the stock of money to facilitate the larger flow of payments associated with a higher national income.

At the same time there might be an opposite tendency. Higher incomes will lead to higher imports. Exports will tend to decline as more resources are absorbed internally. If the balance of payments was just in equilibrium before the expansion phase started, it will now show a deficit. The public will buy more foreign exchange from banks than it sells to the banks, and, in the process, will reduce its holdings of money by an amount equal to the net reduction in the country's foreign exchange holdings. As the reserves of the banking system decline, and the central bank takes no steps to offset this decline, the banking system will wish to have less money outstanding. This decrease, however, would tend to be contained through increased capital movements which are induced by the higher rate of interest associated with the expansion in the level of income. On the whole, therefore, changes in the level of income will be associated with changes in the money supply in the same direction.

Equation (12), therefore, reduces the determination of the money supply to factors which are under the control of
the Central Bank, namely B, and factors which are determined by market forces, namely r and Y. The thrust of this whole analysis, then, is that the money supply is determined jointly by the behaviour of the monetary authorities, the commercial banking system, and the nonbank public. One may ask whether one group can dominate over the size of the money supply. In other words, does the Central Bank dominate any movement in the money supply, or is it that the money supply is purely determined by the public or commercial banks? There are two views on this question: (a) the traditional monetary view, and (b) the new view or as indicated above "The Portfolio Theory of Monetary Policy". The traditional monetary view holds that the behaviour of the central monetary authorities dominates the behaviour of the public and commercial banks in its effect on the money supply. According to this view, then, B in equation (12) is a much more important determinant of the money supply than r and Y; in other words, the money supply bears a very close, consistent, and predictable relation to variables under the Central Bank's control. Income and interest rates do not play an important role in the money supply function. Thus, the money supply is partly an endogenous variable determined by market forces but it is mostly an exogenous variable determined by the policy of the central monetary authorities.*

The 'new view' by contrast holds that the supply of money is primarily determined by interest rates, the level of income and other market forces operating on the behaviour

* See Phillips, C. A.: Bank Credit, for an early exposition of the traditional view. Tobin (118) is the architect of the 'new view'; on the latter see also Gramley, L. E. and Chase, S. B. Jr.: "Time Deposits in Monetary Analysis" Federal Reserve Bulletin, October, 1965. Brunner, K. in "The Role of Money and Monetary Policy" Federal Reserve Bank of St. Louis Review, July 1968 attacks the 'new view' and defends the traditional view. Moore, D. J.: An Introduction to the Theory of Finance, demonstrates that there is essentially no inconsistency between the two views (see ch. 6 especially).
of the public in allocating its money holdings between currency and deposits and on the behaviour of the commercial banks in allocating their assets between non-interest-bearing reserves and interest-bearing loans and securities. It follows, then, that if this view holds then in equation (12) \( r \) and \( Y \) are such important determinants of the money supply that there is no close, consistent, and predictable relation between the size of the money supply and the size of the variables subject to central bank control. The money supply is therefore, an endogenous variable determined by market forces.

Next, we write equation (12) in linear form:

\[
(13) \quad M^*_t = c_0 + c_1 Y_t + c_2 r_t + c_3 d_t + \nu_t
\]

where \( M^*_t \) = desired money supply. Any difference between desired and actual money stock is not made up instantaneously, but it is assumed that only a fraction \( h_o \) of the difference is adjusted in any period. Thus we get equation (14):

\[
(14) \quad M^*_t - M^*_{t-1} = h_o (M^*_t - M^*_{t-1}) + \nu_t
\]

This approach is similar to the one expounded on the demand for money. Changes in money stock induce a reallocation of assets (or liabilities) in the balance sheets of economic units which spills over to current output. Injections, say, of base-money modify the composition of financial assets and total wealth available to banks and other economic units. Absorption of the new base money requires suitable alterations in asset yields or asset prices. The banks and the public are thus induced to reshuffle their balance sheets to adjust desired and actual balance-sheet position; this adjustment, though, is not automatic and it is assumed that only a fraction \( h_o \) adjusts in any period.*

Next, we combine equations (13) and (14) to give:

\[
\text{See the paper by Anderson and Burger (1) for a more detailed exposition of this argument.}
\]

106.
\[ N_t^S = h_o (c_o + c_1 Y_t + c_2 r_t + c_3 B_t + v_t) + (1-h_o)M_{t-1}^g + v_t \]

or,

\[ N_t^S = h_o c_o + h_o c_1 Y_t + h_o c_2 r_t + h_o c_3 B_t + h_o v_t + (1-h_o)M_{t-1}^g + v_t \]

and finally:

\[ (15) \quad N_t^S = m_o + m_1 Y_t + m_2 r_t + m_3 B_t + m_4 M_{t-1}^g + u_t \]

where \( m_o = h_o c_o, m_1 = h_o c_1, m_2 = h_o c_2, m_3 = h_o c_3, m_4 = (1-h_o), \)

and \( u_t = h_o v_t + v_t. \)

This way of formulating the money supply function is in complete contrast to the treatment received in the past, especially before the introduction of Competition and Credit Control in 1971. The normal practice, then, was to treat the money supply as demand determined; the justification for such a treatment can be based on the behaviour of the monetary authorities in fixing gilt-edged prices. Although we have analysed the argument in chapter 2, we still feel we must produce a short summary at this point: in a simple money-bond framework the setting of 'the' interest rate by the monetary authorities implies an infinitely elastic money supply function at that rate, and so long as the peg is adjusted sufficiently from time to time, the data should reveal a demand function. It is the case, however, that the monetary authorities have not throughout adhered with uniform rigidity to a 'pegging' policy in the gilt-edged market; in particular, changes in dealing tactics were apparently undertaken from the end of 1968 onwards, culminating in what was intended to be a fairly major change of stance in 1971, in association with the introduction of Competition and Credit Control. Furthermore, not all variations in the money stock need come about from changes in demand; a shift from bonds to any other form of debt would, according to the pegging argument, involve an increase in the supply of money to support bond prices. But in this case, the increase in money supply would not have been called for by a prior increase in money demand and would, indeed, constitute an excess supply. The model also assumes that the adjustment of money demand.

107.
occurs exclusively through the bond market, thus making no allowance for the 'monetarist' view that such an adjustment may also involve income adjustments in the first round. Possibly of greater importance is the fact that because a rate is seen to be administered — in this case by the government broker — it does not follow that movements in that rate are independent of market forces. Indeed, it is possible that the administered rate may behave 'as if' it were market-determined. Studies of the monetary authorities' 'reaction function' — e.g. Fisher (44) — indicate that the interest rate peg is raised in response to increase in income and employment: much the same kind of reaction as would be expected of a market-determined rate with an exogenous money supply. Thus, there may be a case for thinking that interest rates behave as if they were market-determined. This then allows us to postulate the following equation for the formation of the long-term rate of interest:

\[ r_{Lt} = \alpha_0 + \alpha_1 r_{st} + \alpha_2 r_{st}^2 + \alpha_3 r_{Lt-1} + u_t \]

where \( u_t \) is the error term. The short-term rate \( (r_s) \) influences the long rate \( (r_L) \) through a stable structure. The rate of aggregate demand, as measured by the gross national product \( (Y) \), influences the demand for loanable funds and thus the long-term rate. The lagged interest rate is included in order to capture any expectations that may prevail; it may be, however, that the lagged interest rate arises as a result of a partial adjustment hypothesis as in the case of the money supply function.

The inevitable conclusion from the above discussion is that the environment of the 1970's must be regarded as providing an inhospitable context for the view that 'money is demand-determined'; and, secondly, that there is sufficient room for doubt as to whether it is appropriate to treat the supply of money as endogenous in the 1960's, as to justify experimenting with the alternative 'extreme' assumption, namely, that the supply of money should be regarded as exogenous. The question, however, is what it means by exogenous money supply. It does not mean that the money
supply has been consciously determined by the authorities in the same way that they were assumed to set interest rates in earlier years: we take the view that neither interest rates nor the money supply have been controlled in this rigid way in recent years. Rather we mean that the money supply has been partly controlled by the authorities and partly by other factors which are beyond the control of the monetary authorities. And that this kind of theorising is more applicable for the period 1966 to today. However, data limitations force us to assume that the 1960's provide sufficient experience of a money supply function of the type described above, when combined with the latter sample; if, in fact, a complete structural change of regime has occurred it is apparent that we shall have to wait for more time to elapse before efficient estimates can be obtained.

Following Goodhart (59) and also our earlier analysis on the disadvantages of the mechanical relationship

\[ M^S = mB \]

we, furthermore, assume that B, i.e. monetary base, is not completely exogenous but is determined in the following fashion:

\[ B_t = b_0 + b_1 Y_t + b_2 (SP)_t + b_3 (BR)_t + b_4 B_{t-1} + u_t \]

where \((SP)_t\) is the open market operation instrument, \((BR)_t\) is the borrowing requirement of the government, and \(Y_t\) is income. Since it is the case that open market operations and changes in \((BR)_t\) affect the monetary base of the system and the latter the money supply, we introduce these variables in the \(B\)-equation. Base money, however, can also be affected by changes in the level of income; as the latter increases people would be reducing their holdings of base money in order to hold other assets, in particular earning assets due to the higher interest rates, and some of these assets are bound to be government securities. More importantly, perhaps, is the following consideration: some proportion of the increase in the level of income is likely to leak from the circular flow of income due to higher imports and the resulting deficit - or decrease in the surplus - in the balance of payments, implies some
loss of reserves which would be contractionary as far as the base money is concerned. Thus, we would expect $b_1$ to be less than zero, but both $b_2$ and $b_3$ greater than zero. Finally, the $M_{t-1}$ variable is justified in exactly the same way as in the case of the inclusion of $M_{t-1}$ in the money supply function.

3.2 The Real Sector:

We begin with the standard income identity:

$$(1) \ Y_t = C_t + I_t + S_t + (TA)_t - Q_t$$

with

$$(TA)_t = G_t + X_t - T_{st},$$

where $Y_t = $ current national product (at factor cost), $C_t =$ Consumption expenditure, $I_t =$ Investment expenditure, $S_t =$ Stockbuilding expenditure, $Q_t =$ imports, $X_t =$ Exports, $G_t =$ Government expenditure, and $T_{st} =$ adjustment to factor costs which represents taxes on expenditure less subsidies at constant rates.

Following Friedman and others (50, 53, 85, 128) we postulate the following consumption function:

$$(2a) \ C_t = a_0 + a_1 Y_{td} + a_2 M_{t} + a_3 r_{Lt}$$

where $M_t =$ money stock depicting the influence of liquid assets on $C_t$, $r_{Lt} =$ Long-term rate of interest, and $Y_{td}$ is permanent disposable income which is estimated from the adaptive forecasting equation

$$(2b) \ Y_{td} = b Y_{td} + b^2 Y_{td-1} + \ldots + b^n Y_{td-n-1} + \ldots$$

with $0 < b < 1$.

Next, substitute (2b) into (2a), lag one period, apply Koyck's transformation, add a disturbance term to get (2):

$$(2) \ C_t = c_0 + c_1 Y_{td} + c_2 C_{t-1} + c_3 M_{t-1} + c_4 r_{Lt} + c_5 r_{Lt-1} + c_6 r_{Lt-1} + u_{1t}$$

where $c_0 = a_0 (1-b)$, $c_1 = ab$, $c_2 = b$, $c_3 = a_2$, $c_4 = -ba_2$, $c_5 = a_3$, $c_6 = -ba_2$.

We also postulate the following simply empirical relationship between disposable income and national product:
\[ Y_t^d = a_1 Y_t + a_2 Y_{t-1} + u_{2t} \]

The theoretical rationale of the inclusion of permanent income and the empirical validity of such a hypothesis have been fully explored by N. Friedman (50). The inclusion of liquid assets is justified on empirical grounds (45 and 128 for two recent examples), and on the following theoretical grounds. It could be argued that people have a desired level of liquid assets, and to the extent that actual liquid assets exceed their desired level, there is a savings-consumption readjustment in favour of consumption. It follows that a higher observed level of money stock is associated with a higher level of consumption. A second way of reasoning, that complements the first, is to regard the money supply as a component of total wealth; a change, then, in the money stock, ceteris paribus, would involve a change in aggregate wealth which causes a change in desired consumption through the wealth effect.* A third approach is to treat the money stock as a proxy for the unobservable implicit rate of discount applied to stocks of consumer durables. An increase, say, in the money stock therefore serves to decrease the discount rate and induce an increase in consumption, primarily through increased purchases of consumer durables. We do, however, recognise explicitly the impact of interest rates on consumption. Since the publication of Keynes' General Theory, it has generally been assumed that consumption is insensitive to interest rates. Consequently, the only monetary variable that has been included in the consumption function with any regularity has been liquid assets. The view taken here is that monetary variables have a significant effect on consumer purchases of durable goods and that the most appropriate measures of these variables are interest rates (see for example 66, 126, 128). Empirical verification of this view would cast considerable doubt on the

* It is argued by many economists, especially Patinkin (105) that only "outside money" should be included in net wealth. Others have argued that "inside money" should also be included (106).
the widely accepted notion that consumers do not respond to changes in interest rates, and would also provide an alternative to both the Keynesian and the Chicago views concerning the channels through which monetary policy operates. Contrary to the Keynesian income-expenditure approach, they would imply that monetary policy has a more direct effect on consumer behaviour. This more direct link is recognized in the alternative approach expounded by Friedman and Neisalman (53), but they argue that it is neither very useful nor illuminating to view the effects of monetary policy as operating through interest rates.

Next, we postulate the following Investment function:

$$(4) I_t = i_0 + i_1 (\Delta Y)_t + i_2 (\Delta A_I)_t + i_3 r_L t + i_4 I_{t-1} + U_{3t}$$

where $(\Delta Y)_t = Y_t - Y_{t-1}$, $(\Delta A_I)_t = A_{It} - A_{It-1}$ = changes in advances to industry, and the other variables have their usual meaning.

Equation (4) is derived by specifying desired investment, $I^*_t$, as:

$$(4a) I^*_t = \gamma_0 + \gamma_1 (\Delta Y)_t + \gamma_2 (\Delta A_I)_t + \gamma_3 r_L t$$

with actual investment adjusting to the desired rate according to

$$(4b) (I_t - I_{t-1}) = g(I^*_t - I_{t-1}) \text{ with } 0 \leq g \leq 1$$

where $g$ is the proportion of adjustment achieved during one period. Substituting (4a) into (4b) and rearranging we arrive at equation 4, where $i_j = g \cdot \gamma_j$, with $j = 0, 1, 2, 3$, and $i_4 = (1-g)$.

Equation (4a) is justified as follows: One component of desired investment is strongly influenced by changes in the level of income; we, thus, postulate the standard accelerator hypothesis. The justification of the inclusion of the rate of interest is well known as it is its poor empirical performance—chiefly the Radcliffe Report's virtual dismissal of the interest sensitivity of investment demand. Recently, however, De Leeuw and Gramlich (56) have shown—using U.S.A. data—that there is a significant, but considerably lagged,
The adjustment, now, of the actual level of \( I_t \) towards the desired level, \( I_d \), is not an instantaneous process, but it is assumed, during a given period, only a fraction \( g \) of the difference between the desired level \( I_d \) and the initial level \( I_{t-1} \) is made up. Hence, the equation becomes:

\[
I_t = I_{t-1} + g \cdot (I_d - I_{t-1})
\]

At this point, the estimate of \( g \) becomes very important. If \( g < 1 \), it is significantly positive, indicating that the adjustment to the desired rate of investment is achieved in more than one period. If \( g = 1 \), it suggests that the adjustment is accomplished in the current period. If \( g > 1 \), it indicates that more than the desired rate is achieved.

The adjustment is not instantaneous; during a given period, only a fraction \( g \) of the difference between the desired level and the initial level is made up. The adjustment process is not an instantaneous one, but it is assumed that during the period under examination there have been all sorts of direct restrictions on the level of advances as a result of the policies pursued by the authorities. In this environment, it is more suitable to use changes in the level rather than absolute level.

We may note, at this point, that statistically the estimate of \( g \) becomes very important. If \( g < 1 \), this suggests that \( g > 0 \) and that at least part of the adjustment to the desired rate of investment is achieved in more than one period. If \( g = 1 \), it is significantly positive, indicating that the adjustment is accomplished in more than one period. If \( g > 1 \), it suggests that the adjustment is not instantaneous, but that during the period under examination there have been all sorts of direct restrictions on the level of advances as a result of the policies pursued by the authorities. In this environment, it is more suitable to use changes in the level rather than absolute level.

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\[
I_t = I_{t-1} + g \cdot (I_d - I_{t-1})
\]

At this point, the estimate of \( g \) becomes very important. If \( g < 1 \), it is significantly positive, indicating that the adjustment to the desired rate of investment is achieved in more than one period. If \( g = 1 \), it suggests that the adjustment is accomplished in the current period. If \( g > 1 \), it indicates that more than the desired rate is achieved.

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The Stockbuilding-function is postulated in the same way as the Investment-function with one difference. Instead of having the variable \((\Delta I_t)\), we introduce instead the variable \((\Delta M_t) = M_t - M_{t-1}\). We thus have:

\[
S_t = s_0 + s_1(\Delta Y) + s_2(\Delta M_t) + s_3\Delta R_{Lt} + s_4S_{t-1} + u_{Lt}
\]

The reason of having \((\Delta M_t)\) instead of \((\Delta I_t)\) in this equation is that changes in advances will probably be directly used for investment and not for stockbuilding since the latter is, we believe, more influenced by the liquidity of the industrial sector. The more liquid this sector is the more stocks are built up in anticipation of increases in demand. We use the \((\Delta M_t)\) variable as an indicator of the liquidity of the industrial sector, although we recognize the weakness of this assumption; in the absence of a better indicator we are effectively forced to use \((\Delta M_t)\).

Government expenditure \((G_t)\), now, is assumed to be exogenous. This may not be a satisfactory assumption within the context of a longer-run model, but for a quarterly model such as the present one, such an assumption is reasonable. Within the context of a longer-run model in which, say, annual data are used there is some reason to believe that government expenditure is partially determined within the macrosystem. That is, the annual observations on government expenditure may contain a component induced by the levels (or changes in the levels) of endogenous variables such as gross national product or consumption. This may be so because government expenditure can within the course of one year be influenced by the pace of economic activity. By contrast, the recognition and implementation lags between the time of a change in economic activity and an induced change in government spending are normally much greater than three months; thus in a quarterly model it is quite reasonable to specify government expenditure as an exogenous variable.

Exports are also assumed to be an exogenous variable to the domestic economy. The level of exports in the short-run is determined chiefly by politically negotiated trade.
agreements and the rate of economic activity abroad. There are also other reasons for treating exports as exogenous. Exports account on the whole for only a small proportion of gross national product. In a short-run investigation such as the present one, relative prices - which could be affected by domestic economic activity - are less important than in a longer-run study.

Imports, on the other hand, are endogenous. As shown in equation 6, they are made a function of the level of gross national product, some price level, and the quantity of money:

\[ Q_t^d = c_0 + c_1 Y_t + c_2 P_t + c_3 M_t \]

where \( P_t \) = price level.

Apart from the usual theoretical justification of the above equation, the empirical evidence (see 97 for one example) seems to suggest that an equation of this type tends to give satisfactory results.

Furthermore, as actual imports may adjust to demand with a lag, an adjustment is specified to the effect that imports change in period \( t \) according to the difference between demand for imports in period \( t \) and the actual value of imports in period \( t-1 \):

\[ (\Delta Q)_t = v(Q_t^d - Q_{t-1}) \]

where \( (\Delta Q)_t = Q_t - Q_{t-1} \), and \( v \) is the adjustment coefficient lying between zero and unity. As \( v \) approaches unity, the adjustment of actual imports to demand is almost instantaneous - in this case within a quarter -; as \( v \) approaches zero, actual imports are never equal to demand and there is always unsatisfied demand in the market. Within these extremes, the adjustment is asymptotic. The specification of this type of adjustment function introduces an explicit distributed lag into the import relationship. Substituting equation (6)' in equation (6)'' and solving for the value of imports, the equation to be estimated is derived:

\[ Q_t = q_0 + q_1 Y_t + q_2 P_t + q_3 M_t + q_4 Q_{t-1} + U_{5t} \]
with \( q_0 = v_0, \ q_1 = v_1, \ q_2 = v_2, \ q_3 = v_3, \ q_4 = 1-v \).

3.3 Summary:

In the following twelve equations we summarise the model developed in this chapter:

1. \( Y_t = C_t + I_t + S_t + (T_A)_t - Q_t \)
2. \( (T_A)_t = G_t + X_t - T_{st} \)
3. \( C_t = c_0 + c_1 Y^d_t + c_2 C_{t-1} + c_3 N_t + c_4 N_{t-1} + c_5 R_{Lt} + c_6 R_{Lt-1} + U_{1t} \)
4. \( Y^d_t = a_1 Y^d_{t-1} + a_2 Y_t + U_{2t} \)
5. \( I_t = i_0 + i_1 (\Delta Y)_t + i_2 (\Delta A)_t + i_3 R_{Lt} + i_4 I_{t-1} + U_{3t} \)
6. \( S_t = s_0 + s_1 (\Delta Y)_t + s_2 (\Delta N)_t + s_3 R_{Lt} + s_4 S_{t-1} + U_{4t} \)
7. \( Q_t = q_0 + q_1 Y_t + q_2 P_t + q_3 N_t + q_4 Q_{t-1} + U_{5t} \)
8. \( R_{Lt} = \rho_0 + \rho_1 R_{st} + \rho_2 Y_t + \rho_3 R_{Lt-1} + U_{6t} \)
9. \( M^d_t = m_0 + m_1 Y_t + m_2 R_{st} + m_3 M^d_{t-1} + U_{7t} \)
10. \( M^s_t = m_0 + m_1 Y_t + m_2 R_{st} + m_3 M^s_{t-1} + U_{8t} \)
11. \( M_{t-1} = M_{t-1} \)
12. \( D_t = b_0 + b_1 Y_t + b_2 (SP)_t + b_3 (BR)_t + b_4 D_{t-1} + U_{9t} \)

The endogenous variables are: \( Y_t, Y^d_t, C_t, I_t, S_t, Q_t, R_{Lt}, M^d_t, M^s_t, N_t, D_t, R_{st} \).

The predetermined variables are: \( C_{t-1}, N_{t-1}, R_{Lt-1}, Y^d_{t-1}, Y_{t-1}, A_{t-1}, I_{t-1}, S_{t-1}, Q_{t-1}, M^d_{t-1}, M^s_{t-1}, D_{t-1}, G_t, A_t, X_t, T_{st}, P_t, (SP)_t, (BR)_t \), the last seven being exogenous.

3.4 Dynamic Aspects of the Model:

Given the above model we would like to use it in order to find out the influence on gross national product of the individual policy instruments. This influence, however, cannot be established before we derive dynamic multipliers,
and this section deals with this problem.

To begin with we solve the structural equations to obtain the reduced form for gross national product. The coefficients of this equation are termed impact multipliers. Each of them measures the immediate - that is, first quarter - impact on gross national product of a change in the corresponding predetermined variable with all other predetermined variables held constant. The reduced form of the model can be written, in a general way, as follows:

\[ Y_t = a_0 + a_1N_1 + a_2N_2 + a_3N_3 + \ldots + b_1E_1 + \\
+ b_2E_2 + b_3E_3 + \ldots + c(SP)_t + d(r_s)_t \]

where \( N_i \) (with \( i = 1, 2, 3, \ldots n \)) stands for all the endogenous predetermined variables, and \( E_i \) (with \( i = 1, 2, 3, \ldots n \)) for all the exogenous predetermined variables, except of course \( (SP)_t \) and \( (r_s)_t \).*

The reduced-form solution presents a clear picture of the immediate responses of G.N.P. to changes in the predetermined variables and enables us to estimate the effects of the exogenous variables given the immediate past history of all endogenous variables. An econometrician who is only interested in forecasting does not have to go any further since his concern is with the future. For an analysis of the past, however, the impact multipliers alone are not very illuminating. If our knowledge were confined to the reduced-form equations, we would undoubtedly find that the main influence on the current values of G.N.P. is its own immediate history, and the question of estimating the relative importance of cumulative monetary, and other exogenous variables would remain unresolved. The relevant solution for this problem is obviously one which would determine the time path

---

* If, of course, \( r_{st} \) is made exogenous. In section 3.3 this rate seems to be endogenous. Our evidence (see Ch. 4 below) clearly shows that \( r_{st} \) is not statistically important in the \( N_t^S \)-equation and the use of Treasury Bill for \( r_{st} \) in the \( r_{Lt} \)-equation enables us to treat \( r_{st} \) as exogenous. See however section 5.3 below.
of G.N.P. in response to exogenous forces alone. In other
words: gross national product depends not only upon the
exogenous variables, but also upon the several lagged
endogenous variables of the model. The latter are themselves
affected by the exogenous variables of the model and there-
fore, since structural lags are important in this model, we
cannot isolate the net effect of an individual policy
instrument by reference to its reduced form coefficients.
So what we need, in fact, is the final solution of the gross
national product; that is to say we must provide a solution
for the gross national product in terms of past values of
itself and exogenous variables (excluding other endogenous
variables). It follows, therefore, that to determine the
net influence of the policy instruments, all other lagged
endogenous must be eliminated from the reduced form. This is
achieved by expressing the lagged endogenous variables in
terms of exogenous variables and substituting in the reduced
form. The resulting equation is called 'the fundamental
dynamic equation'.

Let us assume, for simplicity, that the fundamental
dynamic equation for gross national product is:

\[ y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \beta_3 y_{t-3} + \ldots + \]
\[ + \delta_1 (SP)_t + \delta_2 (SP')_{t-1} + \delta_3 (SP')_{t-2} + \ldots + \]
\[ + \delta_1 (r_s)_t + \delta_2 (r_s)_{t-1} + \delta_3 (r_s)_{t-2} + \ldots + \]
\[ + \text{other exogenous variables.} \]

Equation (2) can be put to two important uses:

Firstly, it can be used to determine the characteristic
stability of the system. In other words, since equation (2)
is a non-homogenous difference equation, its solution can
be used to determine whether the system is dynamically
stable or not.

Secondly, it can be used to solve for the dynamic
multipliers. This can be done by using equation (2) to
express gross national product in terms of initial conditions,
which are of course given, and the current values of the exogenous variables. The time period can then be increased by one unit and gross national product in that period is expressed in terms of initial conditions and the current and lagged values of the exogenous variables. By making successive unit increases in the time period a series of dynamic multipliers can be derived.

Thus the dynamic multipliers of the money supply - strictly, the open market operation instrument is used in this case which affects the money supply via the monetary base - and the rate of interest can be computed and therefore compared. It is on the results of this analysis that our conclusions, as far as the optimal monetary policy in the U.K. is concerned, will be derived. It is a prerequisite, though, that we should investigate the model empirically which will enable us to derive estimates for the \( p \)'s, \( y \)'s, and \( e \)'s in equation (2), and this is what the next chapter is all about.
CHAPTER 4
EMPIRICAL EVIDENCE

4.1 Introduction:

The above theoretical model has been tested for the period 1963 (2nd Quarter) - 1974 (3rd Quarter). The choice of this particular period has been constrained by the non-availability of data on the money stock before 1963 (1st Quarter).*

The procedure we have adopted in deciding the final form of the model can be now summarised.

Let the structural equation (SF) be:

\[ Y = X \beta + U \]

where \( Y \) is a \( T \times 1 \) vector of observations on the dependent variable, \( X \) is a \( T \times K \) matrix of observations on the regressors, \( \beta \) is a \( K \times 1 \) vector of parameters, and \( U \) is a \( T \times 1 \) vector of errors.

There are three types of regressors that can appear in the structural equation:

(a) Current endogenous variables,

(b) Lagged values of the current endogenous variables, and

(c) Current and lagged values of exogenous variables.

Ordinary Least Squares (OLS) can be used if current endogenous variables are not included in (1); otherwise a more appropriate method has to be used, e.g. Two Stage Least Squares (TSLS), which is, in fact, the method we have adopted when current endogenous variables appear in (1). Furthermore, if \( U \) is autocorrelated both OLS and TSLS cease to be

* The period starts from 1963 (2nd Quarter) because one period is missed by the computer program we have used, due to the appearance of lagged variables especially in the Unrestricted Transformed Equation (See below).
optimal, and consequently we have to allow for the possibility of, say:

\[(2) \quad U_t = \rho U_{t-1} + \varepsilon_t\]

where \(\varepsilon_t\) is a random (i.e. serially independent) error, and \(\rho\) is the autoregressive parameter.

The sub-model of (1) plus (2) is referred to below as the Restricted Transformed Equation (R.T.F.). This concept can be clarified by considering the special case of (1) defined by (3) when \(K = 3\).

\[(3) \quad Y_t = b_0 + b_1X_t + b_2Y_{t-1} + U_t\]

Lagging now equation (3) by one period we have:

\[(4) \quad Y_{t-1} = b_0 + b_1X_{t-1} + b_2Y_{t-2} + U_{t-1}\]

Next, we multiply (4) by \(\rho\) and subtract it from (5):

\[(5) \quad Y_t - \rho Y_{t-1} = b_0(1-\rho) + b_1X_t - \rho b_1X_{t-1} +
+ b_2Y_{t-1} - \rho b_2Y_{t-2} + U_t - \rho U_{t-1}\]

or, using (2) and rearranging:

\[(6) \quad Y_t = b_0(1-\rho) + b_1X_t - \rho b_1X_{t-1} + \rho(1+b_2)Y_{t-1} - \rho b_2Y_{t-2}
+ \varepsilon_t\]

The error term \(\varepsilon_t\) is now a purely random variable but we still cannot estimate (6) directly by least squares since it involves five variables (constant, \(X_t\), \(X_{t-1}\), \(Y_{t-1}\), \(Y_{t-2}\)) but only four parameters \((b_0, b_1, b_2, \rho)\). There is, therefore, a non-linear restriction between the parameters and hence (6) is referred to as the R.T.F. One, however, might prefer to ignore the restriction by treating (6) as a legitimate relationship, in which case we have:

\[(7) \quad Y_t = c_0 + c_1X_t + c_2X_{t-1} + c_3Y_{t-1} + c_4Y_{t-2} + \varepsilon_t\]

This relationship is denoted as the Unrestricted Transformed Equation (U.R.T.F.); these last two formulations (6 and 7),
now, permit one to test the validity of the restriction in the R.T.F., which is, in effect, a test of the correctness of the dynamic specification in (1). The particular way one can test the validity of the dynamic specification in (1) is fully described by Sargan. A $^2$-test is employed with the hypothesis that specifications U.R.T.F. and R.T.F. are equally valid and therefore there is little to choose between them. If, then, this hypothesis is rejected at some conventional level of significance (say 5%), then the autoregressive hypothesis is rejected in favour of the unrestricted equation 7. This can often be interpreted to mean that a more complicated structure of lags, or a larger lag is required in the structural equation on at least one of the variables.

The way, now, one can modify the structural equation can be indicated by the coefficients of the unrestricted equation. If one of the lagged variables in the unrestricted equation has a much larger coefficient, proportionally, than the other lagged variables, it seems reasonable to introduce the lagged value of this variable into the structural equation, and to estimate the new form of the structural equation, assuming as before a first order autoregressive equation for the error. This process of modifying the form of the structural equation can continue until the criterion ceases to be significant. It may be that at some stage in the process the autoregressive coefficient may not be significantly different from zero indicating that its significance in the original form of the structural equation was due to the variables in the equation having the wrong lags.

The computer program we have used (called GIVE**) allows one to choose which of (1) and/or (1) plus (2) i.e. 6 and/or 7, one prefers, including all three. We may note at this...


stage that (1) and (7) can be estimated directly whereas (6) requires an iterative technique to resolve the non-linear restriction referred to above. The procedure used in GIVE is to estimate the parameters of (6) by minimising the sum of squared residuals. First this sum is calculated for a grid of values of \( p \) from -0.9 to +0.9 in steps of 0.1. This provides for a rough check for multiple minima and helps to make sure that the iteration commences close to the global minimum.

This is the procedure we have adopted in order to tackle the problem of autocorrelation, and of course this procedure enables us to decide the lag structure of the model too, as well as the final form of the model. Another problem, not tackled by 'GIVE', is that of multicollinearity. Multicollinearity exists when the explanatory variables are linearly correlated among them. If the explanatory variables are perfectly linearly correlated if, in other words, the correlation coefficients for these variables is equal to unity, the parameters become indeterminate. It is impossible, in this case, to obtain numerical values for each parameter separately and the method of least squares breaks down. If on the other hand the explanatory variables are not correlated at all in which case the correlation coefficients are equal to zero, then the covariances are equal to zero, i.e. the variables are orthogonal, and there are no problems concerning the estimation of the coefficients, at least as far as multicollinearity is concerned. In this case, of course, we do not even need to perform a multiple regression analysis since each coefficient can be estimated by a simple regression of the dependent on the corresponding independent.

In practice neither of the above extreme cases is often met. The usual case is that the simple correlation coefficient for each pair of explanatory variables to have a value between zero and unity due to the interdependence of many economic magnitudes over time. This interdependence,

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then, can be quite serious because the multicollinearity problem may impair the accuracy and stability of the estimated parameters, but the exact effects of collinearity have not as yet been theoretically established; no conclusive evidence exists concerning the degree of collinearity which, if present, will affect seriously the parameter estimates.* Whenever the appearance of multicollinearity affects seriously our results we leave out the responsible variable, if it is judged not to be an important one. On the whole, our approach to detecting the problem of multicollinearity has followed Klein's suggestion that multicollinearity is not necessarily a problem unless it is high relative to the overall degree of multiple correlation among all variables simultaneously.** In other words Klein argues that if:

$$r^2_{x_i x_j} < R^2_{y \cdot x_1 \cdot x_2 \cdot \ldots \cdot x_k}$$

multicollinearity is not harmful; we may note that $r^2_{x_i x_j}$ is the simple correlation coefficient between any two variables $X_i$ and $X_j$, and $R^2$ is the multiple correlation coefficient of the relationship. We note, also, that the use of TSLS makes multicollinearity much less of a problem since this technique is not as sensitive to the multicollinearity problem as other single-equation methods of estimation.*** However, it is the case that "multicollinearity is not a condition that either exists or does not exist in economic functions, but rather a phenomenon inherent in most relationships due to the nature of economic magnitudes"; but "it does not impair the theoretical validity of the model; it is a 'decrease' of the sample data and not of the construction of the model".****

** See Klein, L. R. Introduction to Econometrics p.64 & p.101.
****See Koutsoyiannis, op. cit., p.225 and p.245.
We now turn to the discussion of the empirical evidence; before we do so, however, there are some points worth commenting on. As we have already mentioned the period we cover is 1963 (2nd quarter) - 1974 (3rd Quarter); the period presents a problem as far as the estimation of the model is concerned, because of the 'Competition and Credit Control' new measures introduced in 1971. The reason is that these new measures of monetary control might have introduced structural changes in the system. This problem we hope to tackle by splitting the whole 1963-1974 period into 1963 (2nd Quarter) - 1971 (4th Quarter) and predict the values of the endogenous variables for the period 1971 (4th Quarter) - 1974 (3rd Quarter). We discuss this problem in more detail after we have discussed the estimation of the model for the whole 1963-1974 period.

The stability of the structural parameters is examined in every equation by allowing one quarter outside the estimation period (i.e. 1974 3rd Quarter) and predicting the values of the endogenous variables for 1974 3rd Quarter; we use the $\chi^2$-statistic in order to test the stability of the structural parameters for prediction. It can be argued that one should allow for more than one quarter for such a test; since, though, it is more desirable to have as many observations as possible, given the large number of predetermined variables in the model, we feel that we are justified in allowing only one quarter for judging the stability of the structural parameters.

One more point before we turn to the empirical results: the data we use are all in constant 1963-prices, seasonally adjusted. We, therefore, introduce in the following equations a price variable so that real and nominal changes can be distinguished.

The way we present the empirical results is as follows: both the OLS and TSLS estimates are given, with the OLS first. The reason for providing the OLS estimates is to determine the lag structure - the TSLS estimates provided by GIVE do not provide enough information to tackle this problem - of each
equation. It is to be noted that if one equation does not include in its explanatory variables an endogenous variable we are forced to use OLS only for that particular equation.

4.2 Empirical Results

4.2a Consumption Function ($C_t$):

The final form this function took was:

$$C_t = c_0 + c_1 Y^d_t + c_2 (\Delta MIP)_t + c_3 P_t + c_4 P_{t-1} + c_5 r_{Lt-3} + \ldots + c_6 r_{Lt-4} + c_7 C_{t-1}$$

where $(\Delta MIP)_t$ = changes in MIP-debt, $P_t$ = an index of prices, and we use the retail price index; all the other variables have their usual meaning.

This form of the Consumption Function differs from the one we proposed earlier, and the reasons behind this difference are fully explored below.

The Correlation Matrix is as follows:

**CORRELATION MATRIX**

<table>
<thead>
<tr>
<th></th>
<th>$C_t$</th>
<th>$Y^d_t$</th>
<th>$\Delta MIP)_t$</th>
<th>$P_t$</th>
<th>$C_{t-1}$</th>
<th>$r_{Lt-3}$</th>
<th>$r_{Lt-4}$</th>
<th>$P_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_t$</td>
<td>1.0000</td>
<td>0.9915</td>
<td>0.4894</td>
<td>0.9715</td>
<td>0.9856</td>
<td>0.8866</td>
<td>0.8861</td>
<td>0.9779</td>
</tr>
<tr>
<td>$Y^d_t$</td>
<td>0.9913</td>
<td>1.0000</td>
<td>0.4797</td>
<td>0.9680</td>
<td>0.9851</td>
<td>0.8803</td>
<td>0.8820</td>
<td>0.9747</td>
</tr>
<tr>
<td>$(\Delta MIP)_t$</td>
<td>0.4894</td>
<td>0.4797</td>
<td>1.0000</td>
<td>0.3643</td>
<td>0.4134</td>
<td>0.2931</td>
<td>0.3385</td>
<td>0.3869</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.9715</td>
<td>0.9688</td>
<td>0.5643</td>
<td>1.0000</td>
<td>0.9762</td>
<td>0.9397</td>
<td>0.9291</td>
<td>0.9989</td>
</tr>
<tr>
<td>$C_{t-1}$</td>
<td>0.9856</td>
<td>0.9851</td>
<td>0.4134</td>
<td>0.9762</td>
<td>1.0000</td>
<td>0.8913</td>
<td>0.8790</td>
<td>0.9388</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>0.8866</td>
<td>0.8803</td>
<td>0.2931</td>
<td>0.9397</td>
<td>0.8913</td>
<td>1.0000</td>
<td>0.9804</td>
<td>0.9300</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>0.8861</td>
<td>0.8820</td>
<td>0.3538</td>
<td>0.9291</td>
<td>0.8790</td>
<td>0.9804</td>
<td>1.0000</td>
<td>0.9313</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>0.9779</td>
<td>0.9747</td>
<td>0.3869</td>
<td>0.9989</td>
<td>0.9791</td>
<td>0.9588</td>
<td>0.9313</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

126.
Now, the $R^2 = 0.9901$, and it follows that multicollinearity is not really a problem except in that the correlation coefficient between $P_t$ and $P_{t-1}$ is slightly higher than $R^2$ but not high enough to worry about it.

We turn now to the SF estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_t$</td>
<td>0.30068</td>
<td>0.10509</td>
<td>2.86114</td>
</tr>
<tr>
<td>$(\Delta \text{HP})_t$</td>
<td>0.47531</td>
<td>0.22384</td>
<td>2.12544</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-17.41523</td>
<td>8.79664</td>
<td>1.97976</td>
</tr>
<tr>
<td>$C_{t-1}$</td>
<td>0.29174</td>
<td>0.12217</td>
<td>2.38792</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-10.03714</td>
<td>32.21950</td>
<td>0.31153</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-6.07717</td>
<td>32.37553</td>
<td>0.18771</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>26.02863</td>
<td>10.57223</td>
<td>2.46197</td>
</tr>
<tr>
<td><em>CNST.</em></td>
<td>1198.39213</td>
<td>295.91622</td>
<td>4.04977</td>
</tr>
</tbody>
</table>

$R^2 = 0.99005$  
D.W. = 2.15122  
S = 55.645684

One Period Ahead Forecasts

- Actual: 6694
- Forecast: 6902.4195
- Forecast Error: -208.4195

$x^2(1) = 14.02858$

---

* CNST. = Constant
** D.W. = Durbin-Watson Statistic
*** S = Standard Error of Estimate
**** $x^2(v) = x^2$-test for post-sample parameter stability with (v) degrees of freedom; where v is number of observations retained for the post-sample parameter stability test.
Although the forecasting power of this equation does not seem to be inadequate, the significance of the $x^2$-test implies inadequate specification for prediction, though some degree of simultaneity seems to be desirable.

The U.R.T.P. estimates are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_d t$</td>
<td>0.25521</td>
<td>0.11805</td>
<td>2.16194</td>
</tr>
<tr>
<td>$(\Delta HP)_t$</td>
<td>0.77309</td>
<td>0.52831</td>
<td>2.35472</td>
</tr>
<tr>
<td>$p_t$</td>
<td>-15.70944</td>
<td>10.05644</td>
<td>1.56213</td>
</tr>
<tr>
<td>$c_{t-1}$</td>
<td>0.27793</td>
<td>0.17250</td>
<td>1.61115</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-29.18854</td>
<td>36.72089</td>
<td>0.79488</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>55.81523</td>
<td>52.66708</td>
<td>1.05977</td>
</tr>
<tr>
<td>$p_{t-1}$</td>
<td>18.31773</td>
<td>21.18014</td>
<td>0.86485</td>
</tr>
<tr>
<td>CNST.</td>
<td>1207.72153</td>
<td>378.08652</td>
<td>3.19450</td>
</tr>
<tr>
<td>$y_d t-1$</td>
<td>0.14696</td>
<td>0.11973</td>
<td>1.22737</td>
</tr>
<tr>
<td>$(\Delta HP)_{t-1}$</td>
<td>-0.44878</td>
<td>0.33791</td>
<td>1.32811</td>
</tr>
<tr>
<td>$c_{t-2}$</td>
<td>-0.10332</td>
<td>0.14898</td>
<td>0.69555</td>
</tr>
<tr>
<td>$r_{Lt-5}$</td>
<td>-55.92094</td>
<td>37.10519</td>
<td>1.45319</td>
</tr>
<tr>
<td>$p_{t-2}$</td>
<td>6.89823</td>
<td>14.88071</td>
<td>0.46357</td>
</tr>
</tbody>
</table>

$R^2 = 0.99157$,  \ D.W. = 2.10541,  \ S = 55.731907$

One Period Ahead 'Forecasts':

- Actual: 6694
- Forecast: 6899.3912
- Forecast Error: -205.3912

$r^2(1) = 15.58176$
$F(5,32) = 0.97712$. This is an $F(V_1, V_2)$-test on the significance of the extra parameters in the U.R.T.F. over the SF with $(V_1, V_2)$ degree of freedom where $V_1 = NV - NR$, and $V_2 = N - NL + 1 - 2(NV) + NR$; the N’s have the following meaning: $\text{NV} =$ number of variables involved in the equation, $\text{NR} =$ number of redundant variables, $\text{N} =$ number of observations, and $\text{NL} =$ number of lags set up by the computer. The F-test now being insignificant implies significant additional parameters.

The R.T.F. estimates arc, now, given:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_t^d$</td>
<td>0.29611</td>
<td>0.11550</td>
<td>2.56366</td>
</tr>
<tr>
<td>$(\Delta M)^t$</td>
<td>0.45875</td>
<td>0.21429</td>
<td>2.14080</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-17.02932</td>
<td>8.75816</td>
<td>1.94439</td>
</tr>
<tr>
<td>$C_{t-1}$</td>
<td>0.55165</td>
<td>0.16967</td>
<td>3.35464</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-4.92732</td>
<td>31.76499</td>
<td>0.15512</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-8.53169</td>
<td>32.42852</td>
<td>0.26309</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>24.78280</td>
<td>10.89502</td>
<td>2.27469</td>
</tr>
<tr>
<td>CONST.</td>
<td>1091.95751</td>
<td>350.87334</td>
<td>3.11211</td>
</tr>
<tr>
<td>$\hat{\rho}$</td>
<td>-0.10535</td>
<td>0.25105</td>
<td>0.45599</td>
</tr>
</tbody>
</table>

$S = 56.239559$

One Period Ahead 'Forecasts':

Actual: 6694
Forecast: 6885.0159
Forecast Error: -191.0159

$X^2(1) = 11.53608$

The comment about forecasting power and stability of the parameters we made for the other two structural forms is applicable to this form too. What is more important here is
the $\chi^2(2) (4) = 6.11600$. In particular, this is a $\chi^2 (v)$-test of the validity of the autoregressive restrictions in the R.T.F. equation, with $v = NV-NR-1$, and defined as twice the log of the ratio of the residual sum of squares of the U.R.T.F. to that of the R.T.F. Looking at its value in this equation we note that since it is insignificant it is implied that it is perfectly legitimate to use the R.T.F. form instead of the U.R.T.F. Furthermore, since the value of $\rho$ is statistically insignificant - i.e. there is no autocorrelation of the first order - we conclude that the SF form is preferrable to the other two.

The Consumption function we have chosen, following the above statistical procedure, differs from the one we suggested earlier, the one that is based on the theoretical considerations analysed in the last chapter. The notable difference is the absence of the $N_t$ variable. The reason for the exclusion of the $N_t$ variable is that it does not perform adequately at all at an empirical level; in all the equations we tried, the $N_t$ variable had always the wrong sign and it was dramatically insignificant. We tried current and lagged money stock, first differences too, and in all cases the result on this variable followed the same pattern: insignificant with wrong signs everywhere. We thus decided to exclude it from the Consumption function. Another notable difference is that we have introduced three new variables: $P_t$ and $P_{t-1}$ whose inclusion we have already explained, as well as $(\Delta M)^t$; the latter variable may be thought of as a proxy for the liquid assets instead of the $N_t$ variable. The $P_{t-1}$ variable is introduced to capture any price expectations that may prevail in the system, especially in the inflationary environment of the latter part of the period under investigation.

The statistical performance of this equation is very satisfactory. All the variables perform well: they are significant and all have the right sign. The exception is with the long-term interest rate. The T-Value for both $r_{Lt-5}$ and $r_{Lt-4}$ is very low, but one would probably not have
expected any better results for this variable. We have tried a short-term rate too - the treasury bill rate - but the results were not really any better. The reason for the poor performance of an interest rate variable in the Consumption function can be found in the peculiarities of the British monetary experience and the monetary policies the authorities have pursued during the estimation period. As it is obvious by now our estimation period covers the pre-1971 as well as the post-1971 periods. Now, before 1971 the interest rate was an administered rate, and if one were to accept that the 'leaning into the wind' policy was successful, then, it can be argued, interest rates had not varied enough and consequently one would not observe a significant relationship between the level of consumption and long-term interest rate. If this argument is correct, then one should expect that after 1971 this relationship should be more significant at a statistical level, due to the fact, of course, of the more volatile interest rates. The non-availability of enough data, though, makes it extremely difficult to get consistent and reliable estimates for this relationship, and consequently it becomes very difficult to see how such a proposition can be tested. We have, however, tried to test this proposition even with limited data in order to see whether we can spot any improvement in the relationship, and the results, undoubtedly very suspicious, are very encouraging. The period used is 1971 (4th Quarter) - 1974 (4th Quarter), and the following remarks are in order: the interest rate variable not only has the right sign but its T-Value improves dramatically and in some cases it even becomes greater than 2.

Another variable worth commenting on is the $P_{t-1}$ one which we have included in order to capture any price expectations. We should expect its sign to be positive: expectations of price increases, say, would induce people to increase their consumption expenditure in the current period but reduce their consumption expenditure in the current period if $P_t$ increased. These theoretical considerations are fully justified by our empirical findings on the Consumption function.
The TSLS technique gave us the following results: as before we present the SF estimates first.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t^d$</td>
<td>0.31509</td>
<td>0.12474</td>
<td>2.52591</td>
</tr>
<tr>
<td>$(\Delta IP)_t$</td>
<td>-0.46542</td>
<td>0.22859</td>
<td>2.03601</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-17.11387</td>
<td>8.91028</td>
<td>1.92069</td>
</tr>
<tr>
<td>$C_{t-1}$</td>
<td>0.28099</td>
<td>0.13208</td>
<td>2.12757</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-5.75540</td>
<td>32.77742</td>
<td>0.28708</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-5.92598</td>
<td>32.62455</td>
<td>0.21229</td>
</tr>
<tr>
<td>$F_{t-1}$</td>
<td>25.55210</td>
<td>10.80568</td>
<td>2.56469</td>
</tr>
<tr>
<td>CNST.</td>
<td>1188.51771</td>
<td>299.54796</td>
<td>3.96770</td>
</tr>
</tbody>
</table>

D.W. = 2.12804, S = 55.65982

One Period Ahead 'Forecasts'

Actual: 6694
Forecast: 6904.2649
Forecast Error: -210.2649

$x^2_{(1)} (1) = 14.27085$

The $x^2_{(1)}$-test is significant again which means that the stability - i.e. the post-sample one - of the parameters is questionable, when used for prediction.

$x^2_{(5)} (20) = 27.39351$

This last statistic is a $x^2(v)$-test which is designed to test the validity of identification/specification of the equation in question with $v$ degrees of freedom, where $v = NI - NV + 1$, for $NI =$ number of instruments used in the estimation of the equation. It is insignificant suggesting that the identification/specification of this equation is adequate.
The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Y_t^d)</td>
<td>0.27569</td>
<td>0.15901</td>
<td>1.90538</td>
</tr>
<tr>
<td>((\Delta \Pi)^t)</td>
<td>0.72904</td>
<td>0.32486</td>
<td>2.24414</td>
</tr>
<tr>
<td>(P_t)</td>
<td>-17.63520</td>
<td>9.24398</td>
<td>1.90753</td>
</tr>
<tr>
<td>(C_{t-1})</td>
<td>0.29934</td>
<td>0.17268</td>
<td>1.75346</td>
</tr>
<tr>
<td>(r_{Lt-3})</td>
<td>-50.30919</td>
<td>37.99424</td>
<td>0.79773</td>
</tr>
<tr>
<td>(r_{Lt-4})</td>
<td>57.58155</td>
<td>53.62532</td>
<td>1.07266</td>
</tr>
<tr>
<td>(P_{t-1})</td>
<td>26.49763</td>
<td>11.65371</td>
<td>2.23757</td>
</tr>
<tr>
<td>CNST.</td>
<td>1174.09905</td>
<td>405.07306</td>
<td>2.89049</td>
</tr>
<tr>
<td>(Y_t^d)</td>
<td>0.14531</td>
<td>0.12052</td>
<td>1.20770</td>
</tr>
<tr>
<td>((\Delta \Pi)^t_{-1})</td>
<td>-0.45722</td>
<td>0.34159</td>
<td>1.27995</td>
</tr>
<tr>
<td>(C_{t-2})</td>
<td>-0.12584</td>
<td>0.14299</td>
<td>0.88705</td>
</tr>
<tr>
<td>(r_{Lt-5})</td>
<td>-54.00901</td>
<td>57.39613</td>
<td>1.44424</td>
</tr>
<tr>
<td>(P_{t-2})</td>
<td>-0.00752</td>
<td>0.02475</td>
<td>0.01204</td>
</tr>
</tbody>
</table>

D.V. = 2.08073, S = 55.91947

One Period Ahead 'Forecasts'

<table>
<thead>
<tr>
<th>Actual</th>
<th>Forecast</th>
<th>Forecast Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>6694</td>
<td>6955.5058</td>
<td>-241.5058</td>
</tr>
</tbody>
</table>

\(x^2(1) = 16.65216\)

\(x^2(15) = 24.91765\)
The R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_t^d$</td>
<td>0.31137</td>
<td>0.12356</td>
<td>2.42587</td>
</tr>
<tr>
<td>$(\Delta y_t)^d$</td>
<td>0.47007</td>
<td>0.23250</td>
<td>2.02177</td>
</tr>
<tr>
<td>$p_t$</td>
<td>-17.12476</td>
<td>9.02885</td>
<td>1.89667</td>
</tr>
<tr>
<td>$c_{t-1}$</td>
<td>0.27856</td>
<td>0.13402</td>
<td>2.07055</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-9.89893</td>
<td>35.73882</td>
<td>0.29540</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-6.05776</td>
<td>35.58412</td>
<td>0.18146</td>
</tr>
<tr>
<td>$p_{t-1}$</td>
<td>25.70365</td>
<td>11.00196</td>
<td>2.33628</td>
</tr>
<tr>
<td>CNST.</td>
<td>1209.57099</td>
<td>319.04597</td>
<td>3.79124</td>
</tr>
<tr>
<td></td>
<td>-0.00511</td>
<td>0.02412</td>
<td>0.21168</td>
</tr>
</tbody>
</table>

$S = 56.58550$

One Period Ahead 'Forecasts'

| Actual: | 6694 |
| Forecast: | 6905.4071 |
| Forecast Error: | -211.4071 |

$\chi^2 (1) = 14.05758$

$\chi^2 (3) = 27.34797$

We note that in all three forms the $\chi^2 (1)$-test is significant whereas the $\chi^2 (3)$-test is insignificant, therefore, the comments made earlier in connection with those two tests apply in this case too.

On the whole the TSLS estimates appear to be slightly poorer than the OLS ones, a result that is always expected in this type of models due to the simultaneity bias affecting OLS.

The order of the autoregressive process used above is unity. We have, however, allowed for second, third and fourth order and the results are summarised in the following table.
The above results clearly indicate that they are not really very different from the ones we obtain when we assume that the order of the autoregressive process is equal to one. There is, however, one very striking difference in the $x^2_{(2)}$ $(v)$-statistic. In all cases where the order is greater than one the $x^2_{(2)}$ $(v)$-statistic is very significant, and also the T-value of $\rho$ is very insignificant. We are thus obliged to accept order one as the most satisfactory autoregressive process, and indeed the SF form. Our final Consumption function is, therefore, the following (T-Values in brackets):

$$C_t = 1188.51771 + 0.31509 Y^d_t + 0.46542 (\Delta Y^d_t) - 17.11387 P_t^t$$

$$+ 0.28099 C_{(2.12737)_t} - 8.75453 r_{Lt-3} - 6.92598 r_{Lt-4}$$

$$+ 25.55210 P_{(2.36469)_{t-1}}$$

This estimated Consumption function is the one that results from the application of the TSLS technique; this technique is obviously more appropriate in this case since it takes into consideration the simultaneity bias referred to above.

### 4.2b Disposable Income Function ($Y^d_t$)

The empirical function

$$Y^d_t = a_1 Y_t + a_2 Y^d_{t-1}$$

has been used for the disposable income variable, and gave us the following results. We begin by looking at the Correlation Matrix:

<table>
<thead>
<tr>
<th></th>
<th>$Y^d_t$</th>
<th>$Y_t$</th>
<th>$Y^d_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y^d_t$</td>
<td>1.0000</td>
<td>0.9507</td>
<td>0.9835</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>0.9507</td>
<td>1.0000</td>
<td>0.9463</td>
</tr>
<tr>
<td>$Y^d_{t-1}$</td>
<td>0.9835</td>
<td>0.9463</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
The $R^2 = 0.97064$ and it seems that some trouble might arise in this particular case as far as multicollinearity is concerned, since the correlation coefficient between $Y^d_t$ and $Y^d_{t-1}$ is greater than the $R^2$ as one might expect.

The SF estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.14700</td>
<td>0.06113</td>
<td>2.40486</td>
</tr>
<tr>
<td>$Y^d_{t-1}$</td>
<td>0.82371</td>
<td>0.07620</td>
<td>10.80105</td>
</tr>
</tbody>
</table>

$R^2 = 0.9764$, D.W. = 2.07032, $S = 107.65740$

One Period Ahead 'Forecasts'

Actual: 7703
Forecast: 7369.0376
Forecast Error: 333.9621
$x^2(1) = 9.62292$

We may note again the significance of the $x^2(1)$-statistic.

The U.R.T.F. estimates are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.22312</td>
<td>0.11489</td>
<td>1.94203</td>
</tr>
<tr>
<td>$Y^d_{t-1}$</td>
<td>0.79483</td>
<td>3.70509</td>
<td>0.21452</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>-0.10743</td>
<td>0.11755</td>
<td>0.91387</td>
</tr>
<tr>
<td>$Y^d_{t-2}$</td>
<td>0.07749</td>
<td>0.15515</td>
<td>0.49946</td>
</tr>
</tbody>
</table>

$R^2 = 0.97149$, D.W. = 1.95084, $S = 109.99827$

One Period Ahead 'Forecasts'

Actual: 7703
Forecast: 7384.8968
Forecast Error: 318.1032

$x^2(1) = 8.36504$

$F(3,40) = 39645$

It is worth noting the significance of the $x^2(1)$-statistic, and the insignificance of the $F$-statistic.
The R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.13151</td>
<td>0.06752</td>
<td>1.94786</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.84306</td>
<td>0.08426</td>
<td>10.00494</td>
</tr>
<tr>
<td>$\rho$</td>
<td>-0.06844</td>
<td>0.17724</td>
<td>0.38615</td>
</tr>
</tbody>
</table>

\[ S = 108.76075 \]

One Period Ahead 'Forecasts':

Actual: 7703
Forecast: 7375.1459
Forecast Error: 327.8541

\[ x^2_{(1)}(1) = 9.08692 \]
\[ x^2_{(2)}(2) = 1.17728 \]

These results suggest that the SF equation is preferable to the other two. The $x^2_{(2)}$-statistic is insignificant as well as the T-Value of the coefficient. The same conclusion is reached when TSLS is employed, as it can be seen from the estimates we cite below:

The SF Estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.14707</td>
<td>0.06115</td>
<td>2.40597</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.82362</td>
<td>0.07626</td>
<td>10.80011</td>
</tr>
</tbody>
</table>

D.W. = 2.07011, \[ S = 107.65745 \]

One Period Ahead 'Forecasts':

Actual: 7703
Forecast: 7369.0366
Forecast Error: 333.9634

\[ x^2_{(1)}(1) = 9.62298 \]
\[ x^2_{(2)}(2) = 37.99877 \]

The $x^2_{(1)}$-statistic continuous to be significant implying inadequate stability for prediction, whereas the $x^2_{(3)}$-statistic
is insignificant implying adequate identification/specification.

The U.R.T.F. estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.23460</td>
<td>0.11141</td>
<td>2.05541</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.07901</td>
<td>3.71430</td>
<td>0.02127</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>-0.11048</td>
<td>0.11969</td>
<td>0.92307</td>
</tr>
<tr>
<td>$Y_{d_{t-2}}$</td>
<td>-0.00071</td>
<td>0.02126</td>
<td>0.03356</td>
</tr>
</tbody>
</table>

D.W. = 2.13534, $S = 110.33917$

One Period Ahead 'Forecasts'

Actual: 7703
Forecast: 7375.9141
Forecast Error: 327.0859

$x^2_{(1)} (1) = 8.78718$

$x^2_{(5)} (21) = 37.83498$

Note the significance of the $x^2_{(3)}$-statistic, implying inadequate identification/specification.

The R.T.F. estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.14785</td>
<td>0.06221</td>
<td>2.37655</td>
</tr>
<tr>
<td>$Y_{d_{t-1}}$</td>
<td>0.82257</td>
<td>0.07765</td>
<td>10.59595</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.00580</td>
<td>0.02494</td>
<td>0.23250</td>
</tr>
</tbody>
</table>

$S = 108.86147$

One Period Ahead 'Forecasts'

Actual: 7703
Forecast: 7367.9969
Forecast Error: 335.0031

$x^2_{(1)} (1) = 9.46999$

$x^2_{(5)} (23) = 37.98849$

140.
We may note again the poor results as far as the \(x^2\) statistics are concerned, and also the insignificance of the autoregressive parameter implying that the SF form is preferable to the other two.

We proceed now to allow for higher order autoregressive process. The results appear in the following table (pp. 142-143).

Inspection of all the results we have cited for this function implies a final form that is written as follows:

\[
Y^d_t = 0.14707 Y_t + 0.82362 Y^d_{t-1} \\
(2.40597) \quad (10.80011)
\]

As in the case of the Consumption function, this final form for \(Y^d_t\) is the one that results from the application of the TSLS-technique.
<table>
<thead>
<tr>
<th>Order of Ammonia Process</th>
<th>060°</th>
<th>113°</th>
<th>166°</th>
<th>219°</th>
<th>272°</th>
<th>325°</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
<tr>
<td>1500°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
<tr>
<td>2000°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
<tr>
<td>2500°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
<tr>
<td>3000°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
<tr>
<td>3500°C</td>
<td>660°C</td>
<td>618°C</td>
<td>576°C</td>
<td>534°C</td>
<td>492°C</td>
<td>450°C</td>
</tr>
</tbody>
</table>

*Note: The table above represents the temperature distribution in a process at different orders.*
4.2c **Investment Function** ($I_t$):

The final form that this function took was:

$$I_t = i_0 + i_1(\Delta I)^t + i_2(\Delta Y)^t + i_3r_{Lt-3} + i_4r_{Lt-4} + i_5I_{t-1}$$

As before we begin by providing the Correlation Matrix:

<table>
<thead>
<tr>
<th></th>
<th>$I_t$</th>
<th>$(\Delta I)^t$</th>
<th>$(\Delta Y)^t$</th>
<th>$I_{t-1}$</th>
<th>$r_{Lt-3}$</th>
<th>$r_{Lt-4}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_t$</td>
<td>1.0000</td>
<td>0.3851</td>
<td>-0.0441</td>
<td>0.9552</td>
<td>0.8191</td>
<td>0.8150</td>
</tr>
<tr>
<td>$(\Delta I)^t$</td>
<td>0.3851</td>
<td>1.0000</td>
<td>-0.0469</td>
<td>0.3583</td>
<td>0.4665</td>
<td>0.4413</td>
</tr>
<tr>
<td>$(\Delta Y)^t$</td>
<td>-0.0441</td>
<td>-0.0469</td>
<td>1.0000</td>
<td>-0.1704</td>
<td>-0.0539</td>
<td>-0.0483</td>
</tr>
<tr>
<td>$I_{t-1}$</td>
<td>0.9552</td>
<td>0.3583</td>
<td>-0.1704</td>
<td>1.0000</td>
<td>0.8355</td>
<td>0.8086</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>0.8191</td>
<td>0.4665</td>
<td>-0.0539</td>
<td>0.8355</td>
<td>1.0000</td>
<td>0.9804</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>0.8150</td>
<td>0.4413</td>
<td>-0.0483</td>
<td>0.8086</td>
<td>0.9804</td>
<td>10000</td>
</tr>
</tbody>
</table>

The $R^2 = 0.94469$; multicollinearity, therefore, can be a problem because in one case the correlation coefficient between $r_{Lt-3}$ and $r_{Lt-4}$ is greater than the $R^2$. Otherwise no serious multicollinearity problems seem to prevail.

The OLS estimates are now provided; we note that TSLS for this function, can not be applied because all the explanatory variables are either exogenous or predetermined.

The SF estimates are given first:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(\Delta I)^t$</td>
<td>0.05152</td>
<td>0.02626</td>
<td>1.96182</td>
</tr>
<tr>
<td>$(\Delta Y)^t$</td>
<td>0.13481</td>
<td>0.04258</td>
<td>3.16575</td>
</tr>
<tr>
<td>$I_{t-1}$</td>
<td>0.87607</td>
<td>0.06349</td>
<td>13.79821</td>
</tr>
<tr>
<td>Cont.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Variable Coefficient Standard Error T-Value
$r_{Lt-3}$ -64.58792 21.99007 2.93711
$r_{Lt-4}$ 65.79097 21.39003 3.09022
CNST. 203.84420 67.08130 3.00295

$R^2 = 0.94469$, $D.W. = 1.95303$, $S = 41.41377$

One Period Ahead 'Forecasts'
Actual: 1796
Forecast: 1743.5441
Forecast Error: 47.4559

$x^2(1) (1) = 1.51314$

The $x^2(1)$-statistic is insignificant, which, of course, means that the equation performs very well as far as prediction is concerned. This is no surprise given the small forecast error.

The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(\Delta A_t)_t$</td>
<td>0.07574</td>
<td>0.02569</td>
<td>2.94848</td>
</tr>
<tr>
<td>$(\Delta Y)_t$</td>
<td>0.12729</td>
<td>0.04074</td>
<td>3.12417</td>
</tr>
<tr>
<td>$I_t-1$</td>
<td>0.53447</td>
<td>0.16046</td>
<td>3.33093</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>-66.10760</td>
<td>20.95328</td>
<td>3.15500</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>77.42619</td>
<td>34.41461</td>
<td>2.24981</td>
</tr>
<tr>
<td>CNST.</td>
<td>187.68909</td>
<td>62.10410</td>
<td>3.02217</td>
</tr>
<tr>
<td>$(\Delta A_t)_{t-1}$</td>
<td>-0.03872</td>
<td>0.02679</td>
<td>1.44515</td>
</tr>
<tr>
<td>$(\Delta Y)_{t-1}$</td>
<td>0.08614</td>
<td>0.05471</td>
<td>1.57437</td>
</tr>
<tr>
<td>$I_t-2$</td>
<td>0.56598</td>
<td>0.15601</td>
<td>3.54536</td>
</tr>
<tr>
<td>$r_{Lt-5}$</td>
<td>-13.02169</td>
<td>22.20985</td>
<td>0.58650</td>
</tr>
</tbody>
</table>

$R^2 = 0.95964$, $D.W. = 2.07715$, $S = 57.54107$

One Period Ahead 'Forecasts'
Actual: 1796
Forecast: 1820.4689
Forecast Error: 244.4689

$x^2(1) (1) = 0.42959$

$F(4, 35) = 3.24222$
Note the adequate stability of the equation for prediction and also the adequacy of the additional parameters.

The R.T.F. estimates are now provided:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(AA_{I})_t</td>
<td>0.03718</td>
<td>0.02121</td>
<td>1.75291</td>
</tr>
<tr>
<td>(AY)_t</td>
<td>0.12493</td>
<td>0.04282</td>
<td>2.91766</td>
</tr>
<tr>
<td>I_{t-1}</td>
<td>0.92218</td>
<td>0.04447</td>
<td>20.76051</td>
</tr>
<tr>
<td>r_{Lt-3}</td>
<td>-45.09777</td>
<td>18.40714</td>
<td>2.45001</td>
</tr>
<tr>
<td>r_{Lt-4}</td>
<td>43.95671</td>
<td>17.91798</td>
<td>2.45322</td>
</tr>
<tr>
<td>CONST.</td>
<td>145.22408</td>
<td>47.60746</td>
<td>3.05045</td>
</tr>
<tr>
<td>\rho</td>
<td>-0.40829</td>
<td>0.16211</td>
<td>2.51870</td>
</tr>
</tbody>
</table>

S = 39.55341

One Period Ahead 'Forecasts'

Actual: 1796
Forecast: 1816.8919
Forecast Error: -20.8919

\( x^2(1) (1) = 0.27899 \)

\( x^2(2) (3) = 8.88094 \)

The important statistic in this case is the \( x^2(2) \)-one, which is just significant at the 5% level, but comfortably insignificant at the 2.5% level. We may, therefore, come to the conclusion that the dynamic specification of this equation is adequate, and that we can use the R.T.F. and U.R.T.F. indiscriminately. Furthermore, since the \( \rho \)-coefficient is significant it follows that the R.T.F. form of the function is preferable to the SF form. As we have already noted no TSLS estimates are provided for this function since it does not include any endogenous variables as arguments. We do, however, provide estimates that arise from using higher order autoregressive process; these are given in the following table (p.148).

Looking at the \( x^2(2) \) \( (v) \)'s and the \( \rho \)'s, it is obvious
that the final form of the I-function is:

\[ I_t = 145.22408 + 0.03718 (\Delta P)_t + 0.12495 (\Delta Y)_t \\
(3.05045) (1.75291) \] 

\[ + 0.92218 I_{t-1} - 45.09777 r_{Lt-3} + 43.95671 r_{Lt-4} \\
(20.76051) (2.45001) (2.45322) \]

This form is the R.T.F. one with the order of autoregressive process being equal to one. All variables have the right sign, except \( r_{Lt-3} \) and all of them, including \( r_{Lt-4} \), are significant, at the 5% level, except in the case of \( (\Delta P)_t \) which is significant at the 1% level. The sign of \( r_{Lt-4} \) seems to be the wrong one, at first sight; there is, however, an explanation as to its positive sign. It can be argued that expectations of further changes, say rises, in interest rates induce, after a while which is a quarter in our case, an expansion in the level of investment following the initial contraction in quarter three; these expectations, however, are expected to be short-lived and in the next quarter the expected contractionary impact on the level of investment materializes again. Thus, the negative sign for the third quarter, the positive one for the fourth quarter, and the negative again in the fifth quarter which we have omitted, though, due to its insignificance. See, however, the U.R.T.F. (p. 145 above) for a confirmation of this result.

One more point on the I-function is that we tried some other variables too, but failed to perform well, and consequently were left out. Notably the variables \( P_t \) and \( M_t \) failed completely to provide the right sign. Whenever they were tried not only did they have the wrong signs but their coefficients were completely insignificant too.

Finally, we note that the coefficient of \( I_{t-1} \) implies a very slow adjustment. In fact it is only about 8% of the discrepancy between desired and actual Investment that is made up in the first quarter. Lags, therefore, in the Investment function are very important indeed.
<table>
<thead>
<tr>
<th>Model</th>
<th>Weight</th>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1000</td>
<td>556.1g</td>
<td>184mm</td>
<td>96mm</td>
<td>46mm</td>
</tr>
<tr>
<td>F1500</td>
<td>655.3g</td>
<td>216mm</td>
<td>126mm</td>
<td>64mm</td>
</tr>
<tr>
<td>F2000</td>
<td>754.5g</td>
<td>248mm</td>
<td>156mm</td>
<td>74mm</td>
</tr>
</tbody>
</table>

**Notes:**
- Measurements are in millimeters.
- Weight is in grams.
14.2d Stock-Building Function \((S_t)\):

The final form of the function tested took the following form:

\[
S_t = s_0 + s_1 (\Delta M)_t + s_2 (\Delta Y)_t + s_3 r_{Lt-3} + s_4 r_{Lt-4} +
\]

\[+ s_5 S_{t-1}\]

The Correlation Matrix is as follows:

<table>
<thead>
<tr>
<th></th>
<th>(S_t)</th>
<th>((\Delta M)_t)</th>
<th>((\Delta Y)_t)</th>
<th>(S_{t-1})</th>
<th>(r_{Lt-3})</th>
<th>(r_{Lt-4})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(S_t)</td>
<td>1.0000</td>
<td>0.0876</td>
<td>0.2725</td>
<td>0.1900</td>
<td>-0.2318</td>
<td>-0.3063</td>
</tr>
<tr>
<td>((\Delta M)_t)</td>
<td>0.0876</td>
<td>1.0000</td>
<td>-0.0155</td>
<td>-0.5464</td>
<td>0.2840</td>
<td>0.2989</td>
</tr>
<tr>
<td>((\Delta Y)_t)</td>
<td>0.2725</td>
<td>-0.0155</td>
<td>1.0000</td>
<td>-0.4590</td>
<td>-0.0539</td>
<td>-0.0483</td>
</tr>
<tr>
<td>(S_{t-1})</td>
<td>0.1900</td>
<td>-0.3464</td>
<td>-0.4590</td>
<td>1.0000</td>
<td>-0.5181</td>
<td>-0.3278</td>
</tr>
<tr>
<td>(r_{Lt-3})</td>
<td>-0.2318</td>
<td>0.2840</td>
<td>-0.0539</td>
<td>-0.5181</td>
<td>1.0000</td>
<td>0.9804</td>
</tr>
<tr>
<td>(r_{Lt-4})</td>
<td>-0.3063</td>
<td>0.2989</td>
<td>-0.0483</td>
<td>-0.3278</td>
<td>0.9804</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

As in the case of the Investment function similarly in the case of this function the only problem seems to be the correlation coefficient between \(r_{Lt-3}\) and \(r_{Lt-4}\) which is well above the \(R^2 = 0.44776\). We may note in passing that the low \(R^2\) should not be surprising; it is expected that when the variables involved in an equation are in first differences, the \(R^2\) is always well below the \(R^2\) estimated using absolute values. In the case of the Stock Building Function all variables, except the \(r_{Lt-3}\) and \(r_{Lt-4}\), are in fact in first differences, thus the relatively low value for the \(R^2\).

We turn now to the OLS estimates. We note, again, that no TSLS estimates are possible because all the arguments in the function are exogenous or predetermined.
First, the SF estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ΔN)&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.14093</td>
<td>0.05821</td>
<td>2.55828</td>
</tr>
<tr>
<td>(ΔY)&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.31139</td>
<td>0.09038</td>
<td>3.44545</td>
</tr>
<tr>
<td>$S_{t-1}$</td>
<td>0.45415</td>
<td>0.15748</td>
<td>2.88396</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>115.61288</td>
<td>57.04920</td>
<td>2.08396</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-155.51293</td>
<td>39.47200</td>
<td>3.47314</td>
</tr>
<tr>
<td>CNST.</td>
<td>152.19459</td>
<td>69.43672</td>
<td>1.90381</td>
</tr>
</tbody>
</table>

$R^2 = 0.44776$, $D.W. = 2.32491$, $S = 76.97784$

One Period Ahead Forecasts:

Actual: 205
Forecast: 157.5263
Forecast Error: 47.4737
$x^2(1) = 0.38034$

We note the insignificance of the $x^2(1)$-statistic implying adequate specification for prediction.

The U.R.T.F. estimates follow:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ΔN)&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.11846</td>
<td>0.06240</td>
<td>1.99841</td>
</tr>
<tr>
<td>(ΔY)&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.38562</td>
<td>0.08818</td>
<td>4.37286</td>
</tr>
<tr>
<td>$S_{t-1}$</td>
<td>0.21736</td>
<td>0.17604</td>
<td>1.23474</td>
</tr>
<tr>
<td>$r_{Lt-3}$</td>
<td>58.79492</td>
<td>41.24062</td>
<td>1.42566</td>
</tr>
<tr>
<td>$r_{Lt-4}$</td>
<td>-44.95326</td>
<td>68.83711</td>
<td>0.65504</td>
</tr>
<tr>
<td>CNST.</td>
<td>53.75824</td>
<td>75.62084</td>
<td>0.71089</td>
</tr>
<tr>
<td>(ΔN)&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.01551</td>
<td>0.06290</td>
<td>0.24667</td>
</tr>
<tr>
<td>(ΔY)&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.32381</td>
<td>0.10605</td>
<td>3.05535</td>
</tr>
<tr>
<td>$S_{t-2}$</td>
<td>0.49708</td>
<td>0.19551</td>
<td>2.54251</td>
</tr>
<tr>
<td>$r_{Lt-5}$</td>
<td>-27.34659</td>
<td>45.46274</td>
<td>0.60152</td>
</tr>
</tbody>
</table>

$R^2 = 0.57531$, $D.W. = 2.18159$, $S = 71.25884$
One Period Ahead 'Forecasts'

Actual: 205
Forecast: 75.6482
Forecast Error: 129.3518
\[ x^2(1) (1) = 3.52192 \]

The last \( x^2(1) \)-statistic is insignificant, which means that this equation is stable enough for prediction.

\[ x^2(2) (3) = 3.55582; \] this is comfortably insignificant suggesting that the dynamic specification of this equation is adequate.

As in the case of the Investment function similarly in this case, since the \( x^2(2) \)-statistic is insignificant, and since the \( \rho \)-coefficient is comfortably significant, it follows that the R.T.F. estimates are preferable to the other two. Next we look at the table (p.153) providing higher order autoregressive processes. According to our standard, by now, statistical criteria the choice of the appropriate function.
\[ S_t = 45.27589 + 0.12344 (\Delta N)_t + 0.41478 (\Delta Y)_t + \]
\[ (0.99875) (2.17534) \quad (4.98662) \]
\[ 0.93453 S_{t-1} + 59.50535 r_{Lt-3} - 70.01728 r_{Lt-4} \]
\[ (6.82218) (1.95854) (2.11993) \]

The signs and the T-Values seem to be the right ones, except perhaps the sign of \( r_{Lt-3} \); this, however, should not be surprising when the two types of investment are taken into consideration. When fixed capital formation is reduced in response to, say, an increase in the rate of interest in quarter three stocks seem to be piling up probably to counteract, so to speak, the reduced volume of fixed capital formation; and vice-versa in response to a decrease in the rate of interest in quarter four. The positive sign of the \( r_{Lt-3} \)-variable can also be explained by taking expectations into consideration. Changes, say rises, in the rate of interest would induce people to pile up stocks, initially, expecting higher interest rates in the future. Given the time lag involved, it is after the third quarter that the usual contractionary effects of higher interest rates start setting in. Thus, we should expect a positive coefficient for the \( r_{Lt-3} \)-variable but a negative one for the \( r_{Lt-4} \)-variable; these are the signs that we actually derive empirically. We note that the adjustment to the equilibrium position following a discrepancy between actual and desired levels is very slow; in fact only 17% of this discrepancy is made up in the first quarter. The \( P_t \) as well as \( P_{t-1} \) variables have been tried but failed completely to provide satisfactory results, so we decided to exclude them from this function.
4.2e Imports Function \((Q_t)\):

The final function took the form:

\[
Q_t = q_o + q_1 Y_t + q_2 P_{t-1} + q_3 M_{t-1} + q_4 P_t + q_5 Q_{t-1}
\]

and the Correlation Matrix was:

<table>
<thead>
<tr>
<th></th>
<th>(Q_t)</th>
<th>(Y_t)</th>
<th>(P_t)</th>
<th>(Q_{t-1})</th>
<th>(M_{t-1})</th>
<th>(P_{t-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Q_t)</td>
<td>1.0000</td>
<td>0.9675</td>
<td>0.9805</td>
<td>0.9847</td>
<td>0.9791</td>
<td>0.9831</td>
</tr>
<tr>
<td>(Y_t)</td>
<td>0.9675</td>
<td>1.0000</td>
<td>0.9456</td>
<td>0.9664</td>
<td>0.9323</td>
<td>0.9519</td>
</tr>
<tr>
<td>(P_t)</td>
<td>0.9805</td>
<td>0.9456</td>
<td>1.0000</td>
<td>0.9833</td>
<td>0.9827</td>
<td>0.9989</td>
</tr>
<tr>
<td>(Q_{t-1})</td>
<td>0.9847</td>
<td>0.9664</td>
<td>0.9833</td>
<td>1.0000</td>
<td>0.9775</td>
<td>0.9848</td>
</tr>
<tr>
<td>(M_{t-1})</td>
<td>0.9791</td>
<td>0.9323</td>
<td>0.9827</td>
<td>0.9775</td>
<td>1.0000</td>
<td>0.9859</td>
</tr>
<tr>
<td>(P_{t-1})</td>
<td>0.9831</td>
<td>0.9519</td>
<td>0.9989</td>
<td>0.9848</td>
<td>0.9859</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

The \(R^2 = 0.98358\); and it seems that multicollinearity can be a problem in this case since not all correlation coefficients are smaller than the \(R^2\). In particular since the correlation coefficient between \(P_t\) and \(P_{t-1}\) is above the \(R^2\) one has to be rather careful with this particular estimated imports function.

The OLS estimates of the SF are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Y_t)</td>
<td>0.21596</td>
<td>0.05589</td>
<td>3.86394</td>
</tr>
<tr>
<td>(P_t)</td>
<td>10.07122</td>
<td>7.54641</td>
<td>1.33457</td>
</tr>
<tr>
<td>(Q_{t-1})</td>
<td>0.08793</td>
<td>0.16322</td>
<td>0.53874</td>
</tr>
<tr>
<td>(M_{t-1})</td>
<td>0.09373</td>
<td>0.02941</td>
<td>3.18736</td>
</tr>
<tr>
<td>(P_{t-1})</td>
<td>-9.77732</td>
<td>9.21938</td>
<td>1.06052</td>
</tr>
<tr>
<td>(CNST.)</td>
<td>-804.72014</td>
<td>223.14911</td>
<td>3.60620</td>
</tr>
</tbody>
</table>

\(R^2 = 0.98358\), D.W. = 2.08129, \(S = 49.31443\).
One Period Ahead 'Forecasts'

Actual: 2697
Forecast: 2752.8932
Forecast Error: -55.8932

\[ x^2(1) = 1.28440 \]

The \( x^2(1) \)-statistic is insignificant implying adequate stability for prediction.

The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>0.20938</td>
<td>0.06383</td>
<td>3.28033</td>
</tr>
<tr>
<td>( P_t )</td>
<td>14.48934</td>
<td>10.59568</td>
<td>1.36748</td>
</tr>
<tr>
<td>( Q_{t-1} )</td>
<td>0.08978</td>
<td>0.19955</td>
<td>0.44808</td>
</tr>
<tr>
<td>( N_{t-1} )</td>
<td>0.08852</td>
<td>0.03783</td>
<td>2.34019</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>-31.03891</td>
<td>17.72067</td>
<td>1.75157</td>
</tr>
<tr>
<td>CNST</td>
<td>-818.07588</td>
<td>344.65718</td>
<td>2.37546</td>
</tr>
<tr>
<td>( Y_{t-1} )</td>
<td>-0.00556</td>
<td>0.08354</td>
<td>0.06657</td>
</tr>
<tr>
<td>( Q_{t-2} )</td>
<td>0.08679</td>
<td>0.19462</td>
<td>0.44593</td>
</tr>
<tr>
<td>( N_{t-2} )</td>
<td>0.00229</td>
<td>0.00865</td>
<td>0.26464</td>
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<tr>
<td>( P_{t-2} )</td>
<td>17.06513</td>
<td>11.90220</td>
<td>1.43378</td>
</tr>
</tbody>
</table>

\[ R^2 = 0.98488, \quad D.W. = 2.15976, \quad S = 49.95541 \]

One Period Ahead 'Forecasts'

Actual: 2697
Forecast: 2648.2314
Forecast Error: 48.7686

\[ x^2(1) = 0.95305 \]

\( F(4,35) = 0.75294 \); both the last two tests mean that the predictive power of the equation is adequate, and the additional parameters are significant.
The R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.21867</td>
<td>0.05991</td>
<td>3.5020</td>
</tr>
<tr>
<td>$P_t$</td>
<td>10.30332</td>
<td>7.74073</td>
<td>1.33104</td>
</tr>
<tr>
<td>$Q_{t-1}$</td>
<td>0.08249</td>
<td>0.16794</td>
<td>0.49119</td>
</tr>
<tr>
<td>$H_{t-1}$</td>
<td>0.09474</td>
<td>0.03036</td>
<td>3.12098</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-10.08300</td>
<td>9.50562</td>
<td>1.06074</td>
</tr>
<tr>
<td>CNST</td>
<td>-815.50122</td>
<td>241.63280</td>
<td>3.37496</td>
</tr>
</tbody>
</table>

$\rho = 0.00939$  
$\sigma = 119.952157$

One Period Ahead 'Forecasts'

Actual: 2697
Forecast: 2751.2875
Forecast Error: -54.2875

$x^2_{(1)} = 1.18109$

$x^2_{(2)} = 3.69561$

The $x^2_{(1)}$-statistic is insignificant implying adequate stability for prediction. What is more, however, the $x^2_{(2)}$-statistic is insignificant which means that the dynamic specification of the function is comfortably adequate. Since now this function involves an endogenous variable amongst the explanatory variables we can use TSLS too, and the appropriate estimates are given below.

As always the SF estimates are given first:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.21576</td>
<td>0.05589</td>
<td>3.86022</td>
</tr>
<tr>
<td>$P_t$</td>
<td>10.05630</td>
<td>7.54645</td>
<td>1.33259</td>
</tr>
<tr>
<td>$Q_{t-1}$</td>
<td>0.08832</td>
<td>0.16322</td>
<td>0.54113</td>
</tr>
<tr>
<td>$H_{t-1}$</td>
<td>0.09368</td>
<td>0.02941</td>
<td>3.18562</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-9.75828</td>
<td>9.21943</td>
<td>1.05845</td>
</tr>
<tr>
<td>CNST</td>
<td>-805.93577</td>
<td>223.15253</td>
<td>3.60263</td>
</tr>
</tbody>
</table>

D.W. = 2.08174,  
$S = 49.51844$

156.
Although the $\chi^2_{(1)}$-statistic is insignificant, the $\chi^2_{(3)}$-statistic is significant implying inadequate specification/identification.

The R.T.F. estimates follow:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.18018</td>
<td>0.05694</td>
<td>3.30482</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.956722</td>
<td>3.55948</td>
<td>1.95737</td>
</tr>
<tr>
<td>$Q_{t-1}$</td>
<td>0.24142</td>
<td>0.21008</td>
<td>1.14917</td>
</tr>
<tr>
<td>$M_{t-1}$</td>
<td>0.08287</td>
<td>0.02639</td>
<td>3.14013</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-7.11305</td>
<td>4.05234</td>
<td>1.75529</td>
</tr>
<tr>
<td>CNST.</td>
<td>-722.42514</td>
<td>351.53983</td>
<td>2.00009</td>
</tr>
<tr>
<td>$\phi$</td>
<td>-0.19004</td>
<td>0.20872</td>
<td>0.91050</td>
</tr>
</tbody>
</table>

$S = 49.50850$

One Period Ahead 'Forecasts'

Actual: 2697
Forecast: 2752.0501
Forecast Error: -55.0301

$\chi^2_{(1)} (1) = 1.23549$

$\chi^2_{(3)} (20) = 31.25351.$

We note that both $\chi^2_{(1)}$- and $\chi^2_{(3)}$-statistics are insignificant, with their appropriate implications.

These results clearly indicate that the appropriate estimated equation to be chosen from both the OLS and TSLS estimates is the SF form of the TSLS technique. We look now at the following tables (p. p. 160-161) where we provide estimates of the Imports function with higher order autoregressive processes.

Careful examination of all these results clearly indicate that the final form of the estimated Imports function should be the following:
<table>
<thead>
<tr>
<th>Vin</th>
<th>C1</th>
<th>C2</th>
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<th>C5</th>
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<th>C7</th>
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</tbody>
</table>

*Note: The table above represents...*
4.2f Long-Term Interest Rate Function ($r_{Lt}$):  
The function tested took the form:  

$$r_{Lt} = \rho_0 + \rho_1 Y_t + \rho_2 r_{st} + \rho_3 P_t + \rho_4 P_{t-1} + \rho_5 r_{Lt-1}$$  
The Correlation Matrix is as follows:  

<table>
<thead>
<tr>
<th></th>
<th>$r_{Lt}$</th>
<th>$Y_t$</th>
<th>$r_{st}$</th>
<th>$r_{Lt-1}$</th>
<th>$P_t$</th>
<th>$P_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r_{Lt}$</td>
<td>1.0000</td>
<td>0.9094</td>
<td>0.8113</td>
<td>0.9851</td>
<td>0.9480</td>
<td>0.9596</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>0.9094</td>
<td>1.0000</td>
<td>0.7042</td>
<td>0.9207</td>
<td>0.9456</td>
<td>0.9519</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>0.8113</td>
<td>0.7042</td>
<td>1.0000</td>
<td>0.7671</td>
<td>0.6947</td>
<td>0.6832</td>
</tr>
<tr>
<td>$r_{Lt-1}$</td>
<td>0.9851</td>
<td>0.9207</td>
<td>0.7671</td>
<td>1.0000</td>
<td>0.9490</td>
<td>0.9426</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.9480</td>
<td>0.9456</td>
<td>0.6947</td>
<td>0.9490</td>
<td>1.0000</td>
<td>0.9989</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>0.9596</td>
<td>0.9519</td>
<td>0.6832</td>
<td>0.9426</td>
<td>0.9989</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

At before multicollinearity can be a problem since the correlation coefficient between $P_t$ and $P_{t-1}$ is greater than the $R^2 = 0.98344$.  

Before we move on to examine the OLS and TSLS estimates we comment on some of the variables included in this function. $P_t$ and $P_{t-1}$ are introduced in order to capture any influence on the long-term rate of interest of changes in the current price level ($P_t$), and of any expectations of changes in the price level affecting the current level of $r_L$ ($P_{t-1}$). We may also note that $r_{st}$ stands for the treasury bill rate which is assumed, as we noted before, to influence the long-term rate via a stable, and of course simple, term structure of interest rates.
The OLS technique gave us the following results:

The SF estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.0000015</td>
<td>0.00029</td>
<td>0.00525</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>0.13505</td>
<td>0.03443</td>
<td>3.92275</td>
</tr>
<tr>
<td>$r_{Lt-1}$</td>
<td>0.72360</td>
<td>0.09427</td>
<td>7.67598</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.10809</td>
<td>0.05158</td>
<td>2.09569</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-0.09567</td>
<td>0.05569</td>
<td>1.71783</td>
</tr>
<tr>
<td>CNST.</td>
<td>-0.39260</td>
<td>1.20550</td>
<td>0.32567</td>
</tr>
</tbody>
</table>

$R^2 = 0.98344$, $D.W. = 1.73193$, $S = 0.28305$

One Period Ahead Forecasts:

Actual: 15.30
Forecast: 14.7690
Forecast Error: 0.5310

$\chi^2 (1) = 3.51875$

We note that the $\chi^2 (1)$-statistic is just insignificant at the 5% level of significance.

The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.00002</td>
<td>0.00056</td>
<td>0.04314</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>0.12023</td>
<td>0.06191</td>
<td>1.94209</td>
</tr>
<tr>
<td>$r_{Lt-1}$</td>
<td>0.86917</td>
<td>0.17750</td>
<td>4.89678</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.10438</td>
<td>0.06209</td>
<td>1.68113</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-0.07410</td>
<td>0.10421</td>
<td>0.71107</td>
</tr>
<tr>
<td>CNST.</td>
<td>-0.76552</td>
<td>1.39511</td>
<td>0.54872</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.00009</td>
<td>0.00036</td>
<td>0.26036</td>
</tr>
<tr>
<td>$r_{st-1}$</td>
<td>-0.00620</td>
<td>0.07267</td>
<td>0.08532</td>
</tr>
<tr>
<td>$r_{Lt-2}$</td>
<td>-0.17488</td>
<td>0.17143</td>
<td>1.02010</td>
</tr>
<tr>
<td>$P_{t-2}$</td>
<td>-0.01920</td>
<td>0.07009</td>
<td>0.27390</td>
</tr>
</tbody>
</table>

$R^2 = 0.98397$, $D.W. = 1.94934$, $S = 0.293966$
One Period Ahead Forecasts
Actual: 15.30
Forecast: 14.6946
Forecast Error: 0.6054

\( \chi^2_{(1)} (1) = 2.43421 \)

\( F(4, 35) = 0.28935 \)

We note that both the \( \chi^2_{(1)} \)-statistic and the \( F \)-statistic are insignificant.

The R.T.F. estimates are now provided:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_t )</td>
<td>0.00005</td>
<td>0.00052</td>
<td>0.14607</td>
</tr>
<tr>
<td>( r_{st} )</td>
<td>0.13769</td>
<td>0.03376</td>
<td>3.55244</td>
</tr>
<tr>
<td>( r_{Lt-1} )</td>
<td>0.68048</td>
<td>0.12797</td>
<td>5.31738</td>
</tr>
<tr>
<td>( P_t )</td>
<td>0.11173</td>
<td>0.05309</td>
<td>2.10438</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>-0.09774</td>
<td>0.05680</td>
<td>1.72081</td>
</tr>
<tr>
<td>( \text{CNST} )</td>
<td>-0.66505</td>
<td>1.40750</td>
<td>0.47250</td>
</tr>
<tr>
<td>( L_t )</td>
<td>0.16150</td>
<td>0.19500</td>
<td>0.82817</td>
</tr>
</tbody>
</table>

\( S = 0.28585 \)

One Period Ahead Forecasts
Actual: 15.30
Forecast: 14.6946
Forecast Error: 0.6054

\( \chi^2_{(1)} (1) = 4.54922 \)

\( \chi^2_{(2)} (3) = 0.54946 \)

The \( \chi^2_{(1)} \)-statistic is significant, whereas the \( \chi^2_{(2)} \)-statistic is insignificant. The insignificance of the latter statistic implies adequate dynamic specification of the equation, and with the \( \rho \) being insignificant we conclude that the SF form is preferable to the other two forms.

164.
We look now at the TSLS estimates, beginning with the SF ones:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.0000014</td>
<td>0.00029</td>
<td>0.00507</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>0.13505</td>
<td>0.03443</td>
<td>3.92267</td>
</tr>
<tr>
<td>$r_{L,t-1}$</td>
<td>0.72360</td>
<td>0.09427</td>
<td>7.67590</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.10809</td>
<td>0.05158</td>
<td>2.09580</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-0.09568</td>
<td>0.05569</td>
<td>1.71795</td>
</tr>
<tr>
<td>CNST.</td>
<td>-0.59281</td>
<td>1.20550</td>
<td>0.52584</td>
</tr>
</tbody>
</table>

D.W. = 1.75192, $S = 0.28505$

One Period Ahead 'Forecasts'

| Actual: | 15.30 |
| Forecast: | 14.7690 |
| Forecast Error: | 0.5310 |

$x^2(1) (1) = 3.51952$

$x^2(7) (21) = 24.09993$

Both $x^2$-statistics are insignificant implying adequate specification for prediction and also adequate overall specification/identification.

Now the U.R.T.F. estimates are given:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.00002</td>
<td>0.00036</td>
<td>0.06890</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>0.11950</td>
<td>0.06203</td>
<td>1.92514</td>
</tr>
<tr>
<td>$r_{L,t-1}$</td>
<td>0.08156</td>
<td>0.18029</td>
<td>4.88962</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.10597</td>
<td>0.06441</td>
<td>1.61455</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-0.09221</td>
<td>0.07043</td>
<td>1.30916</td>
</tr>
<tr>
<td>CNST</td>
<td>-0.58933</td>
<td>1.60037</td>
<td>0.36624</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.00003</td>
<td>0.00036</td>
<td>0.08195</td>
</tr>
<tr>
<td>$r_{st-1}$</td>
<td>-0.00371</td>
<td>0.07278</td>
<td>0.05095</td>
</tr>
<tr>
<td>$r_{L,t-2}$</td>
<td>-0.17379</td>
<td>0.17146</td>
<td>1.01355</td>
</tr>
<tr>
<td>$P_{t-2}$</td>
<td>0.00063</td>
<td>0.00551</td>
<td>0.17842</td>
</tr>
</tbody>
</table>

165.
D.W. = 1.98408, \quad S = 0.29415

One Period Ahead 'Forecasts'

Actual: \quad 15.50
Forecast: \quad 14.7803
Forecast Error: \quad 0.5197

\[ x^2_{(1)} (1) = 3.12207 \]
\[ x^2_{(3)} (17) = 23.43557 \]

Both \( x^2 \)-statistics are insignificant with similar implications as in the SF case.

And, the R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>-0.00005</td>
<td>0.00030</td>
<td>0.15404</td>
</tr>
<tr>
<td>( r_{st} )</td>
<td>0.13520</td>
<td>0.03514</td>
<td>3.84759</td>
</tr>
<tr>
<td>( r_{Lt-1} )</td>
<td>0.73064</td>
<td>0.09592</td>
<td>7.61749</td>
</tr>
<tr>
<td>( P_t )</td>
<td>0.10189</td>
<td>0.05276</td>
<td>1.93130</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>-0.08856</td>
<td>0.05727</td>
<td>1.54631</td>
</tr>
<tr>
<td>( CFST )</td>
<td>-0.19605</td>
<td>1.30411</td>
<td>0.15095</td>
</tr>
</tbody>
</table>

\( \rho \)
S = 0.28656

One Period Ahead 'Forecasts'

Actual: \quad 15.50
Forecast: \quad 14.8028
Forecast Error: \quad 0.4972

\[ x^2_{(1)} (1) = 5.01511 \]
\[ x^2_{(5)} (20) = 24.04368 \]

Both \( x^2 \)-statistics are insignificant; so is the \( \rho \)-coefficient which implies that the SF form is to be chosen at the expense of the other two.

Comparing the OLS estimates with the TSLS ones we find that the former are slightly better than the latter implying that some, very small though, degree of simultaneity is responsible for the better fit when CLS is used. We now
provide estimates for this equation, allowing for higher order autoregressive process (see p. p. 168-169).

Careful inspection of all the results we have provided clearly shows that the appropriate equation is the following:

\[
\begin{align*}
  r_{Lt} &= 0.39281 - 0.0000014Y_t + 0.13505 r_{st} + 0.72360 r_{Lt-1} \\
                   &+ 0.10809 P_t - 0.09568 P_{t-1} \\
           &\quad (0.32584) (0.00507) (3.92267) (7.67590) \\
           &\quad (2.09580) (1.71795) \\
\end{align*}
\]

The main point to note about this estimated equation is the sign of \(Y_t\) which is completely the wrong one. We have tried to find out what happens to the sign of this variable when prices are left out. The result was that an embarrassing improvement in the sign and size of the coefficient occurred; it became positive and the T-Value exceeded two. It seems, therefore, that the inclusion of prices knocks out \(Y_t\) completely, implying that changes in prices as well as expectations of such changes play a more important role in determining the long-term interest rate than income; or, perhaps, nominal income is more important in determining \(r_{Lt}\) than real income, although real income, if left on its own, does have a role to play as far as the determination of this variable is concerned. We also note the strong influence of the treasury bill rate, and that, of course, of lagged long-term rate. The coefficient of the latter implies a very slow adjustment, thus establishing some significance of lags in the formation of long-term interest rates.
<table>
<thead>
<tr>
<th>4.0%</th>
<th>5.0%</th>
<th>6.0%</th>
<th>7.0%</th>
<th>8.0%</th>
<th>9.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0%</td>
<td>0.5%</td>
<td>1.0%</td>
<td>1.5%</td>
<td>2.0%</td>
<td>2.5%</td>
</tr>
<tr>
<td>0.0%</td>
<td>0.5%</td>
<td>1.0%</td>
<td>1.5%</td>
<td>2.0%</td>
<td>2.5%</td>
</tr>
<tr>
<td>Name</td>
<td>Value</td>
<td>Description</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 1</td>
<td>123.45</td>
<td>First item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 2</td>
<td>67.89</td>
<td>Second item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 3</td>
<td>90.12</td>
<td>Third item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 4</td>
<td>45.67</td>
<td>Fourth item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 5</td>
<td>78.90</td>
<td>Fifth item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 6</td>
<td>23.45</td>
<td>Sixth item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 7</td>
<td>56.78</td>
<td>Seventh item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 8</td>
<td>89.01</td>
<td>Eighth item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 9</td>
<td>34.56</td>
<td>Ninth item</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Item 10</td>
<td>21.34</td>
<td>Tenth item</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2g Demand for Money Function \( (N_t^d) \):

The form

\[
N_t^d = d_0 + d_1 Y_t + d_2 r_{st} + d_3 P_t + d_4 P_{t-1} + d_5 N_{t-1}
\]

has been tested and has given us the following results. First of all, though, we provide the Correlation Matrix.

<table>
<thead>
<tr>
<th></th>
<th>( N_t^d )</th>
<th>( Y_t )</th>
<th>( r_{st} )</th>
<th>( P_t )</th>
<th>( N_{t-1} )</th>
<th>( P_{t-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N_t^d )</td>
<td>1.0000</td>
<td>0.9319</td>
<td>0.6342</td>
<td>0.9831</td>
<td>0.9934</td>
<td>0.0861</td>
</tr>
<tr>
<td>( Y_t )</td>
<td>0.9319</td>
<td>1.0000</td>
<td>0.7042</td>
<td>0.9456</td>
<td>0.9323</td>
<td>0.9519</td>
</tr>
<tr>
<td>( r_{st} )</td>
<td>0.6342</td>
<td>0.7042</td>
<td>1.0000</td>
<td>0.6947</td>
<td>0.6779</td>
<td>0.6832</td>
</tr>
<tr>
<td>( P_t )</td>
<td>0.9831</td>
<td>0.9456</td>
<td>0.6947</td>
<td>1.0000</td>
<td>0.9827</td>
<td>0.9989</td>
</tr>
<tr>
<td>( N_{t-1} )</td>
<td>0.9934</td>
<td>0.9323</td>
<td>0.6779</td>
<td>0.9827</td>
<td>1.0000</td>
<td>0.9859</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>0.9861</td>
<td>0.9519</td>
<td>0.6832</td>
<td>0.9986</td>
<td>0.9859</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

As in other cases where both \( P_t \) and \( P_{t-1} \) appear in the same equation, similarly in this case the correlation coefficient between these two variables is higher than the \( R^2 = 0.99273 \); however, the difference between the two is not as great as in some other cases discussed above.

The estimates are now given, starting, as always, with the OLS technique and with the SF form:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>0.27897</td>
<td>0.16843</td>
<td>1.65635</td>
</tr>
<tr>
<td>( r_{st} )</td>
<td>-99.16956</td>
<td>21.19930</td>
<td>4.67796</td>
</tr>
<tr>
<td>( P_t )</td>
<td>59.57826</td>
<td>29.66977</td>
<td>2.00805</td>
</tr>
</tbody>
</table>

Cont.

170.
Variable | Coefficient | Standard Error | T-Value  
---|---|---|---
$Y_{t-1}$ | 0.08714 | 0.09508 | 9.33019  
$r_{s-1}$ | -34.34434 | 37.22900 | 1.45970  
$P_{t-1}$ | -1180.72021 | 685.64589 | 1.72206  
$CNST$ | 0.83711 | 0.09503 | 9.33019  

$R^2 = 0.99273, \ D.W. = 2.83028, \ S = 170.43151$  

One Period Ahead Forecasts:

Actual: 13550  
Forecast: 13551.7023  
Forecast Error: 198.2977  

$x^2(1) = 1.35374$  

The $x^2$-statistic is insignificant implying adequate specification for prediction.

Next, the U.R.T.F. are presented:

Variable | Coefficient | Standard Error | T-Value  
---|---|---|---
$Y_t$ | 0.27832 | 0.19569 | 1.42226  
$r_{st}$ | -109.54144 | 39.00838 | 2.80823  
$P_t$ | 92.77322 | 32.43960 | 2.85983  
$M_{t-1}$ | 0.83632 | 0.11780 | 7.24413  
$P_{t-1}$ | -193.91100 | 56.52867 | 3.43083  
$CNST$ | -1455.88119 | 755.49166 | 1.93218  

$R^2 = 0.99443, \ D.W. = 2.82381, \ S = 157.54147$  

One Period Ahead Forecasts:

Actual: 13550  
Forecast: 12726.1715  
Forecast Error: 823.3285  

$x^2(1) = 27.54537$  

$F(4, 55) = 2.66076$
The $\chi^2$-statistic is very significant in this case, but the F-statistic is just insignificant.

Now, the R.T.F. estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.29460</td>
<td>0.18206</td>
<td>1.61812</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>-99.87237</td>
<td>21.64958</td>
<td>4.61313</td>
</tr>
<tr>
<td>$P_t$</td>
<td>61.46649</td>
<td>30.66900</td>
<td>2.00414</td>
</tr>
<tr>
<td>$M_{t-1}$</td>
<td>0.88991</td>
<td>0.09733</td>
<td>9.14352</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-56.05206</td>
<td>38.65392</td>
<td>1.66269</td>
</tr>
<tr>
<td>CNST</td>
<td>-124.615854</td>
<td>749.90250</td>
<td>1.66269</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.00722</td>
<td>0.03022</td>
<td>0.23907</td>
</tr>
</tbody>
</table>

$S = 172.53201$

One Period Ahead 'Forecasts'

Actual: 13550
Forecast: 13341.1350
Forecast Error: 208.8650

$x^2(1) (1) = 1.46552$

$x^2(2) (3) = 11.88113$

The $x^2(1)$-statistic is, now comfortably insignificant, but the $x^2(3)$-statistic is significant at the 5% level, though it is just so at the 1% level. Ideally, therefore, one should introduce a more complicated lag structure in the above three forms; in particular the variable $P_{t-2}$ should be included in the original SF form. We have not included it, however, for three very good reasons: Firstly, because the value of the $x^2(2)$-statistic is not very far from being insignificant, at the 1% level anyway. Secondly, because of a desire to restrict the number of predetermined variables given that we could only have 47 observations. Thirdly, a more complicated lag structure is considered below when we allow for higher order autoregressive processes. There is one very important lesson to be derived from all these: it seems that the lag structure of
the various estimated demand-for-money functions reported in the literature tend to be unacceptable; they are, in fact similar to the one reported here, and therefore the lag structure as it is tested by the $\hat{2}(2)$-statistic of those functions, has to be more complicated than the one usually reported.

Next, the TSLS estimates are provided with the SF ones first:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.27893</td>
<td>0.16843</td>
<td>1.65640</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>-99.16999</td>
<td>21.19935</td>
<td>4.67797</td>
</tr>
<tr>
<td>$P_t$</td>
<td>59.57930</td>
<td>29.66988</td>
<td>2.00807</td>
</tr>
<tr>
<td>$N_{t-1}$</td>
<td>0.38714</td>
<td>0.09503</td>
<td>4.03020</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-54.54581</td>
<td>37.23006</td>
<td>1.45973</td>
</tr>
<tr>
<td>CNST</td>
<td>-1100.75867</td>
<td>685.64985</td>
<td>1.72210</td>
</tr>
</tbody>
</table>

D.W. = 2.83028, \( S = 170.43151 \)

One Period Ahead 'Forecasts'

| Actual:     | 13550  |
| Forecast:   | 13351.6937 |
| Forecast Error: | 198.3063  |

$\hat{2}(1) = 1.35386$

$\hat{2}(3).(21) = 44.99705$

The point to be made on these estimates is the value of the $\hat{2}(5)$-statistic, which is significant at both the 5% level as well as the 1% level, signifying that the specification/identification of this function is inadequate.

The U.R.T.F. estimates now follow:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.18485</td>
<td>0.181117</td>
<td>1.01863</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>-105.68970</td>
<td>36.88685</td>
<td>2.86524</td>
</tr>
<tr>
<td>$P_t$</td>
<td>64.46686</td>
<td>29.71165</td>
<td>2.16976</td>
</tr>
</tbody>
</table>

Contd.
### Variable Coefficient Standard Error T-Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{t-1}$</td>
<td>0.49161</td>
<td>0.16080</td>
<td>3.05734</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-37.10703</td>
<td>36.97600</td>
<td>1.00354</td>
</tr>
<tr>
<td>CNST</td>
<td>-2472.53735</td>
<td>751.73381</td>
<td>3.28911</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.41536</td>
<td>0.18100</td>
<td>2.29358</td>
</tr>
<tr>
<td>$r_{st-1}$</td>
<td>-44.93904</td>
<td>45.50311</td>
<td>0.99196</td>
</tr>
<tr>
<td>$M_{t-2}$</td>
<td>0.55371</td>
<td>0.15194</td>
<td>3.64427</td>
</tr>
<tr>
<td>$P_{t-2}$</td>
<td>-39.87812</td>
<td>10.52397</td>
<td>3.78927</td>
</tr>
</tbody>
</table>

D.W. = 1.74014, \( S = 148.03873 \)

### One Period Ahead Forecasts

**Actual:** 13550  
**Forecast:** 13055.5499  
**Forecast Error:** 494.4501

\( \chi^2(1) (1) = 11.03603 \)

\( \chi^2(5) (17) = 44.99569 \)

Both \( \chi^2 \)-statistics are significant.

The R.T.F. estimates are as follows:

### Variable Coefficient Standard Error T-Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{t}$</td>
<td>0.50159</td>
<td>0.08531</td>
<td>4.58055</td>
</tr>
<tr>
<td>$r_{st}$</td>
<td>-97.46049</td>
<td>10.23012</td>
<td>9.52682</td>
</tr>
<tr>
<td>$P_{t}$</td>
<td>65.15409</td>
<td>2.81532</td>
<td>23.14273</td>
</tr>
<tr>
<td>$M_{t-1}$</td>
<td>1.01373</td>
<td>0.05376</td>
<td>18.95301</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>-72.39434</td>
<td>5.00122</td>
<td>14.47553</td>
</tr>
<tr>
<td>CNST</td>
<td>-1571.47911</td>
<td>593.39375</td>
<td>3.99467</td>
</tr>
<tr>
<td>$\rho$</td>
<td>-0.55295</td>
<td>0.13796</td>
<td>4.00811</td>
</tr>
</tbody>
</table>

\( S = 146.69970 \)

### One Period Ahead Forecasts

**Actual:** 13550  
**Forecast:** 13082.8401  
**Forecast Error:** 467.1599
Examine the tables (pp. 176-177) for higher order autoregressive processes, and the results presented above, the conclusion is that the equation:

\[ M^d_t = -1409.01913 + 0.34787 Y_t - 100.45359 r_{st} + 65.53835 P_t + 62.96615 P_{t-1} + 0.90228 N_{t-1} \]

is chosen according to the statistical criteria that have already been discussed. It is very important to note that this final form is that one derived by using TSLS and allowing for third order autoregressive process. This is so because it is only then that a satisfactory \( x^2 \)-statistic is achieved, implying adequate dynamic specification of the \( M^d_t \)-function. The overall fit seems to be satisfactory, especially that of the treasury bill rate, but there might be some objections as far as the \( x^2 \) is concerned which is significant at the 5% level but just so at the 1% level. We may note at this stage that we have also tried other interest rates apart from \( r_{st} \)-the treasury bill rate- such as the euro-dollar rate, the local authority rate and the long-term bond rate \( r_{Lt} \); the results are not really any different, if at all, so we have decided to keep the \( r_{st} \) in this particular equation. We also note the significance of the \( M_{t-1} \) variable, and the importance of its coefficient which implies that only 10% of any discrepancy between desired and actual money balances is made up in the first quarter. The significance, therefore, of lags in the \( M^d_t \)-function is thus established.
4.2h Money Supply Function \( (N^S_t) \):

The following form:

\[
N^S_t = m_0 + m_1 Y_t + m_2 r_{dt} + m_3 r_{dt} + m_4 M_{t-1} + M_{D, t-1} + m_6 (ΔA)_t
\]

was tested and gave us the following results. Before we begin our discussion of the empirical results it is imperative to note that the above equation differs from the one we suggested earlier, namely:

\[
N^S_t = m_0 + m_1 Y_t + m_2 r_{dt} + m_3 r_{dt} + m_4 M_{t-1}
\]

In particular, the rate of interest used here is \( r_{dt} \) which stands for the difference between the U.K. treasury bill rate and the U.S.A. treasury bill rate. The reason for not having just one rate is because no such rate has stood up well at all empirically; treasury bill rate, local authority rate, long-term bond rate, all these have been tried and failed totally to give the right sign, and also in most cases the T-value was rather disappointing. The reason for such poor empirical performance of just a single rate in the \( N^S_t \)-function is obvious. During the period under examination the commercial banking sector was very much restricted in their policies by the measures taken by the monetary authorities i.e. restrictions on advances, requests, etc., and consequently the banking sector was not free to react freely, and presumably according to the theoretical considerations discussed earlier, to any changes in interest rates. We, thus, include the \( (ΔA)_t \) variable, which stands for changes in the level of total advances in order to capture the influence on money supply of any restrictions on the level of advances imposed by the monetary authorities. Now, the \( r_{dt} \) variable is introduced because of a belief that the monetary authorities during the period under examination pursued a policy that aimed in controlling short-term interest rates, and the treasury bill rate is used here as a good representative of short-term rates, in order to influence short-term capital movements. Thus, the difference between the U.K. treasury bill rate and the U.S.A. treasury bill rate is used in order to capture any influences on the money supply of inflows or outflows of short-term capital.
Finally, the variable $B_{t-1}$ i.e. lagged base money, is necessarily included on purely statistical criteria; and it is necessary to include it in order to get a non-significant $x^2(2)$, which is absolutely required so that proper dynamic specification of the equation is achieved.

We turn now to the empirical results, beginning with the Correlation Matrix:

<table>
<thead>
<tr>
<th></th>
<th>$N_t^a$</th>
<th>$Y_t$</th>
<th>$B_t$</th>
<th>$(\Delta\lambda)_t$</th>
<th>$N_{t-1}$</th>
<th>$B_{t-1}$</th>
<th>$r_{dt}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_t^a$</td>
<td>1.0000</td>
<td>0.9319</td>
<td>0.9776</td>
<td>0.7042</td>
<td>0.9934</td>
<td>0.9703</td>
<td>-0.2165</td>
</tr>
<tr>
<td>$Y_t$</td>
<td>0.9319</td>
<td>1.0000</td>
<td>0.9567</td>
<td>0.5571</td>
<td>0.9353</td>
<td>0.9668</td>
<td>-0.2335</td>
</tr>
<tr>
<td>$B_t$</td>
<td>0.9776</td>
<td>0.9567</td>
<td>1.0000</td>
<td>0.6273</td>
<td>0.9851</td>
<td>0.9954</td>
<td>-0.2545</td>
</tr>
<tr>
<td>$(\Delta\lambda)_t$</td>
<td>0.7042</td>
<td>0.5571</td>
<td>0.6273</td>
<td>1.0000</td>
<td>0.6999</td>
<td>0.6148</td>
<td>-0.2499</td>
</tr>
<tr>
<td>$N_{t-1}$</td>
<td>0.9934</td>
<td>0.9353</td>
<td>0.9851</td>
<td>0.6999</td>
<td>1.0000</td>
<td>0.9767</td>
<td>-0.2480</td>
</tr>
<tr>
<td>$B_{t-1}$</td>
<td>0.9703</td>
<td>0.9668</td>
<td>0.9954</td>
<td>0.6148</td>
<td>0.9767</td>
<td>1.0000</td>
<td>-0.2557</td>
</tr>
<tr>
<td>$r_{dt}$</td>
<td>-0.2165</td>
<td>-0.2335</td>
<td>-0.2545</td>
<td>-0.2499</td>
<td>-0.2480</td>
<td>-0.2557</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

The $R^2 = 0.98986$, and it seems that since the correlation coefficient between $B_t$ and $B_{t-1}$, as well as that between $N_t$ and $N_{t-1}$, is higher than the $R^2$ we do have to take into consideration that multicollinearity can be a problem.

The OLS estimates are now given, with the SF ones first:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>0.22955</td>
<td>0.19229</td>
<td>1.19375</td>
</tr>
<tr>
<td>$B_t$</td>
<td>1.02413</td>
<td>0.49304</td>
<td>2.07719</td>
</tr>
<tr>
<td>$(\Delta\lambda)_t$</td>
<td>0.15105</td>
<td>0.10906</td>
<td>1.38504</td>
</tr>
<tr>
<td>$N_{t-1}$</td>
<td>0.88549</td>
<td>0.10733</td>
<td>8.22742</td>
</tr>
</tbody>
</table>

Contd.
One Period Ahead 'Forecasts'

Actual: 13550
Forecast: 13645.1196
Forecast Error: -95.1196

\[ x^2(1) = 0.19061 \]

\[ F(5, 35) = 0.33690 \]

Both the \( x^2(1) \)- and the F-statistics are insignificant.

And, the R.T.F. estimates:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>0.23888</td>
<td>0.19798</td>
<td>1.20655</td>
</tr>
<tr>
<td>( B_t )</td>
<td>1.02613</td>
<td>0.49747</td>
<td>2.06272</td>
</tr>
<tr>
<td>( (AA)_t )</td>
<td>0.14950</td>
<td>0.11019</td>
<td>1.35675</td>
</tr>
<tr>
<td>( N_{t-1} )</td>
<td>0.87907</td>
<td>0.11035</td>
<td>7.95649</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>-0.93740</td>
<td>0.50657</td>
<td>1.85049</td>
</tr>
<tr>
<td>( r_{dt} )</td>
<td>40.74297</td>
<td>20.55623</td>
<td>1.98596</td>
</tr>
<tr>
<td>CNST</td>
<td>-104.85913</td>
<td>862.00645</td>
<td>1.21676</td>
</tr>
<tr>
<td>( \rho )</td>
<td>0.01237</td>
<td>0.03520</td>
<td>0.35143</td>
</tr>
</tbody>
</table>

\[ S = 206.29774 \]

One Period Ahead 'Forecasts'

Actual: 13550
Forecast: 13645.8418
Forecast Error: -95.8418

\[ x^2(1) = 0.21583 \]

\[ x^2(2) = 2.08552 \]

The \( x^2(2) \)-statistic is insignificant suggesting that the dynamic structure of the equation is adequate; given, then, that the \( \rho \)-coefficient is insignificant the SF form is preferable to the other two forms. The \( x^2(1) \)-statistic is also insignificant, indeed it is so in all three forms, implying adequate specification for prediction.
We turn now our attention to the TSL5 estimates, beginning with the SP ones:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_t</td>
<td>0.22651</td>
<td>0.19245</td>
<td>1.17701</td>
</tr>
<tr>
<td>B_t</td>
<td>1.12218</td>
<td>0.51592</td>
<td>2.17510</td>
</tr>
<tr>
<td>(AA)_t</td>
<td>0.15251</td>
<td>0.10914</td>
<td>1.39741</td>
</tr>
<tr>
<td>Y_t-1</td>
<td>0.87489</td>
<td>0.10825</td>
<td>0.00181</td>
</tr>
<tr>
<td>B_t-1</td>
<td>-1.01963</td>
<td>0.51566</td>
<td>1.98502</td>
</tr>
<tr>
<td>r dt</td>
<td>0.10205</td>
<td>0.24148</td>
<td>2.03059</td>
</tr>
<tr>
<td>CNST</td>
<td>-973.07564</td>
<td>825.45506</td>
<td>1.17884</td>
</tr>
<tr>
<td>D.W.</td>
<td>2.66057</td>
<td>S = 204.02179</td>
<td></td>
</tr>
</tbody>
</table>

One Period Ahead Forecasts:

Actual: 13550  
Forecast: 13662.3167  
Forecast Error: -112.3167

$X^2(1) = 0.30306$

$X^2(21) = 44.45329$

Although the $X^2(1)$ statistic is insignificant, the same is not true for the $X^2(21)$ statistic, so there some doubts about the identification/specification of this equation.

The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y_t</td>
<td>0.15974</td>
<td>0.25723</td>
<td>0.62100</td>
</tr>
<tr>
<td>B_t</td>
<td>1.00079</td>
<td>0.58021</td>
<td>1.72486</td>
</tr>
<tr>
<td>(AA)_t</td>
<td>0.09534</td>
<td>0.13030</td>
<td>0.75171</td>
</tr>
<tr>
<td>Y_t-1</td>
<td>0.92491</td>
<td>0.14507</td>
<td>6.37580</td>
</tr>
<tr>
<td>B_t-1</td>
<td>-1.40214</td>
<td>0.75991</td>
<td>2.00314</td>
</tr>
<tr>
<td>r dt</td>
<td>39.13278</td>
<td>22.92380</td>
<td>1.70708</td>
</tr>
<tr>
<td>CNST</td>
<td>-1088.66566</td>
<td>984.14596</td>
<td>1.10621</td>
</tr>
</tbody>
</table>

Contd.
### Variable Coefficient Standard Error T-Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{t-1}$</td>
<td>0.06086</td>
<td>0.26750</td>
<td>0.23097</td>
</tr>
<tr>
<td>$(\Delta A)_{t-1}$</td>
<td>0.00069</td>
<td>0.12041</td>
<td>0.00577</td>
</tr>
<tr>
<td>$M_{t-2}$</td>
<td>-0.01147</td>
<td>0.03408</td>
<td>0.33642</td>
</tr>
<tr>
<td>$D_{t-2}$</td>
<td>0.54935</td>
<td>0.58558</td>
<td>0.93814</td>
</tr>
<tr>
<td>$r_{dt-1}$</td>
<td>10.66151</td>
<td>24.97163</td>
<td>0.42775</td>
</tr>
</tbody>
</table>

D.W. = 2.69030, $S = 213.54569$

### One Period Ahead Forecasts

- **Actual:** 15550
- **Forecast:** 15670.766
- **Forecast Error:** -120.7662

\[ Z(1) = 0.31982 \]

\[ Z(3) = 44.54036 \]

We note again the inadequate specification/identification, as it is revealed by the significant $Z(3)$-statistic.

Next, the R.T.F. estimates are cited:

### Variable Coefficient Standard Error T-Value

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_{t}$</td>
<td>0.23585</td>
<td>0.19814</td>
<td>1.19030</td>
</tr>
<tr>
<td>$B_{t}$</td>
<td>1.12589</td>
<td>0.52040</td>
<td>2.15966</td>
</tr>
<tr>
<td>$(\Delta A)_{t}$</td>
<td>0.15088</td>
<td>0.11027</td>
<td>1.36829</td>
</tr>
<tr>
<td>$M_{t-1}$</td>
<td>0.87042</td>
<td>0.11121</td>
<td>7.82648</td>
</tr>
<tr>
<td>$D_{t-1}$</td>
<td>-1.01419</td>
<td>0.52085</td>
<td>1.94716</td>
</tr>
<tr>
<td>$r_{dt}$</td>
<td>40.81079</td>
<td>20.54807</td>
<td>1.98611</td>
</tr>
<tr>
<td>CNST</td>
<td>-1054.78517</td>
<td>862.79930</td>
<td>1.19933</td>
</tr>
</tbody>
</table>

$S = 206.40481$
One Period Ahead 'Forecasts'

Actual: 13550
Forecast: 13667.6903
Forecast Error: -117.6903

\[ x^2_{(1)} (1) = 0.52512 \]
\[ x^2_{(2)} (20) = 44.44903 \]

And the \( x^2_{(3)} \)-statistic continuous to be significant, whereas the \( x^2_{(1)} \)-statistic continuous to be insignificant.

We now look at the tables (pp. 185-187) that provide estimates of higher order autoregressive processes. Careful examination of these tables, and the results provided above, point to the conclusion that the final form should be:

\[
N_t = -973.07584 + 0.22651 Y_t + 1.12218 B_t + 0.15351 (\Delta A)_{t} \\
(1.17334) (1.17701) (2.17510) (1.39734) \\
+ 0.020205 r_{dt} - 1.01965 B_{t-1} + 0.07489 W_{t-1} \\
(2.03509) (1.98502) (6.08181) 
\]

This is the SF form of TSLS chosen according to our usual statistical criteria. The predictive power of this equation is adequate, as it is judged by the \( x^2_{(1)} \)-statistic, but the specification or identification as it is tested by the \( x^2_{(3)} \)-statistic is rather shaky as this statistic is significant at both the 5% and 1% levels. The variables \( Y_t \) and \( (\Delta A)_t \) do have the right signs but their T-Values are very low; the variables \( B_t \) and \( r_{dt} \) have both the right sign and are significant, as well as the variables \( W_{t-1} \) and \( B_{t-1} \). The sign of the latter, actually negative, is justified as follows: an increase, say, of base money in period \( t-1 \) will increase the money stock in the same period and also the level of income. The increase in the level of income now will cause the level of base money to decrease - since we postulate a negative relationship between \( B_t \) and \( Y_t \), and if nothing else happens this will have a decreasing impact on the level of money stock in period \( t \).
These findings, then, seem to indicate that if the authorities can control \( h_t \) and \( r_{dt} \) they can easily control the money stock. Now, \( r_{dt} \) is obviously a very difficult variable to control, but whether \( h_t \) can be controlled is not so clear, and this is actually the next variable whose empirical performance we move on to investigate. Before we do this, however, it is important to note that \( P_t \) and \( P_{t-1} \) have also been tried in the \( N_t^s \)-function but their empirical results were very unsatisfactory so we left the price variables out of this equation. One more point is on the coefficient of the \( n_{t-1} \) variable which implies a very slow adjustment. Lags, therefore, are very important as far as the \( N_t^s \)-function is concerned, as the case is with the \( N_t^d \)-function also.
<table>
<thead>
<tr>
<th>Time (s)</th>
<th>900° C</th>
<th>1100° C</th>
<th>1300° C</th>
<th>1500° C</th>
<th>1700° C</th>
<th>1900° C</th>
<th>2100° C</th>
<th>2300° C</th>
<th>2500° C</th>
<th>2700° C</th>
<th>2900° C</th>
<th>3100° C</th>
<th>3300° C</th>
<th>3500° C</th>
<th>3700° C</th>
<th>3900° C</th>
<th>4100° C</th>
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<tbody>
<tr>
<td>000° C</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
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</tr>
<tr>
<td>400° C</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
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</tr>
<tr>
<td>800° C</td>
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<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
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<tr>
<td>1200° C</td>
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<tr>
<td>1600° C</td>
<td>0.000</td>
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<td>2000° C</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

**Note:** The table represents experimental data, with values for each temperature point. The data is likely used for scientific analysis or process control in a laboratory setting.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Expression</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a$</td>
<td>$a^2 + a + 1$</td>
<td>3</td>
</tr>
<tr>
<td>$b$</td>
<td>$b^2 - b + 1$</td>
<td>2</td>
</tr>
<tr>
<td>$c$</td>
<td>$c^2 + c + 1$</td>
<td>1</td>
</tr>
</tbody>
</table>

**Example Calculation**

For $a = 2$:

- $a^2 + a + 1 = 2^2 + 2 + 1 = 7$
- $b^2 - b + 1 = 2^2 - 2 + 1 = 3$
- $c^2 + c + 1 = 1^2 + 1 + 1 = 3$

**Properties**

- The expressions $a^2 + a + 1$, $b^2 - b + 1$, and $c^2 + c + 1$ are all irreducible over the integers.
- They represent a sequence of numbers with interesting properties in number theory and algebra.
4.2.1 Basic Money Function ($M_t$):

The form that this function eventually took was:

$$M_t = b_0 + b_1 Y_t + b_2 (SP)_t + b_3 (ADR)_t + b_4 P_t +$$

$$b_5 P_{t-1} + b_6 Y_{t-1}$$

with the following table being the Correlation Matrix:

<table>
<thead>
<tr>
<th></th>
<th>$Y_t$</th>
<th>(ADR)$_t$</th>
<th>(SP)$_t$</th>
<th>$P_t$</th>
<th>$Y_{t-1}$</th>
<th>$P_{t-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>1.0000</td>
<td>0.9617</td>
<td>0.0701</td>
<td>0.9380</td>
<td>0.9907</td>
<td>0.9954</td>
</tr>
<tr>
<td>(ADR)$_t$</td>
<td>0.9617</td>
<td>1.0000</td>
<td>0.0544</td>
<td>0.9104</td>
<td>0.9456</td>
<td>0.9668</td>
</tr>
<tr>
<td>(SP)$_t$</td>
<td>0.0701</td>
<td>0.0544</td>
<td>1.0000</td>
<td>0.0634</td>
<td>0.0548</td>
<td>0.0278</td>
</tr>
<tr>
<td>$P_t$</td>
<td>0.9380</td>
<td>0.9104</td>
<td>0.0634</td>
<td>1.0000</td>
<td>0.9090</td>
<td>0.9330</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.9907</td>
<td>0.9456</td>
<td>0.0548</td>
<td>0.9090</td>
<td>1.0000</td>
<td>0.9891</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>0.9954</td>
<td>0.9668</td>
<td>0.0278</td>
<td>0.9330</td>
<td>0.9891</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>0.9910</td>
<td>0.9519</td>
<td>0.0425</td>
<td>0.9043</td>
<td>0.9899</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

With an $R^2 = 0.99561$ we do not seem to be faced with serious multicollinearity problems, except in that the correlation coefficient between $P_t$ and $P_{t-1}$ is slightly above the $R^2$.

The OLS estimates are as follows with the SF ones first:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.06062</td>
<td>0.05913</td>
<td>1.02528</td>
</tr>
<tr>
<td>(ADR)$_t$</td>
<td>0.02957</td>
<td>0.00895</td>
<td>3.30293</td>
</tr>
<tr>
<td>(SP)$_t$</td>
<td>0.13419</td>
<td>0.03426</td>
<td>3.91725</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-12.65610</td>
<td>8.61444</td>
<td>1.46917</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.57425</td>
<td>0.11715</td>
<td>4.90151</td>
</tr>
</tbody>
</table>

Contd.
One Period Ahead Forecasts

Actual: 6017
Forecast: 6020
Forecast Error: -3.9115

\[ x^2_{(1)} (1) = 0.00575 \]

The striking thing about this estimated equation is its terrific specification for prediction, as it is clearly shown by the very low value of the \( x^2_{(1)} \)-statistic.

The U.R.T.F. estimates are:

\begin{tabular}{|c|c|c|c|}
\hline
Variable & Coefficient & Standard Error & T-Value \\
\hline
\( Y_t \) & -0.10565 & 0.07173 & 1.47229 \\
\( (\Delta BR) t \) & 0.05224 & 0.01046 & 3.08281 \\
\( (SP) t \) & 0.14127 & 0.05635 & 3.88347 \\
\( P_t \) & -1.56161 & 11.95687 & 0.11388 \\
\( B_t-1 \) & 0.69520 & 0.17228 & 4.03524 \\
\( P_t-1 \) & 8.32581 & 21.98963 & 0.37862 \\
CNST & -3.75162 & 261.12733 & 0.01437 \\
\( Y_t-1 \) & 0.11329 & 0.06901 & 1.64162 \\
\( (\Delta BR) t-1 \) & 0.00225 & 0.01382 & 0.15528 \\
\( (S1) t-1 \) & -0.07490 & 0.04319 & 1.73413 \\
\( D_t-2 \) & -0.08254 & 0.15467 & 0.55367 \\
\( P_t-2 \) & 2.84943 & 13.78658 & 0.20668 \\
\hline
\end{tabular}

\[ R^2 = 0.99624, \quad D.W. = 2.09733, \quad S = 51.21555 \]
One Period Ahead 'Forecasts'

Actual: 6017
Forecast: 5941.5386
Forecast Error: 75.4714

\[ x^2_{(1)} (1) = 2.17168 \]

\[ F(5, 35) = 1.10578 \]

The \( x^2_{(1)} \)-statistic although insignificant, its value is higher than the equivalent of the SF form.

The R.T.F. estimates are now given:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Y_t )</td>
<td>-0.08556</td>
<td>0.06609</td>
<td>1.29454</td>
</tr>
<tr>
<td>( (\Delta BR)_t )</td>
<td>0.02838</td>
<td>0.00833</td>
<td>3.40688</td>
</tr>
<tr>
<td>( (SP)_t )</td>
<td>0.14936</td>
<td>0.03451</td>
<td>4.32849</td>
</tr>
<tr>
<td>( P_t )</td>
<td>-15.85752</td>
<td>9.12785</td>
<td>1.51816</td>
</tr>
<tr>
<td>( B_{t-1} )</td>
<td>0.48520</td>
<td>0.15408</td>
<td>3.14896</td>
</tr>
<tr>
<td>( P_{t-1} )</td>
<td>28.03038</td>
<td>10.42602</td>
<td>2.68850</td>
</tr>
<tr>
<td>( CNST )</td>
<td>371.18654</td>
<td>273.81607</td>
<td>1.35545</td>
</tr>
<tr>
<td>( \rho )</td>
<td>0.24165</td>
<td>0.21109</td>
<td>1.14477</td>
</tr>
</tbody>
</table>

\[ S = 51.54488 \]

One Period Ahead 'Forecasts'

Actual: 6017
Forecast: 6045.4520
Forecast Error: -26.4320

\[ x^2_{(1)} (4) = 0.26296 \]

\[ x^2_{(2)} (4) = 5.72384 \]

The \( x^2_{(1)} \)-statistic continuous to be insignificant; the \( x^2_{(2)} \)-statistic is insignificant too, suggesting that the dynamic specification of the equation is adequate. The insignificance, now, of the \( \rho \)-coefficient implies that the SF form is preferable to the other two forms.
The TSLS estimates are now presented with the SF ones first, as always:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.06059</td>
<td>0.05913</td>
<td>1.02475</td>
</tr>
<tr>
<td>$(\Delta BR)_t$</td>
<td>0.02956</td>
<td>0.00895</td>
<td>3.50277</td>
</tr>
<tr>
<td>$(SP)_t$</td>
<td>0.13419</td>
<td>0.03426</td>
<td>3.91712</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-12.65349</td>
<td>8.61447</td>
<td>1.46036</td>
</tr>
<tr>
<td>$D_{t-1}$</td>
<td>0.57420</td>
<td>0.11715</td>
<td>4.90126</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>24.17479</td>
<td>9.46011</td>
<td>2.55329</td>
</tr>
<tr>
<td>CNST</td>
<td>226.81270</td>
<td>229.22379</td>
<td>0.98948</td>
</tr>
</tbody>
</table>

D.W. = 1.81963, $S = 51.56871$

One Period Ahead 'Forecasts'

| Actual:  | 6017 |
| Forecast:| 6020.8999 |
| Forecast Error: | -5.8999 |

$x^2(1) = 0.00572$

$x^2(5) = 37.68161$

The $x^2(1)$-statistic is very insignificant indeed, whereas the $x^2(5)$-statistic is only so at the 1% level.

The U.R.T.F. estimates are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.11151</td>
<td>0.06706</td>
<td>1.66298</td>
</tr>
<tr>
<td>$(\Delta BR)_t$</td>
<td>0.03232</td>
<td>0.01046</td>
<td>3.09082</td>
</tr>
<tr>
<td>$(SP)_t$</td>
<td>0.14177</td>
<td>0.03658</td>
<td>5.87555</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-3.30260</td>
<td>10.78575</td>
<td>0.30626</td>
</tr>
<tr>
<td>$D_{t-1}$</td>
<td>0.69687</td>
<td>0.16875</td>
<td>4.12968</td>
</tr>
<tr>
<td>$P_{t-1}$</td>
<td>12.98773</td>
<td>11.93449</td>
<td>1.08825</td>
</tr>
<tr>
<td>CNST</td>
<td>31.00789</td>
<td>291.10134</td>
<td>0.10652</td>
</tr>
<tr>
<td>$Y_{t-1}$</td>
<td>0.11187</td>
<td>0.07052</td>
<td>1.58637</td>
</tr>
</tbody>
</table>

Contd.

191.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta BR$</td>
<td>0.00108</td>
<td>0.01252</td>
<td>0.08591</td>
</tr>
<tr>
<td>$ST$</td>
<td>-0.07426</td>
<td>0.04361</td>
<td>1.70277</td>
</tr>
<tr>
<td>$B_t-2$</td>
<td>-0.08023</td>
<td>0.15593</td>
<td>0.51455</td>
</tr>
<tr>
<td>$P_t-2$</td>
<td>0.13998</td>
<td>0.61581</td>
<td>0.22752</td>
</tr>
</tbody>
</table>

D.W. = 2.07031, $S = 51.20661$

One Period Ahead 'Forecasts'

Actual: 6017
Forecast: 5958.5858
Forecast Error: 58.4142

$x^2(1) = 1.30132$
$x^2(3)(16) = 36.45414$

The $x^2(1)$-statistic continues to be insignificant, but the $x^2(3)$-statistic has now become significant.

Finally, the R.T.F. estimates are provided:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>T-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y_t$</td>
<td>-0.07455</td>
<td>0.06017</td>
<td>1.23888</td>
</tr>
<tr>
<td>$\Delta BR$</td>
<td>0.03018</td>
<td>0.00901</td>
<td>3.35005</td>
</tr>
<tr>
<td>$SP'$</td>
<td>0.13034</td>
<td>0.03159</td>
<td>3.99911</td>
</tr>
<tr>
<td>$P_t$</td>
<td>-14.16909</td>
<td>8.66865</td>
<td>1.65452</td>
</tr>
<tr>
<td>$B_t-1$</td>
<td>0.56260</td>
<td>0.11721</td>
<td>4.79977</td>
</tr>
<tr>
<td>$P_t-1$</td>
<td>26.23109</td>
<td>9.66582</td>
<td>2.71905</td>
</tr>
<tr>
<td>$CNST$</td>
<td>292.78513</td>
<td>236.62067</td>
<td>1.23755</td>
</tr>
<tr>
<td>$P$</td>
<td>-0.03170</td>
<td>0.02162</td>
<td>1.00358</td>
</tr>
</tbody>
</table>

$S = 51.56675$

One Period Ahead 'Forecasts'

Actual: 6017
Forecast: 6030.3366
Forecast Error: -13.3366

$x^2(1) = 0.06689$
$x^2(3)(20) = 37.48422$
The $x^2_{(3)}$-statistic is insignificant at the $1\%$ level only, but the $x^2_{(1)}$-statistic is comfortably insignificant. In fact, the main point to note about all the estimates we have produced in this section (4.21), is the powerful predictive performance of the equation in question. It is obvious that as far as forecasting is concerned this equation performs better than any of the other equations so far presented, according to the $x^2_{(1)}$-statistic. Next we look at the following tables (pp. 194-195) where higher order autoregressive processes are allowed. Careful examination of the results depicted in these tables, and the rest of the results cited above, we conclude that the proper equation to be used for the $B_t$-function is the following:

$$B_t = 226.81270 - 0.06059 Y_t + 0.15419 (SP)_t + 0.02956 (\Delta BR)_t$$

$$- 0.09948 (1.02475) (5.91712) (3.50277)$$

$$- 12.65549 P_t + 24.17479 P_{t-1} + 0.57420 B_{t-1}$$

$$- 0.02956 \text{ (1.46806)} \text{ (2.55329)} \text{ (1.90126)}$$

All the signs are the expected ones, whereas the T-Values are not always significant. The exogenous arguments of this equation are all very significant, indeed; the endogenous arguments, though, are not really very insignificant-including the $P_t$ variable just for simplicity-so the problem as to whether the base money is an exogenous or endogenous component is not clearly solved. We believe, however, that the base money is partly exogenous and partly endogenous and we seem to be justified by the results we have provided in this section. We note that the variable $(\Delta BR)_t$ is used here instead of $(BR)_t$, and this we did simply to restrict the number of predetermined variables, since it was found desirable to include some lag in the $B_t$-function as far as the $(BR)_t$ variable is concerned. Finally, we note that the coefficient of $B_{t-1}$ implies not a very slow adjustment since about $42\%$ of any discrepancy between desired and actual base money is made up in the first quarter.
<table>
<thead>
<tr>
<th>Term</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Notes:**
- The table represents a series of data points or calculations.
- Each column and row corresponds to specific variables or conditions.
- The table is used for comparative analysis or statistical purposes.

**Additional Information:**
- The table is extracted from a scientific or technical document.
- The data is presented in a tabular format for easy reference and analysis.
<table>
<thead>
<tr>
<th>$\mu'$</th>
<th>$\mu''$</th>
<th>$\mu'''$</th>
<th>$\mu^{(4)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.25</td>
<td>0.125</td>
<td>0.0625</td>
</tr>
</tbody>
</table>

**Notes:**
- $\mu'$, $\mu''$, $\mu'''$, and $\mu^{(4)}$ represent different orders of the function $\mu$.
- The values given are for illustrative purposes only.
4.2j Summary of 'Best' Estimates

In this section we summarize the 'best' estimates for each equation, so that they can be used for comparison with other results that we will present below.

(1) \( Y_t = C_t + I_t + S_t + (TA)_t - Q_t \)

(2) \( (TA)_t = G_t + X_t - T_{st} \)

(3) \( C_t = 1188.51771 + 0.51509 X_t + 0.14512 (AI)_{t} + 0.46542 (AI)^{t} + 17.11387 P_t + 0.28099 C_{t-1} - 8.75430 r_{Lt-3} \\
+ 6.92598 r_{Lt-4} + 25.55210 P_{t-1} \)

(4) \( Y_t = 0.14707 Y_t + 0.82562 Y_{d t} \)

(5) \( I_t = 145.22408 + 0.05718 (AI)_{t} + 0.12493 (AY)_{t} + 0.92218 I_{t-1} - 45.90777 r_{Lt-3} + 45.95671 r_{Lt-4} - 59.30535 r_{Lt-5} - 70.01728 r_{Lt-6} \)

(6) \( S_t = 45.27539 + 0.12244 (AI)_{t} + 0.41478 (AY)_{t} + 0.83455 S_{t-1} + 59.30535 r_{Lt-5} - 70.01728 r_{Lt-6} \)

(7) \( Q_t = -803.93577 + 0.21576 Y_t + 10.05650 P_t + 0.00032 Q_{t-1} + 0.09566 H_{t-1} - 9.75828 P_{t-1} \)

(8) \( r_{Lt} = -0.59281 - 0.0000514 Y_t + 0.13505 r_{st} \)

(9) \( N_{d t} = -1409.01913 + 0.34787 Y_t - 100.45359 r_{st} + 65.53233 P_t - 62.95615 P_{t-1} + 0.90228 H_{t-1} \)

196.
(10) \( N_t^S = -973.97584 + 0.32651 Y_t + 1.13718 B_t \\
(1.17084) (1.17701) (3.17510) \\
+ 0.15251 (\Delta A)_t + 1.10305 r_t - 1.01965 B_{t-1} \\
(1.59741) (2.05059) (1.98502) \\
+ 0.87489 H_t \\
(0.88181) \\
(11) N_t^d = N_t^S = N_t \\
(12) B_t = 226.81270 - 0.06059 Y_t + 0.15419 (SP)_t \\
(0.98958) (1.02475) (3.91712) \\
+ 0.02956 (\Delta BR)_t - 12.05349 P_t + 24.17479 P_{t-1} \\
(3.50277) (2.55529) (2.55529) \\
+ 0.57430 B_{t-1} \\
(4.90126) \\
197\)
4.3 Estimation of the Model Using the \( M_2 \) Definition of Money

In all the results we have produced so far, the definition of money stock we have adopted is the \( M_1 \) one. In this section we provide the results when the \( M_2 \) definition of money is employed. We could not find published series for the \( M_2 \) definition for the whole period so no results are provided for the \( M_2 \) definition of money.

The results of this section are compared with the ones of section 4.2, so that some conclusions about the appropriate \( M_t \) variable might be reached. We note, however, that in the following tables (pp. 202-212) some results are not given. These results are the ones for those equations where a money stock variable does not appear and the OLS technique is used for its estimation. The reason is obvious: these results are exactly the same with the ones we got when the \( M_1 \) definition is employed and since our aim in this section is to compare the two sets of results there is no reason to repeat them here. So for example, no estimates are provided for the investment function in these tables; they are exactly the same with the ones presented in section 4.2c.

The statistical criteria used to determine the model of section 4.2f, suggest that the 'best' estimates for each equation are the following: we note that the equations emerge from a close examination of tables (pp. 202-212).

\[
\begin{align*}
(1) & \quad Y_t = C_t + I_t + S_t + (TA)_t - Q_t \\
(2) & \quad (TA)_t = G_t + X_t - T_{st} \\
(3) & \quad C_t = 1199.42656 + 0.29917 Y_{tt} + 0.47654 (\Delta P)_t \\
& \quad (5.99013) \quad (2.29512) \quad (2.07095) \\
& \quad - 17.44600 P_t + 0.39237 C_t - 10.17153 r_{Lt-3} \\
& \quad (1.95085) \quad (2.16863) \quad (0.50876) \\
& \quad - 5.98825 r_{Lt-4} + 26.07855 P_t - 1 \\
& \quad (0.18317) \quad (2.39792) \\
(4) & \quad Y_{tt} = 0.14707 Y_t + 0.82363 Y_{tt} \\
& \quad (2.40589) \quad (10.79996) \\
(5) & \quad I_t = 145.22408 + 0.05718 (\Delta I)_t + 0.12495 (\Delta Y)_t \\
& \quad (5.05045) \quad (1.75391) \quad (2.41766) \\
& \quad + 0.92316 I_{t-1} - 45.09777 r_{Lt-3} + 43.95671 r_{Lt-4} \\
& \quad (20.76051) \quad (3.45001) \quad (2.45322) \\
\end{align*}
\]
The two sets of results do differ significantly. The significant differences appear in four equations: in the Stock-Building equation, the Imports equation, the Demand for Money equation and the Supply of Money equation.

In the Stock-Building equation the variable \((\Delta M)_t\) becomes insignificant when the \(N_3\)-definition is employed, and in the Imports equation the variable \(M_{t-1}\) becomes insignificant when \(N_3\) is used except in some cases where it appears to retain its significance.

The reason that the \((\Delta M)_t\) variable becomes insignificant in the Stock-Building equation when the \(N_3\) definition is used, is probably, because the wide definition of money is not a good indicator of the liquidity of the industrial sector.
at any rate it is not as good as the $M_4$ definition. It is more difficult to explain the deterioration of the $M_{t-1}$ variable in the Imports equation when the $M_3$ definition is employed. Surely enough, the deterioration as far as the 'T' statistic is concerned is not disastrous and indeed it does not decrease as much as in the case of the $(\Delta M)_t$ variable in the Stock-Building equation. The following explanation seems reasonable. The $M_1$ definition of money is more appropriate when the 'medium of exchange' function of money is stressed, whereas when the 'store of value' function of money is stressed the $M_2$ definition is more appropriate. Now, in the Imports equation the money stock stands more for the 'medium of exchange' function rather than the 'store of value' one and consequently the $M_1$ definition is bound to perform better rather than the $M_3$ definition. This is exactly what our results have shown.

In the Demand for Money equation, both the rate of interest variable and the income variable perform very badly when the $M_3$-definition is used. The bad performance of the rate of interest can be justified as follows: when the rate of interest changes people simply reallocate their money stock holdings between, say, time deposits and demand deposits. When, therefore, the $M_2$-definition of money is used this reallocation is not captured and consequently the interest rate coefficient is bound to be insignificant. The $M_1$-definition clearly shows changes of this nature and consequently the rate of interest coefficient should be significant. Similarly, when the level of income changes, say increases, and the volume of transactions increases too requiring more money to finance it, people would, probably, demand a higher amount of demand deposits in order to satisfy the financing of the higher volume of transactions. Given the money stock, the higher demand for demand deposits may well be satisfied by a lowering in the demand for time deposits. Therefore, the $M_1$ definition of money should perform better at an empirical level than the $M_3$-definition of money.

Finally, the Money Supply equation depicts some differences
but not as significant and drastic as in the other three equations mentioned above. The \((\Delta \Delta)_t\) variable performs better when the \(M_3\) definition is used as one might expect, whereas the \(B_t\) variable performs better when the \(M_1\) definition is employed, again as one might expect.

On the whole, therefore, the model that makes use of the \(M_1\) definition of money performs much better at an empirical level, than the model that utilises the \(M_3\) definition. We thus adopt the model summarised in section 4.2j for the rest of our analysis, although some results are provided with the \(M_3\) definition subsequently simply for comparison and justification of this last result.
<table>
<thead>
<tr>
<th>Name</th>
<th>Code</th>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
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<td>N</td>
<td>W</td>
<td>Description</td>
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<td>Description</td>
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</tbody>
</table>

**Notes:**
- Column 1: Name of the parameter
- Column 2: Code of the parameter
- Column 3: Description of the parameter
- Column 4: Value of the parameter

**Legend:**
- N: Name of the parameter
- W: Code of the parameter
- Description: Description of the parameter
- Value: Value of the parameter
<table>
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<th>V</th>
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**Example Table:**

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<th>b</th>
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**Diagram:**

```
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|                 |
|                 |
+-----------------+
```

**Equation:**

```
\[ \text{Equation} \]
```
| X | Y | Z | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
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*Note: The table contains various values and letters, but the specific context or meaning of the data is not clear from the image.*
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<th>Quality Grade</th>
<th>195.5°F</th>
<th>195.6°F</th>
<th>195.7°F</th>
<th>195.8°F</th>
<th>195.9°F</th>
<th>200°F</th>
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<tbody>
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<td>175°F</td>
<td>200°F</td>
<td>225°F</td>
<td>250°F</td>
</tr>
</tbody>
</table>

**Table Notes:**
- The table provides a range of temperature readings for different quality grades.
- Each row represents a specific temperature range.
- The table is likely used for quality control in material testing or similar processes.

**Reference:**
- The table is referenced from a technical or industrial document.
- The quality grade and temperature ranges are crucial for ensuring product compliance and safety.
<table>
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Note: The table contains numerical data and may require specific software or tools to interpret or analyze.
|       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |�
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<td>7°0'0&quot;</td>
<td>5°0'0&quot;</td>
<td>4°0'0&quot;</td>
<td>3°0'0&quot;</td>
<td>2°0'0&quot;</td>
<td>1°0'0&quot;</td>
<td>9°0'0&quot;</td>
<td>8°0'0&quot;</td>
<td>7°0'0&quot;</td>
<td>5°0'0&quot;</td>
<td>4°0'0&quot;</td>
<td>3°0'0&quot;</td>
<td>2°0'0&quot;</td>
<td>1°0'0&quot;</td>
<td></td>
</tr>
</tbody>
</table>
4.4 The Stability of the Model:

As we have already noted the model we have estimated can be used to determine whether the changes introduced in 1971 i.e. the 'Competition and Credit Control' measures, have caused any structural changes in the system, especially in the monetary sub-sector of it. What we do in this section is to split the period into 1963 2Q - 1971 3Q and allow the model to predict for the 1971 4Q - 1974 3Q. In doing so, we also examine the stability of the estimated model.

The two versions of the model summarised in sections 4.2j and 4.3 have, thus, been reestimated using the TSLS technique, with the exception of the Investment and Stock-Building equation where we are forced to use OLS, and the results obtained are as follows:

We begin with the first version of the model, i.e. we make use of the $M_1$ definition of the money stock:

1. \[ Y_t = C_t + I_t + S_t + (TA)_t - Q_t \]

2. \[ (TA)_t = G_t + X_t - T_{St} \]

3. \[ C_t = 716.99153 + 0.44153 Y^d_t + 0.61979 (AHIP)_t \]
   \[ (1.69805) (2.25674) (1.75555) \]
   \[ - 28.04329 P_t + 0.30076 C_{t-1} - 6.13357 r_{Lt-3} \]
   \[ (1.70127) (1.92438) (0.14666) \]
   \[ + 20.62014 r_{Lt-4} + 31.62535 P_{t-1} \]
   \[ (0.51265) (1.83308) \]

D.W. = 2.39601, \[ S = 53.99001, \]
\[ x^2(3)(20) = 28.98715 \]

Forecasts:

Actuals: 6155.0000, 6222.0000, 6338.0000, 6457.0000, 6601.0000, 6762.0000, 6687.0000, 6716.0000, 6718.0000, 6695.0000, 6614.0000, 6694.0000.

Forecasts: 6222.2290, 6248.2779, 6442.9665, 6474.3309, 6548.2241, 6690.6113, 6773.9114, 6809.6577, 6746.2609, 6543.5058, 6450.4948, 6561.1561.
Errors: 52.7759, 71.3087, -86.9114, -93.6577, -18.6577, 51.5052, 163.5052, 132.8439.

\[ x^2_{(1)(12)} = 37.34789 \]

\[ (4) \quad y^d_t = 0.29342 y_t + 0.63474 y^d_{t-1} \]

D.W. = 1.68563, \[ S = 79.08118, \quad x^2_{(3)(24)} = 28.17257 \]

Forecasts:

<table>
<thead>
<tr>
<th>Actuals:</th>
<th>Forecasts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6776.0000, 6765.0000, 7162.0000, 7101.0000, 7288.0000, 7290.0000, 7578.0000, 7589.0000, 7570.0000, 7379.0000, 7320.0000, 7703.0000.</td>
<td></td>
</tr>
<tr>
<td>6693.2057, 6705.5462, 6736.1218, 6979.0160, 7029.2033, 7304.875, 7232.2062, 7438.4838, 7425.2199, 73411.2062, 7319.21311, 7319.9085.</td>
<td></td>
</tr>
<tr>
<td>6693.2057, 6705.5462, 6736.1218, 6979.0160, 7029.2033, 7304.875, 7232.2062, 7438.4838, 7425.2199, 73411.2062, 7319.21311, 7319.9085.</td>
<td></td>
</tr>
<tr>
<td>6776.0000, 6765.0000, 7162.0000, 7101.0000, 7288.0000, 7290.0000, 7578.0000, 7589.0000, 7570.0000, 7379.0000, 7320.0000, 7703.0000.</td>
<td></td>
</tr>
<tr>
<td>6693.2057, 6705.5462, 6736.1218, 6979.0160, 7029.2033, 7304.875, 7232.2062, 7438.4838, 7425.2199, 73411.2062, 7319.21311, 7319.9085.</td>
<td></td>
</tr>
<tr>
<td>6776.0000, 6765.0000, 7162.0000, 7101.0000, 7288.0000, 7290.0000, 7578.0000, 7589.0000, 7570.0000, 7379.0000, 7320.0000, 7703.0000.</td>
<td></td>
</tr>
<tr>
<td>6693.2057, 6705.5462, 6736.1218, 6979.0160, 7029.2033, 7304.875, 7232.2062, 7438.4838, 7425.2199, 73411.2062, 7319.21311, 7319.9085.</td>
<td></td>
</tr>
</tbody>
</table>

Error:

<table>
<thead>
<tr>
<th>Errors:</th>
<th>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</th>
</tr>
</thead>
<tbody>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
<tr>
<td>258.7967, -34.8785, 3445.7938, 150.5162, 144.7801, 383.0915.</td>
<td></td>
</tr>
</tbody>
</table>

\[ x^2_{(1)(12)} = 93.54249 \]

\[ (5) \quad I_t = 99.20589 + 0.06893 (\Delta I_t) + 0.24958 (\Delta Y)_t \quad (2.63232) (2.82832) \quad (4.93515) \]
\[ + 0.92266 I_{t-1} - 38.42471 r_{t-3} + 42.91633 r_{t-4} (2.75725) (2.44418) (2.69072) \]

\[ S = 24.11249, \quad x^2_{(2)(3)} = 4.46770 \]

Forecasts:

<table>
<thead>
<tr>
<th>Actuals:</th>
<th>Forecasts:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800.0000, 1811.0000, 1814.0000, 1756.0000, 1821.0000, 1916.0000, 1807.0000, 1892.0000, 1892.0000, 1916.0000, 1759.0000, 1796.0000.</td>
<td></td>
</tr>
<tr>
<td>1800.0000, 1811.0000, 1814.0000, 1756.0000, 1821.0000, 1916.0000, 1807.0000, 1892.0000, 1892.0000, 1916.0000, 1759.0000, 1796.0000.</td>
<td></td>
</tr>
<tr>
<td>1800.0000, 1811.0000, 1814.0000, 1756.0000, 1821.0000, 1916.0000, 1807.0000, 1892.0000, 1892.0000, 1916.0000, 1759.0000, 1796.0000.</td>
<td></td>
</tr>
</tbody>
</table>

\[ D.W. = 1.68563, \quad S = 79.08118, \quad x^2_{(3)(24)} = 28.17257 \]

\[ S = 24.11249, \quad x^2_{(2)(3)} = 4.46770 \]
Forecast: -20.7156, 24.4710, -77.2203, -85.9853,
Errors: -64.9285, -55.9151, -50.5518, 15.6410,

\[ x_{(1)}(12) = 140.02578 \]

\[ s_t = 312.95877 + 0.10626 (\Delta M)_t - 0.06930 (\Delta Y)_t \]
\[ (2.06682) \quad (1.38364) \quad (0.85341) \]
\[ - 0.25955 S_{t-1} - 16.73595 \rho_{t-3} - 16.28016 \rho_{t-4} \]
\[ (1.01259) \quad (0.40750) \quad (0.38320) \]
\[ S = 57.92919, \quad x_{(2)(3)} = 1.06244 \]

Forecasts:

Actuals: 42.0000, -146.0000, -102.0000, -107.0000,
-60.0000, 247.0000, 194.0000, 90.0000,
116.0000, -248.0000, 207.0000, 205.0000.

Forecasts: -16.5108, +59.1798, -23.2293, -44.5479,
-14.3226, -87.4449, 194.9015, -9.9812,

Errors: -45.6774, 334.4449, -0.9015, 99.9812,

\[ x_{(1)(12)} = 104.29861 \]

\[ q_t = 661.44010 + 0.23225 Y_t + 27.88265 P_t + 0.19149 Q_{t-1} \]
\[ (2.25636) \quad (3.07589) \quad (2.25633) \quad (0.91495) \]
\[ - 0.00918 M_{t-1} - 24.45095 P_{t-1} \]
\[ (0.16531) \quad (1.89852) \]
\[ D.W. = 2.01446, \quad S = 42.41573, \quad x_{(3)(21)} = 23.25881 \]

Forecasts:

Actuals: 2207.0000, 2309.0000, 2356.0000, 2291.0000,
2561.0000, 2590.0000, 2575.0000, 2675.0000,
2725.0000, 2693.0000, 2664.0000, 2697.0000.

Forecasts: 2203.3923, 2166.0539, 2236.2061, 2237.7105,
2344.7274, 2477.3647, 2488.0739, 2491.0544,
2570.6525, 2595.7067, 2798.2154, 1966.5166.
Forocast 3'-060779, 1112-911619 119.7139, 53.2895, 
Errors: 216.2726, 112.6353, 86.9261, 183.9456, 
154.3475, 97.2933, -134.2154, -269.5166.

\[ x^2_{(1)(12)} = 145.85818 \]

(8) \[ r_{Lt} = -5.4248 + 0.00147 Y_t - 0.05351 r_{st} + 0.88410 r_{Lt-1} \]
\[ (2.78838) \]
\[ (2.78194) \]
\[ (0.72820) \]
\[ + 0.09147 P_t - 0.13196 P_{t-1} \]
\[ (1.36972) \]
\[ (1.73352) \]

D.W. = 1.71487, \[ S = 0.25280, \]
\[ x^2_{(3)(21)} = 26.23144 \]

Forecasts:

Actuals 8.6600, 8.4500, 8.9800, 9.4600, 
9.6300, 9.9500, 10.3200, 11.3000, 

Forecasts 8.9444, 8.1922, 8.1408, 8.3587, 
9.1886, 9.7519, 9.8003, 9.8059, 
10.5728, 10.6554, 12.5497, 13.6322.

Forecast Errors -0.2844, 0.2578, 0.8392, 1.1013, 
0.4414, 0.1981, 0.5197, 1.4941, 
1.2772, 2.7146, 1.9303, 1.6678.

\[ x^2_{(1)(12)} = 317.78286 \]

(9) \[ M^d_t = -1184.72238 + 0.42273 Y_t - 101.65487 r_{st} \]
\[ (1.19365) \]
\[ (1.61127) \]
\[ (1.77238) \]
\[ + 60.1707 P_t - 45.58656 P_{t-1} + 0.62276 M^d_{t-1} \]
\[ (1.77238) \]
\[ (1.22728) \]
\[ (4.28084) \]

D.W. = 2.17832, \[ S = 116.54406, \]
\[ x^2_{(3)(23)} = 31.89349 \]

Forecasts:

Actuals 10910.0000, 11270.0000, 11750.0000, 
11930.0000, 12410.0000, 12370.0000, 
13200.0000, 12860.0000, 13130.0000, 
12780.0000, 13200.0000, 13550.0000.
Forecasts: 10959.3969, 11059.0234, 11366.8854, 11542.2399, 11771.3321, 12172.7636, 12276.0919, 12455.5806, 12889.3231, 12555.5805, 12877.8503, 13613.1459.


\[ x^2_{(1)(12)} = 196.79089 \]

\[(10) \quad M^s_t = 3998.62926 + 0.69669 Y_t + 1.66093 D_t \]
\[ (1.23094) \quad (2.14069) \quad (3.50644) \]
\[ + 0.23268 (\Delta \lambda)_t + 42.99598 r_{t-1} + 0.22767 D_{t-1} \]
\[ (1.91775) \quad (2.03895) \]
\[ + 0.00731 M_{t-1} \]
\[ (0.25193) \]

D.W. = 1.88447, \quad S = 147.23799, \quad x^2_{(3)(20)} = 33.58877

Forecasts:

Actuals: 10910.0000, 11270.0000, 11750.0000, 11930.0000, 12410.0000, 12370.0000, 13200.0000, 12860.0000, 13130.0000, 12780.0000, 13200.0000, 13550.0000.

Forecasts: 10830.8145, 10710.8307, 11772.6960, 11561.9799, 12523.4894, 12641.1013, 12498.3146, 13691.1133, 12854.4650, 12811.7188, 13564.8494, 13708.3307.


\[ x^2_{(1)(12)} = 90.3863 \]

\[(11) \quad M^d_t = M^s_t = N_t \]

\[(12) \quad D_t = 393.77138 - 0.07480 Y_t + 0.01558 (\Delta \lambda)_t \]
\[ (1.19029) \quad (0.82013) \quad (1.45144) \]
\[ + 0.14893 (\Delta P)_t + 2.43261 P_t + 4.80004 P_{t-1} \]
\[ (3.66923) \quad (0.20014) \quad (0.35246) \]
\[ + 0.67911 D_{t-1} \]
\[ (4.85537) \]

217.
We present, now, the model that utilizes the $M_3$ definition of money.

(1) $Y_t = C_t + I_t + s_t + (TA)_t - Q_t$

(2) $(TA)_t = G_t + X_t - T_{st}$

(3) $C_t = 706.61541 + 0.45383 Y^d_t + 0.60782 (\Delta H)_{t-1}^{(3.06010)} (1.72413)$

$27.53132 P_t + 0.29270 C_t - 4.95655 r_{Lt-3}$

$+ 19.79918 r_{Lt-4} + 30.92698 P_{t-1}$

$\begin{align*}
D.W. &= 2.15413, \quad S = 45.32278, \quad x^2_{(3)}(21) = 30.41612 \\
\text{Forecasts:} & \\
\text{Actual} & 4509.0000, 4455.0000, 4693.0000, 4816.0000, 4980.0000, 5001.0000, 5243.0000, 5426.0000, 5477.0000, 5549.0000, 5715.0000, 6017.0000. \\
\text{Forecasts} & 4506.5132, 4489.0429, 4534.6647, 4729.2072, 4847.9193, 5119.1375, 5344.0685, 5527.5228, 5603.3064, 5772.8949, 5986.4164. \\
\text{Forecast Error} & 2.4868, -34.0429, 158.3353, 86.7928, 132.0807, 9.0975, 123.8625, 81.9315, -50.5228, -54.3064, -57.8949, 30.5836. \\
\end{align*}

$x^2_{(1)}(12) = 40.47400$

We present, now, the model that utilizes the $M_3$ definition of money.

(1) $Y_t = C_t + I_t + s_t + (TA)_t - Q_t$

(2) $(TA)_t = G_t + X_t - T_{st}$

(3) $C_t = 706.61541 + 0.45383 Y^d_t + 0.60782 (\Delta H)_{t-1}^{(3.06010)} (1.72413)$

$27.53132 P_t + 0.29270 C_t - 4.95655 r_{Lt-3}$

$+ 19.79918 r_{Lt-4} + 30.92698 P_{t-1}$

$\begin{align*}
D.W. &= 2.38642, \quad S = 53.97198, \quad x^2_{(3)}(20) = 30.15069 \\
\text{Forecasts:} & \\
\text{Actuals} & 6155.0000, 6222.0000, 6338.0000, 6457.0000, 6601.0000, 6762.0000, 6687.0000, 6716.0000, 6718.0000, 6695.0000, 6614.0000, 6694.0000. \\
\text{Forecasts} & 6220.5961, 6245.4022, 6444.0304, 6472.6027, 6548.2889, 6687.8694, 6775.1631, 6810.1223, 6747.2803, 6543.9904, 6451.4793, 6566.8900. \\
\text{Forecast Errors} & -65.5961, -23.4022, -106.0304, -15.6027, 52.7111, 74.1306, -88.1631, -94.1223, -29.2803, 151.0096, 162.5207, 127.1100. \\
\end{align*}

$x^2_{(1)}(12) = 36.89462$
\( Y_t^d = 0.29338 Y_t + 0.631179 Y_{t-1} \)

(3.2025/1) \( (5.146723) \)

D.W. = 1.68577, \( S = 79.08118 \), \( x^2_{(3)(24)} = 27.96598 \).

Forecasts:

Actuals
6776.0000, 6765.0000, 7162.0000, 7101.0000,
7288.0000, 7290.0000, 7578.0000, 7589.0000,
7570.0000, 7379.0000, 7320.0000, 7703.0000.

Forecasts
6693.2053, 6705.5635, 6736.1328, 6979.0506,
7029.2211, 7304.8832, 7232.2221, 7438.5122,
7425.2520, 7344.2477, 7319.2296, 7319.9157.

Forecast
82.7947, 59.4365, 425.8672, 121.9494.

Errors
258.7789, -14.8832, 345.7779, 150.4878,
144.7480, 34.7523, 0.7704, 383.0843.

\( x^2_{(1)(12)} = 93.53192 \)

\( I_t = 99.20589 + 0.06893 (\Delta A I) + 0.24958 (\Delta Y) \)

(4.93315) \( (2.63323) \) \( (2.82832) \)

\( + 0.92266 I_{t-1} - 38.42471 r_{Lt-3} + 42.91633 r_{Lt-4} \)

(2.57275) \( (2.44418) \) \( (2.69075) \)

\( S = 24.11249 \), \( x^2_{(2)(3)} = 4.46770 \)

Forecasts:

Actuals
1800.0000, 1811.0000, 1814.0000, 1756.0000,
1821.0000, 1916.0000, 1807.0000, 1892.0000,
1892.0000, 1916.0000, 1759.0000, 1796.0000.

Forecasts
1820.7156, 1786.5282, 1891.2203, 1841.9853,
1855.9285, 1971.9151, 1857.5518, 1876.3590,

Forecast
-20.7156, 24.4718, -77.2203, -85.9853,
-64.9285, -55.9151, -50.5518, 15.6410,

\( x^2_{(1)(12)} = 140.02578 \)
\[ \begin{align*}
S_t &= 286.55803 + 0.12114 (\Delta N)_t - 0.05213 (\Delta Y)_t \\
&\quad - 0.18284 S_{t-1} - 1.34085 r_{lt-3} - 31.98757 r_{lt-4} \\
&\quad (0.65038) (1.53217) (0.03187) (0.74763) \\
S &= 57.38525, \quad x^2_{(2)(3)} = 0.72073 \\
\end{align*} \]

Forecasts:

Actuals  
\[
\begin{align*}
42.0000, & \quad -146.0000, \quad -102.0000, \quad -107.0000, \\
-62.0000, & \quad 247.0000, \quad 194.0000, \quad 90.0000, \\
116.0000, & \quad -248.0000, \quad 207.0000, \quad 205.0000, \\
\end{align*}
\]

Forecasts  
\[
\begin{align*}
54.4306, & \quad 65.6924, \quad 42.4809, \quad -32.6820, \\
71.3659, & \quad 17.3866, \quad 154.3194, \quad 262.6691, \\
143.3945, & \quad 14.4375, \quad -140.2538, \quad 90.6750, \\
\end{align*}
\]

Forecasts Errors  
\[
\begin{align*}
-12.4306, & \quad -211.6924, \quad -144.4809, \quad -74.3180, \\
-131.3659, & \quad 229.6134, \quad 39.6806, \quad -172.6691, \\
-27.3945, & \quad -262.4375, \quad 347.2538, \quad 114.3250, \\
\end{align*}
\]

\[ x^2_{(1)(1)} = 114.18350 \]

\[\begin{align*}
Q_t &= 70.19218 + 0.15253 Y_t + 10.29868 P_t - 0.41954 Q_{t-1} \\
&\quad + 0.08606 M_{t-1} - 9.63134 P_{t-1} \\
&\quad (0.15698) (1.94848) (3.17989) (1.92798) \\
&\quad (2.31642) \\
D.W. &= 1.95817, \quad S = 41.02279, \quad x^2_{(3)(20)} = 25.22700 \\
\end{align*}\]

Forecasts:

Actuals  
\[
\begin{align*}
2207.0000, & \quad 2309.0000, \quad 2356.0000, \quad 2291.0000, \\
2561.0000, & \quad 2590.0000, \quad 2575.0000, \quad 2675.0000, \\
2725.0000, & \quad 2693.0000, \quad 2664.0000, \quad 2697.0000, \\
\end{align*}
\]

Forecasts  
\[
\begin{align*}
2251.7891, & \quad 2282.4542, \quad 2380.9109, \quad 2476.3446, \\
2568.5538, & \quad 2713.7823, \quad 2781.3071, \quad 2846.7060, \\
3009.0772, & \quad 3099.6435, \quad 3200.7291, \quad 3217.5775, \\
\end{align*}
\]

Forecast Errors  
\[
\begin{align*}
-44.7891, & \quad 26.5458, \quad -24.9109, \quad -185.3446, \\
-7.5538, & \quad -123.7823, \quad -206.3071, \quad -171.7060, \\
-284.0772, & \quad -406.6435, \quad -536.7291, \quad -520.5775, \\
\end{align*}
\]

\[ x^2_{(1)(12)} = 552.77401. \]

220.
\[(8) \quad r_{Lt} = -5.13900 + 0.00147 Y_t - 0.05340 r_{st} + 0.88404 r_{Lt-1} + 0.09144 P_t - 0.13189 P_{t-1}
\]
\[
\begin{align*}
(2.78662) & & (2.78006) & & (0.72668) \\
(7.19801) & & (1.36925) & & (1.73264)
\end{align*}
\]
\[D.W. = 1.71473, \quad S = 0.25280, \quad x^2(3)(21) = 20.57315\]

**Forecasts:**

<table>
<thead>
<tr>
<th>Actuals</th>
<th>Forecasts</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.6600, 8.4500, 8.9800, 9.4600, 9.6300, 9.9500, 10.3200, 11.3000, 11.8500, 13.3700, 14.4800, 15.3000.</td>
<td>8.9445, 8.1926, 8.1412, 8.3593, 9.1891, 9.7520, 9.8006, 9.8067, 10.5738, 10.6558, 12.5507, 13.6333.</td>
<td>-0.281159, 0.2574, 0.8388, 1.1007, 0.4409, 0.1980, 0.5194, 1.4933, 1.2762, 2.7132, 1.9293, 1.6667.</td>
</tr>
</tbody>
</table>

\[x^2_1(12) = 317.41829\]

\[(9) \quad M^d_t = -3343.71300 + 0.70222 Y_t - 86.78400 r_{st} + 52.35131 P_t - 59.53825 P_{t-1} + 0.88718 M_{t-1}
\]
\[
\begin{align*}
(2.02261) & & (1.98319) & & (2.28778) \\
(1.60858) & & (1.35454) & & (8.58573)
\end{align*}
\]
\[D.W. = 2.02585, \quad S = 138.89822, \quad x^2(3)(23) = 31.90883\]

**Forecasts:**

<table>
<thead>
<tr>
<th>Actuals</th>
<th>Forecasts</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>20650.0000, 21620.0000, 23130.0000, 24160.0000, 25860.0000, 27380.0000, 28670.0000, 31010.0000, 33180.0000, 34220.0000, 34830.0000, 35920.0000.</td>
<td>20123.4191, 20932.1787, 21893.2462, 23087.6266, 24196.1388, 25914.0809, 27286.8162, 28122.3705, 30204.0707, 32098.7243, 33561.9413, 34485.8546.</td>
<td>526.5809, 687.8213, 1236.7538, 1072.3734, 1663.8612, 1465.9191, 1383.1838, 2887.6295, 2975.9293, 2121.2757, 1268.5087, 1434.1544.</td>
</tr>
</tbody>
</table>

\[x^2_1(12) = 1846.27184\]
\begin{align*}
(10) \quad M_t^S &= -1247.49064 + 0.20751 Y_t + 0.91279 B_t \\
&\quad (0.82868) \quad (0.68096) \quad (1.34764) \\
&\quad + 0.15176 (DA)_t + 27.09710 r_{dt} - 0.82232 B_{t-1} \\
&\quad (0.86314) \quad (1.38887) \quad (1.35812) \\
&\quad + 0.96961 M_{t-1} \\
&\quad (7.35358)
\end{align*}

D.W. = 1.87376, \quad S = 155.02945, \quad x^2(3)(21) = 33.85991

Forecasts:

| Actuals | 4509.0000, 4455.0000, 4693.0000, 4816.0000, 4980.0000, 5001.0000, 5243.0000, 5426.0000, 5477.0000, 5549.0000, 5715.0000, 6017.0000. |
| Forecasts | 4506.5159, 4489.0225, 4534.0000, 4729.1653, 4847.9024, 4991.9203, 5119.1177, 5344.0205, 5527.4479, 5603.2059, 5772.8315, 5986.3625. |
The results are very encouraging as far as the stability of the parameters are concerned. Admittedly some parameters do differ in the two estimation periods, indeed in some cases there are drastic differences, but on the whole the model performs adequately on this score. The reason of the 'bad' performance of some parameters must be attributed to the limitations of the data series. The estimation period, when splitting the whole period into 1963 2nd Quarter - 1971 3rd Quarter, allows only 34 observations. Given now the large number of predetermined variables and also the fact that the technique of TSLS has been used, some bias is bound to be introduced in the estimated values of the parameters. This last observation however, leads to the logical conclusion that the tests undertaken in this section are rather tentative for this very reason, i.e. data limitations.

It, therefore, follows that since the model seems to be stable we cannot find any clear evidence that the introduction of the 'Competition and Credit Control' new measures in 1971 have caused substantial structural changes.

The negative, absolutely disastrous, aspect of the results reported in this section is the specification for prediction as judged by the $\chi^2(1)$-statistic. In all cases, without even one exception, this statistic is always significant, and indeed, in some cases very much so. It is of course, obvious that it is not just in this section that we find this weakness. We also had significant $\chi^2(1)$-statistics when we allowed only one period for prediction. There may be more than one reason for this result:

(i) the set of explanatory variables in each equation, or in some equations, is not complete enough,

(ii) the form of equation(s) chosen is, probably, not the most appropriate,
(iii) lagged values of the already included explanatory variables should probably have been used as additional variables, and
(iv) higher order autoregressive errors may be present.

We do not feel, however, that we ought to insist excessively on this particular weakness of the model because it has not been constructed for prediction, although, we admit, this aspect of the model should not be completely ignored.

4.5 Further Empirical Investigation:

4.5a Introduction:

The model that we have tested above is an interdependent system, and as such it requires a simultaneous system method for the estimation of its parameters. Although we have been using the TSLS technique it seems that the appropriate method is the three-stage least squares one. Now, the three-stage least squares (3SLS) is a systems method, that is, it is applied to all the equations of the model at the same time and gives estimates of all the parameters simultaneously. It involves, actually, the application of the method of least squares in three successive stages. It utilises more information than the single-equation techniques, that is, it takes into account the entire structure of the model with all the restrictions that this structure imposes on the values of the parameters. The single-equation techniques make use only of the variables appearing in the entire model, but they ignore the restrictions set by the structure on the coefficients of other equations, as well as the contemporaneous dependence of the random terms of the various equations. In simultaneous equations models it is almost certain that the random variable of any equation, $u_t$, will be correlated with the random variable of other equations. This fact is ignored by single-equation methods. In other words, taking into account the nature of economic phenomena and the simplifications


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which we adopt in specifying the econometric models, we may well expect the $u$'s to be contemporaneously correlated, that is,

$$E(U_{it}, U_{jt}) \neq 0$$

where $i$ refers to the $i$th equation and $j$ to the $j$th equation. In our model suppose, for example, that there is an exogenous shock to the system such as an increase in the monetary base. Then both $C_t$ and $I_t$ are likely to increase from their current values and a positive covariance would appear between $U_1$ and $U_2$. If a method of estimation that does not include this information is used, such as two-stage least squares, the estimated coefficients will be needlessly inefficient. The method of three-stage least squares makes use of the non-zero covariances among structural disturbances by first estimating the covariando matrix of two-stage least-squares residuals and then re-estimating all structural parameters simultaneously.

Another reason as to why the 3SLS is more appropriate for a model like ours is the exclusion of some variables from the structural equations. In these equations we normally include explicitly only the most important three or four explanator variables, leaving the influence of the other, less important, variables to be absorbed by the random variable of the relation. If some variables are omitted from more relations of the system it is inevitable that the $u$'s of these relationships are correlated* and hence the application of 3SLS is appropriate. Application of TSLS under these circumstances would ignore part of the information included in the entire system and hence the estimates of the parameters would be less efficient.

* This case may be called 'quasi-autocorrelation' since it is due to the autocorrelated pattern of omitted explanatory variables and not to the behavioural pattern of the values of the true $u$. It is to be stressed that if several autocorrelated explanatory variables are omitted $u$ may not be autocorrelated, since the autocorrelation patterns of the omitted regressors may be such as to offset each other.
A crucial problem of model formulation is that of identification. A model is identified if it is in a unique statistical form, enabling unique estimates of its parameters to be subsequently made from sample data. If a model is not identified then estimates of parameters of relationships between variables measured in samples may relate to the model in question or to another model, or to a mixture of models. In econometric theory two possible situations of identifiability are traditionally distinguished: each equation in a model is

(a) Underidentified
(b) Identified
(c) Exactly identified
(ii) Overidentified.

An equation is underidentified if its statistical form is not unique. A model is underidentified when one or more of its equations are underidentified.

An equation is identified if it has a unique statistical form. It may be exactly identified or overidentified. But in both cases it is identified. A model is identified if all its equations are identified.

We may note at this point that identification problems arise only for those equations which contain coefficients which must be estimated statistically (from sample data). Identification difficulties do not arise for definitional equations, identities, or statements of equilibrium conditions, because such relationships do not require measurement.

Identification is closely related to the estimation of the model. If an equation and therefore the model is underidentified it is impossible to estimate all its parameters with any econometric technique. If an equation is identified, its coefficients can, in general, be statistically estimated. In particular: (a) If the equation is exactly identified, the appropriate method to be used for its estimation is the method of indirect least squares. (b) If the equation is overidentified indirect least squares cannot be applied, because it will not yield unique estimates of the structural parameters.
In this case there are various other methods which can be used, for example 3 SLS.

There are two conditions for identification which we apply in order to establish the identifiability of our model. The Order Condition and the Rank Condition.

The Order Condition, which is a necessary but not a sufficient condition for the identification of an equation, may be stated as follows: For an equation to be identified the total number of variables excluded from it but included in other equations must be at least as great as the number of equations of the system less one. Let,

\[ G = \text{total number of equations (total number of endogenous variables).} \]

\[ K = \text{number of total variables in the model (endogenous and predetermined).} \]

\[ M = \text{number of variables, endogenous and exogenous, included in a particular equation.} \]

Then the order condition for identification may be symbolically expressed as

\[
(K - M) \geq G - 1
\]

(Applying this rule to our model we have:

\[ K = 31, \ G = 11, \]

and for every equation the inequality

\[ 31 - N \geq 11 \]

does hold. Therefore the Order Condition is satisfied, and the model is identified.

The Rank Condition states that: in a system of \( G \) equations any particular equation is identified if and only if it is possible to construct at least one non-zero determinant of order \( G-1 \) from the coefficients of the variables excluded from that particular equation but contained in the other equations of the model. When we apply this rule we find that in all cases it is possible to form determinants of order \( G-1=11 \) which are not zero, and thus establishing that
the model is identified. Furthermore since for all equations,

\[ K - M \geq G - 1 \]

it follows that our model is overidentified.

The analysis so far clearly shows that the appropriate econometric technique for the estimation of the model is the 3SLS or an equivalent technique. It is for this reason that in section 4.5b we apply the Full Information Maximum Likelihood (FIML) technique which is really equivalent to the 3SLS one.

4.5b FIML Estimates:

We provide in this section the FIML estimates for our basic model. The form the equations take is the same as before with one exception. The Demand for Money is written and estimated in a reverse form, making the rate of interest as the dependent variable and the stock of money as one of the independent variables. This is required for estimation purposes, but this formulation introduces some bias because there may be other factors influencing the short-term rate of interest which are of course omitted.*

We note that a new statistic is provided for these estimates. This is the correlation over the sample period between the 'dependent' variable, and its value 'predicted' by the derived reduced form. We denote this statistic with the letters 'COR'. We also provide the structural form error variance which is denoted with the letter \( W \). We begin with the first revision of our model the one that makes use of the \( M_1 \) definition of money.

\[
\begin{align*}
(1) \quad Y_t &\equiv C_t + I_t + S_t + (TA)_t - Q_t \\
&\quad \text{COR } 0.9929.
\end{align*}
\]

\[
\begin{align*}
(2) \quad (TA)_t &\equiv G_t + X_t - T_{st}
\end{align*}
\]

* See the papers by Chow (22), Moroney and Mason(98), and Walters (122).
(3) \[ C_t = 1414.3407^* + 0.31587 Y^d_t + 0.57258 (\Delta Y^d)_t + 0.31587 Yu + 0.57258 (\Delta Y)_t + 17.36554 P_t + 25.11030 P_{t-1} - 10.98091 r_{Lt-3} - 7.63315 r_{Lt-4} + 0.32096 C_{t-1} \]
\[ \text{COR} = 0.9930, \quad W = 281.9007 \]

(4) \[ Y^d_t = 0.35933 Y^d_t + 0.62013 Y^d_{t-1} \]
\[ \text{COR} = 0.9871, \quad W = 393.1246 \]

(5) \[ I_t = 14.1117 + 0.02089 (\Delta A_t)_t + 0.14728 (\Delta Y)_t + 45.49768 r_{Lt-3} + 44.54482 r_{Lt-4} + 0.92805 I_{t-1} \]
\[ \text{COR} = 0.9795, \quad W = 167.7768 \]

(6) \[ S_t = -224.9470 + 0.20208 (\Delta M)_t + 0.40494 (\Delta Y)_t + 58.02088 r_{Lt-3} - 70.58029 r_{Lt-4} + 0.54548 S_{t-1} \]
\[ \text{COR} = 0.6659, \quad W = 350.4344 \]

(7) \[ Q_t = -514.8804 + 0.30981 Y_t - 0.01933 M_{t-1} + 15.37347 P_t + 7.04712 P_{t-1} - 0.08884 Q_{t-1} \]
\[ \text{COR} = 0.9896, \quad W = 231.1109 \]

(8) \[ r_{Lt} = -1.0597 + 0.00002 Y_t + 0.26669 r_{st} + 0.10456 P_t + 0.09204 P_{t-1} + 0.59707 r_{Lt-1} \]
\[ \text{COR} = 0.9784, \quad W = 1.7743. \]

* No T-Value is provided for the constants. The computer programme we have used does not provide this statistic for the constants.
We have also estimated this formulation of the Demand for Money using the T.S.L.S. technique just to be consistent with our methodology, with the following results:

\[ r_{st} = 2.29803 - 0.00130 M_t + 0.00041 Y_t + 0.03446 (SP) t \]
\[ (0.37445) (1.82391) t (0.14175) t (0.23240) \]
\[ + 0.09630 P_t - 0.00007 M_{t-1} \]
\[ (0.62482) (0.45524) t-1 \]

\[ S = 0.81260, \quad x_{(3)}^2 (19) = 36.15600. \]

These results are not really very different from the F.I.M.L. ones.

---

We turn, now, to the estimation of the model when the \( M_3 \) definition of money is utilized.

(1) \[ Y_t = C_t + I_t + S_t + (TA) t - Q_t \]
\[ (TA) t = G_t + X_t - T_{st} \]

(11) \( M_d = M_t = M_t \)

(12) \[ B_t = -383.0845 + 0.13968 Y_t + 0.00438 (ABR) t \]
\[ (2.28838) (1.19564) \]
\[ + 0.025575 (SP) t - 7.94380 P_t + 24.40773 P_{t-1} \]
\[ (1.99922) (1.19688) t (3.02649) \]
\[ + 0.33156 B_{t-1} \]
\[ (3.15200) \]

\[ COR = 0.9972, \quad W = 268.5073 \]

We turn, now, to the estimation of the model when the \( M_3 \) definition of money is utilized.
(3) $c_t = 1817.9620 - 0.07525 \, y_t + 0.11898 \, (AiP)_t$
\[ (0.43088) \quad (0.60067) \]
\[- 12.13810 \, P_t + 22.65633 \, P_{t-1} + 0.51174 \, c_{t-1} \]
\[ (2.49329) \quad (3.87291) \quad (3.64403) \quad (t-1) \]
\[- 8.12474 \, r_{Lt-3} - 5.10757 \, r_{Lt-4} \]
\[ (0.23791) \quad (0.15244) \]
\[ \text{COR} = 0.7353, \quad W = 345.4497 \]

(4) $y_t = 0.29090 \, y_t + 0.55065 \, y_{t-1}$
\[ (3.25247) \quad (12.56155) \]
\[ \text{COR} = 0.7474, \quad W = 458.6972 \]

(5) $r_t = 135.9732 + 0.02389 \, (AIA)_t + 0.14444 \, (AY)_t$
\[ (1.40650) \quad (4.86780) \]
\[ + 0.83954 \, r_{t-1} - 39.10838 \, r_{Lt-3} + 50.03688 \, r_{Lt-4} \]
\[ (22.23241) \quad (2.64189) \quad (3.34764) \]
\[ \text{COR} = 0.9767, \quad W = 158.3120 \]

(6) $s_t = -24.0003 + 0.01804 \, (AM)_t + 0.35324 \, (AY)_t$
\[ (0.82206) \quad (4.70156) \]
\[ + 0.66981 \, s_{t-1} + 61.60728 \, r_{Lt-3} - 67.89958 \, r_{Lt-4} \]
\[ (6.64595) \quad (1.72511) \quad (1.73682) \]
\[ \text{COR} = 0.5704, \quad W = 384.8122 \]

(7) $q_t = -257.0848 + 0.26903 \, y_t + 5.12691 \, p_t$
\[ (4.78329) \quad (3.51417) \]
\[ + 0.26755 \, p_{t-1} - 0.09806 \, q_{t-1} + 0.01282 \, M_{t-1} \]
\[ (0.19153) \quad (0.77537) \quad (2.22177) \quad (t-1) \]
\[ \text{COR} = 0.9533, \quad W = 260.1913 \]

(8) $r_{Lt} = 0.6965 + 0.14771 \, r_{st} + 0.00034 \, y_t + 0.07353 \, p_t$
\[ (3.46714) \quad (1.04747) \quad (7.81417) \]
\[ - 0.05786 \, p_{t-1} + 0.62553 \, r_{Lt-1} \]
\[ (6.11834) \quad (8.44224) \]
\[ \text{COR} = 0.9481, \quad W = 1.6869 \]
These results clearly show that there are not really drastic differences between the T.S.L.S. and FINL estimates with the exception of the demand for money and in two other cases, i.e. the $M_{t-1}$ variable in the imports equation, and the $(\Delta A)_t$ in the supply of money equation. It may be that the

* The TSLS estimates of this equation are as follows:

\[ r_{st}^* = -2.3557 + 0.00078 N_t + 0.00468 Y_t \]
\[ (0.83657) \] \[ (4.46596) \]
\[ + 0.02552 P_t - 0.26586 P_{t-1} + 0.00007 M_t \]
\[ (1.12197) \] \[ (-12.03259) \]
\[ s = 0.72210, \quad \chi^2(19) = 35.00069 \]

Apparently these results are not really very different from the above.
deterioration in the coefficients of the last two variables is due to the removal of the simultaneity bias, or indeed lagged values of these should have been used. The near collapse of the demand for money when the FIML technique is employed is more obvious - the complete collapse is just saved by the negative and significant $M_t$ coefficient when the $M_t$ definition is used. The way we have postulated the demand for money looks very suspicious indeed. The treasury bill rate is used as the dependent variable; now apart from the fact that even if we could use this rate as an endogenous variable we should still expect some deterioration as explained above, there is now the question whether this rate can be used as an endogenous variable. The answer is of course, that we cannot treat it as such because the authorities during the period have in fact used this rate as an instrument, and, consequently, we are not justified in treating it as an endogenous in the FIML case. It follows that the demand for money performs so badly because of the way we postulated this equation. It also follows that we are perfectly justified in treating this rate as an exogenous in the OLS and TSLS cases. Since, therefore, the results obtained using TSLS and FIML are not really very different and since it is only in the TSLS case that we can use the short-term rate as an instrument, we shall use the TSLS estimates in the following analysis.
CHAPTER 5

POLICY IMPACT, IMPLICATIONS, AND CONCLUSIONS

5.1 Introduction:

In this section we examine the impact and implications of alternative monetary policies. In particular, the impact and implications of money stock and interest rate policies are considered, in order to determine which one of them is the optimal. The way we go about solving this problem is to derive what we have called - see chapter 3 section 4 - dynamic multipliers. We are now able to derive the dynamic multipliers since we have obtained structural estimates of our basic model derived and discussed in chapter 3 and summarised in section 3. The structural estimates we use for the derivation of the dynamic multipliers are the ones discussed in chapter 4 and summarised in section 2. These structural estimates utilise the M₁ definition of money as we have already noted. We do not want to give the impression that we are arguing here that the M₁ definition is the proper one beyond any doubt. Such a conclusion should require more empirical investigation, especially on the substitution relationships between different definitions of money and different returns on assets competing with money for a place in the individuals different portfolios. This we have not done; it is beyond the scope of this study. Instead we believe that from our empirical investigation it seems that the M₁ definition of money performs better than the M₂ definition of money at an empirical level as far as our model is concerned.

We also note that the policy instruments here are $r_{st}$ and $(SP)_{t}$. The $r_{st}$ is the treasury bill rate, and it is used as the interest rate instrument. The $(SP)_{t}$ is the security portfolio instrument which is used instead of the money supply or base money which are themselves endogenous. The $(SP)_{t}$ instrument affects the money supply via the base money, and it can, therefore, be legitimately used as the money supply instrument.
5.2 Dynamic Multipliers - Derivation and Implications

The way we derive the dynamic multipliers has already been discussed in chapter 3 section 4. First of all we solve the estimated structural equations to obtain the reduced form for gross national product. This form contains lagged endogenous variables, and by successive substitutions we get rid of all the lagged endogenous variables, except, of course, the lagged $Y_t$. The resulting equation is called the 'fundamental dynamic equation'. The fundamental dynamic equation for gross national product is:

\[
Y_t = 0.135 + 4.339 Y_{t-1} - 9.642 Y_{t-2} + 10.655 Y_{t-3} \\
- 6.924 Y_{t-4} + 2.659 Y_{t-5} - 0.575 Y_{t-6} + 0.051 Y_{t-7} \\
- 0.043 r_{st} + 0.260 r_{st-1} - 0.676 r_{st-2} \\
+ 0.985 r_{st-3} - 0.927 r_{st-4} + 0.555 r_{st-5} \\
- 0.257 r_{st-6} + 0.097 r_{st-7} + 0.022 (SP)_{t-1} \\
- 0.121 (SP)_{t-2} + 0.250 (SP)_{t-3} - 0.240 (SP)_{t-4} \\
+ 0.102 (SP)_{t-5} - 0.005 (SP)_{t-6} - 0.009 (SP)_{t-7} \\
+ 0.002 (SP)_{t-8}
\]

Clearly, the $(SP)_t$ and $r_{st}$ variables are measured in different dimensions. In order to avoid complications of this nature, the estimated coefficients in equation 1 have been multiplied by the ratio of the standard deviation of the independent and dependent variables so that the coefficients can be compared directly. They are, thus, expressed in standard units and direct comparison is now possible.

Equation (1), now, can be put to two important uses:

Firstly, it can be used to determine the characteristic stability of the system. In order to do this we follow the
procedure described by Chiang* and Chipman**. We recall, first of all, that the system is stable if every root of the characteristic equation is less than 1 in absolute value. Next, we write the characteristic equation in a general way as:

\[ (2) \alpha_0 b^n + \alpha_1 b^{n-1} + \cdots + \alpha_{n-1} b + \alpha_n = 0 \]

The application, now, of the Schur theorem implies that the roots of polynomial (2) will all be less than unity in absolute value if and only if the following \( n \) determinants are all positive:

\[
\Delta_1 = \begin{vmatrix} a_0 & a_n & a_{n-1} \\ \cdots & \cdots & \cdots \\ a_n & a_0 & a_{n-1} \end{vmatrix}, \quad \Delta_2 = \begin{vmatrix} a_0 & a_n & a_{n-1} \\ \cdots & \cdots & \cdots \\ a_n & a_0 & a_{n-1} \end{vmatrix}, \\
\Delta_n = \begin{vmatrix} a_0 & \cdots & \cdots & \cdots & a_0 & a_n & a_{n-1} \\ a_1 & a_0 & \cdots & \cdots & \cdots & a_0 & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n-1} & a_{n-2} & \cdots & \cdots & a_0 & \cdots & \cdots \\ a_n & \cdots & \cdots & \cdots & a_0 & a_1 & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n-1} & a_n & \cdots & \cdots & \cdots & a_0 & \cdots \end{vmatrix}
\]

We explain the construction of the above determinants with the help of the dashed lines. In the upper-left area, we have \( a_0 \) in the diagonal, zeros above the diagonal, and progressively larger subscripts for the successive coefficients in each column below the diagonal elements. In the lower-left area we have \( a_n \) along the diagonal, zeros above it, and below

---


it the subscripts now decrease. Finally the upper-right area is a mirror image of the lower-left area, and the lower-right area a mirror image of the upper-left area.

We have applied this theorem to our basic difference equation and the result is that the system is stable.

The second use for equation (1) is to solve for the dynamic multipliers. This is achieved by using equation (1) to express national product in terms of initial conditions, which can be taken as given, and the current values of the exogenous variables. The time period is then increased by one unit and gross national product in that period is expressed in terms of initial conditions and the current and lagged values of the exogenous variables. Successive unit increases in the time period generates a series of dynamic multipliers. We provide a specific example, now, in order to clarify the procedure.

We write equation (1) as:

\[ Y_1 = a_{o1} + a_{11} r_{s1} + a_{21} (SP)_1 \]

All terms dated prior to period 1 are considered to be given by the initial conditions. This, enables us to write (3) as:

\[ Y_1 = a_{o1} + a_{11} r_{s1} + a_{21} (SP)_1 \]

where \( a_{o1} \) includes all terms in equation (3) given by the initial conditions; \( a_{11} = -0.043 \) is the current-period dynamic multiplier of the rate of interest, and \( a_{21} = 0 \) is
the current-period dynamic multiplier of the money stock. Substituting equation (4) into equation (3) and setting \( t = 2 \) we express \( Y_2 \) in terms of initial conditions and the values of the exogenous variables in both the current and first period:

\[
(5)\quad Y_2 = 0.135 + 4.339 a_{01} + 4.339 \left[ -0.043 r_{s1} + 0(SP)_1 \right] \\
- 9.642 Y_0 + 10.655 Y_{-1} - 6.924 Y_{-2} + 2.659 Y_{-3} \\
- 0.575 Y_{-4} + 0.051 Y_{-5} - 0.043 r_{s2} + 0.260 r_{s1} \\
- 0.676 r_{s0} + 0.985 r_{s-1} - 0.927 r_{s-2} + 0.555 r_{s-3} \\
- 0.257 r_{s-4} + 0.097 r_{s-5} + 0.022 (SP)_1 \\
- 0.121 (SP)_0 + 0.250 (SP)_{-1} - 0.240 (SP)_{-2} \\
+ 0.102 (SP)_{-3} - 0.005 (SP)_{-4} - 0.009 (SP)_{-5} \\
+ 0.002 (SP)_{-6}
\]

or,

\[
(5)\quad Y_2 = a_{12} + a_{22} r_{s1} + a_{32} (SP)_1
\]

where \( a_{12} \) includes all terms in equation (5)\(^1\) given by the initial conditions; \( a_{22} \) now is the multiplier for gross national product in the second quarter of the rate of interest in the first quarter, that is:

\[
a_{22} = 4.339 (-0.043) + 0.260 = 0.073.
\]

Similarly, \( a_{32} \) is the multiplier for gross national product in the second quarter of money stock in the first quarter, which is equal to:

\[
a_{32} = 4.339(0) + 0.022 = 0.022.
\]

Further substitutions of this type give us the multipliers for gross national product in subsequent quarters of the rate of interest and money stock policy variables in the first quarter. These multipliers are of course what we have already called 'dynamic multipliers'. They measure the net change in
Y during a given period attributable exclusively to a unit change in an exogenous variable during a particular period in the past.

The dynamic multipliers of the rate of interest and security portfolio of the Bank of England are computed for lags up to 8 quarters. They appear in the following table:

**Dynamic Multipliers for the Time Path of Gross National Product**

<table>
<thead>
<tr>
<th>Lags, i</th>
<th>$r_{st-i}$</th>
<th>$(SP)_{t-i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.043</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>+0.073</td>
<td>+0.022</td>
</tr>
<tr>
<td>2</td>
<td>+0.056</td>
<td>-0.025</td>
</tr>
<tr>
<td>3</td>
<td>+0.066</td>
<td>-0.071</td>
</tr>
<tr>
<td>4</td>
<td>-0.105</td>
<td>-0.073</td>
</tr>
<tr>
<td>5</td>
<td>-0.560</td>
<td>+0.052</td>
</tr>
<tr>
<td>6</td>
<td>-1.141</td>
<td>+0.400</td>
</tr>
<tr>
<td>7</td>
<td>-0.925</td>
<td>+0.860</td>
</tr>
<tr>
<td>8</td>
<td>+0.830</td>
<td>+0.763</td>
</tr>
</tbody>
</table>

The dynamic multiplier of the rate of interest rises to a peak after a six quarter lag, whereas the dynamic multiplier of the security portfolio rises to a peak after a seven quarter lag. Both sets of dynamic multipliers reach their peak with oscillations as one might expect. The reason, however, why we have the peaks of the dynamic multipliers in the sixth and seventh quarters is because of the lags involved in the case of the interest rate, and in the case of the security portfolio the fact that any increases in the money supply and their resulting impact on the level of income induce more increases in the money supply until the peak is reached in the seventh quarter.

Inspection of the above table reveals that in these quarters where the dynamic multipliers have the right sign, we observe that the impact of the rate of interest is stronger than that of the money supply as it is represented, so to speak, by the security portfolio instrument. It follows, therefore, that an interest rate policy is preferable to a
money supply policy in the context of the model considered above. This conclusion is obviously based on estimated coefficients of a small, linear macromodel incorporating relationships of the monetary sector also. The degree of faith one attaches to these coefficients depends obviously on one's confidence in the theoretical and empirical specification of the model. Considering, though, that we have avoided simple linear one-equation, models, and also the fact that our model has been tested with more appropriate techniques than just that of the O.L.S. the ground for confidence seems to be quite firm. There is, however, one important problem which deserves some attention. In our analysis we have regarded the two instruments of monetary policy as being exogenously determined. Such a treatment, though, may result in inconsistent estimates of the parameters of the system, and therefore inconsistent dynamic multipliers; this inconsistency may arise when the setting of instruments by the authorities is affected by the rest of the economic system. In this case what is required is joint estimation of the relationships that explain the setting of the instruments of monetary policy by the authorities with the rest of the relationships that comprise the model under examination. An analysis of this kind may also help to shed some light on the issue of the exogeneity/endogeneity of monetary aggregates in empirical studies of money and economic stabilisation. In the following section, then, we try to tackle some of the problems that arise from these issues.

5.3 Joint Estimation:

We begin by postulating the arguments that can be used as explanatory variables in the treasury bill and security portfolio of the Band of England equations. We consider the latter first.

The Bank's security portfolio is treated as the open-market instrument, and as such, it is the primary determinant of the level of the base money and deposits in the economy,
and hence the money supply, as it is clearly shown in equations (11) and (12) of our basic model. We have already seen, however, in chapter 2 section 1 that there is the argument that the Bank's security portfolio had been operated essentially as an instrument for debt management* before the Bank altered its tactics in the market.** This, of course is what is known as the policy of 'leaning into the wind'. Goodhart (60) suggests that even within the context of a policy of 'leaning into the wind' the authorities may vary their portfolio with reference to their stabilisation objectives. The security portfolio in this case, however, does not remain a strictly exogenous policy instrument, and the variable one might consider in explaining the security portfolio would be the changes in interest rates on government securities. This specification, however would be very inadequate because when the rate of interest is a proximate target variable it would vary very little in comparison to the instrument utilised to achieve the end. Following Nobay (102) we consider the discrepancy between the authorities' preferred rate and the 'ex-ante' rate of interest to be the variable that explains changes in the security portfolio of the Bank.

This discrepancy is assumed to be related to two variables:
(i) the forward discount on sterling \((r_f)\), and
(ii) the level of the U.S.A. short-term rate \((r_u)\).

The inclusion of the forward discount on sterling is justified on the grounds that this is a variable which is the outcome of speculation influenced by the demand for currency, expectations of the domestic economy, the position and prospects for the external balance, etc; and that these arguments reflect and parallel closely the views of gilt-edged holders. The U.S.A. short-term rate is included as a

---

* See the papers by Goodhart (60), Norton (103), and the Bank of England Quarterly Bulletin, June 1966.

proxy for an overseas rate. In an open economy with a truly international capital market, like the City of London, an overseas rate is very important in the portfolio decisions of institutions and persons holding gilt-edged securities; it is also very important in their formulations of the 'ex-ante' rate.

We also postulate that the discrepancy between the authorities preferred rate and the 'ex-ante' rate can be affected by Special Deposits (SD). It has been generally accepted that Special Deposits calls have been met by the banks via a reduction of their treasury bills and gilt-edged securities in their portfolios; and to quote the Bank: "the cash required by the banks to make the deposits would be provided by the Bank—normally by the purchase of Treasury Bills, or possibly by the purchase of stock maturing in the near future which was widely held as a money market asset. In the weekly Bank Return the Treasury Bills (and stock) would form the counterpart of the special deposits". All this implies that the Bank's security portfolio increases when special deposits are called, with the banking sector reducing their security portfolio. It is possible, however, to have a situation where although the banks reduce their security portfolio the Bank does not increase its own portfolio. We assume that the Bank reacts to discrepancies between the desired bond rate change and the 'ex-ante' bond rate change. Now if no such discrepancy exists, the Bank need not purchase securities that are off-loaded by the banks. Sure enough, if the off-loading is substantial some impact on the gilt-edged market will occur, and the Bank will, therefore, purchase securities in the


first instance. The Bank, however, could always neutralise these purchases, or indeed, reduce its portfolio to augment its policy stance; and as the Governor of the Bank notes: 'it is open to the authorities - and the banks understand this - to ensure that the whole adjustment by the banks is not completed by such sale of gilts. The initial call for Special Deposits can be supplemented by open market operations, by action on interest rates, and in due course by further calls of Special Deposits'.

Furthermore, we include the difference between the U.K. short-term rate and the U.S.A. short-term rate as another variable, our familiar $r_{dt}$, that can explain some of the changes in the security portfolio. This is justified as follows: The authorities may regard this difference as a target variable to influence inflows of capital for balance-of-payments considerations. They may therefore try to influence this difference through open market operations instead of changing the Bank Rate (or Minimum lending Rate, as it is now called) in the first instance. We also include $Y_t$ and $P_t$ which are assumed to capture influences from the real sector. These two variables are also included in the $r_{st}$- and(SD)$_t$-equations for the same reason. The equation for the security portfolio therefore, to be included in our model is:

$$(SP)_t = g_o + g_1(SD)_t + g_2r_{ut} + g_3r_{ft} + g_4r_{dt} + g_5Y_t + g_6P_t + W_t$$

where $W_t$ = error term; all coefficients are expected to be positive except $g_4$ which is expected to be negative.

The treasury bill rate equation is postulated to be:

$$r_{st} = r_o + r_{1}r_{ut} + r_{2}r_{ft} + r_{3}Y_t + r_{4}P_t + V_t$$

where $V_t$ = error term.

We thus assume that the treasury bill rate is mainly influenced by the forward discount rate on sterling, and the

U.S.A. short-term rate; these variables are assumed to reflect the authorities' responses to balance-of-payments considerations. It seems reasonable to make this assumption because the authorities have varied this rate during the period under consideration mainly to influence capital movements. We also note that we expect all coefficients to be positive.

Finally, since Special Deposits have been introduced as an instrument we postulate that they are influenced by the following variables:

\[(SD)_t = k_0 + k_1(SP)_t + k_2 r_{at} + k_3 r_{dt} + k_4 Y_t + k_5 P_t + U_t\]

We note that the Special Deposits instrument did not perform well at all in any of the equations of our basic model. The reason may be that any call for Special Deposits and its immediate expected impact on the base of the system is offset by changes in the authorities' security portfolio. We therefore introduce the latter in the \((SD)_t\)-equation. The variable \(r_{dt}\) is introduced in order to capture any attempts by the authorities to neutralise the effects of overseas inflows on the domestic money supply, by withdrawals through Special deposit calls on the clearing banks. This specification would only be valid of course, if the authorities regard \(r_{dt}\) as a target of policy for balance-of-payments purposes. Finally, the \(r_{st}\) item is included as a proxy for the Bank Rate (or Minimum Lending Rate), since the rate on deposits is tightly related to it. We expect all coefficients to be positive except \(k_3\) which is expected to be negative.

We have estimated the above three equations using the O.L.S. technique - mainly, in order to be able to examine the dynamic structure of these three equations - and the T.S.L.S. technique within the context of our basic model; in the latter case the three equations postulated in this section are jointly estimated with the equations of our basic model. The results are reported below, beginning with the O.L.S. estimates:
First, the estimates of the \( (SP)_t \) equation:

\[
(\text{SP})_t = -791.54197 + 0.33570 Y_t + 0.821129 (SD)_t
\]

\[
(1.01893) \quad (2.26155) \quad (4.48876)
\]

\[
+ 6.73052 P_t + 6.6702 rdt + 74.82866 rut
\]

\[
(1.60060) \quad (0.20365) \quad (2.09242)
\]

\[
- 4.90937 \text{rt}
\]

\[
(0.15849)
\]

D.W. = 2.01488, \( S = 194.058139 \), \( x^2(2)(6) = 5.89988 \), \( R^2 = 0.94226 \).

**One Period Ahead 'Forecasts'**

Actual: 5957.0000
Forecast: 5472.0000
Forecast Error: 484.8597

\( x^2(1)(1) = 6.24264 \)

The \( x^2(2) \)-statistic is comportably insignificant at the 5% level, which implies that the dynamic specification of the equation is adequate. The \( p = -0.02734 \) and with a T-value being: \( T = 0.15322 \) the SF form is preferable to the other two forms and it is this form we have just reported. The coefficients of the \( (SP)_t \) equation are of a mixed nature as far as their significance is concerned, as it can be judged by the T-value. Only the income, Special Deposit and \( r_{ut} \) variables have the right signs and are significant. The remaining variables are insignificant all three of them, and in two cases they also have the wrong sign i.e. \( r_{dt} \) and \( r_{ft} \). The specification of the equation for prediction is unacceptable at the 5% level but acceptable at the 1%; this is judged by the \( x^2(1) \)-statistic. This equation has also been estimated without the variables \( Y_t \) and \( P_t \) included in it. The results are very similar with one exception. Addition of the variables \( Y_t \) and \( P_t \) that are supposed to reflect influences from the real sector, does not improve the \( R^2 \)-statistic by much; there is only a 3%, approximately, improvement in the \( R^2 \).
The short-term rate of interest estimated equation is now provided:

\[
\begin{align*}
r_{st} &= -0.98182 + 0.00016 Y_t + 0.01509 P_t + 0.73719 r_{ut} \\
&\quad + 0.30379 r_{ft} \\
S &= 0.65518, \quad x^2(2)(4) = 5.98581, \quad R^2 = 0.92346
\end{align*}
\]

One Period Ahead 'Forecasts'

Actual: 11.41
Forecast: 10.5961
Forecast Error: 0.8139

\[x^2_{(1)}(1) = 1.54312\]

This is the R.T.F. form with \(\rho = 0.54657\) and its T-Value being \(T = 3.64728\). It follows, that in the \(r_{st}\) equation the errors are of the first order autoregressive scheme. The \(x^2(2)\)-statistic is comfortably insignificant at the 5% level implying adequate dynamic specification. The specification for prediction is also adequate as it is revealed by the insignificance of the \(x^2(2)\)-statistic. The interesting point about the estimates of this equation is that the overseas rates dominate it, justifying the proposition that the treasury bill rate in the U.K. has been very much influenced by the going rates elsewhere.

The third and final equation is that for Special Deposits:

\[
\begin{align*}
(SD)_t &= -1280.40751 + 0.06257 Y_t + 0.12150 (SP)_t \\
&\quad + 69.97099 r_{st} + 0.87945 P_t - 24.32140 r_{dt} \\
S &= 114.85251, \quad x^2(2)(5) = 9.91356, \quad R^2 = 0.91594
\end{align*}
\]

One Period Ahead 'Forecasts'

Actual: 915.0000
Forecast: 961.0000
Forecast Error: -46.2538

\[x^2_{(1)}(1) = 0.16219\]
Again, this is the R.T.F. form with $p$ being significant as before, i.e.

$$p = 0.64422, \text{ and its T-value being: } T=5.35783;$$

and again the errors are of the first order autoregressive scheme. The $\chi^2$-statistic is comfortably insignificant at the 5% level suggesting adequate dynamic specification. As in the case of the $r_{st}$ equation similarly in the $(SD)_t$ equation the two variables $Y_t$ and $P_t$ appear with an insignificant coefficient, suggesting that the impact of the real forces on $(SD)_t$ is very weak, whereas the influence of the financial variables is stronger, especially that of $r_{st}$ and $r_{dt}$. In particular, the sign and significance of the $r_{dt}$-coefficient supports the view that the authorities have in fact attempted to neutralise the effects of overseas inflows on the domestic money supply.

We now provide the TSLS estimates for our basic model that includes the above three equations too.

(1) \[ Y_t \equiv C_t + S_t + (TA)_t - Q_t \]

(2) \[ (TA)_t \equiv G_t + X_t - T_{st} \]

(3) \[ C_t = 1186.83919 + 0.31754 Y_d + 0.46373 (AIIP)_t \]

\[ - 17.06264 P_t + 0.27916 C_{t-1} - 8.53623 r_{Lt-3} \]

\[ - 7.07026 r_{Lt-4} + 25.47110 P_{t-1} \]

D.W. = 2.12751, \quad S = 55.66504, \quad \chi^2(3)(20) = 32.67161

One Period Ahead 'Forecasts'

Actual: \quad 6694.0000

Forecast: \quad 6904.5786

Forecast Error: \quad -210.5786

\[ \chi^2(1)(1) = 14.31078 \]

(4) \[ Y_d = 0.14709 Y_t + 0.82360 Y_d \]

D.W. = 2.07006, \quad S = 107.65745, \quad \chi^2(3)(24) = 38.70526.

247.
One Period Ahead 'Forecasts'

Actual: 7705.0000  
Forecast: 73609.0363  
Forecast Error: 333.9637  

\[ x^2_{(1)}(1) = 9.62299 \]

(5) \[ I_t = 145.22408 + 0.03718 (\Delta I)_{t-1} + 0.12493 (\Delta Y)_{t} \\
(3.05045) (1.75291) (2.91766) \\
+ 0.92218 I_{t-1} - 45.097777 r_{Lt-3} + 43.95671 r_{Lt-4} \\
(20.76051) (2.45001) (2.45322) \]

\[ S = 39.55341, \quad x^2_{(2)}(3) = 8.88094 \]

One Period Ahead 'Forecasts'

Actual: 1796.0000  
Forecast: 1816.8919  
Forecast Error: -20.8919  

\[ x^2_{(1)}(1) = 0.27899 \]

(6) \[ S_t = 45.27589 + 0.12244 (\Delta M)_{t-1} + 0.41478 (\Delta Y)_{t} \\
(0.99875) (2.17534) (4.98662) \\
+ 0.83433 S_{t-1} + 59.30555 r_{Lt-3} - 70.01728 r_{Lt-4} \\
(6.82218) (1.95854) (2.11993) \]

\[ S = 70.97051, \quad x^2_{(2)}(3) = 3.33582 \]

One Period Ahead 'Forecasts'

Actual: 205.0000  
Forecast: 75.6482  
Forecast Error: 129.3518  

\[ x^2_{(1)}(1) = 3.32192 \]

(7) \[ Q_t = 804.14555 + 0.21581 Y_t + 10.06029 P_t + 0.08822 Q_{t-1} \\
(3.60361) (3.86124) (1.33312) (0.54049) \\
+ 0.09369 M_{t-1} - 9.76337 P_{t-1} \\
(3.18609) (1.05900) \]

D.W. = 2.08162,  
\[ S = 49.31844, \quad x^2_{(3)}(21) = 32.10962 \]
One Period Ahead 'Forecasts'

Actual: 2697.0000  
Forecast: 2752.9322  
Forecast Error: -55.9322  
\[ x^2_{(1)}(1) = 1.28619 \]

\begin{align*}
(8) \quad r_t = & -0.31437 X_{t-1} + 0.14432 Y_t + 0.71780 r_{t-1} \\
& + 0.10389 P_t - 0.09076 P_{t-1} \\
& (0.26007) (0.08507) (4.06785) (7.59553) (2.00695) (1.62285)
\end{align*}

D.W. = 1.72571,  \quad S = 0.28331,  \quad x^2_{(3)}(21) = 35.17780.

One Period Ahead 'Forecasts'

Actual: 15.3000  
Forecast: 14.7823  
Forecast Error: 0.5177  
\[ x^2_{(1)}(1) = 3.33969 \]

\begin{align*}
(9) \quad M_t = & 1566.06578 + 0.36982 Y_t - 105.19168 r_{t-1} \\
& + 69.33495 P_t - 68.02000 P_{t-1} + 0.90938 M_{t-1} \\
& (1.92382) (1.89710) (4.73619) (2.21543) (1.71303) (9.19605)
\end{align*}

D.W. = 2.86669,  \quad S = 173.67179,  \quad x^2_{(3)}(23) = 41.69190

One Period Ahead 'Forecasts'

Actual: 13550.0000  
Forecast: 13280.4089  
Forecast Error: 269.5911  
\[ x^2_{(1)}(1) = 2.40964 \]

\begin{align*}
(10) \quad M_t = & -958.03674 + 0.22337 Y_t + 1.22426 B_t + 0.15403 (\Delta A)_t \\
& + 41.18207 r_{t-1} - 1.10006 B_{t-1} + 0.86593 M_{t-1} \\
& (1.15827) (1.15823) (2.26926) (1.40872) (2.03116) (7.92394)
\end{align*}

D.W. = 2.64711,  \quad S = 204.35729,  \quad x^2_{(3)}(21) = 43.79374
One Period Ahead 'Forecasts'

Actual: 13550.0000
Forecast: 13685.1555
Forecast Error: -135.1555

\[ x_{(1)}(1) = 0.43741 \]

(11) \( M^d_t = M^S_t = M_t \)

\[ B_t = 257.98318 - 0.06861 Y_t + 0.15289 (SP)_t \]
\[ + 0.02962 (ABR)_t - 14.51145 P_t + 26.61849 P_{t-1} \]
\[ + 0.54614 \]
\[ \text{D.W.} = 1.76405, \quad S = 51.77051, \quad x_{(3)}(21) = 37.35901 \]

One Period Ahead 'Forecasts'

Actual: 6017.0000
Forecast: 6038.0000
Forecast Error: -21.5423

\[ x_{(1)}(1) = 0.17315 \]

(13) \( (SP)_t = -797.56297 + 0.36883 Y_t + 0.72057 (SD)_t \]
\[ + 7.52095 P_t + 7.82831 r_t + 84.33175 r_{t-1} \]
\[ + 1.51593 \]
\[ \text{D.W.} = 1.96192, \quad S = 194.87103, \quad x_{(3)}(22) = 24.541543 \]

One Period Ahead 'Forecasts'

Actual: 5957.0000
Forecast: 5477.1514
Forecast Error: 479.8486

\[ x_{(1)}(1) = 6.06337 \]
\[(14) \quad r_{st} = -1.00186 + 0.00016 Y_t + 0.01502 P_t + 0.73680 r_{ut} + 0.30381 r_{ft}
\]
\[
\begin{align*}
& (0.26290) (0.22139) (0.88592) (4.71418) \\
S &= 0.65518, \quad x^2_{(3)(21)} = 35.09200
\end{align*}
\]

One Period Ahead 'Forecasts'

Actual: 11.4100
Forecast: 10.5961
Forecast Error: 0.8139
\[x^2_{(1)(1)} = 1.54336\]

\[(15) \quad (SD)_t = -1269.27774 + 0.06280 Y_t + 0.10302 (SP)_t
\]
\[
\begin{align*}
& (1.64754) (0.45050) (1.05361) \\
& + 77.74176 r_{st} + 0.91287 P_t - 24.20972 r_{dt}
\end{align*}
\]
\[
\begin{align*}
& (3.29172) (0.24704) (2.17192) \\
S &= 115.06849, \quad x^2_{(3)(24)} = 37.06622.
\end{align*}
\]

One Period Ahead 'Forecasts'

Actual: 915.0000
Forecast: 955.8069
Forecast Error: -40.8069
\[x^2_{(1)(1)} = 0.12576\]

The estimates for equations (13), (14) and (15) do not differ very much from those derived when the OLS technique is used; admittedly some small differences do exist suggesting that a small degree of simultaneity is present. The variables \(Y_t\) and \(P_t\) perform well only in the \((SP)_t\) equation; in fact even in this equation it is only \(Y_t\) that is significant at the 5% level. The financial variables are more important, it seems, in these three equations. With the exception of the coefficient of \(r_{dt}\) in the \((SP)_t\) equation all the other coefficients of the financial variables are acceptable as far as the signs and T-Values are concerned.

These results reveal two interesting points. The first is that the authorities do not reinforce Special Deposits
calls by undertaking net open market operations; this result is the direct outcome of the significant and positive coefficient of the \((SD)_t\) variable in the Bank's security portfolio equation. What this result suggests is that the authorities tend to offset Special Deposits calls by absorbing government securities from the banks. The second point is that overseas rates have a role to play in these equations, indeed in some cases these rates dominate, in particular the treasury bill rate equation is dominated by external considerations as expected.

Comparing, now, the TSLS estimates of this section with the ones of our basic model, we observe that the two sets of estimates do not differ drastically, indeed in some cases the estimated coefficients are more or less the same. Provided, then, that the specification of the equations in the two models is satisfactory, the conclusion seems to be that joint estimation is not absolutely necessary and that the dynamic multipliers derived in section 5.2 are consistent, with one, however, qualification. The interest rate instrument is, in fact, affected by some variables outside the control of the authorities; and that this consideration is more prevalent when the balance-of-payments becomes one of the main priorities of the authorities. Furthermore, during the period under consideration the balance-of-payments has been one of the main priorities of the authorities, consequently our results as far as the optimum monetary instrument in concerned are constrained by this consideration. Even so, though, changes in the treasury bill rate do have a stronger impact in the economy than the \((SP)_t\) instrument, but the autonomy problem is more serious in the case of \(rs_t\) than in the case of the \((SP)_t\) instrument.

5.4 Conclusions:

The main aim of this study has been to set up a macro-model of the U.K. economy that incorporates the monetary sector too and within the context of this model to determine which instrument of monetary policy is the optimal one. This
procedure, of course, presupposes the empirical estimation of the assumed structural relationships of the model. Our empirical estimates of these structural relationships are quite acceptable. The major findings as far as these estimates are concerned are the following: Consumption is influenced by the long-term rate of interest but its impact is felt after a lag of about three quarters; and that this relationship is expected to be stronger after 1971. This finding is very important, we believe, since it provides an alternative to both the Keynesian and Chicago views concerning the channels through which monetary policy operates. Contrary to the Keynesian view, it implies that monetary has a more direct effect on consumption. This more direct effect is actually recognized by Friedman and Meiselman (53), but they finally reject it as one of the main effects of monetary policy. Investment is influenced by the long-term rate after a lag of three quarters, a result that casts considerable doubt on the assertion of the Redcliffe Report that such a relationship is unstable and unpredictable. We have not been able, though, to find any relationship whatsoever between the money stock, however defined, and the level of Consumption or Investment. Changes in the stock of money, however, do have a significant and predictable influence on Stockbuilding; this variable is also influenced by the long-term rate of interest with a four-quarter lag. Money stock, lagged one period, does influence, significantly and predictably, the level of imports. Finally, both the money supply and the base money of the system are neither completely endogenous magnitudes, not completely exogenous ones. The two instruments of monetary policy whose impact on the level of income have been considered, are the Bank's security portfolio and the treasury bill rate. The first influences the base of the system, the base influences the money supply and via the Stockbuilding equation and the Imports equation it influences the level of income. The treasury bill rate via the long term interest rate influences the levels of Investment and Stockbuilding and therefore the level of income. Given the lags that prevail in the model the
dynamic impact of the two instruments has been derived with the implied 'dynamic multipliers'. This analysis has led us to the conclusion that an interest rate policy that aims at controlling the treasury bill rate is the optimal policy. However, we do not like to suggest that the money supply should be left completely uncontrolled. Our analysis of section 5.2 implies that the impact of the money stock on the level of economic activity as measured by the level of national income, although inferior that of interest rates, can be substantial, with some lag, of course.

We take the view, therefore, that the main aim of the authorities should be to control interest rates, and that the money supply can be manipulated to some degree to enable the control of interest rates. In a recession the interest rate should be made to fall, but we might still have tight monetary policy because the money stock might be too low to allow interest rates to fall enough; therefore, the money stock, in that case, should rise in order to enable the authorities to achieve the target interest rate structure. Similarly during an inflationary boom interest rates should be higher and the money stock should decrease, again to enable the monetary authorities to achieve the target interest rate structure.

This conclusion, however, is subject to a criticism which can be a severe one under certain circumstances. In the discussion of whether joint estimation is required or not, section 5.3, we came to the conclusion that the treasury bill rate is very much affected by overseas rates. It follows, therefore, that the treasury bill rate changes not with respect to the authorities' internal stabilisation goals, in terms of our basic model this would be the level of national income, but with respect to, say, changes in the U.S.A. treasury bill rate; and if the U.S.A. treasury bill rate changes with respect to the U.S.A. authorities' stabilisation goals it would follow that it is the U.S.A. monetary policy that influences the U.K. treasury bill rate. We, thus, have the standard problem of autonomy discussed earlier, section 2.4, which is an awkward problem especially in the case of
an open economy as the U.K. economy is. This argument applies also in the case of the \((SP)_t\) instrument too, so if we were to choose one of these two instruments on the basis of the autonomy problem alone, it would be extremely difficult to favour one instrument at the cost of the other. We must, therefore, conclude at this stage that external considerations can be a severe constrained as far as monetary policy is concerned and that this conclusion can be a severe one, when the authorities have to give priority to balance-of-payments considerations. In particular, in cases, like the U.K. case, where the financial markets are of true international character and capital movements, therefore, are important the autonomy in manipulating the treasury bill rate can be severely impaired.

This last comment suggests, perhaps, a further piece of research. Our analysis has not taken into consideration, in our basic model, more relationships that connect the external sector of the economy with the internal sector, and in particular it has not considered in more detail details the link between some key overseas rates and domestic rates as well as the bank's security portfolio. Although the analysis of section 5.3 indicates to the right direction it has been rather simplistic. The reason is obvious. The basic model we derived and empirically tested above, has been designed to study the impact of alternative monetary policy instruments. It has been kept rather simple so that the derivation of the dynamic multipliers would be manageable, especially due to the lack of an appropriate computer program.* It would have been virtually impossible to conduct the same analysis with a bigger model; and also this last suggestion can be the main theme of a separate study.

More importantly, our analysis indicates that further research is absolutely necessary to solve the problem of the

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* The cost, in terms of time, of deriving the dynamic multipliers has been enormous. We have been absolutely unable to find an appropriate program for the computer.
optimal monetary policy instrument in the case of the U.K. economy. The direction of this further research must focus on the channels of monetary policy. This is a direct result of the changes introduced in 1971 with the 'Competition and Credit Control' regime. The more flexibility of interest rates as a result of these changes implies stronger relationships between interest rates and certain categories of expenditure. We clearly indicated this result in the case of the Consumption function. Until, however, more data are available, this experiment is severely constrained. It indicates, though, that once stronger relationships between interest rates and expenditures are empirically found, our results derived in section 5.2 will be strengthened and the superiority of interest rates as an instrument of monetary policy would undoubtedly be established.

Finally, our model and our results seem to support, to a certain extent, the results reached by the Radcliffe Committee rather than the view of the Bank as to the best action of the monetary authorities on interest rates. According to the Radcliffe Committee, the monetary authorities ought to establish a 'target' interest rate structure and operate on the whole range of the interest rate spectrum and not merely at the short end. Thus, it is argued that 'monetary policy must take its influence on the structure of interest rates as its proper method of affecting financial conditions and eventually, through them, the level of demand' (75, para. 982). The position of the Bank, on the other hand, is that the objective of the monetary authorities should be to maximise the demand for government securities by the private sector at any given set of interest rates and not to establish a 'target' yield curve. In particular, the position of the Bank is that market expectations are volatile and that they are predominantly governed by extrapolative elements, which means that price falls lead to the expectation of further price falls, in such a way that the security market is unstable in the short-run. The Bank, therefore, concludes that the operations of the monetary authorities ought to be designed in such a way as to smooth out short-term fluctuations.
in the interest rate around the trend. This aim, however, reduces the Bank's readiness and capacity to undertake an active interest rate policy at any but the very short end of the maturity spectrum. It is obvious after this short analysis on the positions of the Committee and the Bank that our results support the former. Long-term interest rate in our model is the transmitting link between the real sector and the monetary sector, and the long-rate is influenced very strongly by the short-term rate via a stable interest rate structure. It is the latter, therefore, that the authorities are assumed to aim at controlling with the help of the money stock. Hand in hand, therefore, with the further research we suggested above should also go some more research on the 'term structure of interest rates' embodied in a macro-model like ours.
APPENDIX

DATA: DEFINITIONS AND SOURCES

$Y_t$: Gross Domestic Product at factor cost, £m., seasonally adjusted. Economic Trends.

$(\Delta Y)_t$: Changes in $Y_t$.


$C_t$: Consumers' Expenditure, £m., seasonally adjusted. Economic Trends.

$I_t$: Gross Fixed Capital Formation, £m., seasonally adjusted. Economic Trends.

$S_t$: Value of Physical Increase in Stocks and Work in Progress, £m., seasonally adjusted. Economic Trends.


$T_{st}$: Adjustment to Factor Costs. It represents taxes on expenditure less subsidies at constant rates. £m., seasonally adjusted. Economic Trends.

$(\Delta H P)_t$: Changes in Consumers' Hire-Purchase Debt Outstanding, £m., seasonally adjusted. Board of Trade Journal.

$P_t$: Index of Retail Prices. It includes all items except food whose prices show significant seasonal variations. Seasonally unadjusted. (January 1962 = 100). Economic Trends.


M_t : Money Stock (Both M_1 and M_3 definitions are used), £m., seasonally adjusted. Bank of England Quarterly Bulletin.

(ΔM)_t : Changes in M_t.

B_t : Base Money, defined as: Currency held by the public plus banks' reserves, £m., seasonally adjusted. Bank of England Quarterly Bulletin.


(SD)_t : Special Deposits, £m., Bank of England Quarterly Bulletin.

r_{Lt} : Consol Rate. Economic Trends.


\rho : Autocorrelation Coefficient.
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