6 Disequilibrium Money: Some Further Results with a Monetary Model of the UK*

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The idea of modelling money as a buffer stock has recently attracted new interest, as papers such as Laidler (1984) and Goodhart (1984) testify, and a number of recent empirical studies are based on the concept. The approach, in some variation, is to embed a term measuring the difference between money held and money desired in one or more equations explaining real or financial adjustments in the economy, and possibly to estimate the parameters of the long-run money demand relation by this indirect route. An early instance was Johnson's monetary approach to the balance of payments (see Frenkel and Johnson, 1976). Other examples, in addition to the present author's work (Davidson and Keil, 1982; Davidson, 1984) include Howitt and Laidler (1979), Laidler and O'Shea (1980), Coghlan (1981), Jonson and Trevor (1981), Laidler and Bentley (1983), and Knoester and van Sinderen (1985).

Another approach to buffer-stock modelling, which is closer to the 'traditional' one of formulating a dynamic regression to explain the evolution of real balances, using either the partial adjustment or error correction principles to model the dynamics, is to include terms measuring money supply shocks in the equation, as in Carr and Darby (1981) and Artis and Cuthbertson (1985). By contrast, the embedding approach is cumbersome to implement and requires some justification. The aim of Section I of the paper is to argue the case that this is the 'correct' approach to the struc-

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tural modelling of money demand. In the following sections, some further developments with the system described in Davidson (1984) are reported.

I

Recent debates about the dynamics of money stock determination have brought a number of key problems into focus. One is the extent to which money is 'endogenous', by which we really mean, the extent to which the holders of money can control their nominal holdings in the aggregate and have the power to neutralise monetary shocks by 'countervailing' adjustments in the short or long run. More generally, the question raised is whether the variables which are important for restoring equilibrium in the money market are interest rates, prices, output, foreign flows, the money stock itself, or perhaps all of these to a significant extent. The 'traditional' money demand equation in which real balances are regressed onto the vector of arguments of money demand and lagged real balances is seen as an increasingly inadequate vehicle for the resolution of these questions (see Judd and Scadding, 1982, for a recent survey). The account of money-market dynamics given by this type of equation is typically rather implausible, with a lagged dependent variable coefficient sufficiently close to unity to cast doubt on the existence of a long-run solution. Cooley and LeRoy (1981) argue that the long-run elasticities of demand are not identifiable from such an equation.

An alternative model which avoids invoking the buffer stock concept, explored by Artis and Lewis (1976), inverts the money demand equation and treats it as a short-run interest rate equation exhibiting overshooting. This theory appears to be rejected empirically, and in any case seems incompatible with alternative explanations of interest rates in the short run (international parity, pegging by the authorities etc) (see also Goodhart, 1984).

It is a characteristic of buffer stock models that the relative speeds of adjustment to monetary shocks of interest rates and nominal income can be the reverse of those in the standard Keynesian model. Akerlof (1973) presents an 'inventory-theoretic' model of buffer stock money in which agents do not have a single-valued demand for money, but merely a band of acceptable holdings whose upper and lower limits depend on the usual arguments, and whose width is a function of information and transaction costs. In this model monetary receipts are absorbed without provoking a response (that is, a trip to the securities market) up to the point at which one or other of the boundaries is crossed. As Akerlof points out, an excess supply of money need not provoke an overshooting response in its price since the money may be *given* by the suppliers (the government, say) to the holders in exchange for goods and services, who therefore acquire it passively without any incentive being required to induce them to do so.

The concept of monetary 'shocks' is always a central one in this type of analysis, and Akerlof reminds us that money has the special characteristic (as the medium of exchange) that people can be induced to acquire additional quantities without demand conditions appearing to have altered. To adapt his quaint illustration, we cannot so easily conceive of an 'onion shock', since people do not acquire onions in the course of their other activities. Sources of monetary shocks, apart from deficit spending by the government, may include trade surpluses and, notably in the case of the UK, the removal of rationing constraints on bank credit issue. In principle open market operations are not shocks in this sense, since a price change is needed to induce a voluntary net sale of bonds by the non-bank private sector (NBPS) – but they can act as shocks if the interest elasticity of bond-holders is different from that of other agents to whom the extra money then passes.

The speed and character of the adjustment to shocks is a central issue here. We would not expect money-bond portfolios to be adjusted instantaneously. But for many small businesses and households towards the lower end of the income scale, transactions costs set the bounds on their permissible money holdings sufficiently wide that they effectively hold all their savings in liquid form, and adjust their holdings only through trades in labour and commodities. The effects of excess balances are transmitted by such trading like ripples through the economy and either dissipate through real balance effects on prices and output, or give rise sooner or later to an inter-sectoral transaction which tends to restore the volume of the nominal stock itself – for example, a purchase of government or foreign securities or an import of commodities. Rather than having a picture of each money-holder in the NBPS adjusting his/her money holdings by direct interaction with the other sectors, so that the rate of aggregate adjustment coincides with the average rate of individual adjustment, it may be more helpful to think of the markets through which money enters or leaves the system as *bottlenecks*.

Consider the money supply identity (which defines M3 if the conventional definition of the banking sector is adopted) showing how the money stock is defined as the sum of the net liabilities of the NBPS to the other main sectors of the economy (see Table 6.1 for variable definitions):

$$A^p + A^{po} + G - B^p + C + S^p - N = M + M^o$$

Setting aside the balancing item N, (the banks' non-deposit liabilities) and the foreign currency components $(A^{po} - M^{o})$, £M3 is obtained for our purposes as the sum of bank loans to the NBPS (A^{p}), the public sector debt net of bond-holdings by the NBPS $(G - B^{p})$, and the net liabilities to foreigners of the NBPS on current and capital account $(C + S^{p})$.

The usefulness of this identity is to remind us of the routes by which money can enter or leave the system. In a simple model, the domestic items of credit are usually taken to be outside the control of the private sector. In the monetary approach to the balance of payments, the short-run demand for money becomes the equivalent of the demand for foreign credit. Since instantaneous adjustment of supply to demand implies unrealistically large imbalances in foreign payments flows, some unwanted money must be held in Johnson's model, and the balance of payments depends upon the supply-demand gap.

More realistically, we recognise that the control over the items of domestic credit has never been solely in the government's hands. The arguments for treating both bonds and bank loans as demand determined are made in Artis and Lewis (1976) for example. The NBPS has a measure of control over each of the components of money supply, in addition to which the path of prices and output can be influenced by a real balance effect associated with being off the money-demand curve.

An argument for very rapid countervailing adjustment of supply to demand is that this can take place through changes in bank credit holdings, particularly because the use of overdraft facilities do not have to be renegotiated every time they are changed. This route of adjustment may of course be curtailed when bank lending is subject to regulation (and such regulations are effective), but what ensures that such adjustments are less than instantaneous is that overdraft facilities are neither freely available to bank customers, nor are they marketable. While the aggregate national overdraft may appear big enough to absorb the requisite degree of aggregate excess money, in practice the holders of the overdrafts and of the excess balances can be different people, who are able to join forces only if they can make mutually advantageous trades in goods and services. Nevertheless, we would expect bank lending to be the most important single source of countervailing adjustments.

Countervailing purchases of government securities are the primary 'Keynesian' adjustment route, although we do not have to believe that prices take up all or any of the adjustment, given that for much of the pre-1979 period interest rates have been a more important target for governments than the money supply. One important characteristic of this particular bottleneck is that most investment decisions are taken by institutional managers with an eye to short-term capital gains, and these decisions are influenced by monetary conditions in the economy as a whole by several removes. Excess money may eventually show up in the form of additional funds available for investment in gilt-edged, but it seems unlikely that these same funds are also the site of the initial injection. The same sort of argument applies to leakages through the international money markets. We conclude that *complete* monetary adjustment must as a rule proceed at the pace of the most sluggish market.

A further conclusion of the foregoing analysis is that we should attempt to model the demand for the assets identified in equation (1), subject to the adding-up constraint. As Brainard and Tobin (1968) have pointed out, such a system of equations, especially if dynamic, embodies a complicated set of cross-equation parameter dependencies (see Green, 1984, for a recent effort at this type of modelling for the UK). Fortunately, the concept of buffer-stock money cuts through the difficulties of this approach by asserting that *money is the residual* in the system. In each period agents trade in goods and assets in a manner which satisfies their ex post wealth constraint. But the existence of a buffer stock allows these decisions to be made in a relatively independent manner. The equation for the buffer variable is, of course, defined by equation (1) together with a set of specifications for the left-hand side components, but there are no grounds to suppose it will have the same functional form as other asset demand equations (for example, elasticities depending on the variables in the same manner, and so on). To do so would almost certainly be to impose a misspecification. One should expect to predict the change in money holdings best as the sum of the net trades in all inter-sectoral markets, and for it to be determined in the short-run *in no other way*.

On this interpretation the traditional money demand equation has to be viewed as the sum of a set of equations explaining the net flows of sectoral liabilities. Whether such an equation should be called a demand or a supply function is really a semantic question. We have argued that the flows are basically demand determined, but supply arguments (shocks) will also appear in it, an aspect of the model captured by the Carr-Darby approach. But each of the constituent equations contributes a set of explanatory variables, and some will be subject to policy switches. It is perhaps not surprising that the dynamics of such a relationship should be hard to capture in a simple and stable specification (Gordon, 1984, argues similarly). As well as resolving this difficulty, the embedding approach has two other distinct advantages. First, it can distinguish between supply shocks and unanticipated changes, whereas Carr and Darby, for example, must use the latter to proxy for the former; secondly, it can make use of information about monetary disequilibrium contained in other economic adjustment relationships, which the simple dynamic money equation cannot capture.

Little has been said so far about the definition of money, but in general the above considerations must apply with greater force, as money is defined more broadly. The underlying assumption is that there are non-negligible transactions costs and/or capital risk involved in switching between money and non-money assets. One of the problems of this area is that the distinction between broad and narrow money as stores of value become increasingly ill-defined as competition increases the liquidity of interest-bearing deposits, and building society deposits become very close substitutes for checking deposits, for example. This is an issue taken up in the empirical work below.

II

The scheme used to model money and related variables is an *error correction system*. Briefly, a relation of the general form

$$M/PY = F(Y; r^l, r^s, \dot{p}) \tag{2}$$

is assumed to represent a target, towards which (the inverse velocity of) money would tend in a steady state. The deviation of the right-hand from the left-hand side of (2), denoted $\hat{V}$, is embedded in a system of dynamic adjustment equations describing the evolution of money-stock components, income, and commodity and security prices. The complete error correction system is written schematically as

$$\mathbf{A}_1(L)\Delta\mathbf{y}_t + \mathbf{A}_2(L)\Delta\mathbf{z}_t + \mathbf{C}(L)\mathbf{f}(\mathbf{y}_{t-1}, \mathbf{z}_{t-1}) = \mathbf{u}_t \tag{3}$$

where $\mathbf{A}_1(L)$, $\mathbf{A}_2(L)$ and $\mathbf{C}(L)$ are matrix polynomials in the lag operator, $\mathbf{y}_t$ and $\mathbf{z}_t$ are the vectors of endogenous and exogenous variables and $\mathbf{u}_t$ is a disturbance vector. $\mathbf{f}(\mathbf{y}, \mathbf{z}) = \mathbf{O}$ is the system of *target relations* corresponding to the long run of the system, and assuming the system to be stable they will be satisfied on a constant steady-state path on which $\Delta\mathbf{y}_t = \mathbf{u}_t = \mathbf{O}$ and $\Delta\mathbf{z}_t = \mathbf{O}$. More generally, the $\mathbf{f}(\mathbf{y}, \mathbf{z})$ for a given realisation of the variables are called the *target deviations*.

The vector of target relations assumed in the present model is given in Table 6.2, the various symbols being defined in Table 6.1. These relations are simplified and not intended to constitute a complete comparative static model of equilibrium. Their role here is to provide a minimal dynamic

Table 6.1 Variable definitions

In general, current values of domestic variables are treated as endogenous, in the sense that they are not available for use as instrumental variables. Variables whose current values have been used as instruments are labelled EXOG below, and note in particular that the exchange rate changes its exogeneity status when the exchange rate regime changes.

A^p	= Sterling bank loans to NBPS
A^f	= Sterling bank loans to overseas sector
B^{pm}	= Market value of public sector debt of NBPS
P^g	= *Financial Times Index* of gilt-edge prices
Y	= GDP at constant 1975 prices
P	= GDP deflator
C	= Cumulated current account surplus
S^p	= NBPS's net capital liabilities to overseas
ϵ	= Exchange Rate (\$/£ rate (EXOG) until 1971 (iv); 2.4x 'sterling effective' index thereafter)
M	= Sterling money balances (M3 or PSL2)
B^b	= Banks' holdings of public sector debt
B^p	= Book value of public sector debt held by NBPS
D	= Bank deposits
R	= Cumulated transactions in official reserves
R^*	= value of official reserves
r^l	= yield on UK government stock over 20 years
r^s	= rate on three months' Local Authority deposits
W	= Average earnings
G	= Cumulated PSBR
Cl	= Dummy for bank lending restrictions
B^f	= book value of public sector debt held by overseas sector
N	= Banking sector's non-deposit liabilities
Pr	= Output per man employed
r^f	= 3-month eurodollar rate (EXOG)
r^{lf}	= yield on US government stock over 20 years (EXOG)
r^{lf*}	= MERM-weighted index of foreign long rates (available from 1972(i) only) (EXOG)
P^f	= Foreign price level (UK imports price index)
D^*	= SD/D, where SD = Banking sector's special deposits with the Bank of England
X	= real exports (EXOG)
ΔO	= balance of trade in petroleum-related products
FP	= 3 months' forward premium on US dollars
$D79$	= Dummy for switch to monetary targets (= 0 to 1979(ii), = 1 thereafter)
Cc	= Dummy for competition and credit control (= 1 in 1971(iii), = 0 otherwise) (EXOG)
EC	= Dummy for removal of exchange controls (= 1 in 1979(iii), = 0 otherwise)
Y^f	= index of world real income
$A(x)_i$	= polynomial distributed lag of x of length 13 quarters and order i
LT	= $1 - 1/(1 + exp\{0.1t-7.7\})$

Table 6.2 The target relations

(a)	$M/PY = \gamma_1 exp\{\delta_1 (r^s - 200.\Delta_2 lnP) + \delta_2 (r^l - r^s) + \delta_3 LT\}$
(b)	$B^{pm}/M = \gamma_2 exp\{\delta_4 (r^l - r^s)\}$
(c)	$(A^p + A^f)/D = \gamma_3$
(d)	$r^l = r^s + ln\{\gamma_4 [(B^p + B^f)/(G + R)]^{\delta_5}\}$
(e)	$r^s = r^f$
(f)	$r^l = r^{lf}$
(g)	$P = \gamma_5 P^f/\epsilon$
(h)	$W/P = \gamma_6 Pr^{\delta_6}$
(i)	$Y = \delta_7 Y^f$
(j)	$S^P = \gamma_8$

framework within which to test theories of money demand. It's important to be clear about this aspect of the modelling methodology, and the following digression will summarise the issues. The stability analysis of models of this kind is discussed more fully in Davidson (1983).

The 'steady state', like any other equilibrium concept, is an imaginary construct. Steady state relationships are defined as the concomitants of an absence of change in the model, and are *not* expected to prevail either in any observed period, nor even 'on average', unless the changes average to zero over the period. In a state of non-zero steady growth of the exogenous variables, they are generally attained only up to a (logarithmically) additive constant (see also Currie, 1981).

A non-stationary time series variable is defined to be an *integrated process of order d* if differencing d times reduces it to a stationary process. If a linear function of d-integrated variables is an integrated process of order less than d, the variables are said to be *co-integrated* (see Granger, 1981; Granger and Weiss, 1984). In a system such as (3), it cannot be legitimate to assume that the disturbances on the system are white noise if the target deviations and the differences of the variables are not integrated to the same order. For simplicity we would take d as one, and in that case, we require the target deviations to form a vector of stationary processes. But clearly, the target deviations need not even be stationary provided the changes in the variables are not stationary either.

The economic theory underlying this kind of model must therefore assert, minimally, that the target deviations must be integrated to the same order as the differences of the variables, and be stationary when the latter are stationary. The model would be rejected if the coefficients of the targets (the relevant elements of $\mathbf{C}(L)$) were not significantly different from zero – although note that the problems of inference in this type of model are not yet well understood (see, for example, Stock, 1984). The special case of target deviations being themselves white noise, so that the target is a stochastic equation in its own right, is subsumed under the general case of co-integration. But it is assumed here that the much weaker requirement that sets of variables are co-integrated is the appropriate method of incorporating stylised equilibrium relations into the model. The money demand function, in particular, is being characterised in just this way.

To take another somewhat controversial case, inclusion of the purchasing power and uncovered interest parity conditions in the model implies a theory that when these conditions do not hold, some variables in the system (exchange rates, relative price levels, and so on) must be changing, or expected to change, and hence that deviations from the targets are correlated with, and help to predict, subsequent changes in the variables. Equations (e) and (f) in Table 6.2 do not contradict covered interest parity, but the cover must be zero when the exchange rate is on a constant path, and it is *un*covered differentials which appear in the exchange rate equation. Note that it is innocuous to include rates of change as arguments of the targets, as may be done to aid interpretation, since such terms can be redeployed into the first two terms of (3); the rate of inflation *is* included in (a) in Table 6.2 since we are interested in the coefficient δ_3. A term for expected capital gains could similarly be added to (b) without altering its status as a steady-state relation one way or the other.

III

In Davidson (1984) estimates of the model are reported for the period 1964(ii) – 1978(iv) with a structural break in 1972(i) corresponding to the switch to floating exchange rates. A non-linear three-stage least squares estimation procedure allows the switch of exogeneity of the exchange rate at this date, also allowing the parameters of the foreign balance equations to shift while keeping the rest of the model fixed, apart from intercepts and error covariances. The aim is to estimate the key behavioural parameters with maximum efficiency while permitting structural flexibility in the model.

The specification nonetheless was found not to be stable beyond 1979, a few added observations proving notably influential and producing implausible switches of sign and magnitude. Some revisions are now incorporated which, while not yet entirely satisfactory, allow the model to give a consistent account of the data up to 1982(iv). First, there are some changes of specification, mainly to the advances and exchange rate equations. Dummy variables are introduced to allow for the policy effects of the removal of exchange controls and concentration on monetary targets post-1979. Secondly, the specification of the money-demand relation is also revised. A unit income elasticity is now imposed – this coefficient had earlier been found to be poorly determined and unstable – and the other arguments are transformed, so that they now comprise the interest spread – the difference of a representative long and short rate – and the ***real short interest rate*** measured as the difference between the short rate and a moving two-quarter average of inflation.

Another possibility considered is of a shift in the money-demand relationship, because of the technological and institutional innovations of recent years. We assume that credit cards and other improvements in the efficiency of making payments may increasingly enable people to economise on money holdings. (Be careful to note though that, as opposed to ***technical*** change, changes in banking institutions and competitive practices such as CCC (Competition and Credit Control) should not affect money ***demand***, although they will affect supply through changes in credit rationing and so on.)

This is a difficult modelling problem, since we are bound to fall back on some sort of dummy variable to represent the change. There are objections, of different kinds, to the use of both intervention dummies ('zero-one' shifts) and linear or polynomial trends as devices to capture such changes, and a compromise which overcomes these to some extent is the ***logistic trend***, a variable with the general form $LT_t = exp\{\alpha + \beta t\}/(1 + exp\{\alpha + \beta t\})$. This permits a smooth transition from one intercept value to another at a rate and date depending on the parameters α and β, which can in principle be fitted to the data, and hence allows us to model the transitional effects of a period of (say) technological innovation. Imposing the constraint that LT_t should be close to zero prior to 1970, experiments with values of β between 0.1 and 0.5 were performed, resulting in the former value being chosen (on the basis of the general characteristics of the equations, rather than a simple 'goodness of fit' criterion). This yields a trend curve which attains the value of 0.57, somewhat above its point of inflection, by the end of the sample.

The other increasingly serious consideration in modelling the recent period is the definition of money. The previous work used £M3, but this series now contains a very large break (about 10 per cent in 1981(iv), corresponding to the redefinition of the banking sector (now called the 'monetary sector'). One of the ways considered to deal with this problem was to distribute the effects of the step change over earlier periods, once again using a logistic trend which is zero before 1970, and attains unity by 1981(iv). This variable multiplied by the difference between the post- and pre-revision figures for 1981(iv) is added to the series in each period prior to that date. The assumption which underlies this scheme is that the appropriate definition of money has been changing progressively, with the published definition being revised belatedly.

The second approach, with the recent availability of a series for PSL2 extending back to 1963, is to estimate the model with the variable 'M' given this broader definition. In view of the arguments of Section I, this ought to be the more appropriate stock, at least in the later part of the sample, if not necessarily in the earlier period before 1970. However, it ought to be emphasised that the model has not been respecified for each case, and the version of the model reported has, for the most part (except where noted in Section IV), been developed with the £M3 definition of money, and using the data to 1978(iv).

Of the four cases examined – two definitions of the money stock, with and without a trend term included in $\hat{V}$ – the full estimates are given only for one (M = £M3 adjusted for break, trend in $\hat{V}$ included) in Table 6.3, while the main results, the coefficients of money-demand and the coefficients of $\hat{V}$ from each equation, are presented for each version in Table 6.4.

IV

This section of the paper provides a commentary on some of the equation specifications. One can jump to Section V without loss of continuity, and return here to aid interpretation of the results, as required. Additional details can be found in Davidson (1984).

Bank loans (equation (i), Table 6.3) are assumed to be demand-determined subject to rationing constraints (see Wills, 1982, for an analysis of bank behaviour). We have consistently failed to find a significant, appropriately signed role for interest rates other than through the $\hat{V}$ term. The ratio of non-public sector loans to total deposits is assumed to have a ceiling at which the banks themselves would ration customers – a term of this type is necessary to ensure the model has a long-run solution. Coghlan's (1981) equation is similar.

Equations (ii) and (iii) describe transactions and prices in the gilt-edged market. To interpret the left-hand side variable in (ii), note that the market value and nominal value of debt holdings are related by

$$B_t^{pm} = \Delta B_t^p + (P_t^g/P_{t-1}^g)\, B_{t-1}^{pm} \tag{4}$$

Table 6.3 Adjustment equations (M = £M3)

These estimates embody the cross-equation restrictions implicit in embedding the deviations from equation (a) (Table 6.2) in log form, denoted $\hat{V}$, in each equation. The estimates of (a) are given in (ix) below. The (incomplete) system is estimated by a variant of non-linear Three Stage Least Squares (3SLS) (a member of the class defined in Amemiya, 1977) in which each equation has its own set of instrumental variables. Each set of instruments is defined as the lagged or exogenous variables included in the equation, plus the first four principal components of the set of all such variables in the system but not in the equation.

The fixed and floating exchange rate regimes define two versions of the system, only the second containing equation (viii). The estimator minimises the sum of the 3SLS criterion functions for the two regimes, but with equality of the slope coefficients (not constants and seasonals, or residual variances and covariances) imposed across regimes in all equations except (vi) and (vii). The covariance matrices used to define the criteria were evaluated from the residuals in a first run of the search algorithm, and the reported parameter estimates obtained in the second run. All computations were performed on the Cray II computer at the University of London Computer Centre.

(i)
$$\begin{aligned}\Delta\ln(A^p/P)_t = {} & \underset{(0.192)}{0.505}\ \Delta\ln Y_t - \underset{(0.051)}{0.287}\ \ln((A^p + A^f)/D)_{t-4} \\ & - \underset{(0.028)}{0.162}\ \ln\hat{V}_{t-3} - \underset{(0.204)}{0.430}\ \Delta D^*_{t-1} - \underset{(0.0034)}{0.0087}\ Cl_t \\ & + \underset{(0.0025)}{0.0174}\ A(Cc)_{1t} - \underset{(0.00022)}{0.0011}\ A(Cc)_{2t} + \underset{(0.028)}{0.157}\ LT_t \\ & + \begin{Bmatrix}-0.056\\-0.092\end{Bmatrix} + \begin{Bmatrix}-0.081\\-0.030\end{Bmatrix} Q1_t + \begin{Bmatrix}-0.014\\-0.030\end{Bmatrix} Q2_t + \begin{Bmatrix}0.007\\0.017\end{Bmatrix} Q3_t\end{aligned}$$

$$s = \begin{Bmatrix}0.0186\\0.0133\end{Bmatrix}; \quad \textit{Correlogram:} \quad \begin{Bmatrix}0.145, & 0.241, & 0.347, & -0.167\\ 0.090, & -0.156, & 0.034, & -0.334\end{Bmatrix}$$

(ii)
$$\begin{aligned}\Delta\ln(B^{pm}/P^g)_t = {} & \underset{(0.070)}{0.502}\ \Delta\ln P^g_t + \underset{(0.173)}{0.074}\ \Delta\ln M_t \\ & - \underset{(0.013)}{0.033}\ (B^{pm}/M)_{t-4} + \underset{(0.001)}{0.0031}\ (r^l - r^f - FP)_{t-4} \\ & - \underset{(0.055)}{0.044}\ (\Delta G/PY)_{t-2} + \underset{(0.036)}{0.054}\ \hat{V}_{t-3} \\ & + \begin{Bmatrix}-0.002\\-0.026\end{Bmatrix} + \begin{Bmatrix}0.012\\0.003\end{Bmatrix} Q1_t + \begin{Bmatrix}-0.007\\-0.006\end{Bmatrix} Q2_t + \begin{Bmatrix}0.013\\0.013\end{Bmatrix} Q3_t\end{aligned}$$

$$s = \begin{Bmatrix}0.0124\\0.0275\end{Bmatrix}; \quad \textit{Correlogram:} \quad \begin{Bmatrix}-0.020, & -0.258, & -0.201, & -0.271\\ 0.429, & 0.077, & -0.048, & -0.161\end{Bmatrix}$$

(iii)
$$\Delta \ln P^g_t = \underset{(0.004)}{-0.0060}\,\Delta r^s_t \underset{(0.0020)}{-0.0058}\,\Delta r^f_t + \underset{(0.152)}{0.787}\,\Delta \ln(B^p + B^f)_t$$
$$- \underset{(0.043)}{0.031}\,\hat{V}_{t-1} + \underset{(0.001)}{0.005}\,[(r^l - r^s) + \underset{(16.0)}{38.7}\,\ln((B^p + B^f)/(G+R))]_{t-2}$$
$$+ \begin{Bmatrix} -0.057 \\ -0.030 \end{Bmatrix} + \begin{Bmatrix} -0.026 \\ -0.011 \end{Bmatrix} Q1_t + \begin{Bmatrix} 0.007 \\ 0.0 \end{Bmatrix} Q2_t + \begin{Bmatrix} -0.012 \\ -0.030 \end{Bmatrix} Q3_t$$
$$s = \begin{Bmatrix} 0.021 \\ 0.034 \end{Bmatrix};\ \textit{Correlogram:}\ \begin{Bmatrix} 0.368, 0.177, -0.080, \ 0.057 \\ -0.199, 0.031, -0.032, -0.223 \end{Bmatrix}$$

(iv)
$$\Delta \ln Y_t = \underset{(0.079)}{-0.287}\,\Delta Y_{t-1} + \underset{(0.062)}{0.174}\,\Delta(\Delta G/PY)_t + \underset{(0.049)}{0.096}\,\Delta(\Delta G/PY)_{t-3}$$
$$+ \underset{(0.026)}{0.192}\,\Delta \ln X_t + \underset{(0.026)}{0.068}\,\Delta \ln X_{t-1} + \underset{(0.109)}{0.090}\,\Delta \ln(M_t/P_{t-1})$$
$$- \underset{(0.135)}{0.088}\,\Delta\Delta_2 \ln P_{t-1} + \underset{(0.026)}{0.030}\,\hat{V}_{t-3}$$
$$+ \begin{Bmatrix} -0.042 \\ -0.040 \end{Bmatrix} + \begin{Bmatrix} 0.081 \\ 0.091 \end{Bmatrix} Q1_t + \begin{Bmatrix} 0.046 \\ 0.069 \end{Bmatrix} Q2_t + \begin{Bmatrix} 0.027 \\ 0.011 \end{Bmatrix} Q3_t$$
$$s = \begin{Bmatrix} 0.0099 \\ 0.015 \end{Bmatrix};\ \textit{Correlogram:}\ \begin{Bmatrix} -0.291, -0.382, -0.006, \ 0.400 \\ -0.033, -0.290, \ 0.074, -0.061 \end{Bmatrix}$$

(v)
$$\Delta \ln P_t = \underset{(0.087)}{-0.219}\,\Delta \ln P_{t-1} + \underset{(0.059)}{0.323}\,\Delta \ln(M/Y)_t + \underset{(0.084)}{0.424}\,\Delta \ln W_t$$
$$+ \underset{(0.076)}{0.090}\,\Delta \ln Pr_{t-2} - \underset{(0.012)}{0.095}\,\ln(\epsilon P/P^f)_{t-1} + \underset{(0.019)}{0.051}\,\hat{V}_{t-1}$$
$$+ \underset{(0.034)}{0.151}\,[\ln(W/P)_{t-1} - \underset{(0.251)}{1.029}\,\ln Pr_{t-4}]$$
$$+ \begin{Bmatrix} -0.034 \\ -0.028 \end{Bmatrix} + \begin{Bmatrix} 0.016 \\ 0.008 \end{Bmatrix} Q1_t + \begin{Bmatrix} -0.005 \\ 0.006 \end{Bmatrix} Q2_t + \begin{Bmatrix} 0.001 \\ -0.002 \end{Bmatrix} Q3_t$$
$$s = \begin{Bmatrix} 0.0071 \\ 0.012 \end{Bmatrix};\ \textit{Correlogram:}\ \begin{Bmatrix} 0.083, -0.039, 0.215, -0.062 \\ -0.154, \ 0.006, 0.168, -0.444 \end{Bmatrix}$$

(vi)
$$(\Delta C/PY)_t = (\Delta O/PY)_t + \begin{Bmatrix} 0.051(0.103) \\ 0.040(0.119) \end{Bmatrix} (\Delta C/PY)_{t-1}$$
$$+ \begin{Bmatrix} 0.185(0.064) \\ 0.253(0.072) \end{Bmatrix} \Delta \ln \epsilon_t + \begin{Bmatrix} 0.294(0.107) \\ 0.418(0.112) \end{Bmatrix} \Delta_2 \ln P_{t-2}$$
$$+ \begin{Bmatrix} -0.095(0.062) \\ 0.029(0.064) \end{Bmatrix} \Delta \ln Y_{t-1} + \begin{Bmatrix} 0.301(0.138) \\ 0.217(0.101) \end{Bmatrix} \Delta \ln Y^f_{t-1}$$
$$+ \begin{Bmatrix} -0.009(0.034) \\ -0.006(0.018) \end{Bmatrix} \ln(\epsilon P/P^f)_{t-4} + \begin{Bmatrix} -0.118(0.024) \\ 0.144(0.070) \end{Bmatrix} \ln(Y/Y^f)_{t-3}$$
$$+ \begin{Bmatrix} -0.005(0.033) \\ -0.033(0.026) \end{Bmatrix} \hat{V}_{t-3} - \underset{(0.0002)}{0.0006}\,A(EC)_{1t} + \underset{(0.003)}{0.0070}\,A(EC)_{2t}$$

Table 6.3 continued

$$+\begin{Bmatrix}-0.018\\-0.006\end{Bmatrix}+\begin{Bmatrix}0.0\\0.014\end{Bmatrix}Q1_t+\begin{Bmatrix}0.006\\0.008\end{Bmatrix}Q2_t+\begin{Bmatrix}0.0\\0.015\end{Bmatrix}Q3_t$$

$$s=\begin{Bmatrix}0.0074\\0.0128\end{Bmatrix};\ \textit{Correlogram:}\ \begin{Bmatrix}-0.195, -0.159, -0.025, -0.243\\-0.033, -0.031, -0.276, -0.267\end{Bmatrix}$$

(vii) $$\Delta S^P_t=\begin{Bmatrix}1433\ (935)\\-24624(6416)\end{Bmatrix}\Delta\ln\epsilon_t+\begin{Bmatrix}-52.9(11.4)\\267\ (66.4)\end{Bmatrix}\Delta\ln r^{lf}_t$$

$$+\begin{Bmatrix}-0.038(0.037)\\0.071(0.044)\end{Bmatrix}S^P_{t-2}+\begin{Bmatrix}1.87\ (11.2)\\155.5(68.8)\end{Bmatrix}(r^l-r^f-FP)_{t-1}$$

$$+\begin{Bmatrix}-0.37\ (470)\\-1105(1150)\end{Bmatrix}\ln(\epsilon P/P^f)_{t-4}+\begin{Bmatrix}-650\ (523)\\-6991(1785)\end{Bmatrix}\hat{V}_{t-1}$$

$$-\underset{(208)}{995}\ A(EC)_{1t}+\underset{(18.3)}{87.8}\ A(EC)_{2t}$$

$$+\begin{Bmatrix}286\\-1370\end{Bmatrix}+\begin{Bmatrix}-223\\13.2\end{Bmatrix}Q1_t+\begin{Bmatrix}27\\899\end{Bmatrix}Q2_t+\begin{Bmatrix}16\\352\end{Bmatrix}Q3_t$$

$$s=\begin{Bmatrix}126\\1005\end{Bmatrix};\ \textit{Correlogram:}\ \begin{Bmatrix}-0.241, -0.135, -0.026,\ 0.011\\0.018,\ 0.087, -0.116, -0.057\end{Bmatrix}$$

(viii) For 1972(i) – 1982(iv):

$$\Delta\ln\epsilon_t=\underset{(0.0046)}{-0.0053}\ \Delta(r^f-r^s)_t+\underset{(0.0048)}{0.0010}\ \Delta(r^f-r^s).D79_t$$

$$\underset{(0.0103)}{-0.0043}\ \Delta(r^{lf*}-r^l)_t+\underset{(0.012)}{0.0054}\ \Delta(r^{lf*}-r^l).D79_t$$

$$\underset{(0.0029)}{-0.0024}\ (r^f-r^s)_{t-1}-\underset{(0.0037)}{0.0013}\ [(r^{lf*}-r^l)-(r^f-r^s)]_{t-1}$$

$$+\underset{(0.013)}{0.033}\ \ln(R^*/\epsilon P)_{t-1}-\underset{(0.061)}{0.081}\ \hat{V}_{t-3}$$

$$+0.245+0.0094\,Q1_t+0.034\,Q2_t+0.028\,Q3_t$$

$s=0.0315$; *Correlogram:* $-0.116, 0.0133, 0.0276, -0.219$

(ix) $$\hat{V}_t=\ln(M/PY)_t-\underset{(0.0026)}{0.0128}\ (r^s-200.\Delta_2\ln P)_t-\underset{(0.0048)}{0.0020}\ (r^l-r^s)_t$$

$$+\underset{(0.178)}{0.401}\ LT_t$$

Notes: Standard errors are in parentheses below or following parameter estimates.
Braces enclose estimates for 1964(ii) – 1971(iv) and 1972(i) – 1982(iv) subperiods.

Standard errors are not available for constant and seasonal dummies.
For a variable x_t, $\Delta_i x_t = x_t - x_{t-i}$, and $i = 1$ implicitly when omitted.

System Test Statistics:
W denotes a Wald test, constructed from the estimates under the alternative. ALR (analogue likelihood ratio) denotes a test based on the difference between the 3SLS criterion functions under null and alternative, equivalent to the T^0 test of Gallant and Jorgenson (1979). Each statistic is asymptotically χ^2 with the degrees of freedom shown in parentheses, though a small-sample correction could shrink them somewhat (see Davidson, 1984).

1. Test of overidentifying restrictions and cross-regime equality of parameters, where imposed: $ALR(117) = 157$
2. Test of cross-regime parameter equality, where not imposed.
   Equation (vi) only: $W(6) = 38$
   Equation (vii) only: $W(8) = 20.8$
   Equations (vi) and (vii): $W(14) = 69$
3. Test of joint significance of $\hat{V}$ coefficients in all equations: $W(10) = 50$
4. Test of the model against linear alternative, arguments of $\hat{V}$ appearing unrestricted in each equation: $ALR(24) = 36.5$

which implies, equating logarithmic and proportionate changes,

$$\Delta \ln(B^{pm}/P^g)_t \approx \Delta B^p_t / B^{pm}_{t-1} \tag{5}$$

Target relation (b), together with (a) and also (j), represents the desired 'outside asset' portfolio of the NPBS. The empirical form of the target deviation combines targets (b) and (e), simply because this relatively parsimonious form is suggested by the data. The right-hand side term in $\Delta \ln P^g_t$ is assumed to act as a proxy for price expectations. Here and elsewhere in the model (for example (a) of Table 6.2) the current or smoothed current changes in a variable have been taken as the best simple measure of short-run expectations. The bond price equation contains policy reaction terms, with (d) representing the trade-off between the government's desires for low interest rates relative to the money rate and for minimum monetisation of the debt. Note that $G + R - B^p - B^f$ corresponds to the monetary base, and we assume that the government has an implicit target ratio of monetary base to total debt which it will intervene in the bond market to maintain, eventually. Of course, if we are to solve (d), (e) and (f) simultaneously and assume that foreign rates are totally exogenous, the implication is that the public sector debt aggregates must move into line under a full steady state – although we should emphasise once again that such scenarios do not need to be entertained very seriously, and the model could be elaborated with a fuller account of the term structure.

Equation (iv) is no more than a minimal reduced form equation for real income, while the inflation equation (v) contains three targets; money disequilibrium, purchasing power parity (g) and a neoclassical labour demand schedule (h). Note that earnings are thought of as jointly determined, though the earnings equation is not specified here.

The two foreign balance equations, (vi) and (vii), are problematic because the available data are for net transactions, which may be of either sign in principle, so that data-admissability enforces a rather awkward semi-logarithmic specification. It appears reasonable to express the current account surplus in a ratio with nominal income, in expectation of a scale effect in trade flows, but there does not appear to be any such basis for scaling net capital flows – hence some parameters of equation (vii) have units of millions of pounds sterling. Equations (i) and (j) in Table 6.2 are stylised steady-state conditions reflecting a deficiency of useful theory in this area. It appears reasonable that different growth rates at home and abroad should lead to current account imbalance *ceteris paribus*, that is, unless other adjustments such as in relative secular inflation rates, are also taking place. On the other hand, the most plausible steady-state value of S^P is probably zero.

The exchange rate equation (viii) is based on the monthly model of Davidson (1985). There is a problem in such equations that the current interest rate coefficients are subject to structural shifts associated with changes of policy. Shift dummies for 1979(ii) are an attempt to allow for this.

V

The main feature of these specifications of the money-demand equation (see Table 6.4) is that the coefficient of the real short interest rate (regarded as the real return on money holdings) is significant and correctly signed, and implies a long-run elasticity with respect to inflation of around -1.5. This is about half the value obtained with the earlier specification, which speaks in favour of the modification. The coefficient of the interest spread is wrongly signed to be interpreted as the current net return on competing assets, although it could evidently be acting as a proxy for the same omitted effect that the trend is intended to capture. There is also the pos-

Table 6.4 Alternative money demand specifications

	M = £M3		M = PSL2	
	1	2	3	4
Coefficients of money demand (equation (a), Table 6.2):				
δ_1	0.014 (0.003)	0.013 (0.003)	0.011 (0.003)	0.012 (0.002)
δ_2	0.014 (0.007)	0.002 (0.005)	0.011 (0.006)	0.002 (0.005)
δ_3	–	–0.401 (0.178)	–	0.857 (0.225)
Coefficients of $\hat{V}$ in adjustment equations:				
(i) (A^p)	–0.148 (0.029)	–0.162 (0.028)	–0.174 (0.031)	–0.174 (0.028)
(ii) (B^{pm})	0.075 (0.034)	0.055 (0.036)	0.081 (0.041)	0.023 (0.038)
(iii) (P^g)	–0.044 (0.039)	–0.031 (0.043)	–0.041 (0.040)	0.001 (0.042)
(iv) (Y)	0.0066 (0.021)	0.029 (0.026)	0.0044 (0.017)	0.013 (0.026)
(v) (P)	0.049 (0.018)	0.051 (0.019)	0.040 (0.015)	0.039 (0.019)
(vi) (S^p) to 1971 (iv)	–0.804 (0.607)	–0.650 (0.523)	–1.254 (0.741)	–0.757 (0.532)
(vi) (S^p) from 1972 (i)	–2.829 (1.399)	–6.99 (1.78)	–1.739 (1.38)	–8.010 (1.867)
(vii) (C) to 1971 (iv)	0.0028 (0.036)	–0.0048 (0.033)	0.015 (0.048)	0.0075 (0.039)
(vii) (C) from 1972 (i)	–0.011 (0.029)	–0.033 (0.026)	0.0035 (0.035)	–0.031 (0.031)
(viii) (ϵ) from 1972 (i)	–0.058 (0.066)	–0.081 (0.061)	0.049 (0.061)	–0.071 (0.066)

sibility, which could account for the sign obtained, that this variable is used as a predictor of future inflation.

The money-disequilibrium term itself is not nominally significant in all the equations, although most of the adjustment coefficients and all the significant ones are correctly signed. Note, none the less, if an attempt is made to exclude those equations where the adjustment coefficients are small or not well-determined, the model collapses. Anything resembling the reported estimates cannot be obtained from the advances and price equations alone, even though the advances equation is a relatively close relation of the conventional money-demand equation. All the equations appear to play some sort of role. The one really surprising result is the consistent absence of any big real balance effect on income. These findings support a decidedly monetarist view of the inflationary process.

Figure 6.1 to 6.4 give the plots of actual and 'desired' $\ln(M/PY)$, deseasonalised and in mean deviation form, for each of the four alternatives reported in Table 6.4. The vertical distance between the two plots is itself plotted at the base of each figure. In Figures 6.5 and 6.6, $\ln M$ (each definition) and $\ln PY$ are plotted together in seasonal mean-deviation form. It is the vertical distance between these two plots which appears as $\ln(M/PY)$ in Figures 6.1 and 6.2, and 6.3 and 6.4 respectively. Figure 6.7 reproduces the movements over time of the two variables in the demand function, so that the pattern of the broken lines in Figures 6.1 to 6.4 can be interpreted. Be careful to note that the true mean distance between the plots in the latter figures is an unidentifiable parameter, and has been arbitrarily set at zero. It is only their *relative* positions which are significant. Moreover, all equations incorporate an intercept shift at the exchange rate regime switch point (see Table 6.3) which implies that a step shift in $\hat{V}$ is 'permitted' by the estimation. This implies some loss of efficiency but no bias in the estimates. In other words, there is implicitly both an intercept term and a shift dummy present in equation (ix), Table 6.3, but their coefficients are both unidentified, since to compute them from the fitted intercepts of the adjustment equations would require us to assume that the latter are uncontaminated by the means of omitted terms in the regression, which is scarcely justifiable. However, the estimated relations between money supply and demand *assuming* stability of the demand function can be compared in the plots, as long as we remember that the observed gap is not imposed in the estimation.

In the period up to 1971, the supply and demand plots can be fitted together quite well, and it is no surprise that ordinary regressions for money are quite stable over this period. Apart from the 1972–5 episode itself, the most notable feature of the data is that the ratio of PSL2 to nominal income appears to fall permanently after that period, while for the 'adjusted' £M3 it does not. In Figure 6.5 we can see rather nicely how in the 1972–6 episode, £M3 and PY moved apart and together again, as the monetary shock was followed by the countervailing inflationary adjust-

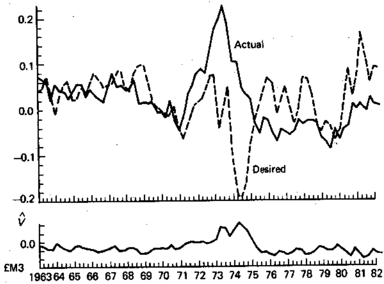

Figure 6.1 $M = £M3, \delta_3 = 0$

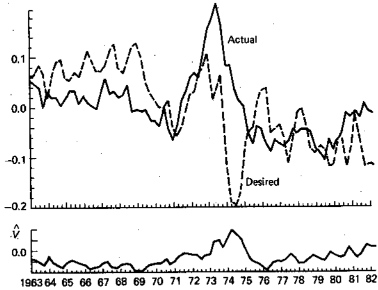

Figure 6.2 $M = £M3, \delta_3 \neq 0$

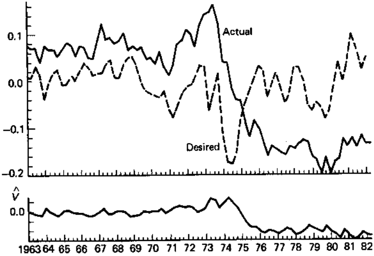

Figure 6.3 M = PSL2, $\delta_3 = 0$

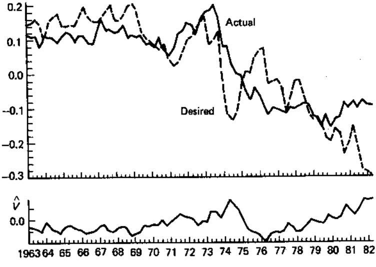

Figure 6.4 M = PSL2, $\delta_3 \neq 0$

Note: Figures 6.1 to 6.4 show the time plots of actual (——) and 'desired' (– – – –) $\ln(M/PY)$, where the latter is estimated from the coefficients in Table 6.4, columns 1–4. The lower part of each figure shows $\hat{V}$, the difference of the 2 upper plots. All data in the plots are residuals from regressions on a constant and seasonals, hence all plots are centred on zero and the relative vertical positions (and the absolute values of $\hat{V}$) have no significance. Also, in assessing the track of $\hat{V}$, note that an intercept shift at 1972(i) is permitted in the estimation. The mean and mean shift of $\hat{V}$ are not identified.

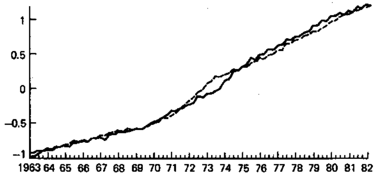

Figure 6.5 $\ln(PY)$ = (——), $\ln M$ = (– – – –), M = £M3

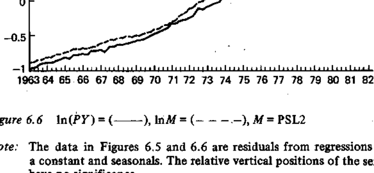

Figure 6.6 $\ln(PY)$ = (——), $\ln M$ = (– – – –), M = PSL2

Note: The data in Figures 6.5 and 6.6 are residuals from regressions on a constant and seasonals. The relative vertical positions of the series have no significance.

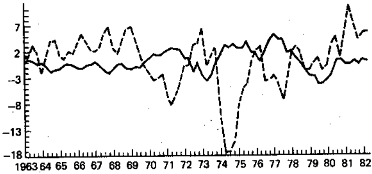

Figure 6.7 $r^l - r^s =$ (——), $r^s - 200.D_2 \ln P =$ (– – – –)

ment. While the two series often grew at different rates over several periods, they have 'tracked' each other over the long span of time and, in the terminology of Section II, they appear cointegrated, that is, their difference might be explained by stationary variables. On the other hand, the tracks of PSL2 and *PY* in Figure 6.6 cannot be superimposed both before 1971 *and* after it, and some secular shift or trend would be required to explain their relationship over the period.

It appears (consider Figures 6.3 and 6.4, and Figure 6.7) that the money-demand equation with or without the trend variable cannot supply the explanation for this, and to stick with the preference for a broad money definition we would be forced to conclude, either that the appropriate definition of money actually changed, or that the model remains inadequate. Probably both of these is true, but it is not clear that relaxing the most obvious limitations of the present demand equation – the imposition of a unit income elasticity, or perhaps the omission of a wealth variable – will explain a fairly large and permanent *rise* in velocity, measured with respect to a fixed definition of money, since the mid-1970s. Financial innovation and the changing role of certain kinds of deposits might be more likely to provide the explanation.

All the models present a similar picture of the 1972–5 episode. The rise in the money stock in 1972 is seen to coincide with a constant or rising excess supply, identifying this event (if we did not know already) as a supply shock. Subsequently, inflation helps to raise velocity, but at the same time reduces the attractiveness of money still further. The rise in velocity after mid-1973 is seen as a corrective response to the shock, through inflation and a slowdown in monetary growth. While the latter will be due in part to the reimposition of credit control, the model predicts quite rapid countervailing adjustments too. Assuming the adjustment of deposits by the running down of bank loans is at a proportionate rate of 0.16 for each percentage point of excess money (from equation (i) of Table 6.3, also Table 6.4, column 2), linearising the equation assuming $A^p/M \approx 0.75$ (the 1975 value) yields a median lag of only $7\frac{1}{2}$ quarters, including the deadstart of three-quarters – rather faster than the estimate of Davidson (1984). By contrast, we still obtain for the same model a median lag in the inflation adjustment of about 13 quarters, and for income of about 25 quarters. Because of the semi-log specification, rates of adjustment are not fixed in the capital account equation, but assuming $M =$ £60 000m. in the floating exchange rate period, we also obtain the surprisingly low median lag of $7\frac{1}{2}$ quarters for monetary adjustment via the capital account of the balance of payments. By comparison this is negligible in the pre-1972 period, and is also a much larger effect than that estimated with the data to 1978(iv).

To conclude, these results still have to be considered provisional since the issues raised in Section III remain unresolved, but they appear to represent a considerable advance over those obtained with the previous versions of the model. The difficulties of this type of modelling are pretty formidable, although this is partly because problems of model specification which are manifest in this approach are merely implicit in single-equation models. However, I believe the results continue to support the basic contention that the money-demand function is not a regression equation; it is a valid operational concept only within the kind of modelling framework employed here.

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