The Demand for M4: A Sectoral Analysis

Part 1 - The Personal Sector

by

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The views expressed are those of the authors and do not necessarily reflect those of the Bank of England. The author would like to thank colleagues at the Bank of England for helpful comments especially Clive Briault, Shamik Dhar, Paul Fisher, Andy Haldane, Paul Tucker and Peter Westaway. The estimation in this paper was carried out using the PCFIML package version 8.0 developed by Jurgen Doornik and David Hendry.

Issued by the Bank of England, London, EC2R 8AH to which requests for individual copies should be addressed: envelopes should be marked for the attention of the Publications Group (Telephone: 0171-601 4030).

ISSN 1368-5562

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Abstract

The paper is the first part of a follow-up study to Fisher and Vega (1993) examining the demand for M4 by different sectors of the UK economy. It estimates a two-equation model of personal sector money holdings and consumption, using the recently developed partial systems methodology of Boswijk (1995). A general closed system of variables is estimated which is then reduced to an open two-equation simultaneous model using weak exogeneity tests, and making particular identifying restrictions on both the short and long-run structure. Money and consumption are shown to be related in the long run to income, wealth and interest rates, the estimated relationships being fairly standard theoretical specifications. But the model reveals interesting short-run interactions between money and consumption. Disturbances to consumption yield a negative correlation between consumption and money in the short run as predicted by "buffer-stock"/"target-threshold" type models of money demand. Disturbances to money on the other hand yield a positive correlation between money and consumption in the short run.

Introduction

Since the mid 1970s broad measures of the money supply have played an important role in the formulation of macroeconomic policy. Between 1976 and 1986, official targets were published for various definitions of broad money. But a growing disillusion with monetary targeting led to a gradual downgrading of broad money's role such that in the current monetary framework, announced in 1992, it is used as an intermediate indicator of inflationary pressures along with a wide variety of other variables. As part of this role a monitoring range (of 3%-9%) is still set for the annual growth of the M4 measure of the broad money supply.

Despite the fact that broad money is no longer the focal point of UK monetary policy, its role as an intermediate indicator requires an understanding of what drives its movements and how it influences other variables in the economy. This paper is the first of a two-part study which attempts to do this for the M4 measure of broad money,(1) building on a number of previous studies on the subject.(2) Throughout the emphasis is on deriving illustrative econometric models which may offer useful insights into the behaviour of broad money.

Two important econometric issues arise for any researcher attempting to model a broad money relationship. The first relates to the determination of the money stock and whether one is actually modelling the demand for money, the supply of money or some combination of the two. This "identification" problem is not easily resolved; it will be shown that deriving separate demand and supply relationships for broad money is not always possible given the unique nature of the demand for money.

Another important and related modelling issue is that of exogeneity. In theory money is likely to be jointly determined with nominal expenditure and financial yields. Yet most empirical models of money demand have traditionally treated these explanatory variables as exogenously given (or determined elsewhere). If money is jointly determined with the variables used to explain it, then strictly it should be modelled as part of a system of economic relationships for consistent estimates of the parameters of the money demand function to be obtained. Moreover, analysing broad money as

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(1) See Bank of England (1987) for a full definition.

(2) Hall, Henry and Wilcox (1989) and Fisher and Vega (1993) have attempted to identify the most important factors driving movements in M4 holdings and have emphasised the importance of income, wealth and relative interest rates as the long-run determinants of the demand for broad money. A non-technical summary of this paper can be found in Thomas (1996).

part of a wider economic system is vital if anything about its role in the transmission mechanism is to be uncovered. But systems modelling is a considerably more difficult exercise than single-equation modelling and often creates more problems than it cures.

In this paper it is argued that the modelling difficulties which arise from these two issues are likely to be most acute when looking at broad money in the aggregate. Modelling money *by sector* may alleviate them to some extent. This approach has been adopted in a number of recent studies such as Congdon and Ward (1993), Dale and Haldane (1993), Fisher and Vega (1993), Chrystal and Drake (1994) and Mizen (1996) as well as in the more distant past, see Price (1972) . Different sectors may have different motives for holding money and this may be exploited to derive better estimates of agents' money demand, at least in the long run. Moreover, examining broad money's role in the transmission mechanism at an aggregate level is likely to require modelling a large system of variables which may be open to a multitude of specification errors and could be too large to handle given the typical size of macroeconomic data sets. Sectoral modelling may permit the analysis of smaller "partial" or "conditional" systems which are able to highlight the important interactions between money and real expenditure, but which involve only a small number of relationships which can subsequently be fed into a larger macroeconomic model.

The first two sections of this paper examine these issues in more detail. Section 1 looks at how in theory the broad money stock is determined and what role it plays in the monetary transmission mechanism. Section 2 then looks at some econometric problems of modelling broad money and how sectoral modelling may alleviate some of them. Section 3 then moves on to the empirical analysis and examines the determinants of the personal sector's holdings of M4. A similar analysis of the corporate sector is undertaken in a companion paper.(3)

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(3) See Thomas (1997).

1 The Determination of the stock of broad money

Much has been written on the subject of the determination of the money stock. A criticism of both monetarist and Keynesian monetary theory is that in both cases the money stock is often thought of as an exogenous variable under the control of the authorities. When the majority of what serves as money is the liability of the banking system (hereafter called deposit money), thinking of the stock of money as an exogenous variable is difficult given the way central banks typically operate monetary policy. This has important implications for the modelling of broad money as well as for understanding its role in the transmission mechanism.

Traditional textbook theory, when looking at the determination of the stock of deposit money, takes the level of reserves available to the banking system as exogenously determined by the authorities. The level of bank liabilities is then determined as some fixed multiple of reserves depending on certain parameters such as the public's desired cash-deposit ratio and banks' desired reserve-deposit ratio. It has long been recognised that this is not a satisfactory way to think of the determination of the money stock. First the ratios upon which this determination of the money stock is based are not constants but endogenously determined parameters given the preferences of and risks faced by both the banking system and the public. But furthermore the method through which central banks typically operate monetary policy in the short run is through setting the price (interest rate) at which it supplies reserves to the banking system rather than setting the quantity of those reserves.(4)

In a system where reserves are supplied elastically by the authorities at a given interest rate, banks are free to accept and bid for deposits from the private sector. The determination of the money stock will then depend upon the need for banks to retain and attract deposits to fund their desired lending at the interest rate set by the authorities, as well as depending on the desire of the non-bank private sector to hold deposit money. If we think of the former as defining the "supply" of broad money by banks and the latter as the "demand" for money by non-banks then at first sight it seems it is possible to analyse the determination of the money stock in terms of the traditional supply and demand analysis that is applied to other commodities. Unfortunately, given the nature of money as a medium of exchange as well as a store of value, this is not so straightforward. In particular it is not clear what variable, if any, adjusts to equate money demand with money supply.

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(4) Over the longer term the determinants of the authorities' interest rate reaction function become important.

One possibility is that relative interest rates (deposit rates relative to the rates of return on alternative assets) move rapidly and continuously to keep the supply and demand for money in equilibrium. A typical exposition of this view is that banks act as liability mangers. Banks undertake all profitable lending opportunities at the level of interest rates determined by the central bank and proceed to bid for deposits to fund that lending. So, faced with an increase in the demand for credit ("supply" of money) banks will typically have to increase deposit rates relative to other financial yields to ensure that funds are retained within the banking system when the loans are spent.(5) In this sense relative interest rates and the stock of money are jointly determined in much the same way as price and quantity are determined in any (monopolistically) competitive market.

The problem with this as a complete explanation of the determination of the money stock is that banks are acting like any other financial intermediary and their liabilities can be considered as being just like any other financial instrument (store of value) albeit imperfect substitutes for them. Banks have to attract funds before or simultaneously with their lending decision and they do this by raising the (relative) rate of return on their liabilities.

But the other property of deposit money is its ability to act as a medium of exchange. This may permit an expansion of credit and the stock of money without necessarily any need for banks to change the rate of return on money, at least in the short run. To see this it is useful to consider the distinction between:

(i) the *acceptance* of money at a given moment in time, as (a possibly very temporary) abode of purchasing power or "buffer stock", which bridges the gap between uncertain payments and receipts;

and

(ii) the desire to *hold* money in equilibrium, which in the case of transactions money should be thought of as an *average amount* that agents demand *over a given time horizon*.

This distinction is useful because it brings out how agents' holdings of money at any moment, may deviate from the amount agents desire to hold in long-run equilibrium. In the short run agents may be prepared temporarily to

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(5) Assuming that the demand for money is increasing in its own rate of return and declining in the rate of return on other assets.

accept higher money balances as a means of payment, even if relative rates of return and the level of nominal income (which determine the equilibrium demand to hold money) remain unchanged This is the central premise of the "buffer stock" theory of money demand(6) but a similar concept also appears in the post-Keynesian "endogenous money" literature.(7) So, following an increase in the demand for credit, banks may be able to grant new loans without having to change deposit rates. This in the knowledge that the deposits created by the extra borrowing(8) will automatically remain within the banking system when the loans are spent since they are willingly accepted as a means of payment by the recipients of the borrowers' expenditure.

Over the longer term the supply and the long-run demand to hold money will be made consistent as agents attempt to shed excess money balances. As Congdon (1992) stresses, it is important to distinguish between the adjustment of an individual agent to excess money balances and the response of agents in aggregate. An individual agent can easily reduce any surplus liquidity by purchasing goods or real and financial assets. But this does not necessarily lead to a fall in aggregate money holdings. It simply passes money balances on to other agents who are then left with surplus money holdings themselves. In the aggregate agents pass excess money balances on to one another like a "hot potato" until ultimately the transactions underlying the transfer of deposits lead either to a rise in the equilibrium demand for money or a fall in its supply. The former will result from agents purchasing goods and services or real and financial assets. This raises nominal expenditure and wealth (asset prices) and reduces the yield on alternative assets, all of which are likely to raise the equilibrium demand for money. A fallback in the money supply occurs primarily through repayment of bank debt. This happens automatically if money balances pass to agents with overdrafts. But the reduction in financial yields resulting from agents purchases of assets, such as bonds and equities, may also induce a switch from bank borrowing to other forms of finance.(9)

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(6) See Laidler (1984) and Milbourne(1988) for a discussion of buffer stock models.

(7) See Moore (1988) and Howells (1995) for recent expositions. The acceptance of money in exchange in this literature is sometimes termed "involuntary saving" or "convenience lending" with an emphasis on flow rather than stock disequilibrium.

(8) The process of credit creation envisaged here involves banks crediting the funds to the borrower's bank account. But a similar story holds when the new loans take the form of a facility or overdraft. In this case the deposits are not created until the borrowers actually draw on the funds and are accepted by the recipients of their expenditure.

(9) See Howells (1995).

In practice one would expect to see certain types of agent using their money balances as financial buffers, but one would also expect individual banks to be active liability managers at the margin. So far the banking system has been treated as a single entity, but it is important not to ignore competitive forces within the banking system. When making loans an individual bank will know that only a certain proportion of the funds lent will return automatically as transactions balances, depending on how many of the recipients of the loan-financed expenditure hold a current account at the bank.(10) A bank also knows it will receive inflows of transactions balances as a result of other banks making loans. But at the margin an individual bank is likely to face a shortfall (or a surplus) of funds. To alleviate this banks typically turn to the wholesale market, for example by issuing a certificate of deposit. This may either attract funds from surplus banks or from (wholesale) customers of other banks. Depending on the distribution of surpluses and shortages in the banking system, the rate of return on wholesale deposits may rise relative to other money market rates if other assets are viewed as imperfect substitutes.

Distinguishing among these different influences on broad money holdings (and the different implications they have for nominal demand) is likely to be difficult at the aggregate level. It may be useful to analyse the money balances of those who hold mainly wholesale money-market deposits such as non-bank financial companies (known in the United Kingdom as “other financial institutions or “OFIs”) separately from those agents, such as households, who hold a larger proportion of their broad money holdings as transactions balances. The former are likely to be highly responsive to relative rates of return and are likely to adjust their portfolios fairly rapidly. The latter, because they use their money balances as a buffer, may take more time to adjust and may do so in a way that has stronger implications for aggregate demand.

2 Econometric issues

Traditionally the empirical analysis of (broad) money demand has been carried out within a single equation framework because of the computational difficulties of simultaneous equation modelling. But a single equation framework is highly restrictive. First, it does not allow an easy distinction to be made between money demand and supply influences. Second, it does not reveal how money interacts with other variables in the transmission mechanism. It is useful to examine these issues in more detail.

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(10) This has been termed the bank’s “retention ratio” by Tobin (1982).

(a) Identifying separate money demand and supply equations

The discussion in section I suggests that the demand to hold money is largely a long-run equilibrium concept. In the short run the general acceptance of money implies that any increase in the supply of money is likely to be held even if it is not demanded in the longer term. This has important implications for the interpretation of the typical dynamic money demand functions estimated by researchers. Take the typical error-correction money demand model given by:

$$\Delta m_t = \alpha_0 + \alpha_1 \Delta (i_{dt} - i_t) + \alpha_2 \Delta y_t + \alpha_3 \Delta w_t - \alpha_4 (m - m^*)_{t-1} \qquad \textbf{(1)}$$

$$m^* = \beta_0 + \beta_1 (i_d - i) + \beta_2 y + \beta_3 w$$

where *m* is the stock of broad money $i_d - i$ is the opportunity cost of holding money, *y* is some measure of transactions or income and *w* is some measure of wealth. In order for this function to be called a "money demand" function then it relies upon agents either being able to get all the money balances they want at given levels of interest rates, income and wealth, or a further equation in the money supply needs to be identified with one of the right hand side variables in **(1)** an endogenous variable. If one were to follow the liability management argument as a description of money stock determination, this money supply function would most likely take the form of a deposit rate setting relationship of the form:

$$\Delta i_{dt} = \gamma_0 + \gamma_1 \Delta i_t + \gamma_2 \Delta m_t - \gamma_3 (i_d - i_d^*)_{t-1} \qquad \textbf{(2)}$$

and

$$i_d^* = \gamma_4 i \pm \gamma_5 m$$

Since equation **(2)** is a monopoly price setting function, it is not independent of the demand function. All the parameters of **(2)** are likely to be dependent on the α's and β's in some way as well as on parameters such as the interest elasticity of demand for credit. Together **(1)** and **(2)** would jointly determine deposit rates and the stock of broad money.

But if agents accept increases in money balances without the need for deposit rates (or any other determinant of the demand for money) to change then one cannot separate the short-run demand for money from its supply. One has to estimate an equation such as **(1)** but interpret it as a "money holdings" relationship rather than purely a money demand or supply function. The only part of equation **(1)** that can be termed the money demand function is the long-run solution given by m^*. The short-run dynamics of the equation are likely to be reflecting changes in the demand and supply of bank credit. If money balances are greater than desired in the long run, then actual money holdings fall back. But this is because agents are choosing to rid themselves of excess liquidity by repaying bank debt not because of dynamic adjustment in the demand for money. Falls in the demand for broad money will not lead to a fall in actual money holdings unless they lead to a similar fall in bank credit.(11)

The difficulties of separating the supply and demand for broad money when deposits are universally accepted in exchange suggests different approaches will be required to model the money holdings of different sectors. In particular, OFIs are the chief counterparts to banks' liability management activities and so it may be possible to separate money demand and money supply influences *at the margin* by modelling their money holdings jointly with (wholesale) deposit rates. For persons and industrial and commercial companies (ICCs) a money "holdings" relationship similar to (1') is probably more appropriate, since they are more likely to hold money as a buffer.

(b) Modelling money's role in the transmission mechanism

The fact that a single "money holdings" equation rather than separate supply and demand functions may be a more appropriate way to model money holdings for particular sectors, does not diminish the need for both estimating and analysing money as part of a broader system of variables. First the joint determination of money and expenditure makes system estimation necessary for obtaining consistent estimates of the parameters of interest. But furthermore system estimation permits a full analysis of how money interacts

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(11) A problem here is that not only will deviations from the long-run demand for money have a negative effect on money holdings, but so will any deviations of the outstanding stock of borrowing from the long-run demand for credit. Agents may not want to reduce their excess money balances through debt repayment, if their current level of debt is already lower than optimal. Thus an additional error-correction term should be added to equation **(1)** - the deviation of the current level of the money supply (demand for credit) from its equilibrium level:

$$\Delta m_t = \alpha_0 + \alpha_1 \Delta (i_{dt} - i_t) + \alpha_2 \Delta y_t + \alpha_3 \Delta w_t - \alpha_4 (m - m^*)_{t-1} - \alpha_5 (m - d^*)_{t-1} \quad (1')$$

where $d^* = \beta_4 (i_d - i) + \beta_5 y + \beta_6 w$

is some equilibrium relationship for the demand for credit. Both m^* and d^* are likely to depend on much the same variables which makes it extremely difficult, in practice, to identify both the long-run money demand and supply functions separately.

with its determinants, especially when the interaction is simultaneous.(12) Estimating single equations separately often implies the imposition of unjustifiable identifying restrictions (such as implicit exclusion restrictions). Such restrictions would be testable in a system framework (see section (c) below).

Recent developments in the econometric analysis of time series have increased the feasibility of estimating systems of simultaneous equations and allow the incorporation of equations for money holdings into a wider system of variables. A recently developed method, which is adopted in this paper, is the "encompassing VAR" approach of Hendry and Mizon (1993). This approach attempts to recover structural economic models from congruent statistical representations of the data where the premium is on making simplifying exogeneity and identifying restrictions.

The starting place is an unrestricted vector autoregression or VAR which contains all the variables y_t we are likely to need to explain the relationship(s) of interest. In the context of this paper y_t will be a vector of variables such as money, prices, income and various rates of return. We marginalise with respect to all other variables.

The closed VAR can be represented by:

$$D(L)\, y_t = \varepsilon_t$$

where $D(L) = I_n - D_1 L - D_2 L^2 - \ldots\ldots\ldots\ldots\ldots - D_p L^p$, L being the lag operator. ε_t is a white noise error term with variance-covariance matrix Σ.

We can reparameterise this general dynamic statistical model to isolate the long-run relationships from the short-run dynamics by formulating the VAR as a vector error correction mechanism or VECM given by:

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(12) In the single equation framework modellers have assumed either that the money stock was the dependent (endogenous) variable and that agents could get all the money balances they desired at exogenously given levels of prices, incomes and interest rates; or they had to assume that money was exogenously given and so "invert" the money demand function to determine something else (prices, incomes or interest rates) as a function of an exogenously given money stock. The only statement that could be made in a single-equation framework was whether a money demand equation conditioned on prices and incomes (ie endogenous money regressed on exogenous prices and incomes) was more stable than a price function conditioned on money, when in a systems approach exogeneity hypotheses can be tested more rigorously. See Hendry and Ericsson (1991) and MacKinnon and Milbourne (1988).

$$\Delta y_t = \Pi \, y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-i} + \varepsilon_t$$

Important here is the order of integration or stationarity of the variables concerned. If the variables are integrated of order 1 but not cointegrated then the long-run matrix Π will be a zero matrix and we obtain a VAR model in differences. If all the variables are stationary then Π will have full rank. When the series are cointegrated Π will have less than full rank and can be decomposed into two matrices α and β', as follows:

$$\Delta y_t = \alpha\beta' \, y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-i} + \varepsilon_t$$

where $\beta' y_t$ is the matrix of cointegrating vectors (which are interpretable as the deviation of variables from their long-run equilibrium levels) and α is a matrix of loading vectors showing how each deviation impacts on other variables. It is clear that for our purposes the α matrix (and transformations of it) will be important. A buffer-stock model would predict that the deviation of money holdings from their equilibrium level should affect a wide variety of real and financial variables in the short run which will imply certain elements of the α matrix to be non-zero. There is thus a natural mapping from testing restrictions on the VECM to testing certain theoretical hypotheses concerning the transmission mechanism.

In its present form the VECM should be considered as an unrestricted reduced form model, with long-run structural information embodied in the long-run relationships β' and short-term structural information to be recovered from the parameters α, Γ and the variance-covariance matrix of ε_t given by Σ. Recent techniques developed by Hendry and Mizon (1993), Johansen & Juselius (1994) and Boswijk (1995) concentrate on recovering structural models from an unrestricted VECM by making identifying restrictions on both the long and short-run reduced form parameters. In this respect a structural model is defined loosely as a representation that allows contemporaneous relationships between the variables:

$$A_0 \, \Delta y_t = \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + a\beta' \, y_{t-1} + u_t$$

where the relationship of the short-run structural parameters with the reduced form parameters is given by:

$$A_i = A_0 \Gamma_i \ , \ a = A_0 \alpha \ , \ u_t = A_0 \varepsilon_t \ , \Omega = A_0 \Sigma A_0'.$$

Note the matrix of long-run structural parameters, β' ,is unchanged by this transformation. The crux of the identification problem is to identify both β', and the matrix A_0 which defines the short-term structural relationships. Clearly both problems are relevant to money's role in the transmission mechanism but theory probably tells us more about β' than it does about the short-run parameters A_o. Identification of β' has been discussed extensively in the literature (see BDrdsen and Fisher (1993) and Johansen and Juselius (1994) for example). The identification of A_o has received less attention (see Boswijk (1995). It is clear from the above relationship that the A_o can be chosen (in the sense of imposing just identifying restrictions) using several criteria:

(i) The first is by imposing restrictions on A_o itself. This may be possible because some variables may be known not to respond to other variables contemporaneously. For example, such restrictions might be imposed on interest rate reaction functions when it is known that data on certain variables are available to the authorities only with a lag.

(ii) The second is by imposing restrictions on the dynamics, so that A_o is chosen to define particular A_i terms in the structural form. As theory often tells us little about dynamics, identifying restrictions are not usually placed on the lagged dynamic terms. The exception is rational expectations modelling which often implies cross-equation restrictions among the dynamic terms; but in general these are overidentifying.

(iii) A_o can be defined so as to restrict the error-covariance matrix. A popular practice in VAR analysis is to restrict the structural errors to be uncorrelated, so that Ω $(= A_o \Sigma A_o')$ is diagonal. As the error-covariance matrix is symmetric this does not uniquely define A_0 and further restrictions need to be imposed. For example A_o is often additionally restricted to be triangular with ones down its diagonal, which defines a Wold causal chain in the contemporaneous relationships.(13)

(iv) A further possibility that has been developed recently is that A_o can be chosen to define how the long-run relationships enter each structural equation ie by defining the matrix $a = A_o \alpha$. It is typically employed when some of the variables in the system are weakly exogenous and the number of cointegrating vectors equals the number of endogenous variables eg the

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(13) This is known as the Choleski decomposition.

“structural error correction model” SECM recently developed by Boswijk (1995) and BDrdsen and Fisher (1993).

To see this, consider adding a number of weakly exogenous variables x_t to our system of endogenous variables y_t. Defining the cointegrating vectors in terms of $z_t{}' = [y_t \;\; x_t]$, leads to a conditional VECM given by:

$$\Delta y_t = \alpha\beta' z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-i} + \sum_{i=0}^{p-1} \Psi_i \, \Delta x_{t-i} + \varepsilon_t \qquad \textbf{(3)}$$

The “structural” model is again defined by pre-multiplying the conditional VECM by $A_o \neq I$.

$$A_0 \, \Delta y_t = \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + \sum_{i=0}^{p-1} B_i \, \Delta x_{t-i} + a \, \beta' y_{t-1} + u_t \qquad \textbf{(4)}$$

where, similar to above, the short-run structural parameters’ relationship to the reduced form parameters is given by:

$$A_i = A_0 \Gamma_i \;, \; B_i = A_o \Psi_i \,, \; a = A_0 \alpha \;, \; u_t = A_0 \varepsilon_t \;\; , \Omega = A_0 \Sigma A_0{}'.$$

The Structural Error-correction Model involves choosing A_o so that only one cointegrating vector enters each of the structural equations ie so that $a = A_o \alpha$, is a diagonal matrix. This method of identification is appealing for its symmetry and (in most cases) its interpretability. But as argued by Ericsson (1995) it should not be thought of as a generic method of identification.

Methods (i) to (iv) above represent largely statistical methods of (exactly) identifying A_o. But what about economic criteria ? None of the above map directly into different theories of the transmission mechanism(14) but they may place some sensible theoretical restrictions on the resulting structural form. One feature of (iv) for example is that it only allows the disequilibrium term for each endogenous variable to influence the other endogenous variables *indirectly* through the contemporaneous relationships. Thus excess money holdings would affect other variables only to the extent that money holdings actually change. This is a sensible restriction for a model of personal sector money holdings since surplus money balances will affect consumption or asset prices only to the extent they are passed to the corporate or overseas sectors. Also, as argued by Congdon (1992), disequilibria in personal sector

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(14) Indeed it would be inconvenient if they did since different theories would be observationally equivalent ie they would all be consistent with the same reduced form model.

money holdings may be not be that persistent, so that it is more likely any buffer stock or liquidity effect would operate contemporaneously. But for the corporate sector, investment spending and asset prices may be affected by excess liquidity without total corporate sector money holdings actually changing. Firms may attempt to shed liquidity by purchasing real and financial assets from each other. Thus it may be preferable to allow corporate sector monetary disequilibria to affect expenditure and asset prices directly in the structural form so that some other method than (iv) might be more appropriate.

Once A_o has been chosen further overidentifying restrictions may be suggested by the resulting exactly identified structural form. These overidentifying restrictions can be tested using the encompassing statistic of Hendry and Mizon (1993).

(c) Full system, partial system and single equation estimation

Unfortunately there are a number of practical difficulties with systems modelling. Given the typical size of macroeconomic data sets, estimating a large system of variables is not always possible, since there may simply not be enough data points to estimate all the parameters of interest. Increasing the number of variables in the system increases the number of parameters to estimate exponentially. Moreover it is well known that (full information maximum likelihood) estimates of simultaneous equation models are very sensitive to specification errors.

Such problems have often led researchers to eschew systems estimation and prevail with a single equation approach, using instrumental variables to cope with any potential endogeneity problems. The separately estimated equations may then be fitted together and their interaction analysed. The obvious disadvantage with this approach is that the endogenous variables are chosen a priori which may impose unjustifiable (over)identifying restrictions. Exogeneity hypotheses (and the restrictions they imply) can be tested in a system.

There is also the problem of instrument choice. Often these tend to be chosen rather arbitrarily and care must be taken to ensure that the correlation between the endogenous variables and the instrument set is stable through time. In this respect an advantage of the full system approach is that long-run information is effectively included in the instrument set, since the effect of the cointegrating vectors on the endogenous variables plays a part in identifying and estimating the structural parameters of the model. Long-run relationships are arguably more suitable instruments than the plethora of dynamic terms which usually make up an instrument set.

These practical difficulties with both single equation (instrumental variable) and full system approaches, provides a motivation for attempting to model "partial" or "conditional" systems such as equations **(3)** and **(4)** above, where some of the variables in the system are treated as weakly exogenous (do not need to be modelled to estimate the parameters of interest). This can be seen as a halfway house between single equation and full system modelling which limits the potential damage from misspecification but can still obtain consistent estimates of the parameters of interest. Testing weak exogeneity hypotheses (see Urbain (1995)) naturally plays an important part in developing such a conditional model.(15)

Summary

In general the methodological issues discussed in (a) to (c)above imply a multi-stage estimation and testing procedure:

(i) Testing for the number of long-run relationships present in the data.

(ii)Identification of the cointegrating vectors and testing for weak exogeneity

(iii) Developing a conditional reduced-form model.

(iv) Identifying and estimating a structural model which encompasses the reduced form.

We apply this procedure to each of the sectors.

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(15) Such exogeneity restrictions are likely to be more plausible at a disaggregated level which provides a further advantage of sectoral modelling.

3 A Model of personal sector M4 and consumption

Introduction

The personal sector holds almost a quarter of its financial assets in the form of M4 instruments. They are likely to serve as both a medium of exchange and a store of value given the range of facilities typically offered by bank and building society accounts. This suggests we can model personal sector M4 using conventional money demand theory relating real balances to income or expenditure, wealth and relative rates of return. However, in view of the fact that money may interact with consumer spending we must ensure we model a system that includes variables which are important in determining personal sector expenditure.

With this consideration in mind a system of eight variables was modelled consisting of real personal sector M4 (m_t), real consumption expenditure (c_t) , real personal disposable income (y_t), gross real personal sector wealth - financial and tangible - (w_t),(16) the three-month Treasury bill rate (i_t), an own-weighted average interest rate on personal sector M4 deposits (i_{dt}), the inflation (consumption deflator) rate (Δp_t), and the change in unemployment (Δu_t) . A full description of the data and sources is given in the Appendix. All variables are in logarithms except the interest rate, inflation and the change in the unemployment rate which were all defined as proportions (ie 10%=0.1). All variables except the interest rates are seasonally adjusted. The sample period is from 1977 Q1 to 1994 Q4 (reliable data on deposit rates precludes a longer sample period).

The inclusion of both consumption and disposable income not only allows flexibility in the choice of scale variable for the money demand function, but,

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(16) We ran the model both using gross and net wealth (for net wealth we subtracted gross financial liabilities of the personal sector) but the overall results were broadly the same except for the fact that the money demand equation using gross wealth yielded a slightly lower standard error. Because we are using logs of wealth the difference between using gross and net wealth (GW and NW) in the system depends on the ratio of the level of gross liabilities (GL) to gross wealth [$NW = GW - GL$], thus $\Delta \log NW \approx \Delta \log GW - \Delta (GL/GW)$. If households tend to tap some of their net wealth by collateralised borrowing (eg on housing) in a relatively stable proportion ie $GL = a\,GW$ (where a is a constant <1), then the elasticity of a variable with respect to gross wealth will be almost the same as that of net wealth. This would seem to tie in with consumption over the 1980s where households tapped their housing equity through mortgage borrowing, and may explain why the results for the wealth elasticity of consumption were little different for gross and net.

as noted above, allows for the possibility that money and consumption may be jointly determined. The change in unemployment is added to allow for the possibility of precautionary saving which previous work has found to be important in modelling consumption. Univariate tests suggested that all the variables are integrated of order 1 - $I(1)$ - including inflation over this particular sample period.

3.1 The long-run relationships

In order to determine the number of long-run relationships among the eight variables the cointegration analysis developed by Johansen (1988) was applied. This first involves estimating a closed VAR model (ie all variables endogenous) which is interpretable as the general unrestricted reduced form of the system. Choice of lag length is always problematic and given the short sample period a low lag length would be desirable.(17) A lag length of 2 was chosen on the basis that there appeared to be no residual autocorrelation in the VAR. Additionally a constant as well as three dummy variables were added, the latter to obtain residual normality and parameter constancy. The dummies took the values of 1 in 1979 Q2, 1988 Q3 and 1989 Q4 respectively, followed by -1 in the subsequent quarter.(18)

Cointegration tests are generally sensitive to the treatment of deterministic elements such as constants and dummy variables, ie whether they are restricted to the long-run relationships or concentrated out of the likelihood function prior to testing (entering the VAR unrestricted). Since the dummy variables are (1,-1) dummies they can be safely concentrated out of the likelihood function as they will still be stationary under the null of no cointegration (and so will not imply an $I(1)$ deterministic element in the levels of the variables under the null). But the presence of interest rates in the system means the best treatment of the constants is not so clear.(19)

Table 3.A shows the results of the cointegration test with both a restricted and unrestricted constant, the dummy variables treated as unrestricted in both

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(17) In a closed VAR of 8 variables and 2 lags with a constant and 3 dummies this means estimating 8x2 + 3 + (8+1)/2 = roughly 24 parameters in each equation (including covariance terms), which given 72 observations leaves 44 degrees of freedom. With 4 lags the degrees of freedom fall to around 28 and with 8 lags we run out.

(18) The 1989 Q4 dummy is required in the equation for disposable income. It is dropped when we move later to a conditional system.

(19) In general it is best to enter constants as unrestricted variables. Under the null of no cointegration, an unrestricted constant would imply a deterministic trend in the levels of the variables. This may not be a sensible null hypothesis for interest rates.

cases. A " * " denotes rejections of the null at the 5% level and ** at the 1% level. In both cases the results suggest at least two cointegrating vectors and we proceed on this basis.(20)

Following Boswijk (1995) we attempt to identify these long-run relationships by partitioning the eight variables which can be denoted by the vector Z_t = (m_t , c_t , y_t, w_t, i_t , i_{dt} , Δp_t , Δu_t) into endogenous variables Y_t and exogenous variables X_t. We proceed on the basis that there are the same number of endogenous variables as cointegrating vectors, as this makes identification of both the short and long-run structure more tractable. Personal sector M4 and consumption were treated as endogenous and Z_t was partitioned accordingly. The validity of these exogeneity assumptions is tested later.

Identifying restrictions were then placed on the cointegrating vectors resulting from the conditional VAR of Y_t' = [m_t , c_t] conditioned on X_t' = [y_t , w_t , i_t , i_{dt} , Δp_t , Δu_t]. The estimates of the cointegrating vectors from the Johansen procedure are identified in an arbitrary manner so identifying restrictions based on theory were made on the cointegrating vectors. These are shown in Table 3.B. The parameter on the *k*'th element of Z_t in the *i*'th cointegrating vector is denoted by β_{ik} where i =1,2 and k =1,2,...7

Two restrictions in each equation are required to exactly identify the long-run relationships. The restrictions chosen were that money does not enter the long-run relationship for consumption and vice versa, so that effectively both long-run relationships are solely dependent on the exogenous common trends. This is represented formally as $\beta_{11} = 1$, $\beta_{12} = 0$, $\beta_{21} = 0$, $\beta_{22} = 1$. These normalising restrictions are made so that the long-run relationships for money and consumption are entirely conventional and would slot in easily to a variety of macroeconomic models.(21)

This yielded two relationships that resembled a money demand relationship and a consumption relationship. Further overidentifying restrictions were then made on the variables, testing a variety of structural hypotheses. These are shown in Table 3.B. The test statistics are distributed as χ^2 with degrees of freedom given by the number of overidentifying restrictions (Johansen and Juselius (1994)). The structural hypotheses were as follows:

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(20) The tests show the possibility that there may be three cointegrating vectors. This may be picking up the near-stationarity of the inflation and interest rate terms (or possibly some combination of them).

(21) This restriction implies that long-run money demand is a function of income rather than expenditure. But the results were very similar when consumption was allowed to enter the long-run money demand relationship and income was excluded.

(i) Long-run homogeneity in income and wealth in both relationships so that $\beta_{13} + \beta_{14} = -1$ and $\beta_{23} + \beta_{24} = -1$. This allows us to reparameterise the money and consumption cointegrating vectors into: first, a relationship between broad money velocity and the wealth-income ratio; and second, the average propensity to consume and the wealth-income ratio. Such relationships would be predicted by permanent income theories of money demand and consumption.(22) The restrictions also allow the cointegrating vectors to be interpreted as the combination of an “error-correction term” and an “integral-control term” as in Hendry and von Ungern-Sterberg (1981).(23)

(ii) The deposit rate and the Treasury bill rate combine to form a term in the spread of the deposit rate above the market rate of interest. Additionally the spread should only enter the long-run relationship for money leaving just the level of interest rates in the long-run consumption function. This implies the restrictions $\beta_{15} = -\beta_{16}$ and $\beta_{26} = 0$. Also in the consumption function the nominal interest rate and the one quarter change in the GDP deflator should combine to form a term in the (*ex post*) real interest rate so that $\beta_{25} = -\beta_{27} / 4$.

(iii) Precautionary Saving. This would imply that the change in unemployment term should only enter the long-run consumption function implying a restriction of $\beta_{18} = 0$.(24)

As the table shows these restrictions could not be rejected at the 5% level. The coefficients on wealth and income in the money demand and consumption functions are very similar to those found by Fisher and Vega (1993) and were restricted accordingly. Altogether some eight overidentifying restrictions were made which the tests show could not be rejected jointly at the 5% level.

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(22) Permanent income theory would predict $C = K.TW$ where TW is total physical and financial wealth W plus human capital which if income is a random walk with drift g and the real interest rate is r can be shown to be $Y / (r-g)$. Rearranging and taking logs yields $c = k - ln(r-g) + y + (r-g) W/Y$, so that strictly the log of the consumption income ratio depends on the level of the wealth-income ratio not on the log.

(23) This relates to the earlier point that there may (and should be) more than two cointegrating vectors present in the data. The integral control term in the wealth income ratio could be considered a cointegrating vector in its own right if there were an equilibrium wealth-income ratio that was fairly stationary.

(24) An increase in consumer prudence might also affect households’ portfolio allocation but it is not clear that this should affect the demand for M4; it may simply affect the reallocation within M4 assets eg between sight and time deposits.

The resulting cointegrating vectors, with inflation rewritten in annual terms so that $\pi_t = 4\Delta p_t$ were given by:

$$m^* = 0.5\, y_t + 0.5\, w_t + 0.44\,(i_{d\,t} - i_t) - 1.6\,\pi_t$$

$$c^* = 0.9\, y_t + 0.1\, w_t - 0.64(\, i_t - \pi_t\,) - 1.21\Delta u_t$$

Chart 3.1 shows the stability of these relationships when the test of the overidentifying restrictions is computed recursively from 1990 Q1 onwards. This is a necessary condition for these to be interpretable as structural relationships.

Both long-run relationships seem sensible. Money is increasing in income and wealth with an elasticity of a half in each case, the former consistent with M4 balances being held as a transactions medium. Personal sector M4 is also increasing in the spread of deposit rates above market rates and decreasing in inflation. The latter is likely to be proxying the relative rate of return between real and financial assets. Consumption is increasing in disposable income and gross wealth (although, as noted earlier, a similar relationship could be derived with net wealth) and decreasing in the three month *ex post* real interest rate with a semi-elasticity of just over a half. The negative term in the change in unemployment is indicative of precautionary saving in response to the implied increase in employment uncertainty.

Table 3.A Cointegration analysis

(a) Constant and dummies unrestricted

	Eigenvalue test			**Trace test**		
H_o:rank=p	$-Tlg(1-\lambda)$	T-nm	95%	$-T\Sigma lg(1-\lambda)$	T-nm	95%
p == 0	85.53**	65.98**	51.4	223.9**	172.8**	156.0
p <= 1	49.68*	38.32	45.3	138.4**	106.8	124.2
p <= 2	36.07	27.82	39.4	88.73	68.45	94.2
p <= 3	19.22	14.83	33.5	52.66	40.63	68.5
p <= 4	16.69	12.88	27.1	33.44	25.8	47.2
p <= 5	10.55	8.141	21.0	16.75	12.92	29.7
p <= 6	5.628	4.342	14.1	6.193	4.778	15.4
p <= 7	0.565	0.436	3.8	0.565	0.436	3.8

(b) Constant restricted, dummies unrestricted

	Eigenvalue test			**Trace test**		
H_o:rank=p	$-Tlg(1-\lambda)$	T-nm	95%	$-T\Sigma lg(1-\lambda)$	T-nm	95%
p == 0	85.55**	66**	52.0	238.9**	184.3**	165.6
p <= 1	55.99**	43.19	46.4	153.4**	118.3	131.7
p <= 2	36.35	28.04	40.3	97.4	75.14	102.1
p <= 3	20.82	16.06	34.4	61.05	47.1	76.1
p <= 4	17.08	13.18	28.1	40.23	31.03	53.1
p <= 5	12.28	9.477	22.0	23.15	17.86	34.9
p <= 6	8.384	6.468	15.7	10.86	8.38	20.0
p <= 7	2.479	1.912	9.2	2.479	1.912	9.2

Vector normality $\chi^2(16)$= 17.511 [0.3533]
Number of lags used in the analysis: 2

Other variables entered unrestricted:
D1979Q2 D1988Q3 D1989Q4

Table 3.B Test of identifying restrictions on the cointegrating vectors

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Identified cointegrating vectors

	β_1	β_2
m	1	0
c	0	1
y	-0.5	-0.9
w	-0.5	-0.1
i_d	-0.44	0
i	0.44	0.63
Δp	6.35	-2.51
Δu	0	1.21

Standardised loading coefficients

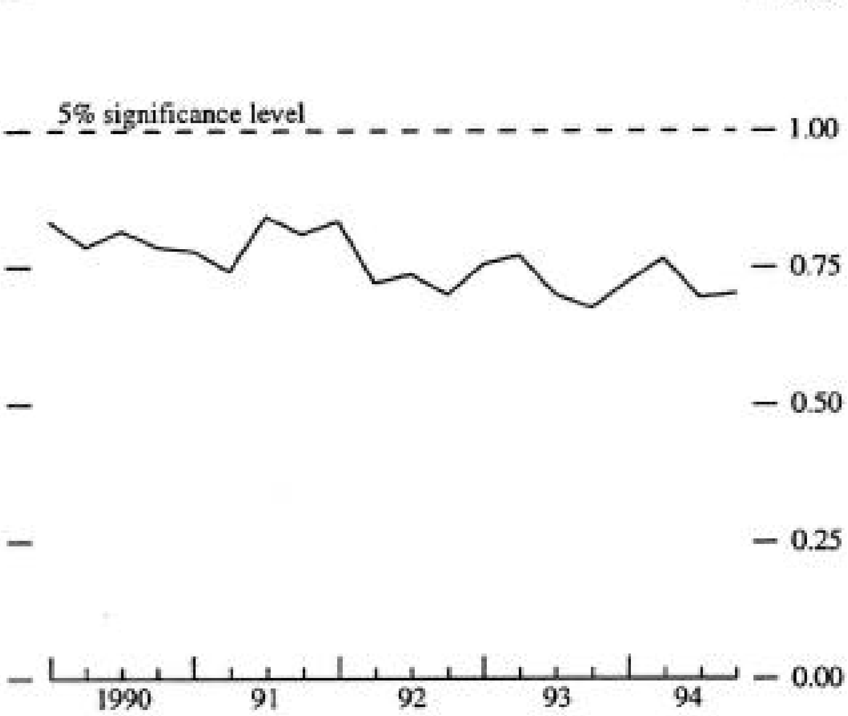
	α_1	α_2
m	-0.09	0.09
c	-0.04	-0.16

Identifying restrictions imposed (four exact identifying restrictions, eight overidentifying restrictions):

$\beta_{11} = 1$; $\beta_{12} = 0$; $\beta_{13} = -0.5$; $\beta_{14} = -0.5$; $\beta_{15} = -\beta_{16}$; $\beta_{18} = 0$;
$\beta_{21} = 0$; $\beta_{22} = 1$; $\beta_{23} = -0.9$; $\beta_{24} = -0.1$; $\beta_{25} = 0$; $4\beta_{26} = -\beta_{27}$;

loglik = 749.181 unrloglik = 755.028
LR-test: $\chi^2(8) = 11.694$ [0.1654]

Chart 3.1
Recursive stability of the long-run relationships



3.2 The simplified conditional VECM

We can now map the $I(1)$ conditional system into $I(0)$ space defining two error correction terms ($m - m^*$) and ($c - c^*$) and expressing the VAR system as a VECM, as described in Section 2. But first we test for the weak exogeneity of the conditioning variables which was assumed in identifying the long-run relationships. Following Urbain (1992), if the cointegrating vectors are not significant in the "marginal" model for X_t(25) then X_t can be treated as weakly exogenous when the parameters of interest are the long-run coefficients (ie the parameters of the cointegrating vector and associated loading coefficients). The testing procedure takes the form of a simple F test. An additional test is required for the validity of the exogeneity assumptions when the short-run coefficients on the exogenous variables in the VECM are of interest as well. This is an orthogonality condition (again see Urbain (1992)) which tests for the significance of the residuals from the marginal models for X_t in the conditional VECM. These tests take the form of a Wald test. The test statistics for weak exogeneity of X_t when both the short and long-run parameters are of interest are shown in Table 3.C. They confirm that the conditional variables can be treated as weakly exogenous for the short-run parameters.

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(25) By which is meant the reduced form equations for X_t from the initial closed VAR.

Table 3.C : Weak exogeneity tests

Presence of cointegrating vectors in marginal model

F-tests on retained regressors

$(m - m^*)_{t-1}$	1.04318 [0.4090]	$(c - c^*)_{t-1}$	1.86791 [0.1049]

Orthogonality

Δp_t	$\chi^2(2) =$	1.1032 [0.5760]	y_t	$\chi^2(2) =$	1.5403 [0.4629]
i_{dt}	$\chi^2(2) =$	0.55254 [0.7586]	i_t	$\chi^2(2) =$	1.7624 [0.4143]
w_t	$\chi^2(2) =$	0.2746 [0.8717]	Δu_t	$\chi^2(2) =$	1.945 [0.3781]

The next stage is to analyse the open VECM of Y_t conditional on X_t given that our test has suggested that the X_t can be regarded as weakly exogenous. The first step is to simplify the conditional VECM and exclude any variables that are insignificant. The implied restrictions are tested using *F*-tests. On the basis of these tests Δc_{t-1} was excluded from the system. Additionally diagnostics are shown on the open VAR testing for any problems with the residuals. As can be seen there do not seem to be any problems with autocorrelation, non-normality or heteroskedasticity. The simplified conditional VECM is shown in Table 3.D. Chart 3.2 shows some recursive test statistics. The first two graphs show recursively computed residual sum of squares for both reduced form equations; the next two graphs show the one-step residuals relative to their anticipated 95% confidence intervals; the final three graphs show a sequence of one- and N-step Chow tests scaled relative to their 5% critical value (any outcome above the 5% line indicating parameter non-constancy). None of the graphs indicate any signs of instability in the reduced form.

Table 3.D: Conditional VECM

Reduced form equation for Δm_t

Variable	Coefficient	Std.error	*t*-value
Δm_{t-1}	0.099	0.138	0.714
$(m - m^*)_{t-1}$	-0.093	0.020	-4.693
$(c - c^*)_{t-1}$	0.088	0.040	2.191
Δy_t	0.068	0.054	1.264
Δy_{t-1}	0.104	0.056	1.856
Δi_{dt}	-0.145	0.160	0.909
Δi_{dt-1}	0.073	0.113	0.642
Δi_t	0.120	0.082	1.470
Δi_{t-1}	0.017	0.078	0.216
Δw_t	0.051	0.026	1.981
Δw_{t-1}	0.053	0.033	1.618
$\Delta^2 u_t$	1.162	0.374	3.105
$\Delta^2 u_{t-1}$	0.587	0.383	1.533
$\Delta^2 p_t$	0.922	0.095	9.689
$\Delta^2 p_{t-1}$	0.029	0.080	0.365

Reduced form equation for Δc_t

Variable	Coefficient	Std.error	*t*-value
Δm_{t-1}	0.456	0.186	2.453
$(m - m^*)_{t-1}$	-0.041	0.027	-1.514
$(c - c^*)_{t-1}$	-0.163	0.054	-3.016
Δy_t	0.134	0.072	1.857
Δy_{t-1}	0.191	0.076	2.532
Δi_{dt}	-0.133	0.215	-0.621
Δi_{dt-1}	0.039	0.152	0.254
Δi_t	-0.162	0.110	-1.473
Δi_{t-1}	0.106	0.104	1.019
Δw_t	0.044	0.034	1.251
Δw_{t-1}	0.051	0.044	1.155
$\Delta^2 u_t$	-1.195	0.503	-2.377
$\Delta^2 u_{t-1}$	-0.780	0.514	-1.517
$\Delta^2 p_t$	-0.394	0.128	-3.082
$\Delta^2 p_{t-1}$	0.124	0.108	1.151

Table 3.D (continued)

Conditional VECM diagnostics

Standard errors and R^2:
$\sigma_m = 0.005$ $\sigma_c = 0.0066$

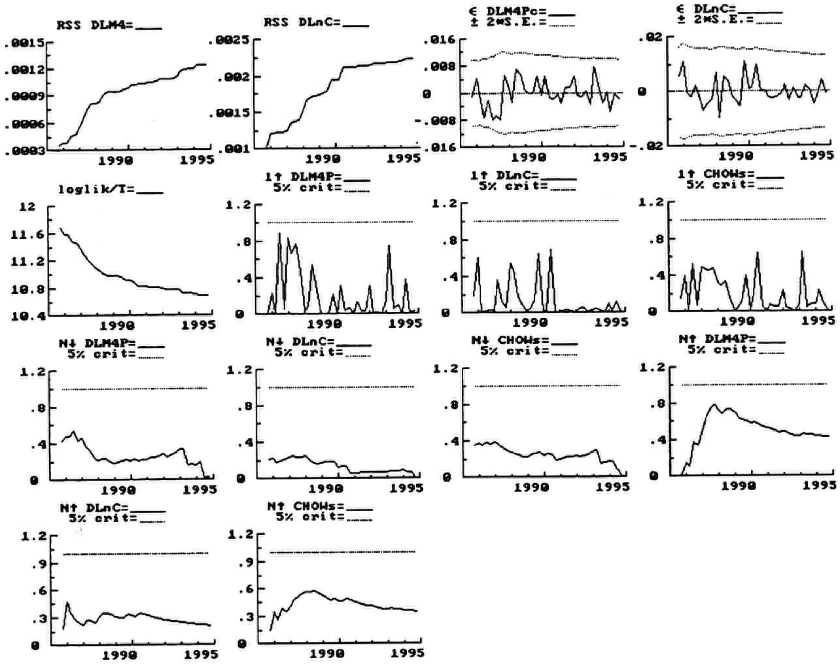
R^2(LR) = 0.938179 R^2(LM) = 0.729833

F-test against unrestricted regressors, $F(30, 100) = 10.073$ [0.0000] **
variables entered unrestricted:
D 1979 Q2 D1988 Q3 Constant

F-tests on retained regressors, $F(2, 50)$

Δm_{t-1}	2.95996 [0.0610]	$(m - m^*)_{t-1}$	10.8022 [0.0001] **
$(c - c^*)_{t-1}$	10.2702 [0.0002] **	Δy_t	1.90592 [0.1593]
Δy_{t-1}	3.67916 [0.0323] *	Δi_{dt}	0.457389 [0.6356]
Δi_{dt-1}	0.202625 [0.8173]	Δi_t	3.24211 [0.0474] *
Δi_{t-1}	0.687751 [0.5074]	Δw_t	2.10319 [0.1327]
Δw_{t-1}	2.91561 [0.0634]	$\Delta^2 u_t$	11.3472 [0.0001]**
$\Delta^2 u_{t-1}$	3.48331 [0.0383] *	$\Delta^2 p_t$	46.0515 [0.0000] **
$\Delta^2 p_{t-1}$	0.972108 [0.3853]		

Chart 3.2
Recursive stability of the conditional VECM



3.3 Deriving the "structural" model

The conditional VECM as estimated represents the reduced form of the model. The final stage is to recover a "structural" representation of the data, which we defined in Section 2 as a representation that allowed contemporaneous relationships between the endogenous variables. As discussed in Section 2 there are many ways we could recover a structural model from the reduced form. In this particular case the BDrdsen and Fisher (1993)/Boswijk(1995) criterion was used to (exactly) identify the structural model such that only one long-run relationship appears in each structural relationship. Thus, for example, the structural money demand relationship responds to only the money demand cointegrating vector *directly*. Importantly this does not preclude both ECM terms having an impact on each variable. The structural model is simply a transformation of the reduced form with the effect of the ECM terms operating *indirectly* through the contemporaneous relationships between consumption and money in each equation. As discussed in Section 2, the reason for choosing this method of identification was that excess liquidity (which is interpreted as the money ECM term) would be unlikely to affect consumption unless money balances actually changed.

Given that this method of identification imposes two restrictions on each equation there is a unique mapping from the reduced form to the structural model. In the tradition of earlier simultaneous equation methodology the structural model can be estimated by indirect least squares with both equations exactly identified. However the resulting structural model may contain terms that although were significant in the reduced form may not be significant in one or other of the structural equations. This implies some overidentifying restrictions which can tested, using the test suggested by Hendry and Mizon (1993), to see if the implied constrained reduced form encompasses the open VECM. The structural model in this case must be estimated by FIML or some other simultaneous method (such as two-stage least squares) since at least one equation will be overidentified.

FIML estimates for the structural model are shown in Table 3.E. The test for overidentifying restrictions is distributed as a $\chi^2(k)$ where k is the number of overidentifying restrictions made. As can be seen the over-identifying restrictions imposed are easily accepted. Additionally the usual diagnostic statistics are shown which indicate no problems, which is unsurprising given the clean testing down procedure from the reduced form. Charts 3.3, 3.4 and 3.5 show in turn the actual and fitted values of the structural equations, the structural residuals and stability tests for the equations. As in Fisher and Vega (1993) both the money and consumption functions perform quite well in tracking real balances and consumption across the cycle. The latter has proved to be a problem on UK data and estimating consumption jointly with money may prove to be a partial solution.

Chart 3.3
Fitted values and residuals of the money equation

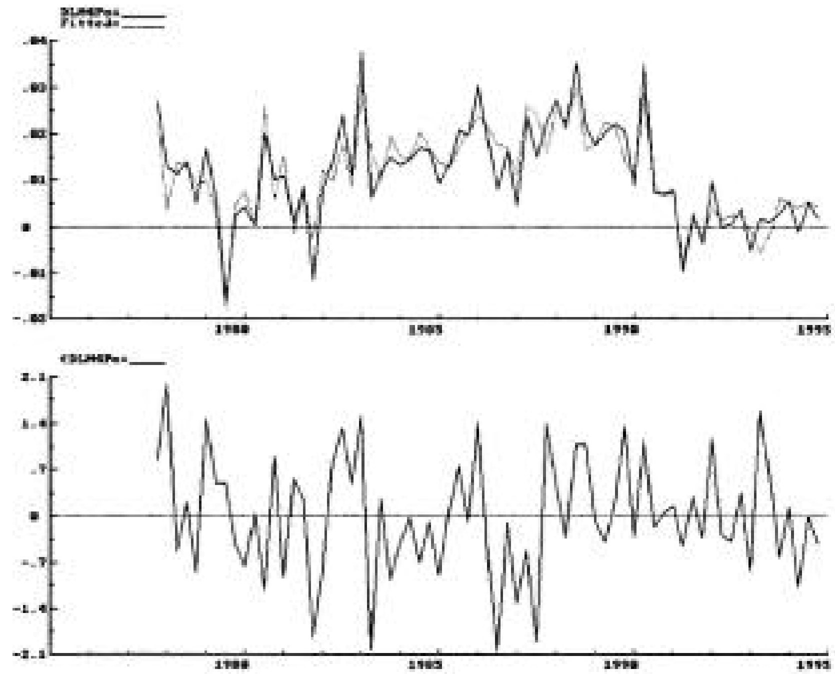


Chart 3.4
Fitted values and residuals of the consumption equation

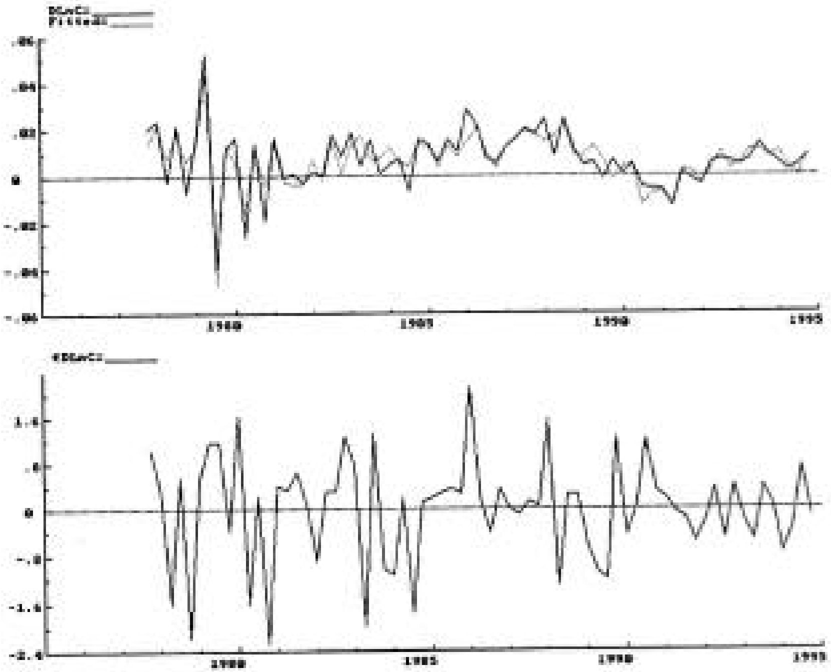


Chart 3.5
Recursive stability of the structural model

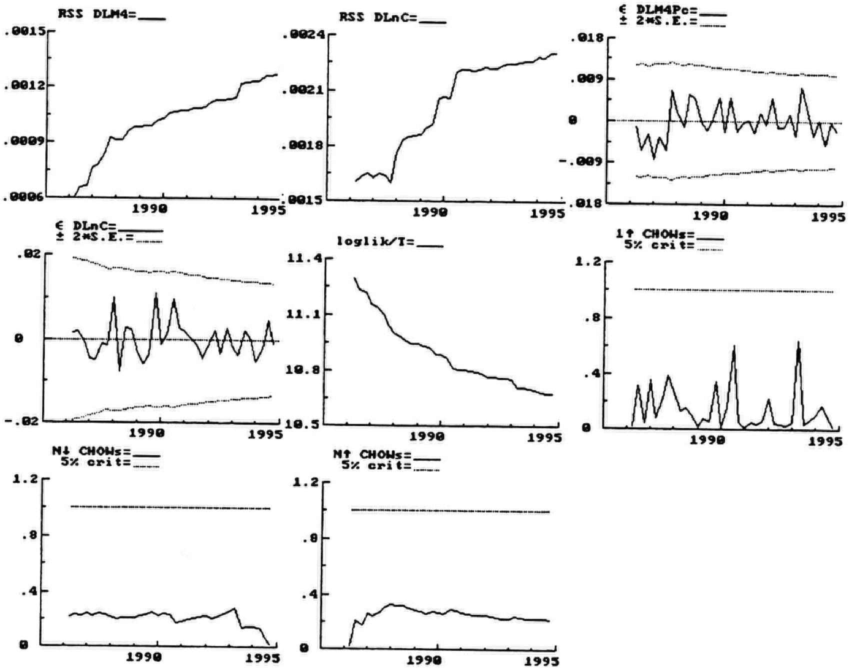


Table 3.E FIML estimates of structural model

Personal sector M4

$$\begin{aligned}\Delta m_t = &- \underset{(0.21)}{0.61}\,\Delta c_t + \underset{(0.13)}{0.39}\,\Delta m_{t-1} + \underset{(0.08)}{0.18}\sum_{i=0}^{1}\Delta y_{t-\mathrm{i}}\\ &- \underset{(0.10)}{0.15}\,\Delta^2 i_{dt} + \underset{(0.03)}{0.06}\,\Delta w_t - \underset{(0.15)}{1.2}\,\Delta^2 p_t\\ &- \underset{(0.02)}{0.11}\,(m - m^*)_{t-1}\end{aligned}$$

s.e.= 0.0071

AR 1- 5F(5, 45) = 1.299 [0.2813] Normality $\chi^2(2)$ = 0.0969 [0.9527]

ARCH 4 F(4, 42) = 0.61853 [0.6518] Xi^2 F(32, 17) = 0.57474[0.9137]

Consumption

$$\begin{aligned}\Delta c_t = &+ \underset{(0.09)}{0.46}\,\Delta m_t + \underset{(0.13)}{0.41}\,\Delta m_{t-1} + \underset{(0.08)}{0.12}\,\Delta^2 p_{t-1}\\ &+ \underset{(0.05)}{0.12}\sum_{\mathrm{i}=0}^{1}\Delta y_{t-i} - \underset{(0.06)}{0.24}\,\Delta i_t + \underset{(0.05)}{0.09}\,\Delta i_{t-1}\\ &+ \underset{(0.03)}{0.09}\,\Delta w_{t-1} - \underset{(0.37)}{1.92}\,\Delta^2 u_t - \underset{(0.38)}{1.07}\,\Delta^2 u_{t-1}\\ &- \underset{(0.04)}{0.20}\,(c - c^*)_{t-1}\end{aligned}$$

s.e.=0.0059

AR 1- 5F(5, 45) = 1.7799 [0.1363] Normality $\chi^2(2)$= 2.4127 [0.2993]

ARCH 4 F(4, 42) = 0.75162 [0.5626] Xi^2 F(32, 17) = 0.93844 [0.5762]

LR test of over-identifying restrictions: $\chi^2(13)$ = 3.00247 [0.9979]

3.4 What does the structural model tell us ?

The model shows that both personal sector money holdings and consumption are increasing in the short run in both disposable income and wealth, while the dynamic terms in the change in unemployment suggest significant precautionary saving effects on consumption. As argued in Section 2 the short-run dynamics of the money equation may well be reflecting changes in the provision of credit to the personal sector. But as this is a sectoral equation personal sector money balances may also rise because of inflows of deposits from other sectors. The dynamic effects of wealth and disposable income on money holdings are likely to be reflecting both these influences. There are also significant dynamic effects on consumption from short-term movements in the nominal interest rate. As previous studies have shown this is likely to be reflecting the effect of cashflow on the spending decisions of constrained consumers (see Muellbauer and Murphy (1989) for a discussion) which operates over and above the traditional effect of real interest rates on unconstrained households that were shown to be important in the long run.

Of greater interest, however, is the interpretation of the short-run interaction between money and consumption, which is the real value added of system modelling over single equation modelling. Although the structural model contains no more information than was in the reduced form, it makes the relationships between real money and consumption in the short run clearer.

The money equation shows that higher consumption reduces personal sector money holdings in the short run, consistent with precautionary/buffer stock theories of money demand. Such models often predict a negative short-run relationship between money and activity but with long-run/target real balances ultimately increasing in income. Thus changes in consumption are partly financed in the short run by the personal sector as a whole running down M4 balances; these balances pass to the corporate sector. In the longer-term however the model predicts household money balances are built up again in line with disposable income.

In the consumption function there is a *positive* short-run relationship between consumption and money. We must be careful in the economic interpretation of this since it operates over and above the direct effects of disposable income and wealth on consumption. In particular our method of identification does not distinguish between the effects of anticipated and unanticipated increases in money balances. Thus the positive correlation between consumption and money is likely to be picking up more than one effect. The effect from the unanticipated part of the change in money balances may reflect a buffer stock effect. An unanticipated increase in money is likely to lead to the personal sector to increase its consumption. As discussed in

Section 2 this contemporaneous rise in consumption works to reduce some (but not all) of the excess liquidity almost instantaneously; we trace out this mechanism in more detail below. The effect from the anticipated part of the change in money holdings is more likely to reflect the effect of a change in liquidity on the spending of constrained households, which operates over and above the effects from wealth and real interest rates on unconstrained consumers' spending. Given the difficulties of separately identifying money supply and demand influences it could well be reflecting the more general impact of short term credit restrictions on consumption.(26)

Whatever the exact interpretation of this correlation, the addition of money to the consumption function appears to improve the ability to track consumer spending across the cycle, especially in predicting the sharp cyclical movements of the late 1980s and early 1990s. Recently other authors such as Blake and Westaway (1993) and Young (1995) have included financial variables in consumption functions (such as proxies for banks' willingness to lend) and have found these to improve the ability of existing consumption functions to fit the recent cycle.

These correlations between money and consumption in our two equations occur simultaneously. It is therefore interesting to see how they interact in response to different disturbances. Charts 3.6 and 3.7 below show the response of money and consumption (in levels) when first there is a positive temporary disturbance to money of 1% and second when there is a negative temporary disturbance to consumption of 1%.(27)

(i) In the case of an innovation to money balances, the chart shows that in the short run money and consumption both rise, reflecting the positive relationship between them in the consumption function. However deposits rise by only 0.8% over the quarter even though the initial impulse to money was of 1%. This reflects the simultaneous impact of higher consumption on deposits in the money equation. Consider the case where the increase in money balances is the result of an increase in personal sector borrowing due to a relaxation of banks' lending criteria. Households initially receive an increase in deposits as banks credit funds to their accounts. But households have borrowed not to hold money but in

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(26) Relating to the discussion in Section 2, it is difficult here to be conclusive about whether this represents a "credit" effect on consumption rather than a "money" effect, especially since personal sector M4 and personal sector M4 lending are highly correlated over the sample period.

(27) Such disturbances should be thought of as exogenous influences that only have a direct effect on one of the equations. Given our method of identification the actual equation errors are not orthogonal and so these disturbances should not really be thought of as unanticipated increases or "shocks" to money and consumption.

order to finance spending; deposits are simply used as a (very) temporary abode of purchasing power or financial buffer. In the process deposits flow into the corporate sector, reducing personal sector M4. Thus although households may have instantaneously been prepared to *accept* money in the very short term as a temporary abode of purchasing power, it does not mean they wish to *hold* money in the longer term as discussed earlier in Section 1. This highlights the usefulness of the structural form over and above the reduced form in interpreting behaviour. The reduced form would simply not have been able to show the intra-quarter rise and partial fall-back of deposits.

(ii) A negative disturbance to consumption increases money balances in the first instance as deposits are used as a buffer by the personal sector. But this forces money balances above their equilibrium target level so that over the longer term money holdings are gradually reduced back to their original levels. This running down of liquidity is used to finance the simultaneous adjustment of consumption back to its equilibrium level.

Chart 3.6
Response of money and consumption to a money disturbance

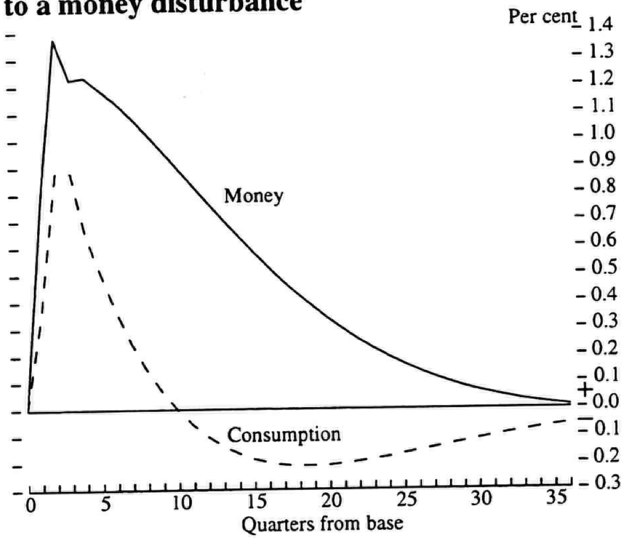
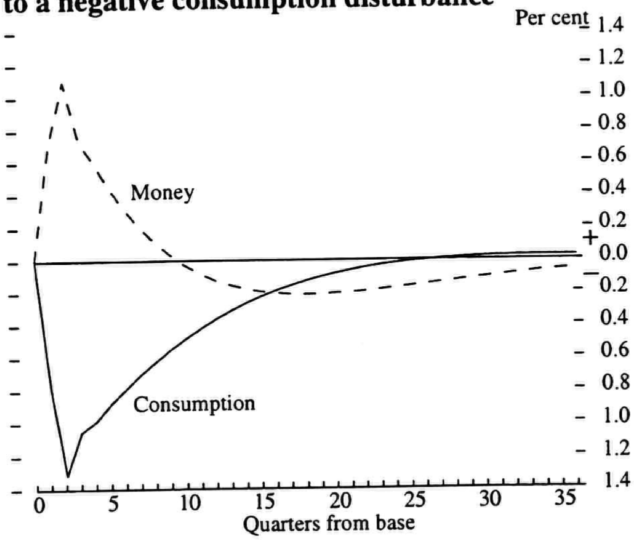


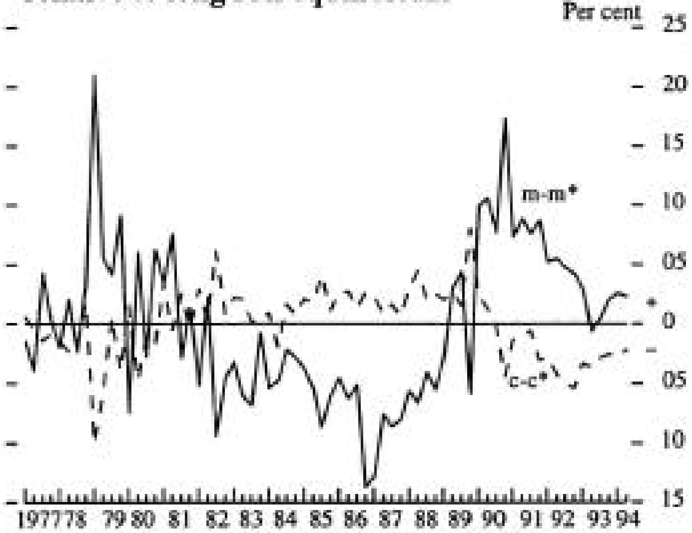
Chart 3.7
Response of money and consumption to a negative consumption disturbance



These experiments provide us with a useful rule of thumb. If we see money balances and consumption moving in opposite directions in the short run, it is more likely that there has been an underlying disturbance to consumption rather than money.(28) If they move in the same direction it is more likely that the disturbance has been to money. Of course a combination of the two correlations may occur eg if there is a shock to one of the exogenous common trends such as disposable income or wealth, which affects both variables directly. But the general point that emerges from Charts 3.6 and 3.7 is that stronger personal sector money growth may have very different implications for current and future consumption spending, depending upon what the underlying disturbance to the economy has been.

As an additional metric Chart 3.8 shows the money and consumption cointegrating vectors (relative to their sample means) across the sample period. Historically when money holdings have been above equilibrium, consumption has tended to be below equilibrium and *vice versa*. Even though this implies that when money balances fall back to equilibrium consumption increases towards its steady state, one should not infer causality in either direction. As Charts 3.6 and 3.7 demonstrated, there is a simultaneous adjustment of *both* money and consumption relative to their steady states.

Chart 3.8
Personal sector money and consumption relative to long run equilibrium



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(28) More precisely an exogenous disturbance that affects only consumption directly.

Overall, however, the consumption function demonstrates the various channels through which households' expenditure is affected by monetary policy. In addition to the effect of real interest rates on unconstrained households' consumption, there are influences from both nominal interest rates and the growth of personal sector deposits which may reflect the effects of monetary policy on the expenditure of liquidity constrained households.

4 Conclusions

The results for the personal sector imply that there is a strong interaction between personal sector holdings of M4 and consumption. Increases in the stock of money have a strong short-term effect on consumption which occurs over and above the effects of real interest rates. The model also predicts that movements in consumption tend to be absorbed in the short run by changes in real balances in accordance with precautionary or buffer-stock theories of money demand.

Overall the results suggest that money is likely to be a proximate indicator of changes in the economic circumstances facing households, since money holdings act as a shock absorber to unanticipated changes in income and spending. However the adjustment by households to a variety of shocks is a complicated dynamic interaction of money, credit and expenditure so that interpreting the nature of the shocks that have occurred is decidedly not simple. But our results suggest we may have some ability to interpret high frequency movements in personal sector money balances and consumption by looking at whether they move together in the short run or whether they move in different directions. Indeed an important result from the paper is that we should not expect to observe a particular positive or negative correlation between personal sector money and consumption. This will differ according to what type of disturbance to the economy has occurred.

Appendix

Data sources

Break-adjusted personal sector M4: *Bank of England*

Real Consumption Expenditure: *ONS code CAAB*

Consumption deflator: *ONS code AIIX/CAAB*

Real Disposable Income. *ONS code CECP*

Weighted own-rate on personal sector M4. *Bank of England*

Three month yield on Treasury bills. *ONS code AJRP*

Gross financial and tangible wealth of the personal sector. *ONS code ALDO + ALLU (the latter interpolated)*

Unemployment rate. *ONS code BCJE*

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