The Demand for M4: A Sectoral Analysis

Part 2 - The Corporate Sector

by

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Abstract

This paper models the broad money holdings of both industrial and commercial companies (ICCs) and other financial institutions (OFIs) in the United Kingdom. It uses the encompassing VAR approach of Hendry and Mizon (1993) to derive structural models from a congruent statistical representation of the data. Weak exogeneity tests, and placing identifying restrictions on both the short and long-run structure play an important part in this procedure. ICCs’ deposits are modelled jointly with investment and the cost of capital and the resulting model suggests the existence of a corporate sector liquidity channel whereby firms’ “excess” money balances have a negative influence on the cost of capital and a positive impact on investment spending. OFIs’ money holdings are modelled according to standard portfolio theory, jointly with the banks’ deposit rate setting decision (liability management).

Introduction

Interpreting movements in monetary aggregates is an important part of the assessment of inflationary pressures in the United Kingdom's current monetary policy framework. At present official monitoring ranges exist for the aggregates M0 (0%-4%) and M4 (3%-9%). Although it is widely accepted among economists that inflation is ultimately a monetary phenomenon, the usefulness of monetary aggregates as indicators of inflationary pressure depends upon the existence of a stable and predictable relationship between movements in money and movements in nominal income and prices. While such a relationship may be uncovered on a purely statistical basis, understanding what drives changes in money holdings and how other economic variables are affected is of considerable importance if such a relationship is to be interpretable.

This paper is the second part of a study on the determinants of the broad money aggregate, M4. Following, Fisher and Vega (1993) two important approaches to modelling broad money are employed: the sectoral modelling of broad money holdings to investigate any differences in the motives for holding money of different agents; and the joint-modelling of money with other variables in order to investigate the effects of changes in broad money on the wider economy. The personal sector is examined in part 1 of the study.(1) This paper concentrates on modelling the demand for broad money by the corporate sector and examines the role corporate sector money holdings play in the monetary transmission mechanism.

Corporate sector money holdings have historically been more volatile than personal sector holdings and as a result have been quite difficult to model (see Fisher and Vega (1993)). This may reflect the close substitutability between the types of deposits which the corporate sector typically holds and other real and financial assets. Shifts in the expected rate of return on these assets may induce large changes in firms' money holdings. Thus our ability to model corporate sector M4 may be improved by developing better proxies for expected rates of return.

A further problem is that, within the corporate sector, different companies may use money for different purposes. In this paper it is found that separating corporate sector M4 into industrial and commerical companies' (ICCs') holdings and non-bank financial intermediaries' (OFIs') holdings is useful in

(1) Thomas (1997)

isolating some of the diverse influences on firms' demand for money. OFIs are likely to hold money primarily for portfolio or speculative purposes and would be expected to respond to a wide variety of different returns on different assets. In particular they are the chief counterparties to banks' liability management activity suggesting their demand for money will interact strongly with banks' deposit rate setting decision. ICCs on the other hand are likely to hold a larger proportion of their money balances for transactions purposes. The results of previous work suggest that a buffer-stock model of ICCs' money holdings may be appropriate,[(2)] implying that liquidity effects on asset prices and expenditure could be important. In particular ICCs' liquidity position may influence the scale of mergers and acquisition activity and the level of investment spending.

The paper is divided into four sections. The first discusses some modelling issues and the overall econometric approach. The next two sections present an empirical analysis of ICCs' and OFIs' M4 holdings. The fourth section summarises the results and offers some conclusions.

(2) See Ireland and Wren-Lewis (1992), Chrystal and Drake (1994) and Mizen (1996).

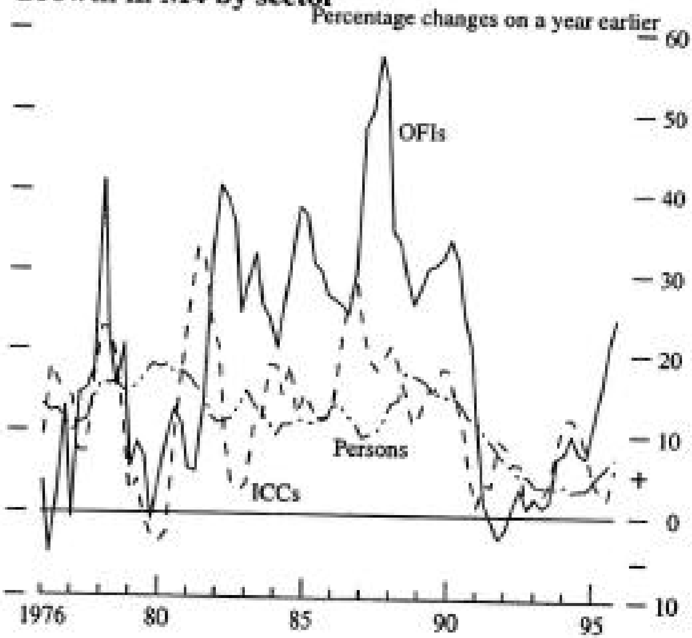
1 Methodology

In this paper we employ two particular approaches to modelling M4: first, broad money holdings are modelled by sector; and second, they are modelled jointly with other real and financial variables as a system of equations. These two approaches have a number of advantages:

(i) Sectoral modelling

Money holdings are modelled by sector because different types of agents are likely to have different motives for holding money. This is implied by recent trends in sectoral money holdings. Chart 1.1 shows a breakdown of M4 growth into three different sectors, the personal sector, industrial and commerical companies (ICCs) and non-bank financial intermediaries (OFIs). As can be seen, corporate sector (ICCs and OFIs) holdings of broad money have been considerably more volatile than personal sector holdings over the last twenty years. And within the corporate sector, OFIs deposits have fluctuated to a much larger extent than those of ICCs.

Chart 1.1
Growth in M4 by sector



As is discussed in more detail in the personal sector paper, there are behavioural reasons why such different sectoral patterns of money holdings may emerge. These will imply a different modelling approach to be employed for different sectors. Here we concentrate on why a separate analysis of ICCs' and OFIs' money holdings may be useful.

Increases in the demand for credit (supply of money) are typically funded, at the margin, by banks bidding for wholesale deposits. OFIs' are the chief source of such marginal funds since they are likely to be the most responsive agents to shifts in relatives rate of return. This suggests OFIs' money holdings should be modelled as a general portfolio model of money demand and possibly jointly with the deposit rate setting decision of banks (liability management). The specification of such a liability management model is outlined in the personal sector paper.

ICCs on the other hand are more likely to use their money balances for transactions purposes. In particular their money holdings may act as a financial buffer which absorbs unexpected changes in spending and receipts. They may take more time to adjust their portfolios and may do so in a way that has stronger implications for aggregate demand (for example by switching out of money into real assets or investment goods). For these sectors the *demand* for money should be thought of as more of a long-run equilibrium concept. In the short run, agents may *accept* an increase in money balances as a means of payment at unchanged deposit rates. Thus any estimated relationship for money holdings is likely to represent a combination of supply and demand influences, with the short-run dynamics in particular likely to be reflecting changes in the supply and demand for credit. More importantly money holdings may deviate from long-run equilibrium holdings for prolonged periods of time. Because banks have little incentive to change deposit rates in such circumstances, nominal spending will have to rise and the yields on other assets must fall in some combination to restore monetary equilibrium. This would suggest modelling the money holdings of ICCs jointly with their expenditure and appropriate alternative rates of return.

(ii) Modelling money jointly with other variables

At whatever level of disaggregation, it also seems sensible to model corporate sector money holdings jointly with other real and financial variables, as Davidson (1987) does for aggregate money holdings. 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 approach, 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 identification restrictions. The paper on the personal sector outlines the approach in detail and discusses its strengths and weaknesses; below we give a brief outline the modelling procedure.

The first stage involves estimating a conditional vector error-correction mechanism (VECM) given by:

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

where z_t is the vector of variables under consideration in the system which are partioned into endogenous variables, y_t and (weakly) exogenous variables, x_t. If the z_t are non-stationary, estimation of the VECM's parameters is carried out in two steps. The first step involves estimating the long-run relationships (cointegrating vectors), β', using some consistent technique such as the maximum likelihood method of Johansen (1988). As is discussed in the personal sector paper, this involves placing and testing a number of identifying restrictions based on theoretical priors. The second step is then to reformulate the system as an unconditional VECM and test whether some of the variables in z_t can be treated as weakly exogenous ie do not need to be modelled for consistent estimates of the parameters of interest (see Urbain (1995)). z_t is then partitioned into y_t and x_t , and a conditional VECM is estimated by OLS.

Once the VECM has been estimated the next stage is to derive a "structural" representation of the system. A structural model is defined as a representation which allows contemporaneous relationships among the variables which involves pre-multiplying the conditional VECM by $A_o \neq I$:

$$A_0 \Delta y_t = \sum_{i=1}^{p-1} A_i \Delta y_{t-i} + \sum_{i=0}^{p-1} B_i \Delta x_{t-i} + a\beta' y_{t-1} + u_t \qquad \textbf{(2)}$$

The relationship between the structural and reduced form parameters is given by:

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

Identifying A_0 is more a difficult task than identifying β', as theory often has little to say about dynamics. In the personal sector paper we discuss a number of ways of identifying A_0, and the implications they have for the resulting structural form. Once A_o has been identified further overidentifying restrictions may be tested, using the encompassing statistic of Hendry and Mizon (1993).

2 Modelling ICCs' M4

Industrial and commercial companies, like the personal sector, are likely to hold money both as an asset and as a transactions medium. The real difficulty in modelling ICCs' demand for M4 is likely to be the large number of alternative assets available to firms that could perform both functions. A wide variety of real and financial assets can act as a store of value, while credit facilities can act as a buffer stock to absorb short-term movements in the need for transactions balances.(3) We also wish to investigate the role of ICCs' money balances in the determination of nominal demand, and so we face the further difficulty of having to model some of ICCs' other decisions such as their investment expenditure when at present there is still disagreement on how to model such variables.

With these issues in mind we analyse a closed system of nine variables: real M4 holdings by ICCs (m_t), real gross fixed capital formation (i_t), real GDP, a weighted own-rate on corporate sector deposits (r_{dt}), the three-month Treasury bill rate (r_t , as a short-term alternative asset), an equity based measure of the real cost of capital (c_{kt} , which should also act as an alternative rate of return on money over and above its role in explaining investment), ICCs' gross financial wealth (w_t), the rate of inflation (Δp_t , given by the quarterly change in the log of the GDP deflator) and a term in capacity utilisation (cu_t) derived from the CBI survey.(4) This last variable is used to proxy the effect from the existing capital stock on investment (since reliable estimates of the capital stock are unavailable, although some researchers, quite justifiably, prefer to use the raw data rather than a rough proxy). Similar proxies have been used in other investment studies such as Bean (1981). The reasoning is simply that the closer firms are to capacity limits the more they want to invest. All data are seasonally adjusted and the sample runs from 1977 Q1 to 1994 Q4.

2.1 The long-run relationships

In order to determine the number of long-run relationships among the variables we applied the cointegration analysis developed by Johansen (1988). This first involved estimating a closed VAR model with all nine variables endogenous. But univariate unit root tests suggested that some of the variables were close to being stationary. Augmented Dickey Fuller

(3) This may suggest that modelling a broader notion of liquidity for ICCs, which includes their credit facilities, would be more appropriate.

(4) This is based on the percentage of firms reported to be operating *below* full capacity. Thus a higher value for *cu* implies less utilisation of capacity.

statistics indicated that six of the variables clearly could not be rejected as non-stationary variables. Of the remaining three variables, the inflation rate (GDP deflator) over this period showed strong signs of stationarity while the real cost of capital and capacity utilisation were close to being I(0). Clearly we could determine the stationarity properties of the variables in the multivariate cointegration analysis but the presence of three potential stationary variables in the long-run relationships makes estimating the number of (and identifying) the cointegrating vectors considerably more difficult and it is generally more efficient to concentrate out all stationary elements from the likelihood function prior to applying the Johansen procedure. Given that inflation was near to being stationary over this sample period and that theory would suggest this to be of the same order of integration as capacity utilisation, both these variables were entered as unrestricted I(0) variables into the VAR.(5) The integration properties of the real cost of capital were left to be determined by the multivariate analysis. As we show below this confirms that it too is stationary, but also endogenous.

A lag length for the VAR of 2 was chosen on the basis that there appeared to be no residual autocorrelation. This was confirmed by Akaike and Schwarz information criterion tests. Additionally a constant as well as two dummy variables were added, the latter to obtain residual normality and parameter constancy. The dummies took the values of 1 in 1983 Q3, 1984 Q2 respectively, followed by -1 in the subsequent quarter.

Table 2.A shows the results of the cointegration test with both a restricted and unrestricted constant. The dummy variables, inflation and capacity utilisation are treated as unrestricted in both cases. A " * " denotes rejections of the null at the 5% level and ** at the 1% level. In both cases the results suggest at least three but possibly four cointegrating vectors. We proceed on the basis that there are three cointegrating vectors.

We attempt to identify these long-run relationships by partitioning the seven I(1) variables which can be denoted by the vector $Z_t = (m_t , i_t , c_{kt} , y_t, r_{dt} , r_t , w_t)$ into endogenous variables Y_t and exogenous variables X_t , the validity of which will be tested later. Following Boswijk (1995) 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. The results from the closed VAR suggested that money, investment and the real cost of capital should be treated as endogenous and Z_t was partitioned accordingly. The validity of these exogeneity assumptions is tested later.

(5) The results did not change materially when inflation was treated as an I(1) variable.

Identifying restrictions based on theory were then made on the cointegrating vectors. These are shown in Table 2.B. In what follows, the parameter on the k'th element of Z_t in the i'th cointegrating vector is denoted by β_{ik} where i =1,2,3 and k =1,2,...7.

Three restrictions in each equation are required to identify exactly the long-run relationships. First, three "normalising" restrictions were made, assigning a value of unity to one of the endogenous variables in each relationship. This implies one restriction in each equation $\beta_{11} = 1$, $\beta_{22} =1$, $\beta_{33}=1$. Two further just identifying restrictions are required for each equation. In the money equation expenditure rather than output (investment rather than GDP) is restricted to act as the scale variable for money demand.(6) This is represented formally as $\beta_{14} = 0$. Furthermore the coefficients on wealth and investment in the money relationship are restricted to sum to unity, so that $\beta_{12} + \beta_{17} = -1$. This allows us to interpret the relationship as consisting of both an error-correction term in velocity and an integral-control term in the wealth-income ratio. In the investment equation the level of real balances is restricted so as not to affect the long-run relationship for investment, implying the restriction $\beta_{21} = 0$. Investment is also restricted to be homogeneous of degree one in output, implying $\beta_{24}= -1$. In the cost of capital equation neither real balances nor investment affect the real cost of capital in the long run, since in an open economy this will be linked to the cost of capital overseas. This implies the restrictions $\beta_{31} = 0$ and $\beta_{32} =0$.

The resulting vectors suggested further overidentifying restrictions on the basis of structural hypotheses. The statistics given are distributed as χ^2 with degrees of freedom given by the number of overidentifying restrictions. The hypotheses fell into three categories:

(i) Restrictions on the scale variables. Homogeneity in expenditure and wealth for the money demand function was used as an exact identifying restriction but (as with the personal sector) the coefficients on investment and wealth were roughly 0.5 on each so a restriction setting them to these theoretically appealing values was made ($\beta_{12} = - 0.5$; $\beta_{17} = -0.5$). In the investment function, when the coefficient on GDP was restricted to unity this led to a very low coefficient in wealth. Thus the latter was additionally restricted to zero, to yield a standard long run solution in the investment:GDP ratio ($\beta_{27} = 0$); see Bean (1981).
(ii) Restrictions on the rates of return. The deposit rate and Treasury bill rate were excluded from the investment equation ($\beta_{25} = 0$; $\beta_{26} = 0$), leaving a simple investment ratio dependent on the real cost of capital in the

(6) This suggests firms hold money as a buffer to absorb short-term fluctuations in investment expenditure. But using GDP as a scale variable yielded similar results.

investment function, while the coefficient on the deposit rate in the money demand function was restricted to be the negative of the Treasury bill rate to yield a spread term ($\beta_{15} = - \beta_{16}$).

(iii) Stationarity of the cost of capital. All terms other than c_k were removed from the third vector to test for the stationarity of the real cost of capital, suggested by the univariate tests. This implied $\beta_{34} = 0$; $\beta_{35} = 0$; $\beta_{36} = 0$; $\beta_{37} = 0$.

Altogether this implied nine overidentifying restrictions which the likelihood ratio tests show could not be rejected even at the 10% level. The signs and size of the freely estimated parameters are a further indication of how suitable these identifying restrictions are. The resulting over-identified cointegrating vectors for money and investment were given as follows:

$$m_t = 0.5\, i_t + 0.5\, w_t + 2.88\,(r_{dt} - r_t) - 5.66\, c_{kt}$$

$$i_t = y_t - 3.23\, c_{kt}$$

Both the money demand and investment relationships seem sensible. Money is held partly as a transactions balance and partly as a store of value by ICCs and is increasing in the relative rate of return on short-term deposits and declining in the real cost of capital (which is in effect the alternative rate of return on real assets). For example a high cost of capital may be reflecting an undervalued stock market, which might induce firms to spend deposits in acquiring undervalued firms. Thus the cost of capital is effectively proxying the incentives for firms to engage in M&A activity.

In the second long-run relationship the investment:GDP ratio depends on the real cost of capital, but nominal interest rates do not appear to be important in determining investment *in the long run*. The size of the investment semi-elasticity of the cost of capital would be consistent with an elasticity of substitution of between 0.1 and 0.2, when the cost of capital is at its sample mean.(7)

Together these relationships imply a general portfolio model of firms' behaviour. A higher cost of capital induces ICCs to reduce investment in fixed capital and increase their purchases of other financial assets, which is

(7) A CES production function would imply an investment ratio $I/Y = c_k^{-\sigma}$ or in logs $i - y = -\sigma \ln c_k$ where σ is the elasticity of substitution between capital and labour. Using the level of the cost of capital rather than the log in our system implies a variable elasticty of subsitution at different levels of c_k. The sample mean of c_k is roughly 0.04 which implies a value of σ of roughly 0.1-0.2.

likely to imply higher M&A activity. They become net purchasers of equity rather than net issuers. Part of the purchase of equity is financed through the running down of firms' other financial assets which implies a fall in the asset demand for money.[(8)] The fall in investment spending will also reduce the transactions demand for money by ICCs.

A necessary (but not sufficient) condition for these cointegrating vectors to represent "structural" relationships is that they are stable. Chart 2.1 below plots the recursive χ^2 statistics (relative to the 5% significance value) of the test of the overidentifying restrictions on the matrix of long-run relationships, as the sample period is extended from 1990 Q1 onwards.

(8) The other part of the firms' financial decision - how it allocates its liabilities, for firms might easily finance takeover activity by borrowing rather than running down financial assets - is not captured by our estimated system of variables and thus we can say little about firms' optimal debt-equity ratio (and how it might affect the real cost of capital).

Table 2.A

Cointegration analysis 1977 (3) to 1994 (4)

(a) Constant Restricted

	Eigenvalue Test			Trace Test		
H_o:rank=p	$-Tlg(1-\lambda)$	$T-nm$	95%	$-T\Sigma lg(1-\lambda)$	$T-nm$	95%
p == 0	62.91**	50.33*	46.4	209.2**	167.3**	131.7
p <= 1	50.98**	40.78*	40.3	146.2**	117**	102.1
p <= 2	39.82**	31.85	34.4	95.26**	76.21*	76.1
p <= 3	33.5**	26.8	28.1	55.45*	44.36	53.1
p <= 4	13.33	10.66	22.0	21.95	17.56	34.9
p <= 5	7.56	6.048	15.7	8.622	6.897	20.0
p <= 6	1.061	0.849	9.2	1.061	0.849	9.2

(b) Constant 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	62.84**	50.27*	45.3	194.8**	155.8**	124.2
p <= 1	49.5**	39.6*	39.4	132**	105.6**	94.2
p <= 2	36.21*	28.96	33.5	82.46**	65.97	68.5
p <= 3	27.61*	22.09	27.1	46.25	37	47.2
p <= 4	10.05	8.036	21.0	18.65	14.92	29.7
p <= 5	7.56	6.048	14.1	8.6	6.88	15.4
p <= 6	1.04	0.83	3.8	1.04	0.832	3.8

Vector normality $\chi^2(14)$= 18.536 [0.1835]
Number of lags used in the analysis: 2

Other variables entered unrestricted:
Δp_t , Δp_{t-1} , Δp_{t-2} , cu_t , cu_{t-1} , cu_{t-2}
D1983Q3 D1984Q2

Table 2.B: Test of Identifying Restrictions on the Cointegrating Vectors

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Identified Cointegrating Vectors

	β_1	β_2	β_3
m_t	1	0	0
i_t	- 0.5	1	0
c_{kt}	5.66	3.23	1
y_t	0	- 1	0
r_{dt}	- 2.88	0	0
r	2.88	0	0
w_t	- 0.5	0	0

Standardised loading coefficients

	α_1	α_2	α_3
m_t	- 0.21	0.09	- 0.11
i_t	0.13	-0.38	0.90
c_{kt}	- 0.05	0.04	- 0.25

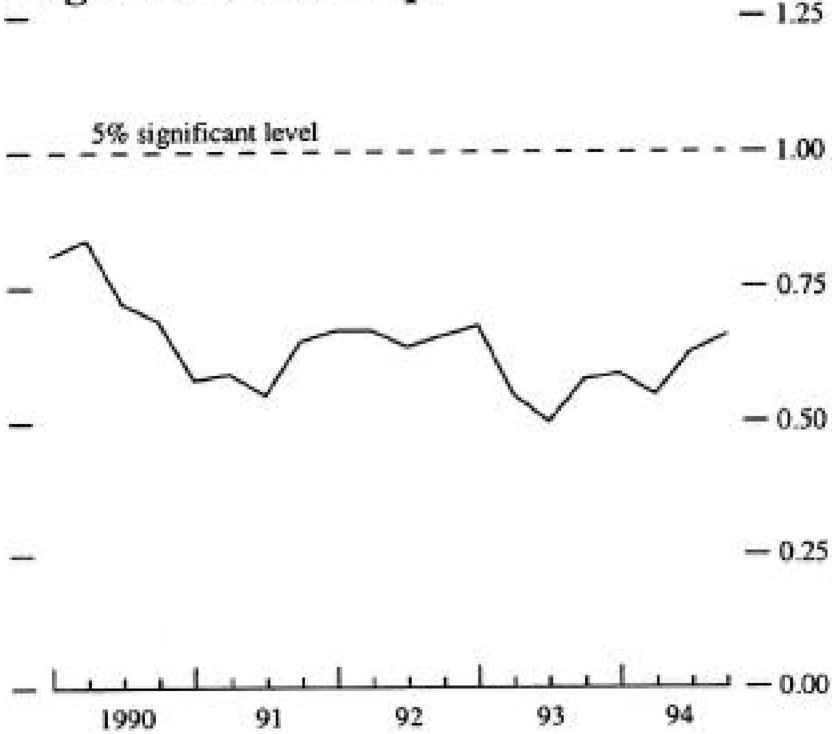
Identifying Restrictions imposed (nine exact identifying restrictions, nine overidentifying restrictions):

$\beta_{11} = 1$; $\beta_{12} = -0.5$; $\beta_{14} = 0$; $\beta_{15} = -\beta_{16}$; $\beta_{17} = -0.5$;
$\beta_{21} = 0$; $\beta_{22} = 1$; $\beta_{24} = -1$; $\beta_{25} = 0$; $\beta_{26} = 0$; $\beta_{27} = 0$;
$\beta_{31} = 0$; $\beta_{32} = 0$; $\beta_{33} = 1$; $\beta_{34} = 0$; $\beta_{35} = 0$; $\beta_{36} = 0$; $\beta_{37} = 0$;

LR-test: $\chi^2(9) = 13.945$ [0.1234]

Chart 2.1

Recursive stability of the long-run relationships



2.2 The simplified conditional VAR

The next stage is to map the conditional VAR into I(0) space and analyse the conditional VECM (Vector Error-Correction Mechanism) of Y_t on X_t. But first we need to test for the validity of the exogeneity assumptions made in identifying the cointegrating vectors. To do this we employ the tests suggested by Urbain (1992).

We define three error correction terms m_t - m^*, i_t - i^* and the level of c_k. To test for the weak exogeneity of X_t when the long-run parameters are of interest, we test whether the three error correction terms enter the "marginal" models for those variables in X_t which entered the long-run relationships. This initially requires estimating a closed VECM with all variables assumed to be endogenous and carrying out an F-Test on the significance of the cointegrating vectors in the equations for X_t . These tests are shown in Table 2.C and indicate we cannot reject the hypothesis that the variables are weakly exogenous when the long-run parameters are those of interest.

We then simplified the reduced form models for X_t by excluding the cointegrating vectors and any other variables which were not significant in the individual equations. We took the errors from these "marginal" models for X_t and tested for their significance in the conditional VECM of Y_t on X_t . Table 2.C shows that we cannot reject the hypothesis that the X_t are exogenous when the short-run parameters are those of interest.

Thus overall our weak exogeneity assumptions seem legitimate and we can proceed with an analysis of a conditional VECM of Y_t on X_t. The next stage is to simplify the conditional VECM by excluding some of the variables that are jointly insignificant. The resulting parsimonious VECM is shown in Table 2.D below together with some diagnostics. Chart 2.2 shows some recursive stability tests for the VECM. The first two graphs show recursively computed residual sum of squares for both reduced form equations; the next two graphs show the 1-step residuals relative to their anticipated 95% confidence intervals; the final three graphs show a sequence of 1- 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, except perhaps for the investment equation in the late 1980s.

Table 2.C

Weak Exogeneity Tests

(a) Significance of cointegrating vectors in marginal model

$m - m^*$	F(4,50) =	1.82 [0.14]
$i - i^*$	F(4,50) =	1.49 [0.22]
c_k	F(4,50) =	1.87 [0.13]

(b) Orthogonality Tests

F-tests on retained regressors,

Ur_{dc}	F(3, 47) =	0.698	[0.556]
Ur	F(3, 47) =	0.96	[0.421]
$U\Delta p$	F(3, 47) =	0.85	[0.474]
Uw	F(3, 47) =	0.58	[0.63]
Ucu	F(3,47) =	0.21	[0.89]
Uy	F(3,47) =	0.461	[0.71]

Table 2.D : Conditional VECM

Reduced Form Equation for Δm_t

Variable	Coefficient	Std.Error	t-value
Δm_{t-1}	0.41	0.09	4.48
Δi_{t-1}	-0.31	0.09	-3.29
$c_{k\ t-1}$	-0.03	0.21	-0.13
Δr_{dc}	0.57	0.42	1.36
Δr_{dct-1}	-0.33	0.26	-1.31
Δr	-0.52	0.31	-1.72
Δp_{t-1}	-2.37	0.54	-4.39
Δw	-0.13	0.11	-1.13
Δw_{t-1}	0.07	0.12	0.62
Δy	0.35	0.37	0.96
Δy_{t-1}	-0.64	0.36	-1.76
cu_{t-1}	-0.08	0.04	-2.22
$\Delta^2 p$	-1.68	0.30	-5.68
$\Delta^2 p_{t-1}$	0.70	0.30	2.35
$(m- m^*)_{t-1}$	-0.20	0.04	-5.25
$(i - i^*)_{t-1}$	0.08	0.07	1.06

Table 2.D (continued):

Reduced Form Equation for Δi_t

Variable	Coefficient	Std.Error	t-value
Δm_{t-1}	-0.04	0.12	-0.34
Δi_{t-1}	0.02	0.12	0.20
c_{k-1}	0.80	0.27	2.93
$(m - m^*)_{t-1}$	0.09	0.05	1.81
$(i - i^*)_{t-1}$	-0.35	0.09	-3.91
Δr_{dc}	-0.39	0.53	-0.73
Δr_{dct-1}	-1.15	0.33	-3.54
Δr	0.26	0.39	0.67
Δp_{t-1}	1.18	0.68	1.72
Δw	0.04	0.14	0.27
Δw_{t-1}	0.22	0.15	1.43
Δy	0.43	0.47	0.91
Δy_{t-1}	0.29	0.46	0.63
cu_{t-1}	-0.18	0.05	-3.79
$\Delta^2 p$	0.23	0.38	0.62
$\Delta^2 p_{t-1}$	-0.03	0.38	-0.09

Table 2.D (continued)

Reduced Form Equation for Δc_{kt}

Variable	Coefficient	Std.Error	t-value
Δm_{t-1}	-0.003	0.04	-0.06
Δi_{t-1}	0.01	0.04	0.28
c_{kt-1}	-0.27	0.10	-2.70
$(m - m^*)_{t-1}$	-0.06	0.02	-3.11
$(i - i^*)_{t-1}$	0.05	0.03	1.36
Δr_{dc}	0.14	0.20	0.72
Δr_{dct-1}	0.09	0.12	0.72
Δr	0.18	0.14	1.22
Δp_{t-1}	-0.82	0.26	-3.23
Δw	-0.01	0.05	-0.15
Δw_{t-1}	-0.13	0.06	-2.25
Δy	0.07	0.18	0.39
Δy_{t-1}	0.14	0.17	0.82
cu_{t-1}	0.01	0.02	0.85
$\Delta^2 p$	-0.004	0.14	-0.03
$\Delta^2 p_{t-1}$	0.30	0.14	2.13

System Diagnostics

$R^2(LR) = 0.955441$ $R^2(LM) = 0.618207$

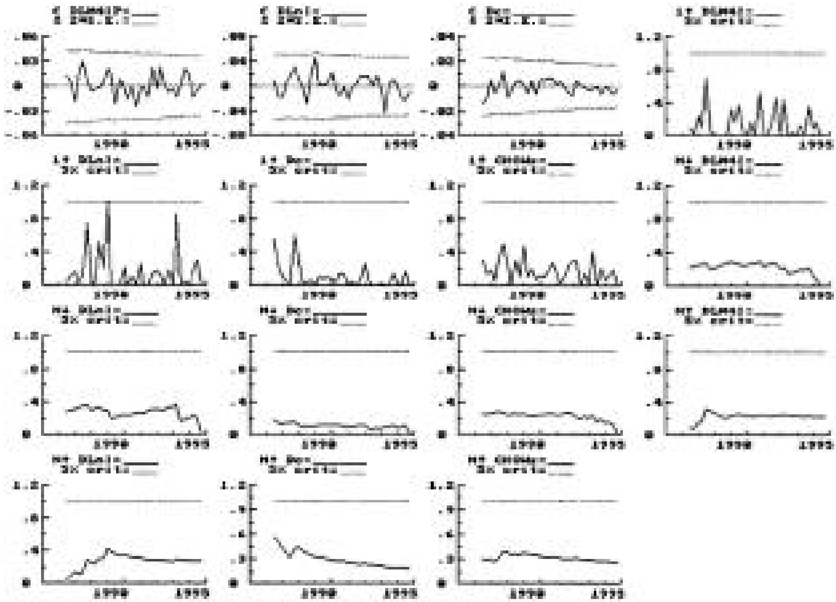
F-tests on retained regressors, F(3, 48)

Δm_{t-1}	8.08894 [0.0002] **	Δi_{t-1}	4.20180 [0.0102] *
c_{kt-1}	7.39488 [0.0004] **	$(m-m^*)_{t-1}$	21.6607 [0.0000] **
$(i - i^*)_{t-1}$	9.27447 [0.0001] **	Δr_{dct}	1.63627 [0.1934]
Δr_{dct-1}	4.58499 [0.0067] **	Δr_t	1.64312 [0.1918]
Δp_{t-1}	17.7486 [0.0000] **	Δw_t	0.645378 [0.5897]
Δw_{t-1}	2.75821 [0.0524]	Δy_t	0.471663 [0.7035]
Δy_{t-1}	1.55103 [0.2135]	cu_{t-1}	5.46120[0.0026]**
$\Delta^2 p_t$	13.5290 [0.0000] **	$\Delta^2 p_{t-1}$	4.64432[0.0063]**

correlation of actual and fitted

Δm	Δi	Δc_k
0.8714	0.7630	0.7069

Chart 2.2
Recursive stability of the conditional VECM



An important feature of the simplified conditional VAR is the impact of the ECM terms on the reduced-form equations for each of the endogenous variables. As can be seen the deviation of money holdings away from their long-run desired level have a positive impact on investment expenditure and a negative effect on the real cost of capital. This sort of result is common to “disequilibrium” buffer-stock models, but has often proved difficult to pick up at the aggregate level using UK data. This supports other work undertaken on the corporate sector by Ireland and Wren-Lewis (1993) which found that the excess liquidity of the corporate sector influenced a variety of firms’ decision variables. There is thus a mechanism through which the excess money balances of ICCs may affect both asset prices and activity, although we need to recover the structural form to understand this channel further.

2.3 The structural model

As discussed in the personal sector paper, there are a number of criteria we could use to exactly identify the structural form. In this case we decided to adopt a block recursive structural form similar to that suggested by Johansen and Juselius (1994). The block recursive form entailed that only the money ECM term entered the equation for money, both the money and investment ECM terms entered the investment equation and all three ECM terms entered the cost of capital equation (which left it essentially as a reduced form equation). It also imposed a Wold causal chain on the contemporaneous relationships, with money at the top and the cost of capital at the bottom. The reason why this form was chosen was primarily to allow excess money balances defined by the money ECM term to affect investment and the cost of capital *directly*. If we had used the Bardsen and Fisher (1993)/ Boswijk (1995) criterion and restricted the structural form to have only one ECM term in each equation then excess money balances could only have an impact on expenditure if money balances actually change (ie through the contemporaneous effect of money on investment and the cost of capital). This seems an acceptable identifying restriction for the personal sector who would be expected to reduce their surplus liquidity by transacting with other sectors. But in the case of ICCs this seems overly restrictive. Investment and the cost of capital may both be affected by excess money balances without total ICCs’ deposits actually changing if individual firms are attempting to shed liquidity by purchasing investment goods or financial assets from other firms in the ICCs’ sector.

The resulting just-identified model suggested some overidentifying restrictions which were tested using the encompassing statistic of Hendry and Mizon (1993). Some of the overidentifying restrictions involved the contemporaneous relationships between the variables and the effect of ECM terms in different equations.

Table 2.E shows FIML estimates of the structural model along with the usual diagnostic statistics while Charts 2.3 to 2.6 show fitted values, residuals and stability tests for the equations for real balances, investment and the cost of capital. All three equations seem reasonably well behaved, although the fit of the investment equation in the 1990s is not altogether satisfactory. Each equation has an interpretable dynamic structure, and the stability tests show that the mapping from the reduced form to the structural model has not worsened the constancy of the model. The only problem was in reducing the sample dependence of the cost of capital equation, which shows some signs of heteroscedasticity, but this is not significant at the 1% level.

Table 2.E: FIML Estimates of the Structural Model

$$\Delta m_t = + \underset{(0.08)}{0.42}\,\Delta m_{t-1} - \underset{(0.21)}{0.47}\,\Delta i_t - \underset{(0.08)}{0.31}\,\Delta i_{t-1}$$

$$+ \underset{(0.35)}{0.68}\,\Delta r_{dct} - \underset{(0.39)}{0.90}\,\Delta r_{dct-1} - \underset{(0.29)}{0.73}\,\Delta r_t$$

$$- \underset{(0.03)}{0.13}\,cu_{t-1} + \underset{(0.38)}{0.84}\,\Delta y_t - \underset{(0.46)}{1.93}\,\Delta p_{t-1}$$

$$- \underset{(0.33)}{1.41}\,\Delta^2 p_t + \underset{(0.36)}{0.84}\,\Delta^2 p_{t-1} - \underset{(0.03)}{0.18}\,(m - m^*)_{t-1}$$

$$\Delta i_t = - \underset{(0.62)}{1.4}\,\Delta c_{kt} - \underset{(0.32)}{0.95}\,\Delta r_{dct-1} + \underset{(0.09)}{0.15}\,\Delta w_t$$

$$+ \underset{(0.21)}{0.66} \sum_{i=0}^{1} \Delta y_{t-i} \; \underset{(0.04)}{-0.15}\,cu_{t-1} + \underset{(0.30)}{0.4}\,\Delta^2 p_t$$

$$+ \underset{(0.33)}{0.65}\,\Delta^2 p_{t-1} - \underset{(0.06)}{0.22}\,(i - i^*)_{t-1}$$

$$\Delta c_{kt} = + \underset{(0.09)}{0.11}\,\Delta r_t - \underset{(0.18)}{0.84}\,\Delta p_{t-1} + \underset{(0.12)}{0.34}\,\Delta^2 p_{t-1}$$

$$- \underset{(0.04)}{0.09}\,\Delta w_{t-1} + \underset{(0.07)}{0.13} \sum_{i=0}^{1} \Delta r_{dct-i}$$

$$- \underset{(0.01)}{0.06}\,(m - m^*)_{t-1} \; \underset{(0.07)}{-0.29}\,c_{kt-1} + \underset{(0.02)}{0.03}\,(i - i^*)_{t-1}$$

(figures in parentheses are coefficient standard errors)

Table 2.E (continued)

Individual Equation Diagnostics

Money
s.e. = 0.02
AR 1- 5F(5, 45) = 1.8535 [0.1217] Xi^2 F(32, 17) = 0.8647[0.6498]
ARCH 4 F(4, 42) = 1.5013 [0.2191]   Normality $\chi^2(2)$= 0.58051[0.7481]

Investment
s.e. = 0.027
AR 1- 5F(5, 45) = 1.2647 [0.2957] Xi^2 F(32, 17) = 0.40535 [0.9866]
ARCH 4 F(4, 42) = 0.50785 [0.7302]   Normality $\chi^2(2)$= 4.0474 [0.1322]

Cost of Capital
s.e. = 0.008
AR 1- 5F(5, 45) = 1.8028 [0.1316] Xi^2 F(32, 17) = 1.3963 [0.2357]
ARCH 4 F(4, 42) = 3.2826 [0.0198] *   Normality $\chi^2(2)$= 2.6703 [0.2631]

System Diagnostics

LR test of over-identifying restrictions: $\chi^2(20)$ = 10.3212 [0.9620]
LR test of restrictions: $\chi^2(2)$ = 0.0835842 [0.9591]
Vector AR 1-5 F(45,116) = 0.98338 [0.5122]
Vector normality $\chi^2(6)$ = 7.5419 [0.2736]
Vector Xi^2 F(192,114) = 0.84624 [0.8455]

Chart 2.3
Fitted values and residuals of the money equation

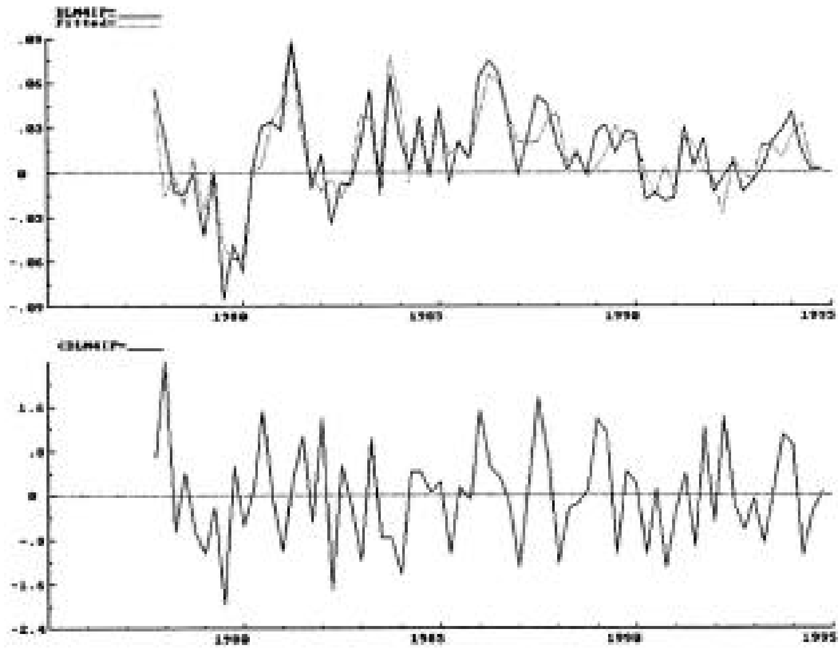


Chart 2.4
Fitted values and residuals of the investment equation

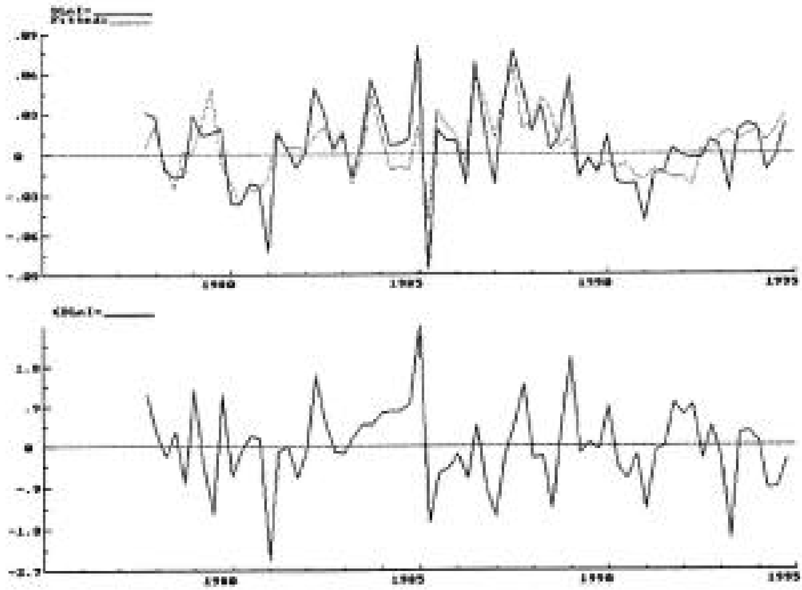


Chart 2.5
Fitted values and residuals of the cost of capital equation

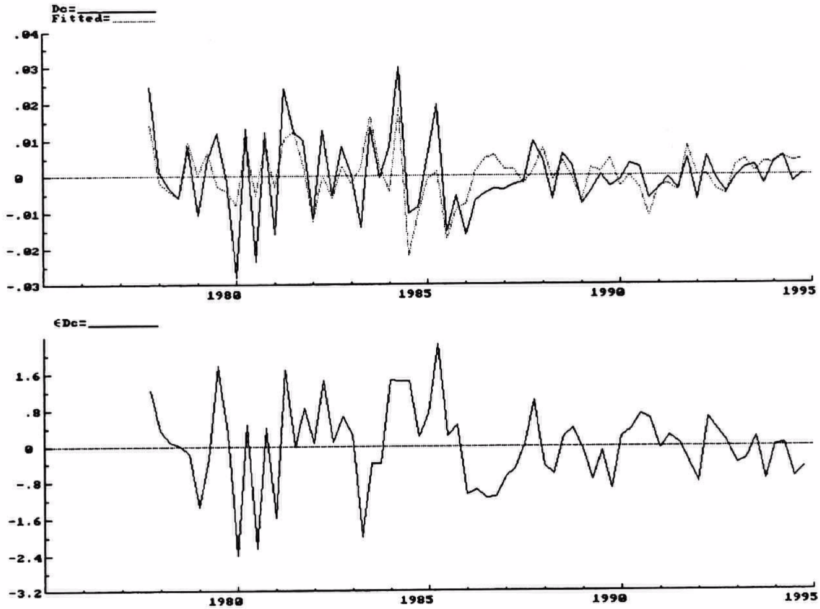
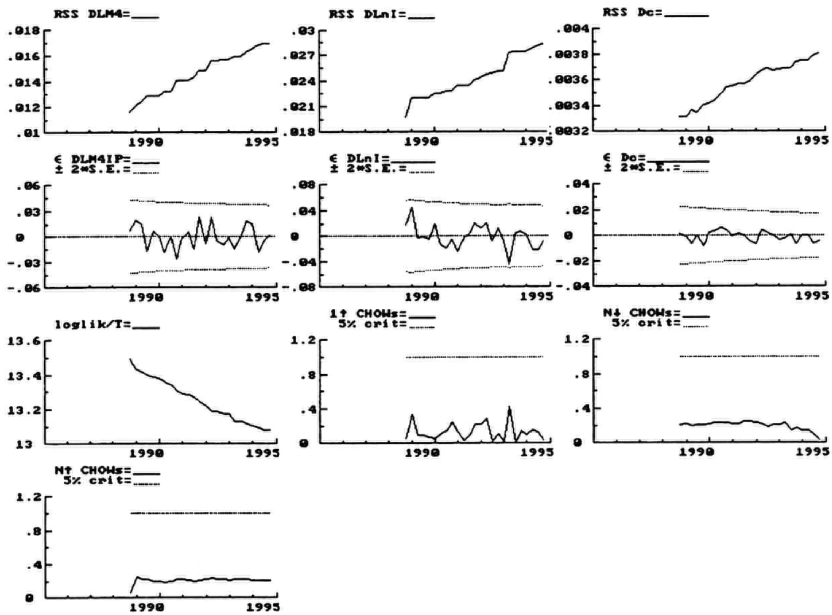


Chart 2.6
Recursive stability of the structural model



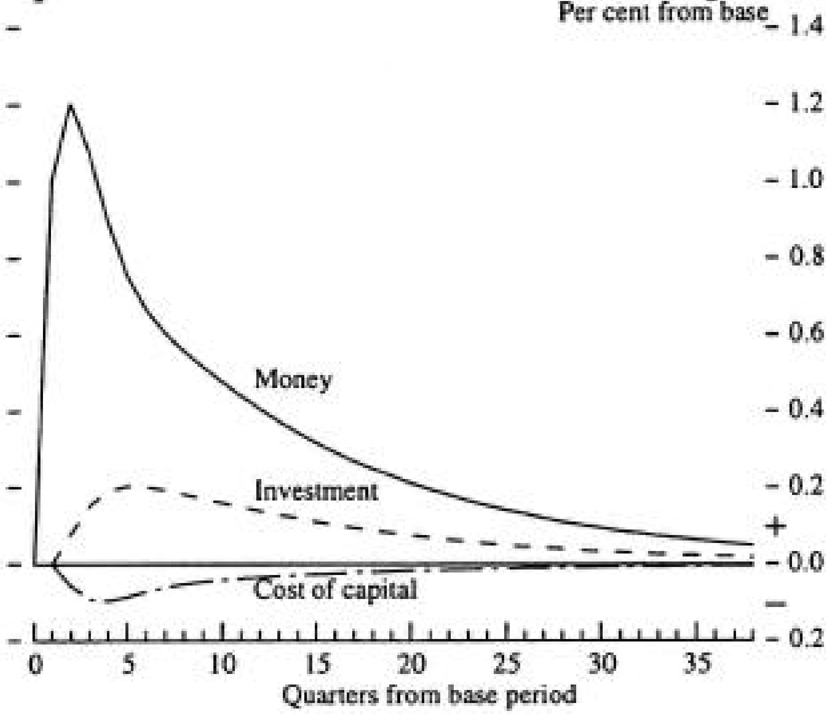
2.4 What does the structural model tell us ?

The simplified structural model (based on the particular identifying restrictions made) offers an interesting mechanism through which changes in firms' liquidity may have an impact on investment expenditure. Firms' "excess" money balances, as defined by $m - m^*$, affect the cost of capital directly,(9) which in turn affects investment through both a contemporaneous effect of the cost of capital on investment and through the investment ECM term which we identified in the cointegration analysis. This suggests that firms attempt to shed "excess" liquidity, in the first instance, by purchasing financial assets and engaging in take-over activity rather than by directly investing. But this process leads to higher share prices and a reduced cost of capital which ultimately influences investment expenditure. Both the rise in investment spending and the fall in the cost of capital raise the long-run demand for money and restore equilibrium in this partial model.(10) Such a chain of events from corporate sector money to mergers and acquisitions activity and asset prices and ultimately to activity has previously been argued to be a significant feature of the UK transmission mechanism.(11) To see this more clearly we introduce a positive 1% innovation to the money equation and trace out the effects on investment and the cost of capital. The result is shown in Chart 2.7 below.

(9) When the block recursive identifying restrictions were made the effect of excess money balances on investment in the structural form became insignficant and restricting this to zero was one of the overidentfying restrictions made on the model.
(10) Of course the rise in investment is likely to have an impact on aggregate demand and prices in the longer term. This was suggested by the marginal model for inflation which showed strong feedback of lagged investment on inflation, suggesting that although inflation is weakly exogenous it is not strongly exogenous and forecasts using this model should attempt to incorporate this feedback.
(11) See Congdon (1992) for example.

Chart 2.7

The effect of 1% a disturbance to the money equation on investment and the cost of capital



As in the case of the personal sector we have to be careful in interpreting the short-run dynamics of the money equation, which generate such deviations of firms' money holdings from their equilibrium levels. Short-term movements in ICCs' money holdings are likely to be reflecting changes in ICCs' borrowing, as well as reflecting changes in their net financial position relative to other sectors.[12] Over the longer term the demand for money by ICCs comes into play and equilibrium is restored through the mechanism outlined above.

There are several additional features in each of the equations that are worthy of mention:

1. In the money equation there is a level effect from inflation in addition to the terms in the change in inflation, which suggests that this should really form part of the money ECM term as it may be proxying the real rate of return on deposits. For example, it could be combined with the cost of capital to yield a relative real interest rate term. Thus even though GDP inflation may be I(0) over the sample period, it may be useful to include inflation in the long-run solution for analytical purposes.

2. Also in the money equation there is a negative contemporaneous relationship between money and investment, similar to the relationship between money and consumption found for the personal sector. Changes to investment expenditure lead to some outflow of money balances from the corporate sector. This is likely to be reflecting either the repayment of debt by capital goods producers or the payment of higher wages and dividends to the personal sector resulting from the extra production. Thus part of the adjustment to a shock to money balances may involve some short-term fall back in the supply of money as well as the rise in the long-run demand for money noted earlier.

3. In the investment equation there is - as expected - a significant negative effect from the capacity utilisation measure (the proportion of firms working <u>below</u> capacity). And the dynamic effects from GDP and the cost of capital are what we would expect. But there are also dynamic effects from nominal interest rates, inflation and gross wealth which suggest that financial variables in general are important in determining investment in the short run. In particular, the effects of nominal interest rates and inflation suggest that both the stock of debt and debt servicing costs may be important influences on investment.

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(12) Simple accounting entails that changes in ICCs' M4 holdings must either result from falls in other sector's M4 holdings, for a given stock of total M4, or must be acquired from the banking system by borrowing which, ceteris paribus, increases total M4.

4. The (change in the) cost of capital is - again as expected - positively related to short-term changes in interest rates, while the negative effect from the lag of the cost of capital confirms its stationarity. Overall this equation yields little other than the important fact that “excess” money balances have significant effects on firms’ cost of finance.

Overall this three-equation model suggests a significant interaction between the liquidity of ICCs and the return on real and financial yields, which in turn influences ICCs’ investment decisions. Such “liquidity” effects are becoming popular in a variety of theoretical models. The tentative evidence above suggests that these effects merit further empirical investigation.

3 Modelling OFIs' M4

As discussed in Section 1, it is likely that a simple portfolio model will be sufficient for modelling OFIs' holdings of deposits. Their activity in the money market as providers of wholesale finance to banks and building societies, at the margin, suggests the need for joint estimation of both their portfolio decision and the determination of deposit rates relative to other rates of return. This could be interpreted as jointly modelling the marginal demand and "supply" of money.

Initially a system of six variables was considered, comprising of real OFIs' M4 -nominal M4 holdings divided by the GDP deflator - (m_t); real total financial assets of OFIs (w_t); the own rate on corporate sector deposits (r_{dct}); a three-month Treasury /commercial bill rate(13) (r_{bt}); a three-month holding period return on equities, calculated by the dividend yield plus the three-month percentage change in the FT-SE ordinary share index, (r_{kt}); and the inflation rate given by the three-month change in the log of the GDP deflator, (Δp_t). The sample period of the data was from 1978 Q1 to 1994 Q4, all data were seasonally adjusted and both money and wealth were logged. The rates of return are defined as proportions (ie 10% = 0.1). Univariate tests suggested that all the variables were non-stationary except for the holding period return on equities and inflation, the latter being borderline as we noted earlier in the system for ICCs over a similar sample period.

3.1 Investigating the long-run relationships

Again the Johansen procedure was used to determine the number of long-run relationships in the data. A constant and two (1,-1) dummy variables for 1985 Q1 and 1987 Q1 were included in the VAR. Unfortunately the cointegration tests were highly sensitive to restricting the constant to enter the long-run relationships (which is unsurprising given that we have a number of interest rates in the VAR which arguably should not have drift terms if non-stationary). They were also sensitive to the inclusion of inflation as an $I(1)$ variable in the closed VAR. The tests suggested between zero and two cointegrating vectors, depending on how the various terms were entered. The only consistency to be found was when inflation was restricted to the long-run. Table 3.A below shows that when inflation is treated as an I(1) variable the tests suggest two cointegrating vectors no matter how the constant is entered into the VAR. We proceed on the basis that there are two long-run relationships.

(13) The choice made little difference to the results.

As for ICCs, we attempt to identify the long-run relationships by partitioning the six variables into endogenous variables Y_t and exogenous variables X_t. Again we assume that there are the same number of endogenous variables as cointegrating vectors, testing for the validity of this assumption later on. Our priors were that our two endogenous variables should be OFIs' money holdings and corporate sector (wholesale) deposit rates, although OFIs' deposits might be expected to have some impact on the holding period return on equities in a similar way to ICCs' M4 and the cost of capital. For the moment we assume that money and deposit rates are endogenous but we test for the endogeneity of other variables later. In the conditional VAR we also allowed the holding period return on equities to enter the long run of the model since we might wish to place some restrictions on this variable jointly with restrictions on the other rates of return.

Two restrictions in each equation are required to identify exactly the long-run relationships. In what follows 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. One identifying restriction in each equation is made by normalising each vector so that a coefficient of unity is placed on each endogenous variable ie $\beta_{11}=1$ and $\beta_{22}=1$. To identify exactly the relationships two further restrictions were placed (one in each equation), one restricting OFIs' money holdings to be linearly homogeneous in wealth in the first relationship, the other to exclude wealth from the second relationship, $\beta_{16} = -1$, $\beta_{26} = 0$.

These restrictions yielded two relationships which appeared to describe a long-run money demand relationship and a deposit rate "setting" relationship. These suggested three further over-identifying restrictions. The first was to restrict the coefficients on the rates of return to form three spread terms, a "money-market" spread defined by the own rate on corporate sector M4 less the three month Treasury bill rate; an "equity market" spread given by the own rate less the *ex post* three-month holding period return on equities; and the *ex post* real deposit rate which proxies substitution between money and real assets. Together this implied $\beta_{12} + \beta_{13} + \beta_{14} = -\beta_{15} / 4$. Two further restrictions were placed excluding the equity holding period return and inflation from the deposit rate equation.

This yielded two long-run relationships given by

$$m = w + 21.3\,(r_{dc} - r_b) + 1.5\,(r_{dc} - r_k) + 6.0\,(r_{dc} - 4\Delta p)$$

$$r_{dc} = 0.93\,r_b + 0.01\,m$$

As Chart 3.1 shows these relationships appear to be stable.

The first relationship describes a standard portfolio model of OFIs' money demand with money holdings homogeneous in wealth and dependent on three relative rates of return of which the money-market spread is the most important. The spread of the own rate above the holding period return on equities does not seem to have strong effect on OFIs' demand for money.

The second relationship may be interpreted as a deposit rate setting relationship with the own-rate tied to other money-market rates. Theoretically this relationship is not independent of the demand for money relationship, since the degree to which deposit rates follow other rates should in part depend on the interest elasticity of demand for deposits. Given the coefficient of near unity on the bill rate, banks have very little power to set deposit rates, reflecting the close substitutability between wholesale deposits and other money-market instruments. But a term in the level of OFIs' money balances is necessary to make the relationship stationary. This is likely to be reflecting the effect of financial liberalisation on money-market spreads. For example, in the late 1970s the operation of the "corset" acted as a significant constraint on banks' ability to manage their liabilities. Following its removal banks were free to compete for wholesale funding without penalty and consequently wholesale deposit rates were bid up towards other money-market rates. OFIs' M4 deposits rose concomitantly and for this reason they are likely to act as a proxy for this process. Alternatively the positive effect of OFIs' deposits on the money-market spread may reflect a small amount of procyclicity in banks' and building societies' margins (due to variable interest elasticities of demand for both money and credit). It seems likely that this relationship would not be stable outside the sample period considered here.

Table 3.A

Cointegration analysis 1978 (1) to 1994 (4)

(a) Constant Unrestricted

	Eigenvalue Test			**Trace Test**		
H_o:rank=*p* -	$Tlg(1\text{-}\lambda)$	*T-nm*	95%	$-T\Sigma lg(1\text{-}\lambda)$	*T-nm*	95%
p = = 0	36.53*	31.16	33.5	84.15**	71.78*	68.5
p <= 1	29.73*	25.36	27.1	47.62*	40.62	47.2
p <= 2	12.89	11	21.0	17.89	15.26	29.7
p <= 3	4.99	4.257	14.1	5.001	4.265	15.4
p <= 4	0.0102	0.0087	3.8	0.0102	0.00872	3.8

(b) Constant Restricted

	Eigenvalue Test			**Trace Test**		
H_o:rank=*p* -	$Tlg(1\text{-}\lambda)$	*T-nm*	95%	$-T\Sigma lg(1\text{-}\lambda)$	*T-nm*	95%
p == 0	37.06*	31.61	34.4	85.98**	73.34	76.1
p <= 1	29.98*	25.57	28.1	48.92	41.73	53.1
p <= 2	13.35	11.38	22.0	18.94	16.15	34.9
p <= 3	5.559	4.742	15.7	5.592	4.77	20.0
p <= 4	0.0334	0.02848	9.2	0.0334	0.02848	9.2

Number of lags used in the analysis: 2
Variables entered unrestricted:
r_k Di1985p1 Di1987p1

Vector Normality $\chi^2(10)$ = 13.737 [0.1854]

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

Identified Cointegrating Vectors

	β_1	β_2
m_t	1	- 0.01
r_{dct}	- 28.8	1
r_t	21.3	-0.93
r_{kt}	1.5	0
Δp_t	24.0	0
w_t	- 1	0

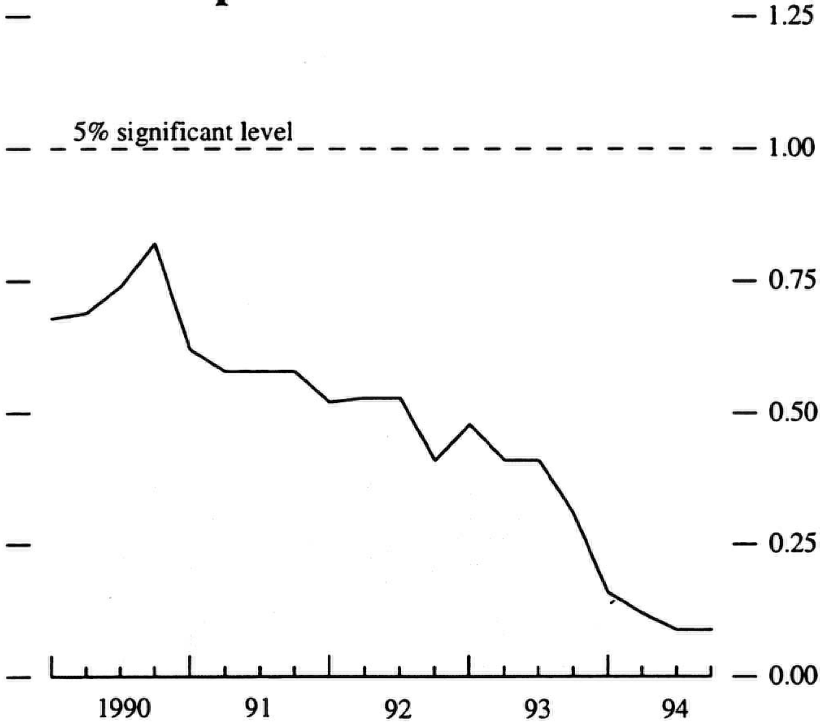
Standardised loading coefficients

	α_2	α_2
m	-0.07	-1.87
r_{dc}	0.004	-0.33

χ^2 (3) = 1.2959 [0.7301]

Chart 3.1

Recursive stability of the long-run relationships



The next stage is to test for the validity of the exogeneity assumptions made when investigating the long-run relationships. Again we define two error correction terms given by (m -m*) and (r_{dc} - r_{dc}*) which are the deviations of money and deposit rates from their equilibrium levels. Table 3.C shows the results of weak exogeneity tests which indicate that $X_t = [r_{bt}, r_{kt}, \Delta p_t, w_t]$ can be treated as weakly exogenous when the parameters of interest are the short and long-run parameters of a conditional model of Y_t on X_t. The significance of this test is that OFIs' deposits do not seem to interact strongly with the rate of return on equity, which is one of the channels through which one might have expected OFIs' deposits to influence real activity. (14)

Table 3.C Weak exogeneity tests

(a) Significance of cointegrating vectors in marginal model

Wald test for general restrictions
GenRes χ^2(8) = 13.353 [0.1003]

(b) Orthogonality Tests

F-tests on retained regressors,

Ur_k	F(2, 49) =	0.714251	[0.4946]
U_{rb}	F(2, 49) =	0.343280	[0.7111]
$U\Delta p$	F(2, 49) =	0.0368424	[0.9639]
Uw	F(2, 49) =	0.752171	[0.4767]

Thus we can legitimately proceed with the conditional VECM of Y_t on X_t . Table 3.D shows the estimates of the conditional VECM after some simplifying exclusion restrictions were made on those variables which were not jointly significant. As the diagnostics and Chart 3.2 shows this seems to be a reasonably stable and well-behaved reduced form representation against

(14) One possibility for the absence of such an effect is that the OFI sector itself is being modelled at too aggregated a level. Congdon (1996) suggests spliting OFIs' money holdings into those of life assurance and pension funds (LAPFs) and other OFIs (OOFIs). LAPF money holdings may have an effect on asset prices which is obscured by aggregating them with the volatile deposits of the OOFIs. We leave this as an avenue for future work.

which to test a structural model, despite an outlier in the deposit rate equation in 1988 Q2. The correlation between actual and fitted values of 85% and 94% respectively suggest a reasonable fit of a model in first differences.

Table 3.D Conditional VECM

Reduced Form Equation for Δm_t

Variable	Coefficient	Std.Error	*t*-value
Δm_{t-1}	0.58	0.10	5.88
Δr_{dct-1}	- 0.57	0.51	- 1.12
$(r_{dc} - r_{dc}*)_{t-1}$	- 1.90	0.98	- 1.94
$(m - m*)_{t-1}$	- 0.07	0.02	- 3.53
Δw_t	0.09	0.07	1.20
Δw_{t-1}	0.01	0.07	0.08
Δr_{kt}	- 0.07	0.05	- 1.50
Δr_{kt-1}	0.09	0.05	1.92
Δr_{bt}	0.80	0.27	2.94
Δr_{bt-1}	0.73	0.54	1.35
$\Delta^2 p_t$	- 1.83	0.37	- 4.95

Reduced Form equation for Δr_{dct}

Variable	Coefficient	Std.Error	*t*-value
Δm_{t-1}	0.06	0.02	3.57
Δr_{dct-1}	- 0.26	0.09	- 3.00
$(r_{dc} - r_{dc}*)_{t-1}$	- 0.34	0.16	- 2.08
$(m - m*)_{t-1}$	0.004	0.003	1.27
Δw_t	0.02	0.01	1.74
Δw_{t-1}	0.01	0.01	1.03
Δr_{kt}	- 0.01	0.01	- 1.35
Δr_{kt-1}	- 0.01	0.01	- 1.09
Δr_{bt}	0.48	0.05	10.42
Δr_{bt-1}	0.29	0.09	3.20
$\Delta^2 p_t$	- 0.05	0.06	- 0.88

Table 3.D (continued)

Diagnostics

standard deviations of reduced form residuals

Δm	Δr_{dc}
0.02	0.004

$R^2(LR) = 0.96415$ $R^2(LM) = 0.774467$

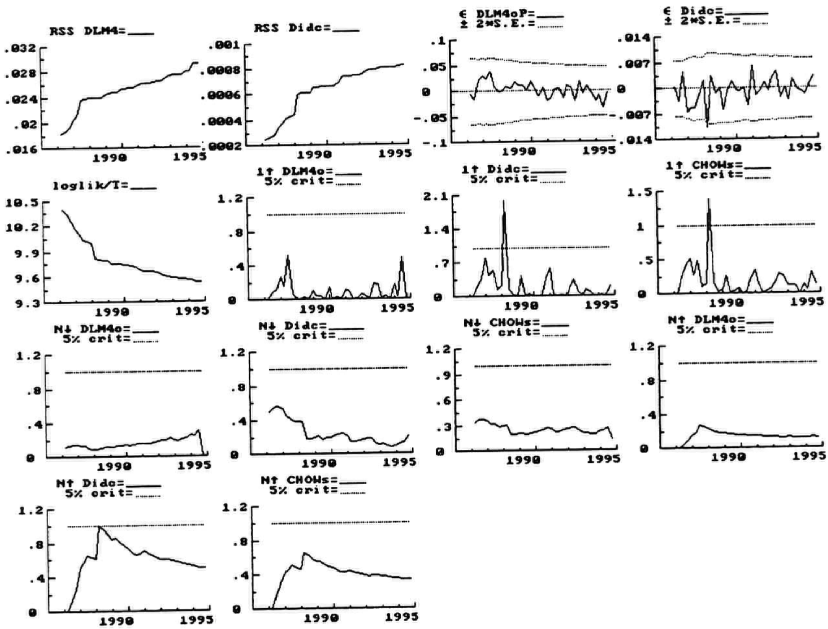
F-tests on retained regressors, F(2, 50)

Δm_{t-1}	31.3477 [0.0000] **	Δr_{dct-1}	6.4355 [0.0033] **
$(r_{dc} - r_{dc}*)_{t-1}$	5.49887 [0.0069] **	$(m - m*)_{t-1}$	6.1468 [0.0041] **
Δw	2.97004 [0.0604]	Δw_{t-1}	0.5863 [0.5602]
Δr_{kt}	2.77326 [0.0721]	Δr_{kt-1}	1.9658 [0.1507]
Δr_b	71.3280 [0.0000] **	Δr_{bt-1}	7.6829 [0.0012] **
$\Delta^2 p$	14.7196 [0.0000] **		

correlation of actual and fitted values

Δm	Δr_{dc}
0.8540	0.9372

Chart 3.2
Recursive stability of the conditional VECM



3.3 The structural model

We now proceed to make identifying restrictions on the conditional VECM and attempt to recover a structural interpretation of the statistical model. Exact identifying restrictions were made in order to diagonalise the loading matrix on the cointegrating vectors in the structural form, following Bordsen and Fisher (1993) and Boswijk (1995). This is in order to recover a dynamic demand schedule for OFIs' M4 and a marginal (inverse) supply of money relationship describing the deposit-rate setting behaviour of banks.(15) This yielded an interpretable structural model shown in Table 3.E. The diagnostics do not indicate any problems and Charts 3.3 to 3.5 indicate that the fit of the model is satisfactory with no obvious signs of instability.

The money equation appears to be a standard dynamic money demand relationship with strong short-term effects from the relative rates of return. But there are some unsatisfactory elements to the equation. The coefficient on the ECM term is quite low while that on the lagged dependent variable is quite high, suggesting a rather slow adjustment to equilibrium.

The deposit rate equation shows sensible dynamic properties, being highly dependent on changes in the bill rate as well as being influenced by short-term movements in OFIs' money and wealth. There is a large coefficient on the error correction term which, together with the other dynamic properties of the equation, suggests a fast adjustment to equilibrium.

Together the two equations describe a simple liability management model of the determination of the stock of OFIs' M4 holdings. Banks and building societies have limited power to set wholesale deposit rates, which are chiefly determined by the going rate in the money market. But any rise in their desire to bid for deposits will lead to a small rise in deposit rates relative to other rates and this will have a significant long run effect on the demand for money by OFIs. Unfortunately the deposit rate equation does not really shed much light on what determines the banking system's desired spread of deposit rates relative to other money-market rates.

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(15) It might be expected that the same identifying restrictions would be used for ICCs and OFIs, recalling the arguments in Section 2.4. But from the discussion in Section 1 of the personal sector paper one might not expect OFIs to use their money balances as a financial buffer and so relative deposit rates would be expected to clear the market at each point in time Thus the BDrdsen and Fisher method is used because it identifies separate supply and demand influences on OFIs money holdings. The error-correction formulation of the money equation is simply representing dynamic adjustment in money demand and not the combination of supply and (long-run) demand influences as in the model for ICCs.

Table 3.E Structural model estimated by FIML

$$\Delta m_t = +3.305\,\Delta r_{dct} + 0.43\,\Delta m_{t-1} - 0.8\,\Delta r_{bt}$$
(0.95) (0.12) (0.58)

$$-1.5\,\Delta^2 p_t + 0.09\,\Delta r_{kt-1} - 0.06\,(m - m^*)_{t-1}$$
(0.37) (0.03) (0.01)

s.e. = 0.03

$$\Delta r_{dct} = +0.05\,\Delta m_{t-1} - 0.22\,\Delta r_{dct-1} + 0.48\,\Delta r_{bt}$$
(0.013) (0.07) (0.04)

$$+ 0.26\,\Delta r_{bt-1} - 0.09\,\Delta^2 p_t - 0.01\,\Delta r_{kt}$$
(0.07) (0.05) (0.005)

$$+ 0.02\,\Delta w_t - 0.48\,(r_{dc} - r_{dc}^*)_{t-1}$$
(0.01) (0.08)

s.e. = 0.004

(figures in parentheses are coefficient standard errors)

Table 3.E (continued)

Single equation diagnostics

m_t

AR 1- 5F(5, 45) = 1.7479 [0.1432] Normality $\chi^2(2)$= 3.506 [0.1733]
ARCH 4 F(4, 42) = 0.27998 [0.8893] Xi^2 F(24, 25) = 0.74357 [0.7645]

r_{dct}

AR 1- 5F(5, 45) = 2.1791 [0.0732] Normality $\chi^2(2)$= 1.1643 [0.5587]
ARCH 4 F(4, 42) = 0.2704 [0.8954] Xi^2 F(24, 25) = 1.1239 [0.3864]

System diagnostics

Vector AR 1-5 F(20, 88) = 1.5449 [0.0864]
Vector normality χ^2(4)= 6.1894 [0.1854]
Vector Xi^2 F(72, 84) = 0.97847 [0.5357]

LR test of over-identifying restrictions:χ^2(10) = 3.95263 [0.9495]

Chart 3.3
Fitted values and residuals of the money equation

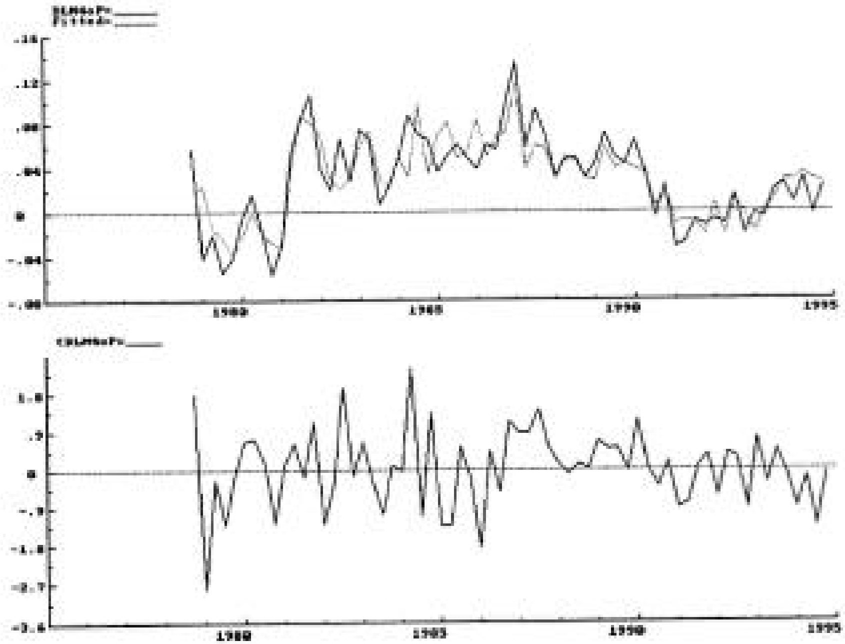


Chart 3.4
Fitted values and residuals of the deposit rate equation

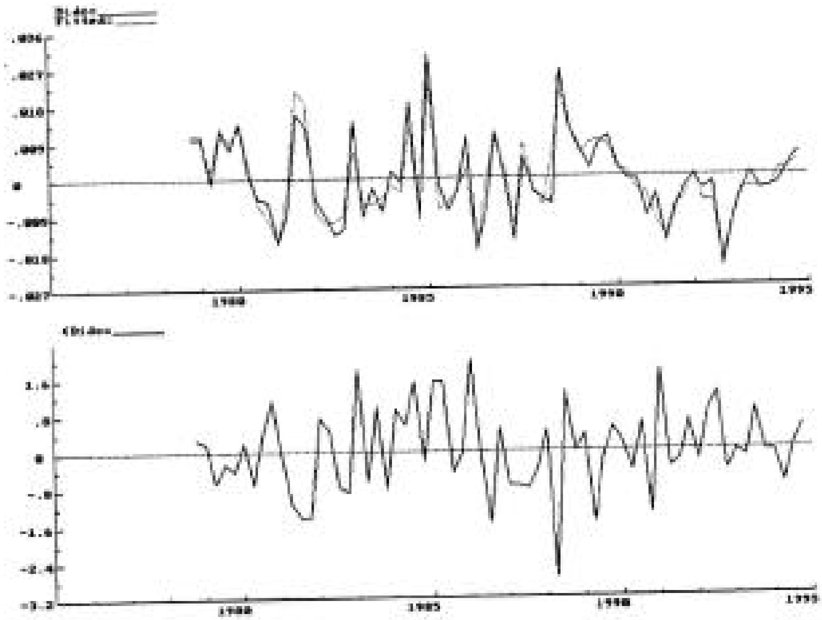
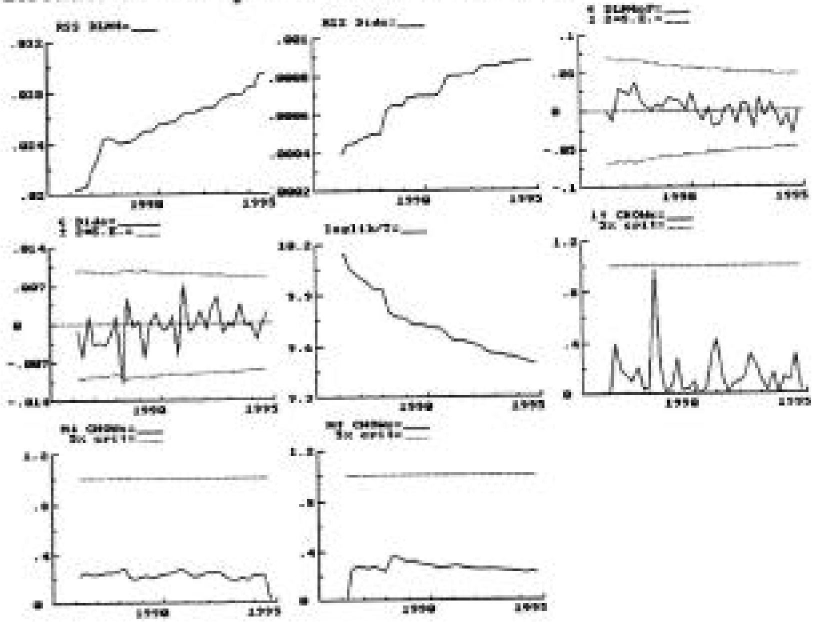


Chart 3.5
Recursive stability of the structural model



4 Summary and conclusions

The results of this paper suggest that sectoral modelling of M4 holdings helps in identifying some of the channels through which movements in broad money may have effects on real expenditure and ultimately prices over the longer term.

Small sectoral monetary models were developed for both ICCs and OFIs, deriving structural relationships from congruent statistical representations of the data. The model for ICCs suggested the presence of a corporate sector "liquidity effect", with changes in firms' money balances relative to their equilibrium levels influencing the real cost of capital and investment. This provides a structural interpretation of the leading indicator properties of corporate sector money over investment found in Astely and Haldane (1995). The model for OFIs illustrates the interaction between the banking system's management of its liabilities with the portfolio allocation decisions of OFIs. But it is not indicative of any particular role for OFIs' deposits in the transmission mechanism.

Appendix

Data Sources:

Break-adjusted M4 for ICCs and OFIs. *Bank of England*

Real gross domestic fixed capital formation. *ONS code DECU*.

ICCs' and OFIs' gross financial wealth. *ONS codes ALCN, AMWF and ASKW*.

Real post-tax cost of capital for ICCs. *Bank of England*

Real GDP at factor cost. *ONS code CAOP*

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

Weighted own-rate on Corporate Sector M4. *Bank of England*

GDP deflator. *ONS code CAOM/CAOP*

FTSE index of ordinary shares, dividend yield - *ONS codes AJMT*,*AJMU*

Capacity utilisation, proportion of firms reported to be working below capacity - *CBI Quarterly Industrial Trends Survey*

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