Money, credit and investment in the UK corporate sector

by

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Abstract

This paper considers the interactions between gross domestic fixed capital formation, an important component of domestic demand, and the real money and credit balances of private non-financial corporations. It is acknowledged that banks and firms both have incentives to form special relationships, and that this may lead to important lines of transmission between credit, money and real activity. Our approach is to use the systems approach of Hendry and Mizon (1993) to model the three variables jointly.

We find long-run equilibrium relationships which confirm that real decisions are important to the financial structure of firms, and that departures from long-run equilibria in money and credit feed back to investment. Evidence of a direct credit channel comes from these causal chains. A further indirect channel operates through the dynamics as the lending spread over Libor feeds through to changes in investment. Together these support the case for a credit channel and indicate that money, credit and investment should be modelled as a system.

1 Introduction

The subject of this paper is the interaction between the real economy and the holdings of money and credit by firms. The paper considers whether the liquid assets and liabilities held by private non-financial corporations (PNFCs) can help to explain investment, which is an important component of aggregate demand. Money and credit conditions are expected to influence investment as monetary policy operates through changes to short-term interest rates, which affect large firms through the financial markets and small-to-medium sized firms through the lending rates offered by banks. The traditional credit channel literature develops this line of reasoning.

Large firms have access to funds from many sources through securities markets but there are certain categories of firms, such as small to medium-sized enterprises (SMEs), that are more likely to be dependent on banks and other credit providers because they do not have access to the financial markets. Banks themselves may wish to foster dependence between suppliers and recipients since there is imperfect substitutability in their own portfolios between private sector loans and other assets. The firms and banks may have incentives to form special relationships. Although we cannot deal with the specialness of bank-firm relationships directly, since our model involves an equilibrium credit equation, we can consider whether there is any 'value added' in including a credit equation in a system with money and investment. The credit equation can be separately identified and included in a three-equation system to test whether it offers significant extra explanatory power over a more restricted structure.

We estimate a single interactive dynamic system using the methodology of Hendry and Mizon (1993) and Hoffman and Rasche (1996). This approach represents a departure from the main body of previous empirical literature that has attempted either (i) to isolate the demand for money equation from credit (see *inter alia* Barr and Cuthbertson (1990); Mizen (1992, 1994); Chrystal and Drake (1994); Drake (1996); or (ii) to model bank lending to the company sector as a separate equation (see Cuthbertson (1985)). However, a number of exceptions do exist, notably: Ireland and Wren-Lewis (1992), which demonstrates the advantages of a systems approach; and Mizen (1994) and Thomas (1997a,b), which model (respectively) money and credit, and money and investment as systems. We are not aware of any previous attempts to model a three-equation system in money, lending and investment.

The rest of the paper is divided up as follows: Section 2 considers the impact of demand and supply-side factors on credit equilibrium and the likely interactions between money, credit and investment; Section 3 summarises the econometric methodology; Section 4 models investment, credit and money in a system and determines whether the expanded system can encompass restricted (two-equation) systems in a formal sense; Section 5 concludes.

2 PNFCs and the role of credit

In this section we focus on the role of credit in the behaviour of the firm. We later use our model to determine whether incorporating credit affects the transmission mechanism from monetary policy changes to investment behaviour. We do so first of all because the paper aims to study the implications of the funding structure of firms for their real activity, and to infer from this the role of credit in the transmission process. But second, the credit market is likely to be the least understood of the three equations in our system, since aggregate money demand and investment equations have a long pedigree but credit equations do not. For this reason the credit equation needs more elaboration than the others in the system.

The decisions of the firm and the Modigliani-Miller theorem

In a world without imperfections, a firm is assumed to maximise the net present value of future profit streams by dealing separately with real production decisions and financial structure. The real decisions of the firm in neoclassical theory involve long-term decisions over investment and short-term variations in inventory holdings to ensure a smooth path for production over time (Miron and Zeldes (1987)). If the Modigliani-Miller theorem holds in this environment, the firm is indifferent about the structure of its finance in these decisions (Modigliani and Miller (1958)). Price differentials will be arbitraged away and firms' decisions about real variables will not be affected by the composition of their debt. This leaves little room for any interaction between the real activity of firms and their financing decisions, but the presence of market imperfections would change all this.

Supply: Imperfect information and the credit channel

With imperfect information on firm type, there will be imperfect substitutability between bank borrowing, new issues of equity and other forms of finance offered by the markets. Market imperfections generate a differential between the costs of external and internal funds, which is proxied by the spread in market rates for alternative external sources of funds over the cost of internal finance. Moreover, Myers and Majluf (1984) argue that firms may have a preference ordering over alternative sources of finance which ranks internal sources, based on retained earnings, above external sources, such as trade credit, bank borrowing, new issues, and other sources. The reason for this rank ordering is the pecuniary and non-pecuniary costs associated with external sources of finance. It implies a rejection of the Modigliani-Miller theorem because real and financial decisions are then interdependent.

There are further reasons to suggest that firms will need to consider financial and real decisions together and concern themselves with financial structure. According to the models of Jaffee and Russell (1976) and Stiglitz and Weiss (1981), a rational bank should be cautious about offering credit and should introduce 'quantity rationing' to exclude some 'unsafe' borrowers, rather than extending loans to all borrowers who are prepared to pay the going price. This cautious response derives from the inability of the banks to assess perfectly the performance and credit worthiness of the companies to which the loans are extended. In the model of Jaffee and Russell it is assumed that lenders can accurately observe the total quantity of lending and that quantity rationing is a rational response to risk at some (high) level of borrowing. This is because it is assumed that the probability of default increases with the total volume of lending, and under these conditions the offer curve of the bank, which is upward sloping over a certain range, should become vertical or backward-bending. In the Stiglitz and Weiss approach there is an assumption that lenders are subject to asymmetric information, and cannot observe default probabilities, creating adverse selection and moral hazard problems. In this model a 'price-rationing' response (ie letting borrowers pay more if they are willing to do so) is insufficient as a rationing device, and would make matters worse. Providers adopt a rationing approach that involves both price and quantity restrictions; this is, nevertheless, an 'equilibrium' solution based on profit maximisation in contrast to Jaffee and Russell.

The fact that lenders use information about company assets and liabilities in determining access to, and terms of, loans is the motivation for what Bernanke and Gertler (1995) call the *balance sheet channel* of the monetary transmission mechanism. In such a world, institutions rely on signals of creditworthiness from the financial performance of companies to determine the volume of loans that should be extended. The rationing is exercised by pricing the loans to reflect the observed risks in balance sheet information, driving a wedge between the relative price of lending and alternative sources of external funds. This limits the exposure of banks. Factors that are easily monitored such as the cash flow, financial wealth, and previous loan payments history, as well as outstanding debt, will be influential in determining the eligibility of a company for access to loans (see Leland and Pyle (1977); Fama (1985)). The financial health of company balance sheets can be influenced by the cycle itself and, since extensions or withdrawals of loan facilities offered on this basis vary with the cycle, credit under the balance sheet channel serves as a financial accelerator to the cycle (Bernanke, Gertler and Gilchrist (1994)). This may result in endogenous credit cycles, discussed by Kiyotaki and Moore (1997).

It is likely that banks have a special role in the credit market, particularly with respect to small to medium-sized enterprises, and this gives rise to the *bank lending channel*, see Bernanke and Blinder (1988). It is assumed that bank loans and alternative sources of finance are imperfect substitutes and that differentials in the spreads emerge because there is imperfect arbitrage. Imperfect substitutability arises first of all because small to medium-sized firms may be unable to access other markets for funds and therefore have a certain dependence on banks for external sources of funds (see Kashyap and Stein (1993); Gertler and Gilchrist (1993, 1994); Bernanke and Gertler (1995)). Banks have some advantages over other financial intermediaries in the provision of credit arising from their role as deposit-takers and providers of payment systems services. This allows them to match their liability structure to the term to maturity of loans, provides access to information on financial background of companies, and reduces their exposure to costs incurred through adverse selection (see Leland and Pyle (1977); Diamond (1984); Fama (1985); Himmelberg and Morgan (1995)). Imperfect substitutability can also arise on the supply side since banks themselves might not regard bank loans and securities as perfect substitutes in their own portfolios, if the former are held for return whilst the latter are held for liquidity. A monetary tightening might then have a direct effect on the provision of loans. If this theory is correct larger spreads do not create incentives to substitute towards other sources of finance, but rather represent a higher cost of the only available source of finance, namely bank lending.

Demand: The business cycle and investment

The long-run equilibrium level of bank lending will be affected by the demand for bank credit as well as the supply, and the factors affecting the banks' readiness to extend credit are also likely to influence firms' readiness to take it up. As the business cycle moves into the recovery phase firms will demand more credit from banks to finance expansion, whereas in a downturn they will reduce their demand for credit as profitable investment opportunities decline. Investment will be undertaken to adjust the existing capital stock towards its desired long-run level. Ultimately, bank credit will be required to finance this expansion of business arising from the general increase in demand for goods that cannot be met from current capacity. As investment is undertaken to enlarge productive capacity, so the demand for bank credit to finance it is likely to grow. Hence, measures of the cycle in output, as well as measures of financial health such as profitability and the accumulation of financial wealth, are likely to be associated with expanding demand for bank credit in the long run.

In the short term, bank credit may also be important. In the upward phase of the cycle, it may be used to finance increased production through overtime payments, while in the downward phase of the cycle unwanted stockbuilding may occur. This could create a need for 'distress' borrowing until such time (over the short to medium term) that production can be adjusted or demand recovers.

In what follows we model the equilibrium demand for credit but cannot unambiguously assign the movements in credit to separate supply or demand-side effects. This rules out an unambiguous definition of the credit channel but it does not prevent us from searching for evidence that credit matters interactively for money and investment equations as a linkage in the transmission mechanism of monetary policy.

3 Econometric approach

The approach taken in this paper is to test restrictions to a vector autoregression of the economic variables of interest. The 'Encompassing the VAR' approach has been documented in detail by Hendry and Mizon (1993) and Hendry (1995) and has been used by Thomas (1997a,b) to examine demand for money in various sectors of the United Kingdom.

The vector of variables of interest, z_t , is partitioned into two vectors, y_t and x_t, which will take on greater significance later. The framework we adopt for the analysis of z_t is a VAR model of the form:

$$\Pi(L)z_t = \varepsilon_t$$
$$\text{where } \Pi(L) = I_p - \sum_{i=1}^{n} \Pi_i L^i \qquad \textbf{(1)}$$

ε_t is a p-dimensional vector of disturbance terms, and I_p is the appropriately dimensioned identity matrix. The p variables in our VAR are not stationary in levels but can be individually differenced once to achieve stationarity. Then an unconditional vector error correction model can be specified of the form:

$$\Delta z_t = \mu + \sum_{i=1}^{n-1} \Pi_i^* \Delta z_{t-1} - \Pi z_{t-1} + \varepsilon_t$$
$$\text{where } \Pi_i^* = -I_p + \Pi_1 + \ldots + \Pi_i \text{ for } i = 1,\ldots,n \qquad \textbf{(2)}$$
$$\Pi = -I_p + \Pi_1 + \ldots + \Pi_n$$

For p variables in the VAR, the rank of the matrix Π provides information on the orders of integration of the variables. Where the rank is equal to p, the VAR contains p individually stationary series, and where the rank is zero the variables are all individually integrated of order one. In between these two extremes there is the possibility of a rank equal to r, where $0 < r < p$, indicating that there are r linear combinations which are cointegrated —reducing the order of the variables from one to zero when they form a particular linear combination. The Johansen procedure tests for the rank of the Π matrix to determine whether there exist linear combinations of variables that are stationary. If there are r cointegrating vectors then thereare only p-r independent random processes driving the non-stationary behaviour of the p-dimensional system.

Following the standard notation, the long-run matrix can be written as the product of two pxr matrices $\Pi = \alpha\beta'$: we refer to β as the cointegrating matrix and α as the loading matrix. We use the usual Johansen procedures to estimate the unconditional VECM, normalise the system and test for the rank of the Π matrix on the basis of maximum eigenvalue and trace tests.

The unconditional VECM can be made conditional by identifying the endogenous and weakly exogenous variables in the system. Taking our partition of z_t into y_t and x_t, and referring to y_t as the endogenous and x_t as the weakly exogenous variables, we can test for the validity of this partition by examining the significance of the loading coefficients in the marginal models for y_t and x_t. Hence we can take the conditional model for y_t and the marginal model for x_t as:

$$\begin{aligned}\Delta y_t &= \omega \Delta x_t + \sum_{i=1}^{n} \left(\Pi^*_{y,i} - \omega \Pi^*_{x,i}\right)\Delta z_{t-i} \\ &\quad - \left(\alpha_y - \omega\alpha_x\right)\beta' z_{t-1} + \mu_y - \omega\mu_x + \left(\varepsilon_{y,t} - \omega_{x,t}\right)\end{aligned} \quad \textbf{(3)}$$

$$\Delta x_t = \sum_{i=1}^{n-1} \Pi^*_{x,i}\Delta z_{t-i} - \alpha_x \beta' z_{t-1} + \mu_x + \varepsilon_{x,t} \quad \textbf{(4)}$$

where $\omega = \Omega_{yx}\Omega^{-1}_{yx}$ and Ω_{ij} for $i, j = x, y$ represent submatrices of the system covariance matrix and the partitioned parameter spaces are denoted by subscripts x and y. Weak exogeneity implies that there is no feedback mechanism from the cointegrating relationship to the marginal process for x_t, and this will be true when the parameter α_x is zero.

If $\alpha_x = 0$, no information of any importance is lost when estimating and conducting inferences on α_y and β using just the conditional model for y_t given by (3). The test for weak exogeneity is an F-test for the joint restriction of $\alpha_x = 0$. The information that some of the variables in the VAR are exogenous can help to identify the system and reduces the computational burden of estimating conditional models for the variables in x_t. In our system we would expect to find that investment, credit and money are endogenous variables and that the other variables representing the stage of the cycle and interest rate spreads would be exogenous to the sector.

After defining which variables are endogenous and which are exogenous we use the conditional VECM (3) to estimate the coefficients α_y and β, without loss of information, conditional on the weak exogeneity of x_t. The final task is then the recovery of the 'structural model' from this reduced-form model, which entails imposing further 'exact-identifying' restrictions on a system that has been sufficiently or 'just-identified' to extract the long-run relationships and error correction coefficients.

The structural model is identified by premultiplying the conditional VECM by a contemporaneous coefficient matrix $H(0) \neq I_p$. Depending on the definition of $H(0)$, there will be different structural implications for the model, arising from the different causal relationships between the variables that this entails. Ultimately this will imply different impulse responses to permanent and temporary shocks. If $H(0)$ is diagonalised following the suggestion of Bardsen and Fisher (1993) and Boswijk (1995), then the covariance matrix will also be diagonalised and only the 'own' error correction term will enter each equation. If $H(0)$ is block recursive, as it is in the Johansen and Juselius procedure, then the 'own' error correction term will enter each equation, but also there will also be feedback from certain 'other' error correction terms in such a way as to imply a causal ordering of endogenous variables.

If $H(0)$ is partitioned into $(H_{yz}, H_{xz})'$, where $H_{yz} = (H_{yy}, H_{yx})$ and $H_{xz} = (H_{xy}, H_{xx})$ then a diagonal structure is given by $H_{yx} = H_{xy} = 0$, while a block recursive structure is given by $H_{xy} = 0$. Hence the structural model of the conditional VECM based on a block recursive structure is:

$$\begin{aligned} H_{yy}\Delta y_t &= H_{yx}\Delta x_t + H_{yz}\sum_{i=1}^{n-1}\Pi_i^*\Delta z_{t-i} - H_{yz}\Pi z_{t-1} \\ &\quad + H_{yz}m + H_{yz}\varepsilon_{yt} \end{aligned} \qquad \textbf{(5)}$$

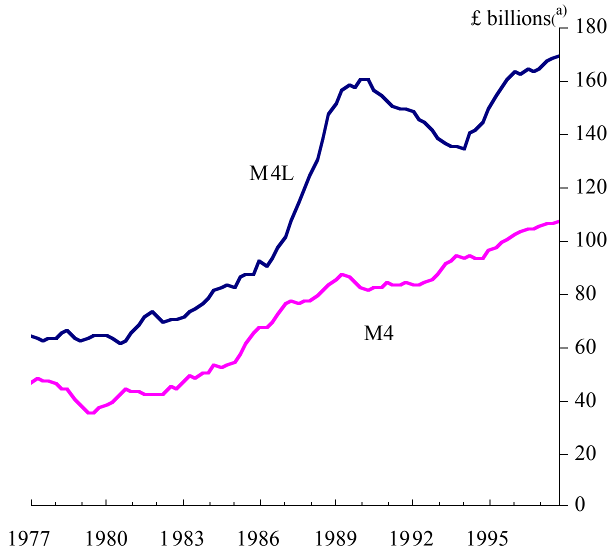
Information from the exogeneity tests and economic theory can help to impose sufficient restrictions to ensure that the model is exactly identified as a structural model. Any further restrictions, which are not required to determine the structural content of the model, are tested as over-identifying restrictions using an encompassing test. The over-identifying restrictions are tested using chi-squared tests. The dynamics of the model can be evaluated by examining the impulse responses of the model when the variables are subjected to permanent or temporary shocks.

In the following section we consider a three-equation system including investment, credit and money as the endogenous variables that are explained by a vector of seven exogenous variables. The system can be formally tested against more restrictive two-equation systems that exclude money or credit (based on Thomas, 1997b) using the encompassing method. In this way we can formally determine whether the addition of money to the model of investment and credit improves the performance of the econometric model.

4 Modelling money, credit and investment

In this section we estimate a VAR that includes three endogenous variables: private non-financial corporations' (PNFCs') real M4 (m); PNFCs' real M4 lending (l); and real whole-economy investment (i). Examining the data for real money and bank lending, we notice that there have been different patterns over the cycle. Chart 1 shows that, in real terms, bank lending to PNFCs grew much faster than PNFCs money balances from mid-1987 to mid-1990 creating a clear change in trend. From the peak in 1990 there was a swift decline in bank lending until 1995, corresponding to a deterioration in economic conditions and the emergence of an adverse relationship between banks and smaller companies. After 1995, as the business cycle turned up, there was a rise no less steep than the initial increase in trend in the 1980s, suggesting that the correlation with the business cycle is robust. The uptake of bank loans by UK companies appears to be heavily dependent on the cycle, yet money, by contrast, had a far more muted role in the cycle and there is barely any evidence of a change in trend from 1980 to the present. This suggests that PNFCs' credit is much more cyclical than their money balances, and we can conclude that something other than money and investment is responsible for the movement of the variable. In short, it can be separately identified and it may prove important to our understanding of the structure of firms' financing in relation to their real activity, and so ultimately to the transmission mechanism.

Chart 1
PNFCs' M4 and M4 lending



(a) At current 1995 prices.

The exogenous variables included in the VAR to explain the three endogenous variables are GDP (y), a measure of the proportion of firms reporting more than adequate stocks of finished goods, which is taken from the CBI monthly trends survey (s_u), PNFCs' real gross financial wealth (w), PNFCs real retained earnings (π), the real user cost of capital (c_k), the spread of the M4 deposit rate over Libor (r_d), the spread of the rate on bank lending over Libor (r_l), and the real value of mergers and acquisitions (ma). The sample period is 1978 Q1 to 1998 Q1. With the exception of the interest rate spreads, which are quoted in decimals, all variables are in natural logarithms.

The first set of variables includes demand factors. Real GDP captures general business cycle conditions, which affect the demand for investment goods and the demand for bank credit. The CBI survey is treated as a 'barometer' of confidence in prevailing economic conditions relating to the cycle, since it records the extent to which firms consider themselves overstocked and therefore less likely to wish to undertake further investment in fixed capital. We use a measure of investment excluding stocks despite the likely interaction between stockbuilding and liquidity (see Callan and

Henry, (1989)).[1]

The second set of variables records the financial position of the sector using gross financial assets of the sector deflated by the implicit price level, as a measure of real gross financial wealth (w). Given the importance of current earnings as a source of finance for investment activity it is not surprising to find that undistributed earnings (π) is also a strong contender for inclusion in any investment or bank lending equation.[2] Undistributed earnings are a measure of the supply of internal (retained) finance, which would tend to diminish recourse to banks for investment funds.

The third set of variables are relative price measures: c_k, r_d and r capture, respectively, the price of investment goods, the return to corporate M4 balances and the cost of bank borrowing.

Our application of the econometric methodology of section 3 is as follows. In the first step we estimate the unconditional VAR system described as

$$\Pi(\mathrm{L})z_t = \varepsilon_t \qquad \textbf{(6)}$$

where $z_t = (v_t, x_t)$ is made up of endogenous variables $v_t = (i_t, l_t, m_t)$ and exogenous variables $x_t = (y_t, s_{u,t}, w_t, \pi_t, c_{k,t}, r_{l,t}, r_{d,t})$. We discover the number of cointegrating relationships (r) in the data and then re-estimate the equations with just r endogenous variables in a conditional system defined as:

$$\Delta v_t = \mu + \sum_{i=1}^{n-1} \Pi_i^* \Delta z_{t-i} - \Pi z_{t-1} + \varepsilon_t \qquad \textbf{(7)}$$

where the estimated matrix of coefficients Π describes the long-run cointegrating relationships between the endogenous variables, v_t, and the exogenous variables, x_t. The structural model is exactly identified and is given as:

(1) Including stockbuilding explicitly is problematical. Planned stockholding in the United Kingdom has a marked downward trend over the 1980s as a result of the introduction of computer-based management systems and just-in-time technology.
(2) Ideally we would like to be able to subtract depreciation and goodwill to ensure that we have measured the current net cash inflow to the company sector, but these are exceptionally difficult to quantify.

$$\Delta v_t = A\Delta x_t + \sum_{i=1}^{n-1} B_i \Delta z_{t-i} + X z_{t-1} + E + \eta_t \qquad \textbf{(8)}$$

where $A=H_{yx}$, $B_i=H_{yx}\Pi_i{}^*$, $X=H_{yx}\Pi$, $E=H_{yx}\mu$ are matrices of coefficients and the error vector is $\eta_t = H_{yx}\varepsilon_t$. Our final equations are given by a parsimonious version of the system (8) defined by acceptable overidentifying restrictions.

Preliminary inspection of the VAR suggested that the unconditional VAR model should be specified with a lag length of two, although the results were not significantly altered by estimating a VAR with three lags. The system includes some variables that are I(1) variables, so we test for the existence of linear restrictions between the variables to reduce the rank of the system through cointegration, using the Johansen procedure.

Table A
Cointegration analysis: Johansen results

	Maximum eigenvalue test			**Trace test**		
H_0: rank=r	$-T\log(1-\lambda)$	T-nm	95% c.v.	$-T\Sigma\log(1-\lambda)$	T-nm	95% c.v.
r == 0	75.03**	56.73	62.8	334.7**	253.1**	233.1
r <= 1	69.55**	52.59	57.1	247.3**	194.3**	192.9
r <= 2	52.85*	39.96	51.4	187.4**	141.7	156.0
r <= 3	41.69	31.52	45.3	134.6**	101.7	124.2
r <= 4	38.63	29.21	39.4	92.9	70.2	94.2
r <= 5	18.14	13.72	33.5	54.2	41.0	68.5
r <= 6	15.74	11.90	27.1	36.1	27.3	47.2
r <= 7	13.93	10.53	21.0	20.4	15.4	29.7
r <= 8	6.26	4.73	14.1	6.4	4.9	15.4
r <= 9	0.17	0.13	3.8	0.2	0.1	3.8

Notes: ** Significant at 5% level
* Significant at 10% level

The results, reported in Table A, imply that the existence of three cointegrating relationships cannot be rejected on the basis of the maximum eigenvalue test at the 5% significance level. The trace test, on the other hand, suggests that there may be up to four cointegrating relationships. In practice we have strong economic reasons to believe that there are three relationships between the variables specifying money, lending and investment. The decision to impose a rank of three was subsequently verified by weak exogeneity tests. These tests verified that the marginal models for the remaining seven economic variables in our vector were not significantly affected by the disequilibrium terms from the cointegration analysis.

Table B
Identified cointegrating vectors

	β_1	β_2	β_3
i	-1.000	0.500	0.500
l	0.000	-1.000	0.000
m	0.000	0.000	-1.000
y	1.000	0.000	0.000
w	0.000	1.000	0.500
π	0.000	-0.500	0.000
s_u	-1.000	0.500	0.500
c_k	**-2.813**	0.000	0.000
	(0.703)		
r_d	0.000	**4.432**	**11.204**
		(2.909)	**(3.922)**
ma	0.000	**0.107**	**0.107**
		(0.029)	**(0.029)**

LR-test chi-sq (17) = 19.251 [0.3143]

Note: Only coefficients in bold were freely estimated. Their standard errors are in brackets.

Three restrictions are needed to identify exactly each of the three cointegrating vectors (giving nine restrictions in total). Trivially, unit coefficients are placed on *m, l* and *i*, in their own equations. We further assume that, in the long run, investment is determined purely by real factors, and so depends neither on money nor on credit. Conversely, money and credit are both conditioned on investment, which acts in place of an income variable (*y*). It is further assumed that PNFCs' credit is not directly influenced by PNFCs' money holdings in the long run, and *vice versa*.These just-identifying restrictions are a natural extension of those employed by Thomas (1997b).

Over-identifying restrictions that appear justified — either on econometric grounds (by inspection of freely estimated parameters) or on theoretical grounds — are tested using a likelihood ratio test. The results are given in Table B. In column 1, investment varies one-for-one with GDP in real terms. As the survey measure of unwanted stocks rises, investment falls proportionally and we infer that this captures the effects of excess capacity and lack of business confidence on planned investment, since these are unwanted stocks. The significant negative coefficient on the real cost of capital shows that when capital is cheap, investment will ultimately increase to take advantage of that fact.

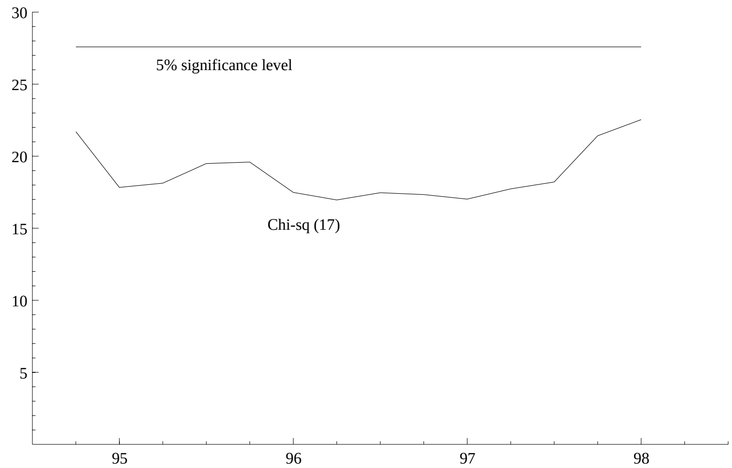
In column 2, the stock of bank lending to PNFCs varies one-for-one with real gross financial wealth, perhaps giving evidence for a balance sheet channel on the supply side (as banks' willingness to lend rises with PNFCs' financial assets). Investment feeds through to lending with a coefficient of one half, introducing a further indirect effect on lending from real GDP and wealth. The coefficient on real retained earnings indicates that lending to PNFCs falls as the alternative and preferred, internal source of funds expands. There is evidence from the positive coefficient (constrained to equal one half) in our model that firms engage in distress borrowing when faced with unwanted stocks of finished goods. The ratio of PNFCs' M4 borrowing to their gross financial assets depends positively on the investment to retained profits ratio (ie what they spend to what they earn). An increase in the deposit spread over Libor represents the cost of running down deposits, and can be considered an opportunity cost variable for bank borrowing. The coefficient indicates that when the return to placing money on deposit is high, making the option of reducing bank lending more costly, firms will tend to raise their borrowing rather than run down their deposits. There is no long-run effect of the lending spread in the cointegrating vector estimated here but there is an impact in the short run, through the dynamics of the system, which leaves the equilibrium unchanged. This suggests that the bank lending channel is a short-run not a long-run (equilibrium adjusting) phenomenon. The increase in mergers and acquisition activity leads to an increase in bank borrowing by firms.

From column 3, the stock of PNFCs' M4 deposits is constrained to vary one-for-one with the sum of investment expenditure and financial wealth. Deposits also rise with the level of unwanted stocks, suggesting a precautionary demand for liquid assets, which matches the response of bank borrowing by firms. The implied semi-elasticity on the interest rate term is appropriately signed and significant. At 11.20, it is larger than the coefficient of 2.88 reported in Thomas (1997b), and may result in part from the constraints on the other parameter estimates. But PNFCs' money balances are volatile and more likely to be actively managed by firms to ensure that the advantages of holding liquidity with the highest available real rate of return are maintained. This will lead to greater sensitivity of money holdings to the real interest rate. The level of merger and acquisitions activity causes money balances to increase, and this is acceptably constrained to be equal to the magnitude of mergers and acquisitions on bank borrowing.

Taking the lending and money equations together we find some desirable properties. The scale variables sum to unity in each equation, and for a given growth rate of the exogenous variables, credit and money would grow at the same rate. The ratio of money to credit is positively related to the ratio of real retained earnings to wealth and the deposit spread over Libor. This implies that additions to the wealth stock in the form of real retained earnings increase money balances relative to bank borrowing *ceteris paribus*. An increase in the opportunity cost of bank borrowing (or the return to placing financial wealth on deposit) serves to raise the ratio of money to bank borrowing. The economic validity of these results gives us greater confidence in the econometric evidence provided by the model.

The likelihood ratio test of restrictions to the cointegrating vector is chi-squared (17) = 19.25. This is not rejected at the 5% significance level. By recursive estimation, we note that the restrictions are not rejected over the interval shown in Chart 2.

Chart 2
Recursive test of long-run restrictions



The matrix of loading coefficients (α) is given below.

Table C
Matrix of loading coefficients

	(i-i)*	*(l-l*)*	*(m-m*)*
i	-0.1742	-0.1429	0.0988
	(0.0469)	(0.0520)	(0.0433)
l	-0.0124	-0.1433	0.0783
	(0.0270)	(0.0299)	(0.0255)
m	-0.0238	-0.0752	-0.0445
	(0.0468)	(0.0520)	(0.0443)

Note: Standard errors are in brackets.

These appear to show slow speeds of adjustment in the money equation, and the lower off-diagonal elements are not significantly different from zero. In subsequent estimation of structural models we restrict them to zero as part of our identification scheme. All coefficients in the first row are significant so that investment is affected by all three disequilibrium terms. The insignificance of the own error correction term for money is undesirable, but the effect disappears when the insignificant lower diagonal terms are eliminated. When the modified block-diagonal structure is imposed and the loadings are re-estimated, the speeds of adjustment on the diagonal also become more plausible. At that stage we can give an economic interpretation to the magnitude and significance of the off-diagonal terms with greater confidence and thereby determine the extent of a credit or a money channel running from disequilibria in money and credit to the dynamics of investment.

Table D
Weak exogeneity tests

Significance of ECMs in the marginal models:

ECM (*i* - *i**)	F(7, 48) = 1.702 [0.1310]
ECM (*l* - *l**)	F(7, 48) = 1.395 [0.2294]
ECM (*m* - *m**)	F(7, 48) = 0.788 [0.6007]

Urbain (1992) test for exogeneity of variables:

Chi-sq (21) = 12.12 [0.936]

Having identified three cointegrating relationships, we proceed to specify a conditional VECM, but before we can do this we need to confirm that the seven explanatory variables are indeed weakly exogenous. We conduct two tests suggested by Urbain (1992), reported in Table D. The first test for weak exogeneity is based on the significance of the equilibrium correction terms from the three cointegrating relationships in the marginal models for the other seven variables. If the coefficients on the equilibrium correction terms (ECMs) are not significantly different from zero, then the seven explanatory variables are weakly exogenous with respect to the long-run parameters of the system. In the second test the residuals from the marginal models of the seven explanatory variables are included in the VECM system. If these residuals are insignificant then weak exogeneity with respect to the short-run parameters of the system is confirmed.

The first test shows that the ECM terms from the investment, credit and money equations are not significant in the marginal model for the other variables. The three F-tests fail to reject the null that the coefficients on these terms are jointly equal to zero. The other variables are confirmed as exogenous by this test. The second test emphasises this result by rejecting the influence of the residuals from the marginal models in the VECM equations for investment, credit and money. A likelihood ratio test does not reject the restricted model which excludes the residuals against an unrestricted model.

We then construct the conditional VECM (not reported). From this general form of the model we seek to specify the structural form by adopting an identification scheme. The two most commonly used options are the block recursive structure suggested by Johansen and Juselius (1994) and the diagonalised structure proposed by Bardsen and Fisher (1993) and Boswijk (1995). The former implies that the model embodies feedback from disequilibria in lending and money in the dynamic equation for investment, feedback from disequilibrium money in the dynamic lending equation, as well as the usual feedback from 'own' disequilibria on 'own' dynamics. The latter implies that only the 'own' ECM enters the structural model for each variable, so that investment dynamics are affected only by investment disequilibria, and likewise for money and lending equations.

In what follows we used a modified block recursive structure. The most appealing theoretical relationship implies that departures from the long-run equilibrium values of real money and real lending cause investment, disequilibrium in real money causes real lending and causality runs from 'own' disequilibria to dynamic adjustment. This ordering could arise if real money balances are accumulated over and above their long-run equilibrium values prior to increases in investment, and if excess borrowing caused expenditure to slow. Disequilibria in real money and lending then 'cause' investment because they occur prior to changes in investment by PNFCs, and disequilibria in real money balances 'cause' lending because money balances are accumulated prior to any recourse to bank borrowing to fund investment. If our causal ordering is correct we would expect to find a positive (negative) and significant coefficient on money (lending) disequilibrium in the investment equation, a positive and significant coefficient on money disequilibrium in the lending equation and negative and significant coefficients on 'own' disequilibria. These findings would provide evidence, respectively, for a money channel by which $(m - m^*)$ increases Δi, a credit effect through which $(l - l^*)$ reduces Δi, and an investment co-funding story that shows money and lending are jointly used to fund investment since $(m - m^*)$ positively influences Δl. To allow for the possible impact of credit on money (since our purpose is to examine the effect of credit on the PNFCs), we retain the role of $(l - l^*)$ in the Δm equation for the time being. To examine these coefficients we derive a reduced form of the conditional VECM model with the modified block recursive identification scheme imposed, which we refer to as the structural VECM. The structural VECM was tested down using acceptable overidentifying restrictions. Our final specification is reported in Table E.

Table E
FIML estimates of structural VECM

Sample 1978 Q1 to 1998 Q1

	Equation					
	Δi_t		Δl_t		Δm_t	
Δi_t						
Δi_{t-1}			**0.1631**	*(0.0503)*	**-0.1233**	*(0.0928)*
Δl_t						
Δl_{t-1}			**0.4107**	*(0.0685)*	**-0.1863**	*(0.1084)*
Δm_t						
Δm_{t-1}					**0.2812**	*(0.0881)*
$(i\text{-}i^*)_{t-1}$	**-0.1565**	*(0.0266)*				
$(l\text{-}l^*)_{t-1}$	**-0.0923**	*(0.0261)*	**-0.1246**	*(0.0212)*	**-0.0350**	*(0.0334)*
$(m\text{-}m^*)_{t-1}$	**0.0839**	*(0.0297)*	**0.0734**	*(0.0196)*	**-0.0632**	*(0.0316)*
Δy_t	**0.5430**	*(0.2545)*	**0.3466**	*(0.1674)*	**0.8271**	*(0.2778)*
Δy_{t-1}			**-0.2516**	*(0.1556)*		
Δw_t					**0.1708**	*(0.0837)*
Δw_{t-1}						
$\Delta \pi_t$			**-0.0418**	*(0.0104)*		
$\Delta \pi_{t-1}$			**0.0216**	*(0.0102)*		
Δs_{ut}			**0.1796**	*(0.0453)*		
$\Delta s_{u,t-1}$						
$\Delta c_{k,t}$					**0.5427**	*(0.2455)*
$\Delta c_{k,t-1}$	**-0.4815**	*(0.2175)*			**0.5527**	*(0.2423)*
$\Delta r_{b,t}$			**-0.7787**	*(0.4218)*	**3.1371**	*(0.7383)*
$\Delta r_{b,t-1}$			**-1.307**	*(0.4323)*	**1.4435**	*(0.8026)*
$\Delta r_{l,t}$	**-0.7779**	*(0.7154)*	**-0.7539**	*(0.3730)*		
$\Delta r_{l,t-1}$	**-0.9988**	*(0.5666)*			**-1.0273**	*(0.6413)*
Δma_t					**0.0084**	*(0.0031)*
Δma_{t-1}			**0.0072**	*(0.0017)*		
Constant	**0.2580**	*(0.1021)*	**-0.3172**	*(0.0598)*		

Notes: Standard errors are in brackets

Table F
Diagnostic checks on structural VECM

By equation

	Δi_t	Δl_t	Δm_t
AR (1-10)	F(10,46) = 1.8448	F(10,44) = 1.6751	F(10,44) = 0.8693
Normality	Chi-sq (2) = 6.3985	Chi-sq (2) = 0.3471	Chi-sq (2) = 1.8362
ARCH 4	F(4,43) = 0.5700	F(4,43) = 0.4674	F(4,39) = 0.6724

Whole system

AR (1-10)	F(10,44) = 1.6751
Normality	Chi-sq (2) = 0.3471
ARCH 4	F(4,43) = 0.4674

LR-test of overidentifying restrictions chi-sq (36) = 24.9509 [0.9170]

The model has acceptable diagnostic statistics for the individual dynamic equations for lending and money. There is some evidence of non-normality in the investment equation. This is probably due to the effect of large one-off purchases (for example purchases of ships and aircraft) that raise the growth rate of investment in one quarter, and lower it by a similar amount in the following quarter. The vector diagnostic statistics do not reject the null in any case, and this indicates that the model is acceptably specified.

Recursive tests of the structural VECM are shown in Charts 3 and 4. Not one is rejected at the 5% level. Actual and fitted values and residual plots for each of the endogenous variables appear in Charts 5, 6 and 7.

Chart 3
Recursive test of short-run restrictions

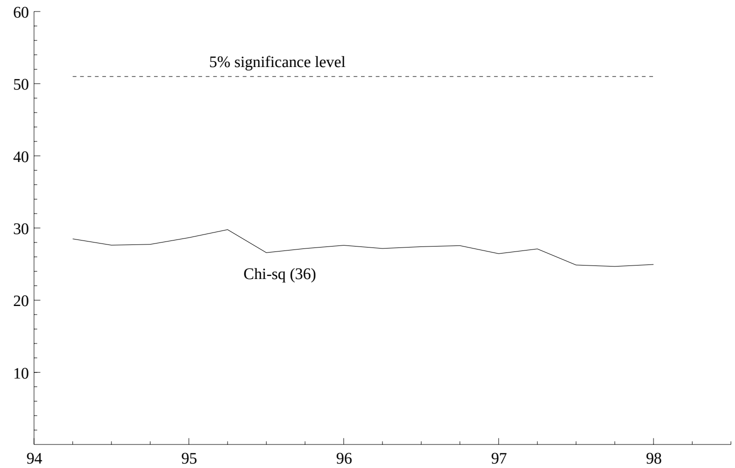


Chart 4
Diagnostic tests on the structural model

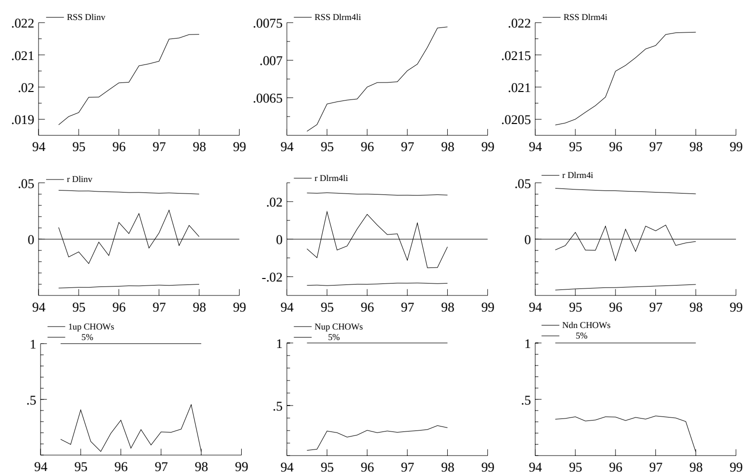


Chart 5
The investment equation

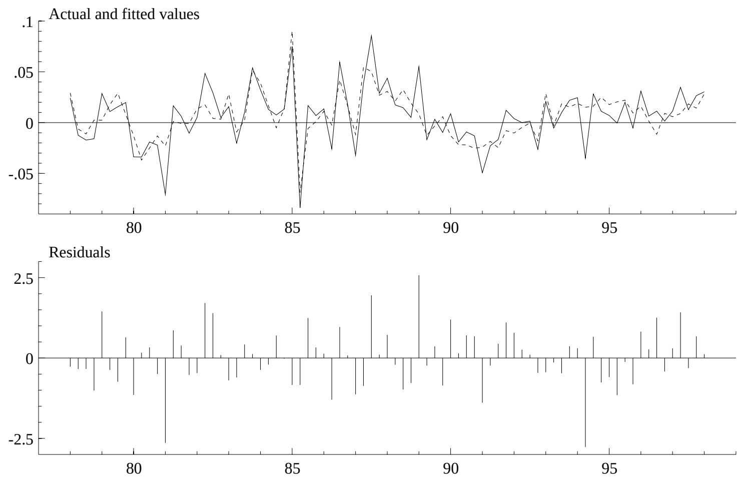


Chart 6
The credit equation

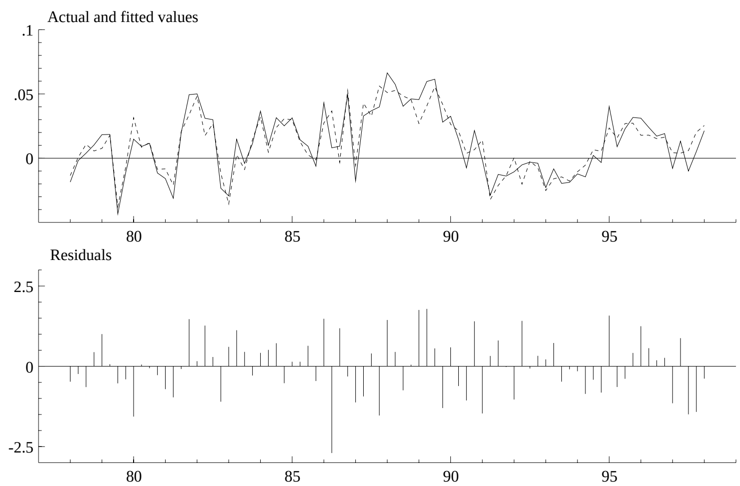
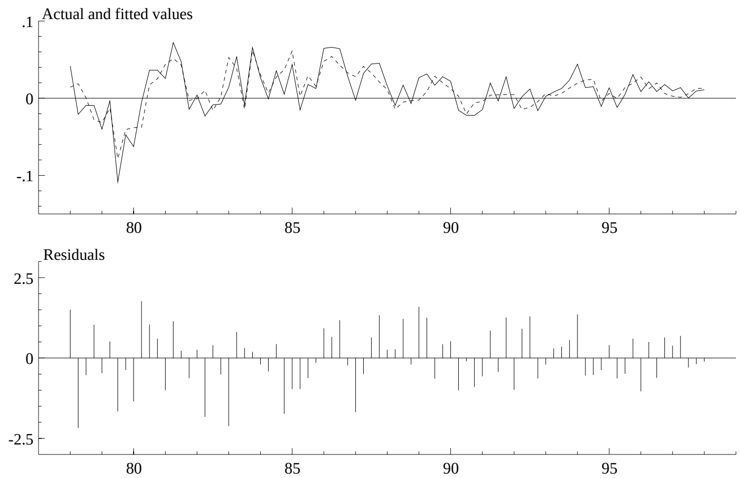


Chart 7
The money equation



In the investment equation, there is equally strong evidence for a money and a lending channel since the coefficient on both $(l - l^*)$ and $(m - m^*)$ are significant at the 5% level. These coefficients can be restricted to be equal and opposite without significant loss of fit. By implication, it appears to be deviations in (a transformation of) PNFCs' net recourse to banks from equilibrium that matter for investment.(3) In the lending equation, the money disequilibrium term causes an increase in bank lending, since the coefficient is both positive and significant. In the money equation there is some suggestion that excess borrowing 'causes' money balances to fall, but the coefficient is not statistically significant. Econometrically, we can say that money and lending 'cause' investment and money 'causes' lending, but lending does not 'cause' money.

The coefficients on the 'own' disequilibria are similar to those reported in the standardised alpha matrix, although in the case of money and lending equations the feedback is bolstered by the role of money and lending disequilibria feeding through Δi (and also Δl for the money equation). Since $(m - m^*)$ and $(l - l^*)$ appear in the equations for Δi and Δl, and Δi appears in the equation for lending, and both Δi *and* Δl appear in the

(3) Intuitively, excess borrowing is no disincentive to invest if matched by excess deposits.

equation for money, the total effect of the money and lending disequilibria is the compound of the direct and indirect effects. In this case the total effect of $(m – m^*)$ on Δm is –0.087 and the total effect of $(l – l^*)$ on Δl is –0.140. Since the signs of the coefficients are negative, the feedback is stabilising.

Taking the dynamic effects in each model in turn we find that the responses of the dynamics of investment, lending and money balances are consistent with theory. In the first equation, investment responds to changes in output so that as output grows investment increases at roughly half the rate. An increase in the real cost of capital (Δc_k) and an increase in the lending spread (Δr_l), both have significant negative effects on investment: investment falls by around 0.5% next period when the real cost of capital increases by one percentage point; a one percentage point rise in the lending spread reduces investment in the same quarter by 0.7%, but this is reversed in the next period (as the sum of the coefficients on the current and lagged spread terms equals zero). So an increase in the lending spread reduces the desirability of investment initially but this is unwound in the next quarter, leaving the long-run equilibrium unchanged. From this we can infer that the bank lending channel does not have a statistically significant effect on equilibrium investment but changes to the lending spread do create an impulse in the dynamics of investment in the short term. We might conclude that firms that have access to sources of credit other than from banks take some time to reorganise their finances and this shows up in investment over the short term. The evidence in the structural model therefore demonstrates the importance of variables that indicate the stages of the business cycle and measures of the real cost of capital and bank lending.

The dynamics of lending are influenced contemporaneously and with a lag by investment, indicating that in the short term as investment rises so lending rises to finance it. Changes in bank lending are shown to be procyclical with the change in output. Undistributed earnings represent an alternative source of funds for investment projects and can therefore be regarded as a substitute for bank lending; this explains the contemporaneous negative effect it has on borrowing. The coefficients on the measures of unwanted stocks and the cost of borrowing indicate that recourse to banks for funds is sometimes sought to cover periods of distress. When unwanted stocks increase, the costs of maintaining the inventories is met by borrowing from banks, likewise increases to PNFCs' debt-servicing costs are met by borrowing in the short term. Nevertheless, an increase in the lending spread leads to a contemporaneous reduction in the amount of credit extended to firms in the short term, as we might expect. When banks wish to reduce the level of outstanding borrowing they raise the spreads over Libor. This is the essence of the bank lending channel and the size and significance of this term indicates that firms that are dependent on banks respond sharply to short-term disincentives to borrow in the form of increasing lending spreads. The impact of an increase in the level of mergers and acquisitions activity is to increase bank lending contemporaneously, but to reduce it by an equivalent amount in the subsequent period. The magnitude of the term Δma is probably indicative of the fact that the infrequent but large scale of mergers and acquisitions by large PNFCs has more of an effect on lending than that of small to medium-sized PNFCs. The importance of the term is supported by its statistical significance.

With the exception of an increase in lending that goes hand-in-hand with an increase in money balances, the effect of many of the variables on the dynamic equation for money balances is explained by much the same economic reasoning as above, but the signs are reversed. As investment rises money balances fall. The one-period lag of (rather than current) investment growth is significant in both money and lending equations. This possibly reflects the invoicing period over which firms are allowed to pay for goods received. Unwanted stocks and an increase in the level of mergers and acquisitions activity both decrease money balances contemporaneously (with a similar magnitude but an opposite sign to the lending equation). Since unwanted stocks and merger and acquisition activity are funded at least in part out of money balances they would be expected to reduce money balances at the same time as increasing bank lending. The impact effect of the cost of bank borrowing can be explained in the same way since it demonstrates that PNFCs reduce money balances in order to meet debt-servicing obligations. Real income has a strong positive impact on short-term money balances and, as the deposits spread increases, there is substitution into money balances.

Money and lending equations are clearly interactive since lagged bank lending within the PNFCs sector reduces PNFCs' money balances directly. The equal and opposite effects of exogenous variables in the money and lending equations gives indirect evidence that money and lending equations depend on the same small set of explanatory variables.

Encompassing tests

LR test for the exclusion of the money equation:
$Chi^2(2) = 17.741$ (0.00050)**

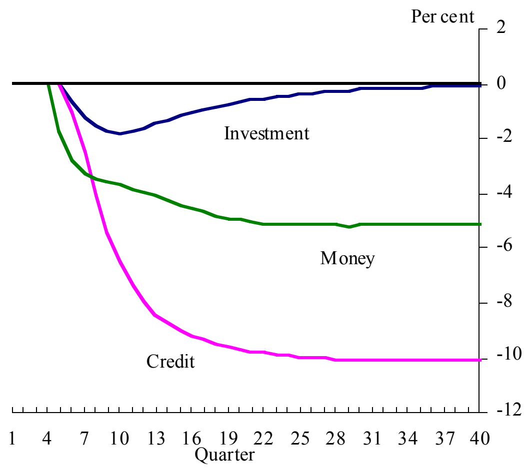
LR test for the exclusion of the lending equation:
$Chi^2(3) = 18.483$ (0.00001)**

The final step is to determine whether the modelling of credit, money and investment together adds to our understanding of the transmission mechanism over and above the model reported in Thomas (1997b). From the structural dynamic equation for investment, we can see that the money and lending disequilibrium terms enter with a significant coefficient since both p-values are less than 1%. Since the three-equation VAR model nests a two-variable system based on lending and investment, and a two-variable system based on money and investment, we can construct tests to discriminate between them. The tests based on likelihood ratio statistics for an unrestricted model (our three-equation system) and a restricted version (which excludes the $(x - x^*)_{t-1}$ and Δx_{t-i} components of lending and money from the system in turn) provide two encompassing tests. The results indicate that the restricted models can be comprehensively rejected at the 1% level, rejecting each of the restrictions on the three-equation system, to reduce it to a two-equation system. We can conclude from this that money, lending and investment should be modelled as a three-equation system since both money and lending have incremental effects on investment. Both these results and the t-tests show that money and lending have an effect on real whole-economy investment — attempts to disentangle the influence of one equation on another can be strongly rejected — and particularly so for the influence of disequilibrium lending and money on investment.

Impulse responses

To assess the potential usefulness of the model for policy analysis we simulated the dynamic properties of the model and subjected it to shocks. In the first simulation, shown in Chart 8, we allow for a permanent 10% fall in real gross financial wealth. This leads to an immediate reduction in real money balances by 5%, since wealth is partly comprised of money balances, and shortly after to a reduction by 10% in lending. After one year investment is some 2% lower, as firms adjust to higher than desired levels of debt. This may be capturing the financial accelerator effect. This effect is temporary and investment returns to equilibrium over the medium term.

Chart 8
Responses of money, credit and investment to a permanent 10% fall in wealth



The second, third, and fourth simulations in Charts 9 to 11 show the effects of 1% temporary increases in real investment, real lending and real money respectively. An increase in real investment results in a rise in real lending and a fall in real money balances — which suggests a co-funding story consistent with the discussion above — that is unwound over a longer horizon. The increase in real lending shows the effect of unwanted indebtedness. As real lending is shocked upwards, money balances and investment fall to clear the stock of outstanding borrowing. A shock to real money balances increases lending and investment with a lag. This is what we would expect if our causal story were correct, since firms accumulate money balances before borrowing from banks to invest. A rise in money balances would stimulate firms to co-fund investment projects with bank lending in subsequent periods. The impulse response functions are all sensible and show how shocks to the endogenous variables and to the policy instrument are accommodated in the model.

Chart 9
Responses of money, credit and investment to an investment disturbance

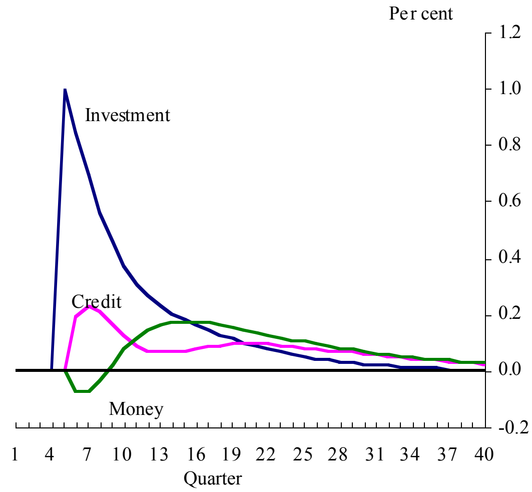


Chart 10
Responses of money, credit and investment to a credit disturbance

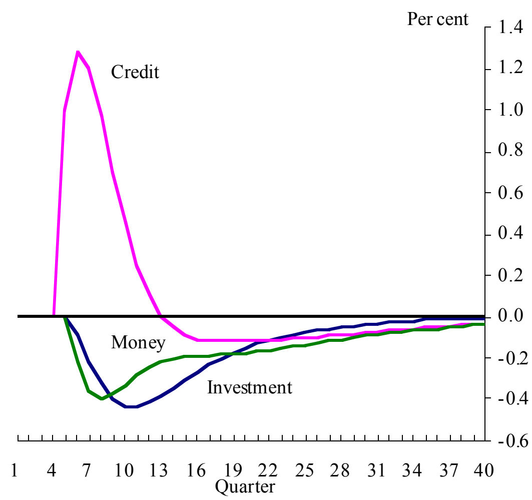
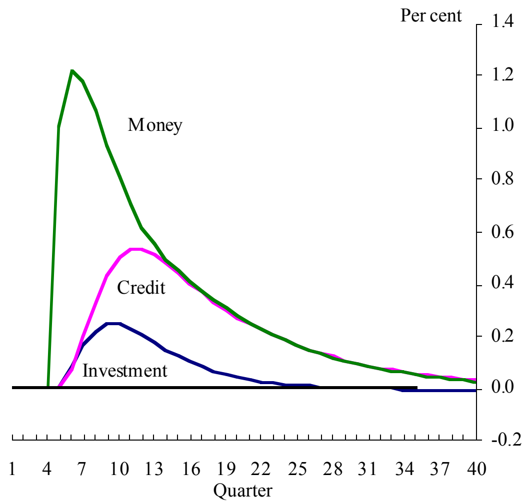


Chart 11
Responses of money, credit and investment to a money disturbance



5. Conclusions

We identify three equilibrium relationships in investment, credit and money for the private non-financial corporations sector in the United Kingdom using the 'Encompassing the VAR' method. The structural dynamic model illustrates the interactions between investment, credit and money. The main findings are as follows:

(i) The long-run equations show that real money and real credit move proportionally with scale variables. This confirms that real decisions are important to the financial structure of the firm. The equilibria in real investment, bank lending and money balances move in relation to scale variables, measures of economic confidence and opportunity cost as economic theory would suggest. The lending equation, which to our knowledge has not been modelled before in an interactive way with money and investment equations, is found to be heavily dependent on balance sheet items such as real gross financial wealth and retained earnings, but not on a bank lending channel influence such as the lending spread.

(ii) The evidence to support the role of credit is to be found in the structural dynamic model of the short run dynamics, conditional on the long-run equilibria described above. When examining the effects of estimated money and lending disequilibria in the dynamic investment equation, we find evidence that a departure from long-run lending equilibrium 'causes' investment (excluding stockholdings) in an econometric sense. There is also evidence for a causal chain from money to investment of a similar magnitude, suggesting that, as firms hold excess credit and money balances, over and above their long-run equilibrium values, they use these to co-fund investment. Money disequilibrium also 'causes' lending to rise. This may reflect the accumulation of money balances that precedes bank lending when the two different sources of funds are used to co-fund investment. The contrary hypothesis that lending 'causes' money balances to rise was rejected at conventional levels of significance.

(iii) We find evidence that is consistent with a credit channel, although it is also possible that it corroborates other channels in the transmission mechanism. There is evidence of a direct credit effect operating through the influence of the term $(l - l^*)$ on Δi. This implies that disequilibrium lending 'causes' changes to investment but since this involves both supply-side and demand-side effects, the influence of the company balance sheet through banks' willingness to lend and firms' readiness to borrow supports both a supply-side 'balance sheet channel' and a demand side effect. This influences the level of equilibrium credit offered to and taken out by firms, and operates through the term $(l - l^*)$. The second effect operates through the short-run dynamic equation where an increase in the lending spread immediately reduces bank lending and has a temporary effect on investment while firms that have access to other credit markets make adjustments to draw on them. This is consistent with the bank lending channel, but again could be taken to show a traditional demand side channel operating through the interest rate. Both results confirm that there is empirical evidence for the influence of credit on investment in the United Kingdom.[(4)]

(iv) The interpretation of credit disequilibria on the real activity of firms is more difficult to interpret than the equivalent disequilibrium in money balances because the reasons for disequilibrium may be a response to future anticipated expansion or the legacy of past excessive borrowing. In the first case this would be a forewarning of an upturn. In the latter it would be a signal that the company sector had a stubborn imbalance in its actual liabilities versus the level of lending that would be desirable under current

(4) Some evidence gathered at the microeconomic level suggests that there may be reason to believe that this is due to a credit channel (see Ganley and Salmon, 1997).

and expected conditions. Monetary disequilibria can also be a feature of past actions or future expectations but they are more readily corrected than outstanding credit, which can remain for some time. This is particularly true for excessive borrowing, but may also be true for insufficient borrowing if banks are wary of providing credit.

(v) Other evidence shows that there is a lagged relationship running from investment to lending, from lending to money and from investment to money. The information on money and credit, if more timely or reliable, may be useful for indicator purposes since it is is a response to changes in investment spending. The direct effect of investment on money with a lag and of investment on money via lending, matches the findings for the company sector in Astley and Haldane (1995) and Dale and Haldane (1995).

(vi) The simulation responses to shocks are consistent with those expected from economic theory. A 10% permanent reduction in the wealth variable temporarily reduces investment over the short to medium term but cuts lending and money balances permanently. Other simulations consider the effects of a 1% temporary impulse to endogenous variables, and these concur with the responses we would expect from theory.

Therefore we draw two principal conclusions from the analysis of PNFCs. First, there are clear econometric gains from modelling investment, money and credit together in a system. The correctly specified system should include credit, and measures of disequilibrium money $(m - m^*)$ can usefully be augmented by measures of $(l - l^*)$ even if these are more difficult to interpret. Second, if this is due to credit channel effects on the supply side these can be split into a balance sheet channel and a bank lending channel. The balance sheet channel has an influence over the equilibrium level of credit and, through the $(l - l^*)$ term, an influence on the dynamic adjustment of lending and investment. The bank lending channel shows that the supply-side response of banks measured by the lending spread over Libor tightens the credit market and influences investment over the short term, while firms that can raise funds elsewhere seek to do so. Even if these are not supply-side responses, we have shown that there is an influential role for credit on whole-economy investment, confirming the importance of credit for the transmission mechanism of UK monetary policy.

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