Consumption, money and lending: a joint model for the UK household sector

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The views are those of the authors and not necessarily those of the Bank of England. We have benefited from earlier joint work with Charles Nolan and Norbert Janssen, and from the comments of Spencer Dale, Shamik Dhar, David Hendry, John Muellbauer, Simon Price, Paul Tucker, Michael Wickens and seminar participants at the Universities of Oxford and York, Cardiff Business School and the Bank of England.

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The Bank of England's working paper series is externally refereed.

Bank of England 2001
ISSN 1368-5562

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Abstract

Previous research has investigated consumers' expenditure and money demand as separable equations. We estimate them jointly as driven by the same influences. Credit is also included as a potential third variable that might provide a source of additional information about the monetary transmission mechanism. Consumption, money and lending equations are modelled as an interdependent system, and the significance of lending for consumption and money is tested. The results using UK household sector data show that a stable credit equation does exist in parallel with money demand and consumption equations, and that interactions modelled in a *conditional* vector equilibrium correction system are favoured over independent equations.

JEL classification: E41.

Summary

Consumption and money demand functions have been the object of countless empirical studies over the last half-century or so. These two relationships still provide the core of textbook models of the macroeconomy, at least at the undergraduate level, and are implicit in the foundations of the more sophisticated models used in graduate textbooks. Consumption behaviour continues to be a topic of major interest to policy-makers, not least because it is the largest single component of aggregate demand and so is central to any macroeconomic forecast. Money demand has been of much less concern recently since many monetary authorities have abandoned monetary targets and adopted inflation targets instead, although, for inflation targeting central banks, money is still of interest when it can be used to help forecast inflation. To do this it must contain leading-indicator properties for some component of aggregate demand, hence if 'money' is to provide useful information it must be demonstrated that it has linkages with consumption or investment expenditure. For the household sector that is studied in this paper it is consumption that is relevant. Any other variable that helped to forecast consumption would also be useful, and in this paper we incorporate credit as another variable of potential interest. Credit could be more useful than money as a leading indicator of consumption if households borrow extensively to finance their spending. Credit is taken out simultaneously with the decision to spend because interest charges are levied on amounts outstanding, but money can be held for long periods as idle balances and might also be regarded as an important form of saving.

Most previous work on consumption and money demand has estimated these relationships as separable single equations. There have been very few studies of credit but those that exist have also tended to use a single-equation approach. We know, however, that decisions to spend, change money holdings or borrow must be interrelated. In this paper we treat them as jointly determined by a common set of driving variables. The driving variables chosen are the obvious ones: labour income, tangible net wealth, and various interest rate spreads between alternative assets and liabilities. The dependent variables are consumers' expenditure, household holdings of broad money (M4), and the stock of unsecured (M4) lending to households.

The method adopted involves estimation in two stages. The first stage identifies long-run (cointegrating) relationships for consumption, money and lending. These relationships include direct effects of money and lending on consumption and they also provide evidence of spillovers of deviations from each equation onto the others. A simple transformation of the estimated cointegrating relationships shows that these results are consistent with plausible parameter values, equivalent to long-run consumption and money demand functions. The long-run unsecured lending equation is less familiar but equally plausible and well determined. In the second stage, deviations of actual dependent variables from their long-run values are embodied in dynamic equations that determine the growth rates of consumption, money holding and unsecured borrowing. Insignificant variables are eliminated from these equations using a general-to-specific search procedure until a parsimonious form is identified. The final form satisfies a battery of specification tests and produces sensible impulse responses to shocks.

The main results are, first, that unsecured household credit can be modelled in the same way as consumption and money demand, and, second, that there are significant spillovers from money and

credit to consumption, and *vice versa*. This may be of particular use for policy-makers in the short run, as money and credit data are available monthly while consumption data are quarterly and are often subject to considerable later revision. Monetary targeting may have been superceded by inflation targets but money and credit data can still be of use as leading indicators of household spending, a major component of aggregate demand, and an underlying guide to future inflation.

1 Introduction

Vast literatures have developed over the past 50 years or so on consumption and the demand for money.[1] Credit on the other hand has been largely neglected, even though it is clearly intimately related to both spending and money holding decisions. Empirical studies of consumption, money (and credit, such as exist) have typically assumed that they can be estimated as unrelated single equations. In this paper, we investigate whether there is a stable empirical relationship explaining credit, along the lines of those explaining consumption and money. And we consider whether there are informational gains from adding credit to a system that also determines consumption and money holding simultaneously.

Hence the focus of the paper is on two key questions. First, is it valid to focus on consumption and money demand relationships at the expense of credit? This issue is central to analysis of the monetary transmission mechanism (MTM) from monetary policy instruments to the real economy and inflation via spending decisions of agents. Traditional textbook models include consumption and money demand equations but exclude credit, while official explanations of the MTM focus, at least in part, on the impact of interest rate changes on demand for loans (see Bank of England (1999)). This question relates to the information content of credit and whether credit information is already encapsulated in money stock data. The money demand function has traditionally been thought to be the key behavioural relationship that links monetary variables to spending and inflation. But doubts have been raised in the past two decades or so about the stability of estimated money demand functions, and researchers have continued to search for a stable functional form.[2]

There are two practical reasons why credit is worth attention. First, the asset side of banks' balance sheets can be thought of as an intermediate variable that interest rate changes are designed to influence. Higher interest rates have their effect on spending, partly via reducing demand for loans. Slower lending growth feeds through into slower money stock growth and into slower spending growth. Hence it is sensible to study directly how bank lending behaves over the cycle, and adjusts in response to policy changes. Second, data on the asset side of banks' balance sheets are routinely produced along with those on monetary aggregates. It is important for monetary policy makers to know whether those data contain additional information, or whether the money stock and lending counterparts are essentially telling the same story. So the study of 'credit', as presently conceived, does not seek to replace the study of money but rather to complement it. There is some evidence that credit variables have significant explanatory power in regression equations explaining consumer spending (see, for example, Church *et al* (1994), Astley and Haldane (1995), and Bacchetta and Gerlach (1997)).

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(1) See Muellbauer (1994) and Muellbauer and Lattimore (1995) for consumption, and Lewis and Mizen (2000) for money demand surveys.

(2) Drake and Chrystal (1994, 1997) and Thomas (1997a, b) have helped to support the case for the existence of stable long-run money demand functions in studies of the personal sector and private non-financial companies (PNFCs) in the United Kingdom. The wider issue has been discussed in Mizen (1997) and accompanying papers. We do not enter the controversy over the appropriate functional form for the money demand function but will estimate a reduced form that is consistent with many theoretical interpretations. We should note that the authors have entered the debate (separately) on opposing sides of the argument, but do not raise those issues here.

The second question addressed is: can we legitimately separate the estimation of these equations when households in practice make simultaneous choices of consumption spending, money holding and borrowing? For a given income path and assets, households' choices of spending patterns, money holding and borrowing are clearly interrelated. However, much of modern macroeconomics would treat the consumption decision as primary while money holding and/or borrowings adjust passively to reconcile consumption plans with income streams. So money and credit would simply accommodate unexpected or transitory income changes while consumption itself was smoothed, and the former would contain no extra information about the likely course of the latter (see, for example, Lucas (1972), Kydland and Prescott (1982) and Cooley (1995)). Monetarists, in contrast, would argue that deviations of real money balances from desired levels would cause changes in spending plans (and other asset prices) and would contain additional information relevant for explaining consumption (see, for example, Friedman (1987) and Schwartz (1998)). Others would argue that credit constraints might also affect spending decisions, so that changes in credit availability could also influence household spending (see Muellbauer and Murphy (1989)). The recent literature on the 'credit channel' (Bernanke and Gertler (1995), Hubbard (1995) and Borio (1997)) would also suggest that influences coming from institutions supplying credit might lead to changes in supply conditions in credit markets that would in turn affect spending decisions.

Even if money and credit adjust passively to accommodate consumption smoothing in the face of income fluctuations, money and credit data may still contain information that is helpful to policy-makers. Money and credit data are available earlier than national accounts data for the same period, so even a passive adjustment of money and credit may contain information in the short term about (as yet unknown) consumption changes.

This paper seeks to provide empirical answers to these two questions focusing on household sector consumer expenditure, money holding and credit in the United Kingdom. We study *unsecured credit*, as this component is unaffected by borrowing for house purchase (*secured lending*) and is most likely to be related to consumer spending.[3] A small set of explanatory variables is used to identify three long-run equilibrium equations representing consumer expenditure, money and credit, as functions of labour income, wealth, deposit and credit spreads and inflation. The methodology employed is a reduced rank cointegrating vector autoregressive model selected by maximum likelihood inference (Johansen (1995)). The paper shows that a stable and information-rich credit equation exists and it complements the information content of a money demand function. Dynamic models estimated using a *conditional* vector equilibrium correction model selected as a reduction from the vector-autoregressive equilibrium correction model (see Johansen (1995), Boswijk (1994, 1995), Ericsson (1995) and Urbain (1995)) answer the second question. They show that restrictions that amount to re-imposing a separable equation approach are rejected, so that significant interactions between consumer spending, money holding and unsecured credit exist. Our conclusion is that credit does add information over and above monetary data, and consumption, money holding and credit equations are interactive.

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(3) Although some consumer spending may be financed by secured lending, ie mortgage equity withdrawal.

The rest of the paper is organised as follows. Section 2 describes the methodology. The results appear in Section 3, and Section 4 provides a conclusion.

2 Empirical modelling of consumption, credit and money

Single-equation models

The traditional approach to modelling consumption, credit and money has taken each equation as a separable function to be estimated in isolation. Thus money demand functions, bank borrowing and consumption functions have been estimated using OLS estimators of single-equation cointegrating relationships between pre-tested I(1) variables. The single choice variable, y_t, (consumption, money holdings or bank borrowing) is a function of a vector of explanatory variables, $\mathbf{x}_t$:

$$y_t = g\mathbf{x}_t + e_t \qquad \textbf{(1)}$$

where g is a vector of parameters. The lagged residual from the cointegrating relationship, e_{t-1}, is included as a regressor, along with lagged dependent and independent variables in a dynamic model derived from a general-to-specific search procedure:

$$\Delta y_t = -a e_{t-1} + \sum_{i=1}^{q-1} p_{i1}\Delta y_{t-i} + \sum_{i=0}^{q-1} p_{i2}\Delta \mathbf{x}_{t-i} + x_t \qquad \textbf{(2)}$$

Examples of this approach for each of the variables mentioned can be found in Muellbauer (1994), Muellbauer and Lattimore (1995) (consumption); Cuthbertson and Taylor (1987), Barr and Cuthbertson (1989) (money); Cuthbertson and Barlow (1990) (lending).

The difficulty with this approach is that there is an implicit assumption that the estimated equation is a 'demand function', despite the fact that the supply of consumption goods, money and credit may not be unlimited or identified separately from the demand relationship. Whether the estimation process is completed in a single step (using the Johansen procedure) or in two steps (using the Engle-Granger method or the fully modified Phillips-Hansen method), identification amounts to choosing one of the variables as the endogenous variable; either by normalisation of its coefficient to unity, or by placing it on the left-hand side of the regression. Further over-identifying restrictions can be tested, but the inter-relatedness of equilibria cannot; the methodology treats them as separable.

A vector equilibrium correction model

A vector equilibrium correction model does allow consumption, money and credit equations to be interdependent. This makes sense because the decisions to borrow, hold money balances or buy goods are made simultaneously. A loan facility may be arranged prior to the spending taking place, and money may be held on deposit before it is spent, but in most cases the loan/money holding itself is activated in the process of paying for the good.[4]

The framework we adopt involves the estimation of an unconditional *q*th order VAR over a sample t =1, 2, ...T:

$$\Pi(L)\mathbf{z}_t = x_t \qquad \textbf{(3)}$$

where $\mathbf{z}_t$ is a vector of p variables, $\Pi(L) = \mathbf{I} - \sum_{j=1}^{q} \Pi_j (L^j)$ is a q-th order lag polynomial and x_t is a p-dimensional random vector of serially uncorrelated error terms with variance-covariance matrix, S.

Equation **(3)** can be rewritten as a linear dynamic system as follows:

$$\Delta \mathbf{z}_t = \Pi \ \mathbf{z}_{t-1} + \sum_{j=1}^{q-1} \Gamma_j \Delta \mathbf{z}_{t-j} + x_t \qquad \textbf{(4)}$$

where G_j are matrices of short-term parameters and P is a matrix of long-run coefficients.

Equation **(4)** is the basis for the Johansen (1992) system analysis of cointegration, whereby the rank of P (denoted r, $0 < r < p$) determines the number of cointegrating vectors according to the characteristic equation:

$$\left| I - \sum_{j=1}^{q} \Gamma_j z^{\,j} \right| = 0 \qquad \textbf{(5)}$$

which states that (p-r) roots, z, equal one and the rest lie outside the unit circle.

The test for the existence of rank reducing cointegrating relationships between these variables using the maximum likelihood based approach of Johansen (1995) entails examining the canonical correlations between Δz_{it} and z_{it-1}. Translating this into a problem in terms of eigenvalues (see Johansen (1995) Theorem 4.2), ranked from largest to smallest as

l_1, l_2, ..., l_p, a likelihood ratio LR(r) = -Tlog(1- l_r) where H(r-1) = $K - \frac{T}{2}\sum_{j=1}^{r-1}\log(1 - l_j)$,

H(r) = $K - \frac{T}{2}\sum_{j=1}^{r}\log(1 - l_j)$ tests whether rank $(\Pi_1) \leq r$ by determining if l_r is statistically different from zero (which it would be for a non-cointegrating combination). A trace test

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[4] One might argue that bank lending to consumers is the flip-side of consumer savings and that, since household consumption equals their income minus their saving, the relationship between bank lending and consumption arises from an identity. The argument is weakened by the fact that not all unsecured lending to households is drawn from the savings of households, nor is all households' saving diverted towards consumers in the form of *unsecured* credit. As is often the case, what holds true regarding the endogeneity of economic variables and the existence of identities in the aggregate for a relatively closed economy does not follow through at the sectoral level. The simultaneity of consumption, money and credit decisions remains a possibility, however.

$\mathrm{Tr}(r) = -T\sum_{j=1}^{r}\log(1-l_j)$ is a joint test of whether all l_j for $j = r, r+1, ..., p$ are insignificantly different from zero. The distributions are non-standard but are given in Osterwald-Lenum (1992) and Johansen (1995). The reduction in the rank, r, allows us to write the long-run equilibrium relationships of the system given by the pxp dimensional matrix P in the familiar form of the product of two pxr matrices a and b. The matrix b defines the cointegration space and the matrix a defines the error correction space, when $\mathbf{x}_t$ is I(1) and the r linear combinations $b'\mathbf{x}_t$ are I(0).

This in itself is insufficient to define the structure of the system defining the relationship between equilibria. The issues that remain involve the distinction between endogenous and weakly exogenous variables, and the identification of the system such that the parameter values of a and b can be retrieved.

Weak exogenity

When the vector $\mathbf{z}_t$ is partitioned into a vector of g-variables, $\mathbf{y}_t$, and a vector of k-variables, $\mathbf{x}_t$, $(q = g+k)$ we can write the general model **(3)** as a conditional model for $\mathbf{y}_t$:

$$\Delta\mathbf{y}_t = \Sigma_{12}\Sigma_{22}^{-1}\Delta\mathbf{x}_t + \sum_{j=1}^{q-1}\Gamma^*_j\,\Delta\mathbf{z}_{t-j} - a^*b'\mathbf{z}_{t-1} + x_{1t} \qquad \mathbf{(6)}$$

where $\Gamma^*_j = \Gamma_{j1} - \Sigma_{12}\Sigma_{22}^{-1}\Gamma_{j2}$ and $a^* = a_1 - \Sigma_{12}\Sigma_{22}^{-1}a_2$ and a marginal system for $\mathbf{x}_t$:

$$\Delta\mathbf{x}_t = \sum_{j=1}^{q-1}\Gamma_{j2}\Delta\mathbf{z}_{t-j} - a_2 b'\mathbf{z}_{t-1} + x_{2t} \qquad \mathbf{(7)}$$

The maximum likelihood estimate of b is the same whether we estimate **(3)** or **(6)** and **(7)** (see Boswijk (1995) and Ericsson (1995)). If the parameters of the conditional and marginal models are variation free and the parameters of interest are only a function of the conditional model, **(6)**, then estimation of **(6)** will be sufficient to recover all the necessary information about b (Johansen (1992, Theorem 1)). When variables are weak exogenous, the neglect of the marginal model does not result in the loss of information.

The necessary and sufficient condition for the weak exogeneity of $\mathbf{x}_t$ is that the part of the error correction space that determines the feedback of the long-run cointegrating relationships on the dynamics of the exogenous variables is composed of zeros (a_2=0). Since the exogenous variables are defined by a marginal process that excludes the long-run relationship P $\mathbf{z}_{t-1}$, the conditional model is sufficient to recover the parameter information about b. We will use two tests proposed by Urbain (1992) to confirm the validity of the partition between endogenous variables, $\mathbf{y}_t$, and the exogenous variables, $\mathbf{x}_t$.

Identification of the structural model

In a vector equilibrium correction model, identification of the matrices a and b is not complete because any transformation $a^* b^{*\prime} = a\mathbf{C}' (\mathbf{C}')^{-1} b' = a b' = \Pi$ using a non-singular matrix **C** gives the same long-run matrix, P . We need to impose zero restrictions and normalisations in the rows of **C** *a posteriori* in order exactly to identify the coefficients (Urbain (1995)). We can impose further restrictions on the parameter values of b by imposing over-identifying restrictions in the elements of each cointegrating vector b_i through individual restriction matrices, $\mathbf{R}_i$, so that $\mathbf{R}_i b_i \geq 0$, $i = 1, ...r$. This can be tested using the rank condition *rank* $(\mathbf{R}_i b_i) = r - 1$ for just-identification, or *rank* $(\mathbf{R}_i b_i) \geq r - 1$ if the model is over-identified. Conditions could also be imposed on a but in this paper we focus on restrictions to the equilibria rather than to the adjustment parameters.

The conditional model is just identified but to ensure that the model is exactly identified in a structural sense we must impose a minimum of a further $s(s\text{-}1)$ additional restrictions, where
$s = p\text{-}r$. Exact and over-identifying restrictions are imposed on the conditional model by premultiplying by a non-singular matrix (g x g), $\mathbf{A}_0$.

$$\mathbf{A}_0\Delta\mathbf{y}_t = \mathbf{A}_0\Sigma_{12}\Sigma_{22}^{-1}\Delta\mathbf{x}_t + \sum_{j=1}^{q-1}\mathbf{A}_0\Gamma^*_j\,\Delta\mathbf{z}_{t-j} - \mathbf{A}_0 a^* b'\mathbf{z}_{t-1} + \mathbf{A}_0 x_{1t} \quad \textbf{(8)}$$

The identification issue requires us to define the structure by creating a matrix of restrictions $\mathbf{A}_0$. A sufficient restriction is to impose normalisations of $\mathbf{A}_{0ii} = 1$, $i = 1,\ldots, g$, which would then leave the remaining parameters identified but unrestricted. Boswijk (1995) suggests that using economic criteria to impose the minimum number of restrictions required for identification allows further restrictions to be imposed on statistical grounds.

Alternative restrictions are: $\mathbf{A}_0 = I_g$, which re-imposes the error correction structure given by **(6)**; $\mathbf{A}_0$ triangular and the variance-covariance matrix $W = \mathbf{A}_0 (S_{11} - S_{12} S_{22}^{-1} S_{21}) \mathbf{A}_0$ diagonal, which creates a recursive structure such that an ordering is imposed on the causal chain; or
$\mathbf{A}_0 a^*$ diagonal, so that each structural dynamic equation has a single equilibrium correction term that can be interpreted as its long-run equilibrium. The first option reinstates the independence of equations for consumption, money and lending since none of the equations is influenced by the long-run behaviour of the other variables or the dynamics. The second option imposes a causal structure and is usually motivated by theoretical restrictions from an economic model. The final option allows causality to be determined by indirect means. The long-run equilibria enter their own equations and others through contemporaneous endogenous variables. The selection of the structure can be based on economic theory and statistical information. Bardsen and Fisher (1993), Johansen and Juselius (1994), Boswijk (1995), Thomas (1997a,b), Hoffman and Rasche (1996) and Favero (2001) provide a deeper discussion of the issues at stake when choosing between alternatives. There is a close relationship between the structural vector error correction model and simultaneous equations models (see Hsiao (1997)).

Estimation method

When the weak exogeneity assumption holds there is no loss information from estimating the conditional model **(8)** rather than the full system **(4)**, so the approach is equivalent to ML estimation and inference on the long-run parameters using likelihood ratio (LR) statistics is based on standard c^2 distributions. Economically justifiable restrictions just-identify the system and further over-identifying restrictions can be imposed at a later stage on statistical criteria (Boswijk (1995) and Urbain (1995)).

The steps in the procedure for integrated I(1) series are as follows:

i) System analysis of cointegration using the Johansen procedure ascertains the number of cointegrating vectors, r, where $0 < r < p$; the parameters of interest are b.
ii) A restricted model is constructed with $g = r$ such that the number of endogenous variables equals the number of cointegrating vectors; restrictions are tested on the cointegrating vectors based on restriction matrices, $\mathbf{R}_i$, so that $\mathbf{R}_i b_i \geq 0$, $i = 1, ...r$.
iii) The remaining variables are tested for weak exogeneity, ($a_2 = 0$); analysis is based on the conditional vector error correction model if this restriction holds.
iv) The structural model is identified by premultiplying the conditional model by the matrix, $\mathbf{A}_0$, defined according to an appropriate diagonal or recursive framework.
v) The model is reduced to a parsimonious form using general-to-specific methodology.
vi) The model is evaluated by examining the diagnostics and the dynamic responses to permanent or temporary shocks.

3 Empirical results

Data

The data used are standard ONS national accounts data for the UK household sector and Bank of England money and lending data; the sample period is 1978 Q1 – 1998 Q4. The variables included are: real consumer expenditure by households (c_t); real M4 balances held by households (m_t); real unsecured M4 lending to households by banks and building societies (l_t).

Real net labour income (y_t) is an important scale variable. Permanent income may be relevant to spending decisions but measured current income may also be an important influence on debt. High-income individuals may not choose to be in debt, but the greater one's income the larger is the sustainable debt. Of course, a short-term or unexpected increase in income could be used to reduce borrowing, so while we might expect to find that, for the household sector as a whole, the long-run equilibrium level of debt is positively related to the level of income, there could be either a negative or positive relationship between changes in debt and income in the short run—depending on whether the desire to repay debt outweighs the increase in sustainable debt at higher incomes. The existence of a personal budget constraint suggests that the debt/income ratio has an upper bound but it may be the case that there is a stable long-run equilibrium level that varies with factors such as interest rates and expected growth.

A further scale effect is household real net total wealth (w_t) defined as housing wealth plus financial assets minus total debt. The influence of wealth on unsecured credit could be positive or negative. Other things being equal, higher wealth can be used to sustain a higher level of borrowing, so unsecured credit is likely to be positively related to wealth. Banks are typically aware of the assets of their customers when they assign credit limits, so wealth will be a determinant of credit levels even for those loans not directly secured on underlying assets. But if consumers have a target level of borrowing in mind that is drawn from secured (ie mortgage equity withdrawal) lending and unsecured lending, then a negative relationship may emerge between unsecured lending and wealth. This is because declining wealth reduces the availability of secured lending and encourages the consumer to maintain consumption levels from unsecured borrowing. However, it is unlikely that this could be sustained for long, so our view is that wealth is most likely to be positively related to unsecured lending.

The opportunity cost variables are measured using inflation (p_t), which is taken as the annual rate of change of the consumer expenditure deflator (measuring the rate of return on physical goods), and two spreads: the interest rate on savings deposits less money market rates, (r_{dt}), which measures the return to bank deposits held as savings; and spread of the consumer credit rate over base rate, (r_{ct}), which measures the relative cost of unsecured household borrowing.

Two additional I(0) variables are included in the VAR. These are the GfK aggregate measure of consumer confidence (*conf*), and the percentage change in unemployment (*Du*) as measured by the claimant count. Neither of these is an endogenous variable and therefore they appear as additional regressors on the right-hand side of equations **(6)** and **(7)**.[5] The first variable, measuring the buoyancy of consumer sentiments over the immediate horizon, is correlated with consumer expenditure patterns. It is often argued that this variable may be driven by the same underlying forces as wealth (asset values), but we do not find evidence of strong collinearity. The second variable allows for upturns (downturns) in the labour market that are correlated with lower (higher) precautionary saving. All data except the inflation rate, interest rate spreads, and the change in the percentage unemployed are converted to natural logarithms.

[5] Wickens and Motto (1999) have shown how the system alters if stationary *endogenous* variables are included in the system.

Estimating the long-run relationships

We use the maximum likelihood estimation procedure explained by Johansen (1995) using the full system unrestricted vector autoregressive model (uVAR). We follow a testing strategy that initially allows for the impact of a constant and deterministic trend in the restricted cointegration space. We then remove the trend leaving just a restricted constant, and subsequently allow the constant to enter unrestrictedly, ie outside the cointegration space. The selection of our final model is based on a lag length of two (using F-tests to examine the nullity of the corresponding VAR columns of additional lags). Dummy variables are used to normalise the residuals according to a Jarque-Bera vector normality test, $\chi^2(18) = 27.342$ [p value = 0.0728] and remove traces of serial correlation (according to Box-Pierce tests for up to ninth-order serial correlation).

The test results reported in Table A suggest there may be as many as five cointegrating vectors on the basis of maximum likelihood and trace tests, although the small-sample correction suggests there are between three and four vectors. *A priori*, we expect there to be three cointegrating relations between the eight variables—one for each of the endogenous variables, money, credit and consumption. We subject the model to exogeneity tests to confirm our view that the remaining five variables are exogenous at a later stage. We use the identification scheme of Boswijk (1994, 1995) and Ericsson (1995) to impose $r = g = 3$, so that the cointegrating rank equals the number of endogenous variables.

Table B reports the restricted cointregating vectors where $r = 3$ is imposed. The null that r = 3 is imposed by placing unit restrictions on consumption, money and credit and imposing two other just-identifying restrictions on each equation. The model rejects the null that there are less than or equal to two cointegrating relations. The long-run equations of the model are over-identified using the following restrictions to the (3x8) b matrix:

$b_{11} = 1$; $b_{14} = -1$; $b_{15} = 0$; $b_{16} = 0$
$b_{21} = 0$; $b_{22} = 1$; $b_{26} = 0$; $b_{27} = 0$; $b_{28} = 0$;
$b_{31} = 0$; $b_{32} = 0$; $b_{33} = 1$; $b_{35} = 0$;

These nine just-identifying restrictions and four over-identifying restrictions complete the identification of the long run. Zero restrictions on consumption in the money and credit equations, and on money in the credit equation, impose causation from long-run money and lending stocks to consumption. The zero restrictions of the deposit spread in the lending equation and the credit spread in money and consumption equations define the appropriate opportunity cost variable—inflation for consumption, deposit spread for money, and credit spread for lending. The remaining two restrictions impose a unit coefficient on income in the consumption equation and a zero coefficient on wealth in the money equation (for reasons based on statistical significance rather than economic theory).

The estimates of the three b vectors are given in Table C. The four additional over-identifying restrictions tested by a likelihood ratio test, which is distributed as chi-squared with four degrees of freedom. The restrictions themselves are not rejected at conventional significance levels (χ^2 (4) = 0.722 [p = 0.949]). Chart 1 shows the actual versus fitted values against time and cross-plotted, and that the residuals from the cointegrating vectors are within two standard errors for each of the three equations above. These provide the ECM terms for the dynamic structural model discussed below.

There are significant direct interactions between these endogenous variables in the cointegrating equations. The levels of real money and credit appear in the equation for households' real consumption. Additionally, real money holdings in the long run are associated with higher real consumption expenditure, but a higher real lending stock can only be sustained in the long run by a lower level of consumption. The consumption equation is homogenous in income. Real lending appears in the equation for real money balances, but lending is not affected directly by the levels of real money or consumption. While all these endogenous variables are determined simultaneously by a common set of driving variables, there are also clearly strong inter-linkages between them.

Substituting out the endogenous variables on the right-hand side of the cointegrating equations gives the resulting long-run solution for each endogenous variable in terms of the exogenous variables. These can be thought of as equivalent to the implied single-equation long-run consumption, money, and credit functions:

$$c_t = 0.807y_t + 0.146w_t - 0.128\boldsymbol{p}_t + 0.449\mathrm{dsp}_t + 0.318\mathrm{csp}_t$$
$$m_t = 1.182y_t + 0.247w_t + 0.629\mathrm{dsp}_t - 0.257\mathrm{csp}_t - 1.09\boldsymbol{p}_t$$
$$l_t = 1.407y_t + 0.652w_t - 0.680\mathrm{csp}_t - 2.89\boldsymbol{p}_t$$

None of these equations contradicts the conventional wisdom from previous single-equation studies. Elasticities are close to their expected magnitudes and signs. Real consumption has a plausible long-run marginal propensity to consume out of real labour income of around 0.8, and is positively related to net wealth. Both elasticities are smaller than those reported in the cointegrating relation since the positive influence of income and wealth on lending feeds through to reduce the net effect on consumption. The theoretical sign of the impact of inflation on consumer expenditure is ambiguous, but most previous studies have found that inflation reduces real consumption, as we do. This could be because inflation increases uncertainty, or because households expect a tightening of future monetary policy when inflation is high and reduce spending accordingly. A further reason could be attempts by households to restore the real value of their nominal savings balances after erosion by inflation.

As would be expected, the credit spread is negatively related to borrowing and money holding is positively related to the deposit spread; in the solution equation for consumption, both spreads have a positive effect. Both of these effects in themselves are highly plausible—unsecured borrowing is reduced by a high price of consumer credit relative to base rate, and consumption is reduced (in the long run) if debt is higher (because interest on the debt has to be paid out of disposable income, so sustainable consumption is that much lower when debt is high). The higher is the deposit spread the greater the money balances held in the long run, and with larger money balances consumption is higher.

The money demand equation has a coefficient on labour income close to unity and a smaller positive coefficient on net financial wealth. As deposit spreads increase, households hold more money on deposit, and as the cost of borrowing increases so money balances are reduced (presumably to reduce outstanding debt). Real money balances fall with inflation. The lending equation is positively related to the same scale variables, although it is more sensitive to labour income and net wealth. Credit appears to be a luxury good. The importance of wealth may represent the significance of net wealth for credit provision via the role of collateral, and the growing readiness to borrow as asset values rise. As the credit spread rises the stock of unsecured bank lending falls, consistent with a predominantly demand-determined credit stock. Uncertainty and the possible expected future monetary policy tightening resulting from higher inflation reduce borrowing in the long term.

The loading coefficients on deviations from these equilibria are given in the lower half of Table C. The adjustment speeds with respect to disequilibria suggest a stabilising dynamic system, given the negative signs on the main diagonal. Again the adjustment speeds are plausible, although lending seems to adjust to its disequilibrium more rapidly than any of the other variables. The off-diagonal coefficients are also significant. This suggests that independent adjustment models in which the dynamics of each endogenous variable responded only to its own disequilibrium would be rejected. Rather, an interactive model in which the dynamics respond to various disequilibria would appear to receive greater support. The element of the loading matrix for money disequilibrium is significant in the consumption equation, and the elements for consumption and money disequilibria are significant in the lending equation. It is plausible that excess consumption causes a rise in lending (household borrowing), while excess money leads to a fall in lending (as household with excess money can reduce debt). The precise form of the interaction is the subject of the identification of the structural model, but the structure does not appear to suggest a simple causal structure of the kind that might require a triangular $\mathbf{A}_0$ matrix.

Exogeneity, identification and the structural model

In defining the structural model we must consider the validity of using the conditional VECM in place of the full system, which requires us to partition the variables into endogenous and exogeneous categories. The test involves consideration of the null hypothesis that the coefficients on the long-run equilibrium relationships are zero, $a_2 = 0$, in the marginal model **(7)** and the test that the residuals from the marginal models **(7)** are not significant in the conditional model **(6)**. Then the parameters of interest are only functions of the conditional model **(6)** and no information is lost relative to **(4)** by estimating **(6)** in isolation.

Weak exogeneity tests are reported in the top panel of Table D. These consist of exclusion tests based on an F-statistic for the null that the coefficients on the equilibrium correction terms are jointly equal to zero for the k variables; rejection implies the marginal models contain information that cannot be ignored and therefore the conditional model cannot be estimated in isolation. We test the five variables labour income, deposit spreads, credit spreads, wealth and inflation, and reject the null in two cases at the 5% level. The subsequent test indicates that re-testing, excluding inflation from the

k variables, does not reject the null. It would appear that labour income, deposit spreads, credit spreads, and wealth are weakly exogenous but inflation may be potentially endogenous on this criterion.[(6)]

A further test is provided by the orthogonality test, which includes the residuals from the marginal models in the conditional models. Both the five-equation and four-equation conditional model do not reject the null that the coefficients can be restricted to equal zero and thus the information in the residuals of the marginal models is not significant in the conditional model (taking inflation as exogenous in the first case and then endogenous). Thus there is no additional information in the residuals of the marginal models in either case that augments the conditional model. Our conclusion is that all five variables can reasonably be treated as exogenous variables.

There are many data-admissible structural VECMs, as we have already mentioned, and the remainder of this section considers the alternative identification schemes with a view to uncovering the 'structural model'. Our selection reflects the choices that must be made based on the desire for parsimony, diagnostic performance and clear economic interpretation. The results reported in Table D are obtained from a model that provides the best performance on these evaluation criteria. Improvements to the log likelihood can be obtained but only at the cost of overfitting and inferior diagnostic performance. The results confirm that there are significant coefficients on the ECM terms; these cointegrating relationships are well determined and provide strong attractors. Our conditional model is estimated using full-information maximum likelihood.

The first class of identification structures where $\mathbf{A}_0 = \mathbf{I}$ is strongly rejected by the data when the likelihood for the restricted model with zeros in the off-diagonals is compared with the unrestricted model. This indicates that independent equilibrium correction models are rejected in favour of interdependent ones. So we turn instead to consider the second class of structures, identified by Boswijk (1995), where $\mathbf{A}_0$ is triangular and the variance-covariance matrix is diagonal. This is a form of interactive model, with a precise form of causal structure imposed by a triangular identification

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(6) We give further consideration to the potential endogeneity of inflation in results that are not reported in the paper. We examine the possibility that the rank of the restricted system is equal to four. The Johansen procedure rejects the null that there are at most three rank reducing relationships in the data using the same maximum likelihood estimation procedure as before. A restricted cointegrating relationship is detected with a unit coefficient on inflation, giving $p_t = (y_t - m_t) + 0.31w_t$. If we use a quantity theory relationship to define $m_t = y_t + p_t$ this gives $p_t = -(p_t) + 0.31w_t$, which could be interpreted as a monetary policy rule in which inflation adjusts to a price target of zero and asset price inflation represented by wealth, w_t. The equation could also be plausibly interpreted as a second money demand function, since $m_t = y_t - p_t + 0.31w_t$. If there really is a fourth cointegrating relationship there should be an equilibrium correction representation (Granger Representation Theorem, see Engle and Granger (1987)). To consider this point we estimate a dynamic system with four endogenous variables – the change in consumption, money, lending and inflation – but we do not find significant adjustment coefficient in *any* of the equations. Apart from the limitations imposed by degrees of freedom when the model has four endogenous variables, even with a single lag, this finding suggests that the detection of a fourth relationship between the level of the variables and the treatment of inflation as endogenous is questionable. While from an economic point of view we might be able to conceive of wealth or labour income being endogenous in a model of the household sector, it is difficult to interpret inflation in this way. Inflation is unlikely to be determined within the context of the household sector alone, so for economic reasons as well as econometric ones we reject the endogeneity of inflation.

scheme. Given that we have no theoretical priors to determine the triangular structure, we take each of the six possible triangular forms that can be imposed by setting three of the off-diagonal coefficients equal to zero, leaving the remainder as unrestricted coefficients. The restrictions are tested using a likelihood ratio statistic, which is distributed as chi-squared with three degrees of freedom. All of the restrictions are comprehensively rejected.

Finally, we use a third schema that diagonalises the equilibrium correction matrix $A_0 \alpha^*$ to identify the model. This does not require us to impose a particular causal structure, but allows the structure to be discovered after the model has been identified. Using this scheme, Boswijk (1995) shows that this implies that the restrictions used to identify the long-run relationships are also imposed on the structural dynamic model. Interaction between the models can occur through the inclusion of contemporaneous endogenous variables, and further over-identifying restrictions can be used to ensure that we have a parsimonious model.

The models are interactive because more than one contemporaneous endogenous variable appears in each of the three models. This means that the equilibrium correction terms enter indirectly through the contemporaneous terms, and the elasticities are calculated from the product of their estimated coefficients and the adjustment parameters on the equilibrium correction variable. There is no natural order in which to discuss the dynamic models but we choose to take them in reverse order from that in the table.

In the dynamic lending equation, the adjustment of unsecured lending to its own disequilibrium is 8% per quarter, a more plausible figure, and more consistent with the other adjustment speeds compared with the a matrix above. The effects of money and consumption disequilibria influence the change in lending through current changes to consumption and money. Excess money balances decrease lending, with an elasticity of –0.556, suggesting that excess money balances are used to pay off borrowing, or as substitute finance for consumption. Excess consumption leads to increases in lending, with an elasticity of 0.194, suggesting that a build-up of unsecured borrowing occurs during or just after periods of abnormally high consumer spending. The dynamic response to past changes in lending reflects the fact that lending is slightly positively autocorrelated. Lending increases when income and wealth decline, at least in the short run, suggesting that short-term borrowing is used to cover variations in earnings from employment and assets. Increases in the cost of credit and the return to deposits (relative to base rate) reduce the growth rate of unsecured lending. The growth of lending is also affected positively by inflation, unemployment and the change in consumer confidence.

In the dynamic equation for money, the adjustment speed to excess money balances is 14%, slightly higher than the 11% reported by Thomas (1997a). Excess lending has a small positive effect on the dynamics of money balances, with an elasticity of 0.015, but money balances are otherwise unaffected by disequilibria in other equations. Changes to income and wealth increase money balances, although changes to deposit rates have a perverse negative effect on money balances. Higher unemployment reduces money growth as do confidence and inflation; these effects support the view that money holdings are precautionary.

The consumption equation implies that 8% of any disequilibrium in consumption is eliminated in each quarter, but consumption itself is negatively autocorrelated quarter-on-quarter. Contemporaneous and lagged changes in money balances have a strong positive effect on consumption, but this implies that excess money balances reduce consumption expenditure growth. If money is held for precautionary reasons this may not be as implausible as it first appears: when money balances increase with higher inflation or unemployment or lower confidence, consumption expenditure also declines. Excess lending increases consumer expenditure growth as we would expect, but the effect is relatively small, with an elasticity of 0.041. Higher deposit and credit spreads over base rates lower consumption growth with a lag. The former reflects the attractiveness of saving over consumption while the latter is associated with the higher costs of borrowing to pay for consumption. The change in the rate of unemployment has a small negative contemporaneous impact on consumption growth as does consumer confidence.

Chart 2 shows that the actual and fitted values of the structural model are closely aligned and the cross-plots lie on a scatter around the 45 degree line. The residuals are within an acceptable range and are randomly distributed without any apparent serial correlation or heteroskedasticity. A check on the dynamic stability of the structural model can be performed by inspecting the diagnostic results in Table E. These statistics indicate that the residuals from each of the dynamic equations are satisfactory for a nine-lag portmanteau test, tenth-order AR test for autocorrelation, Jarque-Bera normality test and a fourth-order ARCH test.(7) The overidentifying restrictions required to ensure parsimony are not rejected at conventional significance levels. Recursive estimation in Chart 3 reports the residual sum of squares and indicates that the residuals lie within two standard errors. The log likelihood and Chow tests for model instability do not violate the 5% critical values, suggesting that the model is stable recursively. Impulse responses from the simulated model show that three separate temporary 1% shocks to the endogenous variables are quickly dampened after one cycle.(8)

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(7) Residual serial correlation occurs in the consumption and money equations but the result for the system as a whole is within the 5% critical value.
(8) These are not reported in this paper but are available from the authors on request.

4 Conclusions

This paper has provided empirical answers to two questions. Is it valid to focus on consumption and money demand relationships at the expense of credit or should we attempt to model credit? And can we legitimately separate the estimation of equations for consumer expenditure, money holding and borrowing?

Using data for the UK personal sector, we examine household-level consumer expenditure, money holding and credit. We select a small set of explanatory variables to identify three long-run equilibrium equations, representing consumer expenditure, money and credit, as functions of labour income, wealth, deposit and credit spreads and inflation. The methodology employed is a reduced rank cointegrating vector autoregressive model selected by maximum likelihood inference (Johansen (1995)). The paper shows that a stable credit equation exists that complements the information content of the equilibrium money function. Dynamic models estimated using a *conditional* vector equilibrium correction model selected as a reduction from the vector-autoregressive equilibrium correction model (see Johansen (1995), Boswijk (1994 and 1995), Ericsson (1995) and Urbain (1995)) answer the second question. They show that restrictions that amount to re-imposing a separable equation approach are rejected, and that interactions between consumer spending, money holding, and unsecured credit can be identified in the UK household sector. Our conclusion is that credit adds information over and above that in monetary data, and contains information useful for anticipating consumer expenditure. Consumption, money holding and credit equations are interactive in the long-run equilibria and in their short-run dynamic adjustment.

The current work can reasonably claim to have made an advance in two important respects. First, we have identified three long-run cointegrating relationships for the household sector including an equation for unsecured credit about which little was known before. Second, including the credit aggregate in a *conditional* vector equilibrium correction model of the dynamics alongside money and consumer spending appears to offer informational gains. Our chosen structural form, selected using the identification method of Boswijk (1995), shows that disequilibria in consumption, money and credit have effects on the dynamics of the endogenous variables beyond their own equations. Importantly, the restriction that defines the equations as separable dynamic equations is rejected.

Table A
Maximum likelihood estimation of cointegrating vectors:
Unrestricted model

Rank(r)	-Tlog(1- l)	for T-*nm*	95%	-TΣlog(1- l_i)	for T-*nm*	95%
r == 0	136.3**	106.7**	57.1	407.6**	319.2**	192.9
r <= 1	79.98**	62.63**	51.4	271.3**	212.5**	156.0
r <= 2	64.4**	50.43*	45.3	191.3**	149.8**	124.2
r <= 3	44.84*	35.12	39.4	126.9**	99.42*	94.2
r <= 4	36.34*	28.46	33.5	82.11**	64.3	68.5
r <= 5	24.23	18.97	27.1	45.77	35.84	47.2
r <= 6	15.75	12.34	21.0	21.54	16.87	29.7
r <= 7	5.756	4.508	14.1	5.789	4.533	15.4
r <= 8	0.03278	0.02567	3.8	0.03278	0.02567	3.8

Number of lags used in the analysis: 2
Variables entered unrestricted:
Du *Du*(1) *Du*(2) *conf* *conf*(1) *conf*(2) *Constant*

Table B
Maximum likelihood estimation of cointegrating vectors:
Restricted model

Rank(r)	-Tlog(1- l)	for T-*nm*	95%	-TΣlog(1- l_i)	for T-nm	95%
r == 0	61.18**	56.75**	21.0	124**	115.1**	29.7
r <= 1	41.85**	38.83**	14.1	62.86**	58.32**	15.4
r <= 2	21.01**	19.49**	3.8	21.01**	19.49**	3.8

Number of lags used in the analysis: 2
Variables entered unrestricted:
Du *Du(1)* *Du(2)* *conf* *conf(1)* *conf(2)* *Dy* *Dy(1)*
Dw *Dw(1)* *Ddsp* *Ddsp(1)* *Dcsp* *Dcsp(1)* *Dp* *Dp(1)*
Constant

Variables entered restricted:
y *w* *dsp* *csp* *p*

Table C
Restricted cointegrating vectors

Normalised *b'* vectors with standard errors (in brackets):

c	*m*	*l*	*y*	*dsp*	*csp*	*p*	*w*
1.000	-0.714	0.737	-1.000	0.000	0.000	1.487	-0.449
(0.000)	(0.118)	(0.042)	(0.000)	(0.000)	(0.000)	(0.670)	(0.093)
0.000	1.000	-0.379	-0.651	-0.630	0.000	0.000	0.000
(0.000)	(0.000)	(0.043)	(0.109)	(0.610)	(0.000)	(0.000)	(0.000)
0.000	0.000	1.000	-1.408	0.000	0.680	2.893	-0.652
(0.000)	(0.000)	(0.000)	(0.182)	(0.000)	(0.349)	(0.902)	(0.111)

Weighting ***a*** matrix with standard errors:

c	-0.149	-0.212	0.056
	(0.099)	(0.060)	(0.067)
m	0.081	-0.091	-0.0496
	(0.099)	(0.060)	(0.067)
l	0.563	-0.138	-0.436
	(0.069)	(0.041)	(0.046)

Log L = 1344.8515 unrestricted log L = 1345.2126
Test of over-identifying restrictions [*p* value in square brackets]:
LR-test, rank = 3:. $\chi^2(4) = 0.722$ [0.949]

Table D
Exogeneity tests

	Variables in marginal model *y, dsp, csp, p, w*	Variables in marginal model *y, dsp, csp, w*
Retained regressors (Urbain 1992)	Distribution F(5, 33)	Distribution F(4, 35)
ECM_{ct}-1	6.949 [0.002]**	1.923 [0.128]
ECM_{mt}-1	1.681 [0.166]	0.604 [0.662]
ECM_{lt}-1	6.945 [0.002]**	2.156 [0.094]
Orthogonality *(Urbain 1992)*	Distribution F(3, 37)	Distribution F(4, 36)
x_y	1.170 [0.334]	1.872 [0.137]
x_w	1.310 [0.286]	1.322 [0.280]
x_{dsp}	0.751 [0.529]	0.898 [0.475]
x_{csp}	1.620 [0.201]	1.409 [0.251]
x_p	2.296 [0.094]	-

Table E
FIML estimates of structural models for households

	Dc_t		Dm_t		Dl_t	
Dc_t	-	-	-	-	-1.5829	(0.4491)
Dc_{t-1}	-0.3535	(0.0898)	-	-	-0.7193	(0.1951)
Dm_t	2.1388	(0.3965)	-	-	3.9165	(0.5721)
Dm_{t-1}	0.2395	(0.0971)	-	-	-	
Dl_t	-0.3781	(0.1219)	0.1375	(0.04299)	-	
Dl_{t-1}	-	-	-	-	0.0676	(0.0402)
ECM_{ct-1}	-0.0842	(0.01613)	-	-	-	-
ECM_{mt-1}	-	-	-0.14205	(0.0186)	-	-
ECM_{lt-1}	-	-	-	-	-0.1091	(0.0210)
Dy_t	-0.2476	(0.1140)	0.2177	(0.0487)	-0.5088	(0.1666)
Dy_{t-1}	-	-	-	-	-	
Dw_t	-0.0484	(0.0412)	0.04173	(0.0189)	-0.1031	(0.0719)
Dw_{t-1}	-	-	-	-	-	
$Ddsp_t$	-	-	-0.4704	(0.10317)	-	
$Ddsp_{t-1}$	-0.32103	(0.1322)	0.1133	(0.1097)	-0.6077	(0.2542)
$Dcsp_t$	-	-	-0.1156	(0.03634)	-0.0573	(0.0329)
$Dcsp_{t-1}$	-0.16302	(0.0630)	-	-		
Dp_t	0.2897	(0.1762)	-0.3855	(0.0827)	0.4322	(0.2749)
Dp_{t-1}	-	-	-0.12454	(0.06116)	-0.0887	(0.0502)
Du_t	-	-	-	-	-	-
Du_{t-1}	-0.00193	(0.0056)	-0.0087	(0.0018)	0.0394	(0.0087)
$Conf_t$			-0.00019	(0.00008)	0.0011	(0.0003)
$Conf_{t-1}$	-0.00007	(0.00003)	-	-	-0.00054	(0.00019)
Constant	-0.6336	(0.1219)	0.1901	(0.0247)	-1.5859	(0.3074)
s	0.0093		0.0048		0.0167	

$$ECM_{ct} = Dc_t + 0.714 Dm_t - 0.737 Dl_t + Dy_t - 1.487 Dp_t + 0.449 Dw_t + ECM_{ct-1}$$

$$ECM_{mt} = Dm_t + 0.379 Dl_t + 0.651 Dy_t + 0.630 dsp_t + ECM_{mt-1}$$

$$ECM_{lt} = Dl_t + 1.408 Dy_t - 0.680 csp_t - 2.893 Dp_t + 0.652 Dw_t + ECM_{lt-1}$$

Table F
Residual diagnostics for structural model

	Dc_t	Dm_t	Dl_t	*System*	
Portmanteau 9 lags	22.999	10.698	10.343	Portmanteau 9 lags	84.584
AR(1-10) F[10, 35)	2.168 [0.045]*	2.548 [0.002]*	2.113 [0.0502]	AR 1- 10 F(90, 84)	1.189 [0.211]
Normality $Chi^2(2)$	1.160 [0.560]	1.912 [0.385]	1.041 [0.594]	Normality $Chi^2(6)$	6.919 [0.328]
ARCH4 F(4, 37)	0.153 [0.961]	0.793 [0.538]	0.131 [0.970]		
Correlation of residuals					
Δc_t	1.0000				
Δm_t	-0.8338	1.0000			
Δl_t	0.9900	0.8320	1.0000		

Log L = 1333.108 unrestricted log L = 1345.2126
Test of overidentifying restrictions [*p* value in square brackets]:
LR-test: $\chi^2(46) = 41.114$ [0.677]

Note: p-values are in square brackets.

Chart 1
Cointegrating vectors for consumption, money and lending

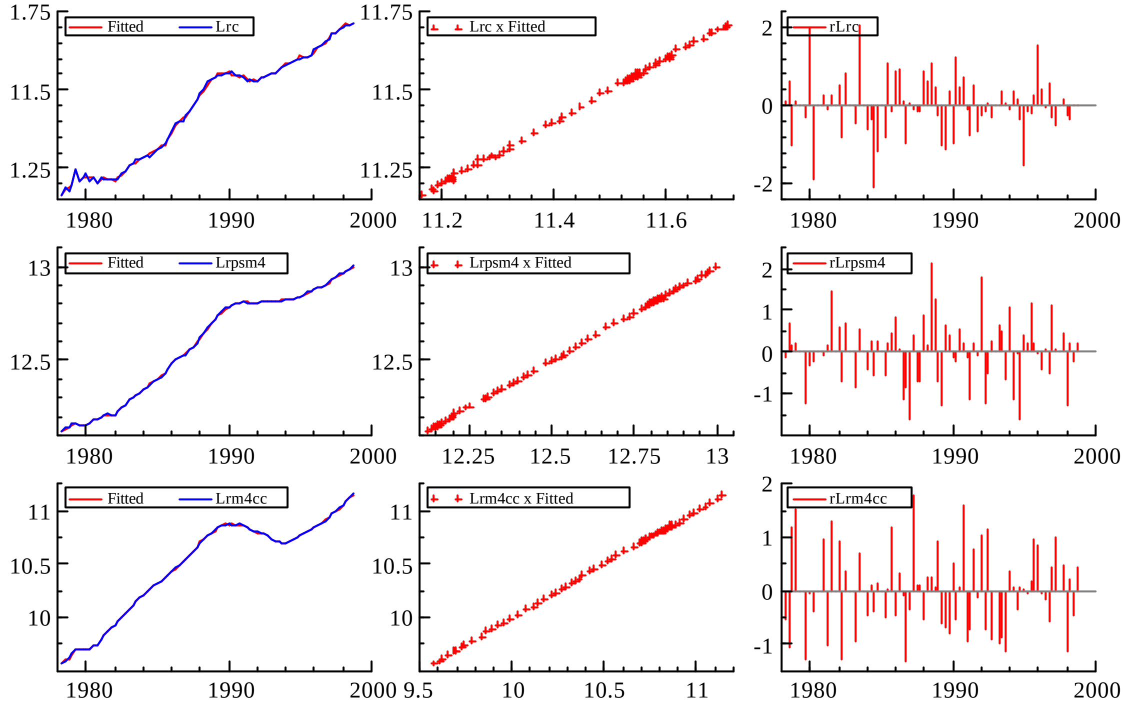


Chart 2
Actual and fitted values for the dynamic structural model

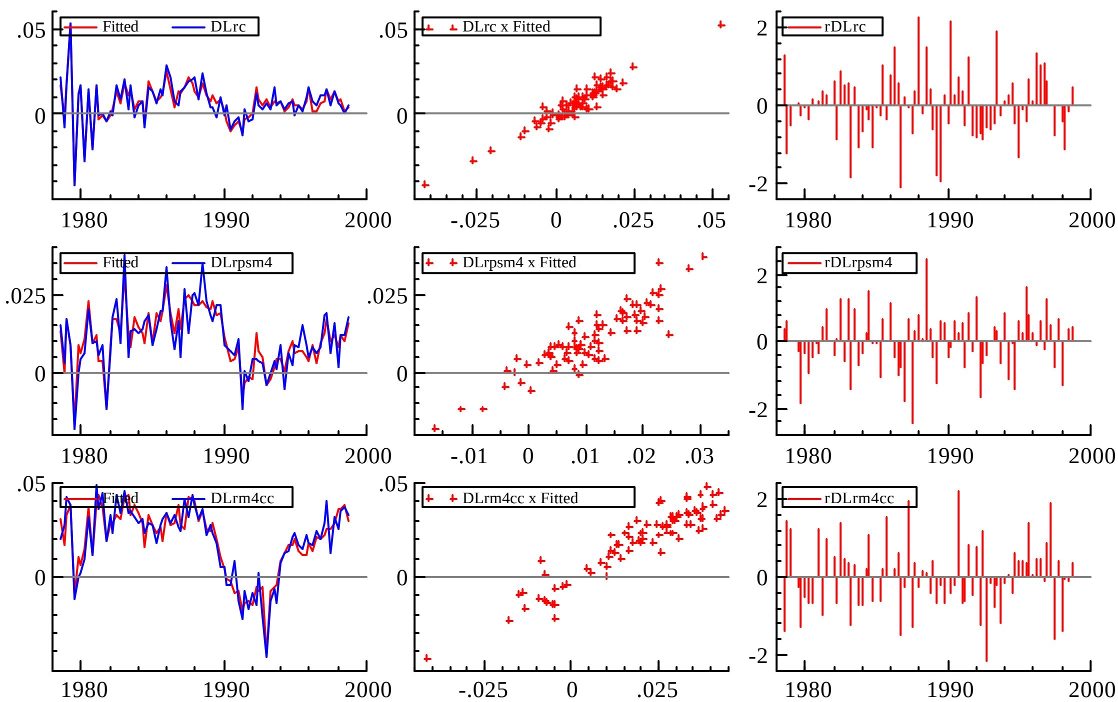
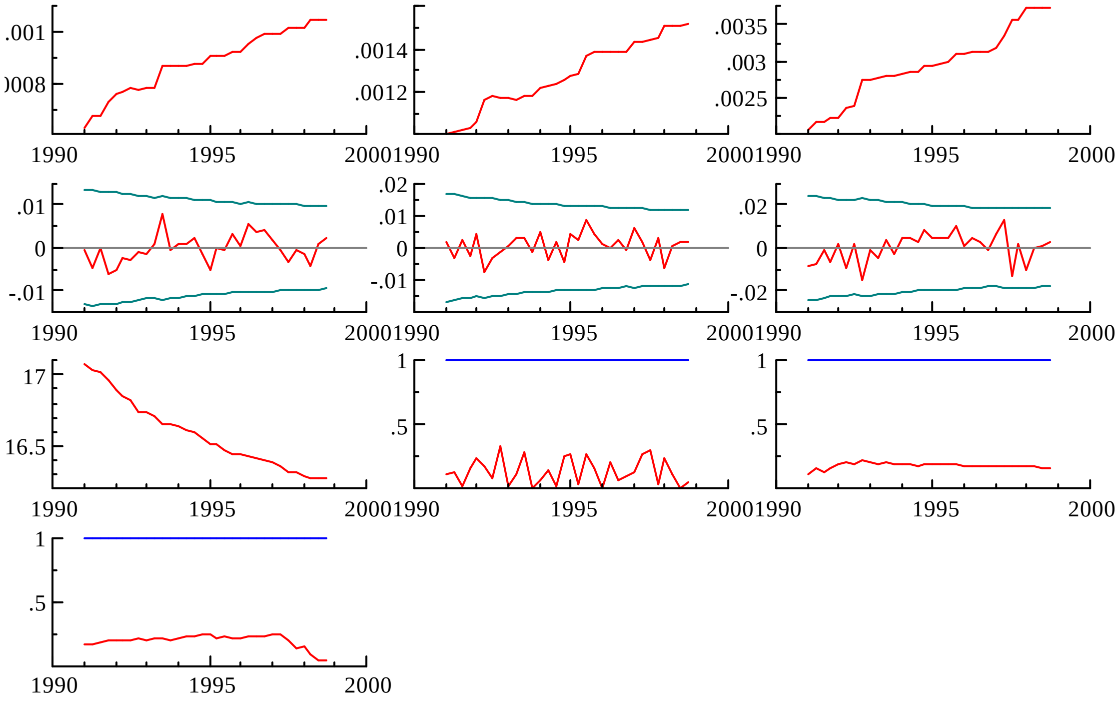


Chart 3
Recursive performance of dynamic model



Notes: Panels 1-3 are residual sum of squares for each equation; panels 4-6 represent the residuals +/- 2 standard errors; panel 7 shows the log likelihood; panels 8-10 show the one-step, break-point and the forecast Chow tests.

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