Bank of England

Discussion Papers

Technical Series

No 30

A data-based simulation model of the financial asset decisions of UK, 'other' financial intermediaries

by

D G Barr

K Cuthbertson

June 1990

No 30

A data-based simulation model of the financial asset decisions of UK, 'other' financial intermediaries

by

D G Barr

K Cuthbertson

June 1990

The object of this *Technical series* of Discussion papers is to give a wider circulation to econometric research being undertaken in the Bank and to invite comment upon it; and any comments should be sent to the authors at the address given below. The views expressed are those of the authors and not necessarily those of the Bank of England. Any errors remain the authors' responsibility.

The authors would like to thank the Bulletin Group for editorial assistance in producing this paper.

Issued by the Economics Division, Bank of England, London, EC2R 8AH to which requests for individual copies and applications for mailing list facilities should be addressed; envelopes should be marked for the attention of the Bulletin Group. *(Telephone: 071-601-4030)*

ISBN 0 903314 90 8

ISSN 0263 - 6123

Contents

Abstract

In this study 'other' financial intermediaries (OFIs) include the UK insurance companies, pensions funds, unit and investment trusts and finance houses. These are key financial institutions for channelling the savings of households to deficit units. Asset switching by these institutions may have implications for changes in relative interest rates and the exchange rate. An understanding of the portfolio decisions of 'other' financial intermediaries (excluding building societies) is important in analysing the impact of changes in monetary conditions on the financial system.

In this paper we provide an empirical model of the asset behaviour of OFIs (excluding building societies). We apply a dynamic model based on consumer theory and find that the choice between liquid assets, public sector debt, UK company securities, foreign currency assets and loans is determined by 'own' rates of return and the rates of return on alternative assets. In our quarterly data we find that the broad changes in asset holdings are influenced by a relatively long term view of asset returns.

In a highly interdependent system it is important to ascertain whether the time profile of movements in asset holdings to changes in rates of return are plausible. Various simulations of the system indicate that there is little or no 'overshooting' as assets adjust and the adjustment speeds are relatively high. Most of the adjustment (to a final equilibrium position) is completed in about 6 months. This is consistent with administrative, organisational and information costs, as well as risk aversion, on the part of fund managers.

There is considerable switching between foreign currency assets, UK company securities and public sector long-term debt. An increase in the return on liquid assets results in a switch out of public sector long-term debt and loans issued by OFIs.

Overall, the results indicate that the medium term portfolio decisions of OFIs (excluding Building Societies) may be explained in a systems model with a stable adjustment process. Portfolio adjustment is influenced by changes in expected yields and portfolio managers consider a reasonably long-term horizon when assessing future changes in yields.

A data-based simulation model of the financial asset decisions of UK, 'other' financial intermediaries

I Introduction

The 'other' financial institutions (OFI) referred to in this paper comprise UK pension funds, insurance companies, unit and investment trusts and finance houses: building societies are excluded. The aim of the paper is to assess how far a particular theoretical model based on consumer demand theory can explain the behaviour of asset holdings of UK OFIs and provide sensible simulation properties.

There is a voluminous applied literature on the demand for financial assets of the non-bank private sector both single equation (eg Laidler 1977, 1980, Hall et al 1989, Roley 1985) and systems approaches (Serletis and Robb 1986, Ennis and Fisher 1984, Perraudin 1987, Backus et al 1980, Feige and Pearce 1977, Christensen et al 1975, Green 1984) but applied work, in our view, has largely neglected a systems approach to the asset decisions of OFIs (but see Keating 1985). For example, Cummins and Outreville (1984) claim that their work represents the first attempt to build a structural model of US pension funds. They utilise Friedman's (1977) optimal partial adjustment model on a three asset system. Results are mixed: some variables have wrong signs, there are no symmetry or homogeneity restrictions in the model and the theory model is eclectic. There are a large number of unidentified parameters in the system and this makes the model somewhat difficult to interpret. Attempts in the United Kingdom have also yielded results that often conflict with the chosen theoretical model or intuitive *a priori* views. Ryan (1973), in a very different model to that in this paper examines the demand for a selection of assets by the UK life funds. Honohan (1980) applies the mean-variance model to the UK insurance companies. He imposes symmetry and homogeneity restrictions but finds that "the model does not perform well....". Similarly Keating's (1985) highly restrictive mean-variance model for pension funds does not perform well (Courakis 1988). Weale (1985) utilises a four-asset model of the life assurance and pension funds and attempts to identify speculative and hedging components. He finds speculative activity is small relative to the hedging component. His model is closest to that used here but he does not impose long-run symmetry and homogeneity and asset shares depend on the aggregate price *level*. The above examples are not meant to highlight specific deficiencies in model building but merely to point out that obtaining acceptable results in this area has proved extremely difficult, to date.

In this paper we use a systems approach where the theoretical structure is based on the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer 1980). The long-run asset demand functions are determined using co-integration techniques (see Hendry 1986, Granger 1986) while in the 'second stage' we apply the 'general to specific' methodology in a systems framework, to establish a data coherent interdependent error feedback model. The long-run and short-run parameters are identified in the model. The methodology adopted allows one to 'search over' alternative short-run specifications independently of the theoretically acceptable long-run co-integrating relationships. We find that with a suitably flexible dynamic structure we obtain demand functions that are intuitively plausible and exhibit parameter stability, when the restrictions implied by the AIDS model are imposed. Thus our main aim in this paper namely to provide acceptable numerical values for the parameters of a model which obeys the restrictions implied by consumer demand theory (ie symmetry and homogeneity) is met. We also simulate the model to ascertain whether the time path to equilibrium is plausible. The simulation properties are important if the model is to be embedded in a large scale econometric model of the financial system. Clearly many different theoretical models are (broadly) consistent with consumer demand theory and we cannot claim generality here. However, when we have a large number of parameters to estimate and interpret and there is a need to investigate simulation properties, the linearity of the AIDS model under symmetry and homogeneity is a considerable practical advantage.

The rest of this paper is organised as follows. In Section II we outline the theoretical model and in Section III we consider the modelling of short-run dynamics in a systems framework and associated econometric problems. In Section IV we discuss data problems and in Section V we present our empirical results. We discuss simulation properties in Section VI and conclude with a brief summary.

II The AIDS model

The representative agent is assumed to distribute his wealth between alternative assets in order to minimise the cost of achieving a given level of utility. [1] The axioms of rational choice in demand theory (ie the existence of consistent preferences) are met providing we choose a cost function that is concave and homogeneous of degree one in prices.[2] Of the several flexible functional forms available we use the Price Independent Generalised Logarithmic (PIGLOG) which, in common with others (eg indirect translog, Christensen et al 1975) is a second order approximation but has the advantage of desirable aggregation properties and (approximately) is linear in parameters. Within the PIGLOG class we use the AIDS cost function (Deaton & Muellbauer 1980).

The budget constraint is:

$$\sum_i p_{it}^{\tau} \, a_{it+1}^{\tau} = W_t^{\tau} \tag{1}$$

where

- $p_{it}^{\tau} = \left((1 + r_{it}) \; (1 - g_z) \right)^{-1}$

- r_{it} = *expected* (proportionate) nominal return on asset i, between t and t+1 (including any capital gains).

- g_z = *expected* (proportionate) rate of goods price inflation between t and t+1.

- $a_{it}^{\tau} + 1$ = *real asset holdings* $\left(= \dfrac{a_{it+1}}{Z_{t+1}} \right)$

- a_{it} = nominal asset holdings of the i th asset

- Z_t = goods price index

1 See footnote on page 20.
2 See footnote on page 20.

- W^{τ}_{t} = real wealth $\left(=\dfrac{W_t}{Z_t}\right)$

The term p^{τ}_{it} is a real discount factor but by analogy with the AIDS model applied to consumer goods we refer to this as an (AIDS) 'real price'. Solving the constrained cost minimisation problem leads to the AIDS share equations (see for example, Barr and Cuthbertson 1989, Weale 1986):

$$s_i = \alpha_i + \sum_j \gamma_{ij} \ln p^{\tau}_{jt} + \beta_i \ln\left(\frac{W^{\tau}}{P^{*\tau}}\right)_t \tag{2}$$

where

- $$s_i = \frac{a_{it}}{W_t} \tag{3a}$$

- $$\ln p^{*\tau}_{t} = \sum s_i \ln p^{\tau}_{it} \tag{3b}$$

Note that $\ln P^{*\tau}_{t}$ may be interpreted as a composite real discount rate. The theoretical restrictions of the AIDS model based on consumer theory are:

The adding up constraints:

$$\sum_i \alpha_i = 1, \ \sum_i \gamma_{ij} = 0, \ \sum_i \beta_i = 0 \tag{4a}$$

Homogeneity:

$$\sum_j \gamma_{ij} = 0 \tag{4b}$$

Symmetry and negativity (of the Hicksian demand functions) are direct consequences of the axioms of rational choice. The former implies:[3]

$$\gamma_{ij} = \gamma_{ji} \tag{4c}$$

Negativity arises from the concavity of the cost function and implies that the matrix of coefficients k_{ij};

$$k_{ij} = \gamma_{ij} + \beta_i \beta_j \ln\left(\frac{W^{\tau}}{P^{*\tau}}\right) - s_i \delta_{ij} + s_i s_j \tag{4d}$$

3 See footnote on page 20.

is negative semi-definite (δ_{ij} is the Kronecker delta).

Our systems approach implicitly imposes data admissability in the form of adding up constraints and the additional theoretical constraints of symmetry homogeneity and negativity. Imposing symmetry and homogeneity reduces the number of parameters to be estimated and simplifies the interpretation of the model. In addition one might wish to judge the model on more intuitive notions, (eg that own price effects are negative, wealth elasticities are 'reasonable' etc).

In our 'consumer demand' approach perceptions of risk (ie variances and covariances of returns) are subsumed in the *parameters* of the cost function and changes in perceptions of risk, if important, will result in parameter instability (for evidence against time varying risk premia in the 1970s for OFIs see Blake 1986).

III Dynamic adjustment and economic issues

The long-run AIDS share equations (2) may be represented in vector notation;

$$s_t^* = \Pi X_t \tag{5}$$

where

- $s_t = kx1$ vector of asset shares;
- $X_t = qx1$ vector of independent variables;
- $\Pi = kxq$ matrix of long-run parameters.

In a system of asset demand equations if we include only own-lags, then we must implicitly accept that all assets adjust at the same rate (Smith 1975). To avoid this problem cross-lagged terms must also be included (Brainard and Tobin 1968). The latter can be rationalised by generalising the quadratic cost of adjustment function of Christofides (1976);

$$L^* = (s-s^*)_t' \, C_1 (s-s^*)_t + \Delta s_t' (C_2) \Delta s_t - (\Delta s_t) C_3 (\Delta s_t^*) \tag{6}$$

where C_i (i = 1, 2, 3) are conformable adjustment matrices. Minimising L^* with respect to s_t subject to the budget constraint we obtain generalised error feedback equations;

$$\Delta s_t = \Pi^* \, \Delta X_t + L(s-s^*)_{t-1} \tag{7}$$

where the disequilibria in (k-1) asset shares at time t-1 influence the current period adjustment of any particular asset share. Since $\sum_1^k (s_i - s_i^*)_{t-1} = 0$, only the ($k$-1) independent disequilibrium shares are required in (7) (ie L is (k x (k-1)) (Anderson and Blundell 1983). The adding up restrictions imply that the columns of Π^* and L sum to zero. In addition, on intuitive grounds we might expect the diagonal elements of L to be negative. However the latter is not required for dynamic stability. As long as the eigenvalues of the appropriate adjustment matrix have moduli less than unity, then the system is dynamically stable.[4]

One can also interpret (7) merely as a reasonably parsimonious method of incorporating dynamics while maintaining the adding up restrictions but without alluding to the cost function (6). We feel that quadratic costs are very unlikely to apply to adjustments in financial assets (eg costs are unlikely to rise smoothly with the size of the transaction undertaken) and we therefore interpret equation (7) merely as a convenient method of characterising sluggish adjustment. In principle it is possible to generalise (6) to yield a *multiperiod* interdependent costs of adjustment function but this rapidly becomes intractable (Currie and Kennally 1985), and still retains the unrealistic quadratic form.

Prior to the use of co-integration techniques estimation of (7) would have proceeded by running the unrestricted set of equations;

$$s_t = \hat{R}_1 s_{t-1} + \hat{R}_2 X_t + \hat{R}_3 X_{t-1} \tag{8}$$

The main disadvantages of this approach are threefold. First, one cannot (easily) impose long-run theory restrictions (eg symmetry and homogeneity) as these depend on the non-linear functions $\left(I - \hat{R}_1\right)^{-1}\left(\hat{R}_2 + \hat{R}_3\right)$ (but see Bewley 1979). Second, in testing down to a parsimonious dynamic representation (via restrictions on the R_i matrix elements) one implicitly alters the long-run solution and the final equation (possibly after considerable 'search-time' has been invested) may be unacceptable on *a priori* grounds. Third, we cannot be sure that the ensuing long-run solution yields a co-integrating vector. For example for the United Kingdom Weale (1985, 1986) is able to impose *short-run* symmetry and homogeneity (on the R_2 matrix) but these properties do not hold in the long run. Yet, one could argue that such properties are more applicable to the long-run rather than the short-run parameters. For the above reasons we consider a systems approach using co-integration techniques.

Co-integration establishes a parameter vector which yields stationary errors (Granger 1986, Engle and Granger 1987). Assuming all variables in the long-run share equations (5) are $I(1)$ and are co-integrated, then in the 'first stage' regression OLS on (5) yields superconsistent estimates of F.[5] The residuals from $(k-1)$ of the share equations are then substituted in the dynamic system error-feedback equations (Hall 1986). The 'general to specific' methodology is then applied in this 'second stage' to obtain parsimonious dynamic equations while holding the long-run parameters fixed (Hendry et al 1984). Although attractive, there are some practical problems with the two-step procedure. The co-integration regression estimates may suffer from small sample bias (Hendry 1986) and the co-integrating vector may not be unique (Johansen 1988). However, given the relatively strong theoretical restrictions to be placed on the long-run share equations (eg homogeneity and symmetry, negative own 'price' effects) we are mainly interested in finding a set of plausible parameter estimates that conform to theory and form a co-integrating vector. We are therefore willing to risk some small sample bias at 'stage one' (and possibly an inferior 'fit' of the final equation) in order to obtain a theoretically consistent approach. We therefore adopt an informal approach, trading-off 'fit' in the second stage regressions against the system restrictions implied by our theoretical model. The theoretical structure imposed by adopting the system approach therefore limits the extent to which one can indulge in 'overfitting' and data-mining. The final parsimonious system of equations is subject to parameter stability tests.

4 See footnote on page 20.
5 See footnote on page 20.

In order to impose cross equation restrictions on the long-run parameters we use maximum-likelihood with a diagonal covariance matrix (obtained from running OLS on each equation separately). When estimating the dynamic short-run equations we report results using 3SLS (Zellner and Theil 1962). Corrections for serial correlation in systems of equations are not possible with our current software (Berndt and Savin 1975) but because of our flexible lag response this was not found to be an acute practical problem.

In testing parameter constancy we have used (0,1) shift and slope dummies. The coefficients and t-statistics on the dummies then yield estimates of those parameters that undergo a structural break. A Wald test $W(r)$ on all the dummies yields an asymptotically valid test of parameter stability in the system as a whole. The dummies are included in the instrument set. As the Wald test is a large sample test and we have a heavily parameterised model we also use an adjusted Wald statistic:

$$WA(r) = W(r)\left(\frac{(nm-k)}{nm}\right) \tag{9}$$

where n = number of observations, m = number of independent equations, k = number of independent parameters in the system (Bewley 1983, Pudney 1981). Under the null, the Wald statistics are asymptotically distributed as χ^2 with r (= number of restrictions) degrees of freedom.

IV Data

We model the following asset categories of the OFIs (excluding building societies):

- Liquid (LQ) = sterling sight and time deposits, building society deposits and local authority temporary debt.
- Public sector long-term debt (PSL) = British Government securities, local authority long-term debt, miscellaneous public sector assets.
- Company Securities (CS) = Ordinary and preference shares of UK companies.
- Foreign currency (FC) = foreign currency deposits (net) and overseas securities.
- Loans (LN) =Lending, mainly in the form of hire purchase (excluding loans for house purchase?)

The above assets account for the bulk of the OFIs financial asset portfolio. We have delineated the problem by assuming decisions concerning the portfolio of financial assets to be weakly separable from real decisions (eg property). We also assume weak intertemporal separability.(6) This allows our set of assets to depend only on interest rates within this set of assets and the total wealth allocated to these assets. Formal non-parametric tests of separability (Varian 1983, Swofford et al 1986) are beyond the scope of the present paper.

6 See footnote on page 20.

The flow data is taken from the 'Flow of Funds' matrix in Financial Statistics. Revaluation indices are chosen to be consistent across sectors of the complete matrix. Benchmark stocks are then chosen such that *all* elements in the matrix satisfy the accounting identities (ie zero row-sums and column sums equal to the net acquisition of financial assets, NAFA). The data on OFIs assets used here therefore comes from a fully consistent complete stock-flow matrix. Data on the sight-time deposit split is only available from 1975(3).

The rates of return for the asset categories are:

- *LQ* : banks' 7 day deposit rate
- *PSL* : yield on long-term government stock plus capital gains based on the FT- Actuaries price index for all government stock
- *CS*: FT Actuaries All Share dividend yield plus capital gains based on FT- Actuaries all share index
- *FC* : Weighted average of (a) US dividend yield plus capital gains based on US share price index and the end quarter $/£ exchange rate; (b) interest on 3 month dollar deposits in London adjusted for exchange rate gains ($/£)
- *LN* : Finance houses base rate

Various forms for the rates of return on the capital uncertain assets, *PSL, CS* and *FC* were tried all of which included the running yield and a measure of capital gains. One quarter ahead and 1 year ahead capital gains variables gave very unsatisfactory results. Empirically, capital gains averaged over the previous three year period yield the best results. The latter suggest that OFIs behaviour may be governed primarily by hedging considerations and that they base decisions on a relatively long view about asset returns (see Weale 1985, for evidence supporting this view). If homogeneity is imposed then asset shares are independent of the rate of (goods price) inflation. We include inflation as a separate independent variable as it may contain additional information about *future* rates of return that are not picked up in our backward-looking rates of return variables.

There have been some major changes in institutional arrangements and in policy over the data period considered. The abolition of exchange controls in 1979 led to a rapid rise in OFIs holdings of foreign currency assets as they adapted to new opportunities in this market: this autonomous change will be reflected in other assets shares in the portfolio. Prior to 1979 the marketing of gilt-edged stock (the major part of PSL) was by 'tap issue' and the OFIs were encouraged to hold a large proportion of such assets by the authorities: the share of these assets rose sharply between 1970 and 1979. The increased pace of financial innovation in the 1980s, led to the introduction of interest bearing current accounts (eg during the 1970s less than 10 per cent of M1 was interest bearing, by 1987 this had risen to 65 per cent) and a wide range of 'new' instruments issued by building societies: *ceteris paribus* such changes might be expected to lead to an increased in the share of liquid assets held by OFIs. We capture these policy induced changes in behaviour with two time trends one capturing the post-1979 abolition of exchange controls and the other pre-1979 institutional arrangements in the gilts market.

All data used are seasonally unadjusted but seasonal dummy coefficients are not reported. The regressions are run over the period 1976(4)—1986(4). Critical values of test statistics are given at a 5 per cent significance level (unless stated otherwise).

V Empirical results

The estimated long-run AIDS share equations are:

$$s_t = \Gamma \, lnp_t^{\tau} + B \, RW_t + Jx + \alpha \tag{10}$$

- $st = k \, x \, 1$ vector of asset shares
- $lnp_t^{\tau} = k \, x \, 1$ vector of real asset prices
- $RW =$ log of real (AIDS) wealth $\left(= ln\left(\frac{W^{\tau}}{P^{*\tau}}\right)_t \right)$
- $x = m$, additional variables (eg inflation)
- $\Gamma = (k \, x \, k)$ matrix of 'price' coefficients
- $B = (k \, x \, 1)$ vector of real wealth coefficients
- $J = (k \, x \, m)$ vector of parameters
- $\alpha = k \, x \, 1$ vector of constants

Homogeneity implies that the row sums of the matrix Γ are zero and symmetry implies $\gamma_{ij} = \gamma_{ji}$. To satisfy the adding up constraint, the column sums of Γ, B, and J are zero and $\sum \alpha_1 = 1$.

The Dickey Fuller (DF) and ADF statistics (Table 1) indicate that none of the series are $I(0)$ (Dickey and Fuller (1979). In testing for $I(1)$ series all of the ADF tests (except those for s_1 and s_4) indicate $I(1)$ behaviour and the DF statistics clearly indicate that the variables are $I(1)$.[7] Given the small sample available we take these results to indicate $I(1)$ variables.

In reporting on a system of equations there is a danger in overwhelming the reader with a plethora of results. We have therefore chosen to concentrate on our preferred equations and their economic interpretation.

7 See footnote on page 21.

Table 1

Order of integration of the variables(1)

	I(0)		I(1)	
	DF	ADF	DF	ADF
s_1(LQ)	-1.2	-2.4	-7.5	-2.1
s_2(PSL)	-0.1	-0.2	-6.6	-3.2
s_3(CS)	-1.7	-1.9	-6.4	-3.8
s_4(FC)	-0.2	-0.1	-5.9	-2.0
RW	-1.1	-0.1	-4.9	-3.0
$\ln p_1$	-1.9	-1.8	-9.9	-3.4
$\ln p_2$	-1.6	-1.9	-10.8	-3.7
$\ln p_3$	-1.7	-1.6	-10.1	-3.4
$\ln p_4$	-1.2	-1.3	-9.8	-2.8
$\ln p_5$	-1.3	-1.6	-6.1	-3.4
g_z	-0.7	-1.9	-3.8	-3.1

(1) The critical values at 5 per cent significance level for DF and ADF are about 2.8 (Dickey and Fuller 1979).

Preferred long-run share equations

The preferred long-run share equations with symmetry and homogeneity imposed are shown in Table 2. The parameters of the AIDS model are not readily interpretable in terms of the usual economic concepts (eg elasticities) but the following general features are of interest.

- The residuals appear to be stationary especially given that the DF statistics have low power against highly dynamic stationary alternatives. The variables in Table 2 therefore provide a set of co-integrating vectors (Engle and Granger 1987, Engle and Yoo 1987). [8]

- The Box-Pierce, BP(1), statistics indicate severe first order serial correlation in the 'static' co-integrating regressions. As we have I(1) variables the *t*-statistics are not distributed as a students *t*-distribution and cannot be used for hypothesis testing on individual coefficients (but see West 1988). However, they do give a crude indication of the relative contribution of each variable in explaining the dependent variable.

- The 'own rate' price coefficients for γ_{ii}, are all negative. The $\gamma_{ij}(i \neq j)$ are positive except for company securities which is complementary with the two capital certain assets, loans and liquid assets. This may reflect a desire to limit the riskiness of the total portfolio when the rate of return on equities is sufficient to cause their demand to increase.

- The matrix of 'kij coefficients' (see equation 3d) evaluated at mean values of variables, has all eigenvalues negative and is therefore negative semi-definite.

- At high rates of inflation there is a net move out of capital certain assets (ie liquid assets and loans) and PSL into CS and foreign currency assets FC. Higher inflation may imply a lower expected sterling exchange rate and hence a higher expected return on foreign assets and this may not have been picked up by our backward looking price variable. Similarly, since future nominal dividend payments rise with inflation we might expect a positive inflation effect from this source, in CS.

- The real wealth effects RW on equities and liquid assets dominate the other three with liquid assets being an inferior good in the long run.

- The post-79 time trend mainly reflects an increase in the share of liquid and foreign currency assets and a fall in PSL and CS. Given the abolition of exchange controls in 1979 and increased financial innovation (eg interest bearing sight deposits, and introduction of a wide range of interest bearing building society deposits) this is not unreasonable.

8 See footnote on page 21.

Table 2

Long-run equilibrium model: homogeneity and symmetry imposed (1)

Price matrix Γ

		lnp_1^τ	lnp_2^τ	lnp_3^τ	lnp_4^τ	lnp_5^τ
1	LQ	-0.25 (1.6)	0.15 (1.4)	-0.15*	0.09 (1.4)	0.16 (1.2)
2	PSL	0.15	-0.52 (2.5)	0.01 (0.2)	0.19 (1.7)	0.17 (5.0)
3	CS	-0.15	0.01	-0.12 (1.5)	0.38 (5.0)	-0.12 (6.4)
4	FC	0.08	0.19	0.38	-0.72 (7.3)	0.06 (3.9)
5	LN	0.16	0.17	-0.12	0.06	-0.28 (2.0)

Diagnostics

		RW	TM (2)	TM79	g_z	R^2	Θ_i (3)	ADF	BP(4) (4)
1	LQ	-0.16 (12.7)	-0.001 (5.9)	0.006 (8.5)	-0.59 (1.76)	0.91	-0.25	-3.2	75
2	PSL	0.01 (0.36)	0.004 (14.56)	-0.010 (9.9)	-0.21*	0.86	-0.43	-4.6	27
3	CS	0.19 (10.4)	0.001 (2.2)	-0.003 (3.1)	0.21* (0.9)	0.90	-0.36	-3.5	31
4	FC	0.05 (2.8)	-0.003 (9.3)	0.006 (6.7)	1.48 (7.6)	0.98	-0.37	-3.7	25
5	LN	-0.08 (25.7)	0.001 (4.2)	0.001 (4.1)	-1.10 (18.4)	0.91	-0.84	-6.5	2.5

(1) Columns may fail to sum to zero due to rounding. 't-statistics' are in parenthesis but these are not distributed as a Students t-distribution. They provide a very imprecise guide to the statistical significance of the coefficients. A star * indicates the coefficient has been constrained.

(2) TM is a 'whole sample' time trend and TM79 is a post-79 time trend beginning in 1980(1).

(3) Θ_i is the coefficient in the regression:

$$\Delta e_{it} = \Theta_i e_{it-j} + \sum_{1}^{4} \Psi_j \Delta e_{it-j} \qquad (j = 1 - 4)$$

where e_i = residuals from the co-integrating regression, $\psi_j = 0$ (j=1-4) for the Dickey-Fuller (DF) test and $\psi_j \neq 0$ for the Augmented Dickey Fuller, ADF test. The critical values for DF and ADF at a 10 per cent signficance level are approximately -3.9 and -3.7 respectively. These are based on simulation (Engle and Granger 1987). We report only the ADF statistics since the estimated values $\psi_j \neq 0$ (j = 1-4) in all equations.

(4) BP(k) is the Box-Pierce statistic for serial correlation of order 1 to k. Under the null of no serial correlation it is asymptotically distributed as central chi-squared with k degrees of freedom. Critical value at 5 per cent significance level is $\chi_c^2(4) = 9.5$.

Table 3
Short-run model
Homogeneity and Symmetry Imposed[1]

Price Matrix C

		Δlnp_1^τ	Δlnp_2^τ	Δlnp_3^τ	Δlnp_4^τ	Δlnp_5^τ
1	LQ	-0.33 (1.4)	0.02 (0.1)	-0.10*	0.18 (1.5)	0.2 (1.2)
2	PSL	0.02	-0.27 (1.3)	0.00*	0.20 (1.4)	0.05 (0.8)
3	CS	-0.10	0.00	-0.02 (0.5)	0.24*	-0.11 (2.9)
4	FC	0.18	0.20	0.24	-0.65 (4.2)	0.04 (1.0)
5	LN	0.23	0.05	-0.12	0.03	-0.20 (1.1)

		ΔRW	ΔTM	$\Delta TM79$	Δg_z	R^2	$BP(8)$ (2)
1	LQ	-0.17 (6.0)	0.0006 (0.3)	0.0034 (1.4)	-0.85 (1.4)	0.41	4.9
2	PSL	0.03 (1.0)	0.0030 (1.6)	-0.0090 (3.2)	0.58 (0.7)	0.74	3.8
3	CS	0.24 (6.3)	-0.0020 (0.9)	-0.0027 (0.8)	0.70*	0.57	2.1
4	FC	-0.01 (0.2)	-0.0018 (1.0)	0.0073 (2.6)	0.77 (1.0)	0.88	2.8
5	LN	-0.09 (8.7)	0.0002 (0.5)	0.0010 (1.7)	-1.2 (5.3)	0.85	5.4

(1) A star * indicates the coefficient has been constrained. Asymptotic *t*-statistics in parenthesis.

(2) BP(k) is the Box-Pierce statistic for serial correlation of order 1 to *k*. Under the null of no serial correlation it is asymptotically distributed as central chi-squared with k degrees of freedom. Critical value at 5 per cent significance is $\chi_c^2(4) = 9.5$

Preferred short-run equations (Table 3)

The short-run equations are estimated by 3SLS, treating prices and wealth as endogenous. The instruments used are two lagged values (t-1, t-2) of all prices, wealth, and expenditure and two lags of the 3-month eurodollar rate. Drawing on (10) and (7), the short-run equations may be represented:

$$\Delta s_t = C \Delta lnp_t^\tau + K \Delta RW_t + F \Delta x_t + L(s - s^*)_{t-1} \quad (11)$$

where C, K, F and L are suitably dimensioned matrices of short-run parameters.

- Homogeneity and symmetry on the short-run price matrix (C) are imposed (Table 3), but are not rejected on a Wald test ($W(6) = 7.6$, $\chi^2_c = 12.6$). All 'own rate' coefficients are correctly signed (ie negative).

- The short-run inflation effect on CS is strongly correlated with its 'own price' coefficient and the latter had the 'wrong sign'. We therefore increased the inflation coefficient in the equation until the 'own price' had the correct negative sign. The return on company securities in the PSL equation was very small and on statistical grounds we could set it to zero, while the short-run coefficient on the equity price in the liquid assets equation was constrained to -0.1 to ensure that the short-run price matrix has the same sign pattern as the long run matrix. Given the large number of short-run parameters in the price matrix, C, the results in Table 3 are reasonable.

- The short-run wealth and inflation effects have the same sign pattern as in the long-run equations.

- The adjustment matrix L is shown in Table 4. All diagonal elements are negative indicating that excess holdings of asset 'i' leads to a fall in the share of asset 'i' in the subsequent period. The eigenvalues of the (augmented) L matrix have 'real parts' -0.79, 0.35, 0.56, 0.12, indicating a stable dynamic system.

Considering that the equations are explaining changes in asset shares the R^2 (Table 3) are good. The Box-Pierce statistics indicate that we can reject the hypothesis of serial correlation in the residuals. The interdependent error feedback formulation therefore appears to provide a data coherent (Hendry et al 1984) dynamic model.

TABLE 4

Short-run model: adjustment matrix, $L^{(1)}$

		Lagged Disequilibria			
		2	3	4	5
1	LQ	0.24 (1.5)	0.28 (2.2)	0.37 (1.9)	-0.53 (0.7)
2	PSL	-0.22 (1.2)	0.30 (2.0)	0.19 (0.9)	0.24 (0.3)
3	CS	0.35 (1.8)	-0.31 (1.8)	0.26 (1.1)	0.50 (0.5)
4	FC	-0.34 (2.0)	-0.27 (1.8)	-0.83 (3.9)	0.60 (0.7)
5	LN	-0.03 (0.7)	0.001 (0.0)	0.01 (0.2)	-0.81 (3.0)

(1) Asymptotic t-statistics in parenthesis.

Stability tests

The stability of the model is tested by adding slope and intercept dummies for the period 1980(1) — 1986(4) and testing the individual dummy coefficients and performing a joint test on all of these coefficients. The Wald and adjusted Wald statistics are $W(44) = 52$, and $WA(44) = 39$, with critical value 56. Parameter stability cannot be rejected on either Wald statistic.[9] Thus even though we have imposed some attractive restrictions on the model from a theoretical and intuitive viewpoint, it does appear to have stable as well as reasonable parameter estimates.

VI Simulations

Of key importance in financial models is the degree of asset substitutability or complementarity. The estimated model

9 See footnote on page 21.

was therefore used to simulate the effects of a 1% change in each of the rates of return. The base run is constructed by fixing all the explanatory variables at their 1986(4) values and allowing the model to run to convergence. The simulation runs are constructed by introducing a step change in the rates of return in 1988(1) Q1. Table 5 shows the one quarter impact effects on asset levels (£m) and the long-run effect of these changes. Charts 1 to 5 show the dynamic response paths.

In each example the asset stocks converge on their long-run levels relatively quickly, usually in about 4 quarters. The pattern over the first three quarters sometimes involves overshooting.

Chart 1 shows the effects of a 1 percentage (point) rise in the rate on liquid assets. It is clear that liquid assets and company securities are complements and adjust rapidly to equilibrium. PSL, LN and FC are substitutes and the latter exhibits overshooting. The response of all assets to a change in either the return on company securities (Chart 2) or foreign assets (Chart 3) is speedy and involves little or no overshooting. Foreign currency FC, assets and company securities are strong substitutes which is plausible. From Chart 2, we note that liquid assets LQ and loans LN are complements with respect to CS and substitutes (Chart 3) with FC assets.

Table 5

Impact on asset levels of changes in rates of return(1)

Current Period Impact Effect (£m)

Rate +1%	LQ	PSL	CS	FC	LN
LQ	269	-47	25	-188	-203
PSL	-14	232	11	-158	-44
CS	99	44	103	-146	107
FC	-149	-167	-205	550	-34
LN	-205	-62	66	-58	174
Long-run effect (£m)					
LQ	203	-159	71	-109	-142
PSL	-130	443	-7	-160	-141
CS	138	25	170	-276	102
FC	-68	-152	-302	617	-52
LN	-143	-157	68	-72	233

(1) Changes in rates of return are used and hence the sign pattern is the opposite of that on the AIDS price coefficients.

In Chart 4, the increase in the rate of return to loans LN, leads to an increase LN and CS: the latter are strongly complementary. This mirrors the results in Chart 2 and reflects the imposition of the symmetry condition. Without imposing this condition loans and company securities could be substitutes with respect to a change in one of the yields and complements with respect to a change in the 'other' yield. Clearly, this would be a somewhat counterintuitive result and is probably unlikely to be incorporated in a large scale econometric model of the financial system.

In Chart 5, we see the strong substitutability between PSL and (FC, LN, LQ) but CS does not respond to the change in the yield on PSL (this is mirrored in Chart 2, because of the symmetry condition). If the UK government uses its large budget surplus to reduce the National Debt by purchasing PSL, then it is likely that the OFIs will move into FC, LN and LQ rather than UK company securities. The net result, from our model is therefore downward pressure on the exchange rate and a faster growth in broad liquidity rather than a revival of the UK corporate bond market.

Chart 1
Simulation : liquid assets rate + 1%

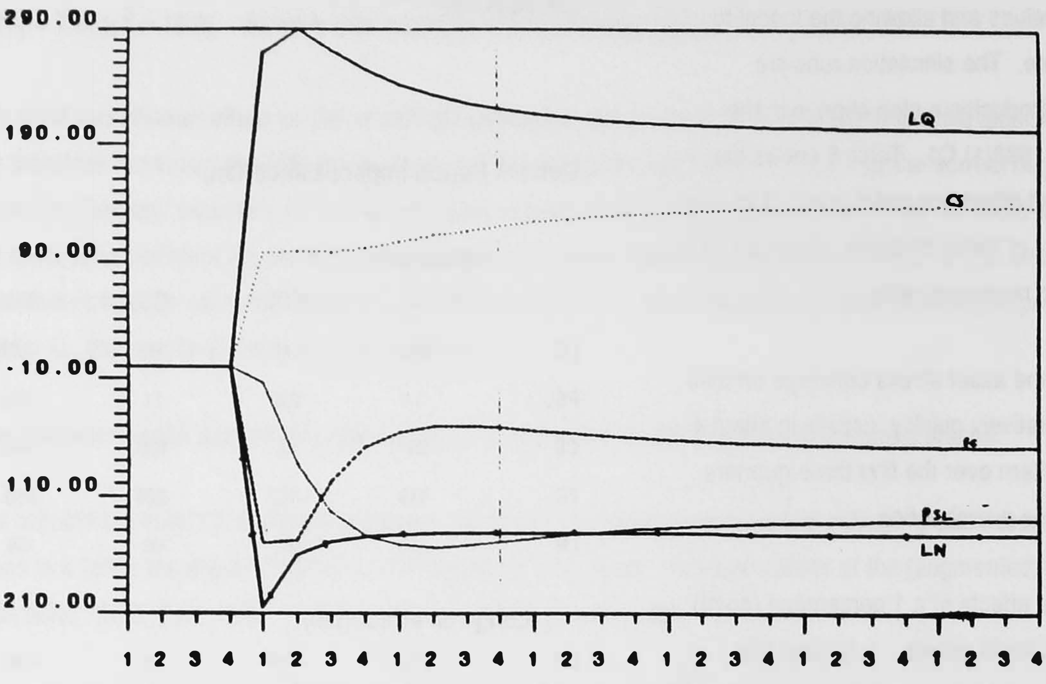


Chart 2
Simulation : CS rate + 1%

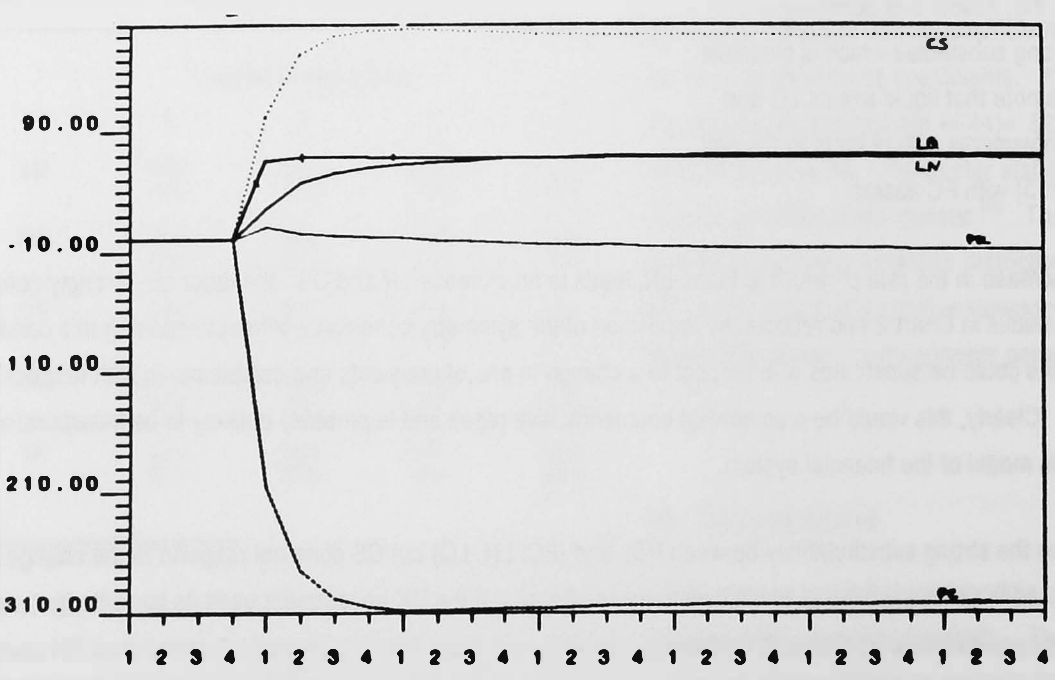


Chart 3
Simulation : Foreign assets rate + 1%

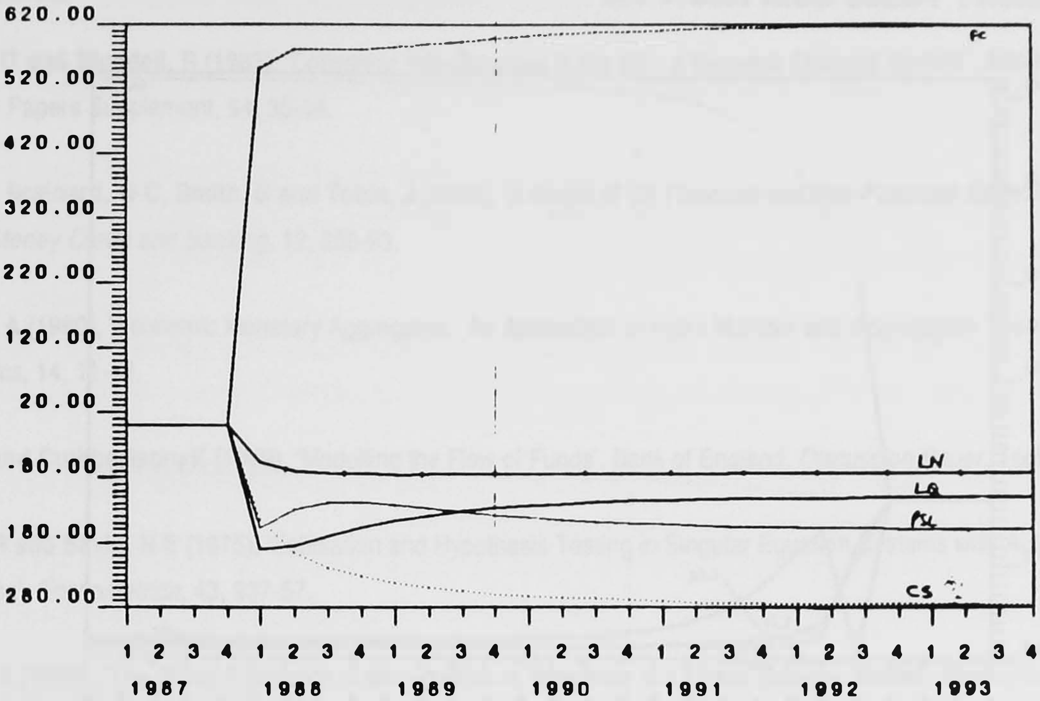


Chart 4
Simulation : Loan rate + 1%

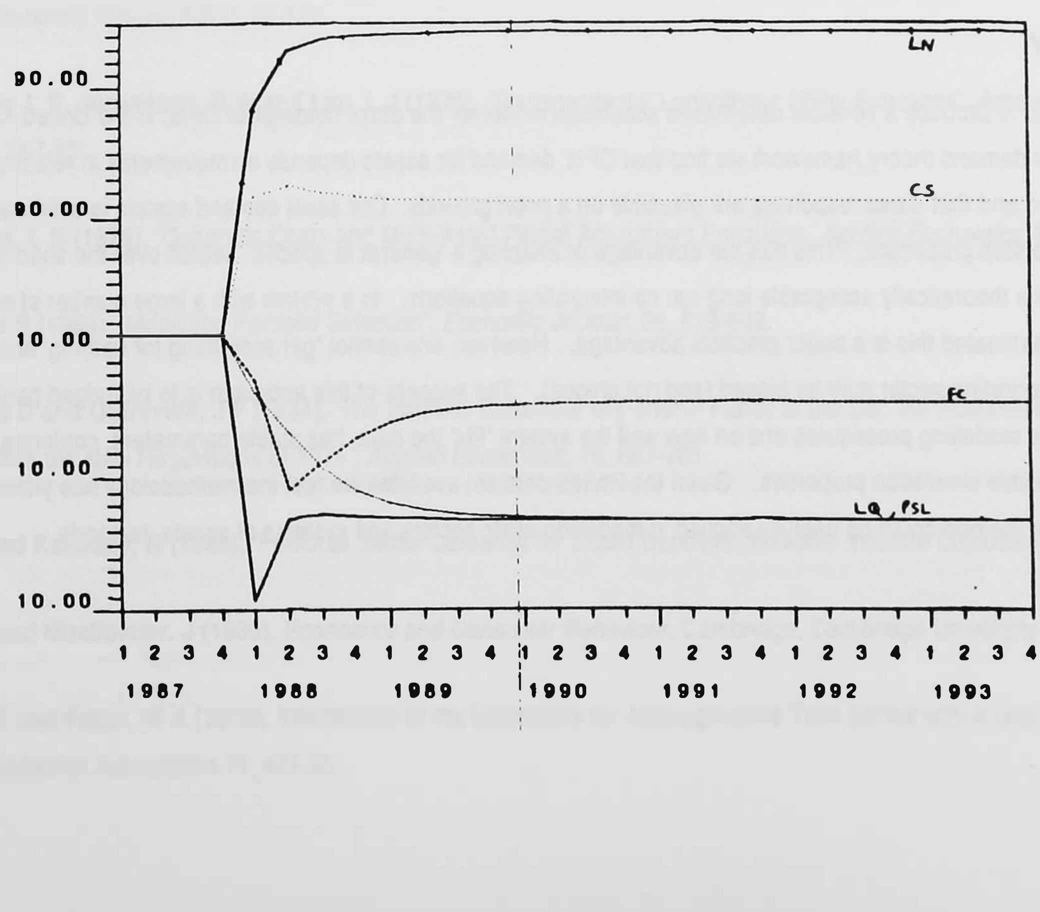
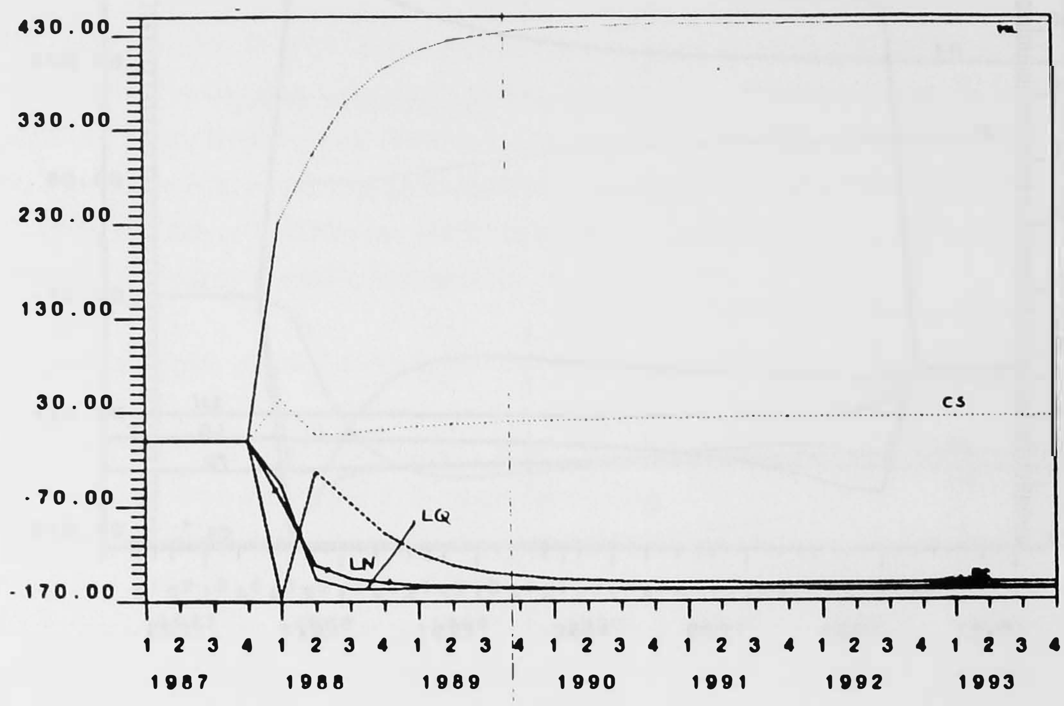


Chart 5
Simulation : Public debt rate + 1%



VII Summary

We have attempted to produce a sensible data-based simulation model for the asset holdings of OFIs, in the United Kingdom. Within a consumer demand theory framework we find that OFIs' demand for assets depends on movements in relative 'prices', real wealth and inflation and that these responses are plausible on *a priori* grounds. Our asset demand system is estimated using the Granger-Engle two step procedure. This has the advantage of enabling a 'general to specific' search over the short-run dynamics independently of the theoretically acceptable long-run co-integrating equations. In a system with a large number of potential parameters to be estimated this is a major practical advantage. However, one cannot 'get something for nothing' and in small samples the co-integrating vector may be biased (and not unique). The success of this approach is to be judged partly against alternative systems modelling procedures and on how well the system 'fits' the data, has stable parameters, conforms to theoretical priors and has sensible simulation properties. Given the limited data set available we feel the methodology has yielded reasonable results and that the method could be usefully applied in modelling other sectors and systems of assets demands.

REFERENCES

Anderson, G and Blundell, R (1983), 'Consumer Non-Durables in the UK: A Dynamic Demand System', *Economic Journal*, Conference Papers Supplement, 94, 35-44.

Backus, D, Brainard, W C, Smith, G and Tobin, J (1980), 'A Model of UK Financial and Non-Financial Economic Behaviour', *Journal of Money Credit and Banking*, 12, 259-93.

Barnett, W A (1980), 'Economic Monetary Aggregates: An Application of Index Number and Aggregation Theory', *Journal of Econometrics*, 14, 11-48.

Barr, D G and Cuthbertson, K (1989), 'Modelling the Flow of Funds', Bank of England, *Discussion Paper*, Technical Series, No 21.

Berndt, E R and Savin, N E (1975), 'Estimation and Hypothesis Testing in Singular Equation Systems with Autoregressive Disturbances', *Econometrica*, 43, 937-57.

Bewley, R A (1979), 'The Direct Estimation of the Equilibrium Response in a Linear Dynamic Model', *Economics Letters*, 3, 357-361.

Bewley, R A (1983), 'Tests of Restrictions in Large Demand Systems', *European Economic Review*, 20, 257-69.

Blake, D (1986), 'Testing A Non-Linear Model of Portfolio Behaviour with Time Varying Expectations and Risks: The Case of UK Private Sector Pension Funds', London Business School EFU, Discussion Paper (16,86).

Brainard, W C and Tobin, J (1968), 'Econometric Models: Their Problems and Usefulness: Pitfalls in Financial Model Building, *American Economic Review*, 58(2), 99-122.

Christensen, L R, Jorgenson, D W and Lau, L J (1975), 'Transcendental Logarithmic Utility Functions', *American Economic Review*, 65, 367-83.

Christofides, L N (1976), 'Quadratic Costs and Multi-Asset Partial Adjustment Equations, *Applied Economics*, 8, 301-5.

Courakis, A S (1988), 'Modelling Portfolio Selection', *Economic Journal*, 98, 619-642.

Cummins, J D and Outreville, J F (1984), 'The Portfolio Behaviour of Pension Funds in the US: An Econometric Analysis of Changes Since the New Regulations of 1974', *Applied Economics*, 16, 687-701.

Currie, D and Kennally, G (1985), 'Personal Sector Demands for Liquid Deposits', National Institute Discussion Paper, January.

Deaton, A and Muellbauer, J (1980), *Economics and Consumer Behaviour*, Cambridge, Cambridge University Press.

Dickey, D A and Fuller, W A (1979), 'Distribution of the Estimators for Autoregressive Time Series with a Unit Root', *Journal of American Statistical Association* 74, 427-31.

Engle, R F and Granger, C W J (1987), 'Co-integration and Error Correction: Representation, Estimation and Testing', *Econometrica*, 55, 251-276.

Engle, R and Yoo, S B (1987), 'Forecasting and Testing in Co-integrated Systems', *Journal of Econometrics*, 35, 143-159.

Ennis, N A and Fisher, D (1984), 'The Translog Utility Function and the Demand for Money in the United States', *Journal of Money Credit and Banking*, 16 (Feb), 34-52.

Feige, E L and Pearce, D K (1977) 'The Substitutability of Money and Near Monies: A Survey of the Time Series Evidence' *Journal of Economic Literature*, 15 (June), 439-469.

Friedman, B M (1977), 'Financial Flow Variables and the Short-run Determination of Long-Term Interest Rates', *Journal of Political Economy*, LXXXV, 661-689.

Gallant, A R and Jorgenson, D W (1979), 'Statistical Inference for a System Simultaneous Non-linear, Implicit Equations in the context of Instrumental Variables Estimation', *Journal of Econometrics* 11, 275-302.

Granger, C W J (1986), 'Developments in the Study of Co-integrated Economic Variables', *Oxford Bulletin of Economics and Statistics*, 48(3), 213-228.

Green,C (1984), 'Preliminary Results from a Five-sector Flow of Funds Model of the United Kingdom 1972-77', *Econometric Modelling*, 1, 304-326.

Hall, S G (1986), 'An Application of the Granger-Engle Two-Step Estimation Procedure to UK Aggregate Wage Data, *Oxford Bulletin of Economics and Statistics*, 48(3), 229-240.

Hall, S G, Henry S G B, and Wilcox J (1989), 'The Long-run Determination of the UK Monetary Aggregates', Bank of England, Mimeo.

Hartley, P R (1988), 'The Liquidity Services of Money', *International Economic Review*, 29(1), 1-24.

Hendry, D F, Pagan, A R, Sargan, J D (1984), 'Dynamic Specification' in Z Griliches and M D Intriligator (eds), *Handbook of Econometrics*, Vol 2, Amsterdam, North Holland.

Hendry, D F (1986), 'Econometric Modelling with Co-integrated Variables: An Overview', *Oxford Bulletin of Economics and Statistics* 48(3), 201-212.

Honohan, P (1980), 'Testing a Standard Theory of Portfolio Selection', *Oxford Bulletin of Economics and Statistics*, 42(1), 17-35.

Johansen, S (1988), 'Statistical Analysis of Co-integration Vectors', *Journal of Economic Dynamics and Control*, 12, 231-254.

Keating, G (1987), 'The Financila Sector of the London Business School Model ' in D Currie (ed), *Advances in Monetary Economics*, Londo, Croom-Helm.

Laidler, D E W (1977), *The Demand for Money*, New York, Dun-Donnelley.

Laidler, D E W (1980) ,'The Demand for Money in the United States: Yet Again. Carnegie-Rochester Conference Series, *On the State of Macroeconomics*, K Brunner and A Meltzer (eds).

Lucas, R E (1984), 'Money In a Theory of Finance', *Carnegie Rochester Series on Public Policy*, 21, 9-46.

Perraudin, W R M (1987) ,'Inflation and Portfolio Choice' *IMF staff papers*, 34, 739-759

Pudney, S E (1981), 'An Empirical Method of Approximating the Separable Structure of Consumer Preferences', *Review of Economic Studies*, 48, 561-77.

Roley, V V (1985), 'Money Demand Predictability', *Journal of Money Credit and Banking*, 17(4), 611-641.

Rossi, N (1987), 'An Intertemporally Quasi-Separable Demand System', *Review of Economic Studies*, August, 449-57.

Ryan, T M (1973), 'The Demand for Financial Assets by the British Life Funds', *Oxford Bulletin of Economics and Statistics*, 35(1), 61-68.

Serletis, A and Robb, A L (1986), 'Divisia Aggregation and Substitutability Among Monetary Assets', *Journal of Money Credit and Banking* 18(4), 430-446.

Smith, S G (1975), 'Pitfalls in Financial Model Building: A Clarification', *American Economic Review*, 65, 510-16.

Swofford, J L and Whitney, G A (1986), 'Flexible Functiional Firms and the Utility Approach to the Demand for Money : A Non-parametric Analysis' , *Journal of Money and Banking* 18(3), 383-389.

Taylor, J C and Clements, K W (1983), ' A Simple Portfolio Allocation Model of Financial Wealth', *European Economic Review 23*, 241-251.

Varian, H R (1983), 'Non Parametric Tests of Consumer Behaviour, *Review of Economic Studies*, L, 99-110.

Weale, M (1985), 'How Important Are Expectations? The Life Assurance and Pension Funds', Department of Applied Economics, Cambridge, Mimeo.

Weale, M (1986), 'The Structure of Personal Sector Short-term Asset Holdings' *Manchester School*, LIV(2), 141-161.

Weissenberger, E (1986), 'An Intertemporal System of Dynamic Consumer Demand Functions', *European Economic Review*, 30, 859-91.

West, K D (1988), 'Asymptotic Normality When Regressors Have a Unit Root', *Econometrica*, 56(6), 1397-1417.

Zellner, A and Theil, H (1962), 'Three Stage Least Squares: Simultaneous Estimation of Simultaneous Equations', *Econometrica* 30, 54-78.

FOOTNOTES

(1) One can argue that ultimately utility depends only on current and future consumption. However, in the absence of fully contingent binding contracts, when saving takes place, agents must hold some asset stocks, and it is reasonable to assume that agents are not indifferent to the composition of their assets. For example, Barnett (1980) incorporates assets and goods in the utility function in deriving Divisia aggregates. Asset holdings represent purchasing power over future consumption goods. In this framework any factors not in the wealth constraint that influence the composition asset holdings will implicitly be captured in the parameters of the utility function (see also Taylor and Clements 1983). An alternative approach as to why agents hold both cash and non-interest bearing chequing accounts may be found in 'cash in advance' models (Lucas 1984, Hartley 1988).

(2) The cost function is also usually assumed to be continuous in prices and that the first and second derivates with respect to prices exist.

(3) Note that 'adding up' and symmetry imply homogeneity. (Although homogeneity and 'adding up' do not imply symmetry.)

(4) If the disequilibrium term for asset 1 is excluded then the *estimated* adjustment matrix is:

$$L = (\underline{1}_2, \underline{1}_3, \ldots \underline{1}_k) \qquad k \times (k\text{-}1)$$

The dynamics of the full model may be written

$$s_t = (I_k + I^*)\, s_{t-1}$$

Where

s_t is $k \times 1$

$L^* = (i, \underline{1}_2, \underline{1}_3, \underline{1}_4)$ is $(k \times k)$

$i = (1,0 \ldots 0)$ is $(k \times 1)$

$I_k = kxk$ identity matrix

One of the eigen values of $(I_k + L^*)$ is unity and stability requires that the other $(k$-1$)$ eigenvalues have negative real parts.

(5) Shares cannot be a random walk since the latter is not bounded, however they can be non-stationary (but with a non-Gaussian error term at the boundary). Similar considerations apply to a variable such as the percentage unemployed or a bilateral exchange rate (which is bounded below). In any case in the data sample, the shares are I(1) and therefore any modelling strategy must utilise results from the unit-root and cointegration literature.

(6) For AIDS models that relax this assumption see Weissenberger (1986) and Rossi (1987).

(7) For s_1 and s_4 additional lagged difference terms $\Delta^2 s_{it-j}$ (j = 1-4) in the ADF test for an I(1) series are not significant. Hence the DF statistic is appropriate.

(8) The distribution of test statistics in multiple equations with I(1) variables and multiple unit roots has not yet been fully developed in the theoretical literature (see, for example, West 1988). This makes inference based on any regression containing I (1) variables hazardous: this caveat holds for the co-integrating t-statistics of Table 2.

(9) There are two dummy variable coefficients in the loans equation which have asymptotic *t*-statistics in excess of the critical value. These occur on the change in wealth and change in inflation variables which have *t*-statistics of 3.0 and 2.8 respectively. In a set of 40 tests at a 5 per cent critical value one would expect to reject a *correct* null hypothesis on two occasions. Hence these two rejections are not surprising.

Bank of England Discussion Papers

	Title	Author
1-5,8, 11-14, 16-17, 19-22, 31	*These papers are now out of print, but photocopies can be obtained from University Microfilms International* [a]	
6	'Real' national saving and its sectoral composition	C T Taylor A R Threadgold
7	The direction of causality between the exchange rate, prices and money	C A Enoch
9	The sterling/dollar rate in the floating rate period: the role of money, prices and intervention	I D Saville
10	Bank lending and the money supply	B J Moore A R Threadgold
15	Influences on the profitability of twenty-two industrial sectors	N P Williams
18	Two studies of commodity price behaviour: Interrelationships between commodity prices Short-run pricing behaviour in commodity markets	 Mrs J L Hedges C A Enoch
23	A model of the building society sector	J B Wilcox
24	The importance of interest rates in five macroeconomic models	W W Easton
25	The effects of stamp duty on equity transactions and prices in the UK Stock Exchange	Mrs P D Jackson A T O'Donnell
26	An empirical model of company short-term financial decisions: evidence from company accounts data	Mrs G Chowdhury C J Green D K Miles
27	Employment creation in the US and UK: an econometric comparison	I M Michael R A Urwin
28	An empirical model of companies' debt and dividend decisions: evidence from company accounts data	Ms G Chowdhury D K Miles
29	Expectations, risk and uncertainty in the foreign exchange market: some results based on survey data	M P Taylor
30	A model of UK non-oil ICCS' direct investment	E J Pentecost
32	The demographics of housing demand; household formations and the growth of owner-occupation	M J Dicks
33	Measuring the risk of financial institutions' portfolios: some suggestions for alternative techniques using stock prices	S G F Hall D K Miles
34	An error correction model of US consumption expenditure	I R Harnett
35	Industrial structure and dynamics of financial markets; the primary eurobond market	E P Davis
36	Recent developments in the pattern of UK interest rates	D K Miles
37	Structural changes in world capital markets and eurocommercial paper	J G S Jeanneau
38	Stockbuilding and liquidity: some empirical evidence for the manufacturing sector	T S Callen S G B Henry
39	The relationship between employment and unemployment	M J Dicks N Hatch
40	Charts and fundamentals in the foreign exchange market	Mrs H L Allen M P Taylor
41	The long-run determination of the UK monetary aggregates	S G Hall S G B Henry J B Wilcox
42	Manufacturing stocks; expectations, risk and cointergration	T S Callen S G Hall S G B Henry
43	Instability in the euromarkets and the economic theory of financial crises	E P Davis
44	Corporate governance and the market for companies: aspects of the shareholders' role	J Charkham
45	Stock-flow consistent income for industrial and commercial companies: the UK experience	K D Patterson
46	The money transmission mechanism	D K Miles J B Wilcox
47	Monetary aggregates in a changing environment: a statistical discussion paper	R D Clews Ms J E C Healey Glenn Hoggarth C R Mann
48	A model of manufacturing sector investment and employment decisions	J W Lomax
49	A simple model of the housing market	M J Dicks

Technical Series

	Title	Author
1-11,14,20 23	*These papers are now out of print, but photocopies can be obtained from University Microfilms International* [a]	
12	The development of expectations generating schemes which are asymptotically rational	K D Patterson
13	The arch model as applied to the study of international asset market volatility	R R Dickens
15	International comparison of asset market volatility: a further application of the ARCH model	R R Dickens
16	A three sector model of earnings behaviour	D J Mackie
17	Integrated balance sheet and flow accounts for insurance companies and pension funds	Raymond Crossley
18	Optimal control of stochastic non-linear models	S G Hall I R Harnett M J Stephenson
19	A multivariate GARCH in mean estimation of the capital asset pricing model	S G Hall D K Miles M P Taylor
21	Modelling of the flow of funds	D G Barr K Cuthbertson
22	Econometric modelling of the financial decisions of the UK personal sector: preliminary results	D G Barr K Cuthbertson
24	Modelling money market interest rates	J S Flemming D G Barr
25	An independant error feedback model of UK company sector asset demands	D G Barr K Cuthbertson
26	A disequilibrium model of building society mortgage lending	S G Hall R A Urwin
27	Balancing the national accounts: an asymptotically maximum likelihood approach using trends	G P Dunn D M Egginton
28	Testing a discrete switching disequilibrium model of the UK labour market	S G Hall S G B Henry M Pemberton
29	The Bank of England Model 1989: recent developments and simulation properties	F J Breedon A J Murfin S H Wright
30	A data-based simulation model of the financial asset decisions of UK, 'other' financial intermediaries	D G Barr K Cuthbertson
31	The demand for financial assets held in the UK by the overseas sector: an application of two-staged budgeting	D G Barr K Cuthbertson

(a) These papers are no longer available from the Bank, but photocopies can be obtained from University Microfilms International, at White Swan House, Godstone, Surrey RH9 8LW.