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Modelling the UK economy in a stock-flow consistent manner

by

E P Davis

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ABSTRACT

Most neo-Keynesian economic theory has tended to concentrate on flows and prices rather than stocks of assets and liabilities, and on comparative static rather than dynamic analysis of policy changes. The majority of large macroeconomic models of the UK economy have followed a broadly neo-Keynesian approach, in which, although some dynamics are included, financial asset stocks and the capital stock are either not defined or play very little role in the workings of the model(1), and thus some important aspects relating to equilibria or disequilibria are excluded. Macroeconomic theorists have generally been aware of these shortcomings in the 'neo-Keynesian approach', but only recently have economic models began to be constructed which allow consistently for stock-flow dynamics. Research on such models has been stimulated by various important recent economic developments in which stock effects are thought to have played a major role. For example, the increase in the personal saving ratio in a number of industrial countries in the 1970s has been attributed to inflation reducing the real value of the stock of monetary assets. Other examples are the evolution of the capital stock since the first oil shock, the stock implications of the US budget deficit, and portfolio shifts underlying the currency instability of the late 1970s and early 1980s. Partly reflecting these changes, there has tended to be a lengthening of the economic policy horizon.

After a discussion of the theory of stocks and flows in macroeconomics, this paper reviews the extent to which principal UK macroeconomic models incorporate stock-flow effects. The comparison reveals many discrepancies between the effects held by theory to be important and those incorporated in existing macroeconomic models. The paper then goes on to outline a small macroeconomic model of the British economy, featuring a fuller specification of the stocks produced by the economic processes involved, their feedbacks to flow equations, and their importance therein. The estimation and simulation properties offer a measure of the significance and size of these effects, and hence of the potential importance of their omission.

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(1) It should be emphasised that till recently this was partly also a consequence both of lack of data and of a relatively short economic policy horizon.

I INTRODUCTION: STOCK-ADJUSTMENT DYNAMICS IN ECONOMIC THEORY AND MACROECONOMIC MODELS OF THE UK

1 Introduction

This section discusses the main theories of stocks and flows in macroeconomics, concluding with an exploration of the extent to which the effects implied are included in macroeconomic models of the UK economy. The key theoretical developments analysed are small "dynamic IS/LM models" of stocks and flows, particularly those stemming from the work of Blinder and Solow (1973), Tobin and Buiter (1976), and Smith (1980). However, other areas of theory are also touched upon, in particular the valuation ratio (Tobin's 'q') as a determinant of investment, portfolio adjustment systems and their use to determine asset prices, and the treatment of capital gains and losses on assets in sectoral income. These give rise to important stock effects which impinge on economic variables. Although the models illustrated are broadly 'Keynesian' in conception they are not necessarily restricted to Keynesian paradigms. 'Monetarist' effects and restrictions are easily imposed and tested.(1)

It should be emphasised that important fields of research are omitted in this brief survey, notably Metzler models (see Metzler (1951), Branson and Teigen (1976), Dornbusch (1975)), and dynamic financial portfolio models (see Backus, Brainard, Smith and Tobin (1980) and Papademos and Modigliani (1983)). However, in general these models describe processes similar to dynamic IS/LM models, and can be seen respectively as simplications for basic analytical purposes and extensions for more articulated analysis.

The author wishes to thank colleagues in Economics Division at the Bank of England and at the Bank for International Settlements for help, encouragement and advice, particularly J S Alworth, P S Anderson, G Bingham, P S O'Brien, G I Evans, W W Easton, J S Flemming, K Gardiner, C A E Goodhart, N H Jenkinson, S Key, P D Mortimer-Lee, G Midgley, I M Michael, K D Patterson, J Ryding I D Saville and C T Taylor. The errors remain his own responsibility.

(1) Monetarists such as Brunner and Meltzer (1972) were amongst the first to draw attention to wealth effects, the importance of the budget constraint and portfolio equlibrium.

2 Dynamic stock-flow effects

The basic implication of stock-adjustment dynamics is that the short run "IS/LM" equilibrium solution of a typical textbook, 'extended Keynesian' model [see, for example, Branson (1979), including IS/LM, a labour market and production function], implies values for the rates of change of stocks that the model takes as given. Movement of these stocks through time changes the short run equilibrium itself and the associated prices and flows. Before considering some of the specific models which capture these stock-flow interactions, and by way of an illustration, the simple example of the stock effects of a budget deficit is considered.

A static 'extended Keynesian' model of a closed economy determines levels of employment, income, interest rates and prices, holding the money stock, government expenditure and the tax schedule constant. However, if in equilibrium tax revenue is less than government expenditure, stocks of assets cannot be constant as the deficit needs to be financed (equation (2.1) below). Thus, if the budget deficit is financed by money creation, the money stock in an initial static IS/LM equilibrium is growing, and the equilibrium itself is shifting as the LM curve moves to the right. This process increases money incomes via falling interest rates, rates rising investment, and the multiplier and hence raises tax revenues (assuming positive marginal tax rates) . Eventually the point is reached where g = t(y), the budget is balanced, the money stock ceases to grow and there is full stock/flow equilibrium. Conditions for stability can be derived as follows. (2.1) can be rewritten as (2.2) because the level of income is a positive function of money and public expenditure (the price level is hence assumed constant). Then, differentiating gives condition (2.3) for stability in the simple case. The requirement for stability is that the money stock must tend to its equilibrium (balanced budget level of income) size at a decreasing rate.

In a simple closed economy with the government deficit wholly monetised:

$$\frac{dM}{dt} = P\,[g - t(y)] \qquad (2.1)$$

$$\frac{dM}{dt} = P\,(g - t[y\,(M,g)]) \qquad (2.2)$$

$$\frac{d(dM/dt)}{M} = -\,Pt' \cdot \frac{y}{M} \qquad 0 \qquad (2.3)$$

where M is the nominal money stock

P is the price level (constant)

t' is the marginal tax rate

y is real pre-tax of income

g is real government expenditure

If prices are allowed to adjust, there may be instability if they change faster than real income, because the budget deficit might grow, rather than contract, as the money supply increases. 'Monetarists' would tend to expect instability, while 'Keynesians' would expect price movements to be slow compared with those of real income, fulfilling (2.3).

The treatment of stock effects of bond as well as money finance of budget deficits, and a more complete description of effects of changes in the money stock, require the introduction of wealth effects to certain demand equations.(1) Wealth effects in the consumption function imply that an increase in real net wealth should boost consumer demand. Assuming that both money and bonds are net wealth,(2) this means that both money and bond financed deficits will shift the IS curve to the right, thus increasing the tendency of the economy to shift towards the income level that implies a balanced budget. Wealth effects in the LM curve imply a portfolio balance approach to the demand for money - a purely 'transactions' view where only income determines the demand for money would omit these effects.

The theory of portfolio-choice suggests that agents distribute demand for financial assets across instruments on the basis of risk, expected returns on each of the relevant instruments and the size of the total portfolio to be allocated. As wealth increases, the demand for all assets, including money, rises. The use of a portfolio balance approach to asset holdings is important to the overall argument of this paper, and is discussed further below. At this stage, the importance of portfolio considerations lies in the inclusion of wealth in the money-demand equation, and hence the LM curve. This implies that, while a money-financed deficit shifts LM to the right, a bond-financed deficit raises the demand for money without changing the supply, shifting LM to the left. Thus a bond-financed government deficit has an ambiguous effect on income, with

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(1) At this stage we only discuss 'outside' wealth issued outside the private sector. For a discussion of inside/outside wealth see pp105.

(2) Some economists [see Barro (1974)] would argue that bonds are not net wealth, as they are in effect cancelled by expected future taxes to repay them. It might be argued that this is unlikely to be the case when deficits are cyclical and thus "washed out" over longer time horizons, but may be so when deficits are structural.

deleterious effects on investment through rising interest rates possibly offsetting the expansion caused by the government expenditure itself, and by wealth effects on consumption.(1) This means that, while the change in income required to balance the budget is identical to the money finance case, given the simple tax function shown on page 3, the economy may actually move away from the income level required to balance the budget.(2)

This analysis may be extended to cover the interaction between the budget and balance of payments. In a fixed exchange rate system with no government deficit, monetary inflows (outflows) accompany a balance of payments surplus (deficit) and shift the LM curve until balance is restored. When there is a money-financed budget deficit, there must be a payments deficit to offset it for a static equilibrium. But this flow equilibrium cannot persist as it will imply a stock disequilibrium, with domestic money continually flowing to foreign holders. Their portfolios will eventually become unbalanced when they hold more domestic money than they desire, generating selling pressure on foreign exchanges and eventually necessitating a devaluation. Full stock equilibrium is again only reached at the level of income generating a zero budget deficit and payments surplus, with the money stock no longer changing, the path to which may be unstable, depending on the characteristics of the various functions.

Besides money, bonds and foreign assets, the capital stock (held privately) also forms part of net private wealth, and changes in it cause changes in productive potential. The static model omits the feedback from fixed investment to the capital stock, which will not only shift the IS and LM curves via wealth effects, but also the production function and the link between the capital stock and its financing. In fact, we would expect a model to exhibit a hierarchy of adjustments over time, with portfolio adjustments being important in the short run, followed by employment, "stock" and price effects, and finally full adjustment with capital accumulation. A long-term definition of stock equilibrium including the capital stock would lead to an explicit discussion of growth theory, which is beyond the scope of this paper. But it is intended to integrate the capital stock as far as possible in the analysis of dynamics below.

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(1) Stein (1976) has argued that this question underlies much of the Monetarist-Keynesian controversy.

(2) For a discussion of possible destabilising effects of bond finance, see Blinder and Solow (1973).

We now go on to discuss theoretical stock flow effects in greater detail, using as a framework the "dynamic IS/LM model" developed from the work of Blinder and Solow (1973), and Tobin and Buiter (1976) by Smith (1980). A review of these models is given in Currie (1978).

3 Dynamic IS/LM models

Smith's basic model of a closed economy (in continuous time) was as follows:

$$\dot{K} + G' - 0.25Y = 0.05\,(3.6Y - W) + \Pi^e\,(m + b) \qquad \text{(I=S)} \qquad (3.1)$$

$$\left(-0.0039 + \frac{0.000695}{r + \Pi^e} + 0.064\,\frac{Y}{W}\right) W = m \qquad \text{(L=M)} \qquad (3.2)$$

$$W = m + b + K \qquad \text{(private wealth)} \qquad (3.3)$$

$$\dot{K} = 0.05\left(\frac{0.30Y}{r + 0.05} - K\right) \qquad \text{(investment)} \qquad (3.4)$$

$$\dot{m} = \alpha(G' - 0.25Y) - \Pi m \qquad \text{(growth of m)} \qquad (3.5)$$

$$\dot{b} = (1 - \alpha)(G' - 0.25Y) - \Pi b \qquad \text{(growth of b)} \qquad (3.6)$$

$$F(K) = 1000K^{0.30}/3000^{0.30} \qquad \text{(production function)} \qquad (3.7)$$

$$= g\,[Y - F(K)] + \psi\Pi^e \qquad \text{(Phillips curve)} \qquad (3.8)$$

$$\dot{\Pi}^e = \psi(\Pi - \Pi^e) \qquad \text{(price expectations)} \qquad (3.9)$$

Where: Y = real net national product, C = real consumption, G' = government expenditure including debt interest, the non-interest element of which is assumed exogenous, ie a policy variable, K = real physical capital stock, P = price level, Π = rate of inflation, Π^e = anticipated inflation rate, B = nominal stock of government bonds, assumed to have fixed interest coupons and redemption values (b = real), M = nominal supply of outside money (m = real), r = anticipated real rate of return on debt, t = income tax rate (policy variables), W = real private wealth.

The model was designed for use in simulations - the parameter values are imposed, based on plausible estimates for the US - but for current purposes it is the specification which is of more interest. As will be shown, each of the equations incorporates a stock-flow effect thus ensuring the model is fully consistent in this sense.

The IS curve, equation (3.1) implies that the private sector has a long run target wealth/disposable income ratio (ignoring rate-of-growth effects) of 4.8,[1] where the income tax rate is 0.25. Savings in equation (3.1) aim to close the gap between actual and desired wealth at 5% per period, where the private sector's budget constraint for asset accumulation is:

$$0.75\,[Y + (r + \Pi^e)\,b] - C - \Pi^e\,(m + b) \qquad (3.10)$$

which equals the saving rate, 0.05 (3.6Y-W)

and, rearranging, the implicit consumption function is:

$$C = 0.76\,(1 - 0.25)\,Y + (1 - 0.25)(r + \Pi^e)\,b + 0.05W - {}^{e}(m + b) \qquad (3.11)$$

This model thus can be seen to have <u>wealth effects</u> in the consumption function in terms of a target wealth/income ratio (as derived above), and to deduct losses incurred as a result of inflation on the real value of stocks of net monetary assets from income - the term $\Pi^e(m + b)$. This adjustment to income, discussed at length for the UK by Taylor and Threadgold (1979), and used empirically by Hendry and Von Ungern Sternberg (1980), leaves income as "the accrual which would <u>cet par</u> leave wealth intact", a definition often attributed to Hicks.[2] The intuitive rationale is that, during inflationary periods, the real value of monetary assets is eroded, and part of personal income must be directed to the maintenance of their real value if portfolio balance is to be maintained. In the case of interest bearing assets such as bonds, part of the interest paid on the assets and included in income is actually repayment of capital in this sense, while notes and coin can be viewed as bearing negative real interest. It should be noted that physical capital is excluded from the definition of monetary wealth, on the ground that it gives a real return (in accordance with the marginal productivity of capital) which is largely unaffected by inflation. Redefinition of income in this manner ensures that real saving equals real accumulation of wealth (abstracting in this simple model from market valuation effects).

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(1) The term (3.6 Y-W) shows the target wealth/total income ratio to be 3.6. Given an income tax rate of 0.25, the corresponding ratio of wealth to disposable income is 3.6/0.75 = 4.8.

(2) The exact quotation, from Hicks (1936) P 172 is "the maximum one can consume in a week and still expect to be as well off at the end as the beginning."

Equation (3.2) is an LM curve where the demand for money depends on wealth, income and the nominal interest rate, the interest rate reflecting the yield spread between money and bonds. In this portfolio adjustment system, bond demand drops out by Walras Law, while in the absence of equity (portfolio claims to real capital) direct asset substitution between these financial assets and capital is not possible[1], though capital is a component of real wealth (equation (3.3)). That is to say, physical capital is assumed to be perfectly illiquid.

Equation (3.4) shows that the demand for capital depends on the gap between market valuation (as proxied by the discounted present value of profits) and replacement cost, where capital's share of income is 0.3, and the risk premium on capital compared with bonds is 5%. This equation introduces a further important use of stock concepts, the valuation ratio, or "q". Basically, this suggests that investment occurs when the ratio of market valuation of firms to the replacement cost of their capital exceeds one (see Tobin (1969), Jenkinson (1981), Hayashi (1982), Abel (1982)).[2] Here the equity valuation is modelled fairly crudely, and average rather than marginal "q" is proxied, but the essential point is conveyed (average and marginal values of q will move together only in a Cobb-Doublas production function).

In equations (3.5) and (3.6), the growth of the real money and bond supplies[3] are shown in terms of the government deficit and the government's gains from erosion of the real value of outstanding liabilities, offsetting the private sector's losses. The obvious point is that an asset of one sector is the liability of another, so changes in the value of assets stocks on one sector imply offsetting changes in another sector. This does not, however, mean that the net effect of erosion is zero as the equations imply asymmetric responses to gains and losses by the private and public sectors.[4]

Equation (3.7) is a production function which shows the determination of full employment output by the capital stock, defined as the output compatible with a zero steady state inflation rate.(5) The labour market is encapsulated in the

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(1) This assumption appears to have the unrealistic corollary that individuals cannot own tangible assets, even houses.

(2) The intuitive explanation is that when "q" exceeds one at the margin, the expected profit stream generated by new capital will exceed the cost of extra finance needed to acquire it.

(3) The value α in this equation reflects the policy choice between issue of money and bonds.

(4) In the long run, such asymmetries could generate growing and unsustainable financial flows.

(5) The mechanisms in the model cause output to fall below full employment when steady state inflation is non zero.

Phillips curve, equation (3.8). A coefficient of ψ of below 1 in this equation can permit a long and short run trade off between output and inflation. If ψ = 1, then F(K) is the 'natural rate' of output, the only level consistent with non-accelerating inflation (bearing in mind that this model leaves out productivity effects). Price expectations in equation (3.9) are adaptive, the degree of adjustment depending on the coefficient θ. Smith's model in equilibrium thus determines income and the interest rate, given stocks, expectations and policy. Changes in stocks and expectations are determined by their own partial adjustment equations, and such changes will feed back to income and the interest rate until the growth of the stocks in real terms is zero. The steady state solutions, ie when all stock changes are zero, price expectations are constant (though inflation can be positive) and assuming ψ = 1, are then:

$Y = F(K)$	(natural rate)	(3.10)
$0.3Y = (r + 0.05)K$	(desired capital)	(3.11)
$G' = 0.25Y + \Pi(m + b)$	(budget balance)	(3.12)
$\Pi[m - \alpha(m + b)] = 0$	(asset composition)	(3.13)
$0.014 + 0.000695/(r + \Pi) = m/W$	(long run LM)	(3.14)
$3.6Y = m + b + K$	(desired wealth)	(3.15)

(3.10) shows that, in a 'natural rate' world, steady state output is supply determined and depends on the size of the capital stock, (3.11) shows desired capital, (3.12) that the government deficit[1] must be large enough for nominal debt to grow as fast as prices, or alternatively that government spending must be financed by tax revenue and capital gains. (3.13) shows that the stock and flow composition of debt must coincide, unless inflation is zero. (3.15) equates actual and desired wealth in terms of total income, while (3.14) is the LM equation consistent with desired wealth. This steady state is implausible as capital accumulation and hence saving is zero. A corresponding set of conditions for balanced growth could be derived by working with variables relative to the capital stock, so that in equilibrium all real quantities grow at the same rate as capital, or by allowing for depreciation of capital, which could be set equal to saving.

Simulations carried out by Smith with this model suggested that fiscal policy effects on the real economy are positive and sizeable, and that the greater the proportion of budget deficits that are money financed, the more likely the steady state is to be stable. This is because output depends on the capital stock, the

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(1) It should be noted that government expenditure is exogenous in this model. A more plausible formulation might relate it partially to Y-F(K).

capital stock depends in turn on the interest rate, and the interest rate has a stronger tendency to fall when the budget deficit is money financed than for bond finance. As in the simple model above, the mechanism is that in order for sufficient tax revenue to be generated to cover a simulated once-for-all increase in government expenditure, income and hence productive capacity must be increased, the transmission mechanism here being the falling real interest rate and increased investment caused by increases in the money stock.

The Tobin/Buiter model as extended by Smith (henceforth TBS) introduces many of the crucial concepts of stock/flow modelling, as outlined above. It is, however, only a two sector model (private and government). It thus leaves out transactions involving assets within the private sector and with the overseas sector. Consequently 'inside wealth' cannot affect economic decisions. Neither does the model analyse in detail the problems of productivity and employment.

Disaggregation of the private sector would allow one to distinguish equity, private bonds and inside money. Such disaggregation will be important if subsectors respond asymmetrically to changes in their stocks of assets and liabilities, as expressed, for example, in a price differential between claims on existing capital and new capital. Inclusion of equity would allow one to define 'q' more precisely than using a proxy as in equation (3.4). Introduction of equity requires a modeller to take a view, inter alia, of the determination of actual and expected equity prices, the real rate of return on equity, the allocation of unexpected capital gains on equity, and also to extend the financial sector. These problems have been discussed at length elsewhere (see, for example, Turnovsky (1979)).[1]

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(1) The main problems discussed in Turnovsky's analysis are as follows. Actual equity prices in equilibrium are determined by the condition of capital market equilibrium that the market value of equity equals the discounted value of expected future profits to be derived from the capital stock. However, the problem of modelling expectations of future profits arises, and also the market may (due to market imperfections, habits and lags) deviate from such an equilibrium. Expected equity prices depend on the expected nature of some future capital market equilibrium. Thus adds the problems of knowing the quantity of equity and of physical capital in existence in the future to those of estimating actual equity prices. In each case the assumption of perfect foresight is the simplest but is not realistic. Alternative expectational paradigm are rational or adaptive expectations.

Extension of the financial sector to include equity as a substitute for money and bonds suggests use of a portfolio system (see, for example, Tobin (1969)). This might be specified as follows:

$$M/P = L\ (Y,\ r_E,\ r_B - \Pi,\ -\Pi,\ W) \qquad (3.16)$$

$$B/Pr = J\ (Y,\ r_E,\ r_B - \Pi,\ -\Pi,\ W) \qquad (3.17)$$

$$P_E E = N\ (Y,\ r_E,\ r_B - \Pi,\ -\Pi,\ W) \qquad (3.18)$$

$$W = M/P + B/Pr + P_E\ E \qquad (3.19)$$

where r_E is the real rate of return on equity, P_E is the real price of equity (the nominal price per share divided by the general price level), E is the number of shares outstanding, Y is the disposable income of the private sector, r_B is the nominal rate of return on bonds and other variables are as above. The wealth constraint imposes restrictions on the partial derivatives of the asset demand functions. The sum of the coefficients on wealth in (3.16 - 3.18) should be unity, (any increase in wealth must be allocated to some asset), while the sum of the coefficients on income and rates of returns should separately equal zero (any increase in demand for an asset due to changes in these variables must be met by a compensatory reduction in demand for other assets).(1)(2) Since wealth holders are assumed not to suffer from inflation illusion, the interest rates must be defined as shown in real terms. This structure is general and can be applied to other financial assets (foreign assets etc). Three limitations of the structure as presented should be noted. First the interest rates and returns on the assets are actually endogenous to the extent that the sector is a dominant holder of these assets and not exogenous to asset demand as implied in the equations.

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(1) These restrictions also mean that only two of the equation 3.16 - 3.18 are independent, while the third drops out. However, care is needed in specification to avoid implausible coefficients being imposed on the implicit third equation, as emphasised by Brainard and Tobin (1968).

(2) Total financial asset holdings, W, are nevertheless responsive to Y and r_i through the consumption function and its implications for saving.

Secondly allocation of unexpected capital gains or losses is not included in the adjustment process. In a portfolio model a plausible mechanism would imply that in each period such gains are partly retained in the asset in which they arise (due to inertia and their unplanned nature) and partly distributed across other assets in accordance with portfolio equilibrium. Thirdly as presented the system does not allow for constraints on asset holdings, which due to financial regulation and the imperfection of capital markets may often have been important. Such effects can be built in to some extent (See Backus, Brainard et al 1980)).

A further extension to include a foreign sector would also require consideration of the foreign demand for money and bonds, a decision whether to combine foreign reserves with the money supply, and the modelling of the government's reactions to changes in the money supply thus defined (sterilisation etc).

Inclusion of more sectors and instruments thus entail many extensions to the simple model described above. Some of these are explored below. The following section briefly assesses several major macroeconomic models of the British economy in the light of the theory discussed above; a more complete analysis of which can be found in the Appendix.

4 Stock-flow effects in macroeconomic models

The above section has highlighted potentially important economic processes which might be incorporated in macroeconomic models of the UK economy. In fact, analysis of the models shows that many are not included and those that are included are often not introduced in a systematic or consistent manner.(1) The results are summarised in the table overleaf, and discussed in more detail in the Appendix, p96. A central deficiency is that the capital stock is rarely used as a link from investment to production, or as an item in the wealth portfolio. Lacking a capital stock, it is difficult (unless a vintage approach is adopted) to utilise the concept of a production function which in an integrated model would influence output, determine full employment output, and give an indication of factor productivity. Equally, the value of equity should be defined in relation to the capital stock and the marginal productivity of capital. Since neither the capital stock nor equity are generally introduced explicitly in macro models, neither Tobin's "q" nor the lagged capital stock (2) can be used in investment functions, nor can personal and company sector responses to the value of the capital stock be distinguished.

Besides the capital/production nexus, there is frequently an omission of portfolio adjustment systems based on demands for stocks of financial assets. These systems could be used directly to determine interest rates and the exchange rate, to help to give a consistent treatment of capital gains and losses on financial assets in sectoral income, and to give a wealth stock usable to influence behaviour in such equations as the consumption and labour supply functions. Finally, omission of the stock effects on money and bonds arising from government deficits, operating via such portfolio demand systems, renders incomplete a model's account of the effects of fiscal policy. For example, changing private asset stocks generated by budget deficits might be expected to feed back to activity, prices and interest rates.

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(1) Some examples of consistent empirical modelling of stock-flow effects have been carried out abroad. In particular, see the work of Masson et al (1980)(1985) for Canada, which may be compared with the work in Section III below.

(2) Of course, the capital stock is often proxied by appropriate lags of investment.

STOCK-FLOW EFFECTS AND CONSISTENCY IN UK MACROECONOMIC MODELS

Model	Capital stock	Production function	Equity stock	Portfolio adjustment	Hicksian sectoral income	Wealth effects on expenditure	Stock effects of budget deficits	External assets
Cambridge	No	No	No	No	Yes	Yes	No	No
National Institute	Manufacturing investment function only	No	No	Non-bank private sector only	Personal sector only	No	Yes	No
Bank Medium Term	Investment function only	No	No	No	No	Inflation rate proxy in consumption function	No	Yes
Bank Short Term	Investment function only	No	No	Personal sector only	Personal sector only	Yes	Yes	Yes
Treasury	Non manufacturing investment function only	No	Personal sector only	Non-bank private sector only	Personal sector only	Yes - consumption and labour supply functions	Yes	Yes
LBS	No	No	Yes	Yes	No	Yes	Yes	Yes
City University	Yes	Yes	No	No	No	Yes	Yes	No
Liverpool	In wealth portfolio but not production function	Yes	No	Yes	No - losses and revaluations in wealth	Yes	Yes	Aggregated with domestic assets

II A STOCK-FLOW CONSISTENT MACROMODEL (SCHEMA) OF THE UK ECONOMY

1 Introduction

Section I has both suggested important stock-flow effects that macroeconomic theory implies may be crucial to an understanding of the dynamics of an economy, and pointed out various lacunae in the modelling of stocks and flows in most macroeconomic models of the British economy. This section describes estimation and simulation of a small annual macromodel of the British economy in which the theoretical effects described in Section I are allowed for - to the extent that "yes" could be entered in all of the columns of the table on page 15. The significance of these effects in estimation give a reflection of their importance. Their operational relevance is also shown by the difference they make to the models' simulation properties, discussed briefly in Section 4b(ii) below. The model is aggregated to four sectors - public, overseas, company and personal sectors, with the overseas sector only very incompletely modelled. It should be emphasised that the model, as presented, has some shortcomings. Use of annual data means a shortage of degrees of freedom in estimation, and hence restricts equations to having simple dynamics, and presents problems in the interpretation of asymptotic diagnostic statistics such as the Lagrange Multiplier test. Quarterly data were not used owing to resource, time, and data constraints. Also the model uses several rather crude statistical series - particularly those for the capital stock and estimates of capacity utilisation - is "eclectic" between neoclassical and Keynesian paradigms in key equations and markets, and has many equations which could perhaps be improved upon statistically. The basic model does not feature "monetarist" effects from the money stock to consumers' expenditure and the labour supply: effects here are confined to total wealth. However, a variant is presented below (page 61) showing the effects on simulation properties of different wealth definitions in the consumption function.

2 Outline of the model

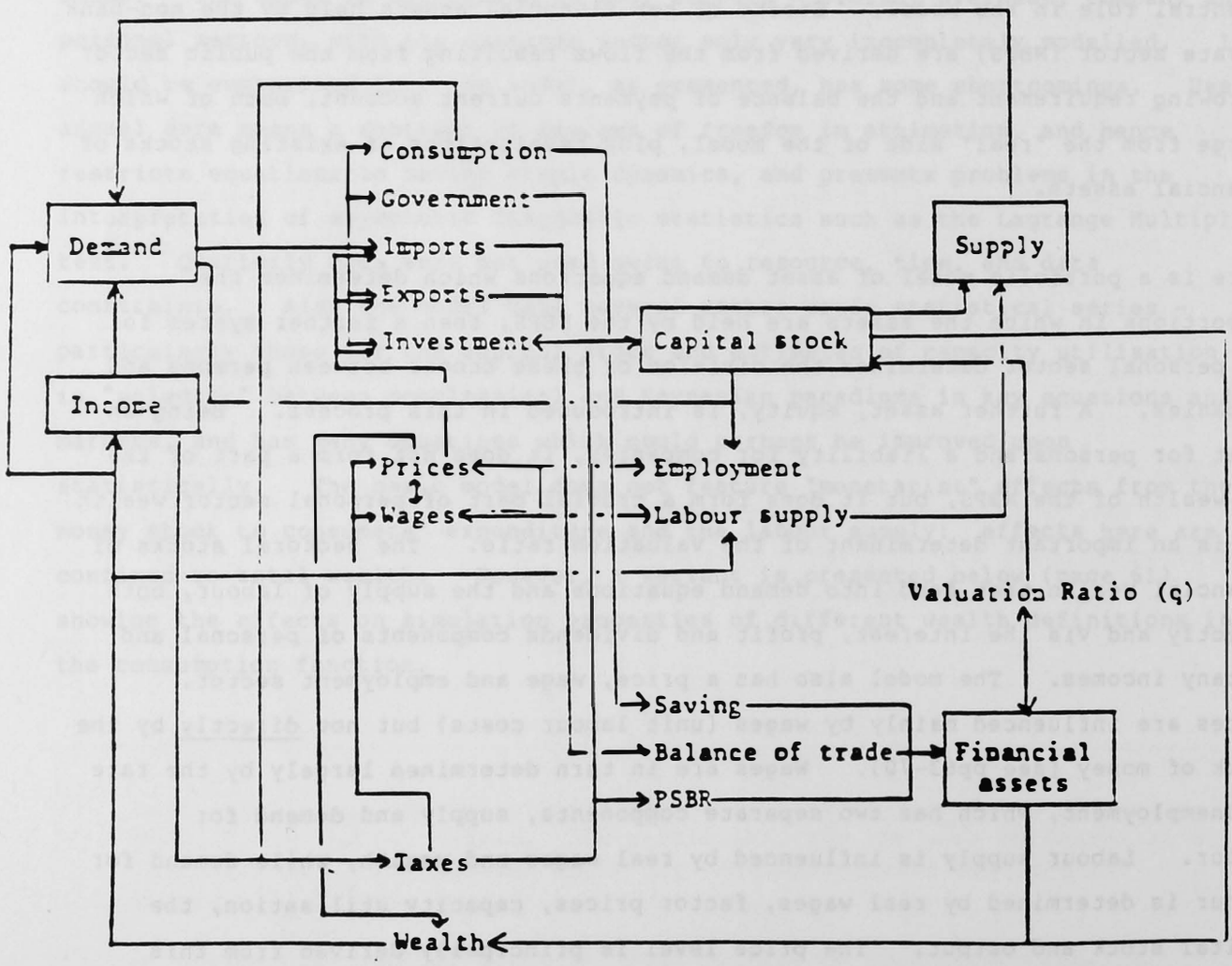
Because of the high level of aggregation the model itself, as its name suggests, is more an outline or a plan than a full disaggregated system. However, further simplification may be of use for showing the processes involved. The basic structure is that of a dynamic IS/LM model, as described above (pages 7-10).

The model builds up expenditure from the components of demand - consumption, investment, etc - in a familar Keynesian manner. However, investment is cumulated to give a capital stock - the investment function itself being basically a neoclassical factor demand equation with the valuation ratio (q) as a key independent variable. This capital stock is combined with the labour force in a mainly imposed production function to give a measure of capacity output which depends in the reduced form on relative prices. The difference between capacity output and actual output (as proxied by aggregate expenditure) then feeds back to the key expenditure and factor demand equations. The capital stock is thus given a central role in the model. Stocks of net financial assets held by the non-bank private sector (NBPS) are derived from the flows resulting from the public sector borrowing requirement and the balance of payments current account, both of which emerge from the "real" side of the model, plus revaluations of existing stocks of financial assets.

There is a portfolio model of asset demand equations which determines the proportions in which the assets are held by the NBPS, then a further system for the personal sector determines the division of these stocks between persons and companies. A further asset, equity, is introduced in this process. Being an asset for persons and a liability for companies, it does not form a part of the net wealth of the NBPS, but it does form a crucial part of personal sector wealth and is an important determinant of the valuation ratio. The sectoral stocks of financial wealth then feed into demand equations and the supply of labour, both directly and via the interest, profit and dividends components of personal and company incomes. The model also has a price, wage and employment sector. Prices are influenced mainly by wages (unit labour costs) but not <u>directly</u> by the stock of money (see pp63-70). Wages are in turn determined largely by the rate of unemployment, which has two separate components, supply and demand for labour. Labour supply is influenced by real wages and wealth, while demand for labour is determined by real wages, factor prices, capacity utilisation, the capital stock and output. The price level is principally derived from this

sector via unit labour costs, and is in turn the key influence on the exchange rate and hence competitiveness, though interest rates and portfolio balance considerations are also important. Interest rates themselves are determined partly by external considerations (the government varies interest rates to stabilise the exchange rate) - a reduced form portfolio effect - but some portfolio effects also enter directly.

This outline is summarised in the diagram below. It should be emphasised that this by no means describes the full set of effects contained in the model. These are described in detail in Sections 3 and 4 below.



3 The model in more detail

It should be noted at the outset that several features of the model are derived from existing modelling practice. In particular, the wage, price and exchange rate equations are developed from those currently used in the Bank of England medium term model, and the factor demand equations are derived from a KLEM production function in a similar way to those used in the CUBS model. Such claims as there are to novelty relate to changes made to these specifications, the rest of the model, and the way in which the whole is assembled.

The following section describes the main equations, their position in the structure and the relationships between them. References are to the list of equations starting on page 71.

(a) Components of aggregate demand

(i) Consumption (equation A8)

The consumption function is an annualised version of the equation proposed by Hendry and Von Ungern Sternberg (HUS) (1980), using variables appropriate to the aims and level of aggregation of the model. The equation is thus used to determine aggregate consumption, while "wealth effects" enter via the real net wealth of the personal sector, netting off building society deposits against mortgages. Hence this aggregate includes money, bonds, foreign assets, equity and the net residential capital stock, less bank advances. Assets held via life assurance and pension funds are included in this aggregate. The lagged asset stock is deflated by the lagged price level. As pointed out by Pesaran and Evans (PE) (1984), this may cause "dynamic misspecifications when prices are changing, and can cause overprediction of consumption when prices are rising rapidly". However, deflation by the current price level may also cause problems. If all assets are indexed and inflation approaches infinity, the wealth term approaches zero, with negative effects on consumption. The adopted solution to this problem has been to redefine the income term as suggested by Patterson (1984), and as shown in equation A7 below.

Income in this model comprises the level of real personal disposable income less the losses due to inflation on the stock of real net liquid assets and plus (minus) the net capital gains or losses on illiquid financial assets such as gilts and equities.

A wider range of inflation adjustments are thus made than in HUS (1980). However, unlike the results of PE (1984), strong effects from illiquid asset revaluations on consumption, were not found. This is economically plausible, as most of these assets are held by the rich (who would have a low marginal propensity to consume) or indirectly via life assurance and pension funds[1]. Grid search (to minimise the residual sum of squares) suggested that a coefficient of only 0.06 was appropriate for these gains and losses. Inflation losses are entered in two terms. The first term is the net proportionate loss due to inflation ($\dot{P}$) times the lagged nominal asset stock, (A), deflated by the current price level (P). However, as:

$$\dot{P}.\ \frac{A_{-1}}{P} = [\frac{\dot{P}}{1 + \dot{P}}].\ \frac{A_{-1}}{P_{-1}}$$

then entering the latter definition ensures the problems posed by very high rates of inflation no longer occur, while still taking into account the change in the price level over the current period. The second term gives the approximate losses due to inflation on the nominal assets appropriated during the period - an effect omitted from the definition above. This is done using the formula:

$$(1 - (1 - \frac{\dot{P}}{1-\dot{P}})^{1/2}).((A - A_{-1})/(P.P_{-1})^{1/2})$$

in each case.

The preferred version of the consumption function (A8) has the expected signs for derivative, proportional and integral control terms. It has a short run marginal propensity to consume (MPC) out of income of 0.6, and a long run MPC from the real asset stock of around 0.2 cet par. The statistical properties are fairly satisfactory. The choice of variables can of course be criticised in various ways. Aggregation of durables with non durables ignores evidence that their behaviour and determinants are rather different (see Mizon and Hendry (1980)) and eliminates the possibility of using stocks of durables as a component of wealth, determinant of expenditure, and influence (via depreciation) on income (see Patterson (1984)). Secondly, other variables such as hire purchase controls and real interest rates (to show intertemporal substitute and/or cost of credit effects) might be felt to be important. However, results to date have suggested that these do not have strong effects in this formulation. Thirdly, the breadth of the wealth definition might be questioned - other studies have generally used the narrower 'net liquid assets' definition. Results presented below (page 85) suggest that, although narrower definitions are accepted by the data, the broader definition is superior in terms of goodness of fit.

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(1) PE did not include such indirectly-held assets in their definitions.

(ii) Stockbuilding (equation A9)

The behavioural equation determines the total level of stockholding, with the flow of stockbuilding determined as the first difference of this stock. The specification postulates a long run homogeneous relationship between the stock level, demand (GDP(E)) and the real interest rate, modified in the short run by the rate of growth of demand, the rate of growth of capacity utilisation and a larger real interest rate effect. Stocks thus build up when the economy grows, when the interest rate falls or when capacity utilisation falls, all of which seem reasonable. Capacity utilisation has a 't' value below two, but, in general, the diagnostics suggest that the equation fits fairly well.

In the simulation presented later (page 48), it is seen that stockbuilding is the main cause of cyclical fluctuations in this model. This is in line with actual experience. The interest rate effect also ensures that it is an important transmission mechanism for financial effects. The term in the growth rate of capacity utilisation, ensures that stocks fulfil a'buffer' function when the economy cycles about its trend path.

The rest of the stockbuilding sector determines nominal stockbuilding and stock appreciation in a fairly conventional way. There are no sectoral stockbuilding equations in the model: for simplicity, inventories are assumed to be held and built up 80:15:5% by the company, personal and public sectors.

(iii) Private gross fixed investment (equations A14 and A15)

The function for non-residential investment is a factor demand equation derived from a KLEM (capital, labour, energy, raw materials) production function as suggested in Nickell and Andrews (1982) and Beenstock et al (1983), substituting out the demand equations for energy and materials into the production function algebra. However, the cost of capital is replaced by the valuation ratio or "q". In theory, "q" should encompass all the necessary information on factor prices and quantities, leaving only itself and the lagged capital stock in the equation. However, experimentation showed that factor prices did not influence the share price, but did have an important independent influence on investment when "q" is in the equation, so they remain. Wages, which proxy the price of labour though excluding employers' National Insurance and pension contributions, were found to be insignificant in the investment function.

'q' is defined broadly as suggested in Jenkinson (1981), as the nominal stock of equity [1] outstanding divided by the replacement cost of the net non-residential capital stock, taking into account investment allowances. As described below, the share price brings into this variable the influence of company liquidity[2], interest rates and capacity utilisation, while 'q' is obviously also influenced by lagged investment, investment allowances, stockbuilding and inflation (which raises the replacement cost of the capital stock).[3] 'q' is thus a pivotal variable in the model. It enters the equation in log form - thus as it varies about its equilibrium value of one, the log changes about zero. This was felt to give a more plausible response path than entering the linear version in a log equation, as it gives a stronger effect of falls in 'q' on investment and weaker effects of rises than the linear case. This asymmetry is in line with the likely pressures on management to act in each case - it is probably easier to postpone investment decisions when business is good than to resist the pressure to cut investment under adverse conditions.

The equation also features the lagged gross capital stock(thus giving it a 'capital stock adjustment' basis), a time trend (giving trend growth) and a constant. All variables are entered with lags, which can be justified by reference to costs of adjustment, delivery lags, planning periods etc. The price elasticities suggest that capital is a complement to energy but a substitute for raw materials, as appears borne out by the fact that fuel crises have been accompanied by declining investment, while increases in general raw material prices have led to greater investment to increase efficiency in use of materials. These materials prices are influenced directly by the exchange rate (equations E14 and E15) on the assumption that fuel and raw materials are generally either imported or priced in dollars, or both. The exchange rate is thus an important influence on investment, with depreciation leading on balance to higher investment. The coefficient of -0.5 on the lagged capital stock suggests that adjustment occurs fairly rapidly towards the desired level of the stock.

The diagnostics suggest that the equation gives a reasonable description of the data, though the Lagrange Multiplier test exceeds the critical level of 6. The size of the time trend also seem a little implausible. The equation for housing

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(1) It has been suggested that use of stock market data for 'q' may be unreliable, as the variance of share prices does not conform with the underlying volatility of dividends. Hence share prices may be a biased proxy for firms' underlying profitability. However, they were the best proxies available.

(2) See also Chappell, Cheng and Richards (1984).

(3) See Abel (1982) for a discussion of 'q' and the interaction of tax policy and accelerated depreciation due to inflation.

investment (A15) has a fairly conventional "supply side" specification, whereby the real short rate (representing builders' borrowing costs), the labour cost/price ratio (showing other costs in relation to a proxy for selling prices) and the lagged capital stock influence investment, in a partial adjustment framework. All signs are as might be anticipated, and all coefficients are significant. The powerful real interest rate effect makes this equation an important conduit for monetary policy. Such an effect has been widely observed elsewhere (see Easton (1985)).

Total fixed investment is completed by public investment, which is exogenous.

(iv) Capital stock (equations A17 -A21)

The capital stock data used in the model are consistent with those published in the 1983 "Blue Book" (CSO 1983). As described on page 114 (ibid), the imputed asset lives were shortened for that set of data, so as to be a great deal more in line with the perceptions of the undertakings owning the capital. While retaining their well-known imperfections (see, for example, Maurice (1968)), the data should thus be more realistic than hitherto.

In order to simplify the model, the real stocks have been defined by deflating the current price stocks by the appropriate (flow) investment deflators. Use of constant price numbers would mean a proliferation of deflators, and perhaps little gain in precision, since the current price numbers are understood by the author to be the basic calculations from which the constant price data are merely derived by estimation. Current price stocks are designated by the letter 'C' in the equation listing, constant price by 'K'.

Turning from the data to the specifications, real gross and net private, (residential and non residential) and gross public, (non-residential) capital stocks are determined endogenously, all at replacement cost. Gross stocks are used throughout in activity equations (investment, production function), as in principle, assuming no deterioration in the physical productivity of the capital good, they measure more closely the productive capacity of the capital.(1) Net

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(1) This is a strong assumption, and is incorrect to the extent that capital equipment deteriorates in physical productivity over its service life. However, the view was taken that any marked deterioration would be met by scrapping, and that the alternative assumption of a continuous falling-off of productivity towards zero at life's end was considerably more unrealistic. To the extent that the assumption is false, the equations will overstate the economy's productive potential and understate the incentive to invest, at least in so far as these depend on levels rather than trends in gross capital.

stocks are used where a wealth measure is required, since they measure the part of capital which is likely to be realisable. (To clarify concepts, 'gross capital' measures the size of the extant capital stock net of scrapped assets, while the net capital stock deducts from this an allowance for depreciation due to the age of assets in relation to their expected lives). In the model, as shown on page 73, the gross stocks are estimated using simple equations whereby gross investment is added to the lagged capital stock less an estimate of scrapping, as captured by a coefficient on lagged capital of below one. Estimates for the non-residential capital stock suggest average asset lives of around 50 years, which is long compared with other countries, though not in comparison with assumptions made by government statisticians. The private residential stock lasts longer, as might be expected, though the lagged dependent variable of 0.999 is perhaps too high.

This methodology for gross stocks is valid in a steady state, where investment occurs continuously and smoothly, and assets are correspondingly scrapped smoothly after asset lives expire. Obviously the history of investment has not been a steady state; cycles, wars, etc having intervened. This methodology will thus be subject to error. However, it was felt that the alternative of determining scrapping explicitly by tracing the history of different types of capital good, using historic investment series and various asset lives would be excessively complex. Hence smooth implied rates of scrapping were used as an approximation and residuals added to aid tracking over historic periods.

The real net stocks are estimated as simple proportions of the gross stock in each case, though a time trend is included in the residential stock. The nominal net stocks are these real stocks times the appropriate price deflators. Thus important valuation effects on these variables during inflationary periods are captured.

(v) Trade equations (equations A22, A23)

The export and import functions embody both "price" and "activity" effects, together with capacity utilisation. Oil is omitted from the equations and left as exogenous.

In the case of exports (A22), there is a long run unit elasticity with world trade (OECD trade weighted industrial production), modified by the ratio of sterling export prices to the sterling equivalent of UK trade weighted competitors' prices, in "effective" units[1] rather than dollars. This construct allows exchange rate modelling to concentrate on the effective and not the dollar rate and should,

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(1) That is, using an index for foreign prices based on the sterling trade weighted exchange rate index.

in any case, give a more sensitive picture of the UK's competitive position, vis-a-vis the world and not just the US. Short run price and activity effects are also entered into the equation. The lower coefficients than those in the long run allow the equation to exhibit 'J curve' effects. The lagged level of capacity utilisation has a positive coefficient, showing that, as utilisation grows, exports are choked off, being sucked back into the home market. It might be felt to be implausible that such an effect should occur independently of price changes, though one might argue that it would occur in the case of 'satisficing' firms, who, with growing capacity utilisation, would take the easier option of serving home market buyers, rather than seeking export markets. Conversely, when demand is slack, there would be more incentive to try to sell abroad, while prices might not be cut so as to protect margins. The export function selected appears to have reasonable statistical properties.

The import function (A23) again features a long run unit elasticity between imports and activity - in this case, domestic activity as indicated by total final expenditure.(1) As in the export function, the restriction of unit elasticity was tested and found to be accepted by the data. This effect is modified by the ratio of sterling import prices to domestic prices, and a time trend, indicating a long run growth in import penetration. In the short run, there is a large response of imports to growth in domestic demand - a short run elasticity of 1.8. This "overshooting" is in line with other studies of imports and past experience. The capacity utilisation term indicates that imports are sucked into the UK economy as full capacity is neared - again a common feature of the trade cycle. Similar arguments about the plausibility of pure volume responses to shortages and excess demand must be accepted. The import function fits badly compared with the export function, and the LM statistic shows that some autocorrelation remains.

(vi) Other elements of demand

The factor cost adjustment (FCA) is the difference between GDP at market prices and factor cost, and comprises the net value of indirect tax and subsidy payments. It was estimated using weights based on the level of such taxes and subsidies on government current expenditure, fixed investment and exports, taken from the Bank of England short term model.

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(1) This aggregate was used instead of GDP as the latter excludes the effect of demand for imports.

The coefficient on consumption was left to be estimated, and gave a coefficient of 0.15. The FCA deflator is defined to follow the path of the GDP deflator, modified by changes in the indirect tax rate.

Aggregated demand is given by the summation of the components described above, in a normal Keynesian manner.

(i) Labour supply (equations B1, B2)

Modelling of the labour supply proved a particularly difficult exercise. Data availability enforced the use of the definition 'employment plus unemployment', which may diverge from those actually in the "labour force", for example, by a lack of benefit entitlement preventing those seeking work from signing on as unemployed. The formulation hypothesises that changes within sample in the labour force participation ratio are composed of two factors. Firstly, there is a demographic shift influenced by social factors, ie the increasing labour force participation of married women, for evidence on which, see Greenhalgh (1980), Joshi (1983). This change is proxied by a constant and a time trend, as it is assumed not to be influenced by economic variables identified in the model. Secondly, deviations about the trend are influenced by economic variables - personal sector real net wealth (as in the consumption function), post tax real wages and the rate of unemployment (the discouraged worker effect). The reason for this two stage process, besides its economic plausibility, is that, if economic variables are entered at the first stage, then trends in wealth and wages capture the 'social' trend, giving implausibly large elasticities. Wages and wealth were chosen as variables as they indicate respectively income available after entering the labour force, and the assets which could be drawn down if an individual chooses not to join the labour force. The equation (B2) could be criticised for omission of non-labour income and also because certain other transfers are not included in wages. Benefits are omitted as their effect is ambiguous - many individuals not in the labour supply are entitled to supplementary benefit, which is at broadly the same level as unemployment benefit, and many who are seeking work are not entitled to unemployment benefit. The rate of unemployment emerges as an important determinant of the labour supply, but causes problems in simulations as it induces cycling of the labour supply and unemployment rate. The imposition of the four year averaging constraint reduces this problem, and may give a plausible planning period for labour supply decisions. The other determinants are also still significant after several lags were taken. The behaviour of this equation in simulations is discussed further below.

(ii) Labour demand (equations B3, B4)

Private sector demand for labour is defined to include the self employed as well as employees in employment. Although objectionable in some ways, as self employment might be seen as a substitute for employment, it may be argued in favour of this aggregation that demand for self employment is likely to depend on similar factors to those determining employment, ie output, costs, the level of the capital stock etc. Labour demand is determined by a factor demand equation derived similarly to the investment function (1), with the addition of a term in aggregate demand. This term was added to give a more plausible response of the equation to increased demand in simulations. Although it makes the equation more of a 'hybrid', it does not significantly change the size or significance of the other terms. Demand was entered both directly and by using instrumental variables which were, however, found not to improve the equation. The equation shows labour to be a complement for fuel and raw materials. Capacity utilisation again enters, suggesting that more labour is demanded when capacity utilisation is high, though inclusion of this variable may cause problems of interaction between labour supply and demand. As with the investment function, all the determinants except demand are lagged; this can be rationalised by reference to contract periods and adjustment costs in hiring and firing labour.

A significant negative time trend showing productivity changes might have been anticipated in this equation, with a size of -0.01 similar to that in the production function, but it proved to be insignificant. In general, the equation is somewhat unsatisfactory and theoretically inconsistent, but improvement did not prove possible in the time available.

Public sector demand for labour is determined by government expenditure. The equal weights on current and investment expenditure may be objectionable, as in practice non-residential public investment has a lower labour content than the others. However, attempts to estimate different coefficients proved unsuccessful.

As noted above, unemployment is left as the difference between the labour supply and total demand for labour. It is a crucial determinant of wages, as discussed in (d) below.

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(1) In theory, the approach adopted implies cross equation constraints between the labour and capital demand and production functions. These were not tested or imposed in this exercise.

(c) Output

(i) Production function (capacity output) (equation C2)

This equation is particularly important to the structure of the model, as using the level of factor availability it determines the potential level of output and hence the pressure of demand in the activity equations, given the existing level of activity. It also uses the weakest data and is itself imposed, and should thus be viewed as exploratory and highly provisional.

The approach to the problem of capacity has been to use data for whole economy capacity utilisation estimated independently by Knoester and Van Sinderen (1983); then to estimate a production function using the implied data for capacity GDP. In short, their method derives an equation for changes in productive capacity, with investment and extra hours worked adding to potential, while depreciation and scrapping reduce it. The KVS data have been extensively criticised by Jenkinson (1984), in particular for low asset lives and a zero elasticity of capacity output with respect to hours worked.(1)

However, for current purposes, the data are convenient in that they are based in OECD estimates, for which a longer time series is not available, and, except for the late 1970s, they have a broadly plausible path. For dynamic simulations, the model will, in any case, follow the path defined by the equation. Experiments were also conducted with data proposed by Artus (1978), which may be more plausible. However, Artus' data only relate to manufacturing and only go up to 1977, so they were not adopted.

Initial attempts were made to estimate freely various production functions, but difficulties were encountered - in particular, labour and capital would not both emerge with a positive sign, perhaps owing to identification or collinearity problems. Beenstock et al (1983) managed to estimate freely without this problem, but included demand variables such as the real money supply in their equation, whereas here the intention was to have a pure supply side specification. The intermediate solution chosen for the current equation was to impose coefficients for the labour force and the capital stock equal to their approximate factor shares in the income measure of GDP(I) - a procedure suggested by Klein (1953) though criticised by Wallis (1979) and others for assuming and not

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(1) A further problem with the index is that it is derived from a clay-clay model so to be fully consistent such a model should be estimated here.

testing constant returns to scale of a Cobb Douglas variety. The imposition of an elasticity of substitution equal to one may also not be warranted. The rest of the KLEM equation was estimated - energy and raw material prices having the correct sign, though the former was insignificant, and the time trend suggesting disembodied technical progress proceeds at a rate of 1.0% pa.

The dependent variable in the equation is, as noted, capacity GDP as defined by GDP(E) divided by capacity utilisation.(1) Owner-occupied rents, ie returns on the residential capital stock, are excluded. The labour force variable is labour supply, the rationale for this being that capacity GDP should imply full employment, whereas use of labour demand in a production function defining capacity would imply that the unemployed are not a potential resource. Capacity utilisation thus is defined to be below unity when there is spare labour capacity as well as unused capital. Of course, this may lead to some counterintuitive results - if sufficient "discouraged workers" re-enter the labour force when employment rises during a recovery, then capacity utilisation may fall - but it may be more tenable than the alternative. Capital is defined in the production function as the mid-year stock of real gross non-residential capital. Owner-occupied rent means that the return from the private residential capital stock is already allowed for, while the return from public residential capital - council house rents - is felt to be sufficiently small to be ignored. The inclusion of the private and public non-residential stocks with equal weights as parts of economic capacity implies that they are equally productive - a view that might be challenged by certain economists.

The equation implies the following path for capacity utilisation, ie actual GDP(E) divided by the estimate of capacity GDP.

1965	89.0 (89.3)	1970	86.6 (85.4)	1975	79.9 (83.6)	1979	78.0 (79.5)
1966	87.6 (88.0)	1971	85.5 (84.7)	1976	83.1 (83.9)	1980	72.9 (72.7)
1967	87.1 (87.3)	1972	82.4 (84.1)	1977	83.1 (80.0)	1981	71.3 (-)
1968	89.4 (87.9)	1973	86.8 (88.7)	1978	80.1 (79.5)	1982	72.1 (-)
1969	87.8 (86.1)	1974	85.6 (85.8)				

The KVS numbers which were used as a basis for the estimation are shown in brackets. It can be seen that the equation picks out the trough of the current recession as 1981, and features higher and perhaps more realistic numbers for 1977-78, though the estimate for 1973 is perhaps rather low.

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(1) Though gross output rather than value added should in principle be the dependent variable in a KLEM function.

(d) Wages and Income from employment

(i) Phillips Curve (equation D1)

The Phillips Curve in the model is similar to that used in the Bank of England medium term model, except that it incorporates a post tax target real wage (1). In the long run, post tax real wages approach a level such that labour cost is a constant proportion of GDP at factor cost, subject to the rate of unemployment (ie labour supply less labour demand), and a positive time trend. In the short run, nominal wages closely follow market prices, productivity and rates of direct tax, though wages are homogeneous in prices only in the long run; ceteris paribus, inflation initially causes real wages to fall. This equation implies that wage bargaining is influenced by, inter alia, direct and indirect taxes and employers' contributions. However, the effect of taxes, which enter the long run solution via the long run target post tax real wage, is relatively small compared with that of employers' contributions, which enter via the labour cost share term. In fact, the ratio is 1:24, so, in the long run, wages are mainly demand determined. Taxes are however more important to wage bargaining in the short run. The restriction on the components of the long run target real wage was tested and found to be accepted by the data ($F = 2.9$ compared with $F(10,2) = 4.1$).

The Phillips Curve, together with the production function and labour supply and demand functions, ensures that the labour market has at least a tendency towards equilibrium, as unemployment reduces wages, which increases labour demand and contracts labour supply. The process is likely to be extremely slow, however. The implied natural rate of unemployment, at a labour cost share of 0.6 and a post tax real wage of 80£ 5,000 is 8 1/2%. Other natural rates arise from other levels of real wages and cost share. The dynamic multiplier on prices (see Patterson and Ryding (1982), Currie (1981)) is (-16), assuming the labour cost share is constant in a constant growth equilibrium.

The dependent variable in the Phillips curve is the average wage of those in employment. This gives some imprecision to the measure of labour income (including self employment and forces), and a residual is used to give more comprehensive measures of personal and company income.[2] The alternative of using 'average labour income' in the Phillips curve was attempted, but the estimate was inferior to that reported here.

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(1) See Henry et al (1976).

(2) Since profits are basically GDP less income from employment.

(ii) Employers' contributions (equations D3, D4)

Employers' contributions must be determined in order that costs of hiring labour may be accurately estimated. National insurance rates are exogenous,[1] while "other" contributions grow at the same rate as the aggregate wage bill, subject to a positive influence of the rate of unemployment.

(e) Prices

(i) Domestic Prices (equations E1-E6)

The level of disaggregation of the model still necessitates determination of a set of price deflators, in order to determine nominal expenditures and hence allow derivation of sectoral net acquisitions of financial assets. All the equations are based on a similar specification, of which the equation for consumer prices may be used as an example.

The formulation is 'cost plus', where prices are determined in the short and long run by unit labour costs (ULC), import prices (PM) and (in the case of consumer prices) "unit indirect tax costs" (UITC), and the equations are in an 'error correction' format. There are no "pressure of demand" effects on consumer prices. The rather sharp contrast in formulation between the price and wage equations may be rationalised by appealing to the greater importance of 'stocks' of unemployed workers in the labour market, and the importance of countervailing pressure from trades unions for target wage increases. The dominant effect in the price equations comes from unit labour costs, defined as labour income plus employers' contributions divided by real gross domestic product, though import prices also have a strong influence. The long run solution of the equation is;

$$\ln PC = 0.39 \ln PM + 0.46 \ln ULC + 0.15 UITC + 0.54$$

The equation fits the data particularly well.

The other equations are in a similar format, though indirect taxes do not influence the level of the deflators. In the stockbuilding deflator equation, capacity utilisation was found to be correctly signed and fairly significant: this was not the case in the other equations. Long run effects of import prices could not be found in the housing investment or government investment deflator equations, and, in the government current expenditure equation, the long run

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(1) In fact, it is likely that the Government increases these at the same time as unemployment rises to balance the fund.

effects were not well determined. Although all the equations pass the LM test, the level of explanation for the private housing investment deflator was rather low.

Besides assessing direct effects of capacity utilisation, the equations were also re-estimated using "capacity unit labour costs", ie labour costs divided by capacity GDP, a variant of "normal cost pricing" (Godley, Nordhaus and Coutts (1978)). However, although theoretically desirable as it allows for the relationship between wages and trend productivity, and as it removes the occasionally spurious changes of prices predicted when actual GDP changes sharply, the result was a far less good 'fit' for all the equations.

Current price GDP and the deflators for current and market price GDP are easily derived from these deflators, as shown in equations E7-9.

(ii) Trade prices (equations E11, E12)

The export and import price deflators are constructed as simple weighted averages of sterling competitors' wholesale prices and the factor cost GDP deflator. In the case of export prices, the weights are 30:70 between foreign and domestic prices, while, for import prices, the weights are 70:30. These figures are broadly in line with those found by more systematic research elsewhere (see Bond (1981)). Although not constrained to sum exactly to one, the coefficients could easily be made to do so with little violence to the data. These trade prices and volumes allow derivation of the trade balance and current account, as described below.

(iii) Exchange rate (equation E13)

The exchange rate equation, which determines the trade weighted index rather than the dollar/sterling rate, is basically a purchasing power parity (PPP) formulation adapted from the Bank of England medium term model. The equation suggests that the exchange rate is determined by the short interest rate in the short run, while in the long term it depends on competitiveness, portfolio balance in the market for net foreign assets, and sterling's status as a petrocurrency. Foreign interest rates enter in the reduced form as they are the main determinant of the short rate (equation H10). The equation was estimated by instrumental variables (IV), using lags of the short rate to determine the instrument, in order to allow for simultaneity between exchange rates and interest rates. The resulting estimate was a considerable improvement over the non-IV estimate, with all coefficients significant and the LM tests indicating no residual autocorrelation. The equation can, however, be criticised in various ways. For

example, it is estimated over a period including regimes of fixed and floating exchange rates, it has a rather large time trend, with 2 1/2% annual depreciation, and oil exports are used as a crude proxy for the state of the oil market and Britain's known reserves. Imposition of PPP in a single equation might be felt less desirable than PPP being a system property, and many would argue that relative unit labour costs are, in any case, a better determinant of competitiveness (for a discussion, see Hotson and Gardiner (1983)).

(f) Public Sector (equations F1-F9)

The public sector of the model is fairly simple and conventional, and, as such, requires little comment. A balance has been attempted between size and a realistic number of government 'levers' that can be used in simulations, while maintaining the accounting identities. Debt interest, current grants and the tax 'take' are endogenous, while other elements of income and expenditure are exogenous. Debt interest is simply defined as a proportion of the long interest rate times non-monetary debt outstanding to the non-bank private sector. Surprisingly, the coefficient exceeds one - perhaps due to measurement error and interest paid by the public sector to other sectors. The equation for current grants assumes that the unemployment benefit rate is an adequate proxy for all benefits. Hence, there is the benefit rate times unemployment to show the amount of benefit paid to the workless, while there is the benefit rate times 55,000 (the total population) less the population of working age not in full time education, to show grants paid to pensioners, students and child benefit. A significant coefficient of 1.6 suggests that this is a reasonable regressor, though obviously some persons in this aggregate receive more than the unemployment benefit rate. A time trend and constant help the tracking of this quantity. An equation was also estimated for the rate of unemployment benefit, but homogeneity with prices was not accepted - an elasticity of 0.8 being implied instead. While it is quite plausible that governments have systematically reduced real benefit rates in the past decade, this did not seem an appropriate assumption in simulations, so an equation with unit elasticity was programmed for use in simulations.

Public sector receipts include endogenous tax receipts, insofar as personal and company incomes are multiplied by the actual average tax rate in each year, imposed as an exogenous variable, with company sector taxable income lagged to allow for the lag between accrual and payment of tax by companies. Given progressive rates, thresholds, etc, use of an average tax rate would not be an adequate assumption for large changes in income, but should be adequate for marginal changes.[1] The nominal factor cost adjustment is also included in

(1) The alternative is a complex derivation of all the tax 'takes' based on actual tax rates such as is found in the Inland Revenue's tax models.

"receipts". Since this is actually indirect taxes less subsidies, "receipts" here differ slightly from the more conventional definition. Payments are amended correspondingly, so that saving is in line with normal usage. Public sector investment is completely exogenous, as are capital transfers. These items plus saving allow derivation of the public sector NAFA (changes in net financial assets of the public sector). The difference (POTH) between this and the net addition to public borrowing PSBR has been also left exogenous.

(g) Balance of Payments (equations G1, G2)

Net property income from abroad is determined endogenously by the stock of net foreign assets times the US bond rate. A dummy which takes the value '1' after the abolition of exchange controls has a significant negative coefficient, suggesting that investors have since then invested in lower-yielding assets. Together with trade volumes and prices and the exogenous residual (net transfers from abroad), property income allows derivation of the current account.

(h) Non Bank Private Sector (NBPS) Financial Model

(i) Inflows (equations H5)

The set of 'real' equations and identities described above determines the public sector borrowing requirement and the current account surplus, which are sources of "outside" financial wealth for the non-bank private sector. Following the usage of the Bank of England Small Monetary Model (see, for example, Coghlan (1979), Johnston (1982)), these flows are used to define the increase in net financial wealth of the non bank private sector, along with revaluations and an exogenous residual (increase in non-deposit liabilities, counterparts identity residual, foreign currency counterparts residual). The algebra proving this correspondence is well known - see the references for a derivation. A further portfolio system for the personal sector, described below, divides these assets between the company and personal sectors, and determines personal sector demand for equity.

(ii) Revaluations (equations H1-H4)

The revaluations are calculated in a fairly standard manner for gilts as the stock times the proportionate change in the price (page 80). The coefficient of 0.7 was imposed, as the mean proportion of non-monetary public sector debt subject to revaluation. Estimation of the equation then suggested that the proxy for revaluations based on this stock times its price warrants a coefficient of 0.78. Net foreign assets are more complex, as the value of assets defined in foreign

currency depends in part on the exchange rate and the foreign interest rate, but some of the assets and liabilities are denominated in sterling. The perhaps unsatisfactory solution chosen was to allow net assets to be affected by both the exchange rate and the US bond rate, while a proportion of net assets, proxying the excess of foreign currency gross assets over foreign currency gross liabilities, once net assets were removed, were indexed by the exchange rate alone. Losses due to revaluations of UK and foreign equities within gross quantities were assumed to cancel. The revaluations of foreign assets were tracked much worse than revaluations of gilts - a coefficient on the proxy of 0.33 being warranted. The residual 'REVR' on revaluations is the difference between the increase in the value of financial wealth and the flows to its components plus revaluations of gilts and net foreign assets.

Revaluations of equity are also determined in this section, though as explained above they are not a net asset of the NBPS. They are defined as the increase in share prices times the stock of equity.

(iii) Portfolio system - introduction

Given the 'inflows' from the PSBR, current account and revaluations, the non bank private sector (NBPS) is assumed to exercise choice over its proportionate holdings of the various assets, via a portfolio system of asset demand equations. The system is not a very sophisticated one - no allowance is made for rationing of certain assets/liabilities such as bank lending, nor are symmetry, adding up, etc restrictions imposed or tested. Not all the a priori interest rate effects could be established as either significant or with the right sign in all the equation. Moreover the portfolio system is not used directly to determine interest rates and exchange rates, as in Keating (1984), though portfolio balance terms are significant determinants of exchange rates and long interest rates. Finally, expectations in this system are purely adaptive, whereas arguments could be made for a forward looking approach.

(iv) Demand for money (equation H6)

The portfolio system used is hierarchical to the extent that the demand for money depends on income, wealth and interest rates, while demand for the other assets depends only on wealth and interest rates. Also, the demand for money is determined in real terms, while the others are nominal. One can justify this structure by reference to the role of money as a means of payment, as a result of which demand for money is closely related to real expenditure, and hence the real size of money balances is a key decision variable. By contrast, other public sector debt, foreign assets and bank loans are only relevant in terms of the

optimal allocation of the net wealth portfolio. A similar argument is deployed in Johnston (1982). The money demand equation in the current model is as shown on page 81. It is in 'error correction' form. In the short run, it relates the real demand for £M3 to real disposable GDP and inflows to real net wealth, while in the long run interest rates are also important (a separate short run effect could not be estimated). There is a long run unit elasticity between the money and wealth stocks, which was tested and accepted. Similar unit elasticities feature in the other equations. The underlying assumption is that, if relative returns on assets are constant, agents will desire constant equilibrium shares of each asset in the portfolio, as long as relative riskiness (assumed here constant) does not change. The long run real income elasticity is just over 2, which might be felt to be rather high, while the short run elasticity is 1.5. The short rate has a positive influence on demand for money, while the long rate has a negative effect. One can argue that this is a plausible result, since £M3 includes time deposits, which yield the short rate. An increase in short rates thus leads the non bank private sector to shift financial assets from other assets (and sight deposits) to time deposits which are within M3. The effect of a general increase in interest rates is to increase demand for money. This is perhaps a less plausible result, and the coefficients on interest rates are so close that they could easily be constrained to be equal. The equation features a 'CCC' dummy covering 1972-4, as the conventional variables were unable to explain the behaviour of money over this period.

The diagnostic statistics for this equation suggest that it fits well - all 't' statistics exceed 2 and there appears to be no autocorrelation.

(v) Demand for gilts and other national debt (equation H7)

The other financial asset demand equations feature a common 'error correction' structure, with a short run non-homogeneous relationship with the 'inflow' to net wealth (including revaluations) and an imposed long run proportionality with net wealth, modified by the level of interest rates. In the case of other public sector debt, the coefficient on the increase in wealth is 1.16, perhaps indicating short run inertia over the dispersion of gains/losses from revaluations of gilts through the rest of the portfolio. The interest rates have the correct sign, but are not significant at the 95% level. The diagnostics suggest that the equation picks up the track of the data reasonably, particularly given the heterogeneity of other national debt which, although mainly gilts, includes national saving, treasury bills, etc.

(vi) Demand for net foreign assets (equation H8)

Net foreign assets, like 'other public sector debt', is a very heterogeneous item, comprising residents' demand for gross foreign assets less foreigners' demand for residents' liabilities, grouping together very different kinds of asset, including direct and portfolio investments. In the light of this, the performance of the specification seems adequate, as all the coefficients except for that on the increase of wealth are significant, and interest rates have the correct sign.

(vii) Demand for bank loans (equation H9)

In normal portfolio manner, an equation is omitted from the system to satisfy the identity, and, in this case, bank lending is left as a residual. The level of NBPS financial wealth then determines the level of company sector wealth, given that of persons, as described below. The implicit equation for bank lending has not been explicitly checked for implausibility (as suggested by Brainard and Tobin (1968)), though the imposition of unit elasticity with respect to wealth in the other equations means it obtains here too, and the correctly signed interest rates elsewhere should suggest similar signs here. In fact, a bank lending equation has been estimated, based on the specification in Davis (1984) and criticised by Green (1984), and shown on page 85. The signs are generally reasonable (the coefficient on the change in wealth should be negative, since loans are a liability, hence entering negatively in wealth), though that on base rates/bank rate is positive. This can be rationalised as an income gearing effect - if rates rise, companies may need to borrow more to pay interest - but is more likely due to misspecification. The credit control dummy is an annual version of the series detailed in Davis (ibid).

(viii) Interest rates (equations H10, H11)

The specification for the short nominal rate is mainly a reaction function rather than a behavioural equation. It hypothesises that the authorities adjust the short rate so as to retain broad parity with the eurodollar rate. The reaction is not instantaneous; 70% occurs in the first year, but parity is maintained in the long run. Such a reaction function is in line with a policy of attempting to prevent excessive changes in the exchange rate resulting from capital outflows when profits can be made by arbitrage. The portfolio adjustment effect is thus implicit - an explicit term could not be obtained in this structure. In the short run, the short rate is positively influenced by the inflation rate, thus giving some tendency towards maintenance of real rates during periods of

inflation, and negatively influenced by an instrument for the exchange rate. The latter effect is weak, however.

The long rate basically follows the short rate in a term structure-style equation. The imposed long run real rate is 3%, while the long run inflation rate has an imposed weight of 0.2 in the equation. Inflation also, in any case, enters the reduced form via the short rate equation and via the PSBR and hence the bond/wealth ratio. The other term in the equation is the difference of the bonds/financial assets ratio. This term ensures that a rising level of bond sales in relation to the level of wealth is penalised by a rising long rate, as new marginal holders require a higher coupon to be induced to hold gilts. The level of the bond/wealth ratio was not found to be a significant determinant of the long rate, however.

The price of gilts is determined by the long rate. The coefficient below one reflects the fact that most gilts are not consols, hence the redemption date affects the price.

(i) Personal sector income and expenditure (equations I1-I5)

Determination of income from employment, current grants and employers' contributions has been described above in sections (d) and (f)[1]. However, to obtain total personal income, an estimate of 'other income', from rent, net interest, profit and dividends is required. These are returns on stocks of assets; the fully consistent stock data derived elsewhere in the model are thus also essential to deriving consistent measures of income and wealth.

Persons' imputed rent is derived as a proportion of the net residential private capital stock. Dividends, debt interest and net property income from abroad can be derived as the total flow of returns from the relevant assets times the share of the personal sector in the stock. The cost of bank borrowing is given by the short rate times the stock, while the residual (other rent, net returns on unidentified financial assets) is given by 10% of the short rate times the total stock of personal sector wealth. It should be borne in mind that, here as elsewhere in the model, life assurance and pension funds' assets and income are aggregated with those of the household sector.

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(1) PYRS in equation I3 is the residual for mismeasurement of labour income, see page 30.

Disposable personal income is derived from total income by use of an 'average' tax rate (including national insurance contributions). The net acquisition of financial assets may then be derived by deducting nominal expenditure from disposable income. Derivation of such nominal expenditure is a principal reason for estimation of a set of price deflators rather than a single 'catch all' deflator[1]. The estimate of NAFA is still inaccurate, as nominal private housing investment is not exactly equal to persons' fixed investment, and the 15% share of stockholding is unlikely to be held constant, so a residual has been imposed to proxy these inaccuracies and unidentified items.

(j) Company sector income and expenditure (equations J1-J5)

'Companies' in this model include industrial, commercial and financial companies. Company profits are the residual in nominal GDP after labour income, income from rent, public corporations' trading surplus and the residual adjustment is deducted. This may be appropriate in that capital is the factor of production whose return is not determined explicitly; instead it must take what is left of the national income after other factor incomes are deducted. Other company income is determined similarly to other personal income, using the relevant returns and wealth stocks, except for dividends.

Dividends are determined in an equation remeniscent of Lintner (1956), the specification incorporating the findings of his study. These were that managers have a target payment ratio for dividends in relation to corporate income, that they desire stability in the path of dividends, and they only adjust dividend payments partially to changes in profits. This policy can be rationalised by a managerial theory of the firm (see King (1977)) wherein managers use dividend policy as a signalling mechanism for the consequences of company policy which is well defined and measurable, which is not too costly to adjust and which management are under pressure to relate to long term expectations. Thus they adjust slowly to a new desired level rather than abuse the signal by increasing its value temporarily. A detailed discussion of this specification, and many other aspects of company behaviour can be found in Ryding (1984). Although an autoregressive distributed lag model is superior to partial adjustment (see Hendry, Pagan and Sargan (1982)), the lag of income was not significant, and was omitted. The restriction of homogeneity was accepted, however. A dummy for 1973 was introduced into the equation to allow for the change in the data series

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(1) An earlier version of this paper described a 3 sector model in which only PGDP and PGDM were used as prices. Copies are available from the author.

when advanced corporation tax began to be deducted from 1973 onward. This is a crude alternative to the measure of the opportunity cost of retained earnings in terms of gross dividends foregone, used in King (1977) and Ryding (1984). The diagnostics suggest that the dividends equation is an adequate representation of the data.

Companies' NAFA is defined similarly to that of persons as gross income less taxes, investment, stockbuilding and stock appreciation. A proxy for taxable income is given by gross income less the nominal value of investment allowances and stock appreciation.

(k) Persons' financial model (equations K1-K7)

Personal sector demands for financial assets are determined similarly to those in the non bank private sector. The supply of new financial assets in each period is equal to the net acquisition of financial assets, determined as described above, plus the share of persons in asset revaluations (revaluations times the share of persons in the stock). A residual is deducted to allow for net acquisition of unidentified financial assets (mainly building society deposits less mortgages).

The portfolio system has the same basis as the system for the NBPS described above. Money is both a medium of exchange and a store of value, while the other assets are seen principally as alternative stores of value. In each case, the demands include those of life assurance and pension funds (LAPFs). Persons have a less interest-elastic demand for money than the NBPS, suggesting plausibly that companies have a high elasticity. The long run income elasticity is 1.5, again lower than the NBPS. The gilt and foreign asset equations indicate a slower response of holdings to changes in portfolio size and to stock imbalances than for the whole NBPS. This perhaps illustrates the tendency of LAPFs to adjust portfolios only at the margin, and then only slowly. The long run unit elasticities are less easily accepted than for the NBPS. Interest rates are correctly signed, but many are insignificant.

The model uses a behavioural equation for bank lending and leaves demand for equity as a residual.(1) The bank lending equation has a long run income elasticity of 0.6, and a very weak interest rate effect.

(1) Companies' financial sector (equations L1-L5)

As NBPS and personal sector demands for financial assets are already determined, companies' holdings of 'outside' financial assets (except equity) drop out by identity. The remaining equations determine the total stock of, and return from, equity.

New issues are modelled as depending on the nominal gross investment which they will help to finance, the state of the share price and the lagged level of issues. The coefficient on the lagged dependent variable is negative, showing the market to be unwilling to accept continuing high levels of issues. The share price has a large short run effect and a smaller, but nonetheless positive, long run effect. Thus a buoyant stock market is implied to be an important factor for successful new issues.

The share price equation is a key equation in this model, but, as is well known, it is an extremely difficult variable to model; indeed its short run behaviour is often claimed to be best described by a random walk. Here one is obviously interested in economic determinants. Hence capacity utilisation and company sector liquidity are used as indicators of companies' expected future profitability, and the long rate is used to proxy the return on a competing asset. The framework is of partial adjustment, with fairly slow adjustment to changes in the independent variables. The long rate only has an effect in the short run. This result was found also when the level and lag were entered separately, the coefficients being equal and opposite. As noted above, real prices of labour and other factors were also assessed in this equation, but they were not significant. Use of portfolio balance terms also proved unsuccessful.

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(1) An alternative equation for the demand for equity is as follows:

$$\Delta \ln KEQJ = \underset{(10.0)}{1.56294}\ \Delta \ln NFWP - \underset{(1.0)}{0.16664}\ \ln (KEQJ/NFWP)_{t-1} - \underset{(0.5)}{0.04796} - \underset{(2.7)}{0.012}\ RUKG + \underset{(1.2)}{0.0012}\ RREQ$$

$\bar{R}^2 = 0.963$ SE = 0.046 DW = 2.1 LM(2) = 2.6 1964-1982

A particularly high short run wealth elasticity is apparent, probably because the value of equity itself is the most volatile component of wealth, and because portfolios are rarely rearranged completely on a stock basis. An alternative model can be generated using this equation, with bank lending as a residual.

Information generated by the share price, capital issue and dividend equations, and by the lagged stock of equity, allows derivation of the current stock of equity and its pre tax rate of return.

4 The SCHEMA model - performance

INTRODUCTION

As has been emphasised earlier, the model as it stands suffers from many weaknesses, not least excessive aggregation, theoretical inconsistency (though with general Keynesian tendencies) and a lack of direct influence on demand of the components rather than the total of financial wealth, apart from equity. However, it remains the core of a small, flexible testbed for different paradigms, which features all of the stock-flow effects identified on page 15, viz the capital stock, equity, production function, portfolio adjustment, Hicksian sectoral income, wealth effects on expenditure, stock effects of budget deficits and external assets.

Its capabilities are explored briefly in the section below, which describes:

(i) Historic dynamic tracking over the 1970s
(ii) Three dynamic simulations
(iii) Out of sample performance

(a) Historic dynamic tracking

The model converges quite satisfactorily over the in sample period 1971-80, dynamically and as estimated, and tracks without instability, giving the results shown in Table 1. It should be stressed, however, that residuals (equal to the difference between the estimated and actual stocks) were imposed in the gross capital stock and bond and foreign asset revaluation equations. This was done in recognition of the theoretical reservations about the plausibility of using smooth depreciation to determine the gross capital stock[1], the crude specification of the revaluation equations, in particular the inadequacies of the price indices, and the significant worsening of tracking performance when these residuals were omitted[2]. The tracking performance is thus conditional on the inclusion of these residuals. The imposition of residuals on the equations is obviously unimportant in simulations, which is the main aim of the model.

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(1) See page 22 above.
(2) Details of tracking without residuals for an earlier model are given in an earlier version of this paper available from the author.

TABLE 1: TRACKING ERRORS 1971-1980

			Single equation	Static	(One Step ahead)	Dynamic
Real gross capital stock	% rmse		-	0.05	(0.12)	0.16
	me (80£bn)		-	0.04	(-0.6)	-0.8
Net private stock of financial assets (nominal)	% rmse		-	3.2	(3.5)	4.0
	me (6mn)		-	-913	(4.5)	330
Persons' real net wealth	% rmse		-	6.8	(8.9)	9.6
	me (80£mn)		-	2,318	(4,813)	3,538
GDPE	% rmse		-	2.1	(2.2)	2.2
	me (80£mn)		-+	660	(1,735)	1,398
Capacity utilisation	% rmse		-	3.7	(3.8)	4.3
	me		-	-0.004	(-0.001)	-0.005
Consumer prices	% rmse		1.1	2.0	(4.9)	5.3
	me		0.00001	0.00029	(0.03)	0.03
Wages (nominal)	% rmse		1.7	2.5	(6.3)	7.5
	me		-12.2	-18.5	(162)	127.9
Unemployment	% rmse		-	15.4	(32.9)	56.5
	me		-	-61	(-73)	66.7
Exchange rate	% rmse		2.6	2.3	(4.3)	4.8
	me		-0.00317	0.00003	(-0.03)	-0.04
Money supply (nominal)	% rmse		1.3	5.2	(5.7)	5.7
	me		142	-319	(211)	-74
Q (valuation ratio)	% rmse		-	17.9	(17.9)	21.0
	me		-	0.005	(0.02)	0.017
Real fixed investment	% rmse	INP	2.6	1.7	(2.3)	2.8
		IHP	7.1			
	me	INP	87.8	148.0	(-108)	-225
		IHP	30.9			
PSBR (nominal)	% rmse		-	25.2	(28.1)	28.0
	me		-	-659	(-688)	-619
Short interest rate	% rmse		11.7	11.5	(12.3)	12.9
	me		0.5	0.5	(1.0)	0.9
Current account (nominal)	% rmse		-	1,303	(384)	240
	me		-	668	(981)	998

Hendry and Richard (1982) have suggested that historic dynamic simulations can tell little of the 'truth' or otherwise of the model, and, in particular, cannot be used to compare different models' performances. While accepting these criticisms, it was still felt that illustration of the ability of the model to track the economy through the 1970s without following an unstable path was of interest, particularly because one can argue that dynamic simulations are useful tools for finding causes of error and irregularity in the model itself (see Dunn et al (1984)). This proved to be the case with the capital stock and revaluations problems.

Hendry and Richard suggest that static or one-step-ahead diagnostics are more appropriate tools for showing the performance of the model. These are accordingly also shown in Table 1, together with single equation tests for comparison. (In the case of GDPE, real personal sector wealth etc, single equation results could not be shown as these are composites of many variables.)

The results themselves show that where single equation and simultaneous performances of variables could be compared, insertion into the model generally gave some deterioration, except for the exchange rate, investment and short interest rates. In the one step ahead simulation, most variables are nonetheless tracked reasonably over this period with root mean square errors (rmse) of less than 10%. Those which performed badly were generally composites of many variables, such as the PSBR, current account, q and unemployment. The dynamic tracks were generally worse than the one step ahead - as might be expected, since errors can cumulate. However, in most cases, the increases in rmse were not large (the majority were still below 10%), and tracking of the current account actually improved. The main problems stem from the labour supply and demand equations, which give inaccuracies in the track of unemployment, and hence those of wages and prices.

To sum up, historic tracking reveals that the model tracks reasonably within sample. However, this exercise tells us little concerning the plausibility of the size and sign of dynamic responses and effects between variables. For this, one must consider simulation and out-of-sample results.

(b) Simulations

The following simulations were all run over a 1971-80 base. There may be problems of base dependence from this approach, but a suitable 10-year future base was not available for a subsequent period. The simulation featuring a change in interest rates allows one to gauge the differences between Schema and conventional models

and the contributions of the stock-flow effect, by reference to simulations quoted in Easton (1985).

(i) Increase government expenditure by 80 £2,000 mn pa

This simulation is shown in Table 2.

An increase in government expenditure, maintained through the simulation, boosts GDP throughout, but only in the first and second year does the multiplier exceed one. By the fourth year of the simulation, the multiplier has fallen to 0.6, a level near which it remains for most of the decade. The endogenous components of this change are as follows.

% changes (* absolute changes) from base

Year	1	2	3	4	5
Consumption	0.6	0.7	0.5	0.4	0.5
Fixed investment	0.0	0.3	-0.3	-0.7	-0.8
Exports	0.0	-0.4	-0.7	-0.6	-0.5
Imports	1.8	1.6	1.4	0.9	1.2
Inventories*	574	26	126	-180	- 77

'Crowding out' can be seen to occur for some of these aggregates. Consumption is initially boosted by increased personal incomes and higher wealth due to a higher PSBR, but income is eroded by declining employment in the private sector as real wages rise, and by inflation reducing the real value of wealth.

Investment initially rises as the share price is boosted by rising capacity utilisation, hence raising 'q'. However, this effect is soon offset by the increasing replacement cost of the capital stock as inflation occurs, which reduces 'q'. This is not entirely plausible and suggests that the share price should be more closely tied to other domestic prices. Exports fall and imports increase due to rising capacity utilisation, imports also rising due to the high short run elasticity of imports with respect to GDP. Inventories complete a cycle over this five year period.

In the labour market, unemployment falls sharply as public employment increases. This increases nominal and, due to lags in the price equations, real wages. Increased real wages reduce the private sector demand for labour and increase the supply, hence the initial reduction in unemployment is not maintained. The private sector demand for labour also declines as a result of the above mentioned crowding out of the increase in GDP. The path of unemployment is not monotonic; it falls back in the sixth and seventh years reaching a peak in year seven as the economy enters the second stock cycle and labour supply falls due to the

'discouraged worker' effect. To have such cycles over such a long simulation period seems a reasonable property of the model.

TABLE 2: DYNAMIC SIMULATION RAISE GOVERNMENT EXPENDITURE BY 80 £2,000 MILLION

Variable	% changes (absolute changes *) from base									
	Year 1	2	3	4	5	6	7	8	9	10
Real gross capital stock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	- 0.1	- 0.1
Net private financial assets stock (nominal)	+ 0.5	- 0.2	+ 0.3	+ 1.4	+ 1.9	+ 2.0	+ 2.0	+ 2.4	+ 3.2	+ 3.9
Persons' real net wealth	+ 1.5	+ 0.3	- 0.2	+ 0.3	+ 0.7	+ 0.7	+ 0.5	+ 0.3	+ 0.6	+ 1.0
GDPE	+ 1.4	+ 1.1	+ 0.8	+ 0.5	+ 0.7	+ 0.8	+ 0.7	+ 0.6	+ 0.6	0.6
Capacity utilisation	+ 1.1	+ 0.9	+ 0.3	+ 0.1	+ 0.3	+ 0.3	+ 0.3	+ 0.1	0.0	+ 0.1
Consumer prices	+ 0.2	+ 1.6	+ 1.9	+ 1.3	+ 1.2	+ 1.6	+ 2.3	+ 2.9	+ 2.9	+ 2.8
Wages (nominal)	+ 0.2	+ 1.6	+ 1.9	+ 1.3	+ 1.2	+ 1.6	+ 2.3	+ 2.9	+ 2.9	+ 2.8
Unemployment * (thousands)	-123	-100	-14	-25	-66	-115	-136	-89	-47	-68
Exchange rate	0.0	+ 0.3	0.0	- 0.3	- 0.5	- 0.6	- 0.7	- 1.0	- 1.4	- 1.7
Money supply (nominal, £m)	+ 2.4	+ 2.0	+ 2.0	+ 2.1	+ 2.9	+ 3.2	+ 3.3	+ 3.6	+ 4.1	+ 4.7
Q (valuation ratio)	+ 2.7	+ 0.1	- 1.9	- 1.1	+ 0.4	+ 0.3	- 0.4	- 1.1	- 0.4	+ 0.6
Real fixed investment	0.0	+ 0.3	- 0.3	- 0.6	- 0.4	- 0.2	- 0.4	- 0.7	- 0.8	- 0.6
PSBR (nominal, £m) *	307	344	572	725	865	864	963	1,171	1,545	1,922
Short interest rate * (percentage points)	- 0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1
Current account * (nominal, £m)	-229	-269	-342	-343	-442	-591	-588	-625	-746	-680

Prices, as noted, rise sluggishly at first with wages as unit labour costs increase. This process is reinforced by a decline in the exchange rate from the fourth year onwards, due to lost competitiveness resulting from the said inflation. A depreciation feeds back into domestic prices via import prices. The depreciation also helps to stem the deterioration of the trade balance (the figures for the current account are in nominal terms).

On the financial side, nominal net private financial wealth is boosted by a higher PSBR, despite a deterioration in the current account position and lower revaluations due to higher interest rates. Contributions to the changes in net (outside) financial wealth over the 10 years are:

£ million

PSBR	+9,073
Current account	-4,918
Gilt revaluations	- 287
Foreign asset revaluations	+ 55
(Equity revaluations)	(+2,290)

The distribution of the increase in financial wealth via the portfolio system is as follows:

£ million

	Year 1	Year 5	Year 10
NBPS			
Money	401	1,060	2,859
Other public debt	88	767	2,778
Foreign assets	51	128	623
Bank lending (-)	388	861	2,338
Net financial wealth	152	1,095	3,923
Persons			
Money	41	623	2,037
Other public debt	121	365	1,661
Foreign assets	68	31	148
Bank lending (-)	0	99	726
Equity	886	704	2,541
Net financial wealth	1,118	1,625	5,662
Companies			
Money	360	437	822
Other public debt	- 33	402	1,117
Foreign assets	- 17	97	475
Bank lending (-)	388	762	1,612
Net liquidity	- 78	174	802

For the non-bank private sector, money stocks increase for most of the period faster than wealth. This is attributable to increased transactions demand as GDP increases. Stocks of other assets increase broadly in line with wealth, though demand for 'other debt' is boosted by an increase in domestic interest rates and a tilt in the yield curve towards the long end. It should be borne in mind that bank lending is the residual asset accommodating to other asset demands - perhaps a plausible assumption on the demand side but not on the supply side, given the history of controls. The split of these assets between persons and companies reveals that persons hold most of the extra money by the tenth year, and generally have a favourable marginal asset/liability position, while companies borrow heavily and end the period closer to a zero balance. This is a plausible response - persons need financial assets both for transactions and as a store of value and also only react slowly (via increased consumption) to changes in the wealth/income ratio. Companies, on the other hand, need financial assets principally as working capital to finance investment and to minimise the risk of

bankruptcy, while not needing to hold financial assets specifically as a store of value. Bank lending is also an important source of funds for investment and finance of stocks in advance of expected future profits, so one would expect it to increase sharply during an expansion.

Capacity utilisation in this simulation is initially far above base, but the discrepancy returns to zero faster than aggregate demand. The increase in capacity GDP arises via increases in the supply of labour and falling relative prices of raw materials and energy. These effects are offset mainly by inflation but also the decline in the capital stock at the end of the simulation.

(ii) Increase the short interest rate by 2% points throughout (table 3)

The effect of this shock is to deflate the economy. GDP is below base throughout, reaching a trough in the second and third years after which the effect is rather small. The paths of the endogenous components of GDP are as follows:

% changes (absolute changes *) from base

Year	1	2	3	4	5
Consumption	0.2	0.1	0.3	0.8	0.9
Fixed investment	-0.3	-1.7	-2.3	-2.0	-1.9
Exports	-0.1	-0.5	-0.5	-0.5	-0.7
Imports	-0.3	-0.6	-0.7	0.0	0.0
Inventory investment*	-420	-514	-555	6	47

£mn

Investment is hit particularly hard, as residential investment is directly interest elastic and because rising interest rates reduce share prices and hence 'q' in the non-residential fixed investment function. Consumption rises because persons are net creditors and hence an increase in interest rates increases their non-labour incomes substantially. This boosts consumption, despite initial falls in persons' real net wealth due mainly to devaluations of illiquid financial assets and reduced housing investment. The trade balance improves only marginally as exports fall as well as imports. Imports fall due to lower aggregate demand, while exports are hit by an appreciation of the exchange rate, induced by the increase in interest rates and reinforced by falling prices. These 'price' effects on exports override the beneficial effects of falling capacity utilisation. Inventory investment is directly hit by rising interest

TABLE 3: DYNAMIC SIMULATION RAISE DOMESTIC SHORT RATES BY 2 PERCENTAGE POINTS

Variable	% changes (absolute changes *) from base									
	Year 1	2	3	4	5	6	7	8	9	10
Real gross capital stock	0.0	0.0	- 0.1	- 0.2	- 0.2	- 0.2	- 0.3	- 0.3	- 0.4	- 0.4
Net private financial assets stock (nominal)	- 4.5	- 6.5	- 4.5	- 2.0	- 0.4	0.2	0.6	1.4	3.7	5.2
Persons' real net wealth	- 5.4	- 7.4	- 5.2	- 2.5	- 1.7	- 1.6	- 1.7	- 2.3	- 1.5	- 0.5
GDPE	- 0.2	- 0.5	- 0.5	- 0.1	- 0.1	- 0.2	0.0	0.0	- 0.1	0.0
Capacity utilisation	- 0.2	- 0.8	- 0.7	- 0.4	- 0.4	- 0.4	- 0.2	- 0.3	- 0.4	- 0.3
Consumer prices	- 0.1	- 0.2	- 0.6	- 1.0	- 1.3	- 1.8	- 2.1	- 2.1	- 2.2	- 2.6
Wages (nominal)	- 0.1	- 0.4	- 1.1	- 1.1	- 1.3	- 1.9	- 2.0	- 1.6	- 1.7	- 2.2
Unemployment * (thousands)	+ 6	+52	+12	+30	+74	+36	-32	-16	+35	+62
Exchange rate	+ 1.2	+ 1.6	+ 2.0	+ 2.6	+ 3.1	+ 3.5	+ 3.9	+ 4.3	+ 4.5	+ 4.7
Money supply (nominal, £m)	- 3.1	- 4.2	- 2.4	+ 0.5	+ 2.4	+ 3.3	+ 4.8	+ 6.3	+ 8.1	+ 9.7
Q (valuation ratio)	- 9.9	-13.3	-10.9	- 8.2	- 6.4	- 6.0	- 6.2	- 8.3	-10.6	-11.5
Real fixed investment	- 0.3	- 1.7	- 2.3	- 2.0	- 1.9	- 1.7	- 1.8	- 2.1	- 2.5	- 2.6
PSBR (nominal, £m) *	142	295	327	308	505	600	778	998	1,364	1,939
Short interest rate * (percentage points)	1.9	2.7	3.0	3.0	3.0	3.0	3.0	3.2	3.2	3.2
Current account * (nominal, £m)	+67	+79	+145	+102	+45	+207	-43	-87	-64	-407

rates, but cycles back after three years of decline to increase in the fourth and fifth years.

Unemployment increases for the first six years, as the demand for labour falls in line with aggregate demand and a declining capital stock. Wages have little effect on quantities in the labour market as unemployment and appreciation combine to give broadly flat real wages. After the first few years, recovering personal sector wealth begins to reduce the supply of labour, leading to an attenuation in the later years of the initial increase in unemployment.

Capacity GDP falls because the capital stock declines and raw material prices increase with the appreciation of the exchange rate. This is reflected in the greater decline of capacity utilisation than in actual GDP.

On the financial side, net financial assets initially fall, due to negative revaluations of gilts when interest rates increase. However, the inflow of assets is positive as a result of the positive PSBR and current account surplus which accompany the recession. By the sixth year, these inflows exceed the negative revaluations. This turnaround is reflected in the demand for money, which is also boosted by a tilt in the yield curve (long rates increase less than short rates). As noted, the stock of equity is heavily devalued by the rising interest rates, thus influencing both persons' real net wealth and the valuation ratio. These are thus shown to be important conduits of monetary policy onto the real economy, as suggested in the theory of Section I above. Comparison of this simulation with results for other UK macroeconomic models can be made by reference to Easton (1985), and give an indication of the importance of the stock-flow effects.

Analysis shows that while changes in GDP are broadly comparable in the Schema model with those of the Bank, National Institute, Treasury and LBS, the composition of GDP differs. Investment falls more in the Schema model, highlighting the importance of stock-flow effects operating via equity prices, q, the capital stock and capacity output, largely absent from the other models. The increase in consumption is less than in the comparable Bank and Institute models (with no direct interest rate effect on consumption) as the decline in wealth due to equity and gilt revaluations offsets the changes in personal income. Using only liquid assets in the consumption function, this effect is missed in the other models. The stock cycle in this model is a feature absent from the other models in the simulation period shown; capacity utilisation, again a unique feature of

the Schema model, helping to produce this. Finally the non-monotonic change in unemployment results partly from the response of the labour supply to wealth and wages, an equation absent from most other models. These considerations suggest that the stock-flow effects highlighted in this paper could make an appreciable difference to the simulation properties of macroeconomic models of the UK.

(iii) Raise investment allowances by 20% (table 4)

This policy has the direct effect of raising the valuation ratio by reducing the replacement cost of the capital stock, and hence investment. As a corollary, it lowers the tax burden on companies, improving their cash flow position to the detriment of the public sector's.

The sharp increase in the valuation ratio raises investment by 1 1/2%-2% throughout the simulation period, which leads in turn to the normal effects on GDP of an increase in demand - higher employment, real wages, personal incomes, consumption and stockbuilding - though with a detrimental effect on the trade balance.

There is less 'crowding out' in this case than for government expenditure. One reason is that increased investment leads to an increase in the capital stock and hence in aggregate supply. Capacity utilisation thus rises initially, but soon falls back towards base levels, thus attenuating the worsening of the current account. Wealth effects are also expansionary; firstly, the PSBR is positive, despite the expansion of the economy, due to the loss of tax revenues, and, secondly, higher "outside" financial assets, capacity utilisation and investment lead to a boost in the share price and equity issues. These lead to an increase in persons' real net wealth throughout, which helps to sustain the increase in consumption. Thirdly, inflation is slow to pick up, partly as a result of the relatively low reductions in unemployment and hence increases in wages compared with the increase in GDP. These combine to give flat unit labour costs. Only after 6-8 years does unemployment fall sufficiently to boost unit labour costs and lead to price inflation and depreciation. This slow build up is also a result of the dependence of labour demand on the capital stock, and on real wage rates themselves rather than unit labour costs. The low elasticity of employment with respect to aggregate demand, including effects arising via capacity utilisation, is a feature of this model that some might wish to question - in this simulation, it appears to be around 0.25, while that of unemployment (expressed as a percentage of the labour force) is around 0.16.

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TABLE 4: DYNAMIC SIMULATION RAISE INVESTMENT ALLOWANCES BY 20%

Variable	% changes (absolute changes *) from base Year 1	2	3	4	5	6	7	8	9	10
Real gross capital stock	0.0	+ 0.05	+ 0.15	+ 0.23	+ 0.31	+ 0.4	+ 0.5	+ 0.61	+ 0.7	+ 0.77
Net private financial assets stock (nominal)	0.0	+ 0.6	+ 1.0	+ 1.6	+ 2.0	+ 2.5	+ 2.7	+ 2.9	+ 3.3	+ 4.0
Persons' real net wealth	0.0	+ 0.7	+ 0.8	+ 1.0	+ 1.1	+ 1.4	+ 1.5	+ 1.6	+ 1.6	+ 1.6
GDPE	0.0	+ 0.4	+ 0.4	+ 0.3	+ 0.3	+ 0.4	+ 0.4	+ 0.5	+ 0.4	+ 0.4
Capacity utilisation	0.0	0.3	0.3	0.1	0.1	0.2	0.2	0.2	0.1	0.0
Consumer prices	0.0	-0.1	0.0	0.0	0.0	0.0	+ 0.1	+ 0.2	+ 0.3	+ 0.4
Wages (nominal)	0.0	+ 0.1	+ 0.4	+ 0.4	+ 0.3	+ 0.4	+ 0.5	+ 0.7	+ 0.9	+ 0.9
Unemployment * (thousands)	0.0	-13	- 5	-	- 2	-16	-23	-21	-11	- 8
Exchange rate	0.0	0.0	+ 0.1	+ 0.1	0.0	0.0	0.0	0.0	- 0.1	- 0.2
Money supply (nominal, £m)	0.0	2.4	2.6	3.1	3.5	4.3	4.7	5.0	5.4	6.3
Q (valuation ratio)	+24	+26	+27	+32	+35	+35	+35	+35	+36	+38
Real fixed investment	0.0	+ 1.5	+ 1.6	+ 1.6	+ 1.7	+ 1.8	+ 2.0	+ 2.2	+ 2.1	+ 2.1
PSBR (nominal, £m) *	0.0	327	320	459	580	671	755	810	1,064	1,762
Short interest rate * (percentage points)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Current account * (nominal, £m)	0.0	-84	-107	-142	-155	-239	-298	-376	-403	-361

(iv) Summary

These simulations reveal that the model gives a plausible picture of the behaviour of the British economy, albeit suggesting rather a large amount of labour market inflexibility. Most other markets appear to work well, though some doubts have been expressed concerning the demand for labour and the response of share prices to inflation. Some of the differences with other UK macroeconomic models have been highlighted.

The next section considers the out of sample performance of the model.

(c) Out of sample performance over 1980-3

Although some of the equations were estimated up to 1982, the period 1980-3 covers some years of out of sample performance for most of them, and at the time of writing data for 1984 was in any case not available. The model used was the basic model described above. The results are shown in Table 5.

GDP is broadly underpredicted over this period, particularly in 1982-3, principally due to an underprediction of consumption and a pessimistic projection of the non-oil trade balance. Investment is predicted fairly well, despite underpredictions of the level of the valuation ratio, and the stock cycle is captured in sign if not level.

	1980	1981	1982	1983
Inventory investment				
Predicted	-4,500	-1,467	-1,721	1,807
Actual	-2,899	-2,739	-1,247	207

The growth of unemployment is tracked reasonably well, though the public sector labour demand function fails to capture the reduced elasticity of employment with respect to government expenditure over this period, and thus accounts for most of the errors. The labour supply and private sector labour demand functions predict developments well over this period, despite the difficulty of tracking the "labour shakeout", as shown.

TABLE 5: DYNAMIC SIMULATION OVER 1980-3

% error (* absolute error)

Variable	Year 1980	1981	1982	1983	% rmse
Real gross capital stock	0.1	0.1	0.1	0.2	0.1
Net private financial assets stock (nominal)	0.2	-0.2	3.0	11.8	6.1
Persons' real net wealth	8.7	9.4	12.6	17.2	12.5
GDPE	1.4	0.2	3.3	4.6	2.9
Capacity utilisation	-0.7	-0.7	2.2	4.9	3.8
Consumer prices	0.5	-0.2	-2.1	-4.9	2.7
[inflation rate]	[15.9]	[12.0]	[10.3]	[8.0]	
Wages (nominal)	0.1	-2.8	-1.0	0.6	1.5
Unemployment * (000s)	0	-37	24	476	8.1
Exchange rate	0.8	-1.1	-2.8	-7.9	4.2
Money supply (£m nominal)	1.0	2.9	5.9	7.5	5.0
Q (valuation ratio)	14	19	21	35	24.0
Real fixed investment //	1.6	-2.3	3.4	1.4	2.3
PSBR* (£m nominal)	-1,615	-2,211	-2,107	7,804	41.8
Short interest rate * (percentage points)	1.1	-4.0	-2.9	-1.3	20.8
Current account * (£m nominal)	436	2,705	2,112	1,554	38.8

// Non-residential 3.1%
Residential 8.9%

\+ Labour supply 0.7
Private labour demand 1.1
Public labour demand 2.9

Employment and unemployment - errors in thousands

	1980	1981	1982	1983
Labour supply	+354	- 39	- 17	+ 71
Private labour demand	+350	+ 73	+118	- 63
Public labour demand	+ 4	- 75	-160	-341
Unemployment	0	- 37	+ 24	+476

The growth of wages is followed closely, though prices are somewhat overpredicted in 1983. The exchange rate equation does not capture the rate of decline observed over 1981-3, perhaps because of the positive influence of North Sea Oil exports in the equation, which the market itself had in fact already discounted at this stage. Overprediction of the exchange rate accounts for the pessimistic prediction of the trade balance. In the financial sector, net financial assets are underpredicted in 1983, mainly due to a sharp underprediction in that year of the PSBR and the current account surplus. Financial assets are thus at a lower level than actuals but the shares are predicted well, as shown below.

Shares in NBPS gross financial wealth - Actual (predicted)

Per cent

	Money	Other Debt	Net foreign assets	Bank lending
1980	40 (40)	45 (46)	15 (14)	31 (32)
1981	40 (39)	43 (45)	17 (15)	31 (33)
1982	37 (38)	43 (46)	20 (16)	31 (32)
1983	37 (40)	43 (42)	20 (17)	33 (34)

Some of the shares are roughly constant, which shows that the specifications, in terms of error correction equations related to long run desired shares, may be reasonable. The slight relative decumulation of money and bonds and accumulation of net foreign assets and bank loans are captured by the system.

In the equity market, problems arise both due to inaccuracies in the share price equation and a failure of the actual share price index to capture the revaluations which occurred over this period. Problems with the stock of equity account for the large errors in 'q' over the period.

To sum up, 1980-3 is tracked imperfectly, problems arising particularly in the exchange rate equation and in the valuation ratio - showing the practical problems of using the latter in a forecasting model. However, the root mean square errors generally remain below 10% and such variables as GDP, wages, investment, the labour market variables and wealth are tracked fairly accurately.

5 Assessment

A model has been presented which makes some progress towards integrating stock and flow effects on the UK economy in an interesting and economically plausible manner. This section has outlined the structure of the model, described the equations, and presented results from tracking and simulation exercises, including contrasts with results from other models. The model suggests that stocks of assets, in particular the capital stock and financial assets, should have a central place in an explanation of the behaviour of the British economy, notably of physical investment, inventory investment, consumption, employment and developments in financial markets, and that these magnitudes can be tracked by a fairly simple structure, subject to sizeable errors from 'vintage effects' and revaluations. The model does, however, have several specification problems, as pointed out in the text. In particular, further research is needed into the labour supply and demand, exchange rate, equity market, more accurate modelling of the capital stock and better data for capacity utilisation. The next section relates this model to the economic theory described in Section I.

III CONCLUSION: THE SCHEMA MODEL AND THE THEORY OF STOCK-ADJUSTMENT DYNAMICS

By way of a conclusion, this final section briefly considers three questions which relate the modelling exercise of Section II to the economic theory described in Section I.

1 What is the effect of using different wealth definitions in the expenditure functions?

2 What determines the price level?

3 To what extent do the properties of the Schema model differ from the analytical properties of the paradigms?

1 The effect of changing the wealth definitions in the expenditure functions

The Schema model incorporates a certain judgement about the nature of wealth effects on the economy, by choice of a particularly wide wealth aggregate to influence consumption. One might ask what difference changing the weights on the components of wealth makes in this framework; if only money enters the consumption function, for example, does one get powerful effects on demand via the interest rate (or yield curve in this model), as money is substituted for other assets? Table 6 presents three simulations wherein current grants are increased by £1,000 million per year, the resulting deficit being financed by money creation. The portfolio system is then used to distribute this increase in the money stock, and the real effects assessed for each of three different consumption functions.

These equations feature personal sector holdings of money, personal sector holdings of 'outside' wealth and total personal sector wealth (as in the main model) respectively. The equations are given in the appendix, page 86. The equation with wider wealth gives the best explanation of the data, though autocorrelation is worse. The 'money' equation gives a faster response to income and wealth; the short run income and wealth elasticities are higher, and the lagged dependent variable of 0.69 gives a faster approach to the long run solution. The 'financial wealth' equation is intermediate, except that it has a lower wealth elasticity than the 'total wealth' equation.

TABLE 6: DYNAMIC SIMULATION, INCREASE CURRENT GRANTS TO PERSONS BY £1,000 MILLION PA, FINANCED BY MONEY CREATION

Total wealth / Outside financial assets / Money as wealth term in consumption function	1	2	3	4	5	6	7	8	9	10
	% change (absolute change *) from base									
Real gross capital stock	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.1	+ 0.1	+ 0.1	+ 0.1
	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.1	+ 0.1	+ 0.1	+ 0.1
	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.0	+ 0.1	+ 0.1	+ 0.1
Net private financial assets stock (nominal)	+ 1.3	+ 2.1	+ 3.3	+ 4.4	+ 4.4	+ 4.6	+ 4.3	+ 4.5	+ 4.7	+ 4.4
	+ 1.3	+ 2.0	+ 3.2	+ 4.2	+ 4.1	+ 4.2	+ 3.9	+ 4.1	+ 4.2	+ 3.9
	+ 1.1	+ 1.7	+ 2.7	+ 3.6	+ 3.4	+ 3.3	+ 2.8	+ 2.7	+ 2.7	+ 2.3
Persons' real net wealth	+ 1.7	+ 1.8	+ 2.0	+ 2.3	+ 2.4	+ 2.5	+ 2.4	+ 2.3	+ 2.1	+ 1.9
	+ 1.7	+ 1.7	+ 1.9	+ 2.1	+ 2.2	+ 2.2	+ 2.1	+ 1.9	+ 1.8	+ 1.5
	+ 1.7	+ 1.5	+ 1.5	+ 1.7	+ 1.6	+ 1.5	+ 1.1	+ 0.8	+ 0.6	+ 0.4
GDPE	+ 0.9	+ 0.8	+ 0.6	+ 0.3	+ 0.4	+ 0.4	+ 0.4	+ 0.3	+ 0.2	+ 0.1
	+ 1.0	+ 0.8	+ 0.6	+ 0.3	+ 0.4	+ 0.4	+ 0.4	+ 0.4	+ 0.3	+ 0.2
	+ 1.2	+ 0.9	+ 0.7	+ 0.4	+ 0.5	+ 0.6	+ 0.6	+ 0.5	+ 0.4	+ 0.3
Capacity utilisation	+ 0.8	+ 0.7	+ 0.4	+ 0.2	+ 0.3	+ 0.4	+ 0.3	+ 0.2	+ 0.1	+ 0.1
	+ 0.8	+ 0.7	+ 0.4	+ 0.2	+ 0.3	+ 0.4	+ 0.4	+ 0.2	+ 0.1	+ 0.1
	+ 1.0	+ 0.8	+ 0.4	+ 0.3	+ 0.5	+ 0.5	+ 0.5	+ 0.3	+ 0.2	+ 0.2
Consumer prices	- 0.2	+ 0.2	+ 0.3	+ 0.3	+ 0.2	+ 0.4	+ 0.6	+ 0.8	+ 0.8	+ 0.8
	- 0.2	+ 0.2	+ 0.3	+ 0.3	+ 0.2	+ 0.4	+ 0.6	+ 0.8	+ 0.8	+ 0.8
	- 0.3	+ 0.2	+ 0.4	+ 0.3	+ 0.2	+ 0.4	+ 0.6	+ 0.8	+ 0.8	+ 0.7
Wages (nominal)	+ 0.2	+ 1.0	+ 1.1	+ 0.7	+ 0.5	+ 0.8	+ 1.2	+ 1.5	+ 1.3	+ 1.1
	+ 0.2	+ 1.0	+ 1.2	+ 0.7	+ 0.6	+ 0.8	+ 1.2	+ 1.5	+ 1.3	+ 1.0
	+ 0.3	+ 1.2	+ 1.3	+ 0.8	+ 0.6	+ 0.9	+ 1.3	+ 1.6	+ 1.3	+ 0.9
Unemployment (thousands)*	-31	- 9	+43	+29	-10	-38	-40	- 1	+28	+ 9
	-32	-10	+45	+31	- 6	-34	-37	+ 3	+32	+13
	-38	- 7	+56	+40	- 1	-30	-30	+18	+51	+26

	1	2	3	4	5	6	7	8	9	10
Exchange rate	0.0	+ 0.2	+ 0.0	- 0.1	- 0.2	- 0.2	- 0.2	- 0.4	- 0.6	- 0.7
	0.0	+ 0.1	0.0	- 0.1	- 0.2	- 0.2	- 0.2	- 0.4	- 0.6	- 0.7
	0.0	+ 0.2	- 0.0	- 0.2	- 0.2	- 0.2	- 0.3	- 0.4	- 0.6	- 0.7
Money supply (nominal, £mn)	+ 7.4	+10.2	+11.9	+12.3	-12.4	+12.7	+12.3	+11.9	+11.3	+10.4
	+ 7.4	+10.2	+11.9	+12.2	+12.3	+12.4	+12.0	+11.6	+10.9	+10.0
	+ 7.7	+10.2	+11.7	+11.9	+12.0	+12.0	+11.5	+10.8	+10.0	+ 8.9
Q (valuation ratio)	+ 2.3	+ 2.4	+ 2.4	+ 3.6	+ 4.4	+ 4.6	+ 4.3	+ 4.0	+ 4.4	+ 4.7
	+ 2.8	+ 2.3	+ 2.4	+ 3.3	+ 4.1	+ 4.3	+ 4.0	+ 3.7	+ 4.1	+ 4.5
	+ 3.0	+ 2.0	+ 1.7	+ 2.7	+ 3.7	+ 3.8	+ 3.4	+ 3.0	+ 3.4	+ 3.9
Real fixed investment	+ 0.1	+ 0.4	+ 0.2	+ 0.1	+ 0.3	+ 0.3	+ 0.3	+ 0.2	+ 0.1	+ 0.2
	+ 0.1	+ 0.4	+ 0.2	+ 0.1	+ 0.3	+ 0.3	+ 0.3	+ 0.2	+ 0.1	+ 0.2
	+ 0.1	+ 0.5	+ 0.2	+ 0.1	+ 0.3	+ 0.4	+ 0.3	+ 0.2	+ 0.1	+ 0.3
PSBR (nominal, £mn)*	+661	+660	+786	+832	+809	+765	+791	+898	+1,038	+1,033
	+655	+650	+776	+813	+779	+730	+756	+864	+ 991	+ 967
	+621	+619	+753	+766	+691	+616	+639	+740	+ 812	+ 712
Short interest rate (percentage points)	0.0	+ 0.1	+ 0.1	0.0	0.0	0.0	+ 0.1	+ 0.1	0.0	0.0
	- 0.1	+ 0.1	+ 0.1	0.0	0.0	0.0	+ 0.1	+ 0.1	0.0	0.0
	- 0.1	+ 0.1	+ 0.1	0.0	0.0	0.0	+ 0.1	+ 0.1	0.0	0.0
current account (nominal, £mn)*	-154	-189	-241	-222	-253	=359	-412	-458	- 455	- 344
	-160	-198	-256	-245	-287	-401	-452	-495	- 490	- 397
	-188	-228	-298	-303	-375	-529	-595	-653	- 659	- 539
Consumption	1.7	1.8	1.6	1.2	1.1	1.1	1.1	1.1	1.0	0.8
	1.8	1.9	1.8	1.4	1.2	1.2	1.3	1.2	1.0	0.8
	2.1	2.2	2.0	1.6	1.5	1.6	1.6	1.5	1.3	1.1

The broad effect of the shock is similar in each case. Higher current grants and higher personal sector wealth boost consumption, which leads to the familiar multiplier effects on investment, stockbuilding, imports, etc. In the labour market, real wages increase because productivity is boosted by the expansion, and the share of company income in GDP rises. This gives rise to offsetting effects on labour demand and supply, leaving unemployment roughly flat. The stock of money is boosted directly in the simulation by £1,000 million per annum. The demand for money is increased by the increase in GDP, but this is more than offset by portfolio balance considerations, as the share of money in total financial wealth becomes excessive. Hence only 60% of the total increase in the money stock remains in this form at the end of the simulation, the rest being distributed across the rest of the portfolio. Persons' net real wealth increases in the simulation due to increases in the saving ratio as personal income is boosted. Towards the end, however, this boost is eroded by inflation.

The key difference made to the simulation by adoption of the different consumption function is the greater expansion apparent when money is entered into the consumption function. This effect, arising from higher consumption, is due both to the (imposed) greater percentage increase in real money stock than in wider definitions of wealth (where £1,000 m represented (in 1980), 2% of person's money holdings, 1% of person's net financial wealth and 1/2% of person's net wealth) and to the speedier and larger response (scaled by the coefficient) of the consumption function with money as the wealth stock. As shown in the table, these effects cause consumption to be at least 0.2-0.4% higher in the 'money' simulation than the others. As a concomitant, personal sector net acquisitions of financial assets are lower in the money-orientated simulation, so persons' real net wealth falls back much more rapidly. Higher GDP in this simulation leads to higher real wages, capacity utilisation and investment, a lower PSBR and a worse current account balance in the familiar manner. The lower PSBR and current account lead to lower inflows of financial assets to the non bank private sector and hence a lower nominal money supply. Company sector liquidity is also lower, despite a higher level of consumption, leading to a lower share price and 'q'.

It should be noted that this simulation is particularly favourable to the hypothesis that differing wealth definitions lead to differing simulation properties. Thus a simulation where the PSBR had been financed so as to leave asset holders on their demand curves would give a much smaller increase in the real money supply, and a greater similarity in the simulations. It should also be pointed out that, in this model, a sharp increase in the money supply does not lead to sharp falls in the interest rate, as a simple IS/LM model would suggest. This stems from the estimation results - money demand did not have a large

interest rate elasticity, nor were monetary disequilibrium terms found to be important determinants of the short interest rate. If these effects had obtained, all the simulations would have proved more expansionary, and the difference between the simulations would also be more marked. A changing interest rate would lead to portfolio shifts that would influence consumption in the case where money is used as a measure of wealth, while the wider wealth measures would be unchanged. The same considerations would apply to portfolio shifts between financial assets and capital (equity and housing) when comparing the other two simulations.

To conclude, differing definitions of wealth can make significant differences to the simulation properties of the model presented in this paper, but lack of empirical success in confirming the importance of money for interest rate behaviour means that the differences are not as substantial as theory would lead one to anticipate.

2 What determines the price level?

Determination of the level of prices is an important feature of a macroeconomic model which professes to be able to simulate long run effects of changes in the economy and to have a determinate steady state.

One may first dismiss two variables as long run determinants of prices. Foreign prices would ultimately fix the domestic price level in the case of a fixed exchange rate regime. In this model, however, the exchange rate adjusts to absorb changes in relative inflation and foreign prices can no longer act as an anchor. Wages do not fix prices either because the wage equation purely determines relative prices and not the absolute level. This is a consequence of the assumption of non-accommodation of wage inflation.(1) Wages are, however, part of the causal chain which leads to fixing of the price level.

The anchor of prices is the stock of nominal 'outside'(2) financial assets, in particular the money stock. Suppose outside wealth is driven above its

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(1) It should be noted that the model is based on certain policy assumptions, notably that the government does not expand the money supply in order to accommodate higher wages at the same level of employment, although this may have been an accurate description of UK economic policy for part of the 60s and 70s. Were this to be the case, and if wages increased <u>autonomously</u> ie not in response to earlier inflation, then wages <u>would</u> be the anchor of prices in the model. As the model is specified, however, wage inflation is self defeating as lacking monetary "accommodation" it increases unemployment as the 'relative' price of labour has increased, and reverses itself.

(2) This should be distinguished from 'inside' money which is generated through financial intermediation within the private sector. This is <u>not</u> an anchor of prices.

equilibrium levels. This leads to a distribution of the increase across the wealth portfolio, in line with the unit elasticities of the various assets with respect to wealth. However, real income enters both the personal and NBPS demand for money functions in the short and long run, and an increase in money leads to a disequilibrium in the money/income ratio, such that agents are dissatisfied with their asset holdings. They then adjust their expenditures, this being expressed in two principal ways. Consumption increases because real wealth has increased. Investment increases owing to higher company sector liquidity, which increases the share price and hence the valuation ratio. These stimuli act to raise real incomes via the multiplier process, and hence in the reduced form the model acts to satisfy the long run solution of the money demand function. However, the adjustment does not end at this stage, because higher real incomes lead to lower unemployment and to a higher level of capacity utilisation.

The long run solution of the model (which is very long to occur) is such that these factors eventually cause real incomes to decline towards their original level and most of the adjustment, is expressed in prices, though capacity GDP also increases. Consider first the equilibrating effects of higher capacity utilisation. Capacity utilisation cannot increase permanently; firstly it induces a trade deficit, reducing aggregate demand directly, secondly it causes investment increases, which lead to increases in supply itself and thirdly it raises demand for labour, which reduces unemployment. The equilibrating tendencies of the first two of these effects are obvious. Higher employment, however, also leads to a new equilibrium due to the long run natural rate of unemployment in the wage equation. This implies that the economy cannot remain in the long run at a reduced level of unemployment without inflation. The inflation that results from increased employment eventually nullifies the increase in real balances which stimulated the increase in consumption, and increases the cost of the capital stock thus lowering 'q'. Real demand is hence eventually reduced towards its original level. These processes converge on a steady state, with the same level of capacity utilisation and unemployment, higher prices, and somewhat higher capacity GDP and actual GDP except in the unlikely case that capacity GDP grows faster than aggregate demand.

In the long run, the model therefore translates an increase in nominal demand due to increased financial assets into prices, except for any increases in real demand consistent with a new higher level of capacity GDP (due to higher productivity, capital accumulation or growth of the labour force), and the equilibrium level of capacity utilisation, and also any effects of changes in relative commodity prices on capacity utilisation. At this new, higher level of nominal income, agents in the economy will again be content with the stock of money they are holding.

To sum up, analysis of the long run properties of the model suggest that the price level is fixed by outside wealth in the very long run, subject to increases in capacity GDP which necessitate increases in the real money supply for transactions purposes.

3 To what extent do the properties of the Schema model differ from the analytical properties of the paradigms?

Section I above described analytical models featuring stock flow consistency. Comparison of these models with the estimated model described in this section gives a measure of the success of the modelling project, and indicates some of the difficulties involved in empirical implementation of such paradigms. (Of course, a lack of success in empirical modelling may also indicate a lack of realism in the features of a text book model!)

A principal of the Schema model in this respect is the lack of a strong money stock-interest rate relation normally encapsulated in the LM curve. Instead, the demand for money depends on the yield curve - the choice of monetary aggregate in fact implies a positive relation of money demand to the short rate. The short rate is determined by foreign interest rate parity without direct reference to money demand or supply. However, in defence of this feature, it can be argued that foreign rates have historically been a crucial determinant of UK short rates, and few macroeconomic models have been able to demonstrate a strong causal relation of money to the interest rate in the UK. A corollary of this result, together with use of total wealth in expenditure functions, is that <u>strong</u> differential effects of money and bond financed deficits are absent. Weak effects arise via the portfolio balance term in the long rate equation, as described above.

Some unsatisfactory features of the Schema model arise in the financial system. For example, there is generally not an endogenous determination of asset prices by asset demands and supplies. At most, asset prices are determined in reduced form equations, with portfolio imbalance terms feeding in wealth disequilibrium effects. Foreigners' portfolio preferences are not explicitly modelled, while theoretical considerations suggest that they should be an important determinant of the exchange rate. Thirdly, there is no explicit modelling of certain non cleared markets, such as those for bank advances, as suggested by Backus et al (1980).

Concerning wealth effects, these are restricted, except in the experiment above (pages 61-5), to determination of expenditure by total wealth. Desired personal sector wealth (in the consumption function) depends only on income, though it is influenced by interest rates in the reduced form - as, for example, higher real interest rates increase personal incomes via their non-labour component, and hence they increase desired wealth. The sequential decision process in the model could also be criticised. To summarise, given income and lagged wealth, the decision to spend is a primary decision, determining also the total accumulation of assets. Investment is then separately determined, leaving financial assets as a residual, which is then split among the financial asset portfolio. Certain of the analytical models quite correctly treat these decisions as simultaneous. The sequential approach would be more appropriate if interest rates affected expenditures directly. However, empirical evidence from estimations suggests that these effects are relatively weak.

Inflation effects on income are identified above as an important conduit of stock effects on real behaviour. Although this is implemented for persons, it is not carried through for the company. overseas, and public sectors. In these cases, the stock-flow modelling is not consistent.

Finally, one may consider the influence of prices. Explicit modelling of price expectations is avoided except implicitly as backward-looking, adaptive expectations, for example in the wage equation, with only long run homogeneity of wages and prices. 'Rational' or forward-looking price expectations are an obvious alternative, and might be expected also to feature in the exchange rate equation, the financial system and certain real expenditure equations (in this connection, see Easton and Matthews (1986)). Rational expectations might also be appropriate in other areas of the model.

These problems, of which interest rate determination is perhaps the most serious, mean the model does not entirely encapsulate the properties of the analytical models - in particular a money-financed expansion does not exert an expansionary influence on the economy via a strong downward pressure on the interest rate. Effects arise instead via wealth effects on consumption and labour supply and liquidity effects on investment. The expansionary result still arises, however; but it would do so equally through a bond financed expansion, except to the extent crowding-out occurs via an increase in the long rate.

On the credit side, the modelling exercise does incorporate most of the other properties of the paradigms, encapsulated in the discussion of desirable properties of macroeconomic models enumerated above (page 14). Certain features of the model could also be highlighted as useful additions to the paradigms. For

example, the model has a foreign trade sector, with trade volumes, prices and the exchange rate endogenous. There is also a wide disaggregation of investment, labour demand, prices, financial assets and of income and expenditure at a sectoral level. One could point out in particular the disaggregation of equity, which allows substitutability for persons of financial assets with claims to capital. It also allows a more complete determination of Hicksian income. Like other asset prices, however, equity prices are only modelled as a reduced and not a structural form.

A further distinction of the Schema model is endogenous capacity utilisation, which is used widely to influence market clearing. The specification of potential output, with a time trend, and labour supply determined by population growth, gives endogenous growth to the model and hence positive capital accumulation and net saving in a steady state, unlike certain analytical models.

The model encapsulates the slow process of market clearing in an economy, and hence might be thought more 'realistic' than certain of the analytical paradigms. This is achieved principally by use of market clearing long run solutions in key equations, but only partial adjustment in the short run and slow adjustment to the steady state. The accuracy of the model's representation of the market behaviour of the economy is of course subject to the weakness of data, the inaccuracy of the prior choice of independent variables, the estimation methods, the Lucas critique etc.

Finally, one might note the use of wealth as a determinant of the labour supply, and company liquidity as a determinant of the equity price.

On balance, it can be claimed that the modelling exercise represents progress in consistent stock flow modelling, but there remain some problems and deficiencies. The shortcomings of the model in relation to the paradigms listed in the first part of this section thus form an important area of future research. Other areas could also be noted, however, which are important to stock/flow modelling but are not analysed either by the theoretical work instanced in this paper, nor in the modelling exercise. Future work on stock flow modelling would be needed to take them into account.

1 The role of bank credit as a determinant of expenditures and a determinant of interest rates. A complete treatment obviously requires modelling of the banking system.

2 Treatment of the PSBR vis a vis private sector borrowing - should it have different effects on the economy, as it does implicitly in the work above?

3 Identification of a buffer variable and/or direct effects of disequilibrium assets on real variables apart from via their total levels. In the Schema model, it has been suggested that inventories form a 'buffer' on the real side, and bank lending on the financial side, but the treatment is not explicit.

4 Should the real exchange rate be allowed to change in the long run, as is not permitted by the purchasing power parity formulation adopted here?

EQUATION LISTING - 4 SECTOR SCHEMA MODEL

(a) Real Expenditure

Inflation rate of consumer prices (A1)

$$IPC = (PC - PC_{t-1})/PC_{t-1}$$

Average inflation rate of PC over past 2 years (A2)

$$WIPC = (IPC + IPC_{t-1})/2$$

Inflation rate of gilt prices (A3)

$$IPG = (GP - GP_{t-1})/GP_{t-1}$$

Average inflation rate of GP over past 2 years (A4)

$$WIPG = (IPG + IPG_{t-1})/2$$

Inflation rate of share prices (A5)

$$ISP = (SPUK - SPUK_{t-1})/SPUK_{t-1}$$

Average inflation rate of SPUK over past 2 years (A6)

$$WISP = (ISP + ISP_{t-1})/2$$

Adjusted personal income (A7)

$$YA = YD/PC - (WIPC/x)*[(NCWP - 0.7\ KNDJ)/PC]_{t-1}$$

$$-[1 -(1 - WIPC/x)^{0.5}]*[\Delta(NCWP - 0.7\ KNDJ)/(PC*PC_{-1})^{0.5}]$$

$$+ y*(KEQJ/PC)_{t-1} + z*(0.7\ KNDJ/PC)_{t-1}$$

$$+(1-(1-y)^{0.5})*[\Delta KEQJ/(PC*PC_{-1})^{0.5}]$$

$$+(1-(1-z)^{0.5})*[\Delta 0.7\ KNDP/(PC*PC_{-1})^{0.5}]*0.06$$

where $x = 1 + WIPC$

$y = (WIPS - WIPC)/(1 + WIPC)$

$z = (WIPG - WIPC)/(1 + WIPC)$

Consumption Function (A8)

$$\Delta \ln C = \underset{(10.4)}{0.57047}\ \Delta \ln YA - \underset{(1.4)}{0.14895}\ \ln (C/YA)_{t-1}$$

$$+ \underset{(2.5)}{0.02674}\ \ln (((NFWP + CPDN)_{t-1}/PC)/YA_{t-1}) - \underset{(1.8)}{0.023}$$

$\bar{R}^2 = 0.899$ SE = 0.007414 DW = 2.7 LM(2) = 5.2 1966 - 1982

Stockbuilding (A9)

$$\Delta \ln KIIT = - \underset{(2.3)}{0.29056}\ \Delta[\ln (1 + RLB/100) - \Delta \ln PS]$$

$$+ \underset{(1.4)}{0.2031}\ [\ln (1 + RLB/100) - \Delta \ln PS_{t-1}] + \underset{(3.3)}{1.5606}\ \Delta \ln GDPE$$

$$+ 0.66473 \ln (GDPE/KIIT)_{t-1} - 0.7248 + 0.17638\ \Delta \ln (GDPC/GDPE)$$

$\bar{R}^2 = 0.814$ SEE = 0.014 DW = 0.014 LM(2) = 7.4 1964 - 1980

Inventory Stock-Flow Identity (A10)

$$II = KIIT - KIIT_{t-1}$$

Nominal Stockbuilding (A11)

$$II£ = II * (PS + PS_{t-1})/2$$

Stock Appreciation (A12)

$$YSA = (KIIT * PS) - (KIIT * PS)_{t-1} - II£$$

Tobin's "Q" (average) (A13)

$$Q = KEQC/(CPNN * (1 - IALL)) + (KIIT * PS)$$

Private non-residential fixed investment (A14)

$$\ln INP = -0.54635 \underset{(1.6)}{\ln (KPNG)_{t-1}} - 0.11768 \underset{(2.1)}{\ln (PFL/PGDP)_{t-1}}$$
$$+ 0.52891 \underset{(3.6)}{\ln (PMBM/PGDP)_{t-1}} + 0.1429 \underset{(2.5)}{\ln Q_{t-1}}$$
$$+ 0.08191 \underset{(4.4)}{TIME} + 15.65668 \quad (3.8)$$

$\bar{R}^2 = 0.968$ SE = 0.032162 DW = 2.4 LM(2) = 6.6 1966 - 1982

Private sector housing investment (A15)

$$\ln IHP = 0.55981 \underset{(4.1)}{\ln IHP_{t-1}} - 1.82649 \underset{(3.9)}{[\ln (1 + RLB/100) - \Delta \ln PGDP]}$$
$$- 0.34198 \underset{(3.2)}{\ln KPDG_{t-1}} + 3.57662 \underset{(3.3)}{\ln (PGDP/ULC)} + 6.68591 \quad (3.6)$$

$\bar{R}^2 = 0.7$ SE = 0.06917 DW = 2.1 LM(2) = 3.8 1964 - 1982

Aggregate Fixed Investment Identity (A16)

$$IF = INP + IHP + ING + IHG$$

Real Gross Capital Stock: Public non -residential (A17)

$$KUNG = ING + \underset{(114.6)}{0.9889\ KUNG_{t-1}}$$

$\bar{R}^2 = 0.999$ SE = 9992 DW = 1.4 LM(2) = 5.0 1966 - 1982

Real Gross Capital Stock: Private non-residential (A18)

$$KPNG = INP + \underset{(130.5)}{0.97756\ KPNG_{t-1}}$$

$\bar{R}^2 = 0.999$ SE = 10065 DW = 1.4 LM(2) = 1.7 1968 - 1982

Real Gross Capital Stock: Private residential (A19)

$$KPDG = IHP + \underset{(121.9)}{0.99906\ KPDG_{t-1}}$$

$\bar{R}^2 = 0.999$ SE = 6582 DW = 1.6 LM(2) = 5.1 1964 - 1982

Real Net Capital Stock: Private non-residential (A20)

$$KPNN = \underset{(280.6)}{0.61471\ KPNG} \quad (Nominal\ CPNN = KPNN.PINP)$$

$\bar{R}^2 = 0.999$ SE = 3089 DW = 0.2 LM(2) = 15.4 1965 - 1982

Real net capital stock: Private residential (A21)

$$KPDN = \underset{(193.4)}{0.59372}\ KPDG + \underset{(11.9)}{566.256}\ TIME \quad (\text{Nominal } CPDN = KPDN.PIHP)$$

$\bar{R}^2 = 0.999$ SE = 892 DW = 0.3 LM(2) = 14.3 1963 - 1982

Export volume excluding oil (A22)

$$\Delta \ln (X - XG2) = \underset{(3.6)}{0.67429}\ \Delta \ln TWIP - \underset{(0.9)}{0.14391}\ \Delta \ln \left(\frac{PX}{WPIM/EER}\right)$$

$$- \underset{(2.7)}{0.5404}\ \ln \frac{X - XG2_{-1}}{TWIP} - 0.46204 \ln \left[\left(\frac{PX}{WPIM/EER}\right)_{t-1}\right]$$

$$- \underset{(2.7)}{3.2819} + \underset{(1.5)}{0.33051}\ \ln \left(\frac{GDPC}{GDPE}\right)_{t-1}$$

$\bar{R}^2 = 0.742$ SE = 0.024 DW = 2.6 LM(2) = 4.2 1964 - 1981

Import volume excluding oil (A23)

$$\Delta \ln (M - MG2) = \underset{(2.9)}{1.7747}\ \Delta \ln (GDPE + M) - \underset{(1.5)}{0.33657}\ \ln (M - MG2)/(GDPE + M)_{t-1}$$

$$- \underset{(1.0)}{0.14683}\ \ln (PM/PGDP) - \underset{(1.0)}{0.3718}\ \ln (GDPC/GDPE)_{t-1}$$

$$+ \underset{(2.2)}{0.01496}\ TIME - \underset{(1.4)}{0.6914}$$

$\bar{R}^2 = 0.441$ SE = 0.04 DW = 2.0 LM(2) = 7.2 1964 - 1981

Factor cost adjustment (A24)

$$FCA = \underset{(155.8)}{0.07757}\ G + 0.06989\ I + 0.04318\ X + 0.15266\ C$$

$\bar{R}^2 = 0.9988$ SE = 572 DW = 0.6 1955 - 1982

Deflator for FCA (A25)

$$TREF = TREF_{-1} \cdot PGDP/PGDP_{-1} + 0.15186\ \Delta RIT/RIT_{-1}$$

$\bar{R}^2 = 0.286$ SE = 0.039 DW = 1.6 1964 - 1982

Demand (GDP at factor cost) (A26)

$$GDPE = C + IF + II + G + X - M - FCA$$

Total Final Expenditure (A27)

$$TFE = GDPE + M$$

(b) Labour Market

Labour Supply (B1)

$$\ln (LS/POWA) = 0.00314\ TIME - 0.26749 + DLPT$$

$\bar{R}^2 = 0.763$ SE = 0.00977 DW = 0.6 LM(2) = 9.9 1966 - 1982

Deviations of log of participation rate from trend (B2)

$$DLPT = \underset{(1.1)}{0.07521} \ln [(WS\ (1 - TRYW))/PC]_{t-1}$$

$$- \underset{(0.6)}{0.0578} \ln [(WS(1 - TRYW))/PC]_{t-2}$$

$$+ \underset{(2.4)}{0.13603} \ln [(WS\ (1 - TRYW))/PC]_{t-3}$$

$$- \underset{(1.7)}{0.04277} \ln (NFWP + CPDN)/PC_{t-1}$$

$$+ \underset{(0.9)}{0.03018} \ln (NFWP + CPDN)/PC_{t-2}$$

$$- \underset{(2.6)}{0.08048} \ln (NFWP + CPDN)/PC_{t-3}$$

$$- \underset{(3.4)}{1.266} \sum_{i=1}^{4} LU/LS_{t-i}$$

$\bar{R}^2 = 0.53$ SE = 0.0068 DW = 1.9 LM(2) = 3.3 1967 - 1982

Private sector demand for labour (B3)

$$\ln LDP = \underset{(1.8)}{0.19054} \ln (KPNG)_{t-1} - \underset{(1.0)}{0.18791} \ln (PFL/PGDP)_{t-1}$$

$$- \underset{(0.6)}{0.03399} \ln (PMBM/PGDP)_{t-1} - \underset{(1.5)}{0.68664} \ln (WS + (YEC/LD)/PGDP_{t-1})$$

$$- \underset{(1.5)}{0.23105} \ln (GDPC/GDPE)_{t-1} + \underset{(12.7)}{11.12176} + \underset{(1.3)}{0.1812} \ln GDPE$$

$\bar{R}^2 = 0.895$ SE = 0.011 DW = 1.9 LM(2) = 8.3 1966 - 1981

Public employment (B4)

$$\ln LDU = \underset{(2.7)}{0.43518} \ln (G + ING + IHG) - \underset{(1.2)}{0.00287} \ln (LDU/(G + IHG + ING))_{t-1}$$

$\bar{R}^2 = 0.38$ SE = 0.0202 DW = 1.6 1965-1982

Demand for labour (B5)

$$LD = LDU + LDP$$

Unemployment (B6)

$LU = LS - LD$

(c) Output

Mid-year non-residential real gross capital stock (C1)

$$K = \sum_{i=0}^{1} (KPNG + KUNG)_{t-i.} - 2$$

Production function (capacity output) (C2)

$$\ln GDPC = \overline{0.6}\ \ln LS + \overline{0.4}\ \ln K + \underset{(215.3)}{3.52004} - \underset{(4.2)}{0.21525}\ \ln (PMBM/PGDP)$$

$$+ \underset{(7.3)}{0.01022}\ TIME - \underset{(0.9)}{0.00556}\ \ln (PFL/PGDP)$$

$\bar{R}^2 = 0.805$ SE = 0.0226 DW = 1.5 LM(2) = 1.8 1966 - 1980

Capacity utilisation (C3)

$CAPU = GDPE/GDPC$

(d) Wages and income from employment

Phillips Curve (D1)

$$\Delta \ln WS = - \overline{1.0}\ \ln (YWS + YEC)/GDPE + \underset{(1.6)}{0.46381}\ \Delta \ln GDPE/LD + \underset{(1.6)}{0.41622}\ \Delta \ln PC$$

$$- \underset{(2.5)}{2.13583}\ (LU/LS)_{-1} + \underset{(2.8)}{0.0113}\ TIME + \underset{(3.1)}{0.08974}\ D75 + \underset{(1.1)}{0.1038}\ \Delta \ln TRYW$$

$$- \underset{(18.4)}{0.03892}\ \ln (WS_{t-1}\ (1 - TRYW)/PC)$$

$\bar{R}^2 = 0.991$ SE = 0.019 DW = 1.6 LM(2) = 1.1 1964 - 1982

Labour income (D2)

$YWS = WS * LD * 0.001$

Employers' national insurance contributions (D3)

$YECN = ANIR.YWS$

Employers' other contributions (D4)

$$\Delta \ln YECO = \underset{(2.2)}{1.0}\ \Delta \ln YWS + \underset{(1.7)}{2.72571}\ LU/LS + 0.02145$$

$\bar{R}^2 = 0.17$ SE = 0.0495 DW = 2.0 LM(2) = 3.4 1964 - 1982

Total employers' contributions (D5)

$YEC = YECO + YECN$

Unit labour costs (D6)

ULC = ((WS * LD) + YEC)/GDPE

(e) Prices

Consumer Price deflator (E1)

$$\ln PC = \underset{(7.1)}{0.39021}\ \ln ULC + \underset{(5.4)}{0.19937}\ \ln PM + \underset{(1.7)}{0.08707}\ \ln (FCA£/GDPE)$$

$$+ \underset{(2.6)}{0.15393}\ \ln (PM/ULC)_{t-1} - \underset{(3.7)}{0.39883}\ [\ln (PC/ULC)_{-1}$$

$$- 0.15\ \ln (FCA£/GDPE)/ULC_{-1}] + \underset{(3.7)}{0.21289}$$

$\bar{R}^2 = 0.957$ SE = 0.010636 DW = 2.2 LM(2) = 0.2 1964 - 1982

Inventory price deflator (E2)

$$\ln PS = \underset{(4.6)}{0.23209}\ \ln ULC + \underset{(6.6)}{0.29718}\ \ln PM + \underset{(6.2)}{0.21227}\ \ln (PM/ULC)_{t-1}$$

$$- \underset{(5.1)}{0.31673}\ \ln (PS/ULC)_{-1} + \underset{(2.4)}{0.10491} - \underset{(1.5)}{0.11579}\ \ln (GDPC/GDPE)_{-1}$$

$\bar{R}^2 = 0.974$ SE = 0.0095 DW = 2.4 LM(2) = 4.5 1964 - 1981

Private non-residential fixed investment price deflator (E3)

$$\ln PINP = \underset{(4.6)}{0.56303}\ \ln ULC + \underset{(1.8)}{0.14223}\ \ln PM + \underset{(2.1)}{0.1643}\ \ln (PM/ULC)_{t-1}$$

$$- \underset{(2.3)}{0.43343}\ \ln (PINP/ULC)_{t-1} + \underset{(1.5)}{0.0992}$$

$\bar{R}^2 = 0.845$ SE = 0.022125 DW = 1.3 LM(2) = 3.7 1966 - 1982

Private housing investment price deflator (E4)

$$\ln PIHP = \underset{(3.2)}{0.78675}\ \ln ULC + \underset{(2.1)}{0.41918}\ \ln PM - \underset{(1.2)}{0.17761}\ \ln$$

$$(PIHP/ULC)_{-1} + \underset{(0.8)}{0.01927}$$

$\bar{R}^2 = 0.576$ SE 0.05259 DW = 1.2 LM(2) = 5.8 1964 - 1982

Government current expenditure price deflator (E5)

$$\ln PG = \underset{(10.2)}{0.8379}\ \ln ULC + \underset{(2.1)}{0.14755}\ \ln PM + \underset{(0.8)}{0.26548}\ \ln (PM/ULC)_{t-1}$$

$$- \underset{(0.8)}{0.20836}\ \ln (PG/ULC)_{-1} + \underset{(0.76)}{1.78333}$$

$\bar{R}^2 = 0.94$ SE = 0.015012 DW = 2.0 LM(2) = 3.1 1964 - 1982

Public sector investment price deflator (E6)

$$\Delta \ln PING = \underset{(6.3)}{0.74744}\ \Delta \ln ULC + \underset{(3.7)}{0.28269}\ \Delta \ln PM - \underset{(1.0)}{0.15449}\ \ln (PING/ULC)_{-1} + \underset{(1.2)}{0.04242}$$

$\bar{R}^2 = 0.851$ SE = 0.025 DW = 1.6 LM(2) = 1.9 1966 - 1982

Current price GDP (E7)

$$GDP£ = (C * PC) + (INP * PINP) + (IHP * PIHP) + ((ING + IHG) * PING) + (G * PG) + (X * PX) - (FCA * TREF)$$

GDP deflator (E8)

$$PGDP = GDP£/GDPE$$

Deflator for market price GDP (E9)

$$PGDM = (GDP£ + (FCA * TREF))/(GDPE + FCA)$$

Distributed lag of inflation rate of PC (E10)

$$PC7 = 0.26 * IPC + 0.22 * IPC_{-1} + 0.18 * IPC_{-2} + 0.14 * IPC_{-3} + 0.1 * IPC_{-4} + 0.07 * IPC_{-5} + 0.03\ IPC_{-6}$$

Export Prices (E11)

$$\ln PX = \underset{(1.7)}{0.15197}\ \ln (WPIM/EER) + \underset{(1.8)}{0.19379}\ \ln (WPIM/EER)_{-1} + \underset{(3.0)}{0.47435}\ \ln PDGP + \underset{(1.5)}{0.20302}\ \ln PGDP_{-1} + \underset{(1.0)}{0.0198}$$

$\bar{R}^2 = 0.998$ SE = 0.0242 DW = 1.54 1964 - 1982

Import Prices (E12)

$$\ln PM = \underset{(5.1)}{0.74484}\ \ln (WPIM/EER) + \underset{(0.2)}{0.03435}\ \ln (WPIM/EER)_{-1} + \underset{(2.4)}{0.30506}\ \ln PGDP - \underset{(1.2)}{0.02791}$$

$\bar{R}^2 = 0.995$ SE = 0.0435 DW = 1.2 1964 - 1982

Exchange Rate (E13)

$$\Delta \ln EER = \underset{(4.3)}{-0.38047} \ln PGDP/(WPIM/EER)_{-1} \underset{(12.2)}{-2.62936} \underset{(9.5)}{-0.02687} TIME$$

$$\underset{(3.4)}{-0.07708} D68 \underset{(11.6)}{+0.33886} \ln XG2$$

$$\underset{(2.6)}{-0.09486} \ln (KNFA/NFA)_{-1} \underset{(3.2)}{+0.00624} \Delta \hat{RLB}$$

$\bar{R}^2 = 0.930$ SE = 0.017 DW = 2.2 LM(2) = 0.4 1968 - 1982

Price of raw materials (E14)

PMBM = FMBM/EER

Price of fuel (E15)

PEL = FFL/EER

(f) Public sector debt interest (F1)

Public sector debt interest

EDBT = $\underset{(75.0)}{1.11069}$ [RUKG/100] KNDP

$\bar{R}^2 = 0.9967$ SE = 291 DW = 1.1 1963 - 1982

Rate of unemployment benefit (use in simulations) (F2)

$\Delta \ln RUB = \Delta \ln PC$

Current grants to persons (F3)

$$YJG = \left(\frac{RUB}{1000} * LU\right) \underset{(7.5)}{+1.61382} \left(\frac{RUB}{1000} * (55000 - POWA)\right) \underset{(6.7)}{-6491.6} \underset{(2.6)}{-837.8} TIME$$

$\bar{R}^2 = 0.959$ SE = 1885 DW = 1.4 1964 - 1982

Current price government current expenditure (F4)

G£ = PG * G

Current price government investment (F5)

IG£ = (ING + IHP) * PING + 0.05 * (II£ + YSA)

Public sector receipts (F6)

$T^* = (YWS * YTAX) + (CTAX * YCT_{t-1}) + FCA.TREF + YGTA + YGRA$

Public sector payments (F7)

$G^* = G£ + EDBT + YJG + EGTA$

Public sector saving (F8)

$SG = T^* - G^*$

Public sector borrowing requirement (F9)

$PSBR = IG£ - FTKG - SG - POTH$

(g) Balance of Payments

Net property income from abroad (G1)

$$BYPA = \underset{(5.6)}{0.82352}\ [RUSG/100].KNFA - \underset{(3.8)}{2510.3}\ DEC$$

$\bar{R}^2 = 0.688$ DW = 1.5 SE = 459 1963 - 1982

Current account (G2)

$CA = (PX.X) - (PM.M) + BYPA + CARE$

(h) Non-bank private sector financial model

Revaluations of gilts (H1)

$GREV = (IPG) * (0.7 * KNDP_{-1}) * 0.78$

Revaluations of equities (H2)

$$EREV = \underset{(5.1)}{1.16}.ISP.KEQC_{t-1}$$

$\bar{R}^2 = 0.57$ SE = 10025 DW = 2.2 1964 - 1982

Revaluations of foreign assets (H3)

$FREV = (FRE1 + FRE2) * 0.33$

$FRE1 = [EER/EER_{-1} * (KNFA_{-1} * (0.6)) - KNFA_{-1} * (0.6)]$

$FRE2 = [EER/EER_{t-1} * (RUSG_{t-1}/RUSG) * KNFA_{-1}] - KNFA_{-1}$

Revaluations accruing to non-bank private sector (H4)

$REV = GREV + FREV + REVR$

Supply of financial assets to non-bank private sector (H5)

$$NFA = NFA_{t-1} + CA + PSBR + REV + FRES$$

Money demand (H6)

$$\begin{aligned}\Delta \ln KM3£/PGDM = {} & 0.6433 \ln ((GDP£/PGDM) * (1 - DTAX))_{-1} \\ & (4.7) \\ & -0.3153 \ln (KM3£/NFA)_{-1} + 1.54382 \Delta \ln ((GDP£/PGDM * (1 - DTAX) \\ & (4.8) \qquad\qquad (4.5) \\ & +0.56963 \Delta \ln (NFA/PGDM)_{-1} - 7.81841 + 0.14108 CCD \\ & (5.2) \qquad\qquad (4.7) \quad (6.1) \\ & +2.02085 (\ln (1 + RLB/100) - \Delta_1 \ln PGDM)_{-1} \\ & (2.7) \\ & -1.92974 (\ln (1 + RUKG/100) - \Delta_1 \ln PGDM)_{-1} \\ & (2.7)\end{aligned}$$

$\bar{R}^2 = 0.909$ SE = 0.0243 DW = 2.3 LM(2) = 1.2 1965 - 1982

Demand for gilts and other national debt (H7)

$$\begin{aligned}\Delta \ln KNDP = {} & 1.16277 \Delta \ln NFA - 0.36026 \ln (KNDP/NFA)_{-1} - 0.26878 \\ & (4.7) \qquad\qquad (1.5) \qquad\qquad (1.5) \\ & +0.01036 RUKG - 0.00387 RLB - 0.00047 RUSG \\ & (1.1) \qquad (3.3) \qquad (0.1)\end{aligned}$$

$\bar{R}^2 = 0.695$ SE = 0.057 DW = 2.5 LM(2) = 4.6 1964 - 1980

Demand for net foreign assets (H8)

$$\begin{aligned}\Delta \ln KNFA = {} & 0.74427 \Delta \ln NFA - 0.71685 \ln (KNFA/NFA)_{-1} - 1.13785 \\ & (1.3) \qquad\qquad (3.0) \qquad\qquad (2.9) \\ & -0.04462 RUKG + 0.06843 RUSG \\ & (2.3) \qquad (2.7)\end{aligned}$$

$\bar{R}^2 = 0.508$ SE = 0.157 DW = 2.2 LM(2) = 5.0 1964 - 1980

Demand for Bank loans (H9)

$$KBLP = KBLP_{-1} + \Delta KM3£ + \Delta KNDP + \Delta KNFA - \Delta NFA$$

Short rate (H10)

$$\begin{aligned}\Delta \ln (1 + RLB/100) = {} & 0.70741 \Delta \ln (1 + REU\$/100) + 0.19812 \Delta \ln PC - 0.03515 \Delta \ln \hat{EER} \\ & (3.2) \qquad\qquad (1.7) \qquad\qquad (0.6) \\ & -0.01756 - 0.60986 \ln \left(\frac{1 + RLB/100}{1 + REU\$/100}\right) \\ & (1.4) \quad (2.2)\end{aligned}$$

$\bar{R}^2 = 0.32$ SE = 0.017 DW = 2.2 LM(2) = 7.5 1968 - 1982

Long interest rate (H11)

$$RUKG = \underset{(23.2)}{0.82805\ RLB} + \overline{3.0} + \underset{(1.6)}{\overline{0.2}\ PC7} + 17.01881\ \Delta(KNDP/NFA)$$

$\bar{R}^2 = 0.967$ SE = 1.5 DW = 1.4 LM(2) = 1.3 1964 - 1982

Gilt price index (H12)

$$\Delta \ln GP = \underset{(7.9)}{-0.70236\ \Delta \ln RUKG}$$

$\bar{R}^2 = 0.76$ SE = 0.04508 DW = 1.8 LM(2) = 2.1 1964 - 1982

Net wealth of non-bank private sector (H13)

NW = NFA + CPNN + CPDN

(i) Personal sector income and expenditure

Owner occupiers' imputed rent (I1)

$$ORNT = \underset{(70.7)}{0.0595\ KPDN} - \underset{(1.8)}{113.63}$$

$\bar{R}^2 = 0.996$ SE = 18.1 DW = 1.0 1963 - 1982

Other income, excluding income from self-employment (I2)

$$YJOS = ECDV.(KEQJ/KEQC) + EDBT.(KNDJ/KNDP) + BYPA.(KNFJ/KNFA)$$
$$- (RLB/100).KBLJ + ORNT + \underset{(23.8)}{0.10172\ (RLB/100).(NCWP + KEQJ + CPDN)}$$

$\bar{R}^2 = 0.966$ SE = 428 DW = 1.7 1963 - 1982

Total personal income (I3)

YJ = YWS + YEC + YJOS + PYRS

Personal disposable income (I4)

YD = YJ * (1 - YTAX)

Person's net acquisition of financial assets (I5)

FJ = YD - (PC.C) - (IHP.PIHP) - 0.15 (YSA + II£) + PNFR

(j) Company Sector Income and Expenditure

Company profits (J1)

$$YCP = GDP\pounds - YWS - PYRS - YEC + YSA - YR - YGTA - RESE$$

Company dividends (J2)

$$\ln ECDV = \underset{(5.9)}{0.62708}\ \ln ECDV_{t-1} + \overline{0.37292}\ \ln (YCP + YCO - (0.8.YSA) + ECDV - (CTAX.YCT_{t-1})) - \underset{(3.4)}{0.44242} - \underset{(1.5)}{0.13134}\ D73$$

$\bar{R}^2 = 0.961$ SE = 0.0972 DW = 1.8 LM(2) = 1.9 1967 - 1982

Other company income less appropriations (J3)

$$YCO = EDBT.((KNDP - KNDJ)/KNDP) + BYPA.((KNFA - KNFJ)/KNFJ) - ECDV + 0.075\ (RLB/100).(NCWC - KEQC + CPNN) - (RLB/100)*(KBLP-KBLJ)$$

Companies' net acquisition of financial assets (J4)

$$FC = YCO + YCP - (INP.PINP) + CNFR - 0.8\ (YSA + II\pounds) - (CTAX.YCT_{t-1})$$

Companies' taxable income (J5)

$$YCT = YCO + YCP - (IALL.(PINP.INP)) - 0.8\ YSA$$

(k) Persons' financial model

Supply of financial assets to persons (K1)

$$NFWP = NFWP_{t-1} + FJ - POFA + FREV.(KNFJ/KNFA) + GREV.(KNDJ/KNDP) + EREV.(KEQJ/KEQC)$$

Persons' demand for money (K2)

$$\Delta \ln (KM3J/PC) = \underset{(5.3)}{0.61055}\ \ln (YD/PC)_{t-1} - \underset{(6.9)}{0.44445}\ \ln (KM3J/NFWP) + \underset{(4.6)}{0.34726}\ \Delta \ln (NFWP/PC) - \underset{(5.4)}{7.83759} + \underset{(3.7)}{0.09947}\ CCCD - \underset{(0.9)}{0.29886}\left[\ln (1 + RUKG/100)_{t-1} - \Delta \ln PC_{t-1}\right]$$

$\bar{R}^2 = 0.816$ SE = 0.03276 DW = 2.4 LM(2) = 3.0 1964 - 1982

Persons' demand for other public sector debt (K3)

$$\Delta \ln KNDJ = \underset{(3.2)}{0.74115}\ \Delta \ln NFWP - \underset{(0.1)}{0.01541}\ \ln (KNDJ/NFWP) - \underset{(0.6)}{0.13781}$$

$$+ \underset{(1.7)}{0.01562}\ RUKG - \underset{(0.2)}{0.0021}\ RUSG - \underset{(0.7)}{0.00114}\ RREQ$$

$\bar{R}^2 = 0.624$ SE = 0.077874 DW = 2.2 LM(2) = 3.0 1964 - 1982

Persons' demand for foreign assets (K4)

$$\Delta \ln KNFJ = \underset{(3.6)}{0.79599}\ \Delta \ln NFWP - \underset{(1.6)}{0.28811}\ \ln (KNFJ/NFWP) - \underset{(1.5)}{0.77909}$$

$$- \underset{(3.4)}{0.04571}\ RUKG + \underset{(3.9)}{0.06511}\ RUSG$$

$\bar{R}^2 = 0.705$ SE = 0.11616 DW = 2.4 LM(2) = 7.0 1964 - 1982

Persons' demand for bank lending (K5)

$$\Delta \ln KBLJ = \underset{(2.6)}{0.2684}\ \ln YD_{t-1} - \underset{(2.9)}{0.40285}\ \ln (KBLJ/NFWP)_{t-1} - \underset{(3.0)}{3.76926}$$

$$- \underset{(0.1)}{0.00094}\ RLB - \underset{(3.0)}{0.12442}\ CCD$$

$\bar{R}^2 = 0.578$ SE = 0.121 DW = 1.4 LM(2) = 2.2 1964 - 1982

Persons' demand for NFA (K6)

NCWP = KM3J + KNDJ + KNFJ - KBLJ

Persons' demand for equity (K7)

KEQJ = NFWP - NCWP

(1) Companies' financial sector

Companies' demand for NFA (L1)

NCWC = NFA - NCWP

New issues of equity (L2)

$$\ln CPI = \underset{(1.1)}{-0.18826}\ \ln CPI_{t-1} + \underset{(3.1)}{0.35243}\ \ln (INP.PINP) + \underset{(0.9)}{2.62}$$

$$+ \underset{(5.2)}{2.51412}\ \ln SPUK - \underset{(4.5)}{2.18673}\ \ln SPUK_{t-1}$$

$\bar{R}^2 = 0.674$ SE = 0.292678 DW = 2.0 LM(2) = 4.5 1965 - 1982

Share price (L3)

$$\ln SPUK = \underset{(3.3)}{0.62236} \ln SPUK_{t-1} + \underset{(2.3)}{0.33488} \ln NCWC - \underset{(1.6)}{0.05707} \Delta RUKG$$

$$- \underset{(1.7)}{1.56276} \ln (GDPC/GDPE) - \underset{(0.4)}{0.51842}$$

$\bar{R}^2 = 0.701$ SE = 0.1033 DW = 1.9 LM(2) = 6.4 1964 - 1980

Stock of equity outstanding

$$KEQC = KEQCt\text{-}1 + CPI + EREV$$

Pre-tax rate of return of equity (L5)

$$RREQ = [ISP + (ECDV/KEQC)] * 100$$

ALTERNATIVE CONSUMPTION FUNCTIONS

Money as wealth term

$$\Delta \ln C = \underset{(9.5)}{0.67237}\ \Delta \ln YA - \underset{(2.1)}{0.31202}\ \ln (C/YA)_{-1} + \underset{(2.0)}{0.05336}\ \ln \frac{(KM3J/PC)}{YA_{t-1}} + \underset{(1.9)}{0.03775}$$

$\bar{R}^2 = 0.878$ SE = 0.00813 DW = 2.1 LM(2) = 0.1 1966 - 1982

Net 'outside' financial assets as wealth term

$$\Delta \ln C = \underset{(10.4)}{0.58926}\ \Delta \ln YA - \underset{(1.8)}{0.20627}\ \ln(C/YA)_{-1} + \underset{(2.2)}{0.02180}\ \ln \frac{(KM3J+KNDJ+KNFJ-KBLJ/PC)}{YA_{t-1}} - \underset{(0.1)}{0.00082}$$

$\bar{R}^2 = 0.884$ SE = 0.0079 DW = 2.4 LM(2) = 1.2 1966 - 1982

Total wealth as wealth term

$$\Delta \ln C = \underset{(10.1)}{0.57453}\ \Delta \ln YA - \underset{(1.7)}{0.18358}\ \ln (C/YA)_{-1} + \underset{(2.3)}{0.03282}\ \ln \frac{(W/PC)}{YA_{t-1}} - \underset{(2.0)}{0.0329}$$

$\bar{R}^2 = 0.885$ SE = 0.007886 DW = 2.6 LM(2) = 4.6 1966 - 1982

Bank lending to NBPS (alternative to identify H9, p81)

$$\Delta \ln KBLP = \underset{(3.7)}{-1.16}\ \Delta \ln NFA \underset{(1.0)}{-0.09}\ \ln (KBLP/NFA)_{-1} \underset{(0.1)}{-0.014} + \underset{(2.8)}{0.024}\ RLB \underset{(3.4)}{-0.082}\ CCD$$

$\bar{R}^2 = 0.57$ SE = 0.07 DW = 2.0 LM(2) = 5.9 1964 - 1980

VARIABLES

(1) Equation

(2) Sources

(S = Short term model)

(N = elsewhere, see page 93)

(3) Exogeneity:

(X = Exogenous)

(E = Endogenous)

		(1)	(2)	(3)
ANIR	= Average (of wage bill) rate of employer's national insurance contribution	-	S	X
BYPA	= Net property income from abroad	(G1)	S	E
C	= Consumers' expenditure at 1980 prices	(A8)	S	E
CA	= Current account	(G2)	S	E
CAPU	= Capacity utilisation	(C3)	N	E
CARE	= Current account residual	-	S	X
CCD	= Credit control dummy	-	N	X
CCCD	= Dummy for 'competition and credit control' period	-	N	X
CNFR	= Companies NAFA residual	-	S	X
CPI	= New issues of equity	(L2)	S	E
CPNN	= Net non residential capital stock, end year	(A20)	N	E
CPDN	= Net residential capital stock end year	(A21)	N	E
CTAX	= Average rate of direct tax on companies	-	S	X
DEC	= Exchange controls abolition dummy	-	N	X
D_{ii}	= Dummy for year ii	-	N	X
DLPT	= Deviation of log of labour force participation ratio about trend	(B2)	N	E
DTAX	= Average rate of direct tax on GDP	-	S	X
ECDV	= Company dividends	(J2)	S	E
EDBT	= Debt interest paid by public sector	(F1)	S	E
EER	= Effective exchange rate index	(E13)	S	E

		(2)	(3)
EGTA	= Net public sector transfers abroad	-	SX
EREV	= Revaluations of equity	(H2)	NE
FC	= Net acquisition of financial assets: companies	(J4)	SE
FCA	= Factor cost adjustment at 1980 prices	(A24)	SE
FCA£	= Factor cost adjustment	-	SE
FFL	= World price of fuel (= PFL * EER)	-	SX
FJ	= Net acquisition of financial assets: persons	(I5)	SE
FMBM	= World price of raw materials (= PMBM * EER)	-	SX
FRES	= Residual on private sector wealth identity	-	NX
FREV	= Revaluations of net foreign assets	(H3)	NE
FTKG	= Net capital transfers by public sector	-	SX
G	= Current government expenditure at 1980 prices	-	SX
G*	= Public sector current expenditure excluding subsidies	(F7)	SE
G£	= Government current expenditure	(F4)	SE
GDPC	= Capacity output (gross domestic product at factor cost, 1980 prices, divided by estimate of capacity utilisation)	(C2)	NE
GDPE	= Demand (gross domestic product at factor cost, 1980 prices)	(A26)	SE
GDP£	= Gross domestic product at factor cost	(E7)	SE
GP	= Gilt price index	(H12)	NE
GREV	= Revaluations of gilts	(H1)	NE
IF	= Total fixed investment at 1980 prices	(A16)	SE
IALL	= Investment allowances - present value per unit of investment	-	NX
IG£	= Public sector investment	(F5)	SE
IHG	= Public sector residential fixed investment at 1980 prices	-	SX
IHP	= Private sector residential fixed investment at 1980 prices.	(A15)	SE
II£	= Investment in stocks	(A11)	
II	= Investment in stocks at 1980 prices	(A10)	SE
ING	= Public sector non residential fixed investment at 1980 prices	-	SX

		(1)	(2)	(3)
INP	= Private sector non residential fixed investment at 1980 prices	(A4)	SE	
IPC	= Consumer price inflation rate	(A1)	SE	
IPG	= Rate of change of gilt price	(A3)	SE	
IPS	= Rate of change of share price	(A5)	SE	
K	= Non residential fixed capital, at 1980 prices, mid year estimate	(C1)	NE	
KBLJ	= Stock of bank lending to persons, end year	(K5)	NE	
KBLP	= Stock of bank lending to the non bank private sector, end year	(H9)	NE	
KEQC	= Stock of equity outstanding, end year	(L4)	NE	
KEQJ	= Stock of equity held by persons, end year	(K7)	NE	
KIIT	= Stock of inventories and work in progress, end year	(A9)	SE	
KM3J	= Stock of £M3 held by persons, end year	(K2)	NE	
KM3£	= Stock of £M3, end year	(H6)	NE	
KNDJ	= Stock of gilts and other non monetary public sector debt held by persons, end year	(K3)	NE	
KNDP	= Stock of gilts and other non monetary public sector debt, end year	(H7)	NE	
KNFA	= Stock of net foreign assets held by the non bank private sector debt, end year	(H8)	NE	
KNFJ	= Stock of net foreign assets held by persons	(K4)	NE	
KPDG	= Private sector residential gross capital stock, end year at 1980 prices	(A19)	NE	
KPDN	= Private sector non residential net capital stock, end year at 1980 prices	(A21)	NE	
KPNG	= Private sector non residential gross capital stock, end year at 1980 prices	(A18)	NE	
KPNN	= Private sector non residential net capital stock, end year at 1980 prices	(A20)	NE	
KUNG	= Public sector non residential gross capital stock, end year at 1980 prices	(A17)	NE	
LD	= Demand for labour (employed labour force) (000)	(B5)	SE	
LDP	= Private sector demand for labour (000)	(B3)	SE	
LDU	= Public sector demand for labour (000)	(B4)	SE	

		(1)	(2)	(3)
LS	= Labour supply (employed plus registered unemployed) (000)	(B1)	SE	
LU	= Number of registered unemployed workers (000)	(B6)	SE	
M	= Imports at 1980 prices	(A23)	SE	
MG2	= Fuel imports at 1980 prices	-	SX	
NCWP	= Stock of NBPS financial wealth held by persons	(K6)	NE	
NCWC	= Stock of NBPS financial welath held by companies	(L1)	NE	
NFA	= Net financial wealth of the non-bank private sector, end year	(H5)	NE	
NFWP	= Persons' net financial wealth	(K1)	NE	
NW	= Net wealth of the non-bank private sector, end year	(H13)	NE	
ORNT	= Imputed rent of owner occupied houses	(I1)	SE	
PC	= Consumer price deflator	(E1)	SE	
PC7	= 7 year distributed lag of inflation rate of PC	(E10)	SE	
PFL	= Deflator for imports of fuel (AVI)	(E15)	SE	
PG	= Deflator for government current expenditure	(E5)	SX	
PGDM	= Deflator for GDP at market prices	(E9)	SE	
PGDP	= Deflator for GDP at factor cost	(E8)	SE	
PIHP	= Deflator for residential fixed investment	(E4)	SE	
PING	= Deflator for public sector fixed investment	(E6)	SE	
PINP	= Deflator for non residential fixed investment	(E3)	SE	
PM	= Deflator for imports	(E12)	SE	
PMBM	= Deflator for imports of raw materials	(E14)	SE	
PNFR	= Persons' NAFA residual	-	SX	
POFA	= Persons' acquisition of financial assets other than NBPS assets and equity	-	SX	
POTH	= Public sector NAFA less PSBR	-	SX	
POWA	= Population of working age excluding those in full time education	-	SX	
PS	= Deflator for inventories	(E2)	SE	
PSBR	= Public sector borrowing requirement	(F9)	SE	
PX	= Deflator for exports	(E11)	SE	

		(1)	(2)	(3)
PYRS	= Residual for mismeasurement of income from wages and salaries	-	SX	
Q	= Valuation ratio	(A13)	NE	
RESE	= Unidentified error in national accounts	-	SX	
REU$	= Eurodollar rate	-	SX	
REV	= Revaluation of financial assets	-	NE	
REVR	= Residual on revaluations	-	NX	
RIT	= Rate of indirect tax	-	NX	
RLB	= Base rate/MLR	(H10)	NE	
RREQ	= Rate of return on equity	(L5)	NE	
RUB	= Annual rate of unemployment benefit	(F2)	SE	
RUKG	= Rate on 20 year gilts	(H11)	SE	
RUSG	= Rate on 10 year US bonds	-	SX	
SG	= Public sector saving	(F8)	SE	
SPUK	= Share price index	(L3)	SE	
T*	= Public sector current receipts net of subsidies	(F6)	SE	
TFE	= Total Final Expenditure	(A27)	SE	
TIME	= Time trend	-	NX	
TREF	= Deflator for factor cost adjustment	(A25)	SE	
TRYC	= Marginal tax rate on non wage income	-	NX	
TRYW	= Marginal tax rate on wage income	-	NX	
TWIP	= OECD trade weighted industrial production	-	SX	
ULC	= Unit labour costs (including self employed and forces)	(D6)	SE	
WIPC	= Average of IPC over past 2 years	(A2)	SE	
WIPG	= Average of IPG over past 2 years	(A4)	SE	
WIPS	= Average of IPS over past 2 years	(A6)	SE	
WPIM	= UK trade weighted competitors wholesale prices (in "effective" currency)	-	SX	
WS	= Average wages and salaries per annum	(D1)	SE	
X	= Exports	(A22)	SE	
XG2	= Exports of fuel	-	SX	

		(1)	(2)	(3)
YA	= Real personal disposable income adjusted for capital gains and inflation losses on financial wealth	(A7)	SE	
YCO	= Company non profit income less appropriations	(J3)	SE	
YCP	= Company profits	(J1)	SE	
YCT	= Companies' taxable income	(J5)	SE	
YD	= Personal disposable income	(I4)	SE	
YEC	= Employers' contributions	(D5)	SE	
YECN	= Employers' national insurance contributions	(D3)	SE	
YECO	= Employers' other contribtuions	(D4)	SE	
YGRA	= Public sector income from rent, non trading capital, dividends and interest	-	SX	
YGTA	= Public corporations' gross trading surplus	-	SX	
YJ	= Total personal income	(I3)	SE	
YJG	= Current grants to persons by public sector	(F3)	SE	
YJO	= Other personal income, excl self-employment income	(H2)	SE	
YR	= Income from rent	-	SX	
YSA	= Stock appreciation	(A12)	SE	
YTAX	= Average direct tax rate on personal income	-	SX	
YWS	= Income from employment, self employment and forces	(D2)	SE	

DATA APPENDIX

Most of the data above is taken from well known and easily accessible sources and was taken by the author from the Bank of England's main quarterly econometric databank (QED). The variables taken from it or derived from combinations of qed variables are denoted "S" in the variable list above. The other variables, denoted "N", are not available in the qed, or are not recognised economic variables. Their data sources or derivations are detailed below.

Variable	Definition	Source
CAPU	Capacity utilisation	See GDPC
CCD	Credit control dummy	Subjective
CNFR	Companies' NAFA residual	FC - (YCO + YCP - (INP * PINP) -(0.8*(IIE + YSA))-(CTAX * YCT_{-1})
Dii	Dummies	-
GDPC	Capacity GDP	Derived as GDPE/CAPU where CAPU is a measure of capacity utilisation. Use Knoester and Van Sinderen (1983) or estimates from production function as described above.
EREV	Revaluations of equity	KEQC - CPI as obtained elsewhere
FREV	Revaluations of net foreign assets	KNFA + DFA as obtained elsewhere
GP	Gilt price index	FT gilt edged securities index
FRES	Residual on private sector wealth identity, equal to CPRS + FCRS where CPRS = (PSBR + DNDL - DB + DEFC + DBL) - DM and FCRS = DEFC - (CA + DFA), and:	
DB	Public sector debt sales to non-bank private sector	Economic Trends Annual Supplement Table 148
DBL	£ lending to UK private sector	
DEFC	External & fc counterparts	
DM	Change to £M3	
DNDL	Non deposit liabilities	
DFA	Non-bank private sector capital account	Fin Stats Table 11.6
GREV	Revaluations of gilts	KNDP - DB as obtained elsewhere
IALL	Investment allowances	Use series CS COPRTQ on Bank of England company sector group's database "Present value of investment allowances", or similar proxy Make consistent with past data by suitable adjustment

Variable	Definition	Source
KBLJ	Stock of bank loans to persons	Finstats Table S15 for persons: life and pension funds in Finstats Tables 7.11 - 7.13
KBLP	Stock of bank loans to NBPS	Finstats Table S15
KEQC	Stock of equity outstanding from all companies	Finstats Table S15
KEQJ	Stock of equity held by persons	See KBLJ
KM3J	Stock of £M3 held by persons	See KBLJ
KM3J	Stock of £M3 held by NBPS end year	Finstats Table S15 "Money".
KNDJ	Stock of gilts and other non monetary national debt held by persons	See KBLJ
KNDP	Stock of gilts and other non monetary national debt held by NBPS	Finstats Table S15
KNFA	Stock of net foreign assets of NBPS	Finstats Table S15 "Foreign assets" less "Foreign liabilities"
KNFJ	Stock of net foreign assets held by persons	See KBLJ
KPDG, KPDN, KPNG, KPNN, KUNG	Capital stocks	Consistent back-run is produced after each "Blue Book". Ring CSO for printout, around winter/spring
LSS	Deviation of log of labour force participation rate from trend	Residuals from equation (B1)
PNFR	Persons' NAFA residual	FJ - (YD - (C * PC) - (IHP * PIHP) - ((0.15 * (II£ + YSA)))
POFA	Persons' net acquisition of unidentified financial assets (mainly building society deposits less mortgages)	NFWP - $NFWP_{-1}$ - FJ - REVP where REVP is revaluation accruing to persons
PYRS	Residual for mismeasurement of YWS	YWSX + YSE + YFJ - YWS where YWSX is 'true' income from employment and YWS is defined as in the model

Variable	Definition	Source
REVR	Revaluations residual	NFA - GREV - FREV - (DB + DM - DFA - DBL) as obtained elsewhere
RIT	Rate of indirect tax	Proxy by rate of VAT: see FSBR
RLB	MLR/Base Rate	Use MLR up until its abolition, then replace with clearing banks' base rate. MLR/Bank Rate is in TAS, page 192. Base Rate is on stm database, code RCBR
TIME	Time trend	-
TRYC	Marginal tax rate on non wage income	Prosy by basic rate of corporation tax, see FSBR
TRYW	Marginal tax rate on wage income	Basic rate of income tax plus contracted out rate of national insurance contributions. Annual Abstract T 3.14 and 16.11

APPENDIX: Stock-flow effects in UK macroeconomic models a detailed analysis

1

The models

This section considers in detail the extent to which the stock-flow effects described above are embodied in the main UK macro models, those of the Bank of England, Treasury, National Institute, London Business School, City University, Liverpool and Cambridge Economic Policy Group[1]. These models cover the broad spectrum of economic thought in a manner illustrated below:

Model	Category	
Cambridge	Keynesian	
National Institute	Eclectic Keynesian	)
Bank of England (Medium Term)	Eclectic Keynesian	) Becoming more
Bank of England (Short Term)	Eclectic Keynesian	) monetarist and
Treasury	Eclectic Keynesian	) neoclassical
London Business School	Eclectic Keynesian	)
City University	Neoclassical	
Liverpool	Neoclassical/Monetarist	

The spectrum ranges from the Keynesian where demand is crucial, markets may fail to clear[2], fiscal influences are regarded as important and expansionary policy is thought to be effective, to neoclassical where monetary influences tend to be emphasised, market clearing is assumed and the general impotence of government expansionary policy under the "crowding-out" hypothesis is stressed.

Not all the relationships embodied within the models are estimated, reflecting areas where the modeller's "judgments" fail to concur with the estimation results (or where no estimation has been done). In general, the "eclectic" Keynesian models are based largely on empirically determined coefficients and relationships, although in certain areas the theoretical and empirical basis is rather weak. By contrast, the other models tend to rely rather more on imposed relationships which reflect the modeller's theoretical economic priors rather than any empirical

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(1) References: Dunn, Jenkinson, Michael and Midgley (1984); Bank of England (1982); HM Treasury (1984); National Institute for Economic Research (1983); London Business School (1984); Beenstock et al (1983); Minford et al (1984); Coutts (1984). The Cambridge model described is regarded by the authors as a prototype rather than a complete model. For a more detailed analysis of financial effects in the earlier versions of the Treasury and Institute models, see Bladen-Hovell, Green and Savage (1982).

(2) Markets fail to clear due to slow adjustment of prices (particularly wages) to changes in demand and supply. This is captured in the models by, for example, a smaller and lagged coefficient on unemployment in the wage equation than that needed to get a market clearing real wage.

results. Hence the degree of credence given to the model output inevitably depends on the prior views of the reader on the merits of the theoretical and econometric basis of the model.

The table on p15 shows the extent to which the stock-flow effects described above are incorporated into these forecasting models of the British economy. The pattern is strikingly different even for the supposedly similar "eclectic Keynesian" models of the Bank, Treasury, Institute and LBS. All of these models have a similar 'core' interpretation - output is demand determined and supply has no influence on the level of activity in the short run, while wages are related to unemployment and prices via a Phillips curve process, and the exchange rate (except for the LBS) is determined by relative interest rates in the UK and abroad. The Cambridge model also lies broadly in this tradition. The City and Liverpool models differ radically from these mainstream models. The City University model focusses on the determination of aggregate supply and the modelling of the associated factor markets; demand has no long run impact on output as the aggregate supply schedule is vertical at full employment. The Liverpool model is a rational expectations model of the UK under fixed and floating exchange rates. Rational ('model consistent') expectations implies that variables are forecast (consistently) by agents within the model. The effect of this assumption is that the model has an equilibrium path from which discretionary government policy is unable to shift it for more than a brief period.

Before a detailed discussion of the stock-flow effects, it should be noted that this study is of necessity a 'snapshot' of the models at the time of writing (end-1984). By the publication date, it is likely the models will have been amended, and may in so doing have improved their coverage of stock-flow effects.

2

Stock-flow effects

The stock-flow effects are dealt with below under the following headings:

(a) The capital/production nexus
  (i) The capital stock
  (ii) The equity stock
  (iii) The production function

(b) The financial sector
  (i) A portfolio adjustment system
  (ii) Definitions of sectoral income
  (iii) Real balance effects
  (iv) Stock effects of government deficits
  (v) Exchange rates and the external asset stock

(a) The capital/production nexus

(i) The capital stock

Since the Keynesian models broadly assume that aggregate domestic supply has no effect on the level of activity in the short run, and that output is demand determined over this period, they unsurprisingly do not go to great lengths to measure capital, and where it is measured it only affects investment itself. This means that the level of investment only affects the models via aggregate demand (where it is treated identically to current expenditure) and via lagged effects on itself (where investment is crucially determined by lags of the dependent variable).

In the Cambridge and the LBS models, the level of the capital stock is not included. The investment functions feature lagged investment, the stock having been eliminated by differencing, except in the Cambridge model, where investment is aggregated into a private expenditure function, discussed below. In the Bank of England short term model, the gross capital stock is identified and used in the investment function to help determine demand for investment goods (showing replacement demand), while in the Bank of England medium term model, the net capital stock, both actual and desired, determine gross investment in a partial adjustment framework. The Treasury and Institute models follow the Cambridge/LBS

approach for manufacturing investment, removing the capital stock by differencing, though the non manufacturing capital stock is defined and used in the corresponding investment functions. Among the more neoclassical models, the capital stock is determined in the CUBS model, where it determines both output and factor demand. However, in the Liverpool model, capital is combined with consumer durables as a subject of portfolio choice, while in the production function, capital stock is proxied by a time trend. In such models, which encapsulate the 'natural rate' hypothesis, the stock of capital is clearly crucial to the determination of supply and employment, so one would expect it to play a central role, since potential output and hence the natural rate, depend on the capital stock as a limiting factor, as long as technology is not putty-putty. The determination of the capital stock in the CUBS model features a mixture of demand (prices of other factors) and supply influences, though the latter uses, somewhat arbitrarily, the distribution of the population to proxy those age-groups that should be net savers.

Compared with the capital stock, the stock of inventories is much more central to the output of Keynesian models. This is because changes in the level of stocks are one of the more volatile components of aggregate demand and thus activity, and such changes depend on variations in companies' desired levels of stocks. These stocks are determined in the two Bank models, the Treasury, Institute, LBS and Cambridge models. Typically, the desired level of stock is determined by expected sales and the cost of holding stocks, in terms of real rates of interest, while there is a long run equilibrium stock-output ratio.

The neoclassical models do not separately determine inventory investment.

(ii) Stock of equity

It has been shown above that the value of equity is theoretically determined by reference to the stock of capital and its marginal product, and that, in addition to being a component of the financial asset portfolio and a means of finance for firms, it should ideally be used to help determine the rate of investment via the valuation ratio. None of the Keynesian models use equity as a link between the real and financial sectors in this sense - unsurprisingly since most do not determine the capital stock either.

In The Treasury model, only equity holdings of the personal sector are defined, with equity prices being determined by real interest rates and the profit share in domestic income. This stock feeds to persons' net financial wealth, which

influences consumers' expenditure on durable goods, the labour supply, and demand for equity itself. The equity stock is not determined as a liability of companies, and obviously "washes out" in the private sector wealth measures used to determine demand for money and other government debt.

In the LBS model, financial asset holdings are determined after real economy decisions are taken, and there are no feedback effects from, say, the value of equity to investment, nor does the value of equity depend directly on productivity or the capital stock. Instead, the equity price is determined by sectoral demand and supply for the outstanding stock, which in turn depend on net worth and the lagged variance of the asset price. The latter may encapsulate indirect evidence on productivity.

In the Bank and Institute models, the stock of equity is not determined, though in these Keynesian models the flow of new issues is tracked as a component of companies' net acquisitions of financial assets.

The neoclassical models do not determine equity as such, or employ the valuation ratio. In the CUBS model, the stock of equity is assumed equal to, or at least sufficient to finance, the capital stock, given a required distribution of savers in the population. In the Liverpool model, as noted above, consumers are assumed to hold "capital" directly, though it is combined with durable goods and dwellings. Consumers are hypothesised to choose between "goods" in this sense and financial wealth - comprising government and foreign assets and excluding equity. There is thus no role for equity in this model.

(iii) The production function

A typical Keynesian model has no role for an explicit production function in determining output. Instead production is determined by demand and competitiveness, the latter showing the extent to which demand is satisfied by imports. In turn, production helps determine the demand for labour and capital. However, it can be argued that, within this basic outline, which broadly describes the Bank, Treasury, Institute and LBS models, there are some underlying supply influences. For example, in the reduced form of the Bank short term model, employment is determined principally by demand (via output) in a simple inverted production function, but is also influenced by supply factors such as companies' income gearing, profitability, real wages and time trends proxying productivity. Also competitiveness is influenced by supply considerations, either directly via comparative unit labour costs or indirectly through the price equations.

In the CUBS model, the production function is crucial, as the supply side is presumed to determine output. The private sector output equation incorporates a KLEM (capital, labour, energy, raw materials) production function, where the use of these factors uniquely determines the long run level of output. In the short run, the real money supply and world trade feed through from the demand side, and the growth of prices at factor cost and output are simultaneously determined.

In the Liverpool model, the production function is inverted to give a real exchange rate equation (1), and, as noted, the capital stock, which is given by the consumers' decision, is proxied by a time trend. The actual determinants of prices are wages and sterling import prices. Thus no stock effects feed through to output.

(iv) Summary

The section above suggests that use of stock-flow identities in UK macromodels to determine capital and output is limited. Even among the neoclassical models the stock of equity is not separately determined and the Liverpool model does not use the capital stock itself to determine supply. In Keynesian models, such supply considerations are not so central to the structure; hence, none feature production functions[2], and even where capital and equity stocks are determined, they are not used to the extent that the economic theory described in Section I would suggest.

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(1) "The exchange rate equation is derived from a marginal cost pricing equation with a constant return to scale production function, where, since prices are a weighted average of labour and import costs (foreign prices in domestic currency), the real exchange rate (prices relative to foreign prices in domestic currency) is directly related to real wages by an elasticity which depends on relative shares." Minford et al (1984) pages 41-42.

(2) Though it should be noted that an explicit production function is not necessary to determine potential output, as its coefficients could be derived from the factor demand equations, then used to determine output potential.

(b) The financial sector

(i) A portfolio adjustment system

The theory noted above suggests that economic agents have a demand for stocks of financial assets, based on the risk and return from the individual assets, wealth and possibly also income or saving. These demands should be estimable as a system in which plausible restrictions such as symmetry and additivity should be accepted. Progress in modelling such asset demand systems has not been marked in the UK, though this may be more due to poor data and disappointing results, with many counter-intuitive signs on coefficients, than to neglect. This lack of progress is reflected in the portfolio systems in the main macromodels, which typically feature flow rather than stock adjustment, ad hoc, imposed structures and no cross equation constraints. The Bank of England medium term and Cambridge models have no financial sectors. The Bank short term model features a flow of funds system where, for example, personal sector demand for public sector short debt is determined by lags of the PSBR, and consumers' demand for short debt is determined by their flow of bank deposits. In each case, there is no reference to the underlying stock of the asset held by the sector, nor total sectoral wealth to be allocated. There are some exceptions to this rule of flow adjustment only - persons' holdings of liquid as opposed to illiquid financial assets are determined by a stock adjustment mechanism and the share of building society deposits in persons' liquid assets is similarly determined. Certain flows are cumulated to give, for example, a proxy for companies' liquid assets, but they do not form the basis for demands for financial assets.

This structure of mainly flow-adjustment equations, with few financial stock effects and no systematic modelling of portfolio demand based on desired stocks, is also true of the Treasury and Institute models. In each case, there is a small stock adjustment system for the non-bank private sector, where financial wealth is used to determine stock-demand for government short and long debt. And in the Treasury model, the company liquidity also is determined, and feeds back to determine certain expenditure decisions. But there are no consistent definitions of sectoral stocks.

The LBS model (see Keating (1984)) does feature a consistent portfolio system of demands for stocks of financial assets, which is highly disaggregated, and works to determine the market clearing asset prices of gilts, equities and the exchange rate (short rates being exogenous). The restrictions of zero sums for

parameters on returns and a unit sum on the budget constraint are accepted by the data. However, although such a system is consistent and theoretically desirable, the simplifying assumptions made in estimation and necessitated by the degree of disaggregation are perhaps excessively restrictive. In particular, the covariance matrix of asset yields is assumed to be diagonal. This allows a considerable economy of parameters since weighted average returns on "other assets" can be used in estimation, but at a cost that, for example, a fully anticipated increase in the supply of bonds and private wealth reduces the price of gilts but has no effect on any other freely moving asset price. Secondly, there are no income effects on asset holdings - influences on asset demands being limited to risk aversion, lagged adjustment post tax yields and wealth. Thirdly, many of the coefficients are imposed rather than estimated.(1)

There is no portfolio system in the CUBS model - as noted, saving and financial asset accumulation to finance capital accumulation are proxied by the population distribution. In theory, the modellers recognise that government bonds, if they are regarded as net wealth by the private sector, should be an alternative asset to capital, but are unable to find this in estimation. The demand for money drops out of the model by Walras' Law.

The Liverpool model features a recursive structure for private sector asset demands. In common with the Keynesian models, the decision to consume is primary, then the residue is split between financial assets and capital goods and finally financial assets are divided between money and other financial assets. Portfolio demands are determined by wealth, interest rates and time trends, plus lagged dependent variables to proxy adjustment costs in the portfolio. As in the LBS model, there is no role for income in asset demands.

(ii) Definitions of sectoral income

It was pointed out above that the income definitions given in the National Accounts differ from those based on sensible economic concepts, particularly during periods of inflation. Incomes as measured may include net interest payments, part of which are actually capital repayments on outstanding monetary debt, where the purchasing power of such debt is declining during inflationary periods.

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(1) For a detailed discussion of this sector, see Green (1984).

Secondly, real capital gains made on items of the wealth portfolio are excluded from income - yet these could be consumed while leaving income constant on the Hicksian approach "the accrual that would leave real wealth intact".

This section assesses the extent to which income has been redefined in macroeconomic models to allow for such effects. The Cambridge model features the most consistent use of inflation adjustment. All real sectoral disposable incomes are measured after such adjustment, so differences between real income and expenditure are consistent with changes in real stocks. In other models, the effects are confined to personal sector income, with a deduction of inflation losses on net liquid assets, in a Hendry-von Ungern Sternberg style consumption function. This is the case in the Bank of England short term model, the Treasury model, and the Institute model (with the distinction that the effects on consumption of "income" and "inflation losses" are allowed to differ). Such inflation losses are not directly allowed for in the Bank medium term or LBS models, while, in the CUBS model, there is, in any case, no role for sectoral income. In none of the models, apart from Cambridge, are Hicksian adjustments made for the company, public, financial or overseas sectors.

Capital gains and losses on the stock of illiquid assets are not included in income in any model. The Keynesian models generally allow increases in share and gilt prices to increase the stock of real wealth, however - thus any effect on demand must be via wealth rather than income effects.

In the Liverpool model, both inflation loss and capital gain effects are encapsulated in the private sector real financial assets equation - a differenced (log of) interest rate proxies revaluations, while a differenced (log of) price level term captures inflation losses. Wealth then has powerful direct effects on consumption and accumulation (see next section).

None of the models allows for direct effects of increasing house prices on income ie inflation-adjusting imputed rent. The Bank of England and LBS models feature the value of housing as a component of personal sector net wealth, but in the Bank model this only affects consumption indirectly by influencing the proportion of financial wealth held in liquid form.

(iii) Wealth effects

Wealth effects in supply or demand equations arise via changes in the value of the stock of net assets held by an agent, for example, increases in the value of

monetary assets when prices fall, which affect the demand for, and supply of commodities by the agent. To have an effect on the economy as a whole, there must be asymmetric responses such that the changes are not offset by changes in the behaviour of the sector issuing the corresponding liabilities. In theory, wealth effects should only arise in the case of government-issued money and debt stocks ie "outside" wealth, though it will be seen that macroeconomic models typically also assume asymmetries within the private sector, by allowing intra private sector claims "inside" wealth such as building society deposits to give rise to wealth effects in the aggregate. One justification for this may be the differing liquidity of such assets and liabilities such as mortgages. Wealth effects as defined here can be distinguished from the essentially "accounting" problems in income flows arising from their correct definition of interest payments and capital repayments during inflationary periods, as discussed in (ii) above.

Wealth effects are generally introduced only in the personal sector, via effects of changes in the ratio of the real value of the stock of net liquid assets to income on consumption. In the Bank short-term model, such effects arise in both the non-durable and durable consumption functions. The Treasury non-durables function also has this effect, while the durables function features the stock of net financial wealth - excluding mortgages as a liability. In the National Institute model, there are no real balance effects in the non-durables function, though real net liquidity is included in the durables function. By contrast, total wealth, including the value of the housing stock, features in the LBS non-durables function, and building society deposits and bank lending enter the durables function. The non-durables function thus implies that consumers react in a similar way to increases in real wealth from whatever source in making their decision to consume. The specification might be challenged by reference to the difference in liquidity between, say, housing and money, which would suggest that wealth effects from the former should be proportionately smaller at least in the short run. In the Bank medium term model, wealth effects are proxied by the inflation rate. In the CUBS Model, there is no consumption function as such, but, in line with theory, the level of real money balances, but not other components of wealth, are a determinant of demand. The structure of the model allows such wealth effects to influence both output and prices in the short run, though only prices in the long run. In the Liverpool model, the level of net wealth, including physical assets, affects all the stages of the consumers' consumption/investment/portfolio decision - a structure which is in line with the model's 'monetarist' background, though widening the scope for such effects from

outside money to a broader wealth concept. The Cambridge model encapsulates the "New Cambridge Hypothesis" that total private sector expenditure is determined by stable norms for the private sector accumulation of financial assets and debt in relation to income (for a full discussion, see Godley and Cripps (1983)). The hypothesis implies that the mean lag of expenditure behind income is equal to the steady state wealth-income ratio. The empirical implementation of the hypothesis is thus in terms of a distributed lag of private sector net income, the wealth term being implicit.(1)

Besides affecting demand, the neoclassical theory of the supply of labour would suggest that an increase in the value of wealth should stimulate substitution of leisure for work. Only the Treasury model allows for such a wealth effect, including persons' real net wealth in the labour supply equation.

In no cases are wealth effects allowed to influence the behaviour of the company or financial sectors, though, in theory, they too may be affected by inflation via their holdings of 'outside' wealth, and also, if their assets or liabilities are held to give wealth effects in other sectors, some effect with an opposite sign would be expected on these sectors.

(iv) Stock effects of government deficits

These effects are among the most basic dynamic effects in macroeconomic models. They imply that, as long as governments' budgets do not balance, portfolio adjustment must be taking place in the economy, and this is likely to influence behaviour - there cannot be a static equilibrium when such a deficit is run. All of the models take account of this "criticism of IS/LM" in some way (except Cambridge, which does not relate the money stock to the budget deficit), but they differ in the route whereby the changing stocks affect the path of the economy.

The most common structure in the models is for the stocks of money created by deficits to be identified in the model and weakly to influence the exchange rate(2) and the personal sector via the wealth effects noted above. This is the case in the Bank Short Term, Treasury, LBS and Liverpool models. In the Institute and Bank Medium Term models, the exchange rate is only affected by real

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(1) This suggests that such distributed lags in other models may have implications for wealth.

(2) The stock of money used is generally £M3. Depending on the funding rules, this implies a fairly weak influence of government deficits on the exchange rate but a potentially strong effect of private sector money creation (eg bank lending) on the exchange rate.

factors (and, in the latter case, by intervention). The stock of gilts is not identified in the Bank short term or Institute models, and in the other models its influence is restricted to wealth effects operating via net financial wealth.

Interest rates, if they are to act as market clearing prices should, in principle, be determined by the stocks of money and gilts, operating via the private sector's portfolio preferences to clear the relevant markets. This process is implemented in the LBS Model for equity prices and gilt prices (though the short rate remains exogenous) subject to the caveats on the portfolio structure noted above. In the Bank short term model, flow considerations tend to predominate, stock effects only operating via the exchange rate. The pivotal local authority rate is determined broadly by the eurodollar rate, exchange rate, and price expectations, while the long rate is based on the short rate and the PSBR/GDP ratio. A similar structure obtains in the medium-term model. The market clearing function of interest rates is thus not modelled directly. In the Treasury model, the short rate is formally exogenous, but the model can be run with a given money supply and short rates endogenous. The stock of £M3 also indirectly affects long rates via price expectations.

The CUBS model does not feature an interest rate, while, in the Liverpool model, their direct determination is in terms of price expectations and the exchange rate.

One may conclude that most models do not allow strong influences of budget deficits on the economy via stocks of financial assets; the Keynesian models, in particular, remaining fundamentally flow based.

(v) Exchange rates and the external asset stock

Some features of exchange rate determination as related to government deficits are noted above. However, another key 'stock effect' of the flows in the balance of payments is the stock of external assets held by domestic residents, and the stock of UK assets held by foreigners. These stocks are cumulated in the Bank short and medium term models, the Treasury and LBS models, but only in the LBS is the exchange rate itself directly determined via stock equilibrium in the asset market; in the Treasury model, the stock equation for the relevant speculative flows is differenced before inversion. In the Bank short term model, foreign asset stocks do not directly affect the exchange rate; the stocks are mainly calculated to give interest, profit and dividend flows. Obviously, in each model, the magnitude of structural capital flows helps determine the basic balance, and hence the change in reserves/pressure on the exchange rate.

4

Summary

In general, macroeconomic models do not fully model either physical or financial stocks, or their effect on the economy. It has been emphasised that this is partly a result of the underlying assumptions of the models - thus Keynesian models do not concentrate on the capital stock as they are operated over periods in which it can be assumed to be constant. A further problem is poor data, which has tended to generate weak and counter intuitive estimates of the effects predicted by economic theory. This is a problem particularly in the financial sector. Thirdly, some of the more detailed effects described above are omitted from the annual models, due to aggregation.

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