

A STOCK-FLOW CONSISTENT MACRO-ECONOMETRIC MODEL OF THE UK ECONOMY—PART I

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SUMMARY

This paper surveys briefly the main theoretical developments in the analysis of stock and flow integration in macro-economics, then proceeds to use this corpus of theory as a critique of the structure of existing macro-econometric models of the British economy. An outline is then suggested for a model which would take all of these stock-flow effects into account, given the macro-economic data currently available. In a following paper (Davis, 1987) we give a detailed account of estimation and simulation of such a stock-flow consistent model.

1. INTRODUCTION

This paper is the first of a series of two which address the problems of constructing a stock-flow consistent empirical macro-economic model of the British economy. The research was conducted under the auspices of the Bank of England as part of the Bank's programme of research aimed at the improvement of the Bank's models.

Most neo-Keynesian economic theory tended historically 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 macro-economic 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,* and thus some important aspects relating to equilibria or disequilibria are excluded. Macro-economic theorists have generally been aware of these shortcomings in the 'neo-Keynesian approach', but only recently have economic models begun 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, and partly reflecting disillusion with fine tuning, there has tended to be a lengthening of the economic policy horizon. Since stock effects are likely to be more important in the long run, such a lengthening of the policy horizon implies a far greater need to take stock-flow effects into account.

After a brief discussion of the relevant theory of stocks and flows in macro-economics, this paper reviews the extent to which the principal UK macro-economic models incorporate

*It should be emphasized that till recently this was partly also a consequence both of lack of data and of a relatively short economic policy horizon.

stock-flow effects. The comparison reveals many discrepancies between the effects held by theory to be important and those incorporated in existing macro-economic models, as well as suggesting by implication that incorporation of some of these effects involves some of the most difficult areas of empirical modelling. We then go on briefly to outline a small macro-economic 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 second article (Davis, 1987) will describe in full the estimation and simulation of this model using annual UK data. The estimation results and simulation properties offer a measure of the significance and size of stock-flow effects, and hence of the potential importance of their omission.

II. STOCK ADJUSTMENT DYNAMICS IN ECONOMIC THEORY

This section offers a brief overview of the most important issues relating to consistent modelling of stocks and flows in macro-economics. This overview offers a background for the critique of British macro-economic models which follows in Section III, and provides a theoretical underpinning for the modelling exercise outlined in Section IV and detailed in the following article (Davis, 1987). Such an overview is inevitably rather short and selective; for a more detailed analysis of these issues the reader is directed particularly to surveys by Currie (1978), Branson (1979) and Turnovsky (1979) as well as to the theoretical modelling exercises presented in Tobin and Butler (1976), Smith (1980) and Tobin (1982).

The basic implication of stock-adjustment dynamics is that the equilibrium solution to a traditional flow-based macro-economic model implies values for the rates of change of stocks that the model takes as given. These stocks may be both financial (money, bonds, equities, loans) and real (the capital stock). The movements of these stocks through time may change the short-run equilibrium itself, and the associated prices and flows. Omission of these stocks from a model may therefore lead to false predictions of the consequences of policy changes or of exogenous shocks to the system. The aim of this paper and the following one, in Davis (1987), is to obtain some indications of the magnitude of these errors.

The principal theoretical stock-adjustment dynamics dealt with in this section are as follows:

1. the stock effects of money- and bond-financed government deficits, and their incidence on the economy via wealth effects in demand equations and systems of portfolio demand equations;
2. effects of inflation on sectoral income resulting from the mismeasurement of interest payments, and the corresponding potential redistribution of wealth from creditors to debtors;
3. effects arising from changes in the net asset position *vis-à-vis* the external sector;
4. effects arising from the existence and growth of the capital stock and its relationship with the stock of equity outstanding.

I consider first the simple example of the stock effects of a budget deficit, with the introduction to a Keynesian IS/LM model of the government budget constraint (a result first outlined in the work of Christ, 1967, 1968 and Ott and Ott, 1965). As well as being one of the first types of stock-adjustment effect explored in the literature, it also provides a background for the analysis of the other stock-flow effects.

1. The Basic Model

A static 'extended Keynesian' model of a closed economy with fixed prices determines levels of employment, income and interest rates, holding the money stock, government expenditure,

the capital stock and the tax schedule constant. A realistic model must also, however, take into account the existence of a *government budget constraint*. This means that, given a level of government expenditure, not all fiscal and monetary instruments can be used independently. Rather, given the level of the others, one instrument must accommodate to the financing of the expenditure. Thus, for example, if in equilibrium tax revenue is less than government expenditure, stocks of assets cannot be constant as the deficit needs to be financed by issue of money or bonds. Indeed, stock equilibrium is only reached when the budget is balanced. Suppose government expenditure increases with no change in tax rates (where tax revenue depends on income). This leads to an increase in income via the multiplier in the first period, and also a budget deficit. 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, operating via the money demand function, which leads in turn to rising investment, multiplier effects, and hence raises tax revenues (assuming positive marginal tax rates).^{*} Eventually the point is reached where tax revenue equals government expenditure, the budget is balanced, the money stock ceases to grow and there is full stock/flow equilibrium. The increase in income caused by the original fiscal policy action is the inverse of the marginal tax rate: this generally implies a higher multiplier than in the simple IS/LM model.

All of the theoretical work discussed in this section builds on this basic model. 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.[†] Wealth effects may arise, for example, from the desire of the private sector to maintain a certain ratio of income to wealth. Such wealth effects in the consumption function imply that an increase in real net wealth should boost consumer demand. The importance of wealth effects in the aggregate depends on asymmetric responses to changes in net wealth positions. Thus an increase in consumer demand must not be offset by a decline in government expenditure resulting from a deterioration in the net wealth position of the government. Assuming such asymmetric responses, and that both money and bonds are net wealth, 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. However, before discussing the portfolio balance approach, I note a critique of the analysis of this paragraph.

Some economists (see Barro, 1974) would argue that government bonds are not net wealth, as they are in effect cancelled by expected future taxes to repay them, hence bond finance is equivalent to increased taxes. It might be argued that this is most unlikely to be the case when deficits are cyclical and thus 'washed out' over longer time horizons. Even when deficits are structural the required assumptions are strong; the same discount rate must be applied by all individuals both to present tax benefits and future interest payments; individuals probably lack the required degree of information and foresight; the present generation must regard taxes on future generations as equivalent to their own. Finally, Barro assumes rather unrealistically that interest payments are met from higher future tax rates, with no change to equilibrium output.

^{*}Silber (1970) showed that with lump-sum taxes instead of income-linked tax revenues the expansion of demand continues indefinitely.

[†]At this stage I only discuss 'outside' wealth issued outside the private sector. For a discussion of inside/outside wealth see Section III below.

By assuming initial full employment, Barro thus ignores cases where there is under-employment and fiscal policy can increase output. Barro's hypothesis can in principle be tested by testing for separate coefficients on money and bonds in the consumption function.

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 portfolio balance approach 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. As shown by Silber (1970), 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, and may have a net contractionary effect on demand. (This rise in interest rates is often called the 'liquidity effect', while the wealth effect of bond issue is 'the Lerner effect'.) Thus a bond-financed government deficit may have an ambiguous effect on income, with deleterious effects on investment through rising interest rates possibly offsetting the expansion caused by the government expenditure itself, and by wealth effects on consumption,* i.e. the liquidity effect may outweigh the Lerner effect. While the change in income required to balance the budget is identical to the money finance case, given the same tax function (and hence in a comparative static sense the choice between money and bond finance is irrelevant, as pointed out by Ott and Ott, 1965), the economy may actually move away from the income level required to balance the budget. Of course, in practice either a return to money finance or a change of fiscal policy would occur should this instability begin to manifest itself. Indeed, one could question whether a purely bond-financed fiscal policy is sensible in the first place, as a mixed money- and bond-financed policy is less likely to push up interest rates and is more in line with long-run stock-flow equilibrium. A comprehensive discussion of the possible destabilising effects of bond finance is given in Currie (1978); see also, inter alia, Blinder and Solow (1973), Tobin and Buiter (1976), Currie (1976, 1977a,b), Buiter (1977), Choudry (1976). An obvious extension to the analysis is to allow for the possibility of rising prices (see Buiter, 1976, as discussed by Currie, 1978). Given inflation, the Government can appropriate resources corresponding to the fall in the real value of money held by the private sector. If bonds yield a fixed nominal coupon, and if inflation is unexpected, this is also the case for bonds. These effects mean that even if taxes and government expenditure are constant in real terms, the budget in equilibrium will be unbalanced by an amount equal to these '*inflation taxes*'. To maintain private sector portfolio equilibrium the deficit must be financed in proportion to the value of the outstanding stocks: conversely, if a fixed nominal stock of money is targeted, inflation must be zero in equilibrium.

An implication of the 'inflation tax' is that the measure of income of the sector which holds bonds or money should be reduced during periods of inflation by an amount equal to the inflationary loss, and correspondingly increased for the liability holders. Redefinition of income in this manner ensures that real saving equals real accumulation of wealth (abstracting in this simple model from market valuation effects). As in the case of wealth effects, the inflation tax is only significant for aggregate activity if responses to it are asymmetric between sectors; for example, if the private sector reduce their demand for goods without an offsetting increase from the public sector. Given such an asymmetry, policy shifts such as those noted above are required during periods of inflation in order to prevent cumulative contraction of

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

activity. Inflation raises further problems regarding the stability of bond finance, (see Currie, 1978).

2. Extensions

The above discussion of the stock effects of budget deficits introduces the basic concepts of stock-flow consistency in macro-economics. To summarize these concepts briefly, when a sector runs a financial deficit by borrowing from other sectors, this in turn may affect the financial and real behaviour of the lending sector; the former via portfolio adjustment, the latter via wealth effects. These in turn may influence the level of interest rates and of demand in the economy. These concepts are general, and apply to all of the stocks of assets in the economy. Differences in the effects result largely from the different aims of the sectors and characteristics of the assets.

Tobin (1982), in his Nobel Lecture, illustrated the generality of these concepts by setting out a model of the economy based on a flow-of-funds matrix. Each column shows a sector's balance sheet (for stocks) or sources and uses of funds (flows). Meanwhile, a row shows the stock or flow of an asset as it is distributed among the supplying and demanding sectors. The model then sets out to determine the values for the columns by sectoral portfolio or savings functions, while the rows are a set of simultaneous market clearing equations which determine asset prices and returns each period.

In the basic model outlined above there was only one source of 'outside' financial wealth to the private sector, viz. the budget deficit. However, if one disaggregates the external, company and personal sectors one may also distinguish components of wealth such as net foreign assets, capital and claims to capital in the form of equity. These components of the supply of assets result from the current-account deficit and from the investment decisions of firms.

A principal requirement for the modelling of such a disaggregated system is an expanded set of *portfolio demand equations*. The arguments of the functions are typically wealth, the returns on each asset, and in some cases disposable income. The *wealth constraint* imposes restrictions on the partial derivatives of the asset demand functions, in line with Walras's Law (that the excess demand and functions of an economic agent must sum to zero for every vector of the variables that are arguments in any of the functions). Thus, the sum of the coefficients on wealth 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). * Since wealth-holders are assumed not to suffer from inflation illusion, the interest rates must be defined in real terms. Modelers often make the further assumption of *gross substitutability*, which means the partial derivative of the demand for each asset is positive with respect to its own yield but non-positive with respect to others. This is a stronger assumption than summation to zero, and may not always be warranted; assets may be complements, for example, if their returns have a strong negative covariance. The functions may be dynamic, i.e. with partial adjustment to desired portfolios in any one period, as a result of costs of transactions and decisions. The set of portfolio demands determined by such a system then interacts with the supply of assets to determine asset prices. Before considering the feedbacks and transmission mechanisms from the different asset markets to

* These restrictions also mean that only $n - 1$ of the equations are independent, where n is the number of assets, while the last equation drops out. However, care is needed in specification to avoid implausible coefficients being imposed on the implicit equation, as emphasized by Brainard and Tobin (1968).

the rest of the economy, three problems of a simple portfolio system, as discussed here and outlined by Tobin (1982), should be noted. Firstly, the interest rates and asset demands are endogenous to the demand equations, and this should be taken into account in estimation. Secondly, allocation of unexpected capital gains and losses should be included in the adjustment process. In a portfolio model a plausible mechanism would imply that in each period such gains are partially 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, a system should allow for constraints on asset holdings, which due to financial regulation and the imperfection of capital markets have often been important. Backus *et al* (1980) and Papademos and Modigliani (1983) address some of these issues.

In a four-sector model (foreign, public, company, household) the principal asset prices determined within the system are the interest rate, the price of equity and the exchange rate. Feedbacks resulting from changes in interest rates on the real behaviour of the economy have already been discussed in Section I. What of equity prices and exchange rates?

The ratio of market valuation of *equity* to the replacement cost of the capital stock is the *valuation ratio* or ' q '. The ratio may differ from one, in which case there is an incentive for the rate of investment to be faster or slower than normal. The reason for this is that the market valuation of equity in equilibrium equals the discounted present value of future profits. When this value exceeds the replacement cost of the capital stock, profits to be made by increasing the size of the capital stock exceed the cost of extra finance needed for such investment. If government policy influences the interest rate (at which profits are discounted) or expected output, it will also influence the value of equity. This point illustrates the interaction of stock-flow effects within the economy. It should be noted that because of costs of adjustment, gestation lags, etc. adjustment to a new equilibrium capital stock cannot be instantaneous, and deviations of market value from replacement costs can and do persist. Further detail on the q -theory of investment is provided, *inter alia*, in Tobin (1969), Jenkinson (1981), Hayashi (1982) and Abel (1982).

Increases in the value of equity may not have an impact solely on fixed investment. Analogous to money and bonds, an increased value of equity may lead to wealth effects on consumption, with a positive effect on demand in the economy. It should be borne in mind that inclusion of equity in a model introduces certain problems. It 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 and the allocation and effect of unexpected capital gains. These problems have been discussed at length elsewhere (see, for example, Turnovsky, 1977).*

Stock-flow effects also result from changes in the stock of *net foreign assets*. The nature of these effects obviously depends on whether there is a fixed or floating rate regime. For a small economy in a fixed exchange rate system with no government deficit and no sterilization, monetary inflows (outflows) accompany a balance-of-payments surplus (deficit). In fact the balance-of-payments constraint is analogous to the government budget constraint

*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. This 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 paradigms are rational or adaptive expectations.

for a closed economy, and the analysis of Section I applies. The increase in private sector net wealth resulting from a balance-of-payments surplus, if it is in the form of money, will shift the LM curve, raising demand till balance is restored. The export multiplier is the inverse of the marginal import propensity, though in a large country case effects on foreigners' wealth may be important and the multiplier lower. If the government sterilizes the inflow and offers domestic bonds to the private sector, instability, as noted above, may arise. Again, if the country accepts the 'world' inflation rate, and the domestic budget remains balanced, there is an inflation tax on the private sector and hence increased saving and a balance-of-payments surplus. The inflation tax accrues to the overseas sector, and the monetary authorities accumulate reserves; alternatively the government may run a deficit which reduces the balance-of-payments surplus and appropriates part of the inflation tax. These results illustrate the intimate link between the budget deficit and balance of payments noted by Oates (1966) and McKinnon (1969); both influence private sector wealth by identity and may offset each other, leaving the private sector and hence the economy in equilibrium (see Currie, 1976). The importance of these linked effects again illustrates the interaction of stock-flow effects between different asset markets. This link between the Government and external budget constraints is a central feature of the model developed in our subsequent article (Davis, 1987). Further insights into the importance of the external sector are given by Dornbusch (1975), who presents an analysis using the Metzler* model of the effects of stock adjustment dynamics in a small open economy with fixed exchange rates.

Results are rather different in the case of flexible exchange rates. As before, 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. Applying Tobin's portfolio demand/asset price relationship, 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 depreciation. 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.

As in the case of equity, consistent inclusion of net foreign assets introduces complex problems for a modelling exercise. For example, the foreign demand for money and bonds is now relevant and should be modelled; one must decide whether to combine foreign reserves with the money supply and also how to model the government's reactions to changes in the money supply thus defined (sterilization, etc.).

The *capital stock* may have effects on the economy independent of its relationship with the equity stock. Changes in the capital stock influence the level of productive potential in the economy and hence move the aggregate supply curve. The relationship between potential and actual output may be used to indicate the likelihood that short-run capacity constraints will influence output (or inflation). Tobin and Buiter (1976) and Smith (1980) introduced certain of these considerations to their 'dynamic IS/LM' models by endogenizing the capital stock, using it in a production function to determine inflation. However, as pointed out in Davis (1986) in a review of the Smith model, their models were still implausible, as in a steady state capital

*The Metzler model provides an analytically tractable approach to the modelling of stock and flow interactions. For a discussion, see Branson and Teigen (1976) and the original article by Metzler (1951); the model has also, however, been used by Mundell (1960, 1963), Pesek and Saving (1963), Phelps (1965) and Waud (1970).

accumulation, and hence saving was zero. (In order for a model to incorporate steady-state growth, exogenous elements of growth such as population growth and technical progress are required.) The models also restrict effects of capacity utilization to influence prices and not quantities. Development of the supply side is still one of the major challenges in economics, as pointed out by Klein (1978). The major problem is that potential output is unobservable. However, as with the other major stock-flow effects discussed above, some attempt is made in the modelling exercise described in the succeeding paper (Davis, 1987) to incorporate such a supply side into a model of the British economy.

3. Summary

This brief survey has discussed a range of potentially important effects on the behaviour of an economy resulting from the existence of stocks of real and financial assets. These effects complicate the simple predictions of static macro-economic models, implying that, for example, a budget deficit or a trade surplus will cause changes in asset stocks, which will in turn cause shifts in prices and incomes until the new stocks are willingly held by agents. Some efforts at modelling these effects have been noted and criticized, and some of the difficulties encountered in implementation have been enumerated. The stock-flow effects highlighted above are those most often discussed in the literature. However, it should be noted that others may be of equal importance, but have generally been ignored, at least by theorists. These include wealth effects on the labour supply, where one would expect an increase in wealth to reduce the supply of labour. Housing wealth is an important component of the personal sector balance sheet, and increases in its value may give rise to important wealth effects. Similarly, pension wealth forms a large proportion of the total, but its effects may be limited to effects via total wealth and interest rates. I note that the models are, however, not *necessarily* restricted to analysis of Keynesian paradigms (focusing on the importance of total wealth rather than money); 'monetarist' effects and restrictions are easily imposed or tested.* In the next section the main UK macro-economic models are analysed in the light of these theoretical issues. The broad conclusion is that stock adjustment dynamics are often not modelled, or are modelled inconsistently, thus leading to potentially important problems in the models' structure and functioning. This leads me to propose an alternative structure which will deal with these effects more fully.

III. STOCK-FLOW EFFECTS IN UK MACRO-ECONOMIC MODELS

1. Introduction

The above section has highlighted potentially important economic processes which might be incorporated in macro-economic models of the UK economy. In fact, analysis of the models

* Monetarists such as Brunner and Meltzer (1972, 1976) and Brunner (1976), were amongst the first to draw attention to wealth effects, the importance of the budget constraint and portfolio equilibrium.

shows that many such processes are not included, and those that are included are often not introduced in a systematic or consistent manner. * The results are summarized in Table 1, and discussed in more detail below.

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 utilize 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† can be used in investment functions, nor can personal or 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. 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. Similarly, if *external assets* are not defined in a model, then balance-sheet effects on prices and quantities—in particular the exchange rate—resulting from trade deficits and capital flows will be not be captured.

2. The Models

We now go on to consider in detail the extent to which the stock-flow effects described in Section II 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.‡ These models cover the broad spectrum of economic thought in a manner illustrated in Table 2.

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

*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 Davis (1987).
 †Of course, the capital stock is often proxied by appropriate lags of investment.
 ‡References: Dunn, Jenkinson, Michael and Midgley (1984); Bank of England (1982); HM Treasury (1984); *et al.* (1984); Courts (1984). The Cambridge model described is regarded by the authors as a prototype rather than a complete model. It should be distinguished from the Cambridge Growth Project model, which is not analysed here. 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).
 §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.

Table 1. 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 National Institute	No Manufacturing investment function only	No	No	No Non-bank private sector only	Yes Personal sector only	Yes No	No Yes	No No
Bank medium-term	Investment function only	No	No	No	No	Inflation rate proxy in consumption function	No	Yes
Bank short-term Treasury	Investment function only Non manufacturing investment function only	No	No	Personal sector only Non-bank private sector only	Personal sector only Personal sector only	Yes Yes—consumption and labour supply functions	Yes Yes	Yes Yes
LBS City University Liverpool	No Yes In wealth portfolio but not production function	No Yes	Yes No	Yes No	No No	Yes Yes	Yes Yes	Yes No Aggregated with domestic assets

Table 2

Model	Category
Cambridge	Keynesian
National Institute	Eclectic Keynesian
Bank of England (medium-term)	Eclectic Keynesian
Bank of England (short-term)	Eclectic Keynesian
Treasury	Eclectic Keynesian
London Business School (LBS)	Eclectic Keynesian
City University (CUBS)	Neo-classical
Liverpool	Neo-classical/monetarist
}	
Becoming more monetarist and neo-classical	

Not all the relationships embodied with the models are estimated, reflecting areas where the modeller's 'judgements' 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 empirical econometric 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.

Table 1 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, National Institute and London Business School. 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 London Business School) is determined by relative interest rates in the United Kingdom 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 focuses 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 United Kingdom under fixed and floating exchange rates. Rational ('model-consistent') expectations imply 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 short 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). However, the outline description of the models and of recent changes presented in Wallis (1985, pp. 10–17), suggests that no changes had been made which would significantly alter the following analysis.

3. 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. The 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 London Business School 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, determines gross investment in a partial adjustment framework. The Treasury and Institute models follow the Cambridge/London Business School 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 neo-classical 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 of England models, the Treasury, Institute, London Business School 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 neo-classical models do not separately determine inventory investment.

(ii) *Stock of Equity.* It has been noted 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 London Business School 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 of England 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 neo-classical 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 hypothesized 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 London Business School models—there are some underlying supply influences. For example, in the reduced form of the Bank of England 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 KLEMS (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,* and, as noted, the capital stock, which is given by the consumers' decision, is

*The exchange rate equation is derived from a marginal cost pricing equation with a constant returns 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), pp. 41–42.

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 relationships in UK macro-models to determine capital and output is limited. Even among the neo-classical 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,* and even where capital and equity stocks are determined, they are not used to the extent that the economic theory described in Section II would suggest.

(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 United Kingdom, 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 macro-models, which typically feature flow rather than stock adjustment, *ad hoc*, imposed structures and no cross-equation constraints. The Bank of England and medium-term and Cambridge models have no financial sectors. The Bank of England 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. In the Treasury model company liquidity is also determined, and feeds back to determine certain expenditure decisions, but there are no consistent definitions of sectoral stocks.

The London Business School model (see Keating, 1984) does feature a consistent portfolio system of demand 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

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

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.*

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 recognize 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 London Business School model, there is no role for income in asset demands.

(iii) *Definition 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.

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 macro-economic 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 (1980) 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). For a comparison of consumption functions, see Davis (1984a). Such inflation losses are not directly allowed for in the Bank of England medium-term or London Business School 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

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

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, i.e. inflation-adjusting imputed rent. The Bank of England and London Business School models feature the value of housing as a component of personal sector net wealth, but in the Bank of England model this only affects consumption indirectly by influencing the proportion of financial wealth held in liquid form (see Davis, 1984b).

(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, i.e. 'outside' wealth, though it will be seen that macro-economic models typically also assume asymmetries within the private sector, by allowing intra-private sector claims or '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 of England 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 London Business School 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 of England medium-term model wealth effects are proxied by the inflation rate. In the CURBS model there is no consumption function as such, but, in line with theory, the levels 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 models' 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.*

Besides affecting demand, the neo-classical 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 macro-economic 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[†] and the personal sector via the wealth effects noted above. This is the case in the Bank of England short-term, Treasury, London Business School and Liverpool models. In the Institute and Bank of England medium-term models the exchange rate is only affected by real factors (and, in the latter case, by intervention). The stock of gilts is not identified in the Bank of England 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 London Business School 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 of England 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 Euro-dollar 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, remain fundamentally flow-based.

*This suggests that such distributed lags in other models may have implications for wealth. †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 (e.g. bank lending) on the exchange rate.

(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 of England short- and medium-term models, the Treasury and London Business School models, but only in the London Business School model 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 of England 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.

IV. CONCLUSIONS

1. The Stock-flow Consistency Problem

In general, it has been shown in Section III that UK macro-economic models do not fully model either physical or financial asset stocks, or their effect on the economy. Modelling practice thus contrasts strongly with the theoretical literature discussed in Section II. For 'neo-Keynesian' models this is particularly the case for the omission of the supply side (production function, capacity output, capital stock, equity market and Tobin's q). Equally, no extant forecasting model incorporates all the desirable features of financial stock-flow integration, portfolio adjustment and wealth effects that the theoretical literature highlights. It has been emphasized that these omissions are 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, and which is a problem particularly in the financial sector. Also, many of the data for stocks of financial assets have only become available recently. Thirdly, some of the more detailed effects described above are omitted from the annual models, due to aggregation.

2. A Proposed Stock-flow Model of the UK Economy

Given the contrasts highlighted above between theory and econometric models of the United Kingdom, I set out to construct an empirical estimated macro-econometric model, using all the available data, which would encapsulate as far as possible the stock-flow effects discussed in this article. Such an exercise would enable the significance of such effects in estimation, and their effects on simulation properties, to be assessed, and hence the potential importance of their omission. It would also indicate some of the difficulties entailed in stock-flow consistent modelling. I conclude by outlining such a model, full details of which are included in a subsequent paper (Davis, 1987).

The basic structure of the model is that of a 'dynamic IS/LM model', as described in the work of Tobin and Buiter (1976) and Smith (1980). The structure is illustrated in Figure 1. The model builds up expenditure from the components of demand—consumption, investment, etc.—in a familiar Keynesian manner. However, investment is cumulated to give a capital stock—the investment function itself being basically a neo-classical factor demand

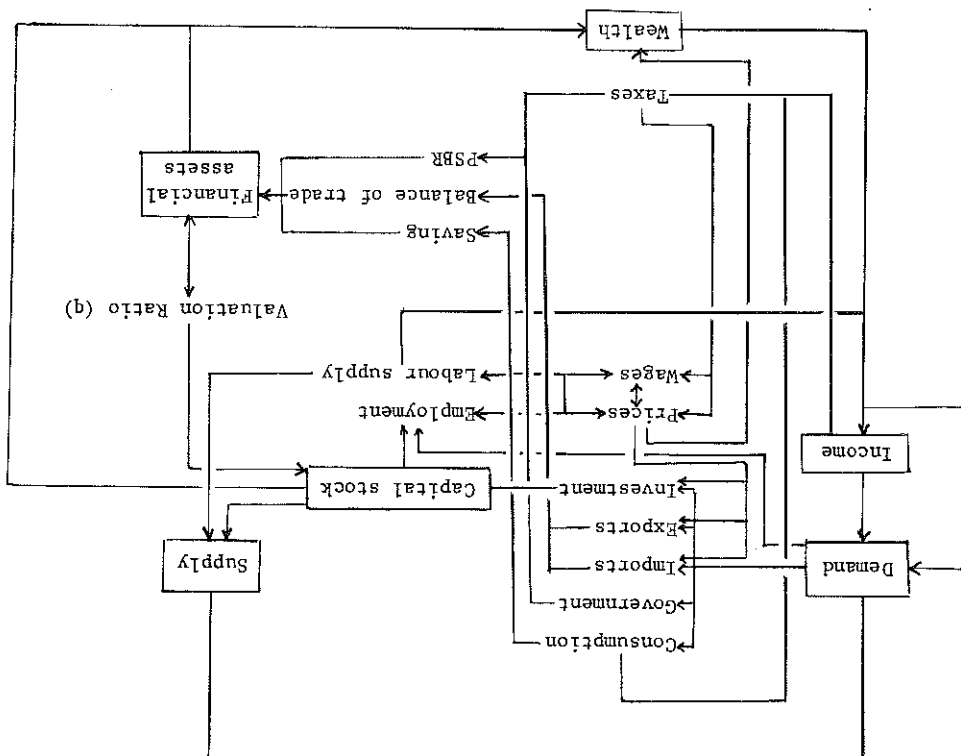


Figure 1

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 *directly* by the stock of money. 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 utilization, 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 stabilize the exchange rate)—a reduced form portfolio effect—but some portfolio effects also enter directly.

This outline is summarized in Figure 1. In Davis (1987) I detail in full the estimation and simulation properties of this model. These lead me to conclude that effects arising from stocks of assets are important to the explanation of past changes in economic variables, and that omission of stock-flow effects influences the simulation properties of existing models, especially over a long time horizon.

ACKNOWLEDGEMENTS

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. Andersen, 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, also the editor of this journal and two anonymous referees. The errors remain his own responsibility.

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