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by

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THE IMPORTANCE OF INTEREST RATES IN FIVE MACROECONOMIC MODELS

Contents:

This paper is a development of earlier papers written jointly with E P Davis. Mr Davis was also instrumental in liaising with the modellers to obtain the simulations reported here. The project was supervised by K D Patterson. The author would like to thank the modellers for their assistance in running and interpreting the simulations and their comments on earlier drafts. The author would also like to thank E P Davis, J S Flemming, N H Jenkinson, K D Patterson, J Ryding and other colleagues at the Bank of England for numerous helpful comments on this and earlier drafts. The author retains responsibility for the interpretation of the simulations and any errors.

INTRODUCTION

The purpose of this paper is to consider the role of interest rates in the five main macroeconomic models of the United Kingdom and the importance of the various mechanisms through which interest rates are thought to affect the economy. Of these models, the Bank of England, National Institute of Economic and Social Research, Her Majesty's Treasury and the London Business School are large scale models based on quarterly data, whereas the Liverpool University model is much smaller in scale and based on annual data; all are used regularly for forecasting and simulation analysis. These models encompass a broad spectrum of economic thought from the fairly traditional Keynesian view embodied in the National Institute model to the new classical or monetarist Liverpool model.

There are two approaches to considering the role of interest rates in empirical macroeconomic models. One is concerned with identifying a role for interest rates in single equations, or possibly single sectors, of the models with emphasis on the magnitude of the coefficients on interest rate variables. The second, and complementary approach, concerns assessing the impact on the complete model of including interest rate variables in particular equations or sectors. The technique normally used in this latter assessment is that of simulation. The model is first solved for a period with the exogenous variables set at realistic values to establish a base run; a change is then made - for example the path of an exogenous variables could be altered or an endogenous variable could be made exogenous by overwriting the relevant equation in the model - and differences from the base can then be attributed to the 'shock' which has been applied.

Within macroeconomic models there are distinctions between interest rates of different maturities, between nominal and real interest rates, and between domestic and foreign interest rates.

All of these distinctions are of some importance in the five models under consideration. For example, when considering an investment decision, a firm may wish to know the present value of returns over a decade or more, and so it would probably be appropriate to consider a long rate rather than a short rate.

There are differences among the models in the way that interest rates themselves are modelled. In the Liverpool model a domestic nominal short rate is related to inflation expectations and a real short rate; the real short rate is then related to a corresponding real rate in the United States. In the Bank model a reaction function is specified which relates a pivotal domestic nominal short rate to variables thought to influence authorities' behaviour. The coefficients in such reaction functions are typically imposed rather than estimated and the reaction function may well be overwritten when the model is used for forecasting. Such differences affect the way in which the simulations reported here have been carried out. In the Liverpool model the 'shock' is administered by altering US real rates, whereas for the other models pre-tax domestic nominal short rates are altered thus effectively switching off any reaction functions.

The structure of the paper is as follows. In section one we provide a detailed analysis of the interest rate effects within the five models on a single equation or single sector basis. As well as identifying where such effects are present, we attempt to illustrate the relative magnitude of these effects in a single equation context by isolating individual equations from the rest of the model. In section two we report the results of simulations run by the model proprietors in which domestic nominal short rates are reduced by 2% points. We present alternative simulations with the exchange rate free or fixed and in addition, we note the effects in the LBS and Liverpool models of distinguishing between a permanent and a temporary shock. Section three is a brief conclusion.

SECTION I: THE SINGLE EQUATION PROPERTIES OF THE MODELS

Introduction

Whilst the overall effects of interest rates in the models are determined by means of full simulations which allow all of the interactions within the models to function, the initial modelling and assessment of interest rate effects is usually undertaken in a single equation (or single sector) framework. The purpose of this section is to consider in detail the individual mechanisms through which interest rates are thought to affect the economy; such an approach allows the relative magnitudes of changes in interest rates to be compared across different models.

In discussing the single equation properties, it is necessary to distinguish between nominal and real interest rates. The majority of the single equation effects identified in the models are due to nominal interest rates. However, where the single equation effects are due to real interest rates, it is important to recognise that changes in either nominal rates or the rate of inflation can alter real interest rates. In addition, if a change in nominal rates affects a price deflator (as with the RPI), the change in real rates will not be the same as the change in nominal rates. In the discussion of the single equation effects, we implicitly assume changes are to nominal rates unless specified otherwise. Where a real rate is specified, we assume that the change in the real rate is caused by an identical change in nominal rates and the other determinants of the equation are held constant. Hence the single equation effects are <u>conditional</u> on the other determinants being unchanged.

It is also important to consider the relationship between short-term and long-term interest rates - the yield curve. The equation for persons' holdings of net liquid assets in the Bank model is an example of an equation where both short and long-term interest rates are determinants. Here the shape of the yield curve is crucial as a change in the relative yield on assets would induce substitution between assets, with possible consequences for activity. Apart from Liverpool, the models treat short-term rates as exogenous, and have a yield curve relationship specified which ceteris paribus determines long-term rates given the change in short-term rates.

All the models except Liverpool use more than one short-term rate and in some sectors differentials between short-term rates are also important. For example, inflows to the building societies will typically depend on differentials between building society share rates and bank deposit rates. This will affect building society liquidity and possibly house prices or housing investment. However, we limit our analysis to changes in all short rates and this ensures constant differentials.

The subsequent sections report in detail the single equation (or intra-sector where appropriate) effects of interest rate changes. Whilst the emphasis is on direct interest rate effects in particular equations, ie the occurrence of interest rates as a determinant in an equation, reference is also made to related equations where these are thought to be important in understanding the context in which the interest rate effects have been modelled. For each model, five specific areas of real side activity are considered: non-residential investment, residential investment, stockbuilding, consumption expenditure on durables and consumption expenditure on non-durables. The financial sector of each model and the exchange rate are also considered.

Table 1 presents a brief summary of the direct interest rate effects present in these areas of the models.

TABLE 1: DIRECT INTEREST RATE EFFECTS IN THE MODELS

Model Equation		Bank of England	National Institute	Treasury	LBS	Liverpool
Non-residential investment		No	No	RL(-)	No	)
Residential investment		RS(-)	RS(-)	RS(-)	RS(-)	)
Stockbuilding		RS(-)	No	RS(-)	RS(-)	) 1 (-)
Consumption of durables		RS(-)	No	RS(-)	RS(-)	)
Consumption of non-durables		No	No	RS(-)	RS(-)[2]	RL(-)
Monetary aggregates	M0 :	RS(-)	No	RS(-)	4	RS(-)
	Ml :	RS(-)	RS(-)	RS(-)	4	No
	£M3:	3	3	RS(+)		No
Exchange rate		(RS-RF) (+)	(RS-RF) (+)	(RS-RF) (+)	4	No

RS = Domestic short interest rate
RL = Domestic long interest rate
RF = Eurodollar rate
(-) = Indicates a negative influence

1 The Liverpool model only disaggregates into consumption of non-durables and 'goods', where the latter includes fixed capital, consumer durables and inventories.

2 The LBS model considers only total and durable consumption, with consumption of non-durables given by identity.

3 £M3 is determined by the counterparts in the flow of funds matrix but interest rates enter some of the behavioural equations in the matrix.

4 The exchange rate and monetary aggregates in the LBS model are determined by the demand for various assets within the financial sector. The demand for assets is related to the relative yields which are themselves determined within this sector.

HOW ARE INTEREST RATES DETERMINED?

The discussion of the single equation interest rate effects and indeed the simulations reported in section two, analyse the impact of a change in interest rates without considering what might cause such a change. With the exception of the Liverpool University model, all the models view short-term nominal interest rates as a policy instrument which is under the control of government.* In deciding upon the appropriate level of interest rates, the authorities might react to changes in world or domestic variables and the latter are determined within the model. Alternatively, the authorities may choose to let interest rates be determined solely by market forces without any direct control, in which case interest rates should be fully endogenous. Clearly in either case, interest rates are influenced by events within the model.

One potential solution to this problem is to have a reaction function which seeks to explain the movement of nominal short interest rates by the authorities' response to such factors as pressure on exchange rates or the growth of monetary aggregates. All of the models have a facility for a reaction function, although the estimation of such functions has been fraught with difficulty and has at best been only partially successful. The reaction functions used in the models are largely imposed and reflect the modellers' views rather than empirical evidence. Consequently, with the exception of the Liverpool model, the models are limited in their ability to explain what might cause the changes in interest rates which are being analysed.

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*In the Liverpool model both nominal and real domestic interest rates are endogenous. Real interest rates are given by the imposition of the efficient markets hypothesis which forces the real domestic/foreign interest rate differential to offset the expected capital gain or loss from changes in the real exchange rate. Nominal and real interest rates are then forced into consistency by the Fisher identity which gives the nominal rate as the real rate plus expected inflation.

Given the problems in specifying a suitable reaction function, there is considerable merit in exogenising interest rates and switching off the reaction function, as is the case in the simulations reported in section two. This allows interest rate effects to be analysed in isolation from discussions of the accuracy of the particular reaction function, and ensures that an identical change in interest rates can be applied to each model. In addition it allows the resulting changes in each model to be attributed solely to the changes in interest rates, rather than a combination of the change in interest rates and the change in the factors which determine interest rates. However, it must be stressed that this exogeneity of short interest rates is artificial, and it imposes limitations on the realism of the simulations by preventing any feedback from changes in other variables to interest rates. For example, if the authorities react to the growth of £M3 (with increased growth inducing higher interest rates), then a cut in interest rates which induced higher growth in £M3 would in the longer term induce a rise in interest rates, although the magnitude of the increase would depend on the precise reaction function.

The models, with the exception of Liverpool, consider more than one short-term interest rate and these are typically related to a pivotal exogenous short-rate by simple technical rules. In addition, the relationship between long and short-term interest rates - the yield curve - is determined within the model. As we discuss below, the yield curve relationship is potentially important as differentials between short and long rates can influence activity. Accordingly we briefly consider the determination of short and long interest rates in each model.

(a) Bank of England model

The pivotal short-term rate in the Bank model is the end-quarter local authority three-month deposit rate (RLAE). The technical relationships which link the short-term interest rates are as follows:

$$RLA = (RLAE + RLAE_{-1})/2$$

$$RCD = RLA$$

$$RCBR = RLA - 0.5$$

Where:

RLA = Quarterly average local authority 3-month deposit rate

RCD = Rate on 3-month sterling certificates of deposits

RCBR = Clearing banks' base rate

Building society interest rates are in fact given by estimated equations, but the independent variables are all other short-term interest rates. However, to preserve comparability with the other models, these equations were switched off during the simulations reported in section two and building society interest rates were linked directly to the pivotal rate.

The yield curve equation in the Bank model gives RUKG, the yield on 20-year government stock. The equation is:

$$RUKG = 5.36223 + 0.18818\ D76A \sum_{i=0}^{3} a_i (100\ PSBR/GDP£)_{-i-1}$$

$$+ 0.15375\ (1-D76A) \sum_{i=0}^{3} a_i (100\ PSBR/GDP£)_{-i-2}$$

$$+ 0.27526\ RLA + 0.21337\ PEXP$$

$a_0 = 0.4 \quad a_1 = 0.3 \quad a_2 = 0.2 \quad a_3 = 0.1$

$R^2 = 0.953$ SE = 0.6 DW = 1.6 1969 Q1 - 1977 Q4

Where:

RUKG = Rate on long-term (20 years) UK government stock

PEXP = Proxy for expected rate of inflation (prices)

PSBR = Public sector borrowing requirement

GDP£ = Gross domestic product (expenditure estimate) (£ mn)

RLA = Local authority 3-month rate (quarterly average)

D76A is 0 until 1976 Q1 and 1 thereafter

Price expectations depend on the expected change in the sterling dollar rate and the index of producer prices for manufactured output.

Thus the long-term interest rate is influenced by short-term rates, short-term price expectations and the ratio of the PSBR to GDP£, reflecting the possible need to increase interest rates in order to finance a larger PSBR.

b) National Institute model

The pivotal short-term interest rate in the National Institute model is usually RTB, the Treasury Bill rate.

Alternatively, the domestic real rate of interest (RRIUK7) is taken to be exogenous and RTB is derived from the following rule:

$$RTB = 100\,\frac{RRIUK7/100 + (\Delta_4\ PWMF/PWMF)_{-4}}{1 - RRIUK7/100}$$

Where:
PWMF = Wholesale price of manufactures

Given RTB or RRIUK7, the bank lending rate, certificate of deposit rate, local authority rate, building society share and deposit rate and national savings rate are all determined by assuming an unchanged differential with the Treasury bill rate. For example, the change in bank lending rate equals the change in Treasury bill rate.

The long-term interest rate is the yield on 2.5% consols which is estimated as:

$$\Delta RCNSL = \underset{(0.4)}{0.0225} + \underset{(1.2)}{0.114}\ \Delta RCNSL_{-1} + \underset{(1.4)}{0.139}\ \Delta RCNSL_{-2} + \underset{(6.2)}{0.301}\ \Delta RTB$$

R^2 = 0.39 SEE = 0.535 LM(8) = 4.4 1965Q2 - 1983Q2

RTB = Treasury Bill rate
RCNSL = Yield on 2.5% consols

Here the change in long-term rates is determined solely by the change in the pivotal short rate and previous changes in the long rate.

(c) HM Treasury model

The Treasury bill rate is also the pivotal short-term rate in the Treasury model. The technical relationships which link the short-term rates ensures that constant pre-tax differentials are maintained between all the rates. The equation for the long-term interest rate is as follows:

$$RLONG = 0.8308\ RLONG_{-1} + 0.789 + 0.3109\ RTB - 0.2517\ RTB_{-1} + 0.05522\ PEXPF$$

Where:

RLONG = Long-term interest rate

RTB = Treasury Bill rate

PEXPF = Price inflation expectation

Price inflation expectations depend on trend productivity, unit labour costs, a unit value index for imports of capital and the growth of £M3.

Thus the only determinant common to these three equations for long-term rates is the short rate. The Bank and Treasury both allow backward-looking expectations to influence long rates, but only the Bank allows any influence from the size of the PSBR relative to GDP.

The LBS model also considers short-term interest rates to be exogenous but the interest rate on gilts is determined within the financial sector by the price of gilts. This is a market clearing price which depends on all the individual sectors' asset demands and returns. The financial sector of the LBS model is described in detail below.

In the Liverpool University model domestic interest rates are endogenous with real rates given by the efficient markets hypothesis and nominal rates derived from a Fisher identity. The efficient markets hypothesis links domestic real interest rates to the real exchange rate and foreign real interest rates by forcing the real domestic/foreign interest rate differential to offset the expected capital gain or loss from changes in the real exchange rate. Hence domestic real interest rates are closely related to foreign real interest rates which are exogenous.

BANK OF ENGLAND QUARTERLY MODEL (AUTUMN 1984)

On the activity side, the Bank of England model has interest rate effects in the equations for consumers' expenditure on durables, residential fixed investment and some of the categories of stockbuilding. However, there are no such effects in the equations for consumers' expenditure on non-durables or in either category of non-residential fixed investment.

(a) Non-residential fixed investment

The equations for private non-residential investment are based on a conventional accelerator model and relate investment to the appropriate capital stock and output variables. There is no provision for interest rates to alter the cost of capital or the expected rate of return, and there are no liquidity effects which might influence the availability of finance.

(b) Residential fixed investment

In contrast, the equation for private fixed residential investment has a number of interest rate effects. The equation is:

$$\underset{}{IHP} = \underset{(7.9)}{0.7039}\ IHP_{-1} + \underset{(0.9)}{75.5986}\ (PAHM/(0.444\ PPOX + 0.556\ ULC))$$

$$- \underset{(3.5)}{15.8955}\ RCBR + \underset{(3.8)}{399.9732}$$

$\bar{R}^2 = 0.773$ SE = 71.8 DW = 2.2 1968 Q2 - 1981 Q4

Where:

IHP = Private sector residential fixed investment (80£mn)

PAHM = Price deflator for all houses, mix adjusted (1980=1)

PPOX = Producer price of manufactured output (excluding food, drink and tobacco) (1980=1)

ULC = Unit labour costs, whole economy (£/80£)

RCBR = Clearing banks' base rate (% pa)

The equation considers only the supply side, with short-term interest rates reflecting the cost of borrowing by builders to finance construction. The positive influence of the ratio of house prices to labour and manufacturing costs reflects the profit potential for the builders.

A 2% point cut in the base rate, immediately increases real housing investment by 32 80£mn or 3.0% of its 1984 Q2 value. If the cut in base rates was sustained, the long run steady state effect would be to raise investment in housing by 9.8%. The second group of interest rate effects enters through the house price term. The equation for house prices is:

$$\begin{aligned}
\Delta \ln PAHM = {} & \underset{(3.9)}{21.55334} (\Delta \ln PAHM_{-1})^3 + \underset{(4.5)}{0.42954} \Delta \ln PAHM_{-2} \\
& + \underset{(5.6)}{0.48397} \ln (RPDI/OHS)_{-1} \\
& + \underset{(7.1)}{0.20471} \ln ((KZNA + KHBB + KHPG + KHPV)/PAHM)_{-1} \\
& - \underset{(4.2)}{0.59231} (RZMG/100.0 *(1 - MC (TRY/100)))_{-1} \\
& + \underset{(2.2)}{0.06314} (3 \Delta \ln RPDI + 2 \Delta \ln RPDI_{-1} + \Delta \ln RPDI_{-2}) \\
& - \underset{(3.2)}{1.31347} \Delta(RZMG/100 * (1 - MC^* (TRY/100))) \\
& - \underset{(7.2)}{2.75237} - \underset{(0.6)}{0.00316} Q1 + \underset{(3.3)}{0.01631} Q2 + \underset{(5.4)}{0.02617} Q3
\end{aligned}$$

$\bar{R}^2 = 0.842$ SE = 0.012 DW = 1.6 1969 Q1 - 1981 Q4

Where $MC = 71/68\ D821_{-5} + 1 - D821_{-5}$

$MC1 = 71/68\ D821_{-6} + 1 - D821_{-6}$

Where:

PAHM = Price deflator for all houses, mix adjusted (1980=1)

RPDI = Real personal disposable income (80£mn)

OHS = Stock of owner-occupied housing (£mn)

KZNA = Stock of building society loans for house purchase (£mn)

KHBB = Stock of bank loans for house purchase (£mn)

KHPG = Stock of public sector housing loans excluding council house sales (£mn)

KHPV = Stock of insurance company mortgage loans (£mn)

RZMG = Interest rate on building society mortgages (% pa)

TRY = Standard rate of income tax (% pa)

Qi = 1 in the ith quarter of each year

The non-linearity in the equation means that the effect of interest rates is base-dependent, but by setting $\Delta \ln PAHM = 0.02$, some impression of the size of the effect can be gained. A 2% point cut in the interest rate on mortgages (1.4% after tax) immediately increases house prices by 1.8%. At 1984 Q2 levels,this would increase real housing investment by only 1.7 80£mn. After one year, the cumulative effect is to increase house prices by 3.9% and after two years 4.6%. However, an increase in house prices of 4.6% will raise housing investment by only 0.4%.

Interest rates have an additional effect on house prices through KZNA, the stock of building society loans for house purchase. The equation for KZNA is:

$$\Delta(KZNA/NLAJ) = -\underset{(2.3)}{0.05317}\,(KZNA/NLAJ)_{-1} + \underset{(5.1)}{0.00151}\,ZLIQ_{-1}$$
$$-\underset{(3.3)}{0.00230}\,(RZMG\,(1-(TRY/100)))_{-1} + \underset{(1.6)}{0.01399}$$
$$-\underset{(2.0)}{0.01164}\,PAHM_{-1}$$

$R^2 = 0.457$ SE = 0.004 DW = 1.6 1968 Q3 - 1981 Q4

Where:

NLAJ = Persons' holding of net liquid assets (end-quarter)(£mn)

ZLIQ = Proxy for building societies liquidity position (%)

A fall in the mortgage rate increases the flow of building society loans directly, but interest rates also affect building society liquidity and persons' holdings of net liquid assets. The proxy for building society liquidity is given by ZLIQ=(1-KZNA/KZSD)*100, where KZSD is stock of building society shares and deposits. Approximately 90% of KZSD is KZJ, the stock of personal sector deposits with building societies. The equation for KZJ is:

$$\Delta\frac{KZJ}{NLAJ+KBMS-KHBB} = -\underset{(3.5)}{0.03522}\,(KZJ/(NLAJ + KBMS - KHBB))_{-1}$$
$$+\underset{(3.6)}{0.0031302}\,\Delta RZSG + \underset{(5.3)}{0.00287}\,RZSG_{-1}$$
$$-\underset{(6.2)}{0.0024839}\,\Delta RCBR - \underset{(6.3)}{0.0023888}\,RCBR_{-1} - \underset{(3.4)}{0.0053852}$$

$R^2 = 0.556$ SE = 0.003 DW = 1.2 1963 Q2 - 1981 Q4

Where:

KZJ = Stock of personal sector deposits with building societies (£mn)

KBMS = Stock of bank advances to persons (£mn)

RZSG = Gross interest rate on building society shares (% pa)

The equation represents personal sector portfolio allocation behaviour, with the returns available on alternative assets affecting the inflows to building societies. The holdings of net liquid assets are also influenced by interest rates, and so the precise effect of interest rates on building societies inflows, building society lending, house prices and hence housing investment, are difficult to determine. The simulations in section two illustrate the overall building society sector properties but include the direct interest rate effects on housing investment and house prices, as well as the influence of interest rates on the building society sector. Note that the effect of interest rates on holdings of net liquid assets is discussed in the section on consumption.

(c) Stockbuilding

Stockbuilding is disaggregated into four categories - materials and fuels held by manufacturers, manufacturers' work in progress and finished goods, distributors' stocks and other stocks - with direct interest rate effects on materials and fuels and work in progress and finished goods. The equation for materials and fuels is:

$$IIBM = \underset{(3.7)}{0.151}\ MPRO + \underset{(1.8)}{0.105}\ MPRO_{-1} - \underset{(1.2)}{0.058}\ MPRO_{-2} - \underset{(8.3)}{0.190}\ KIBM_{-3}$$

$$+ \underset{(5.0)}{0.010}\ ((KLI - KBLI)/PEF)_{-1} - \underset{(2.3)}{0.022}\ (R-P)\ (MPRO)_{-1}$$

$R^2 = 0.743$ SE = 104.5 DW = 2.4 1964 Q1 - 1981 Q4

Where:

$$R = (1 - TRYC/100)\ 0.25 \sum_{i=0}^{3} (RCBR/100)_{-i}$$

$$P = (1 - D.TRYC/100)((PMAM - PMAM_{-4})/PMAM_{-4})$$

D	=	Dummy for stock appreciation tax relief
IIBM	=	Stockbuilding: materials and fuels held by manufacturers (80£mn)
MPRO	=	Manufacturing production (80£mn)
KIBM	=	Stock level: materials and fuels held by manufacturers (80£mn)
KLI	=	Proxy for ICCs' stock of net liquid assets (£mn)
KBLI	=	Proxy for ICCs' liabilities (£mn)
PEF	=	Price deflator for total final expenditure (1980=1)
TRYC	=	Annual tax rate on corporate income (%)
RCBR	=	Clearing banks' base rate (%)
PMAM	=	Adjusted price deflator for imports of goods and services (excluding finished manufactures)(1980=1)

The static steady state solution of this equation is:

KIBM/MPRO = 1.04 - 0.116 (R-P) + 0.053 (KLI-KBLI)/PEF)/MPRO

which gives the stock output ratio as a negative function of real post-tax interest rates and a positive function of the ratio of real liquid assets to production. A 2% point reduction in real pre-tax interest rates (1.1% points after tax) would increase the stock output ratio by 0.00128. With manufacturing production unchanged, this would eventually imply a long-run increase in the stock level of just 16 80£mn. This reflects increases in stockbuilding of 8 80£mn in the first and second years.

The equation for work in progress and finished goods has a similar structure and the long-run solution is:

KIFW/MPRO = 1.69 - 0.49 (R-P) + 0.065 ((KLI-KBLI)/PEF)/MPRO

Here a similar reduction in interest rates would imply a long-run increase in the stock level of 69 80£mn which reflects increases in stockbuilding of 30 80£mn in the first and second years. Note that interest rates also affect both categories of manufacturers' stocks indirectly through their influence on the proxy for ICC's liquidity. Interest rates also affect other stockbuilding via their influence on companies' gross interest payments and hence gross income gearing.

(d) Consumers' expenditure

The final specific area of activity considered here is consumers' expenditure on both durable and non-durable goods. The equation for non-durables expenditure does not have a direct interest rate effect, although the role of interest rates in determining persons' holdings of net liquid assets (NLAJ) is again important, as NLAJ is a major determinant of consumption.* The equation for NLAJ is:

$$
\begin{aligned}
\Delta(NLAJ/PC) = \; & \underset{(4.0)}{0.562}\,\Delta(NAFJ/PC) - \underset{(6.6)}{37943.886}\,\Delta(\Delta_4 PC / PC_{-4}) \\
& + \underset{(2.8)}{267.786}RSHT_{-1} - \underset{(2.9)}{246.194}RUKG_{-1} + \underset{(1.8)}{4804.193} \\
& (\Delta_4 PCD_{-1} / PCD_{-5}) - \underset{(3.5)}{18186.052}(\Delta_4 PCND_{-1}/PCND_{-5}) \\
& + \underset{(3.5)}{0.643}\,(NAFJ/PC) - \underset{(0.9)}{21745.950}\,(NLAJ/PC/ \\
& (((NWJ-VOHS)/PC) + (VOHS/PAHM)) + \underset{(1.2)}{3588.694}
\end{aligned}
$$

$\bar{R}^2 = 0.688$ SE = 626.2 DW = 2.0 1968 Q3 - 1981 Q4

Where:

RSHT = (RZSG * ((NLAJ + KBMS)/NLAJ)) - ((RCBR + 3.1)(KBMS/NLAJ)) which is a proxy for the rate of return on net liquidity.

NLAJ = Persons' holdings of net liquid assets (end-quarter)(£mn)

NAFJ = Adjusted personal sector net acquisition of financial assets (£mn)

KBMS = Stock of bank advances to persons (£mn)

PC = Price deflator for total consumption (1980=1)

PCD = Price deflator for consumption of durable goods (1980=1)

PCND = Price deflator for consumption of non-durable items (1980=1)

RUKG = Rate on long-term (20 year) UK government stock (% pa)

NWJ = Personal sector net wealth (£mn)

VOHS = Value of owner occupied housing stock (£mn)

The disparity between the coefficients on the terms representing short and long interest rates means that, even if the shape of the

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*The elasticity of real net liquidity in the static long-run solution of the equation for consumers' expenditure on non-durables is 0.42.

yield curve remained unchanged when interest rates fell, there would be a slight reduction in the holdings of net liquid assets. More importantly, a tilt in the yield curve with, for example, long rates falling by less than short rates, would induce a shift towards illiquid financial assets. The reduction in holdings of liquid assets would in turn reduce consumers' expenditure on non-durables. This illustrates the potential importance of the relationship between short and long rates.

The equation for consumers' expenditure on durables is also temporarily subject to the effects of a change in the yield curve on liquid asset holdings, but in addition the equation contains two other interest rate effects. The equation is:

$$\ln(CD/CDD) = -\underset{(5.9)}{0.663}\ \ln(CDD/YDLD)$$

$$+\underset{(5.1)}{0.066}\sum_{i=0}^{2}\ln((LHBB + LHPG + LZNA + LHPV)/PCD_{-i})$$

$$-\underset{(3.3)}{0.215}\sum_{i=0}^{2}(\ln(1.0+(RCBR/100))-(\ln PC_{-1} - \ln PC_{-5}))_{-i}$$

$$+\underset{(8.9)}{0.275}\sum_{i=0}^{2}(3-i)\ln(YDLH/YDLD) - \underset{(5.6)}{3.062}$$

$$+\underset{(3.4)}{0.164}\ D681 - \underset{(2.7)}{0.166}\ \Delta\ln RMD + \underset{(2.7)}{0.129}\ D731$$

$$+\underset{(5.1)}{0.245}\ D79 + \underset{(1.6)}{1.280}\ \Delta\ln(PCNL/YDLD)$$

$\bar{R}^2 = 0.734$ SE = 0.046 DW = 1.6 1964 Q2 - 1981 Q4

Where:

$CDD = (CD_{-1} * CD_{-2} * CD_{-3} * CD_{-4})^{**}\ 0.25$

$YDLD = (YDLH_{-1} * YDLH_{-2} * YDLH_{-3} * YDLH_{-4})\ ^{**}\ 0.25$

$PCNL = ((NLAJ/PC)_{-1} * (NLAJ/PC)_{-2} * (NLAJ/PC)_{-3} * (NLAJ/PC_{-4})^{**}0.25$

CD = Consumers' expenditure on durable goods (80£mn)
YDLH= Adjusted proxy for household real disposable income (80£mn)
LHBB= Loans for house purchase by banks (£mn)
LHPG= Loans for house purchase by local authorities (£mn)
LZNA= Net advances on mortgages by building societies (£mn)
LHPV= Loans for house purchase by other financial institutions (£mn)
RMD = Effective minimum deposit rate for durables.(%)
D681(D731) = 1 in the first quarter of 1968(1973)
D79 = 1 in the second quarter of 1979

The clearing banks' base rate enters the equation directly as a real interest rate. A 2% point cut in real rates immediately increases consumers' expenditure on durables by about 0.4%. After one year the increase is approximately 1.5% and after two years 1.9%. The other interest rate effect enters through the flow of mortgage lending by building societies, reflecting the use of some mortgage funds for durables expenditure. However, as was discussed above, the precise effect of interest rates on the building society sector is difficult to determine and depends on the overall model dynamics.

(e) Other income/financial effects

The discussion above has concentrated on the effects of interest rates on specific areas of activity, but interest rates also have a more general influence on activity through flows of sectoral interest, profit and dividend incomes which reflect the position of a sector as a net debtor or creditor. Apart from international leakages, the changes to domestic sectoral incomes should cancel, but as different sectors respond in different ways to changes in their income, there may be some aggregate effects.

For example, a fall in interest rates will reduce debt interest payments by government, and the personal sector's receipt of interest, profit and dividend income. The personal sector reacts by reducing consumption but because the government is exogenous to the model, there is no reaction to the net reduction in the PSBR. Therefore overall, a cut in interest rates would tend to reduce consumption by lowering personal sector income.

The financial side of the Bank model is relatively sparse by comparison with the activity side, reflecting the model's heritage. Consequently, the financial effects of interest rates are limited to liquidity effects on persons and companies, the effects on the monetary aggregates and the exchange rate.

The growth in the £M3 is determined by changes in the counterparts and interest rates have a weak influence on £M3 via some of the behavioural equations in the flow of funds matrix. For example, the stock of notes and coin is negatively influenced by the net rate of interest on building society shares, and the identity for persons' domestic bank deposits contains the change in persons' holdings of net liquid assets.

The equation for the stock of notes and coin is:

$$\ln KNCS = \underset{(2.4)}{0.28141}\ln KNCS_{-1} + \underset{(6.4)}{0.65913}\ln C£ \ \underset{(1.2)}{-0.00567}RZSN \ \underset{(1.5)}{-0.00710}RZSN_{-1}$$
$$\underset{(6.4)}{-1.30536}((POWA-LE)/POWA) \ \underset{(3.2)}{+0.23781}$$

$\bar{R}^2 = 0.999$ SE = 0.016 1963Q4 - 1981 Q4

Where:

KNCS = Stock of notes and coin in circulation (£mn)

C£ = Total consumers' expenditure (£mn)

RZSN = Net rate of interest on building society shares (%)

POWA = Population of working age excluding those in full time education (000's)

LE = Employees in employment (UK)

A 2% point cut in the net building society share rate will immediatel increase the stock of notes and coin by 1.1% and after one year the increase is 3.5%. The long-run effect is an increase of 3.55%. The equation for the stock of M1 is also negatively influenced by a short interest rate. The equation is:

$$\ln KM1 = \underset{(26.7)}{0.85467}\ln KM1_{-1} + \underset{(4.8)}{0.14461}\ln EF_{-1} + \underset{(5.9)}{0.13936}\ln PEF_{-1} \ \underset{(6.7)}{-0.00549}RL$$

$\bar{R}^2 = 1.0$ SE = 0.016 DW = 1.9

Where

KM1 = Stock of M1 (£mn)

EF = Total final expenditure (80£mn)

PEF = Price deflator for total final expenditure (1980=1)

RLA = Local authority three month rate (%)

A 2% cut in the local authority rate will immediately increase the stock of M1 by 1.1% and after one year the increase is 3.5%. The lo run effect is an increase of 7.5%.

overall, however, the effects of monetary growth in the model are largely concentrated on the effects of £M3 on the exchange rate.

(f) Exchange rate

The exchange rate is determined by equations which estimate the pressure on the exchange rate and then allocate the pressure between a change in reserves and a change in the sterling/dollar rate. The pressure on the exchange rate is largely determined by the relative real monetary growth in the US and the UK together with the covered differential between local authority and eurodollar rates. The equation is:

$$
\begin{aligned}
PERK = {} & 0.0596 \left[\frac{EE\$ - E\$EQ}{E\$EQ}\right]_{-1} 100 \\
& + 0.2384 \left[\Delta \frac{M2US}{M2US_{-1}} - \frac{DCES + R\$E_{-1}/E\$EQ_{-1}}{KM\pounds S_{-1}}\right] 100 \\
& + 0.894 \ \Delta(RLAE - RFDE - REUE) \\
& + 0.0596 \left[\frac{BAL - \sum_{i=0}^{7} 0.8^{i}\, BAL_{-i} / \sum_{i=0}^{7} 0.8^{i}}{\sum_{i=0}^{7} 0.8^{i}\, GDP\pounds_{-i} / \sum_{i=0}^{7} 0.8^{i}}\right] 100 \\
& + 0.2384 \left[\frac{\Delta PCUS}{PCUS_{-1}} - \frac{\Delta PC}{PC_{-1}}\right] 100 + 0.596\, DE\$E_{-1} + 2.35
\end{aligned}
$$

Where:

PERK = Pressure on the £/$ exchange rate (%)
EE$ = Equilibrium $/£ exchange rate ($/£)
E$EQ = $/£ exchange rate (end-quarter)
M2US = US money supply (M2, quarterly average, stock)(US$ bn)
DCES = Sterling domestic credit expansion(£ mn)
R$E = Expected change in reserves (US$mn)
KM£S = Stock of sterling M3 (£mn)
RLAE = Local authority 3-month rate (end quarter)(% pa)
RFDE = Forward discount rate on sterling (end quarter) (%)
REUE = Three-month eurodollar rate (end-quarter)(% pa)
BAL = Current balance of payments (£mn)
GDP£ = Gross domestic product (expenditure estimate)(£mn)
PCUS = US consumer price index (1980=100)
DE$E = Expected change in $/£ exchange rate (%)

$$EE\$ = 28 \frac{M2US}{KM£S} \left[\frac{\sum_{i=0}^{7} 0.8^i EF£_{-i} / \sum_{i=0}^{7} 0.8^i}{\sum_{i=0}^{7} 0.8^i EFVS_{-i} / \sum_{i=0}^{7} 0.8^i} \right]$$

Where

EF£ = Total final expenditure (£mn)

EFUS = US final expenditure (US$bn)

Although the temporary direct interest rate effect appears to be more powerful than the relative money growth effect, the influence of the level of money stocks on the equilibrium exchange rate ensures that changes in the relative rates of monetary growth are more important. Note however, that these equations and the equation which allocates the pressure between a change in reserves and the exchange rate are not estimated. Rather they reflect the modellers' views on the relative importance of these effects and the general failure of attempts to estimate satisfactory equations.

NATIONAL INSTITUTE MODEL 7 (November 1984)

The current version of this model contains few direct interest rate effects, with housing investment the only activity variable which is directly influenced. However, as with the Bank model, there are a number of secondary effects.

(a) Non-residential investment

Non-residential investment is disaggregated into 3 categories:

1 Manufacturing industry
2 Distribution and services
3 The rest of industry

There are no direct interest rate effects, but manufacturing investment does depend on the real cash flow of the non-oil company sector.

The real cash flow is defined as gross trading profits less taxes paid and stock appreciation, all deflated by a fixed investment deflator. However, taxes paid depend on a series of lags, of the rate of corporation tax times gross profits minus the appropriate allowances for investment in plant machinery and vehicles, building investment, stock appreciation and the change in stocks. So there is no facility for interest rates to influence the cash flow of companies and hence investment.

(b) Residential investment

The equation for gross investment in private dwellings contains two direct interest rate effects and also a secondary effect through building society liquidity. The equation is:

$$QDKPD = \underset{(1.7)}{141.5} + \underset{(7.7)}{0.642}\ QDKPD_{-1}$$

$$- \underset{(4.6)}{15.6}\ [RMORT\ (1 - SRT/100)\ PNH/CPI]_{-1} \quad \text{(Cost of house purchase)}$$

$$+ \underset{(2.2)}{250.7}\ \left[\frac{1 + (\Delta_4\ PNH)/(PNH_{-4})}{1 + 0.01\ RLA}\right] \quad \text{(Relative rate of return)}$$

$$+ \underset{(3.3)}{4.03}\ \left[\frac{DKDEP + GLOAN}{PNH}\right]_{-1} \quad \text{(Real flow of funds to building societies)}$$

OLS; $R^2 = 0.83$ SEE = 59.8 LM(8) = 14.1;
1964 (Q2) - 1983 (Q2)

Where:

QDKPD = Investment, private sector dwellings (80 £mn)
RMORT = Building society mortgage rate (%)
SRT = Standard rate of income tax (%)
PNH = Price of new houses (1980=100)
CPI = Consumer price index (1980=100)
RLA = Interest rate on LA debt (3 month) (%)
DKDEP = Net increase in building society shares (£mn) and deposits
GLOAN = Government loan to building societies (£mn)

The equation represents a demand function for housing which reflects the cost of house purchase, the return available from other assets and the flow of mortgage advances. This equation forms a simultaneous sub-system with the equation for the price of new houses, but unlike the Bank model, house prices are not directly influenced by interest rates.* When calculating the magnitude of single equation interest rate effects, the other determinants in the equation (apart from any lags of the dependent variable) are usually held constant and hence the simultaneity between housing investment and house prices can be ignored. However, the simultaneity does mean that the overall system properties may differ from the single equation effects.

*The change in house prices is determined by a lagged dependent variable, the change in an exogenous index of building costs and the deviation of housing investment from trend.

The cost of house purchase reflects both the post-tax rate of interest on mortgage advances and the relative price of houses. A 2% point cut in the mortgage rate (ie a 1.4% post-tax cut) would increase housing investment by 22 80£mn or 1.25% after a one period lag.

Residential investment is also influenced by a proxy for the relative rate of return on housing compared with other investments. This recognises that households view dwellings as an investment with the prospect of (tax-free) capital gains. A 2% point cut in the interest rate on local authority debt would immediately increase housing investment by around 5 80£mn or 0.28%.

The final direct effect of interest rates on residential investment enters through the equation for the change in building society shares and deposits. The equation is:

$$DKDEP = \underset{(1.8)}{54.1} - \underset{(7.8)}{0.00101}\ [FAPER*RLA*(1 - SRT/100)]$$

$$+ \underset{(1.5)}{0.00043}\ (FAPER*RSHR) + \underset{(3.6)}{0.0971}\ DFAPER + \underset{(17.7)}{0.842}\ DKDEP_{-1}$$

OLS; $R^2 = 0.95$ SEE = 162.4 LM(8) = 15.2;

1963 (Q4) - 1983 (Q2)

Where:

DKDEP = Net increase in building society shares and deposits (£mn)

FAPER = Stock of financial assets, persons (£mn)

RSHR = Building society recommended share and deposit rate (%)

DFAPER = Net acquisition of financial assets, persons (£mn)

Note that interest rates have an influence on persons' net acquisition of financial assets through personal sector net property income. This is a component of the other personal income identity which in turn feeds into the identity for the net acquisition of financial assets.

The equation for the net change in building society liquidity represents portfolio behaviour of the personal sector, with the local authority interest rate giving the yield available on alternative assets. A 2% point cut in both the building society share rate and the local authority rate would increase the net flow of building society shares and deposits by around 120 80 £mn in the same quarter.* The direct stimulus from the cut in interest rates lasts only one quarter, but the lagged dependent variable means that the net flow of shares and deposits will be increased in subsequent quarters, although the magnitude of the increase will decline. An increase of 120 80£mn in the net flow of shares and deposits will increase residential investment by about 4 80 £mn after a lag of one quarter.

The combined effect of the three direct interest rate effects (ignoring the simultaneity with house prices) is to raise residential investment by around 63 80£mn or 3.6% after one year, and 76 80£mn or 4.4% after two years.

(c) Stockbuilding

Stockbuilding is disaggregated into manufacturing, distribution and other, but none of the equations is influenced by interest rates. The long-run solution for manufacturers' stockbuilding has an equilibrium stock/output ratio while distributors' stocks depend positively on output and negatively on consumption. Stockbuilding in the rest of industry is determined solely by lags of output.

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*Both the building society share rate and the local authority interest rate are tied to the Treasury Bill rate and so must move together. Consider a 2% point cut from 11% to 9%. The terms in interest rates then become $-0.000707(9*FAPER-11*FAPER_{-1})$ $+0.00043(9*FAPER-11*FAPER_{-1})$ and summing these we have $-0.000277(9*DFAPER-2*FAPER_{-1})$. Notice that although strictly the effect is base dependent, it is only the term in DFAPER that depends on the level of interest rates. FAPER is roughly 100*DFAPER and so the term in DFAPER is relatively small.

(d) Consumers' expenditure

Consumers' expenditure on non-durables is primarily determined by real personal disposable income. In addition, the change in the real value of personal sector financial assets is included, reflecting a desire to maintain a share of wealth as (relatively liquid) financial assets. If the real value of financial assets falls relative to real incomes, consumers try to restore the value of these financial assets and cut back on consumption expenditure. The equation is:

$$\begin{aligned}
\ln QCND = {} & \underset{(1.6)}{0.585} - \underset{(2.2)}{0.361}\,\Delta\ln QCND_{-1} - \underset{(1.4)}{0.213}\,\Delta\ln QCND_{-2} \\
& + \underset{(4.2)}{0.244}\,\Delta\ln QRDY + \underset{(2.3)}{0.193}\,\Delta\ln QRDY_{-1} + \underset{(0.5)}{0.0393}\,\Delta\ln QRDY_{-2} \\
& + \underset{(1.2)}{0.0692}\,\Delta\ln QRDY_{-3} - \underset{(0.8)}{0.0701}\,\ln(QCND/QRDY)_{-1} \\
& - \underset{(1.6)}{0.0574}\,\ln QCND_{-1} - \underset{(2.7)}{0.00818}\,ILN
\end{aligned}$$

Where:

$ILN = (\Delta_4 \ln CPI)(QFAPER_{-1}/QRDY)$

$QFAPER = 100\ FAPER/CPI$

OLS; $R^2 = 0.43$ SEE = 0.00816 LM(6) = 7.6;

1968 (Q1) - 1984 (Q1)

Where:

QCND = Consumers' expenditure on non-durables (80£mn)

QRDY = Personal disposable income (80£mn).

As was noted in the discussion of the equation for investment on dwellings, interest rates influence persons' stock of financial assets through personal sector net property income which is a component of the change in this stock. The magnitude of the effect is discussed below.

In contrast to the other models, the equation for expenditure on durable goods is not subject to an interest rate effect and depends only on disposable income and the hire-purchase regulations.

(e) Other income/financial assets

Although interest rates do not affect income from rent, they do affect the net property income of the personal, company and public sectors. The equation for the net property income of the personal sector is:

$$
\begin{aligned}
(400\ NPIPER/NWPER) = {} & \underset{(1.8)}{0.548} + \underset{(2.6)}{0.311}\ (400\ NPIPER/NWPER)_{-1} \\
& + \underset{(2.0)}{0.172}\ (400\ NPIPER/NWPER)_{-4} \\
& + \underset{(5.0)}{0.254}\ [(4\ RSHR + RTB + RLA)/6]
\end{aligned}
$$

OLS; $R^2 = 0.81$ SEE = 0.496 LM(8) = 4.8;

1968 (Q2) - 1983 (Q1)

Where:

NPIPER = Dividends and interest income, persons (£mn)

NWPER = Net wealth, persons (£mn)

A 2% point fall in all short interest rates would decrease persons' net property income by about 12.0% of the 1984 Q1 value and this would reduce personal disposable income by about 0.7%, with a consequent reduction in consumption. The long-run responses would be about 23% and 1.35% respectively. The fall in personal disposable income will reduce consumption and tax on persons' income and these will partially offset the fall in persons' net property income when determining persons' net acquisition of financial assets. Nevertheless, the reduction in persons' net acquisition of financial assets will be of the order of 10% and this would reduce the stock of persons' net financial assets by around 0.1% each quarter.

The equations for property income in the company and public sectors are broadly similar although their only role in the model is in determining the net acquisition of financial assets by these sectors.

The other financial effects of interest rates relate to debt interest payments by the public sector, bank lending to the personal sector (other than for house purchase), bank lending to ICCs, the demand for M1 and the stocks of other public sector debt and national savings. These equations identify some of the main financial transactions between sectors of the economy but the feedbacks from the monetary sector to the activity side are limited. The equation for M1 is

$$\ln QM1 = \underset{(3.3)}{0.0282} - \underset{(3.6)}{0.0495} \ln(M1/GDPMP)_{-1} + \underset{(1.8)}{0.232} \Delta \ln QGDPMP_{-1}$$

$$- \underset{(4.0)}{0.00606}\, RLA - \underset{(1.8)}{0.00275} \Delta RLA_{-2} - \underset{(4.3)}{0.00465}\, RLA_{-2}$$

$$QM1 = M1/PMP$$

$R^2 = 0.41$ SEE = 0.0166   LM(4) = 0.96   1964 Q1 - 1982 Q4

Where M1 = Money supply, M1 definition (£mn)
PMP = Deflator, GDP at market prices
GDPMP = Gross domestic product at market prices (£mn)
QGDPMP = GDP (expenditure estimate) at market prices (80£mn)
RLA = Interest rate of local authority debt - 3 month (%)

A 2% point reduction in the local authority rate will immediately increase the stock of M1 by 1.2% and after one year the increase is 3.4%. The long-run effect is an increase of nearly 19%.

The exchange rate

The exchange rate equation is based on a model which determines the real effective rate and recognises the influence of real interest rate differentials, the real value of the balance of goods and services and additional factors such as the real value of North Sea oil reserves (evaluated at dollar export prices). All the variables are deflated by the wholesale price index. In addition, it is argued that the authorities seek to moderate nominal exchange rate movements by manipulating interest rates. This behaviour is given by a reaction function for the domestic interest rate (given expected prices) which is substituted into the real exchange rate equation.

Domestic real interest rates are given by:

$$RRIUK7 = 100 \; \frac{RTB/100 - (\Delta_4 PWMF)/PWMF_{-4}}{1 + RTB/100}$$

Where:

RRIUK7 = UK real interest rate

PWMF = Wholesale price of manufactures (1980 = 100)

The equation for the real exchange rate is:

$$\Delta RRI = \underset{(23.2)}{30.1}\, RID - \underset{(1.1)}{13.4}\, RID_{-1}$$

$$+ \underset{(4.7)}{0.320}\, [BGS - (BGS_{-1} + BGS_{-2})/2] + \underset{(3.0)}{0.00524}\, \Delta VOIL$$

Where:

RRI = real exchange rate

= EFFRAT PWMF/PF6

BGS = real value of the balance of goods and services

= (EX - M)/PWMF

VOIL = real value of oil reserves

= ORES PFEXOILD/PWMF

RID = [RRIUK7 - RRIW7]/100 (real interst rate differential)

Iterative estimation technique;

SEE = 2.55 LM(8) = 6.8;

1972 (Q2) - 1983 (Q1)

Where:

EFFRAT	= Sterling effective exchange rate	(1980=100)
PF6	= World wholesale prices	(1980=100)
EX	= Total exports	(£mn)
M	= Total imports	(£mn)
ORES	= Oil reserves	(£mn)
PFEXOILD	= Deflator, exports of oil (in US $)	(1980=100)
RRIW7	= World real interest rate	(%)

The effect of a cut in real domestic interest rates is to increase the domestic foreign differential and the possibilities of arbitrage. The depreciation this induces will be quantified in the simulation reported in section two.

H M TREASURY MODEL (JUNE 1984)

The Treasury model features direct interest rate effects on non-residential investment, residential investment, stockbuilding, consumers' expenditure on durables and consumers' expenditure on non-durables. Unlike the Bank and National Institute models, both categories of investment and consumers' expenditure are directly influenced. In addition, there are secondary effects, broadly similar to those previously identified in the other models.

(a) Non-residential fixed investment

Non-residential investment is disaggregated by investing sector rather than by asset. The two largest categories are private manufacturing and non-manufacturing, but only private manufacturing investment is subject to an interest rate effect.

The equation is:

$$\begin{aligned} \ln IMB = {} & \ln IMB_{-4} + 0.5431 + 0.5728\,\Delta_4 \ln YMF + 0.4433\,\Delta_4 \ln YMF_{-5} \\ & - 1.4 \ln (IMB/YMF_{-5})_{-4} - 0.4056\,\Delta_4 \ln (IMB/YMF_{-5})_{-1} \\ & + 0.3017 \sum_{i=1}^{4} \ln (IMB/YMF_{-5})_{-i} - 0.0094\,\Delta_3\, RLONG \\ & + 0\ 6026\,\Delta_4 \ln IMB_{-1} \end{aligned}$$

Where:

IMB = Total private investment in manufacturing

YMF = Manufacturing production index adjusted for stock changes (1980=100)

RLONG = Long-term interest rate (% pa)

The nominal interest rate term is viewed as a component of the cost of capital* and the complex lag structure is a product of the

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* Free estimation of the individual components of the cost of capital showed that the interest rate term was the dominant influence. This specification was preferred as the cost of capital could become negative, causing a log formulation to fail.

error-correction formulation. The immediate effect of a 2% point cut in long interest rates is to raise manufacturing investment by 1.9%. After one year the increase is 3.3%, which represents an increase of approximately 0.8% in total non-residential private investment. After two years the increase has fallen to 2.3% and in the long run, the change in interest rates has no effect.

(b) Residential fixed investment

The equation for private fixed investment in dwellings is:

$$IPRD = 338.1\ KLAPE/PPRD + 15.1$$
$$+0.787\ (IPRD - 338.1\ KLAPE/PPRD - 15.1)_{-1}$$
$$-3.713\ RSHRT_{-1} + \sum_{i=o}^{3} a_i\ (NHP/PC)_{-1}$$
$$a_o = 1257.7 \quad a_1 = -1246.9 \quad a_2 = -1244.14 \quad a_3 = 1268.53$$

where: IPRD = Private gross fixed investment in dwellings (80£mn)
KLAPE = Capital grants: local authorities to persons (£mn)
PPRD = Deflator for private investment in dwellings
RSHRT = Short-term interest rate (% pa)
NHP = New house prices (average)
PC = Consumers' expenditure deflator (1980 = 100)

The equation is demand determined and considers real investment in dwellings after local authority grants have been deducted ie real investment in dwellings financed by the private sector. The short-term interest rate reflects the cost of borrowing to finance house purchase and a 2% point cut will raise real investment in dwellings by 7.5 80£mn or 0.45% after a lag of one quarter. After one year the increase is 1.1% and after two years 1.75%. The long-run steady state effect is to raise real investment in dwellings by 2.2%.

Interest rates also have an indirect effect on housing investment through house prices. The equation for house prices is:

$$NHP/PC = -0.2707 + 0.811\ (NHP/PC)_{-1} + 0.937\ \Delta(NHP/PC)_{-1}$$
$$+ 0.4523\ \Delta(NHP/PC)_{-2} + 0.0000681\ RYPDY + 0.1083514\ ADVR$$

Where:

RYPDY = Real personal disposable income (80£mn)

ADVR = Ratio of building society advances to earnings

Building society advances are given by the change in the stock of mortgages outstanding plus repayments of principal. The equations are:

$$RPRIN/MORTS_{-1} = -0.2093 + 0.2256\ MORTS/MORTS_{-1} + 0.0109\ MORTS_{-1}/MORTS_{-2} - 0.0007\ RBM_{-1}$$

Where:

RPRIN = Repayments of principal (£mn)

MORTS = Mortgages outstanding (£mn)

RBM = Weighted average interest rate on mortgages (%)

The equation for mortgages outstanding is:

$$\Delta \ln MORTS = \sum_{i=0}^{7} a_i\ \Delta \ln (SHDEP)_{-i} - \sum_{i=2}^{4} b_i\ \Delta \ln (REBM)_{-i} + 0.15\ \Delta \ln YPDY$$

a		a		b	
0	0.2	4	0.05	2	0.031
1	0.36	5	0.02	3	0.006
2	0.18	6	0.01	4	0.048
3	0.09	7	0.01		

Where:

SHDEP = Stock of building society shares and deposits (£mn)

REBM = Effective rate of interest on mortgages (%)

YPDY = Personal disposable income (£mn)

The equation for building society shares and deposits is:

$$SHDEP = PC\ [0.0722\ (SVPE/PC) + \sum_{i=0}^{4} b_i\ (\Delta(RBS/(1-TPBRZ)) - \Delta RSHRT) + 14.045]$$

b		b	
0	1.522	3	1.294
1	1.619	4	0.814
2	1.057		

Where:

PC = Consumers' expenditure deflator (1980=100)

SVPE = Personal savings (£mn)

RBS = Weighted average interest rate on building society shares and deposits (%)

TPBRZ = Basic rate of income tax (%)

RSHRT = Short-term interest rate (%)

As with the Bank model, the overall effect of a change in interest rates on the building society sector is complex and depends on the system dynamics. A fall in interest rates will tend to increase the demand for mortgages and, unless there is a change in the differential between building society and short rates, the flow of shares and deposits will not be changed. Thus, overall, a fall in interest rates is likely to raise the flow of mortgage lending and the ratio of building society advances to earnings. This in turn will raise house prices which feed into the equation for housing investment. A step increase in house prices of 1% will immediately increase housing investment by 0.8%, but after one year, housing investment has been reduced by 0.2%. The long-run effect is to increase housing investment but only by 0.1%.

(c) Stockbuilding

As with fixed investment, stockbuilding is disaggregated between manufacturing and non-manufacturing. There are no interest rate effects on non-manufacturing stockbuilding. Stockbuilding in manufacturing is further disaggregated between work in progress and raw materials, but only work in progress is influenced by interest rates. The equation for manufacturing work in progress is:

$$\Delta \ln SWPB = -0.00061\,(\Delta RSHRT - 100\,[PPIO/PPIO_{-1} - PPIO_{-1}/PPIO_{-2}])$$

$$+ \sum_{i=0}^{3} a_i \ln(381.2\,YMF - \Delta SWPB)_{-i} + 0.0293 \ln(381.2\,YMF - \Delta SWPB)$$

$$+ 0.0776 - 0.0411 \ln SWPB_{-1}$$

a_0 = 0.1048
a_1 = 0.1088
a_2 = 0.0404
a_3 = 0.0984

Where:

SWPB = Manufacturing work in progress (stock)

RSHRT = Short-term interest rate (%)

PPIO = Wholesale price index for domestic sales of manufacturing industry excluding food, drink, tobacco and petroleum products (1980=100)

YMF = Manufacturing production index adjusted for stock changes

A 2% fall in short rates immediately adds about 14 80£mn to the stock level but in the long run has no effect. This reflects an initial increase of 14 80£mn in stockbuilding followed by a series of small reductions.

(d) Consumption of durables

In common with the Bank model, there is a direct interest rate effect on consumption of durables, although its impact is temporary. In addition, interest rates enter the equation indirectly through their influence on net financial wealth. The equation is:

$$\Delta_4 \ln CDURB = -5.2604 + 0.3921 \ln CDURB_{-1} + 1.3613\,\Delta_4 \ln RYPDY$$

$$+ 0.8537 \ln (RYPDY/CDURB)_{-4}$$

$$+ 0.2920\,\Delta_4 \ln (NFIN_{-1}/PC)_{-3} - 0.225\,\Delta_4\,\Delta \ln (PC/NFIN_{-1})$$

$$- 0.004\,(\Delta_4\, RBLPE - \Delta_4\, PEXPP)$$

Where:

CDURB = Consumption of durables (80£mn)
RYPDY = Real personal disposable income (80£mn)
NFIN = Net financial wealth
PC = Consumers' expenditure deflator (1980=100)
RBLPE = Rate on bank lending to persons (%)
PEXPP = Consumer price expectations

The immediate effect of a 2% point cut in the interest rate on bank loans to persons is to raise consumption of durables by 0.8% and after one year consumption of durables rises by 1.3%. Thereafter, the shock to interest rates is removed by the difference term and by the end of the second year, the increase in consumption of durables is only 0.3%.

The identity for net financial wealth contains several terms which are influenced by interest rates. The flow of mortgage lending by building societies is a component of the identity and the effect of interest rates on this was discussed in the section on housing investment. National savings by the non-bank private sector (NATSAV) also enter the identity as does total net acquisitions by persons (NAFPE). These are in turn partly determined by personal savings (SVPE) and interest receipts and payments by persons are components of savings. The personal sector is a net creditor (net interest receipts were about 1.25 £billion in 1984 Q4) and so a fall in interest rates will reduce net interest receipts, and hence saving and net financial wealth.

(e) Consumption of non-durables

In contrast to the Bank and National Institute models, the equation for consumption of non-durables contains a direct interest rate effect. Real net liquid assets enter the equation and so there is also an indirect effect. The equation is:

$$\Delta_4 \ln CND = -0.0687 + \sum_{i=0}^{3} a_i \Delta_4 \ln AY_{-i} - 0.2255 \ln (CND/AY)_{-4}$$
$$+ 0.1429 \Delta \ln (NLQ)_{-1} + 0.1490 \Delta_4 \ln (PC)$$
$$- 0.0388 \Delta_4 \ln (PC)_{-1} - 0.00111 RSHRT_{-1} - 0.00021 RSHRT_{-2}$$
$$+ 0.0446 \ln (NLQ/AY)_{-1}$$

a_0 = 0.3028
a_1 = 0.2160
a_2 = -0.1023
a_3 = 0.0262

Where:

CND = Consumption of non-durables (80£mn)
AY = Inflation adjusted real disposable income (80£mn)
NLQ = Real net liquid assets
PC = Consumers' expenditure deflator (1980=100)
RSHRT = Short-term interest rate (%)

Note that the equation was not freely estimated as when both interest rates and the liquid assets/income ratio (NLQ/AY) were included in the equation, the liquid assets/income ratio became insignificant. This ratio is crucial in establishing long-run proportionality between income and wealth and if it is not present, a step change in interest rates would lead to a permanent change in consumption. The interest rate coefficients were constrained to a smaller magnitude, a restriction which caused the liquidity/income ratio to become significant, although there was little change in the fit of the equation.

A 2% point cut in short rates leads to a 0.25% increase in non-durable consumption after one year, and a 0.45% increase after two years. The indirect interest rate effect enters through the identity for real net liquid assets. This identity relates the change in real net liquid assets to amongst other things the change in bank lending to persons,* the change in the stock of building society shares and deposits and the change in national savings by the non-bank private sector. Bank lending is

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* Note this is subtracted from the identity.

negatively influenced by interest rates while the flow of money to building societies is positively influenced by the difference between building society rates and short rates. National savings are related to savings by persons which has as a determinant net interest receipts by persons. Overall, a cut in interest rates will reduce net interest receipts by persons and increase bank lending. These combine to reduce real net liquid assets and hence consumption. However, the magnitude of this effect depends on the properties of the system as a whole and is not considered here.

(f) Other income/financial effects

Many of these effects have already been illustrated in the discussion of the activity variables. For example, net personal interest receipts influence saving and hence net financial wealth, while bank lending to persons, flows to building societies and national savings are instrumental in determining real net liquid assets.

The Treasury model also contains a system of gross liquidity adjustments to company expenditure, and interest rates play an important role in determining these. The rationale for these adjustments is the need to relate company expenditure decisions to changes in companies' disposable income. The key to the system is an estimated equation for ICCs' gross liquidity and the discrepancy between this equation's prediction for ICCs' liquidity and the liquidity implied by the identity defining the companies' budget constraint. Interest rates have a negative influence on estimated gross liquidity, reflecting the desire for the company sector (which is a net debtor) to reduce costly bank borrowing when interest rates increase.

The discrepancy between the directly estimated gross liquidity and that implied by the budget constraint is then allocated in arbitrary proportions between stockbuilding, dividends, employment, bank lending and implicitly (by not allocating all the discrepancy) to gross liquidity itself. Thus a fall in interest rates would give an increased discrepancy between the two levels of liquidity, and some of this increase would be allocated to increase stockbuilding. In essence, the system recognises that there are omitted liquidity effects in the equations for stockbuilding, bank lending, dividends and employment. However, the discrepancy between the direct estimate of liquidity and that implied by the budget identity may be due to prediction errors anywhere in the model. Hence, although this system of adjustments allows interest rates to influence company liquidity and expenditure, the precise effects are open to distortion by prediction errors elsewhere in the model.

Unlike the Bank and National Institute models where £M3 is constructed from the counterparts, the Treasury model contains an explicit equation for £M3. The equation is:

$$\begin{aligned} \ln(\text{£M3PR/PTFE}) = & -0.4385 + 1.051 \ln(\text{£M3PR/PTFE})_{-1} \\ & -0.179 \ln(\text{£M3PR/PTFE})_{-3} \\ & + \sum_{i=o}^{3} a_i \ln((\text{GROSWPR-CUMREV})/\text{PTFE})_{-i} \\ & + \sum_{i=o}^{3} b_i \ln(\text{GROSWPR}/(\text{GROSWPR-CUMREV}))_{-i} \\ & + \sum_{i=o}^{3} c_i \text{RGRM}_{-i} \\ & + \sum_{i=o}^{3} d_i \ln \text{TFE}_{-i} - 0.0009654(\text{TIME}) \end{aligned}$$

<u>Coefficients</u>

Lag	a	b	c	d
0	0.87	0.290	-0.0035	0.2500
1	-0.89	-0.230	0.0035	-0.2230
2	0.00	0.035	-0.0005	0.0110
3	0.15	0.035	-0.0004	-0.0075

where:
- £M3PR = Sterling money supply (£mn)
- PTFE = Price deflator for total final expenditure
- GROSWPR = Gross financial worth of private sector (£mn)
- CUMREV = Cumulated revaluations in the private non-bank gilts portfolio
- RGRM = Post-tax yield on gilts relative to £M3
- TFE = Total final expenditure (80£mn)

The post-tax relative yield on gilts includes both the interest differential between gilts and £M3 and the expected capital gain on gilts. A cut in the interest rate on £M3 will increase this relative yield, and a 1% point increase in the relative yield will reduce the estimated demand for £M3 by 0.35% immediately. After one year the decrease is 0.5% and after two years 0.65%. The Treasury model also contains explicit equations for M1 (notes and coin plus sight deposits on the banks) and notes and coin held by the non-bank private sector - denoted CASHPR - (the major component of MO). The equation links the demand for M1 to a measure of transactions and to the level of interest rates. A 2% point cut in the short interest rate will increase M1 by 1.2% immediately, 2.4% after one year and 5.4% in the long run. The equation for CASHPR is:

$$\Delta \ln (CASHPR/PC) = -0.177 - 0.398\, \Delta \ln (PMY/PC) + 0.338 \ln (PC_{-1} * PMY/CASHPR_{-1} * PC) - 0.0047 PPBA + \sum_{i=o}^{7} a_i RSHRT_{-i}$$

a_0	=	-0.0021	a_4	=	-0.0006
a_1	=	-0.0012	a_5	=	-0.0007
a_2	=	-0.0007	a_6	=	-0.0008
a_3	=	-0.0005	a_7	=	-0.0006

where: CASHPR = Notes and coin held by non-bank private sector (£mn)

PC = Consumers' expenditure deflator (1980=100)

PMY = Permanent income (£mn)

PPBA = Bank accounts: population ratio

RSHRT = Short-term interest rates (%)

A 2% cut in short interest rates increases MO by 0.4% immediately, 1.75% after one year and 3.8% in the long run. However, as with the Bank and National Institute models, there are limited feedbacks from the monetary aggregates to the activity variables, except through the exchange rate.

Exchange rate

The sterling effective exchange rate is determined by a system of three equations in the Treasury model. These equations are:

$$\ln RX = -0.008 + 0.0025\ \Delta SUD + 1.1\ (CBNSA - BOF + CAPP)/£M3_{-1} + 1.2\ OPEC/£M3_{-1} + \ln RX_{-1} + \Delta \ln RXE$$

Where:

RX = Sterling effective exchange rate
SUD = Short-term uncovered differential (RSHRT - ROSHT)
ROSHT = Trade weighted 3-month overseas interest rates
CBNSA = Current balance (not seasonally adjusted) (£mn)
BOF = Balance for official financing (£mn)
CAPP = Capital flows classified as non-market clearing (£mn)
£M3 = Sterling money supply
OPEC = Net change in OPEC's sterling holdings (£mn)
RXE = Effective exchange rate expected next quarter

$$\Delta \ln RXE = -0.35\ \Delta \ln (M3W/£M3) + 0.15\ \Delta \ln (RX.WCF/RXD.WH) + 0.0009177\ \Delta(EXNST.WPO/UKCP) + 0.006709\ SUD - 0.277 \ln (RX/RXQ)_{-1}$$

Where:

M3W = World wide money index
WCF = Index of unit wage costs of competitors (1980=100)
RXD = Sterling dollar cross rate (RXD/RX = 0.0233)
WH = Trend labour costs per unit of manufacturing output (1980=100)
EXNST = Real value of expected NSO stock
WPO = World price of oil (1980=100, dollar terms)
UKCP = UK competitors' export prices, UK export weighted (1980=100, dollar terms)
RXQ = Expected long-run sustainable exchange rate

$$\ln RXQ = 9.12 - 0.005\ time + 0.013\ SUD + 0.0014\ (EXNST.WPO/UKCP) - 0.7 \ln (£M3/M3W) - 0.3 \ln (RXD.WH/RX.WCF) - 0.3*3.7107$$

Substituting for RXQ and RXE in the equation for RX, we have:

$$\ln RX = 2.13757 - 0.001385\ time + 0.723\ \ln RX_{-1} + 0.009209\ \Delta SUD$$
$$+ 0.003601\ SUD_{-1} + 1.1\ (CBNSA - BOF + CAPP)/£M3_{-1}$$
$$+ 1.2\ OPEC/£M3_{-1} + 0.0009177\ (EXNST.WPO/UKCP)$$
$$+ 0.0003871\ (EXNST.WPO/UKCP)_{-1} - 0.35\ \ln(£M3/M3W)$$
$$- 0.1939\ \ln(£M3/M3W)_{-1} + 0.15\ \ln(RX.WCF/RXD.WH)$$
$$+ 0.0831\ \ln(RX.WCF/RXD.WH)$$

(Note that RX/RXD = 42.918)

SUD is the uncovered differential between UK short interest rates and a trade weighted 3-month overseas rate. A 1% point increase in this differential would give an immediate 0.9% appreciation in the effective rate. The long-run steady state effect (coming from the term SUD_{-1}) is to induce a 1.3% appreciation.

LBS MODEL (November 1984)

The overall structure of the activity side of the LBS model is similar to those in the models already considered. The major difference is the addition of a structural model of the financial sector which considers sectoral supplies and demands of financial assets. In addition, the expectations of prices used within the asset demand equations of the financial sector are determined rationally. Although the financial sector does not influence the single equation properties of the activity equations, the system properties of the model as a whole are conditioned by the financial sector and its relationship with the rest of the model. Consequently, the description of interest rate effects on single activity equations reveals rather less about the overall model properties than in the other models.

(a) Non-residential fixed investment

In common with the Bank and National Institute models, there is no interest rate effect on non-residential fixed investment. The equation for personal sector non-residential investment in current prices is substantially influenced by the base rate, but this equation only allocates total private investment between the personal and company sectors. A 2% point fall in the base rate increases personal sector non-residential investment by 27% after one year but only at the expense of company sector non-residential investment. There is no direct effect on private sector non-residential investment and hence no direct effect on GDP.

(b) Residential fixed investment

Interest rates influence private sector housing investment via their influence on the number of private sector housing starts. The equation for housing starts is:

$$\begin{aligned}\ln HSP = {} & \underset{(5.8)}{0.4396} \ln HSP_{-1} + \underset{(7.2)}{0.2329} \ln RPDI_{-1} \\ & + \underset{(1.1)}{0.5651}\, \Delta \ln (PNH/PGDP)_{-1} - \underset{(7.5)}{0.04864}\, RLB_{-1} - \underset{(0.05)}{0.001796}\, Q1 \\ & + \underset{(7.9)}{0.3045}\, Q2 + \underset{(2.1)}{0.07477}\, Q3 + \underset{(3.4)}{0.2884}\, DV15 - \underset{(3.9)}{0.4662}\, DV4\end{aligned}$$

$R^2 = 0.845$ SE = 0.1158 DW = 1.87 LM(5) = 5.2

FORE(8) = 17.1* 1960 Q1 - 1980 Q4

Where:

HSP = UK private dwelling starts (000s)

RPDI = Real disposable income (80£mn)

PNH = Real price of new houses (1980=1)

PGDP = Price of GDP at factor cost (1980=1)

RLB = Clearing banks' base rate (%)

The equation is supply orientated with relative prices indicating the profit potential and the base rate reflecting the cost of borrowing to finance construction. A 2% point cut in base rates increases the number of starts by 9.7% after one period and after one year the increase is 15.8%. The number of starts feeds into the equation for private sector housing investment which is:

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* LM(5) is a Lagrange Multiplier test for up to fifth order autocorrelation and FORE(8) is a chi-squared parameter stability test for up to eight periods.

$$\ln IHP = \ln IHP_{-1} - \underset{(1.35)}{0.16502}\ \Delta\ln IHP_{-1} + \underset{(3.55)}{0.1398}\ \Delta\ln HSP$$
$$- \underset{(2.65)}{0.1074}\ \ln (IHP/HSP)_{-1} + \underset{(2.62)}{0.3494}$$

$R^2 = 0.219$ SE = 0.0657 DW = 2.02 LM(5) = 6.8

FORE(8) = 3.4 1966 Q1 - 1980 Q4

Where:

IHP = Private sector residential gross domestic capital formation (80£mn)

A 1% increase in housing starts immediately increases housing investment by 0.14%. After one year the increase is 0.35% and after two years 0.55%. However a 2% point cut in base rates induces an increase in housing starts rather larger than 1%. If the increases in housing starts are entered into the equation for housing investment the effect of the 2% point cut in base rates is to increase housing investment by 1.36% after a lag of one quarter. At the end of the first year the increase is 3.9% and after two years it is 8.1%.

(c) Stockbuilding

Stockbuilding in the model is given by the differences implied by the equations for stock levels. The levels of both manufacturing and distributive stocks are directly influenced by interest rates.

The equation for manufacturing stocks is:

$$\ln KIIM = \underset{(19.9)}{1.6935}\ \ln KIIM_{-1} - \underset{(9.0)}{0.7361}\ \ln KIIM_{-2} + \underset{(2.3)}{0.03759}\ \ln MAND1$$
$$- \underset{(2.0)}{0.0008921}\ RLB_{-1} + \underset{(1.0)}{0.08639} - \underset{(3.1)}{0.02451}\ DV7401$$
$$+ \underset{(4.7)}{0.03798}\ DV7402$$

$R^2 = 0.997$ SE = 0.00782 DW = 1.99 LM(5) = 4.71

FORE(8) = 11.8 1960 Q1 - 1980 Q4

Where:

$MAND1 = 109.665\ RETS_{-1} + 87.0275\ XMAN_{-1}$

RETS = Retail sales volume (1980=100)

XMAN = Export volume: manufactures (1980=100)

KIIM = Stock level manufacturing (80£mn)

DV7401(02) = 1 in 1974 Q1 (Q2)

After one quarter, a 2% point cut in base rates increases the stock level by 0.18%, and after one year by 0.86%. This reflects increases in manufacturers' stockbuilding of 265 80£mn in the first year and 520 80 £mn in the second year. The equation for the level of distributive stocks has a similar specification and after one period, the stock level rises by 0.2%. After one year, the increase is 0.76%. These changes reflect increases in distributors' stockbuilding of 125 80£mn in the first year and 200 80£mn in the second year.

(d) Consumers' expenditure

Consumption is modelled as total consumption and durables consumption, with non-durables consumption given by the difference between total and durables consumption. Both total and durables consumption are subject to interest rate effects and hence implicitly non-durable consumption is also directly influenced by interest rates. The equation for total consumption is:

$$\begin{aligned}\ln C = {} & \ln C_{-1} - \underset{(1.4)}{0.17101} + \underset{(4.2)}{0.29178} \ln (RPDI/C)_{-1} + \underset{(3.1)}{0.18237} \Delta \ln RPDI \\ & - \underset{(1.2)}{0.13701} \Delta \ln PC - \underset{(4.4)}{0.024621} \ln RSLA \\ & + \underset{(1.7)}{0.024948} * \ln ((0.99\ W_{-1} + KIHP£_{-1})/PC_{-1}) + \underset{(2.5)}{0.0213}\ DV6801 \\ & + \underset{(4.2)}{0.03598}\ DV6802 + \underset{(4.1)}{0.02356}\ \Delta DV7301 + \underset{(4.5)}{0.02772}\ \Delta DV7902\end{aligned}$$

$R^2 = 0.7217$ SE = 0.00809 DW = 1.9545 LM(5) = 8.0
FORE(8) = 5.7 1967 Q1 - 1980 Q4

Where:

C = Consumers' expenditure (80£mn)

PC = Price of private consumption (1980=100)

RSLA = Local authority deposit rate (%)

W = Persons' wealth (£mn)

KIHP£ = Stock of residential housing (£mn)

Wealth is determined by the financial sector of the model and is considered below, although it will clearly be influenced by interest rates. A 2% cut (not a 2% point cut) in local authority interest rates increases total consumption expenditure by 0.05% immediately. After one year, the increase is 0.125% and after two years 0.16%. Thus a 2% point cut in local authority rates from 10% to 8% (ie a 20% cut) would increase total consumption by about 0.5% immediately. After one year, the increase would be approximately 1.25% and after two years 1.6%.

The equation for durables consumption is:

$$\ln CD = \ln(RPDI) - \underset{(6.15)}{3.5700} + \underset{(4.44)}{0.3731} \ln (CD/RPDI)_{-1}$$

$$+ \underset{(4.91)}{0.2467} \ln CD_{-3} - \underset{(3.21)}{0.00603} \Delta RMD$$

$$- \underset{(1.75)}{0.00330} \Delta RMD_{-1} + \underset{(2.77)}{1.4334} \Delta \ln(AB/PC)_{-1}$$

$$+ \underset{(2.07)}{0.3373} \Delta \ln(-AL/PC) - \underset{(3.34)}{0.5380} \Delta_2 \ln(1+RRI/100)$$

$$- \underset{(1.43)}{0.2145} \ln(1+RRI_{-3}/100) + \underset{(3.17)}{0.1412} DV6801 - \underset{(5.42)}{0.2453} DV6801_{-1}$$

$$+ \underset{(3.98)}{0.1197} \Delta DV7301 + \underset{(4.33)}{0.1918} \Delta DV7902$$

$R^2 = 0.888$ SE = 0.0421 DW = 1.82 LM(5) = 6.16

FORE(8) = 7.75 1964 Q4 - 1980 Q4

Where:

CD = Durable consumption (80 £mn)

RMD = Minimum deposit rate for durables (%)

AB = Personal sector building society deposits (£mn)

AL = Personal sector, unit and investment trusts bank borrowing (£mn)

RRI = Real rate of interest (%)

$$RRI = RSLA - ((PC/PC_{-2})^2 - 1) * 100$$

A 2% point cut in <u>real</u> rates immediately increases durables consumption by 1.1%. The peak effect is to raise durables consumption by 1.5% in the second quarter and at the end of the first year the increase is about 0.9%. Thereafter the increase is approximately 1.1%. Note that it is the local authority deposit rate which enters both the consumption equations and that a 2% point cut produces an increase in total consumption of 1.25% after one year with an increase in durables consumption of 0.9% after the same period. This implies that non-durable consumption increases by slightly more than 1.25% in this period.

(e) The financial sector of the LBS model*

The financial sector is a structural model of sectoral supplies and demands of financial assets. Nine sectors are identified, each of which chooses among up to 15 assets and the asset prices are endogenously determined. Each sector faces a budget constraint determined by its own income and expenditure decisions and by asset revaluations. The income and expenditure decisions are exogenous to the financial sector and so for example, there is no provision for changes within the financial sector to influence the level of consumers' expenditure from a given level of real income.

Agents are assumed to maximise a simple objective function which considers the expected return on the portfolio, risk aversion times the 'variance' of the portfolio and the cost of changing the portfolio. The demand for each asset is a function of the difference between its own return and an average return and also the budget constraint. The return on the ith asset R(i) is a function of its nominal interest rate, expected capital gain, tax rates and the previous holdings of the asset adjusted for any price changes. The adjusted return on the ith asset is given by:

$$R(i) = I(i)*t + D(i)*tg + k(i) + h(i)*A(i,-1)*P(i)/P(i, -1)$$

Where:

I(i) = Nominal interest rate on ith asset
D(i) = Expected capital gain on ith asset
P(i) = Price of ith asset
A(i, -1) = Lag of asset demand
k(i),h(i)= Parameters
t, tg = One minus income and capital gains tax rates respectively

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* A detailed exposition of this sector of the model is given in Keating, G (1984), "The financial sector of the LBS model", LBS discussion paper no 115.

For flexible price assets* the prices are generated as market clearing 'jump' variables ie they move immediately to the market clearing level in response to news. The expected capital gain is given by the one period ahead expected increase in asset price and this expectation is model consistent.** Consistent expectations allow future events to influence current expectations and hence current variables which are partially determined by these expectations. Consequently it is important to determine whether an interest rate shock is temporary or permanent as this will influence the expected asset prices. If the shock is only temporary, agents will perceive this through their consistent expectations. Since the expected asset prices reflect their anticipation of a return to the pre-shock level of interest rates, their response to the shock will be attenuated.

As with the Bank, National Institute and Treasury models, short-run interest rates are all related to the exogenous base rate by simple technical relationships. Long-term interest rates are determined by the price of gilts while the effective exchange rate is determined by the inverse of the price of overseas assets. These prices are market clearing and hence depend on all the individual sectors' asset demands and the returns on these assets. For example, a change in the differential between domestic and foreign interest rates alters the relative returns and hence the prices of various assets. A relative increase in domestic interest rates will make overseas assets less attractive and so demand for these assets will fall. This will induce a fall in the price of overseas assets. Since the exchange rate is given by the inverse of the price of overseas assets, the relative increase in domestic interest rates will induce an exchange rate appreciation.

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* The three flexible price assets are equities, gilts and overseas assets.

** Model consistent expectations require that the expectations of economic agents' be consistent with the models used to explain the agents' behaviour. Accordingly, expectations of the future are determined by the model solution values in the future. For example, agents' expectations now, of inflation next quarter, are equal to next quarters' model solution for inflation. This requires an additional iterative solution process for the expectations.

LIVERPOOL UNIVERSITY MODEL (AUTUMN 1984)

The discussion of the four models so far has revealed considerable differences in the magnitudes of interest rate effects therein, but in addition it has demonstrated that with the exception of the LBS financial sector, the overall structures and theoretical underpinnings of the models are similar. However, the structure of the Liverpool model is very different.

The Liverpool model is a new classical or equilibrium model which incorporates rational expectations and the efficient markets hypothesis, and the model is monetarist in character. The model's basic structure can be related to only seven stylised equations - the demand and supply of goods, the demand and supply of money, the change in wealth, a Fisher identity defining nominal interest rates and the efficient market hypothesis which links domestic and foreign real rates and the real exchange rate. The supply side is explicitly modelled and in the long run, the model converges on the equilibrium or natural rate of unemployment. In contrast to the other models, the Liverpool model is based on annual data.

The GDP 'identity' is constructed as:

$$Y = C + g + 0.586g_{-1} + eg + xvol - afc$$

Where:

C = non-durable consumption (£80mn)
g = stock of goods (£80mn)
eg = government spending (£80mn)
xvol= trade balance excluding terms of trade effects (£80mn)
afc = adjustment to factor costs (£80mn)

Non-durable consumption is directly affected by interest rates and there is an indirect influence through total private sector wealth. The equation for non-durable consumption is:

$$\ln C = - 0.0598 + 0.38 \ln W + 0.18\, QEXP - 0.20\, r_L + 0.57 \ln C_{-1}$$

Where:

W = Total private sector wealth (£80mn)
QEXP = E(y/y*) = expected output deviation from equilibrium output
r_L = Real long-run interest rate

A 2% point cut in the real long rate will increase non-durables consumption by 0.4% in the first year and 0.63% after two years. Total wealth is defined as goods (g) plus financial assets (θ), and the stock of goods demanded (including fixed capital, consumer durables and inventories) is determined by a portfolio balance equation. This reflects the role of goods as a way of holding wealth rather than as a productive instrument. The adjustment of the stock of goods provides the impetus for private investment, inventory and durables expenditure. The equation for g is:

$$\ln g/\Theta = 10.914 - 1.04\, r_L - 1.2 \ln W + 0.066\, t + 0.46 \ln(g/\Theta)_{-1}$$

Financial assets (Θ) are split into money (m) and bonds with the bond market eliminated by Walras' Law. The equation for money demand is:

$$\ln MO/P = -2.915 + 0.1137*\ln B + 0.1878*TE + 0.332*TY - 0.542*R_S - 0.017*TIME + 0.635*\ln RDY + 0.598*\ln MO/P_{-1}$$

Where MO = Stock of MO

B = Real unemployment benefits

TE = Employment taxes

TY = Income taxes

RDY = Real disposable income.

Thus real interest rates influence non-durable consumption and all categories of 'goods' directly, and also indirectly through the effect of interest rates on the components of wealth. In a single equation context, a 2% point cut in the real long rate will increase the stock of goods by 2% in the first year and 3% after two years. Note that an increase in the stock of goods will simultaneously increase wealth, although there will also be valuation effects on financial assets which may offset this. An overall increase in wealth will tend to moderate the increase in the stock of goods. A 2% point decrease in the nominal short rate will increase the demand for money by 1.1% in the first year and 1.7% after two years.

Nominal interest rates are given by the Fisher identities:

$$R_L = r_L + PEXPLR$$
$$R_S = r_S + PEX_P$$

Where:

$$pEXP = E(\Delta \ln P_{+1})$$

$$pEXPLR = E\left[\sum_{i=1}^{5} \Delta \ln P_{+i}\right]/5$$

Real interest rates are given by the efficient markets hypothesis:

$$r_L = r_{LUS} + (RXR - ERXRL)/5$$
$$r_S = r_{SUS} + RXR - ERXR$$

Where:

r_{LUS}, r_{SUS} = long, short foreign real interest rate
RXR = real exchange rate (log deviation from 1975=100)
ERXR = $E(RXR)_{+1}$
ERXRL = $E(RXR)_{+5}$

The real exchange rate is principally determined by the real wage and other labour and supply side factors. The rate of inflation is given as the rate of growth of the money supply less the rate of growth of the demand for real money balances, with the underlying rate of growth of the money supply obtained from the long run PSBR/GDP ratio. The overall model structure ensures that the economy has an equilibrium path from which discretionary government policy can achieve only temporary deviations, with rapid crowding out of any stimulus.

SUMMARY

The particular equations in any model reflect both the theoretical structure of the model and the parameters (either estimated or imposed) that are embodied in it. Thus differences between the models under review derive from different general theoretical approaches as well as from empirical differences.

The Bank, National Institute and Treasury models are fairly similar in their structure. The components of aggregate demand are modelled in some detail and interest rates affect various of them. Interest rates also affect the exchange rate and hence the trade balance. Financial aggregates are influenced by interest rates but they do not themselves have a strong direct impact on activity.

The activity side of the LBS model is also similar, but the distinguishing characteristic of this model is the integrated financial sector. Within this sector, certain asset returns are modelled as jump variables which immediately move to the market clearing level in response to news. Expectations are determined rationally and so the change in interest rates must be specified as permanent or temporary. This is particularly important for the exchange rate as the simulations reported in section two demonstrate.

The Liverpool model is based on a fundamentally different new classical or equilibrium approach, with markets always clearing. This means that the properties of individual equations are dominated by the overall model properties which force the economy to the equilibrium path even in response to discretionary policy.

In comparing the estimated effects on specific areas of activity, it is important to recognise the difficulties in making exact comparisons. Although the bulk of the data will have come from the same raw sources, there are often considerable differences in the definition of apparently similar variables, in particular with respect to the degree and type of aggregation. For example, stockbuilding is typically disaggregated into several categories and there are often differences in the precise definitions used. Nevertheless, although exact comparisons are not possible, the relative magnitudes of the effects can be assessed.

Of the five models considered, only the Treasury includes direct interest rate effects on non-residential fixed investment, although implicitly, some of the change in the stock of 'goods' in the Liverpool model will represent such investment.*

In the Treasury model, total private manufacturing investment is influenced by a proxy for long-term interest rates with a 2% point cut boosting this category of investment by 1.9% immediately, 3.3% after one year and 2.3% after two years. However in the long run the change in interest rates has no effect. Total private manufacturing investment is approximately a quarter of total private non-residential investment and so after one year, the 2% point cut in long rates would increase total private non-residential investment by 0.8%. Note that although total personal non-residential investment in the LBS model is not influenced by interest rates, the split between persons and companies is sensitive to interest rates.

The area of activity which the models agree is most sensitive to interest rates is residential investment, although differences in definition preclude an exact comparison across models. As was outlined in the discussion, interest rates can influence housing investment in a number of ways. The effects through house prices and building society liquidity are rather complicated and depend on the dynamics of this complete sector in the models. However, short-term interest rates also affect housing investment directly, reflecting the cost of borrowing for house purchase or the cost of borrowing by builders to finance construction. A 2% cut in short rates boosts housing investment in the Bank model by 3% immediately and the long-run steady state increase is 10%. The data definition is rather different in the National Institute and Treasury models and so the percentage changes are not comparable. In the National Institute model a 2% point cut in

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* This argument also applies to residential investment, stockbuilding and consumers' expenditure on durables.

short rates increases housing investment by 1.95% (after a lag of one quarter) and the long-run steady state increase is 4.3%. The corresponding figures for the Treasury model are 0.45% and 2.15% respectively. Interest rates also affect housing investment in the LBS model although they do so indirectly by influencing the number of housing starts. Here a 2% point cut in base rates increases housing investment by 1.36% after a lag of one quarter and the long-run steady rate increase is 17.3%.

The equations for stockbuilding are one of the most difficult areas to compare directly due to the different categories used. However, a 2% point reduction in short rates increases total stockbuilding in the Bank model by about 38 £80mn in both the first year and second years. In the Treasury model a similar cut in interest rates increases stockbuilding by about 12 £80mn in the first year but thereafter the effects are negligible. The effect in the LBS model is much greater with an increase of nearly 400 £80mn in the first year and 720 £80mn in the second year.

Consumers' expenditure on durables is directly influenced by short-term real interest rates in all the models except the National Institute. A 2% point cut in the Bank model produces an increase of 1.5% after one year and 1.9% after two years. In the Treasury model the increase after one year is 1.3% but after two years it is only 0.3%. The effect in the LBS model is again similar with an increase of 0.9% after one year and 1.1% after two years. Interest rates also influence consumption of both durable and non-durables through holdings of net liquid assets and the yield curve may play an important role here.

Although the Treasury and LBS models allow real net liquid assets to influence non-durable consumption, they also feature a direct interest rate effect. Given the importance of non-durable consumption as a determinant of aggregate income, even small percentage changes have a significant effect on GDP. A 2% point cut in short rates in the Treasury model gives an increase in consumers' expenditure on non-durables of 0.25% after one year and 0.45% after two years. After allowing for the aggregation of expenditure on durables and non-durables in the LBS model, the effect is rather larger with an increase of over 1.25% after one year. In contrast there are no direct effects in either the Bank or National Institute models.

Comparison of the interest rate effects on the financial sectors of the models is much harder, reflecting the considerable differences in the structure of the models in this area. The financial variables which are influenced are largely common to all the models with the emphasis on the monetary aggregates and most importantly the exchange rate. All of the models allow the differential between domestic and foreign interest rates to influence the exchange rate, although the magnitude of the effects can only properly be assessed by simulation.

The discussion of the single equation properties has revealed specific areas of activity where interest rates have potentially important effects, although there is considerable disagreement between the models on the size of the effects. For example, consumption of non-durables is directly influenced by interest rates in both the Treasury and LBS models but the Bank and National Institute models have no such direct effects.

We now consider the effects of a 2% point reduction in interest rates on the complete model. This allows us to assess the importance to the economy as a whole of the changes to specific areas of activity and demonstrates how these effects combine. The simulations also demonstrate the way in which interactions between sectors of the economy can modify the properties of the single equations.

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SECTION II: INTEREST RATE SIMULATIONS

Introduction

Having analysed the single equation or intra-sector interest rate effects, we now consider the impact of interest rates on overall model properties by means of a series of interest rate simulations. This is an essential step in understanding how interest rates influence the complete models as only by examining simulations can the interactions between different sectors of the model be illustrated.

Where possible, we relate the simulation properties to those identified in the single equation analysis. However, where there are simultaneities in the model or where the effects depend on the interactions between several sectors or equations, it is not possible to attribute a simulation property to a particular effect in a single equation. It is usually possible to identify the direction of such effects but they cannot be quantified.

The simulations we examine were all run by the modellers themselves. Apart from the constraints necessary to fix the exchange rate, the results were supplied without any modification to the model's output, although the simulations typically assume constant government expenditure volume, indexation of all taxes and benefits and (in the case of the Treasury) a balancing of the National Insurance Fund.

It should be emphasised that the simulations are entirely mechanistic and that there is much more to policy evaluation in the context of a macroeconomic model than unchallenged acceptance of the simulation results. There are undoubtedly aspects of the models' behaviour in which the modellers have little confidence, and they will often exogenise areas of models or augment the existing behaviour with the 'judgemental' use of residuals or off-model rules. For example, account is likely to be taken of changes in expectations that might be affected by interest rate changes but which are not modelled explicitly. The purpose of the simulations then, is to illustrate the properties of the model. They do not necessarily represent the modellers' best view of what would happen were interest rates to change.

The simulations we consider are, with the exception of the Liverpool model,* for changes in domestic nominal short interest rates. Given the changes in nominal rates, the models then determine the change in real interest rates as the difference between the changes to nominal rates and the resulting changes in the price level. For example, in the Treasury model with the exchange rate free, a 2% point reduction in nominal short interest rates induces a rise in prices of 1.4% by the end of the second year. Allowing for the increase in the price level of 0.34% in the first year, this implies a reduction in real short rates of about 3.05%. A number of the single equation effects identified in the previous section related to real interest rates and so when analysing the simulation results, the change in both nominal and real interest rates should be considered.

The simulations were run with the term structure equation which calculates the change in nominal long interest rates switched on, and so given the change in short rates, the models determine the associated change in long interest rates. Long interest rates and the differential between long and short interest rates have important effects on activity - especially in the Bank and Liverpool models. In addition, as we discuss below, the change in the differential between short and long rates is an indicator as to whether the change in interest rates is perceived to be temporary or permanent.

Although such a distinction does not influence the Bank, National Institute or Treasury models in their present form, the simulations assume that agents have no prior knowledge that a change in interest rates is about to occur. Where model consistent expectations are present, agents' expectations of the future influence their current actions. Hence if it was announced that interest rates would be cut, and it was known

* The nature of the Liverpool simulation is discussed in detail below.

that this would induce an exchange rate depreciation, the announcement would induce arbitrage against the exchange rate which would immediately start to depreciate. However, the simulations on the LBS and Liverpool models assume the shock is unannounced; it is a surprise to agents and so there is no prior reaction.

One of the features of the simulations with the exchange rate free is the difference between the size of the exchange rate depreciation induced by the same cut in interest rates. This reflects the general difficulty in modelling the exchange rate experienced by all the model proprietors. In an open economy such as the UK, the exchange rate is an important influence on the rest of the economy and so the size of the depreciation could potentially dominate all the other interest rate effects. Given the difficulties in modelling the exchange rate, it is worthwhile comparing the model properties when the exchange rate is fixed. This allows a comparison of model properties in isolation from the 'disagreement' on the effect of interest rates on the exchange rate. However, we stress that the overall model properties considered should be those with the exchange rate free. Note that the simulations with the exchange rate fixed might also be interpreted as resulting from an identical change in domestic and foreign interest rates. However, if the exchange rate is influenced by factors other than interest rates, then an unchanged differential between domestic and foreign interest rates is not a sufficient condition for an unchanged exchange rate.

The simulation results we present relate to a 2% point reduction in domestic short rates, but they can be generalised to either reductions of a different magnitude or increases. The construction of the models we consider ensures that the responses of the models are broadly linear and so we would expect a 2% point cut to produce nearly a mirror image of a 2% point increase. Equally, a 2% point cut should give responses very nearly twice those of a 1% point cut. This property is likely to be local rather than global, and so may not hold for large changes. For example, a 6% point cut is likely to produce responses rather different to 3 times those from a 2% point cut. Nevertheless, for changes in interest rates of either sign that are 2% points or less, the results we present should provide a fairly accurate guide to the model responses.

I Bank of England Model

Tables 2a and 2b present a summary of the simulation results on the Bank model with the exchange rate free and fixed respectively. One of the most striking features of the simulations is the small exchange rate depreciation induced by the cut in domestic short rates. Even after 3 years, a 2% point reduction in short rates gives less than 0.5% depreciation in the effective exchange rate. Apart from a small improvement in the current balance of trade, this has an extremely limited effect on the simulation results and so the analysis below considers only the exchange rate free simulation.

GDP and Employment

The overall effect of the cut in short interest rates is to increase GDP by 0.14% or 72 80£ mn at the end of the first year. By the end of the second year, GDP has increased by only 0.06% relative to base, and, at the end of the third year, GDP is lower than base. The effect on unemployment is similarly modest with a maximum reduction of 24,000 at the end of the second year.

Investment

Although total fixed investment increases by around 1%, this is almost entirely due to the increase in residential investment of about 9%. For example, at the end of the second year total fixed investment has increased by 120 80£ mn, of which 110 80£ mn is increased residential investment.*

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* The increase in residential investment is close to that suggested by the direct effect in the single equation analysis. The maximum increase in house prices during the simulation is 3.5% at the end of the second year and so this indirect effect will have limited impact.

TABLE 2a

BANK OF ENGLAND MODEL: 2% point cut in domestic nominal short rates - exchange rate free

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.14	0.06	- 0.08
Employment	(000s b)	21	33	21
Unemployment	(000s b)	-16	-24	-15
Total consumption	(80% b)	- 0.09	- 0.40	- 0.70
Total fixed investment	(80% b)	0.84	1.08	0.98
Residential investment	(80% b)	7.55	9.22	9.10
Total stockbuilding	(80A £mn)	115	103	-46
Exports of goods and services	(80% b)	0.02	0.05	0.05
Imports of goods and services	(80% b)	0.20	- 0.20	- 0.52
Effective exchange rate	(% b)	- 0.16	- 0.29	- 0.55
Consumer prices	(% b)	0.04	0.21	0.47
Real personal disposable income	(80% b)	- 0.39	- 0.30	- 0.34
PSBR	(A £mn)	-732	-970	-833
Debt interest payments	(A £mn)	-440	-577	-733
Bank lending to private sector	(A £mn)	539	597	224
Current balance of payments	(A £mn)	207	446	943
Stock of £M3	(% b)	0.18	0.80	1.31
Stock of notes and coin in circulation	(% b)	2.63	2.68	2.57
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.57	- 0.57	- 0.54

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

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TABLE 2b

BANK OF ENGLAND MODEL: 2% point cut in domestic nominal short rates - exchange rate fixed

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.14	0.04	- 0.12
Employment	(000s b)	20	30	15
Unemployment	(000s b)	-15	-22	-11
Total consumption	(80% b)	- 0.08	- 0.38	- 0.67
Total fixed investment	(80% b)	0.84	1.07	0.97
Residential investment	(80% b)	7.55	9.24	9.13
Total stockbuilding	(80A £mn)	120	110	-45
Exports of goods and services	(80% b)	0.00	0.00	- 0.02
Imports of goods and services	(80% b)	0.24	- 0.13	- 0.42
Effective exchange rate	(% b)	Fixed	Fixed	Fixed
Consumer prices	(% b)	0.02	0.15	0.32
Real personal disposable income	(80% b)	- 0.37	- 0.29	- 0.33
PSBR	(A £mn)	-718	-935	-759
Debt interest payments	(A £mn)	-439	-574	-728
Bank lending to private sector	(A £mn)	540	602	225
Current balance of payments	(A £mn)	195	391	846
Stock of £M3	(% b)	0.26	0.90	1.38
Stock of notes and coin in circulation	(% b)	2.62	2.62	2.44
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.57	- 0.58	- 0.56

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

Stockbuilding

The changes in stockbuilding are due to a combination of several different effects. Firstly, there are the direct interest rate effects which the single equation analysis suggested would add about 37 80£mn in each of the first two years in response to a 2% point cut in real short interest rates. Note that in the simulation, real interest rates fall by slightly more than 2% points due to the increase in prices and so the direct effect would be slightly larger. There are also indirect effects through the proxy for ICC's net liquidity, which, by the end of the second year of the simulation has increased by some 400 £mn. This increase is largely due to higher bank deposits and will tend to raise stockbuilding.

Stockbuilding is also positively influenced by the level of manufacturing production and in the case of distributors' stocks, the level of consumption. Although consumption is lower than base throughout the simulation, manufacturing production is above base until the middle of the second year. The various effects combine to raise stockbuilding above base in the first and second years but in the third year, the effects of the lower consumption and manufacturing production outweigh the positive effects from interest rates and liquidity and so total stockbuilding is below base.

Trade and Balance of Payments

The effects of the interest rate cut on exports and imports are limited, even when the exchange rate is free. In either case, competitiveness is practically unchanged and so the only effect comes through the influences of demand components - housing investment, stockbuilding and consumption - on the demand for manufactured goods which is allocated between imports and domestic supply. The immediate increase in housing investment is gradually offset by falling consumption and (less importantly) lower stockbuilding and hence real imports of goods and services rise and then fall.

The visible trade balance is reduced by 100 £mn in the first year, although by the third year, the activity influences on imports increase the balance by 400 £mn. Throughout the simulation, the balance on interest profit and dividend payments is increased by over 300 £mn. Overall, the current balance of payments is increased by 200 £mn in the first year and 950 £mn in the third year.

Consumers' expenditure

By the end of the third year of the simulation, GDP is below base, and this is due to the fall in total consumption which outweighs the fall in imports and increase in fixed investment. Although the cut in interest rates increases consumers' expenditure on durables, there are substantial negative influences from persons' holdings of net liquid assets, the flow of mortgage advances by building societies and real personal disposable income.

The equation for persons' holdings of net liquid assets depends on the shape of the yield curve and although nominal short interest rates have been cut by 2% points, nominal long interest rates fall by only 0.6% points and so the differential between nominal long and short rates is increased by 1.4% points.* This induces a large shift out of net liquid assets and by the end of the third year, persons' stock of net liquid assets is over 8 £billion (in current prices) lower than base, representing a fall of just over 5%. This has a powerful effect on consumers' expenditure on non-durables.**

The portfolio reallocation also affects building society inflows which are down by about 750 £mn each quarter throughout the second and third years of the simulation. The reduction in inflows

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* Note that the change in the differential is approximately maintained throughout the simulation.

** The elasticity of real net liquidity in the static long-run solution of the equation for CND is 0.42, whilst that on inflation adjusted disposable income is 0.58. However, consumers' expenditure on non-durables is slow to adjust and so in the length of simulation reported here, the response is substantially less.

reduces both building society liquidity and mortgage lending which is down by about 450 £mn per quarter in the latter part of the simulation. The long-run static solution of the equation for expenditure on durables has an elasticity with respect to the flow of real mortgage advances of 0.3, and even after only three quarters, the elasticity is 0.215. At 1984 Q1 levels, the flow of real mortgage advances was about 60% of consumers' expenditure on durables. This implies that after three quarters about 35% of the change in real mortgage lending feeds into consumers' expenditure on durables. The fall in consumption due to the tilt in the yield curve rather dominates interest rate effects on the other activity variables and so, for the purposes of comparison, the appendix presents simulations on the Bank model when both long and short rates are reduced by 2% points.

In addition to the yield curve effects, both categories of consumption are reduced by the fall in real personal disposable income (adjusted for inflation losses on liquid assets). Real personal disposable income is down by around 0.3%, largely due to the fall in persons' income from dividends and net interest of about 200 £mn per quarter. The various effects on consumption combine to reduce total consumers' expenditure by 270 80£ mn after three years, of which 42% is the fall in consumers' expenditure on durables.

PSBR and £M3

The PSBR is reduced throughout the simulation with much of the reduction due to lower debt interest payments. In the first two years of the simulation when GDP is above base, there is an increase in tax receipts from income tax and national insurance contributions which also reduce the PSBR.

The reduction in the PSBR is split almost equally between long and short debt. The reduction in short debt is split between sales by persons and other financial institutions (including building societies) but the reduction in gilts is the difference between sales of gilts by other financial institutions (reflecting their loss of liquidity) and increased purchases of gilts by the personal sector (reflecting the tilt in the yield curve). Bank lending to the private sector increases, reflecting the lower cost of borrowing, and bank deposits (to persons) fall due to the shift out of liquid assets. These contribute to a modest rise in the stock of £M3, although the impact of this on the exchange rate is clearly limited.

II National Institute Model

The simulation results from the National Institute model with the exchange rate free and fixed are summarised in Tables 3a and 3b respectively. Unlike the Bank of England model, the cut in domestic short rates has a considerable effect on the effective exchange rate and so it is appropriate to examine both exchange rate scenarios in detail. We first consider the simulation with the exchange rate free.

(a) Exchange rate free

Effective exchange rate, trade and balance of payments

The cut in the domestic nominal short rates induces an immediate depreciation in the effective rate which by the end of the first year is 2.8% below base. The depreciation continues throughout the simulation period reinforced by the increase in prices which lowers real interest rates further. The increase in export prices is smaller than the depreciation in the effective exchange rate and so the volume of exports increases and is 3% above base by the end of the third year. Although import prices in foreign currency terms fall, the magnitude of the exchange rate depreciation is such that import prices in sterling increase. This is partially offset by the increase in GDP which will tend to increase imports, but throughout the first three years, imports are below base by about 0.6%.

Despite these changes in trade volumes, the current balance of payments deteriorates by 365 £mn in the first year and nearly 2.2 £bn in the third year. Net property income of the overseas sector (determined as the residual of property incomes) increases by 400 £mn in the first year and nearly 1.7 £bn in the third year. This is caused by the substantial reduction in persons'

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TABLE 3a

NATIONAL INSTITUTE MODEL: 2% point cut in domestic nominal short rates - exchange rate free

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.07	0.27	0.67
Employment	(000s b)	6	22	61
Unemployment	(000s b)	- 5	-21	-58
Total consumption	(80% b)	- 0.57	- 0.90	- 1.28
Total fixed investment	(80% b)	0.49	0.48	0.63
Residential investment	(80% b)	3.32	4.38	4.96
Total stockbuilding	(80A £mn)	74	205	353
Exports of goods and services	(80% b)	0.32	1.26	2.94
Imports of goods and services	(80% b)	- 0.52	- 0.64	- 0.58
Effective exchange rate	(% b)	- 2.76	- 7.22	-14.48
Consumer prices	(% b)	0.34	1.20	3.15
Real personal disposable income	(80% b)	- 1.05	- 1.55	- 2.04
PSBR	(A £mn)	108	56	397
Debt interest payments	(A £mn)	-476	-309	+955
Bank lending to private sector	(A £mn)	877	3,769	5,824
Current balance of payments	(A £mn)	-365	-1,211	-2,194
Stock of £M3	(% b)	1.67	5.86	10.30
Stock of notes and coin in circulation	(% b)	- 0.44	- 0.77	- 1.12
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.78	- 0.81	- 0.81

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

net property income due to the direct interest rate effect and the smaller increases in company sector and public sector net property income. In addition, after modest increases in the first and second years, the current visible balance of trade is 560 £mn below base in the third year. This is due to the relative increases in import and export prices which outweigh the effects of changes in trade volumes. The sustained exchange rate depreciation means that import prices adjust faster than volumes throughout the simulation,* and by the third year this outweighs both the price and volume increases on exports.

GDP and employment

The overall effect of the cut in domestic short interest rates is to raise GDP by 0.07% or 40 80£ mn at the end of the first year. The boost to GDP continues throughout the simulation and, by the end of the third year, GDP is 0.67% or 372 80£ mn above base. The effect on unemployment reflects this increase in GDP, with a fall of 5,000 after one year and 58,000 after three years.

Investment and stockbuilding

Total fixed investment increases by around 0.5% throughout the simulation period but, as with the Bank of England model, this is almost entirely due to the increase in residential investment. After one year, residential investment is up by 3.3%, and after three years it has increased by nearly 5%.

The analysis of the single equation properties demonstrated that housing investment is affected by interest rates both directly and indirectly through building society inflows and new house prices. New house prices are increased by 2% by the end of the third year but the flow of building societies' shares and deposits has fallen by about 250 £mn. These effects work in opposite directions, illustrating the complexity of interest rate effects

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* The increase in GDP will tend to increase import volumes and this will partially offset volume adjustments due to price increases.

in this area. However, the size of the increase in housing investment is consistent with those single equation properties which it was possible to quantify. The increases in stockbuilding are entirely a reflection of the changes in activity as there are no interest rate effects in this area of the model.

Consumers' expenditure

As with the Bank of England model, consumers' expenditure is reduced by the cut in interest rates, although the mechanism through which the effect operates is rather different. There are no direct interest rate effects on either category of consumers' expenditure but interest rates affect consumption through their influence on real personal disposable income.* At the end of the first year, real personal disposable income is 1.05% below base and by the end of the third year it is 2.04% below base.

By the second year of the simulation much of the fall is due to the increase in prices and indeed in the third year of the simulation, nominal disposable income increases. In the first year of the simulation real personal disposable income falls by 1.05% although prices rise by 0.34%. This is due to the influence of interest rates on persons' net property income. Even in the first year of the simulation this is down by nearly 18%. By the end of the third year, persons' net property income is nearly 24% below base but this is now offset by an increase in income from employment (due to higher activity and prices) of 2.1%, and this ensures that nominal disposable income is above base.

In a single equation context, a 1% cut in real personal disposable income would reduce consumers' expenditure on non-durables by 0.42% after four quarters, while the same cut would reduce

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* The equation for consumers' expenditure on non-durables is also influenced by the change in the value of real financial assets relative to real incomes. Interest rates affect persons' acquisition of financial assets through their influence on persons' net property income.

consumers' expenditure on durables by 1.45% in this period. In the simulation, consumers' expenditure on non-durables has fallen by 1.04% (353 80£ mn) at the end of the third year, while expenditure on durables has fallen by 3.16% (137 80£ mn). This reflects the relative sensitivities to the change in real personal disposable income.

PSBR and £M3

Although debt interest falls* and public sector net property income increases, the overall effect of the interest rate cut is to increase the PSBR. The fall in personal sector net property income lowers tax receipts from persons and the rise in the price level increases current grants from government and public authorities' consumption. In addition, public sector investment increases and the combined effect is to raise the PSBR by 100 £mn in the first year and 400 £mn in the third year.

Bank lending to the private sector increases, and in the third year it is nearly 6 £billion above base. This is largely responsible for the growth of £M3 which is over 10% above base by the end of the third year. However, there are no feedbacks from £M3 to activity.

(b) Exchange rate fixed

The absence of the substantial depreciation in the effective exchange rate reveals that there are few other direct interest rate effects in the National Institute model. On the activity side, the only direct effect is on residential investment which is increased by very nearly the same amount as before.

In the absence of the depreciation, exports are practically unchanged, although imports still fall due to the shift in the composition of demand from consumption to investment. The

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* By the third year of the simulation, the depreciation in the effective exchange rate increases debt interest payments.

TABLE 3b

NATIONAL INSTITUTE MODEL: 2% point cut in domestic nominal short rates - exchange rate fixed

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.00	- 0.04	- 0.04
Employment	(000s b)	1	0	- 1
Unemployment	(000s b)	- 1	0	1
Total consumption	(80% b)	- 0.47	- 0.62	- 0.66
Total fixed investment	(80% b)	0.50	0.46	0.51
Residential investment	(80% b)	3.31	4.31	4.65
Total stockbuilding	(80A £mn)	36	46	4
Exports of goods and services	(80% b)	0.00	0.00	0.02
Imports of goods and services	(80% b)	- 0.50	- 0.71	- 0.75
Effective exchange rate	(% b)	Fixed	Fixed	Fixed
Consumer prices	(% b)	0.00	- 0.10	- 0.20
Real personal disposable income	(80% b)	- 0.88	- 1.11	- 1.12
PSBR	(A £mn)	- 45	- 348	-543
Debt interest payments	(A £mn)	-656	-1,232	-1,627
Bank lending to private sector	(A £mn)	636	3,042	4,116
Current balance of payments	(A £mn)	- 55	- 484	- 725
Stock of £M3	(% b)	1.30	4.54	7.06
Stock of notes and coin in circulation	(% b)	- 0.38	- 0.55	- 0.62
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.78	- 0.81	- 0.81

80% b = percentage differences from base variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

compositional change gives a small rise in stockbuilding but this is rather smaller than in the previous case, reflecting the almost unchanged level of GDP in this simulation. Consumption again falls due to the influence of real personal disposable income, but the effect is smaller, with real personal disposable income down by 1.1% after three years. The fall in persons' net property income is again over 20% but, in this simulation, income from employment is 0.35% below base (due to the absence of the effects from higher activity and prices). However, prices fall by 0.2% in contrast to the 3% increase when the exchange rate is free, and so real personal disposable income falls less. The fall in the price level reflects the absence of imported inflation and the much smaller decrease in unemployment which reduces pressure from wages.

The deterioration in the balance of payments is reduced and in the third year it is 725 £mn down on base. In this case, the current visible balance of trade remains above base throughout the simulation reflecting the lower import volumes and the absence of any substantial movement in import or export prices given the fixed exchange rate. However, the overseas sectors' net property income increases by a similar amount as before and so overall, the balance of payments still deteriorates.

Once again, debt interest payments initially fall, but the fall in the price level ensures that government expenditure does not increase and so the overall effect is to reduce the PSBR by 45 £million in the first year. The absence of the exchange rate depreciation ensures that debt interest payments remain below base and so in the third year, the PSBR falls by 543 £mn.

III H M Treasury Model

The simulation results for the Treasury model with the exchange rate free and fixed are summarised in Tables 4a and 4b respectively. Once again, the cut in domestic short rates induces an exchange rate depreciation and so we examine the different exchange rate scenarios separately. We first consider the simulation with the exchange rate free.

(a) Exchange rate free

Effective exchange rate, trade and balance of payments

The cut in domestic short rates induces an immediate depreciation in the effective rate which, by the end of the first year, is 4.4% below base. The depreciation increases slightly throughout the simulation, and, by the end of the third year, the effective rate is 5.9% below base. The depreciation boosts exports which are 1.1% above base by the end of the second year. Imports are also increased throughout the simulation reflecting the larger elasticity with respect to activity than competitiveness.

Despite an increase in the balance on interest, profit and dividends, the current balance of payments deteriorates by nearly 700 £mn in the first year due to the deterioration in the visible trade balance. In the first two years of the simulation, import volumes increase by slightly more than export volumes, but more importantly the relative increases in import and export prices mean that the current visible balance of trade is 800 £mn below base in the first year. By the third year of the simulation the current visible balance of trade is 1,098 £mn below base and although the balance on interest, profit and dividends in 354 £mn above base and the balance on services is nearly 600 £mn above base, overall the current balance of payments is 258 £mn below base.

GDP and employment

The overall effect of the cut in domestic short interest rates is to raise GDP by 0.7% at the end of the first year. At the end of

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TABLE 4a

HM TREASURY MODEL: 2% point cut in domestic nominal short rates - exchange rate free

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.70	1.21	1.04
Employment	(000s b)	94	203	203
Unemployment	(000s b)	-62	-133	-133
Total consumption	(80% b)	0.40	0.79	0.85
Total fixed investment	(80% b)	1.19	1.96	1.30
Residential investment	(80% b)	3.31	3.52	1.13
Total stockbuilding	(80A £mn)	545	776	693
Exports of goods and services	(80% b)	0.59	1.14	1.12
Imports of goods and services	(80% b)	0.85	1.37	0.74
Effective exchange rate	(% b)	- 4.40	- 5.03	- 5.94
Consumer prices	(% b)	0.34	1.39	2.70
Real personal disposable income	(80% b)	0.07	0.72	1.04
PSBR	(A £mn)	- 286	- 886	-1,639
Debt interest payments	(A £mn)	- 496	- 555	- 533
Bank lending to private sector	(A £mn)	2,240	2,891	2,667
Current balance of payments	(A £mn)	- 687	- 576	- 258
Stock of £M3	(% b)	2.12	2.13	1.89
Stock of M0	(% b)	1.87	4.29	6.34
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.59	- 0.44	- 0.35

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

the second year, GDP is 1.2% above base, but this is the peak increase and, by the end of the third year, it is 1.0% above base. Unemployment falls by 62,000 at the end of the first year and the peak effect is a fall of 145,000 after 2 1/2 years. At the end of the third year the decrease is 133,000.

Investment

Unlike the Bank and National Institute models, non-residential fixed investment is directly influenced by long-term interest rates, although the effect is only on one particular category - private manufacturing. At the end of the first year, private manufacturing investment is up 2.9%, while the increases for the end of the second and third years are 3.8% and 3.0% respectively. Since the yield curve relationship gives a fall in long-term interest rates of 0.6%, this increase is rather larger than might be suggested by the single equation properties. The larger increase is due to the rise in manufacturing output which induces an accelerator effect.

Private residential investment is also directly increased by the cut in interest rates with increases after one, two and three years of 3.3%, 3.5% and 1.2% respectively. The effect of these increases and the increases in private manufacturing investment is to increase total fixed investment by 1.2% after one year. The increases for the second and third years are 2.0% and 1.3% respectively.

Stockbuilding

The changes in stockbuilding are due to a combination of three different effects. Firstly, there is a modest direct interest rate effect on stocks of work in progress in manufacturing. More importantly, there is also a general effect on all categories of stockbuilding which respond to increases in GDP and, in some cases, the increases in consumption. The final effect comes from the system of gross liquidity adjustments on company expenditure which allocates some of ICCs' increased liquidity to stockbuilding. However, this effect is difficult to quantify as the increase in liquidity may be due to changes anywhere in the model.

Consumers' expenditure

Consumers' expenditure represents about 40% of GDP and so the direct and indirect interest rate effects on consumption in the Treasury model explain much of the larger increase in GDP relative to the Bank and National Institute models. Both categories of consumers' expenditure are directly influenced by the fall in interest rates. In a single equation context, a 2% point cut in nominal short rates increases consumers' expenditure on durables by 1.3% after one year, but 0.3% after two years. The effect on non-durables expenditure is smaller but more sustained, with an increase of 0.25% after one year rising to 0.5% at the end of the second year. Note that both categories of consumption are influenced by real interest rates and given the rise in prices due to the exchange rate depreciation in the simulation, the fall in real interest rates is rather greater than 2% points. Hence the direct effects of interest rates on consumption will be larger in the later period of the simulation.

Real personal disposable income is also an important determinant of consumption,* and in a single equation context a 1% increase raises consumers' expenditure on durables by 2.2% after one year and 1.9% after two years. The corresponding increases for expenditure on non-durables are 0.4% and 0.5%. Unlike either the Bank or National Institute models, real personal disposable income increases during the simulation, and by the end of the second year, it is 0.7% above base. Here the increase in employment together with higher activity and prices outweigh the personal sectors' loss of interest receipts.

The increase in real personal disposable income reinforces the direct interest rate effects on consumption and the overall effect

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* Inflation adjusted real personal disposable income determines non-durables' expenditure.

is to raise total consumers' expenditure by 0.4% after one year and 0.8% after two years. This accounts for over 45% of the increase in GDP in the Treasury model.

PSBR and £M3

The PSBR is reduced throughout the simulation with a reduction in debt interest payments of about 500 £mn contributing to this. In the second and third years, the increased activity gives higher tax receipts and by the third year, the PSBR is down by over 1.6 £bn. The growth in £M3 reflects the growth of GDP.

(b) Exchange rate fixed

The absence of the exchange rate depreciation reduces the overall effect on GDP, although it increases by 0.45% at the end of the first year and 0.9% at the end of the second year. In the absence of the change in competitiveness, exports are practically unchanged but the increase in activity still boosts imports. The increase in consumption is rather larger, reflecting the fall in the price level which gives a larger increase in real personal disposable income although this will be offset by the smaller reduction in real interest rates which becomes more important in the latter part of the simulation. The smaller increases in stockbuilding and investment reflect the lower increase in activity.

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TABLE 4b

HM TREASURY MODEL: 2% point cut in domestic nominal short rates - exchange rate fixed

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.45	0.87	0.78
Employment	(000s b)	58	142	150
Unemployment	(000s b)	-38	- 93	- 99
Total consumption	(80% b)	0.61	1.11	1.20
Total fixed investment	(80% b)	1.07	1.68	1.25
Residential investment	(80% b)	3.64	3.96	1.70
Total stockbuilding	(80A £mn)	332	564	595
Exports of goods and services	(80% b)	0.05	0.11	0.11
Imports of goods and services	(80% b)	1.11	1.97	1.38
Effective exchange rate	(% b)	Fixed	Fixed	Fixed
Consumer prices	(% b)	- 0.60	- 0.69	- 0.57
Real personal disposable income	(80% b)	0.40	0.84	0.98
PSBR	(A £mn)	- 248	- 551	- 930
Debt interest payments	(A £mn)	- 568	- 670	- 755
Bank lending to private sector	(A £mn)	1,132	1,936	716
Current balance of payments	(A £mn)	- 290	- 791	- 937
Stock of £M3	(% b)	0.85	1.36	0.94
Stock of M0	(% b)	1.34	2.74	3.49
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 0.61	- 0.59	- 0.58

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

IV London Business School Model

As we discussed in Section I, the LBS model differs from the Bank, National Institute and Treasury models in that it has a structural model of the financial sector which considers sectoral supplies and demands of financial assets. For flexible price assets, the prices are determined rationally as market clearing 'jump' variables, which move immediately to market clearing levels in response to 'news'. Consequently, it is important to determine whether the interest rate cut (ie the news) is perceived by agents to be permanent or temporary. If the shock is perceived only to be temporary, the response to the shock will be attenuated as agents anticipate the post-shock environment.*

The simulations we report for the floating exchange rate scenario each consider the effects of a 2% point reduction in domestic short rates which lasts for two years only. The distinction between a permanent or temporary shock is achieved by varying the length of time over which the simulation is run. The shortest period is two years, which matches the length of the shock. Hence agents are unable to anticipate the post-shock environment and so view the shock as permanent. We also consider five and ten year solution periods wherein agents perceive the shock to be temporary.

The use of consistent expectations means that the length of the solution period is important, even where both simulations are perceived to have temporary shocks. In the ten-year solution period, agents anticipate a longer post-shock period than with the five-year solution. This tends to dilute the impact of the shock relative to that in the five-year solution. In practice the differences between the five and ten-year simulations are not great which suggests that the discounted impact on the early part of the simulation of extending the end date beyond five years is small.

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* In effect, they anticipate the effect of a future increase in interest rates on asset prices. The three price varying assets are equities, gilts and overseas assets.

The effective exchange rate in the LBS model is determined as the inverse of the price of overseas assets and so the exchange rate is a jump variable which depends on all the individual sectors' asset demands. It is only possible to exogenise the exchange rate in the LBS model at the expense of creating huge behavioural inconsistencies between asset demands and supplies in all sectors. As in the real world, at least one independent policy instrument must be changed if the exchange rate is to remain on its own base-run path following the fall in interest rates. The model proprietors have therefore carried out a simulation in which the monetary authorities sell foreign reserves to prevent a short-run fall in the exchange rate. Choosing another policy instrument (eg changing tax rates) would produce different simulation results. The calculation of the precise pattern of intervention required has been made using optimal control techniques developed at the LBS. Asset price expectations were assumed to be formed consistently during the simulations. A working paper giving more details is available from the LBS.

(a) Exchange rate free

Table 5a presents a summary of the three simulations with the exchange rate free. In assessing the third year results for the simulations with temporary shocks, it is important to recognise that the shock has been removed and the model is now reacting to an increase in interest rates. The simulations are fundamentally different to those on the other models, and it would be completely erroneous to compare the third year results from the LBS model with those from the other models.

Effective exchange rate and trade

The simulations are dominated by the depreciation in the effective exchange rate which is nearly 15% when the interest rate shock is perceived to be permanent. Where the shock is perceived to be temporary, the effect on the exchange rate is rather less, although the depreciation is still 8.4% in the first year of the five-year solution, and 7.9% in the ten-year solution. This illustrates the importance of specifying a permanent or temporary shock.

TABLE 5a

LBS MODEL: 2% point cut in domestic nominal short rates lasting for two years - exchange rate free

		End of Year 1 (1)	End of Year 1 (2)	End of Year 1 (3)	End of Year 2 (1)	End of Year 2 (2)	End of Year 2 (3)	End of Year 3* (2)	End of Year 3* (3)
GDP	(80%)	1.18	0.98	0.94	1.50	1.07	1.05	0.06	0.04
Employment	(000s)	160	115	113	295	192	189	139	135
Total consumption	(80%)	0.54	0.74	0.72	0.54	0.93	0.93	0.07	0.10
Total fixed investment	(80%)	0.25	0.45	0.42	0.67	0.97	0.98	0.56	0.57
Residential investment	(80%)	3.46	3.47	3.47	6.45	6.50	6.50	5.01	5.02
Total stockbuilding	(80£bn)	0.22	0.21	0.21	0.26	0.25	0.25	0.00	0.00
Exports	(80%)	1.94	1.33	1.17	2.55	1.23	1.17	0.31	0.26
Imports	(80%)	0.57	1.10	1.02	0.71	1.56	1.59	0.62	0.67
Effective exchange rate	(80%)	-14.37	- 8.40	- 7.95	-14.90	- 5.07	- 4.77	- 2.90	- 2.73
Consumer prices	(%)	2.22	1.28	1.32	4.98	2.64	2.62	3.78	3.70
Real personal disposable income	(80%)	- 0.70	- 0.45	- 0.48	- 0.24	- 0.08	- 0.06	0.36	0.37
PSBR	(£bn)	- 3.60	- 2.24	- 2.15	- 2.32	- 0.94	- 0.86	- 0.98	- 0.90
Current balance	(£bn)	- 2.02	- 1.60	- 1.68	- 2.97	- 3.15	- 3.13	- 4.01	- 4.08
Stock of £M3	(%)	0.40	- 0.34	0.35	1.48	0.08	0.71	- 0.49	0.09
Nominal short interest rates	(%pts)	- 2.00	- 2.00	- 2.00	- 2.00	- 2.00	- 2.00	0.00	0.00
Nominal long interest rates	(%pts)	0.05	0.06	0.07	0.32	0.19	0.19	0.11	0.11

(1) Permanent shock - 2-year solution period
(2) Temporary shock - 5-year solution period
(3) Temporary shock - 10-year solution period

80% = percentage differences from base (variables in 1980 prices)
% = percentage differences from base
80 £bn = £ billion 1980 prices, difference from base
£bn = £ billion current prices, difference from base
%pts = percentage points
000s = absolute differences (thousands) from base

* Clearly, the two-year shock to interest rates cannot be permanent after the second year.

The fall in the level of the exchange rate relative to base is less in the second or third year of the temporary simulations implying a steady appreciation following the impact depreciation. The rate of appreciation is approximately two per cent in the third year - the same as the cut in interest rates.

The increases in exports reflect the jumps in competitiveness, while the increases in imports are due to the relative sizes of the elasticities with respect to competitiveness and the level of activity.

GDP and employment

The overall effect of the temporary shocks is to raise GDP by around 1% in both the first and second year. The effect of the permanent shock is larger with an increase 1.2% in the first year and 1.5% in the second. The increases in employment reflect these changes in GDP with the temporary shock giving increases of about 115,000 and 190,000 in the first and second years, while the permanent shock gives increases of 160,000 and 295,000.

Investment and stockbuilding

Interest rates have a direct effect on the number of housing starts which is the major determinant of private sector residential investment. After one year, residential investment is up by about 3.5% in each of the simulations and, after two years, by 6.5%. The increases in residential investment combine with the increased activity to raise total fixed investment. Note that although the increase in GDP is larger when the shock is permanent, the increase in total investment is smaller which suggests there has been a shift in the share of profits away from the company sector. The increase in stockbuilding reflects both the direct interest rate effects on manufacturing and distributive stocks and the increased level of activity.

TABLE 5a

Consumers' expenditure

Consumers' expenditure on durables and total consumers' expenditure are both subject to direct interest rate effects. The single equation analysis suggests a 2% point cut in domestic rates would increase total consumption by 1.25% after one year and durables consumption by 0.9%. There is also a further boost from the wealth term in the total consumption equation as the falling short-term rates increase the price of financial assets such as equities and gilts* and hence increase wealth.

These increases are offset by the falls in real personal disposable income which are largely due to the effect of the exchange rate depreciation on domestic prices. The larger depreciation in the permanent simulation induces a bigger rise in domestic prices and hence a larger fall in real personal disposable income. This accounts for the smaller increase in consumption with the permanent interest rate shock. By the end of the second year of the simulations, the falls in real personal disposable income are rather less, reflecting the positive effects of higher employment and prices on income from employment and wage rates. These outweigh the effects of the larger increase in prices.

The financial sector of the LBS model

The falls in the PSBR are rather larger than in the other models and to an extent, this reflects the effect of the larger exchange rate depreciations on North Sea oil revenues, and the increases in non North Sea tax receipts due to the increases in activity. However, there is also an element of base dependency as North Sea oil and tax revenues were peaking during the LBS simulation base. This illustrates the potential hazards of comparing simulation results other than in terms of percentage changes.

An interesting result from the financial sector is the apparently perverse effect that the cut in domestic short rates induces an increase in domestic long rates. However, agents are assumed to

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* The effects of the interest rate cut on the financial sector are discussed below.

consider the total return on assets which consists of both the coupon and the expected capital gain or loss, and the total return is lower in the simulation.

In the first quarter of the ten-year simulation, gilt prices rise by about 1.25% in response to a fall in the long rate. As the interest rate shock is known to be temporary, agents expect that future gilts prices will return to the previous level and hence they anticipate a capital loss. After two quarters, the yield on gilts is marginally above base, but this is offset by a gilts price which remains above base, although it gradually declines to its original level. Hence, although the coupon is above base, the expected capital loss ensures that the total return is below base.

Third-year simulation results

These results are included solely for interest as they are not comparable with those for the third years of other models. Essentially, they demonstrate the speed with which the level of GDP returns to base, although there remain compositional shifts within the almost unchanged total. Note that, despite the increase in consumer prices relative to year two, real personal disposable income is now above base. This reflects the restoration of personal income from dividends and interest to its pre-shock level, together with the lagged effects from the increases in employment and prices.

(b) Exchange rate fixed

Although the absence of the exchange rate depreciation attenuates the increase in GDP, the summary results in Table 5b demonstrate that GDP is increased by 0.7% in the second year of the five-year simulation. The composition of the increase in output has changed somewhat, reflecting both the absence of competitiveness effects on trade and the fall in price level now that the depreciation has been removed.

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TABLE 5b

LBS MODEL: 2% point cut in domestic nominal short rates lasting two years - exchange rate fixed

[Five year solution period]

		End of Year 1	End of Year 2	End of Year 3
GDP	(80%)	0.58	0.72	0.11
Employment	(000s)	43	88	73
Total consumption	(80%)	1.08	1.35	0.31
Total fixed investment	(80%)	0.83	1.39	0.84
Residential investment	(80%)	na	na	na
Total stockbuilding	(80 £bn)	0.19	0.23	0.00
Exports	(80%)	- 0.02	0.13	0.12
Imports	(80%)	1.82	2.52	0.88
Effective exchange rate	(80%)	Fixed	Fixed	Fixed
Consumer prices	(%)	- 0.34	- 0.42	- 0.09
Real personal disposable income	(80%)	- 0.12	- 0.07	0.19
PSBR	(£ bn)	0.46	- 0.29	- 0.54
Current balance	(£ bn)	- 1.04	- 3.96	- 6.90
Stock of £M3	(%)	- 0.17	- 1.11	- 2.63
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	0.04	0.09	0.07
Change in reserves	(£ bn)	- 2.56	- 3.39	- 1.40

80% = percentage differences from base (variables in 1980 prices)
% = percentage differences from base
80 £bn = £ billion 1980 prices, difference from base
£bn = £ billion current prices, difference from base
%pts = percentage points
000s = absolute differences (thousands) from base

In the absence of the depreciation, exports are practically unchanged. However, imports increase by rather more than when the exchange rate was free since the increase in imports is now driven by the increase in domestic activity. The bigger increase in consumption reflects the fall in the price level which tends to increase real personal disposable income, although overall, the reduction in personal interest receipts means that real personal disposable income still falls relative to base in the first two years of the simulation.

The reduction in the PSBR is rather less than before, indeed, the PSBR increases by 460 £million in the first year. Thereafter, it falls by 290 £million and 540 £million in the second and third years respectively, as the absence of the depreciation means there is no substantial increase in North Sea oil and tax revenues. Note that the changes in reserves necessary to maintain an unchanged exchange rate are substantial. Indeed, if the simulation were extended, by the end of the fifth year reserves would be almost zero. This would of course be an unsustainable scenario as such a fall in reserves would be perceived by the foreign exchange markets leading to speculative movements of capital.

V Liverpool University Model

As we discussed in Section I, the theoretical underpinnings of the Liverpool model are very different from those of the other models we consider. This is particularly apparent from the role of interest rates in the Liverpool model where nominal interest rates are determined by Fisher identities and real interest rates are determined by the efficient markets hypothesis.

The efficient markets hypothesis relates domestic real interest rates to foreign real interest rates and the real exchange rate, and forces the differential between domestic and foreign real rates to offset the expected capital gain or loss due to expected movements in the real exchange rate. Given domestic real rates, the Fisher identities force nominal interest rates into consistency by giving the nominal rate as the sum of the real rate plus expected inflation. Since both nominal and real domestic interest rates are thus endogenous, a cut in domestic interest rates has to be engineered by a change in the exogenous determinants of interest rates. The only endogenous determinant is US real interest rates, and so the simulations we report below are based on a reduction in US short real interest rates.

Consider the effects in the Liverpool model of a fall in domestic nominal short rates without for the moment considering how such a change might occur. Unlike the other models, interest rates do not affect the exchange rate directly but instead enter indirectly through the money markets identity and real wages. A fall in domestic nominal short rates increases the demand for MO. The money markets identity ensures that real money demand is equal to the supply of real money balances, and since nominal money balances are fixed, the increase in the demand for MO must induce a fall in the price level. The fall in the price level means that actual inflation is lower than expected, and this will tend to increase real wages.* Real wages have an important positive

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* Note that it is assumed that the cut in US interest rates is not announced ie it is an unanticipated shock. Had the cut been announced prior to the event, agents would have anticipated the lower inflation in the future and so there would no longer be an increase in real wages. However, the fall in the price level would still give an appreciation in the nominal exchange rate.

influence on the real exchange rate and so the effect of the fall in domestic nominal rates is to induce an appreciation. Note that this mechanism does not consider the simultaneties, which arise between real interest rates and the real exchange rate or prices and nominal interest rates due to the endogeneity of nominal and real domestic interest rates.

The endogeneity of real interest rates arises from the equilibrium relationship $rs = rsus + RXR - ERXR$

where rs = domestic short real interest rate
rsus = US short real interest rate
RXR = real exchange rate
ERXR = $E(RXR_{+1})$

Hence, to induce a fall in domestic real interest rates, the exogenous foreign real rate is reduced. The resulting disequilibrium is removed by a combination of a fall in domestic real rates and a real exchange rate appreciation. However, because of the appreciation in the exchange rate when domestic rates fall, it is necessary to cut foreign real rates by more than 1% point to induce a fall of 1% point in domestic real rates.

In an effort to aid comparability with the other model, the results of a 2% point cut in US real short interest rates are scaled to give a 2% point cut in domestic nominal short rates. Thus for example, in the temporary simulation a 2% point reduction in US real short rates initially gives a 1.15% point reduction in domestic real short rates and a 1.00% point reduction in domestic nominal short rates. The simulation changes from base are then multiplied by a scaling factor of 2.0 to give a 2% point reduction in domestic nominal short rates during the first year.

Although the overall result is to induce the same cut in domestic nominal short interest rates as in the other models, the need to shock foreign interest rates and the indirect effect of domestic nominal rates on the exchange rate means that the simulation appears rather different from those on the other models. For example, if the same change in the differential between domestic and foreign interest rates were applied to other models, they would also give an exchange rate appreciation. However, it is important to emphasise that the structural mechanism which induces the appreciation in the Liverpool model is the effect of domestic interest rates on real wages and not the change in the differential between domestic and foreign interest rates.

As with the LBS model, it is necessary to distinguish between a temporary or permanent shock and accordingly we consider two types of simulation, both with the exchange rate free. The methodology underlying the temporary simulation is identical to that used for the LBS model with a cut in US short real interest rates which lasts for two years only, although here the simulation period is twelve years. The permanent simulation is achieved by cutting interest rates in each of the twelve years, and so unlike the LBS model, the permanent and temporary simulation periods are of equal length.

US short and long real interest rates are linked by an off-model term structure specification:

$$rlus = E_t[\sum_{i=1}^{5} rsus_{t+i}]/5$$

where rlus = US long real interest rate
rsus = US short real interest rate
$E_t(rsus_{t+i})$ = expectation at time t of rsus at time t+i

For the permanent shock, this specification implies that the change in rlus is identical to that in rsus since the shock to rsus lasts for longer than five years. However, the temporary shock with rsus 2% points lower for two years only, gives a cut in rlus of 0.8% points in the first year and 0.4% points in the second year. The smaller changes in rlus in turn give smaller decreases in domestic long interest rates. The smaller changes in domestic real long interest rates have important consequences for activity. Table 6A presents a summary of the results for the temporary shock and Table 6B for the permanent shock.

(a) Temporary shock

The nominal exchange rate appreciation of 5.7% in the first year dominates the simulation and induces a deterioration in the nominal trade balance (excluding terms of trade effects) of 3.2 £bn in the first year. Although all the other components of GDP increase, the overall effect is to lower GDP by 0.36%. In the second year of the simulation, the only component of GDP which is above base is non-durable consumption and although the deterioration in the trade balance is reduced, the overall effect is to lower GDP by over 1%.

TABLE 6A: LIVERPOOL UNIVERSITY MODEL - 2% point reduction in domestic nominal short rate - TEMPORARY SHOCK, exchange rate free

Note: Liverpool model is based on annual data

		Year 1	Year 2	Year 3
GDP	(80%)	-0.36	-1.05	-1.01
Unemployment	(000's)	224	362	360
Stock of goods	(80%)	0.05	-0.29	-0.65
Flow of goods	(80%)	1.30	-7.82	-8.16
Consumption (non-durables)	(80%)	0.37	0.16	-0.16
Government expenditure	(80%)	0.99	-0.23	0.06
Effective nominal exchange rate	(%)	5.72	3.66	3.48
Inflation	(% pts)	-0.86	0.30	1.34
Nominal balance of payments*	(£mn)	-3,216	- 516	- 490
Nominal PSBR	(£mn)	+ 144	+ 86	+1,758
Nominal debt interest	(£mn)	-1,078	- 758	+ 672
Demand for MO	(80%)	0.86	0.56	-0.78
Real Income**	(80%)	1.64	0.26	-0.34
Nominal long rate	(% pts)	-0.46	0.00	+0.30
Nominal short rate	(% pts)	-2.00	-1.32	+0.88
Real long rate	(% pts)	-0.72	-0.18	+0.40
Real short rate	(% pts)	-2.30	-2.66	+0.88
Goods	(80%)	0.05	-0.29	-0.65
Financial Assets	(80%)	0.18	-0.44	-0.98
Total private sector wealth	(80%)	0.07	-0.32	-0.70

Scaling factor = 2.0

* Defined as trade balance excluding terms of trade effects.
** Real income is calculated as real wage rate times numbers in employment.

80% = percentage changes from base (variables in 1980 prices)
£mn = absolute differencese from base (£ million)
% = percentage changes from base
% pts = absolute difference in percentage points
000s = absolute differences 000s

Private sector wealth and 'goods'*

Total private sector wealth increases in the first year of the simulation but by only 0.07%. Although both the stock of goods and financial assets increase relative to base, there is a modest portfolio reallocation from goods to financial assets. The increase of 0.05% in the stock of goods reflects an increase of 1.3% in the flow.

In the second year of the simulation total private sector wealth falls by 0.3% relative to base with a similar fall in the stock of goods reflecting a fall in the flow of goods of 7.8%. These decreases partly reflect the increase in the domestic real long interest rate between the first and second years, as in the second year this interest rate is only 0.18% points below base.

Non-durable consumption

Consumers' expenditure on non-durables is negatively influenced by the level of real long interest rates and in addition the stock of total private sector wealth has a positive influence. The cut in real long interest rates in the first year increases non-durable consumption by 0.37%. In the second year, the smaller decrease in real long interest rates is partially offset by the influence of lagged consumption and overall the increase in non-durable consumption is 0.16%

Government expenditure

Government expenditure on goods and services is related to an underlying level of expenditure (EG*) which is derived from an exogenous PSBR target and tax revenue net of debt interest. That is EG* = PSBR* + Ty* - RDI, where PSBR* is the exogenous PSBR target, Ty* is tax revenue and RDI is real debt interest. The reduction in debt interest payments due to the cut in nominal long

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* The Liverpool model disaggregates into consumption of non-durables and 'goods', where the latter includes fixed capital, consumer durables and inventories. Both the flow of goods and a term for the lagged stock of goods enter the 'identity' for GDP.

and short interest rates outweighs the loss of tax revenue in the first year, and since the PSBR target is fixed, underlying government expenditure increases. Actual expenditure varies around underlying expenditure in a countercyclical manner, but the dominant influence in the simulation is the increase in underlying expenditure. Although real debt interest remains below base in the second year, the greater fall in GDP means that the fall in tax revenues now dominates, and so government expenditure falls below base.

(b) Permanent shock

The major difference between the two simulations relates to the increases in the stock of total private sector wealth by 0.8% in the first year of the simulation. This is due to the influence of real long interest rates on the stock of goods, with the resulting increase in the stock of goods by 0.9% reflecting a 23.5% increase in the flow of goods. The larger fall in real long interest rates also increases non-durable consumption by over 1% and again government expenditure rises by around 1%.

Although the increase in the stock of wealth and the greater exchange rate appreciation mean that the deterioration in the trade balance is even larger, the overall effect is to raise GDP by 1.16% in the first year. Note however that the increase in real wages outweighs the effects of higher GDP and so unemployment still increases, although only by 20,000 in the first year. The PSBR now falls, with the increase in expenditure due to the lower debt interest payments outweighed by the increase in tax revenues.

In the second year of the simulation, the flow of goods is increased by only 2.6% but the previous increase in the stock of goods, together with increases in non-durable consumption and government expenditure again outweigh the deterioration in the trade balance. However the increase in GDP is now only 0.28% and coupled with the increase in real wages, this means that unemployment now rises by over 100,000.

Note that in this simulation, the demand for MO increases in the second year over and above the increase in the first year so that inflation remains below base in the second year. This reflects the influence of the permanent shock on nominal short interest rates and hence the demand for real money balances.

TABLE 6B: LIVERPOOL UNIVERSITY MODEL - 2% point reduction in domestic nominal short rate - PERMANENT SHOCK, exchange rate free

Note: Liverpool model is based on annual data

		Year 1	Year 2	Year 3
GDP	(80%)	1.16	0.28	0.28
Unemployment	(000's)	21	104	105
Stock of goods	(80%)	0.91	0.98	0.96
Flow of goods	(80%)	23.50	2.59	0.36
Consumption (non-durables)	(80%)	1.05	1.53	1.71
Government expenditure	(80%)	0.98	1.68	1.87
Effective nominal exchange rate	(%)	6.90	4.49	3.34
Inflation	(% pts)	-1.83	-0.64	-0.49
Nominal balance of payments*	(£mn)	-7,213	-4,756	-4,444
Nominal PSBR	(£mn)	-1,480	- 214	- 249
Nominal debt interest	(£mn)	-1,220	-1,429	-1,649
Demand for MO	(80%)	1.81	2.45	2.93
Real Income**	(80%)	2.61	1.59	1.10
Nominal long rate	(% pts)	-2.39	-2.46	-2.54
Nominal short rate	(% pts)	-2.00	-2.20	-2.39
Real long rate	(% pts)	-2.07	-2.24	-2.40
Real short rate	(% pts)	-1.39	-1.70	-2.01
Goods	(80%)	0.91	0.98	0.96
Financial Assets	(80%)	0.32	-0.46	-1.40
Total private sector wealth	(80%)	0.82	0.75	0.57

Scaling factor = 10/7

* Defined as trade balance excluding terms of trade effects.
** Real income is calculated as real wage rate times numbers in employment.

80% = percentage changes from base (variables in 1980 prices)
£mn = absolute differencese from base (£ million)
% = percentage changes from base
% pts = absolute difference in percentage points
000s = absolute differences 000s

Summary

As we suggested in Section I, there are considerable difficulties in making exact comparisons between models due to definitional differences. Thus, in comparing overall model properties, the emphasis should be on relative magnitudes rather than particular numerical values. This is especially true when comparing the Liverpool model with the others as its structure is rather different.

The use of model consistent expectations and the consequent ability for the future to influence present events, highlights the need to consider whether the shock in interest rates is perceived to be temporary or permanent. In their present forms, such a distinction makes no difference for the Bank, National Institute or Treasury models but it is nonetheless important when comparing results from different models.

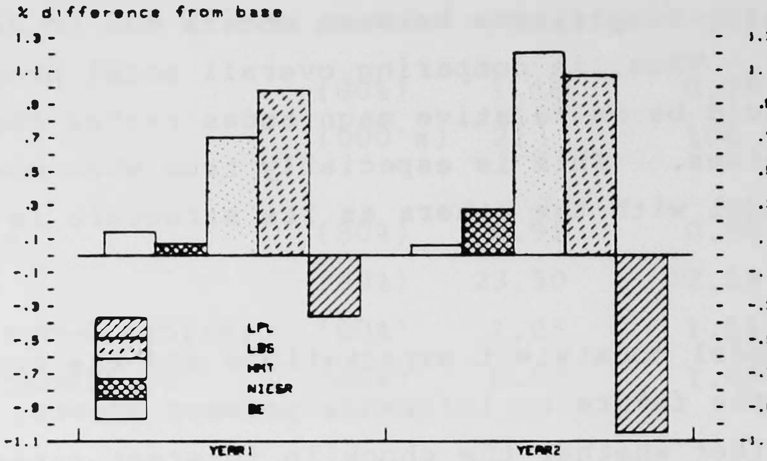
It could be argued that the Liverpool simulation should not be compared directly with those from the other models as in contrast to the other models, the differential between UK and US interest rates increases in favour of the UK. Clearly if such a change in the differential were applied to the other models they would also suggest an exchange rate appreciation. However, we stress that the appreciation in the Liverpool model arises from the structural influence of domestic interest rates on inflation and hence real wages, although the change in the differential is indicative of the endogeneity of interest rates in the Liverpool model.

One notable feature of the simulations on the Bank, National Institute and Treasury models is the way in which the term structure equation gives a substantially smaller cut in long interest rates for a given cut in short rates. If the shock to short interest rates were thought to be permanent, the change in the long interest rate would be much closer to the change in the short rate and so implicitly the models seem to view the interest rate shock as temporary. Accordingly in this summary the temporary shocks from the LBS and Liverpool models are considered in a group with the simulations from the other models.

Figure one illustrates the effects of the cut in interest rates on GDP across the different models when the exchange rate is free.

With the exception of the Liverpool model all suggest that GDP will rise, but there is considerable disagreement as to the size of the increase.

Figure 1 GDP (exchange rate free)



Although there are important differences between the suggested increases in fixed investment and stockbuilding, the major differences arise from the changes in consumers' expenditure and the effective exchange rate. Figure two shows the changes in total consumption with the Bank and National Institute models giving a decrease whereas the other models all have consumption increasing. Real personal disposable income (RPDI) is an important determinant of consumption in all the models except Liverpool, and figure three illustrates the considerable differences amongst the changes in RPDI.

Figure 2 Total Consumption (exchange rate free)

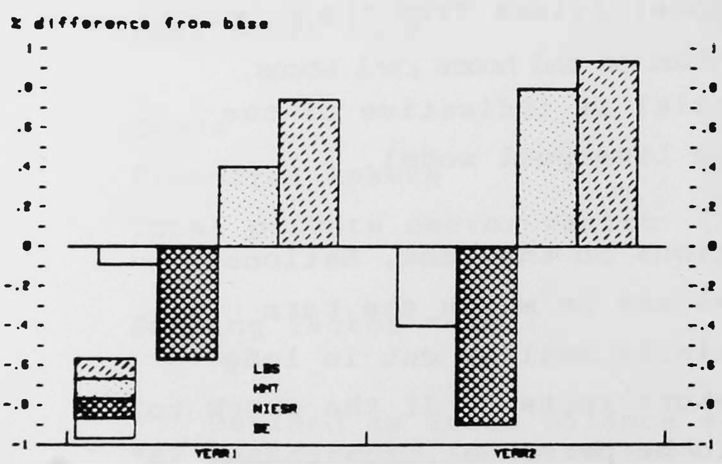
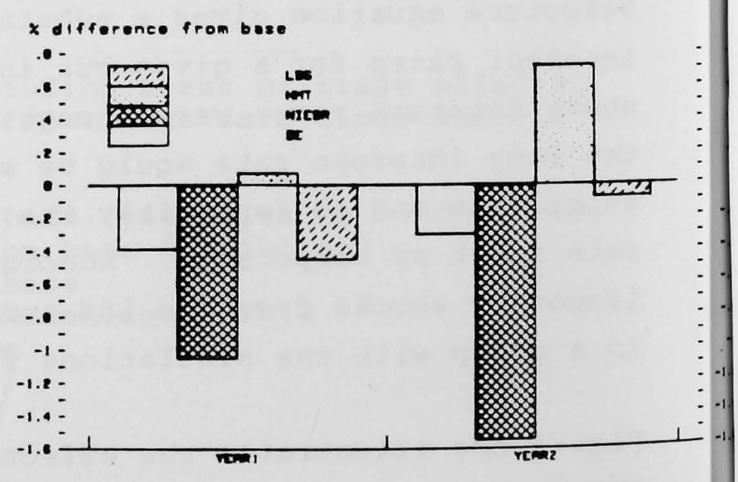


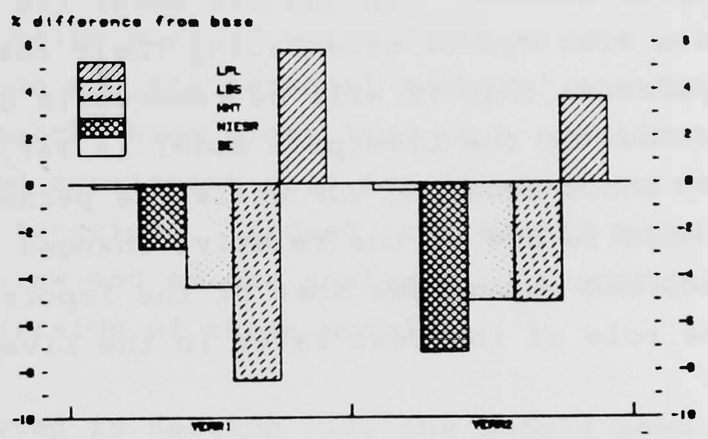
Figure 3 Real Personal Disposable Income (exchange rate free)



The changes in RPDI are obviously dependent on the changes in the price level, which in turn are dependent on the depreciations in the effective exchange rate. However, there are also important differences amongst the influences on nominal income - notably the effects of increases in employment and GDP - which mean that RPDI rises in the Treasury model, and although the increase in prices is largest in the LBS model, the fall in RPDI in the second year is much smaller than in either the Bank or National Institute models. Falling interest rates also influence personal sector nominal income by reducing the personal sectors' net interest receipts. In addition to the different changes in RPDI, the presence of direct real interest rate effects is important in both the Treasury and LBS models - especially the latter where despite a fall in RPDI, consumers' expenditure increases by more than in the Treasury model where RPDI increases.

Figure four illustrates the substantial variation in the movements of the effective exchange predicted by the different models.

Figure 4 Effective exchange rate



As we suggested above, in all the models except Liverpool, movements in the exchange rate are potentially a major influence on the change in prices and will eventually influence all the variables in the model. The different paths of the exchange rate account for much of the difference between the predicted changes in inflation and in addition there are important differences in trade volumes and the current balance of payments. Indeed, the Bank model suggests an improvement in the current balance whilst the other models suggest a deterioration, although this is also due to differences in the way interest rates affect flows of interest, profit and dividends.

Unfortunately a simulation with the exchange rate fixed was not available for the Liverpool model. In all the other models, the absence of an exchange rate depreciation reduces the increase in GDP, although given the size of the depreciation in the Bank model, the reduction is negligible. The differing effects on consumption are again important, but in each of the models the increase in consumption is larger (or the decrease smaller) as real personal disposable income decreases less (increases more) due to the smaller rise in consumer prices. The smaller rise in GDP reflects a deterioration in the trade balance. Price competitiveness is practically unchanged and hence there is little effect on exports. However, imports still increase due to the positive elasticity with respect to activity and so the trade balance deteriorates.

Although the main emphasis is on simulations which implicitly view the change in interest rates as temporary, it is useful to note the differences between the temporary and permanent simulations in the LBS and Liverpool models. In the LBS model the difference is simply one of scale with agents attenuating their response to the shock when they perceive that it will be removed in due course. However, the behaviour in the Liverpool model is very different, with the temporary shock reducing GDP while the permanent shock increases GDP. This is due to the relative changes in short and long interest rates and emphasises some of the important differences in the role of interest rates in the Liverpool model.

SECTION III: CONCLUSIONS

As we cautioned in the introduction to Section II, there is much more to policy evaluation using these models than an unchallenged acceptance of the mechanistic simulation or single equation properties. Nevertheless, the simulation results and indeed the single equation analysis in Section I contain much of interest.

One of the major differences between the models is in the response of the exchange rate but this undoubtedly reflects the difficulties of estimating satisfactory equations in this area. In an open economy such as the United Kingdom, the exchange rate is particularly important and so the differences in the exchange rate path account for many of the differences between the overall simulation properties. However, there are also important differences in other areas, notably consumption. Whilst such differences may to an extent reflect alternative views on how the economy works, they also reflect the intermediate stage of much of the underlying work in this area. For example, within the Bank, research is being pursued which looks at the joint determination of consumption and the personal sectors' portfolio of assets - a line of research which might lead to a quantitatively more important and consistent role for interest rates in the consumption function. Indeed, the entire models are subject to periodic review and so our analysis is a snapshot of one particular version of these models.

As we suggested in Section II, the models seem to view a change in nominal short interest rates alone as implicitly transitory. Although the distinction between a temporary or permanent change does not affect the Bank, National Institute or Treasury models as they are presently formulated, it will undoubtedly influence the modellers' views on any modifications to the model properties which may be necessary. There is clearly a need to run further simulations which explore the distinction between permanent and temporary shocks, and the relationship between changes in long and short interest rates in more detail.

The analysis in both Sections I and II emphasised that there are differences among the models in the way that interest rates themselves are modelled, with only the Liverpool model requiring an explanation of the reason for the change in interest rates. Because of this, the analysis focuses on the opportunity cost effects and the cash flow and liquidity effects of changes in interest rates. Insofar as changes in nominal interest rates are the consequences of changes in the level or variability (uncertainty) of inflation expectations, the associated changes in expectations may have important effects on activity. Such effects might be represented in the models by terms other than interest rates. Clearly, when considering the simulation properties of the models it is important to consider what might cause the change in interest rates and the effects which changes in the determinants of interest rates may have on the economy.

APPENDIX

The simulation results for the Bank of England model demonstrated the importance of the yield curve in the model. Although domestic short interest rates fell by 2% points, the yield curve relationship in the Bank model gave a fall in long interest rates of 0.6%. Faced with a 1.4% improvement in the yield on gilts relative to that on liquid assets, the personal sector reallocates its portfolio towards gilts, largely at the expense of building society deposits. The stock of net liquid assets held by persons is an important determinant of consumption and so the tilt in the yield curve reduces consumption.*

This effect is not unique to the Bank model as both the Treasury and LBS models have similar terms in their consumption equations. However, the magnitude of the effect is much larger in the Bank model and it accounts for a substantial proportion of the fall in consumption. If we reduce short and long domestic interest rates by the same amount, ie exogenise the long interest rate, this effect is removed and we can assess the importance of the other interest rate effects in the Bank model. Tables 7a and 7b present the results of a 2% point cut in both short and long nominal rates with the exchange rate free and fixed respectively.

The overall effect when the exchange rate is free is to increase GDP by nearly 0.25%, and the increase is more sustained than before as by the end of the third year, GDP is 0.16% above base. This compares with an increase of 0.14% after one year and a decrease of 0.08% at the end of the third year when only short rates are cut.

In the absence of the yield curve effect, consumers' expenditure with the exchange rate free is slightly above base in the first two years of the simulation. This compares with a fall of 0.4% by the end of the second year and a fall of 0.7% at the end of the third year when only short rates are cut. The increase in

* The elasticity of real net liquidity in the static long-run solution of the equation for consumers' expenditure on durables is 0.42, whilst that on inflation-adjusted disposable income is 0.58.

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TABLE 7a

BANK OF ENGLAND MODEL: 2% point cut in all domestic nominal rates - exchange rate free

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.23	0.22	0.16
Employment	(000s b)	26	54	59
Unemployment	(000s b)	-10	- 34	- 43
Total consumption	(80% b)	0.17	0.03	- 0.10
Total fixed investment	(80% b)	0.86	1.18	1.16
Residential investment	(80% b)	7.58	9.50	9.76
Total stockbuilding	(80A £mn)	143	249	102
Exports of goods and services	(80% b)	0.01	0.04	0.04
Imports of goods and services	(80% b)	0.55	0.38	0.16
Effective exchange rate	(% b)	- 0.15	- 0.24	- 0.48
Consumer prices	(% b)	0.00	0.13	0.36
Real personal disposable income	(80% b)	- 0.33	- 0.16	- 0.14
PSBR	(A £mn)	- 595	-1,105	-1,241
Debt interest payments	(A £mn)	- 465	- 681	- 934
Bank lending to private sector	(A £mn)	398	772	663
Stock of £M3	(% b)	0.00	0.54	1.09
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 2.00	- 2.00	- 2.00

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

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TABLE 7b

BANK OF ENGLAND MODEL: 2% point cut in all domestic nominal rates - exchange rate fixed

		End of Year 1	End of Year 2	End of Year 3
GDP	(80% b)	0.22	0.20	0.12
Employment	(000s b)	25	51	55
Unemployment	(000s b)	- 9	- 33	- 40
Total consumption	(80% b)	0.18	0.04	- 0.08
Total fixed investment	(80% b)	0.86	1.17	1.15
Residential investment	(80% b)	7.59	9.52	9.79
Total stockbuilding	(80A £mn)	148	255	100
Exports of goods and services	(80% b)	0.00	0.00	- 0.02
Imports of goods and services	(80% b)	0.59	0.43	0.24
Effective exchange rate	(% b)	Fixed	Fixed	Fixed
Consumer prices	(% b)	- 0.02	0.07	0.24
Real personal disposable income	(80% b)	- 0.31	- 0.15	- 0.13
PSBR	(A £mn)	- 582	-1,076	-1,175
Debt interest payments	(A £mn)	- 465	- 680	- 929
Bank lending to private sector	(A £mn)	400	776	660
Stock of £M3	(% b)	0.07	0.62	1.13
Nominal short interest rates	(% points)	- 2.00	- 2.00	- 2.00
Nominal long interest rates	(% points)	- 2.00	- 2.00	- 2.00

80% b = percentage differences from base (variables in 1980 prices)
% b = percentage differences from base
80 A £mn = annual differences in £ millions (1980 prices)
A £mn = annual differences in £ millions (current prices)
% points = absolute differences in percentage points
000s b = absolute differences from base (thousands)

consumption contributes to a higher level of GDP and this leads to modest additional increases in fixed investment and stockbuilding. However, the higher activity also increases imports and this partially offsets some of the increase in consumption.

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