A FINANCIAL MODEL OF THE UK ECONOMY

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by

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ABSTRACT

The object of the study is the construction of a quarterly rational expectations financial model of the UK economy. Within this approach the real sector is taken as given. It is hoped that a model of this type will throw some light on the relationships existing between the money supply, bank credit, interest rates and the exchange rate. The estimation period runs from 1973 quarter 1 to 1980 quarter 4. The study also involves close links with a wider study of the behaviour of these variables for other European countries carried out at the University of Leuven, Belgium.

We commence by examining other studies of the UK financial sector including those contained in the mainstream macroeconometric models of the UK economy. Subsequently in chapter 3, a small scale theoretical model is developed to illustrate the general nature of the approach followed. Chapters 4 and 5 deal with the estimation of the portfolio behaviour of the non-bank private sector and the banking sector respectively. The estimation for the former sector follows the same general methodology used in the Liverpool macroeconomic model of the UK economy (i.e. a hierarchy of portfolio decisions) rather than the standard Tobin/Brainard approach. The banking sector portfolio decision making process is also estimated in ratio form.

Data sources are described in chapter 6 and the complete model is assembled in chapter 7. This chapter also includes i) the processes generating the exogenous variables and ii) the assessment of the model. In chapter 8 we examine simulation of shocks to the model and in chapter 9 discuss the potential for intervention by the authorities in the foreign exchange markets. Our conclusions are presented in chapter 10.

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ABBREVIATIONS

(see also pages 208 - 210)

Note:

Δ	=	First difference of the variable
E_t		Expected value of the variable (expectation formed at period t)
Ln	=	Natural logarithmic value of the Variable
nbps	=	non-bank private sector
*	=	Foreign counterpart of the domestic variable
$\delta Y/\delta X$	=	The first derivative of Y with respect to X

B	=	Government bonds held by the nbps
BB	=	Government bonds held by the banks
BCB	=	Government bonds held by the Bank of England
B^s	=	Total supply of government bonds
BLPUB	=	Bank lending to the public sector
BOF	=	Balance for official financing (Balance of payments; = ΔRES)
BOS	=	Public Sector Debt held by the overseas sector
BSCB	=	Public Sector Debt held by the Central Bank
CA	=	Current Account (Balance of payments)
CL	=	Lending by the Central Bank to the banking sector
CR	=	Intensity of credit restrictions
D	=	Total £ bank deposits held by the nbps
D$	=	$ Bank deposits held by the nbps
DAS	=	Gross domestic financial assets held by the nbps

DB	=	Bank Deposits held by the Banks at the Central Bank
DCB	=	Public sector bank deposits held at the Central Bank
DCE	=	Domestic Credit Expansion
DGCB	=	£ bank deposits held by the public sector at the Central Bank
DOS	=	£ bank deposits held by the overseas sector with the banks
DPS	=	£ Bank Deposits held by the public sector at the banks
DS	=	£ sight deposits held by the nbps at the banks
DT	=	£ time deposits held by the nbps at the banks
F	=	Net overseas assets held by the nbps
FB	=	Net overseas assets held by the banks
FLB	=	Net overseas liabilities held by the banks
FP	=	The forward premium on $s
FPPSD	=	Fixed price public sector debt held by the nbps
FS	=	The forward exchange rate
Gilts	=	Variable price public sector debt held by the nbps
H	=	Total monetary base
HB	=	Monetary base held by the banks
L	=	£ loans by the banks to the nbps
LOS	=	Bank lending in £ to the overseas sector
L$	=	Bank Lending in $ to the nbps
LP	=	Liquidity premium on long-term financial assets
M	=	Money (unspecific)
M1	=	Narrow definition of money held by the nbps
M2	=	Broad definition of money held by the nbps
MON	=	Sterling + foreign currency deposits held by the nbps with UK banks
MONFRC	=	Money held by the nbps denominated in foreign currency
NAFA	=	Net acquisition of financial assets

NBPS = The non-bank-private sector

NC = Notes and coins held by the nbps

NCB = Notes and coins held by the banks

NDA = Net domestic assets held by the nbps

NDL = Non-deposit liabilities of the banks

NOSPS = Net overseas assets of the public sector

NWB = Net worth of the banks

NWOS = Net worth of the overseas sector

NWPS = Net worth of the nbps

OL = Other liabilities of the banks

OTHER = Non-defined components of the balance of payments

P = Domestic price level

PEXP = Expected price level

PSBR = Public sector borrowing requirement

R* = Uncovered foreign rate of interest

RC* = Covered foreign rate of interest

RD = Rate of interest on bank deposits

RG = Rate of Interest on governement debt

RL = Rate of interest on bank loans

RLR = Long-term rate of interest

RM = Money market rate of interest

RSR = Short-term rate of interest

RES = Stock of foreign currency reserves held by the Central Bank

RESID = Non-defined components of wealth of the nbps

RP = Risk premium on foreign assets

RW = Real value of financial wealth of the nbps (i.e. W/P)

S = Spot exchange rate (£ per $1)

SPECD = Special deposits held by the banks at the Bank of England

T = Time

TBL = Total Bank lending in £

V = Nominal financial wealth of the nbps

Y = Nominal GDP

YEXP = Expected real GNP

CHAPTER 1 INTRODUCTION

The aim of this study is the construction and estimation of a quarterly financial model of the UK economy for the period 1973 to 1980. At the outset it should be emphasised that this is a partial equilibrium model taking the real sector as given. We hope that this model will be able to highlight certain key issues which are at the forefront of current macroeconomic thinking. In particular the model should be able to deal with the determination of the money supply and its interaction with bank credit. It should also be able to deal with the interaction of the exchange rate, monetary policy and expectations, the determination of interest rates and the influence of overseas monetary conditions. Furthermore the model should reflect the UK institutional environment relevant to the observation period. A particularly important application of such a model is the evaluation of the effect of different intervention policies in the foreign exchange markets.

We selected the years 1973 to 1980 because of the existence of a relatively homogeneous financial environment within the period. The then-new system of Competition and Credit Control was introduced in September 1981 and continued, though with amendments, until 1981. Similarly the floating of sterling in the spring of 1972 heralded the introduction of a regime of generalised floating exchange rates. It would be expected that the new arrangements would take some time to settle down so we selected as the observation period the first quarter of 1973 to the last quarter of 1980. We do, of course, recognise that environmental changes took place within this period (such as, for example, the introduction of supplementary special deposits and the abolition of exchange controls) but would, nevertheless, argue that the period selected is sufficiently homogeneous for the purpose in view.

One of the dangers of such an ambitious project is to go overboard in the extent of detail, incorporating all the institutional factors and presenting a final model containing a morass of detail which obscures the essential economic relevance of the exercise. On the other hand there is the possibility of over-simplification which necessarily hides the principal chain of causation defeating the object of the study. For example the exclusion of the behaviour of the banking sector in a model leads inevitably to the assumption that the money supply (or monetary base) is exogenous in the sense that it could be controlled by the authorities should they so desire. In attempting to strike a fine balance between these two dangers, the level of aggregation has been determined by the principal questions posed by such a model. For the UK any model financial or otherwise must recognise the openness of the economy and also must incorporate the interaction between the balance sheets of the public and private sectors.

Three major strands of current macroeconomic thinking lie at the heart of the theoretical specification of the model. First, portfolio balance of the banking and non-bank private sectors assumes a critical role. Second, the model differs from traditional portfolio balance models since bank lending is an important variable in the portfolio choice. In this connection, the model owes much to the theoretical credit market models developed by Brunner and Meltzer. Third, and perhaps the most novel feature, is the adoption of the rational expectations hypothesis within the model. Expectations are rational in the sense of Muth [1960] in that the expectations formed by economic agents are consistent with the predictions of the model used to explain their behaviour. In this particular model the expected value of the exchange rate is consistent with the model predictions of that variable. One of the major arguments raised against the rational expectations hypothesis is whether it is being assumed that the relevant agents know the structural parameters of the complete model. Clearly such an assumption cannot be literally true since as Schiller [1978] (page 34) points out "while it may be sometimes useful as an expositional device to assume that agents have this much information, the assumption cannot be taken seriously. If economists are only now discovering these models, we cannot seriously propose that everyone else knew them all along". Our response to this argument is to suggest that we are trying to model explicitly the imperfect hunches of smart market operators. In this sense we are appealing to the 'as if' clause and not necessarily assuming that agents know the full model. We also assume that the parameters of the model are constant but that expectations of future exchange rates are formed rationally. Consequently, we are not able to claim that we are meeting the full force of the 'Lucas' critique that the equation coefficients within a model should not be invariant to changes in the policy regime. This caveat must be borne in mind in any assessment of the policy simulations reported in chapters 8 and 9.

The plan of this study is as follows. In chapter 2 the financial sectors of existing mainstream macroeconomic models of the UK economy are surveyed. In chapter 3 a simple stylised portfolio balance model is presented in order to provide the flavour of the approach adopted in advance of the estimation of a more detailed empirical model described in chapters 4 and 5. In chapter 6 the data sources are described together with the processes defining the projection of the exogenous variables. In chapter 7 the model as a whole is considered together with its tracking ability. Simulation experiments are reported in chapters 8 and 9. These cover examination of the effect of shocks on the exchange rate and the extent to which the authorities can modify the impact of these shocks by intervening in the foreign exchange markets. The general conclusions reached suggest that both sterilised and non-sterilised intervention will affect the exchange rate but that the cost in reserves may be excessive. In chapter 9 we review the study as a whole.

CHAPTER 2 EMPIRICAL STUDIES OF THE UK FINANCIAL SECTOR

2.1 Introduction

In this chapter we review existing studies of the financial sector of the UK economy. These empirical studies can be divided into two groups; i) studies which are part of a complete macroeconomic model and ii) isolated studies of the monetary/financial sector of the UK economy. We commence by examining the financial sector of the main macroeconomic models of the UK economy in sections 2 to 8 and subsequently in sections 9 and 10 the other type of studies.

There are a large number of macroeconomic models of the UK economy in current use. However many of these models are treated as confidential so we concentrate on those models which have been the subject of widespread comment in the news media or those which are considered to be relevant for other reasons (e.g. the Bank of England models). The models ' discussed below are those constructed at the Treasury, the National Institute of Economic and Social Research, the London Business School, the Cambridge Economic Policy Group, the University of Liverpool and the Bank of

England. In terms of basic philosophy, the Treasury, National Institute and Bank of England models are generally regarded as Keynesian and the London Business School model as monetarist though none of them takes an extreme position. In contrast the other two models take a more radical view though from opposite sides of the fence. The Liverpool model reflects the views of the 'New Classical' school whereas the Cambridge model adopts the extreme Keynesian viewpoint. It is important to realise that each of the models is evolving over time and the description below refers to how the models looked in the recent past. An econometric model is a complex structure so considerable simplification is necessary to summarise the mass of detail coherently. This is particularly relevant to the transmission mechanism whereby monetary effects are transmitted to the real sector. In order to simplify the exposition, there are a number of differences between the presentation in this chapter and that in the original literature. First a standard form of notation will be used. Second details of lags and of dummy variables (for special events and seasonal influences) will be omitted from the discussions. Third in many instances it is not particularly critical whether or not the equation is estimated in logarithmic form so this fact will only be mentioned if the circumstances warrant it.

For the remaining type of studies, in section 9 we review estimation of mean variance portfolio models of the UK financial sector and in section 10 further studies including a structural portfolio model of the UK financial sector.

2.2 The Treasury Model

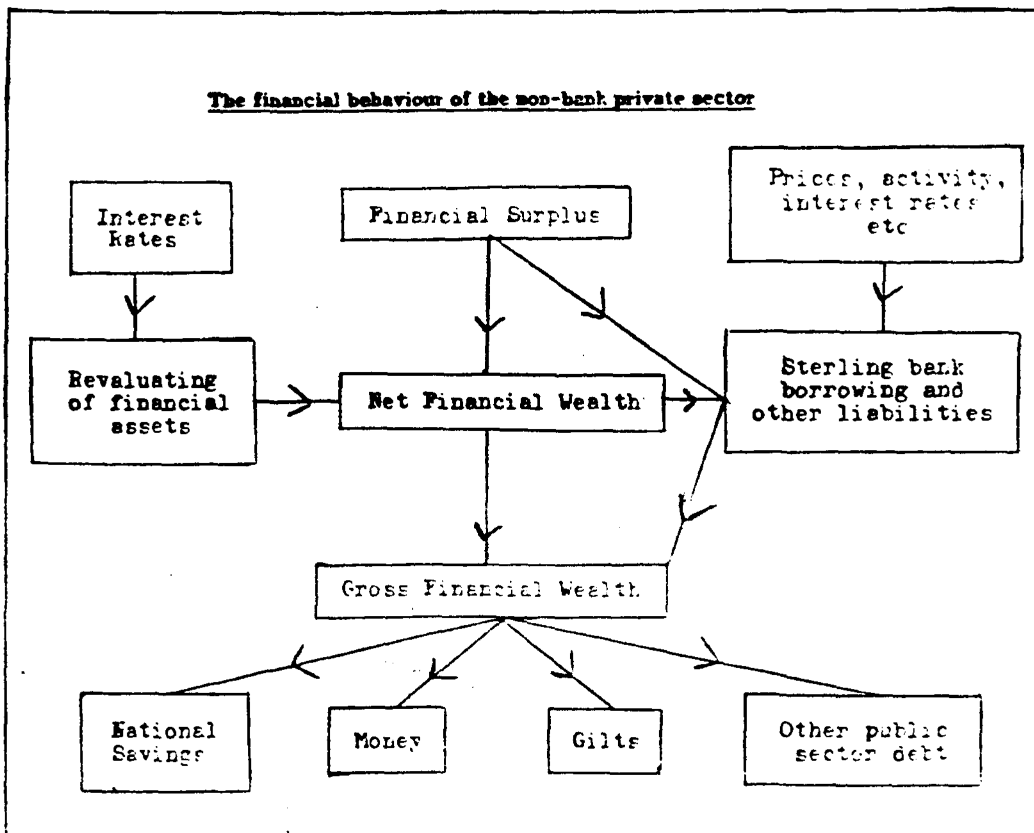
The monetary sector of the Treasury Model is of recent development with the 1979 edition of the technical manual being the first to incorporate experimental models of the financial sector and external capital flows. Subsequently these sectors became more firmly integrated into the model and the following discussion is based on the version of the model incorporated in the 1982 technical manual. Compared with other models, the sectors dealing with the financial aspects and external capital flows are quite large consisting of some 70 or so equations. It shares this aspect with the National Institute and Bank of England models. Disaggregation within the financial sector extends to consideration of the banking, non-bank private and overseas sectors. The basic instrument of analysis is the consolidated balance sheet of each of these sectors involving specification of their desired holdings of assets and liabilities. The main (i.e. income/expenditure or real) model generates gaps between the income and expenditure of the different sectors. These deficits and surpluses are allocated by the financial model between the various assets/liabilities whilst still preserving the balance sheet equality between assets and liabilities for each sector.

The basic structure of the financial behaviour of the non-bank private sector is demonstrated below in figure 2.1 extracted from

HMT [1982]. Liabilities of the private sector are mainly sterling bank borrowing and net overseas and foreign currency liabilities with the latter being determined within the capital flows sector of the model. Once gross financial wealth is determined it is then allocated to the various assets mainly according to relative rates of return but activity variables also play a role. In this version of the model the balance sheet identity is achieved by treating holdings of gilts as the residual asset. The supply side of the monetary aggregates is based mainly on the behaviour of the banks which are assumed to be oligopolistic price setters who accept all deposits offered at the rates of interest set (zero in the case of sight deposits). Their discretionary assets consist of bank lending to the private sector and their holdings of cash, local authority temporary money, gilts and reserve assets as well as their net foreign asset position. Within their balance sheet, holdings of certificates of deposit are determined by the requirement that the parallel money markets clear at existing rates of interest. Consequently the banks' balance sheet identity is achieved by variation in special deposit calls though in the present system of monetary control, this in practice represents the scale of intervention by the authorities in the money market.

Within this framework, the key equations requiring further amplification are those explaining the non-bank private sector's holdings of sterling M3 and bank lending to the private sector. Before dealing with these it is worth mentioning that the non-bank private sector's holdings of liquid assets such as notes and coins,

Figure 2.1


The financial behaviour of the non-bank private sector
Interest Rates
Financial Surplus
Prices, activity, interest rates etc
Revaluating of financial assets
Net Financial Wealth
Sterling bank borrowing and other liabilities
Gross Financial Wealth
National Savings
Money
Gilts
Other public sector debt

public sector debt other than gilts and also M1 are essentially demand determined depending on such variables as the price level, own and competing rates of interest and wealth or activity variables. In a similar way bank holdings of cash, local authority temporary money, gilts and excess reserve assets are mainly demand determined. Reverting back to the key equations, sterling bank borrowing is disaggregated into three components; i) lending to persons, ii) lending to industrial and other companies and iii) lending to other financial institutions. For all three categories bank lending is essentially demand determined with little or no allowance for supply side factors. For lending to persons the flow of bank lending depends positively on lending in the previous period, real disposable income and net financial wealth and negatively on the rate of lending to persons and also on the price level. Similarly bank lending to the other two categories is purely demand determined depending on such factors as own and competing rates of interest and income/output variables. Also in the case of bank lending to companies it depends positively on the gap between the short term rate of interest and the own interest rate.

Turning to the asset side one of the most important assets is non-bank private sector holdings of sterling M3 which depends on final expenditure, interest rates and the return on money relative to that on gilts [2]. Other holdings of public sector debt are easily dealt with. The flow of national savings is a function of the personal sector's financial surplus. Holdings of certificates of tax deposits are a function of corporation and petroleum tax accruals.

The determination of interest rates hinges around the short-term rate of interest, which as far as this model is concerned, is the three month Treasury bill rate. This is set exogenously in the model though in simulation experiments it may be treated as endogenous by allowing it to vary within the experiment until a target for another variable such as the growth of the money supply is achieved. Other rates of interest are set relative to the Treasury bill rate by a mark-up process.

2.3 The National Institute Model

The precise version referred to in the following description is that described in 'National Institute Model 6' (NIESR [1983]). This model contains a fairly detailed description of the supply side of the monetary sector. However the transmission mechanism does not provide for money to have very strong effects on the real side of the model.

The general strategy followed by the NIESR is to model the supply side of the monetary process. No simple demand for M3 function is included in the model no doubt because of a prior belief that the effect of monetary expansion on the real sector depends critically on the credit flow which brought the monetary expansion about. Hence emphasis is placed on disaggregating money into its constituent credit flows. Explanation of monetary changes hinges around two identities; finance of the PSBR and the identity specifying M3:

$$PSBR = \Delta B + \Delta NC + \Delta BLPUB + Other \quad (2.1)$$

where ΔB = flow of non-bank private sector lending to the public sector

ΔNC = change in notes and coins held by the non-bank private sector

$\Delta BLPUB$ = flow of bank lending to the public sector

Other = other exogenous items such as, for example, external financial transactions and dealings in bills

In this identity PSBR is given from the real sector of the economy. Behavioural equations are incorporated to explain ΔB and ΔNC so that $\Delta BLPUB$ is treated as the residual. The definition of changes in broad money i.e. M3 is:

$$\Delta M3 = \Delta BLPUB + \Delta L - \Delta OL \quad (2.2)$$

where ΔL = flow of lending to the non-bank private sector

ΔOL = change in other liabilities of the banks.

As far as the right hand side of (2.2) is concerned, ΔOL is treated as exogenous, $\Delta BLPUB$ is the residual from (2.1) and behavioural equations explain ΔL. Within this framework the key equations are those explaining sales of public sector debt to the private sector ΔB) and bank lending to the private sector (ΔL). The following examination concentrates on these two functions and it is necessary merely to note that the quantities of M1 and ΔNC are essentially demand determined. Both equations follow the error correction model [3] - a feature shared by many of the equations in the National Institute model. The short-run structure for both equations was freely estimated. In the case of the M1 equation there is a steady state property of unit elasticity of M1 with respect to nominal income and a long-run property that the ratio of M1 to nominal income varies inversely with the level of short-term rates of interest. In the case of the ΔNC the equation shows steady state unit elasticity of currency with respect to consumer expenditure and also the ratio of currency to consumer expenditure declining over time due to institutional changes.

The flow of non-bank private sector lending to the public sector is disaggregated into two components; i) net sales of national savings and ii) net sales of all other types of debt. The first component is treated as exogenous and total non-bank private sector lending to the public sector (ΔB) depends on i) the level of the Consol rate, ii) the differential between the Consol rate and a short-term rate of interest and iii) the cumulated sum of net acquisitions of financial assets as a proxy for wealth. Clearly this variable (ΔB) is demand determined on the not unreasonable assumption that the authorities sell as much debt as they can given the structure of interest rates.

Bank lending to the private sector is disaggregated into six categories of loans: to industrial and commercial companies, to the personal sector (excluding house purchase), to the personal sector for house purchase, to other financial intermediaries, transactions in bills of exchange by the Bank of England and residual loans. The last four categories are treated as exogenous but behavioural equations are estimated for the first two components. Both equations follow the same general form of a stock adjustment equation with the flow of bank advances depending on the stock of advances in the previous period. Additional explanatory variables are i) an appropriate activity variable, ii) the net acquisition of financial assets by the sector concerned as determined in the real sector of the model and iii) own rate of interest and rates on alternative sources of finance. The main thrust of these equations is that bank lending is demand determined. Nevertheless some allowance is made for a supply side influence since both equations include dummy variables to capture the effects of the introduction of Competition and Credit Control.

Turning now to the question of interest rate determination, the pivot of the interest rate structure is the Treasury bill rate which is forecast exogenously. All other interest rates are linked directly to the Treasury bill rate. For example the bank lending rate is linked to the lagged value of the certificate of deposit rate which in turn is set equal to the Treasury bill rate. Similarly the change in the Consol rate depends positively on lagged values of both the change in the Treasury bill rate and the rate of inflation. Clearly the structure of interest rates is largely independent of monetary conditions.

2.4 The London Business School Model

The financial sector of the London Business School model is quite small in comparison with the two models surveyed in the previous sections. Two functions dominate this sector, namely i) money supply creation and ii) interest rate determination. Many of the equations in this model follow the error correction approach [4].

The determination of sterling M3 starts from the public sector borrowing requirement after removing the effects of changes in the balance of payments. No attempt is made to model the various components of finance for the PSBR and the more simple expedient is adopted of using the ratio of the PSBR to the nominal stock of M3 as one of the determinants of the change in M3. The form taken by the equation is:

$$\Delta M3 = f^{n}(PSBR/M3;\ M3;\ RM\text{-}RSR;\ NAFA/M3;\ \Delta RL; Time;\ \Sigma PSBR\ ) \quad (2.3)$$

where RLR = the long-term rate of interest

RM = the return on money

NAFA = Net acquisition of financial assets

ΣPSBR = the cumulated value of PSBR

This equation includes both demand and supply influences. Two further supplementary equations explain the non-bank private sector's holdings of i) notes and coins and ii) time deposits. The flow demand for notes and coins is a transactions demand depending on the lagged value of the stock of notes and coins, consumer non-durable expenditure and the long-term rate of interest. The ratio of the stock of time deposits to bank deposits is specified as a function of the rates of interest on i) time deposits (positively) and building society deposits (negatively). Neither of these two equations influences expenditure in the real sector.

Apart from the determination of interest rates, three further aspects of the monetary sector remain to be examined: i) the determination of domestic credit expansion, ii) the flow of bank lending to the private sector and iii) the behaviour of the building societies. Domestic credit expansion is always a constant percentage of the PSBR and does not have any independent influence on expenditure or the money stock. Specification of the flow of bank lending equation follows the error correction model so that in long-run equilibrium the ratio of the stock of bank advances to consumer durable expenditure is a function of tax relief on bank advances. Behaviour out of equilibrium depends on similar variables so that the flow of bank lending is mainly determined by the demand for credit. Building societies are the financial intermediaries explicitly considered within the model - their lending is relevant because it is one of the determinants of housing starts. Real deposits with the building societies depend on i) real disposable income ii) the rates of interest on deposits at the societies and at the banks and iii) the long-term rate of interest. Real advances by building societies depend on lagged increases in deposits and shares at the societies and the rates of interest charged on such loans.

Determination of short-term rates of interest depends critically on the three month Treasury bill rate with other rates (i.e. those on bank deposits, M3, deposits with local authorities and the banks base rates) following a simple mark-up process. The Treasury bill rate depends on its own past values and the Eurodollar rate. The long-term rate of interest (Consol) depends on its own lagged values and past inflation. Therefore as in the National Institute model, the various rates of interest influence monetary conditions but are not directly affected by them.

2.5 The Cambridge Economic Policy Group Model

In this model the monetary sector appears almost as an appendix. It is influenced by the real sector but does not transmit any influence of its own. The precise version of the model referred to is the technical manual, sixth edition, Coutts et al [1980].

The cursory treatment of the monetary sector is exemplified by the fact that it consists only of five equations of which two are definitional or quasi-definitional. Apart from identity (2.4) below the equations incorporate a time trend of the general form

$$Y = a + bT + u$$

where a and b are constants estimated from the data by ordinary least squares. The financing of the public sector borrowing requirement is described by:

$$\Delta B = PSBR + BOF - \Delta NC - \Delta BLPUB \qquad (2.4)$$

where BOF = balance for official financing

all other variables as before

The size of the PSBR is determined in the rest of the model by the gap between total public sector expenditure and revenue. The specification of this identity is the subject of a curious twist in as much as changes in i) bank lending to the public sector (ΔBLPUB) and ii)currency held by the private sector (ΔNC) are treated as exogenous. Since the size of BOF is given from the external sector this approach permits private lending to the public sector to be treated as the residual component in the financing of the PSBR. This is a significant departure from the traditional approach which treats bank lending to the public sector by way of 'reserve assets' as the residual component of the public sector's finance.

Sterling M3 is then determined by:

$$M3/Y = f^n(BLPUB + NC)/Y;\ CR) \quad (2.5)$$

where Y = nominal GDP

CR = degree of credit restrictions in force

The first explanatory variable represents the liquidity of the banks. This equation, like that for the London Business School model, is a mixture of both demand and supply influences but a notable omission is any interest rate variable. A second identity then explains domestic credit expansion as the change in sterling M3 minus the basic balance of payments. Two interest rates are determined within the model; minimum lending rate (MLR) and the yield on war loan (RG). These rates are only marginally influenced by monetary conditions and are explained without any reference to government macroeconomic policy. The two equations are:

$$MLR - R^* = f^n(BLPUB/M3) \quad (2.6)$$

$$RLR = f^n(MLR;\ Time) \quad (2.7)$$

where R^* = Eurodollar rate of interest. The variable BLPUB/M represent domestic bank liquidity and the higher the value of this the lower will be the rate of interest.

2.6 The Bank of England Main Model

This is a large scale model consisting of some 680 or so equations. It is a quarterly model and unlike many other models uses data which is already seasonally adjusted. Many of the behavioural equations have coefficients "which are partly or wholly imposed judgementally" (Bank of England [1979] page 10).

The basis of the financial sector is flow of funds analysis with the sectoral surpluses generated in the real sector being allocated to the various financial assets. The relevant flow of funds matrix is shown in table 2.1. Before commenting further, it is worth noting that there is no explicit demand for money function. Such a function is however implicit since holdings of money must be consistent with the holdings of the other assets/liabilities specified in the model. Supply side influences on money arise mainly through modelling the financing of the PSBR. Further, unlike the Treasury model, there is no explicit role for wealth in decisions concerning expenditure or asset selection. Consequently asset revaluations due to interest rate changes play no role in the model. Permanent non-grant income does appear in some portfolio equations but the proxy for permanent income is based on a weighted average of disposable income minus personal income.

In view of the large size of the flow of funds matrix - some six sectors and twenty five types of instrument - some selection is inevitable in the following description of the financial sector of this model. The Bank of England itself selects the most important functions as; i) persons net acquisition of liquid assets, ii) sales of gilt-edged securities, iii) bank lending and iv) flows

Table 2.1

Flow of funds matrix								
Item		Public sector	Overseas sector	Personal sector	Industrial and commercial companies	Banking sector	Other financial institutions	Unallocated
Financial surplus/deficit	1	FC	FC	FJ	FFI	FB	*FV	RESI
Financial transactions (receipts –, payments +)								
Public sector lending	2	*LOT	LPO	LPJ	LPI		LPV	
Accruals adjustment	3	AAC		AAJ	*AAI	AAB	AAV	
Deposits with								
Building societies	4			*LBJ	LBI		–LBSD	
NSB/TSB/FP companies, etc.	5	DVG	DVO	DVJ	DVI		*DVV	
Life assurance and pension funds receipts	6	LVG		LVJ			*LVV	
Credit extended by retailers	7	LRCG		*LRCJ	LRCI			
Loans for house purchase by:								
Building societies	8			*LHSJ			LHSA	
Banks	9			*LHBJ		LHBB		
Other	10	LHPC		*LHOJ			LHPV	
Miscellaneous private sector transactions	11			LVOJ	LVOI	LVOB	*LVOV	
Portfolio {capital issues / investment}	12	IPC	IPO	*IPJ	{CPII / IPI}	IPCB / IPB(a)	CPIV / IPV	
Private sector net investment overseas	13		ILO		*ILI	ILB(b)	ILV	
Overseas column residual	14		OCRO		*CROI	CROB		
Bank lending:								
£ to overseas	15		LBO			*LBOB		
£ to UK private sector	16	}		LDJ	LDI	{*LBSB	LDV	
¢ to UK private sector	17	}				LBSB}		
Banks' net currency lending to overseas	18		[illegible]			[illegible]		
Bank deposits: non-resident £	19		[illegible]			*[illegible]		
£ domestic	20	} [illegible]		¢[illegible]	¢[illegible]	{*[illegible]	¢[illegible]	
¢ domestic	21					[illegible]}		
Sub-total = sum 2 to 21	22							
Unidentified = 1-22-24	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Public sector borrowing requirement = 26+33+34	24							
Finance of the PSBR								
Overseas take-up of gilts	25	*BGSO	BGSO					
Reserves, etc.	26	*[illegible]	[illegible]					
Other external finance	27	*[illegible]	[illegible]					
Total external finance = 25+26+27	28							
Domestic non-bank:								
[illegible]	29	[illegible]		[illegible]	[illegible]			
Other [illegible]	30	*[illegible]		[illegible]	[illegible]		[illegible]	
[illegible]	31	*[illegible]		[illegible]	*[illegible]		[illegible]	
[illegible] commercial bills	32	[illegible]			*[illegible]			
Total domestic non-bank finance = 29+30+31+32	33							
[illegible] finance of PSBR	34	[illegible]				*[illegible]		

[illegible]
[illegible] foreign currency [illegible]
[illegible]
* [illegible]
† [illegible]

into building societies. These are therefore the functions selected for further examination. In all the relevant equations portfolio restrictions are maintained by imposing restrictions on the interest rate coefficients such that over the period of the lag they sum to zero. Consequently changes in interest rates produce once-and-for-all rather than persistent changes in the desired composition of the portfolio.

The personal sector's net acquisition of liquid assets is based on two principles; a desired long-run position and a desired short-run position. In the long run desired holdings of net liquid assets are a constant proportion of nominal permanent non-grant income. Short-run desired holdings depend positively on i) current period savings, ii) the gap between the current desired long-run position and actual holdings lagged one period and iii) the gap between current non-grant income and nominal permanent non-grant income. Within this total there are equations explaining other components e.g. the change in deposits held with other financial intermediaries (except Building Societies) is constrained to a ratio of 0.1 of the change in bank deposits. The residual in the net acquisition of liquid assets is the flow into bank deposits

Domestic finance for the PSBR is obtained through issues of i) notes and coins, ii) short-term debt, iii) long-term debt and iv) bank finance which is the residual. The stock of notes is demand determined depending on consumer non-durable expenditure (positively) and the long-term rate of interest (negatively).

Take-up of long-term debt for each of the three sectors is specified by an equation taking the following general form:

$$\Delta(B/P) = f^{n}(RLR;\ RLR-RSR;\ \Delta PEXP) \qquad (2.8)$$

As mentioned before the value of the coefficients for the lagged values of each of these variables sum to zero representing portfolio considerations. Additional variables appear in each sector's equation: the gap between desired long-run and actual short-run holdings of liquid assets for the private sector; domestic bank deposits for industrial and commercial companies; the private sector financial surplus for other financial institutions. Sales of short-term debt to all three sectors follow a similar structure based on the size of the financial surplus and recent movements in rates of interest.

The behaviour of the banks within the model is entirely passive in the sense that i) the supply of bank deposits is the sum of sectoral row residuals in the flow of funds matrix and ii) bank lending is the sum of the various sector's demand for bank loans. In general terms real bank lending for all three sectors follows a similar pattern being dependent on an activity variable and the real rate of interest (proxied by the nominal rate minus the expected rate of inflation). In the case of other financial institutions no activity variable is included but the return on government securities appears as an additional explanatory variable. All the lagged coefficients for the interest variables sum to zero in accordance with portfolio theory. For the output coefficients the sum is less than zero implying that when output is increasing (or transitory income is greater than permanent income) bank lending will decrease. However the initial two coefficients are signed positively so that the impact effect is perverse but this is more than offset in the long run.

The final major financial flow to be considered relates to the behaviour of the building societies. Net inflows into the societies depend mainly on i) real disposable income, ii) the gross rate of interest on building society deposits and iii) differentials between this and other rates. The flow of net real mortgages is a weighted average of supply and demand factors with supply factor taking most of the weight. Demand factors are captured by real income and housing prices relative to consumer prices.

We now turn to discussing the determination of interest rates. Monetary influences affect interest rates indirectly through expectations of future changes in price levels. Expectations of future inflation are modelled in two ways. First price based expectations are derived from the past behaviour of prices modified by expectations of the future behaviour of the exchange rate which is in turn influenced by the relative rate of monetary expansion in the UK compared with that in the USA. Second monetary based expectations are modelled to depend positively on i) previous rates of monetary expansion in the UK and ii) the expected rate of monetary expansion proxied by the current pace of DCE and expected changes in foreign reserves. The pivotal short-term rate of interest is the three month local authority deposit rate. This is determined by the Eurodollar rate (with a weight equal to 0.5) and price expectations (both price and money based) with a combined weight equal to 0.2 plus a constant term. This rate is also influenced by changes in reserves in the previous period (positively) and by pressure on the exchange rate - pressure for an appreciation leading to an easing of the interest rate. The long-term rate (i.e. the yield on 20 year gilts) is related to the short-term rate, price based expectations of inflation and to the scale of the PSBR relative to nominal GDP. The clearing banks base rate and the three month sterling certificate of deposit rate are directly related to the short rate via the 'mark up' principle. Building society rates are also linked to the pivotal short rate but with an allowance representing their reluctance to change rates too frequently.

2.7 The Bank of England Small Monetary Models

In addition to the main models the Bank of England has developed two small scale monetary models; one annual (Coghlan [1979]) and the other quarterly (Hoffman [1980]). The monetary sectors in both these models are closely integrated into the other sectors of the models so that "it is not possible to make any distinction between money/finance and income/expenditure markets" (Coghlan [1979] page 2). Estimation follows the specification of the error correction model with many variables appearing in the equations in first difference form. The models cater for disequilibrium situations with the transactors being pushed off their demand functions. Consequently monetary variables appear in the private expenditure and price equations in the form of first differences or rates of change. When equilibrium is re-established these variables drop out so that the level of expenditure is independent of the quantity of money.

The basic identity underlying these models is that defining the changes in the money supply (defined as sterling M3 minus public sector deposits) i.e.:

$$\Delta M = PSBR - \Delta B + \Delta L + CA - \Delta F - \Delta OL - \Delta DG \qquad (2.9)$$

where OL = net non-deposit liabilities of the banks

F = Stock of overseas assets held by the nbps

DG = Public sector bank deposits (all currencies)

CA = current balance of payments.

ΔOL and ΔDG are treated as exogenous. Both the quarterly and the annual model consist of nine equations and all other components of identity (2.9) are explained within the model.

Discussion begins with the annual model. The PSBR is defined in the customary manner with real government expenditure, average tax rates and transfers being treated as exogenous. Sales of government bonds are essentially demand determined with an equation of the following functional form:

$$(\Delta B/EP) = f^{n}(RG;\ RLR^{*};\ \Delta RLR^{*};\ \Delta RSR;\ M/EP;\ L/M) \qquad (2.10)$$

where EP = nominal private expenditure

RLR = long-term rate of interest

RSR = short-term rate of interest

all other variables as before

The interest rate terms reflect returns on bonds and competing assets though it is perhaps surprising that the level of interest rates is used for the domestic long-term rate of interest since portfolio theory would suggest that the stock of bonds held depends on the level of interest rates. The last two terms are 'disequilibrium' terms representing the "fact that the demand for debt is considered in the context of a portfolio that includes bank loans, money and real goods "(Hilliard [1980] page 7).

The flow of bank lending to the private sector is defined by an equation similar in structure to that specifying bond sales:

$$(\Delta L/EP) = f(D;\ \Delta S;\ \Delta EP;\ RLR;\ M/EP) \qquad (2.11)$$

where D = total bank deposits

S = the exchange rate

all other variables as before

In addition dummy variables are incorporated to capture the effects of lending restrictions, special and supplementary special deposits, direct credit controls and the pressure of demand. The variable M/EP is a disequilibrium term with the same rationale as in the bond sales equation. ΔS is justified as an expectational variable with an appreciation fostering favourable expectations for the economy. The rate of change of expenditure (ΔEP) is justified by an appeal to the accelerator mechanism since "there is a financing mechanism prior to the actual delivery of goods" (Hilliard [1980] page 7). Interest rates have proved to be a problem in estimating this equation. The rate on bonds originally appeared with a positive sign. This caused simulation problems since a rise in the rate of interest increased bond sales reducing monetary growth but it also led to an increase in bank lending which offset the former effect. Attempts to include the own rate of interest were unsuccessful so the sole remaining interest rate effect is the world long-term rate of interest.

The surplus/deficit on the current account of the balance of payments arises from the equations specifying exports and imports. These are fairly traditional demand type equations with the flow of goods depending on i) relative prices and ii) demand variables. Private sector capital flows are mainly determined by domestic credit expansion relative to nominal private sector expenditure both here and in the USA. The rationale for this is that the higher DCE is relative to expenditure the greater the ability to invest abroad. Other determinants are i) changes in the current account and ii) exchange rate expectations proxied by current movements in the exchange rate. The equation therefore takes the following form:

$\Delta F = f^n(DCE;\ EP;\ DCE(US);\ EP(US);\ CA;\ \Delta S)$ (2.12)

where ΔF = private sector capital inflow

all other variables as before and US indicates an American Variable

A single equation determines private sector real expenditure. This captures the monetarist (Friedman school) principle that money affects both prices and real output in the short run but only prices in the long run. This is achieved by including in the set of dependent variables i) the long-term rate of interest and ii) changes in current and lagged values of real balances and rates of interest. Consequently long-run equilibrium output is independent of the money supply but dependent on the long-term rate of interest. In its turn the long-term rate of interest is set at a fixed differential above the corresponding rate in the USA and is therefore independent of monetary influences in long run equilibrium. In the short run, however, the long-term rate of interest can be driven away from the fixed relationship by changes in i) the short rate ii) the rate of inflation, iii) in the exchange rate and iv) in foreign currency reserves. The short-term rate is treated as a policy variable and is therefore formally exogenous.

The price equation specifies the rate of inflation as being dependent on i) the level of the ratio of the money supply to nominal private expenditure, ii) the rate of monetary expansion and iii) changes in sterling import prices, private sector real expenditure and the nominal short-term rate of interest. Elimination of variables expressed as rates of change etc. produces an equation specifying a long-run relationship between the price level and real private sector expenditure. An alternative explanation for this equation is that it represents an implicit demand for money function of the following form:

$$(M/P)^d = \alpha EP^\beta \qquad (2.13)$$

There is no direct provision for the transmission of monetary changes via the exchange rate which is determined by a reaction function. The basic idea in estimating this equation was the consideration of a range of variables representing possible final and intermediate targets. Selection was made according to the performance of the variable concerned. Four influences were found to be significant. These were i) UK sterling prices relative to dollar prices, ii) the level of capacity utilisation, iii) the current account of the balance of payments deflated by nominal private sector expenditure and iv) the amount by which the domestic long-term rate of interest exceeds the world rate.

The quarterly model follows the same basic principles though with some differences of detail. For example the bond-sales equation omits the disequilibrium variable (BL/M) but includes new variables such as i) exchange rate changes and ii) UK inflation rates relative to those in the USA. These last two variables were used to represent market confidence. Similarly the bank-lending equation omits the special deposits dummy variables and also the disequilibrium variable (M/P). The rate of interest is not included as a determinant of private sector expenditure in the long-run equilibrium but does appear in the long-run implicit money demand function. The consequences of these changes are fairly small and do not affect the basic hypothesis that money alters prices and real expenditure in the short run but only prices in the long run.

2.8 The Liverpool Model

In contrast with the other models discussed in this chapter, apart that is from the Bank of England small monetary model, the Liverpool model is a small scale annual model consisting of some 20 or so equations. Consequently unlike the Treasury, Bank of England and National Institute models there is no detailed specification of flows of funds between the various sectors. Rather long-run portfolio growth conditions are required. The model was first published in Minford, Brech and Matthews [1978] and the version described below is contained in Minford, Marwaha, Matthews and Sprague [1984].

Because the underlying rationale of the Liverpool model is fundamentally different from that of the other models so far examined, it is necessary to look at these differences before discussing the monetary sector of the model. First, it is an equilibrium model and markets are assumed to clear in an 'ex ante' sense. That is agents are assumed to agree wages over the coming contract period which equate expected demand and supply. Errors in expectations may lead to 'ex post' excess demand or supply but such errors will become one of the factors affecting the next contract. Second expectational variables are widely used in the model and are assumed to be generated according to the rational expectations hypothesis and are therefore model predictions of the relevant variables. Third, and closely related to the previous point, financial markets are assumed to be efficient so that expected real returns for similar types of assets are equal across domestic and in some cases foreign markets.

As noted earlier interest rate determination within the model reflects the efficient markets hypothesis in two directions. First the 'strong' Fisher hypothesis so that both the short-term and the long-term rates of interest are equal to the real rate plus the relevant rate of inflation. Second, efficiency in the foreign exchange markets is assumed so that the two interest rates are equal to their US counterparts after allowing for the relevant expected real exchange rate change. Consequently domestic real rates of interest are determined by the exogenous world rates together with the expected change in the real exchange rate. Demand for goods will also be influenced to the extent that the real rate of interest changes.

The monetary sector of the Liverpool model is quite small with no specification of the behaviour of the banking system. The precise details of the sector vary according to the exchange regime which applies. In the fixed exchange version of the model the supply of money is determined by demand with foreign currency reserves acting as a slack variable to absorb the difference between money demand and domestic credit. This adjustment takes place via the capital account of the balance of payments which is not explicitly modelled. Equilibrium is ensured by Walras's law given that the remaining markets are in equilibrium. The demand for money function is expressed in ratio form with the ratio of money demanded (in real terms) to total financial wealth as the dependent variable. This ratio depends on total wealth (negatively), the short-term rate of interest (negatively), the price variance variable (positively) and a time trend (positively). Since financial assets can be held in the form of money or bonds, the money demand equation also implies a demand for bonds function. The situation changes for the floating exchange rate regime where the money supply is controlled by the government. The precise process is a feedback rule with the percentage growth in the money supply being determined by the equilibrium budget deficit as a percentage of GNP and the equilibrium rate of inflation. The previous money demand equation applies.

2.9 Mean-Variance Portfolio Studies of the UK Financial Sector

A number of studies following the Tobin/Markowitz mean variance approach portfolio have been carried out with the purpose of explaining the behaviour of the banking sector. These include Parkin, Gray and Barrett [1970], Courakis [1974], White [1975], Bewley [1981] and Spencer [1984]. The objective of these studies was limited to the explanation of the quantities of the various assets held whilst treating the structure of interest rates as exogenous.

Parkin et al studied the behaviour of the London Clearing Banks for the period 1953 to 1967 using quarterly data. The endogenous items of their balance sheets comprised call loans, Treasury bills, commercial bills and bonds. All other items including bank advances were treated as exogenous. The normal balance sheet constraints were incorporated in the equations together with the assumption of symmetry due to the assumption of normality. Consequently the estimated equation system took the following form:

$$Y_t = \theta R_t + \lambda X_t + \psi D \qquad (2.14)$$

with the following balance sheet constraints

i The matrix θ was symmetric

ii $i'\theta = 0$

iii $i'\lambda = -1$

iv $i'\gamma = 0$

v $\gamma i' = 0$ (no constants were included)

where:

Y = a vector of endogenous variables

R = a vector of relevant interest rates

I = a vector of relevant exogenous variables.

D = relevant dummy variables

The expected rates of interest were proxied by quarterly averages of actual interest rates set at the end of the relevant thirteen weeks. Assets appearing in the equations were in real terms being deflated by the implicit GDP deflator. Satisfactory estimation results were obtained with six out of the ten independent interest rate coefficients being significantly different from zero. However there appears to be one oddity in the results in that Treasury bills and commercial bills are complements rather than substitutes

Courakis [1974] provides a more detailed study of the portfolio decisions of the London Clearing banks using the same data and time period as Parkin et al [1970]. The classification of the balance sheet assets/liabilities into exogenous and endogenous variables was also the same. The greater detail concerned the assumptions underlying the utility function. Estimating equations were derived from both i) a quadratic utility function and ii) the negative exponential utility function noting the fact that the negative exponential function implies absolute risk aversion i.e. that the degree of risk aversion is invariant to changes in wealth. A minor difference between the two studies was that utility functions in the Courakis study were expressed in terms of expected wealth whereas those in Parkin et al were in terms of expected profits. These two approaches should however be equivalent.

In addition a distinction was made between what Courakis called myopic and non-myopic models. In the former case, in addition to the normal balance sheet constraints, the effects of the exogenous variables on specific endogenous variables were constrained to be equal for all exogenous variables. The rationale for this additional constraint is that banks are concerned only with the composition of the choice (i.e. endogenous) set variables in their portfolio. The non-myopic model removed this additional constraint on the grounds that banks are influenced and concerned with the composition of their total portfolio. Four models were therefore specified:

Quadratic Utility Function: Myopic and Non-myopic

Negative Exponential Utility Function: Myopic and Non-myopic

Again like Parkin et al, the stocks of assets/liabilities were deflated by the implicit GDP deflator but Courakis also reports that estimates in nominal terms did not differ significantly from those expressed in real terms. Estimation was carried out by the full maximum likelihood method and similar balance sheet constraints as the Parkin study were imposed with the exception of symmetry in the case of the quadratic utility functions.

The results showed no support at all for the myopic models. Improved, but not completely satisfactory, results were obtained using the non-myopic assumptions. The negative exponential utility function results were particularly unsatisfactory with respect to interest rate coefficients. The own-rate coefficients were always negative and insignificant whereas cross-rate coefficients were often positive. The non-myopic results were better in this respect. Own-rate coefficients were always positive and in two cases significant whereas cross-rate coefficients were generally negative. Nevertheless the general tenor of the results forced Courakis to conclude that "this most general of the Tobin/Markowitz hypotheses here presented has also to be rejected as failing to provide a statistically significant explanation of the British clearing banks over the relevant period" (Courakis [1974] page 192).

White [1975] using quarterly data for the period 1963 to 1970 examined the behaviour of the deposit banks (i.e. the London Clearing, Scottish and Northern Ireland banks). Both static and dynamic models were estimated with the various asset/liability demand equations being derived using the negative exponential utility function. Unlike Parkin et al the stocks of the assets/liabilities were in nominal terms. A further difference arose in the case of bank advances. Instead of treating all advances as exogenous, White made a distinction between endogenous and exogenous advances. Exogenous advances comprise loans to the public sector plus those made to finance exports under official schemes. Remaining advances were treated as endogenous on the grounds that, although lending ceilings were in force, actual lending frequently diverged from those ceilings. Normal balance sheet constraints were imposed including that of symmetry for the estimation of the static model but the results were always inferior to those when the symmetry condition was not imposed. Two methods of representing expected interest rates were tried; i) current average quarterly interest rates and ii) average quarterly rates with Almon lags. Method (ii) always provided superior results.

White's results were also less than satisfactory so he noted that "whether the models tested were static or dynamic, the signs of the estimated coefficients of the interest rate variables used were not always those expected on a priori grounds" (White [1975] page 496). White attributed this to the high degree of multicollinearity amongst the various interest rates.

The study of London Clearing bank portfolio behaviour contained in Bewley [1981] is essentially an extension of the work carried out by Parkin et al [1970] and White [1975]. The period covered by the study i.e. 1963 to 1971 is again prior to the introduction of Competition and Credit Control. The portfolio model is derived from a negative exponential utility function in expected profits. The estimated model was, in terms of the previous terminology, dynamic and non-myopic with the usual balance sheet constraints being observed. Symmetry was not imposed. The main differences between this study and the earlier studies are i) the use of monthly rather than quarterly data ii) the classification of advances into endogenous or exogenous according to the severity of the lending restrictions in operation and iii) estimation was subject to the restriction of a desired liquid asset ratio. Apart from the treatment of advances, the classification of endogenous and exogenous variables follows White [1975]. Valuation of the assets/liabilities was in nominal terms.

The estimation procedure provided for direct estimation of the equilibrium parameters. It was not found possible to reject the imposed desired liquid asset restriction at the 2.5% level of significance. The equilibrium parameters were reasonably well determined. Own-rate coefficients were positive with the exception of that pertaining to government securities. Cross-rate coefficients were generally, but not always, negative - those with positive signs not being significantly different from zero. Bewley expressed the view that the negative own-rate coefficient for government securities could be explained by the fact that "banks were more concerned with the capital value of the securities resulting in a tendency to sell as rates rose" (Bewley [1981] page 201).

Spencer [1984] estimated a model of bank behaviour over the period 1972 to 1984 following the same general principles as the earlier Parkin et al study. A simple exponential utility function was employed to explain the behaviour of the choice assets of the banking sector; i.e. cash balances, reserve assets, local authority deposits, gilt edged securities and net money market assets. All liabilities were treated as exogenous as was the variable 'advances'. The own-interest rate coefficients all take a positive sign and are significant.

2.10 Further Studies of the UK Money Supply

In this section we consider further studies of the UK money supply process. These are Crouch [1967], Melitz and Sterdyniak [1979] and Kearney and MacDonald [1984).

Crouch's study followed the money base approach. During the observation period (i.e. 1954 to 1965) the banks were subject to two ratios (a cash ratio of 8 per cent and a liquid asset ratio of 30 per cent, reduced to 28 per cent in 1964) but Crouch argued that the basic determinant of the supply of bank deposits was the banks' holdings of notes and coins plus their deposits at the Bank of England. Two models were presented in the study - one aggregated all bank deposits whereas the other distinguished between demand and time deposits. The underlying rationale was the same for both models which contained equations specifying i) the demand for bank deposits, ii) the supply of bank reserves and iii) the supply of bank deposits. The models were closed by the incorporation of a simple quantity theory with the flow of nominal income as the dependent variable.

The supply of reserves to the banks is a function of i) the demand for cash, ii) open market operations and iii) special deposit calls. This equation is of course very close to being an identity and the estimated coefficients were not significantly different from their expected values of -1, +1 and -1 respectively. The supply of bank deposits was specified to be a function of the supply of reserves available to the banks. Estimation of this equation produced a coefficient close to the value of 12.5 predicted by the monetary base approach since the cash reserve ratio was 8% at this time. The demand for bank deposits depends on nominal income and the long-term rate of interest.

The causation in the model is quite clear. The supply of reserve assets available to the bank permits the creation of bank deposits which are willingly held given the level of nominal income and the rate of interest. The supply of reserve assets depends mainly on government monetary policy and there was no attempt to incorporate any link between the PSBR and the quantity of reserve assets.

Unlike Crouch, Melitz and Sterdyniak start from the balance sheet identities defining the public, banking and non-bank private sectors. The model consists of seven equations specifying i) the rate of interest on loans, ii) the demand for bank loans, iii) a set of equations defining portfolio equilibrium i.e. the ratio of deposits to money, the demand for money and the ratio of private sector holdings of government debt to money, iv) the structure of interest rates on government debt and v) balance sheet identities.

The specification of the various equations follows fairly standard lines. The supply of bank loans depends on the rate of interest on bank loans and also reserve requirements but this equation is inverted to obtain the rate of interest on bank loans as the dependent variable. The demand for bank loans depends on a variety of interest rates including that on loans, real income and the expected rate of inflation. Similarly the portfolio equations include as explanatory variables, rates of interest and real income. The spread of interest rates on government debt is based on the principle that the government sets the price of both long and short-term securities so as to obtain a desired relationship between the return on these two types of securities. However this relationship will vary positively according to the foreign rates of interest and the rate of inflation. Implicit in this specification is a concern by the authorities over the size of the monetary base. consequently rises in long-term rates of interest may be necessary in the conditions mentioned above to persuade the private sector to take up government long-term debt and avoid increases in the monetary base. Estimation runs over the period 1963 to 1974 using quarterly data [5].

The chain of causation in the model can be described by the following simple framework. Banks set the rate of interest on loans and the private sector determines the quantity of such loans given the rate of interest and the price level. Similarly the government sets the rate of interest on its debt and the private sector determines the quantity of public sector debt it wishes to hold. The quantity of money follows from an accounting identity given the quantity of bank loans and additional information concerning the size of the PSBR, official reserves and the net worth of the banks. The existence of the demand for money function determines either the price level or the change in foreign reserves depending on the exchange rate regime in operation.

Kearney and MacDonald [1984] follow a different approach from the other studies discussed so far since the main thrust of their study is directed towards an explanation of price variables such as rates of interest and the exchange rate rather than the quantity variables. Their model is a structural portfolio balance model of the sterling/dollar exchange rate consisting of four asset demand equations explaining the demand for money, bank loans, domestic bonds and foreign assets. Their approach follows the traditional portfolio approach incorporating the adding-up restraints imposed by the balance sheet identities (see, for example, Brainard and Tobin [1968]). The stocks of assets are given historically so that the market clearing mechanism determines the returns on these assets and also the exchange rate given the uncovered foreign rate of interest. Expectations are held constant within the model though Kearney and MacDonald [1985] present a variation of the model incorporating expectations formed according to the rational expectations hypothesis. The model can then be used to explain movements in the exchange rate given changes in the stocks of assets and in the composition of the asset portfolio of the private sector due, for example, to intervention in the foreign exchange markets by the authorities.

2.11 Conclusions

We will now draw together the main strands of our discussions in order to highlight the similarities and differences of the main models surveyed. Apart from their different sizes, the first major point is that the Liverpool model is not like the other models. It does not follow the traditional income/expenditure approach that they adopt. The role of stocks as opposed to flows is of vital importance in the explanation of private sector expenditure. A second important difference concerns the role of of expectations. In the Liverpool model expectations are assumed to be formed according to the rational expectations hypothesis. In practice this implies that, within the model, agents' expectations are consistent with the model forecasts. Closely associated with this is the assumption that financial markets conform to the 'efficient markets hypothesis'. This stance is not taken up by any of the other models, although some of them have methods of expectation formation which use variables which would play an important role in the rational expectations approach. For example, in the Treasury model, the underlying speculators' view of the equilibrium exchange rate is a weighted average of relative quantities of money and wage costs in the UK and the rest of the world.

The remaining models all follow the broad income/expenditure approach. Although, as a result, the real sectors are quite similar the monetary/financial sectors are widely different. Both the Treasury and National Institute models contain well articulated monetary sectors. Explanation of financial behaviour in the National Institute model hinges around two basic identities: the financing of the PSBR and the consolidated balance sheet of the banking sector. The Treasury model goes further and ensures that sectoral surpluses/deficits are allocated between the various financial assets and liabilities in a manner which ensures consistency between prices and quantities of the various assets/liabilities. Consequently the financial sector of the Treasury model is more closely integrated into the real sector than is the case for the National Institute model. The Bank of England main model incorporates a flow of funds matrix which involves a relatively large degree of disaggregation. In contrast the Cambridge Economic Policy Group and London Business School models have poorly defined monetary sectors. Single equations (representing both demand and supply factors) explain the quantity of money in both models. In all five models the structure of interest rates hinges around the determination of a central or key interest rate though, monetary factors have an important role in interest rate determination only in the Treasury model. For this latter model the key rate is the three month deposit rate which is set to clear the parallel money market. For the National Institute model (the Treasury bill rate) and the London Business School model (MLR prior to to the change in system of monetary control) interest rates are mainly determined by government exogenously. In the Bank of England main model interest rates are related to the Eurodollar rate and other variables including price expectations, pressure in the foreign exchange markets and the PSBR. In the Cambridge Economic Policy Group model the short-term rate of interest is constrained to equal the Eurodollar rate of interest subject to the influence of bank liquidity.

Wide differences appear in the process of exchange rate determination within the models. In the Treasury model the exchange rate is implicitly rather than explicitly determined and the model can either predict the exchange rate given assumptions about the volume of official intervention in the foreign exchange markets, or the change in reserves given the desired path of exchange rate changes. Monetary factors are important in this process because of their influence on private sector expenditure decisions and capital flows. Also, the underlying equilibrium exchange rate depends on relative quantities of money and wage costs in the UK and the rest of the world. For the National Institute model, the exchange rate follows purchasing power parity in the long run but can be driven away from this equality by covered interest differentials and the real balance of payments visible balance. This latter variable is a proxy for expected exchange rate changes. Clearly, monetary factors have a less important role in exchange rate determination in the National Institute model than in the Treasury model. In the London Business School model, monetary factors play a dominant role. For the Bank of England main model, the sterling exchange rate reflects relative rates of inflation and monetary expansion in the UK and the USA, interest rate differentials and the current account of the Balance of Payments. Expectations also play a role and a reaction function divides this pressure between changes in the rate itself and in reserves. In the Cambridge Economic Policy Group model the exchange rate is treated as exogenous in as much as it is determined by government policy.

As far as the money supply itself is concerned, the common feature of the studies surveyed in section 2.10 is the fact that bank holdings of base/reserve assets play a role in the determination of the quantity of money. This contrasts with the stance adopted in the macroeconomic models. Despite the fairly detailed specification of the financial sector in the Bank of England main model, the National Institute and Treasury models, supply influences via bank holdings of reserve assets play no role in the determination of the quantity of money. This view is in direct opposition to both the money market and credit market approaches to the determination of the money supply mentioned in chapter 1 section 1. In chapter 3 we develop an alternative theoretical specification of a financial/monetary sector of an economy which incorporates demand and supply features in accordance with the credit market approach.

Notes

1 More detailed discussion of the mainstream UK macroeconomic models is contained in Holden, Peel and Thompson [1982]. Further discussion of the main models of the UK economy is also available in Artis [1982], Brech [1983] and Wallis et al [1984]. In this study we concentrate on the financial sectors of the various models.

2 Included in the return on gilts is the variable 'expected capital gains' which itself is a function of the long-term rate of interest (positively) and the short-term rate (negatively) as well as the expected change in prices and the ratio of the public sector borrowing requirement to the net worth of the public sector. Lagged independent variables are included with opposite signed coefficients to ensure that permanent changes in these variables do not induce persistent expectations of capital gains/losses. The expected change in prices depends, in this instance, on the past growth of wage costs, import prices and of the money supply relative to output changes.

3 The error correction model has been suggested by Hendry amongst others (see for example Hendry [1979]). It sidesteps the problem of assessing how expectations are formed and concentrates on how agents move towards a desired long-run relationship. Currie [1981] points out that, whilst the static long-run properties of such models are "typically sensible and

well determined", their "long-run dynamic properties are often not" (page 704).

4 Keating [1984) presents a disaggregated structural model of UK financial flows which is fully integrated with the London Business School model. The procedure adopted follows the mean variance approach to portfolio modelling.

5 The unusual aspect of this study is the precise definition of money used. Two alternative definitions of the quantity of money were employed but both definitions were in fact wider than the official definition of M3. The narrower definition specified money as M3 plus all national savings and deposits with local authorities. The wider definition added deposits with the building societies.

CHAPTER 3 THE ANALYTICAL FRAMEWORK

In contrast to the empirical models discussed in chapter 2 we develop a stylised portfolio balance model of the financial sector of the UK economy. This is a small-scale model designed purely to illustrate the essential nature of the more detailed empirical model; the specification of which is discussed in chapters 4 and 5. We incorporate within the model the portfolio behaviour of both the banking and non-bank private sectors. As mentioned in chapter 1 this aspect of the study owes much to development of the theoretical credit market models by Brunner and Meltzer (see e.g. [1964] and [1968]).

The plan of this chapter is as follows. Section 2 presents an algebraic description of this simple theoretical portfolio balance model within the environment of a pure floating exchange rate and examines the comparative static properties of the model. In section 3 we present a graphical representation of the same model in order to illustrate more clearly the relevant properties of the model. Finally in section 4 we examine the dynamic behaviour of the model.

3.1 Analysis of the Model

The analysis in this section draws heavily on De Grauwe, Frattiani and Nabli [1985] which in turn refers to earlier work by Brunner and Meltzer [1968], Brainard and Tobin [1968] and de Grauwe [1982]. In this simple model, we start with the volume of saving and investment into real assets as being given so that the next decision in the portfolio choice is the allocation of financial wealth between the various financial assets and liabilities. The non-bank private sector holds four assets - notes and coins (NC); bank deposits, all assumed for the sake of ease of exposition to be interest bearing, (D); government bonds (B); and a net composite foreign currency asset (F) - and one liability, bank credit (L). A simplified flow chart illustrating the various options open to the the non-bank private sector is shown in figure 3.1 where, in addition to the standard abbreviations, DAS represents gross domestic assets (NC+D+B) and NDA net domestic assets (DAS-L). The banking sector supplies bank loans and bank deposits and holds reserve assets - monetary base - (HB), net foreign assets (SFB) and government bonds (BB). The two balance sheet identities representing this framework are shown below:

Non-bank private sector

$$NC + D + B + F.S - L = W \qquad (3.1)$$

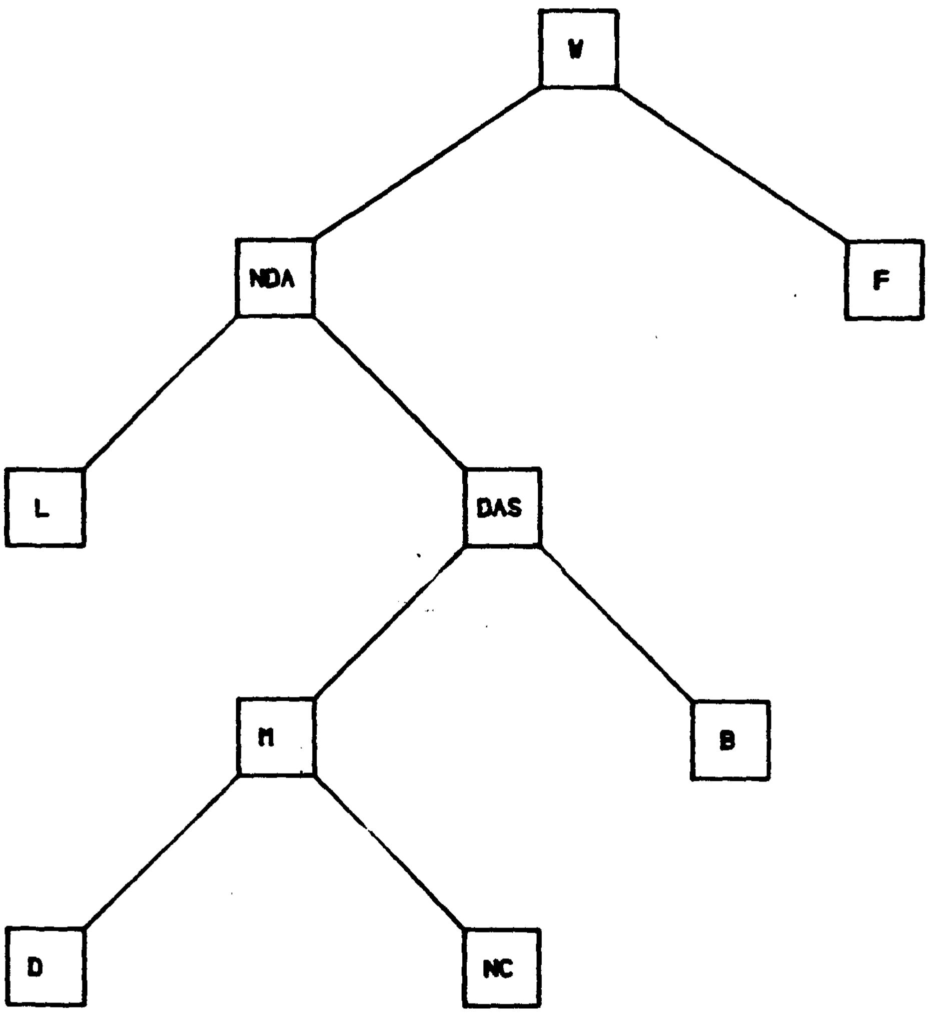
Banking sector

$$D = HB + BB + L + SFB \qquad (3.2)$$

FIGURE 3.1

NON-BANK PRIVATE SECTOR

HIERARCHY OF PORTFOLIO DECISIONS



In addition two definitions are pertinent to the analysis:

Definition of monetary base

$$H = NC + HB \tag{3.3}$$

Definition of money

$$M = NC + D \tag{3.4}$$

where S is the spot exchange rate (units of domestic currency per unit of foreign currency).

Note in this framework we are concentrating on financial assets so that W represents net financial wealth of the non-bank private sector and also we are assuming that the net worth of the banking sector is zero.

The assets within the non-bank private sector portfolio are assumed to be gross substitutes so that an increase in the return on one asset leads to an increase in the demand for that asset and to a decrease or no change in the demand for other assets. An increase in wealth is assumed to induce increased holdings of all assets and to induce a greater willingness to accept more liabilities (i.e. bank loans). The following set of asset/ liability demand equations reflect these assumptions:

$$NC = \tau(\overset{-}{RD};\ \overset{-}{R^{*}+E_tLnS_{t+1}-LnS_t};\ \overset{+}{W}) \tag{3.5}$$

$$D = \epsilon(\overset{+}{RD};\ \overset{-}{RL};\ \overset{-}{RG};\ \overset{-}{RD^{*}+E_tLnS_{t+1}-LnS_t};\ \overset{+}{W}) \tag{3.6}$$

$$B = \mu(\overset{-}{RD};\ \overset{+}{RG};\ \overset{-}{RD^{*}+E_tLnS_{t+1}-LnS_t};\ \overset{+}{W}) \tag{3.7}$$

$$F = \psi(\overset{-}{RD};\ \overset{-}{RG};\ \overset{+}{RD^{*}+E_tLnS_{t+1}-LnS_t};\ \overset{+}{W}) \tag{3.8}$$

$$L = \theta(\overset{-}{RL};\ \overset{+}{R^{*}+E_tLnS_{t+1}-LnS_t};\ \overset{+}{W}) \tag{3.9}$$

where

RG, RD and RL refer to the rates of interest on government bonds, deposits and bank loans respectively, * indicates the foreign rate of interest and the term $E_tLnS_{t+1}-LnS_t$ represents the expected appreciation of the foreign exchange rate. (LnS = the log of the exchange rate S; units of domestic currency per unit of foreign currency)

Note following Brainard and Tobin [1968] the column sum of the coefficients (including -L) are for i) the interest rates, zero and ii) the wealth term, 1.

The underlying rationale for the banking sector supply equations is, as noted earlier, the multiplier analysis of Brunner and Meltzer. Assuming that the non-bank private sector maintains currency in a ratio ω to deposits (assumed for the sake of ease of exposition to be a constant), i.e.

$$NC = \omega D \qquad (3.10)$$

and noting from the balance sheet identity (3.2)

$$L + BB = D(1-\lambda-\rho) \qquad (3.11)$$

where λ = the banks' reserve asset ratio (HB/D)

ρ = the bank's foreign asset ratio (FB/D)

and using identities (3.3) and (3.4) it is trivial to derive the two relevant multipliers [1]:

$$M = [(1+\omega)/(\omega+\lambda)]H \text{ or } M = mH \qquad (3.12)$$

$$BB+L = [(1-\lambda-\rho)/(\omega+\lambda)]H \text{ or } BB+L = eH \qquad (3.13)$$

Note as is well known from the work of Brunner and Meltzer, the credit multiplier (e) is not the mirror image of the money multiplier (m).

Assuming that the banks set the rate of interest on loans to maximise their profits given the following profit function:

$$\Pi = D[(1-\lambda)RL-RD] - \pi D \tag{3.14}$$

where π is the cost of supplying deposits (assumed to be a constant, again for ease of exposition).

The first order condition for profit maximisation requires:

$$RL = (RD+\pi)/(1-\lambda) \tag{3.15}$$

Consequently

$$RD = (1-\lambda)RL-\pi \tag{3.16}$$

We can replace RD by RL in (3.5) to (3.9) and combine equations (3.5) and (3.6) to produce a money demand equation using the assumption that the coefficient for RD (and therefore RL) in (3.5) is greater in absolute value than that in (3.6):

$$M^{d} = \gamma(\overset{-}{RL};\ \overset{-}{R^{*}+E_{t}LnS_{t+1}-LnS_{t}};\ \overset{+}{W}) \tag{3.17}$$

Similarly it is more convenient to replace (3.12) and (3.13) by their functional forms which are assumed to be:

$$M^{s} = \Omega(\overset{+}{RL};\ \overset{-}{R^{*}+E_{t}LnS_{t+1}-LnS_{t}};\ \overset{-}{\lambda};\ \overset{+}{H}) \tag{3.18}$$

$$L^{s} = \theta(\overset{+}{RL};\ \overset{-}{RG})\alpha(\overset{+}{RL};\ \overset{-}{R^{*}+E_{t}LnS_{t+1}-LnS_{t}};\ \overset{-}{\lambda};\ \overset{+}{H}) \tag{3.19}$$

$$BB = (1-\theta)(\overset{+}{RL};\overset{-}{RG})\alpha(\overset{+}{RL};\ \overset{-}{R^{*}+E_{t}LnS_{t+1}-LnS_{t}};\ \overset{-}{\lambda};\ \overset{+}{H}) \tag{3.20}$$

The negative signs assigned to both $\delta M/\delta RC^{*}$ and $\delta L/\delta RC^{*}$ follow from the assumption that an increase in the covered foreign rate of interest lowers deposits more than currency i.e. the value of ω is increased. In fact as we note later the UK monetary authorities have not attempted to control the quantity of monetary base (H) but have rather fixed the rate of interest and have been prepared to supply the quantity of monetary base demanded at that rate [2]. Consequently it is necessary to replace the variable H in (3.18) to (3.20) by the money-market rate of interest (RM) noting that an increase in RM leads to a reduction in the monetary base (H) and therefore in the money supply, the supply of credit and the banks' demand for bonds (M^s, L^s and BB respectively).

Full equilibrium requires equilibrium in all four markets but given the wealth restraint one of the demand equations becomes redundant. In the case of this model we take this to be the demand for foreign assets by the non-bank private sector leaving the model to be solved for three markets (i.e. bonds, money and credit). A further simplification for the sake of ease of exposition can be obtained by assuming bonds and loans are perfect substitutes in the banking sector's portfolio so that RL=RG. Hence equations (3.19) and (3.20) can be combined to produce:

$$L^s + BB = \phi(\overset{+}{RL};\ \overset{-}{R^* + E_t LnS_{t+1} - LnS_t};\ \overset{-}{\lambda};\ \overset{-}{RM}) \qquad (3.21)$$

where L^s+BB is often designated domestic earning assets

Equilibrium in the bond and credit markets requires that i) the demand for loans equals the supply of loans and ii) the demand by the banking sector for bonds equals the supply of bonds available to them; i.e.

$$L^s = L \qquad (3.22a)$$

$$BB = B^{*} - B \tag{3.22b}$$

Given the assumption of perfect substitution these two equations can be combined to produce:

$$L^{*} + BB = L + B^{*} - B \tag{3.22c}$$

Further simplification is possible by combining the equations for L (3.9) and that for B (3.7) using the assumption that the absolute value of the wealth coefficient in (3.9) is greater than that in (3.7). Consequently only two market clearing equations are necessary to solve for the interest rate (RL) and the exchange rate (S). These are for the money and credit markets which can be specified as:

credit market

from (3.21), (3.9) and (3.22)

$$\phi(\overset{+}{RL};\ \overset{-}{R^{*}+S^{*}-LnS_t};\ \overset{-}{\lambda};\ \overset{-}{RM}) = \theta(\overset{-}{RL};\ \overset{+}{R^{*}+S^{*}-LnS_t};\ \overset{+}{W};) + B^{s} \tag{3.23}$$

money market

from (3.17) and (3.18)

$$\Omega(\overset{+}{RL};\ \overset{-}{R^{*}+S^{*}-LnS_t};\ \overset{-}{\lambda};\ \overset{-}{RM}) = \gamma(\overset{-}{RL};\ \overset{-}{R^{*}+S^{*}-LnS_t};\ \overset{+}{W}) \tag{3.24}$$

where $S^{*} = E_t LnS_{t+1}$

Noting that financial wealth can be defined as [3]:

$$W = H + B^{*} + F.S$$

and $RC^{*} = R^{*} + S^{*} - LnS_t$

and, in order to examine the comparative static properties of the model, totally differentiating equations (3.23) and (3.24) after substituting for W and RC^{*} produces the following set of equations (3.25):

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} dRL \\ dS \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} & \beta_{16} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} & \beta_{25} & \beta_{26} \end{bmatrix} \begin{bmatrix} dRM \\ dR^{*}+dS^{*} \\ d\lambda \\ dH \\ dB^{*} \\ dF \end{bmatrix}$$

where:

$\alpha_{11} = \delta\theta/\delta RL - \delta\phi/\delta RL < 0$

$\alpha_{12} = [(-\delta\theta/\delta RC^{*} + \delta\phi/\delta RC^{*})/S] + F(\delta\theta/\delta W) < 0$ by assumption

$\alpha_{21} = \delta\Omega/\delta RL - \delta\gamma/\delta RL > 0$

$\alpha_{22} = (-\delta\Omega/\delta RC^{*} + \delta\gamma/\delta RC^{*})/S - F(\delta\gamma/\delta W) < 0$ by assumption

$\beta_{11} = \delta\phi/\delta RM < 0$

$\beta_{12} = -\delta\theta/\delta RC^{*} + \delta\phi/\delta RC^{*} < 0$

$\beta_{13} = \delta\phi/\delta\lambda < 0$

$\beta_{14} = -\delta\theta/\delta W < 0$

$\beta_{15} = -(1 + \delta\theta/\delta W) < 0$

$\beta_{16} = -S(\delta\theta/\delta W) < 0$

$\beta_{21} = -\delta\Omega/\delta RM > 0$

$\beta_{22} = \delta\gamma/RC^{*} - \delta\Omega/\delta RC^{*} < 0$ by assumption

$\beta_{23} = -\delta\Omega/\delta\lambda > 0$

$\beta_{24} = \delta\gamma/\delta W > 0$

$\beta_{25} = \delta\gamma/\delta W > 0$

$\beta_{26} = S(\delta\gamma/\delta W) > 0$

Ambiguity exists concerning the sign of three of the coefficients. In the case of α_{12}, the assumption is made that the two substitution effects ($\delta\theta/\delta RC^*$ and $\delta\phi/\delta RC^*$) dominate the wealth effect ($F(\delta\theta/\delta V)$) on the demand for credit, hence the sign of α_{12} is negative. Similarly in the case α_{22} the overall effect is assumed to be negative since two out of the three coefficients point in that direction. Finally the demand for money is assumed to be more responsive to foreign interest rate changes than the money supply so that β_{22} is negative.

Stability of the model requires:

$\alpha_{11} + \alpha_{22} < 0$

and $\quad Det = \alpha_{11}\alpha_{22} - \alpha_{12}\alpha_{21} > 0$

Both these requirements are satisfied but it should be noted that in this respect the assumed signs of α_{12} and α_{22} play a crucial role. In chapter 8, we discuss three simulation experiments showing the response of the model to shocks in the uncovered foreign rate of interest (R^*), the domestic money-market rate of interest (RM) and the current account surplus (equivalent to a change in F). The comparative static analysis of these shocks can be derived by solving the equation set (3.25) using Cramer's rule. The resulting multipliers are shown in Table 3.1.

Table 3.1

Change in	RL	S
R*	$(\beta_{12}\alpha_{22}-\alpha_{12}\beta_{22})/Det$	$(\alpha_{11}\beta_{22}-\alpha_{21}\beta_{12})/Det$
	> 0 provided	> 0
	$\beta_{12}\alpha_{22} > \alpha_{12}\beta_{22}$	
RM	$(\beta_{11}\alpha_{22}-\alpha_{12}\beta_{21})/Det$	$(\alpha_{11}\beta_{21}-\alpha_{21}\beta_{11})/Det$
	> 0	> 0 provided
		$\lvert\alpha_{11}\beta_{21}\rvert > \lvert\alpha_{21}\beta_{11}\rvert$
F	$(\beta_{16}\alpha_{22}-\alpha_{12}\beta_{26})/Det$	$(\alpha_{11}\beta_{26}-\alpha_{21}\beta_{16})/Det$
	> 0	> 0 provided
		$\alpha_{21}\beta_{16} > \alpha_{11}\beta_{26}$

As can be seen from Table 3.1 three out of the six multipliers have ambiguous signs. These ambiguities can be further clarified by examining the various derivatives which comprise the relevant multiplier. This is carried out below:

a The effect of a change in R* on RL

The relevant multiplier is $\beta_{12}\alpha_{22}-\alpha_{12}\beta_{22}/Det$.

$\beta_{12}\alpha_{22}= (-\delta\theta/\delta RC^{*} + \delta\phi/\delta RC^{*})[(-\delta\Omega/\delta RC^{*}+ \delta\gamma/\delta RC^{*})/S - F(\delta\gamma/\delta W)]$

$\alpha_{12}\beta_{22}= [(-\delta\theta/\delta RC^{*} + \delta\phi/\delta RC^{*})/S +F(\delta\theta/\delta W)](\delta\gamma/\delta RC^{*}-\delta\Omega/\delta RC^{*})$

Given that both $\beta_{12}\alpha_{22}$ and $\beta_{22}\alpha_{12}$ are both > 0, this multiplier is more likely to be positive the larger $\beta_{12}\alpha_{22}$ is relative to $\beta_{22}\alpha_{12}$. $\beta_{12}\alpha_{22}$ will be larger the larger in absolute values are:

$\delta\theta/\delta RC^{*}$; the derivative of the demand for loans with respect to the covered foreign rate of interest

$\delta\phi/\delta RC^{*}$; the derivative of the supply of loans w.r.t. the covered foreign rate of interest

$\delta\gamma/\delta RC^{*}$; the derivative of the demand for money w.r.t. the covered foreign rate of interest

$\delta\gamma/\delta W$; the derivative of the demand for money w.r.t. wealth

and the smaller in absolute value is:

$\delta\Omega/\delta RC^{*}$; the derivative of the supply of money w.r.t. the covered foreign rate of interest

In contrast $\beta_{22}\alpha_{12}$ will be smaller the smaller in absolute value are:

$\delta\gamma/\delta RC^{*}$; the derivative of the demand for money w.r.t. the covered foreign rate of interest

$\delta\theta/\delta RC^{*}$; the derivative of the demand for loans w.r.t. the covered foreign rate of interest

$\delta\phi/\delta RC^{*}$; the derivative of the supply of loans w.r.t. the covered foreign rate of interest

and the larger are:

$\delta\Omega/\delta RC^*$; the derivative of the supply of money w.r.t. the covered foreign rate of interest

$\delta\theta/\delta V$; the derivative of the demand for loans w.r.t. wealth

b The Effect of an Increase in RM on S

The relevant multiplier is $\alpha_{11}\beta_{21}-\alpha_{21}\beta_{11}/\text{Det}$.

$\alpha_{11}\beta_{21}= (\delta\theta/\delta RL - \delta\phi/RL)(- \delta\Omega/\delta RM)$ and

$\alpha_{21}\beta_{11}= (\delta\Omega/\delta RL - \delta\gamma/\delta RL)(\delta\phi/\delta RM)$

Given that both $\alpha_{11}\beta_{21}$ and $\alpha_{21}\beta_{11}$ are both < 0, this multiplier is more likely to be negative the larger $\alpha_{11}\beta_{12}$ is and the smaller $\alpha_{21}\beta_{11}$ in absolute value.

$\alpha_{11}\beta_{21}$ will be larger the larger in absolute value are:

$\delta\theta/\delta RL$; the derivative of the demand for loans w.r.t. the loan rate

$\delta\phi/\delta RL$; the derivative of the supply of loans w.r.t. the loan rate

$\delta\Omega/\delta RM$; the derivative of the supply of money w.r.t. the money market rate

$\alpha_{21}\beta_{11}$ will be smaller the smaller in absolute value are:

$\delta\Omega/\delta RL$; the derivative of the supply of money w.r.t. the loan rate

$\delta\phi/\delta RM$ the derivative of the supply of loans w.r.t. the money market rate

$\delta\gamma/\delta RL$; the derivative of the demand for money w.r.t. the loan rate

c The Effect of an Increase in F on S

The relevant multiplier is $\alpha_{11}\beta_{26}-\alpha_{21}\beta_{16}/\text{Det}$.

$\alpha_{11}\beta_{26}= (\delta\theta/\delta RL - \delta\phi/\delta RL)\{S(\delta\gamma/\delta W))$

$\alpha_{21}\beta_{16}= (\delta\Omega/\delta RL - \delta\gamma/\delta RL)\{-S(\delta\theta/\delta W))$

Given that both $\alpha_{11}\beta_{26}$ and $\alpha_{21}\beta_{16}$ are < 0, the multiplier is more likely to be positive the smaller in absolute value is $\alpha_{11}\beta_{26}$ and the larger $\alpha_{21}\beta_{16}$

$\alpha_{11}\beta_{26}$ will be smaller the smaller in absolute value:

$\delta\theta/\delta RL$; the derivative of the demand for loans w.r.t. the loan rate

$\delta\phi/\delta RL$; the derivative of the supply of loans w.r.t. the loan rate

$\delta\gamma/\delta W$; the derivative of the demand for money w.r.t. wealth

$\alpha_{21}\beta_{16}$ will be larger the larger in absolute value:

$\delta\Omega/\delta RL$; the derivative of the supply of money w.r.t. the loan rate

$\delta\gamma/\delta RL$; the derivative of the demand for money w.r.t. the loan rate

$\delta\theta/\delta W$; the derivative of the demand for loans w.r.t. wealth

Clearly the direction of these three multipliers depends on the magnitude of a whole host of derivatives and consequently it is difficult to derive any firm 'A Priori' conclusions. Recourse to the assumption of gross substitutability fails to assist since most of the multipliers are based on either own interest rate coefficients or cross interest rate coefficients rather than a mixture of both. Nevertheless it is possible to make some comments. First the direction of multipliers (b) and (c) above are likely to be the same since for example small absolute values of $\delta\theta/\delta RL$, $\delta\phi/\delta RL$ and a large absolute value for $\delta\Omega/\delta RL$ are likely to lead to both multipliers being positive. The position with respect to multiplier (a) above is less clear cut since the effect of the various derivatives often point in different directions; for example a large $\delta\gamma/\delta W$ leads to a greater possibility that both $\beta_{12}\alpha_{22}$ and $\beta_{22}\alpha_{12}$ will be positive.

We now turn to present a graphical analysis of the model in section 3.2 in order to ascertain whether it is possible to obtain a clearer intuitive picture of the comparative static properties of the model.

3.2 A Graphical Representation of the Model

In order to present the graphical analysis the two equilibrium equations (3.23) and (3.24) are presented below in linear form:

credit market

$$\alpha_1 RL+\alpha_2(R^*+S^*-LnS)+\alpha_3(H+B^e+F.S)+B^m = \alpha_4 RL+\alpha_5((R^*+S^*-LnS)$$

$$+\alpha_6\lambda+\alpha_7 RM \qquad (3.26)$$

$\alpha_1, \alpha_5, \alpha_6, \alpha_7 < 0 < \alpha_2, \alpha_3, \alpha_4$

note α_1 to α_3 refer to demand factors and α_4 to α_7 to supply side influences

money market

$$\beta_1 RL+\beta_2(R^*+S^*-LnS)+\beta_3\lambda+\beta_4 RM = \beta_5 RL+\beta_6(R^*+S^*-LnS)+$$

$$\beta_7(H+B^e+F.S) \qquad (3.27)$$

$\beta_2, \beta_3, \beta_4, \beta_5, \beta_6 < 0 < \beta_1, \beta_7$

note β_1 to β_4 reflect supply influences and β_5 to β_7 demand factors

Figure 3.1 shows these two equilibria conditions in the RL/S plane given a fixed expectation of future exchange rates (i.e. S^* is assumed to be constant). CM refers to the credit market and MM to the money market. The CM curve is derived from (3.26) as follows. First the equation is solved for the loan rate producing:

$$RL = [-\alpha_3 F.S+(\alpha_2-\alpha_5)LnS+(\alpha_5-\alpha_2)(S^*+R^*)-\alpha_3 H$$

$$-(1+\alpha_3)B^e+\alpha_6\lambda+\alpha_7 RM]/(\alpha_1-\alpha_4) \qquad (3.28)$$

The negative slope of the CM curve can be demonstrated by differentiating RL w.r.t. S and defining $1/(\alpha_1-\alpha_4)$ as Z (<0) so as to give:

$$\delta RL/\delta S \ (CM) = Z[-\alpha_3 F+ (\alpha_2-\alpha_5)/S] \qquad (3.29)$$

Noting that α_1, α_5 and Z are < 0 and α_2, α_3 and α_4 are > 0; and assuming that F > 0 (as is the case of the UK non-bank private sector), $\delta RL/\delta S$ will be negative provided the magnitude of α_2 minus α_5 (the degree of substitutability of domestic for foreign loans in the demand for and supply of bank credit) is sufficient to outweigh the wealth effect (α_3) [4]. The economic interpretation of the negative slope of the CM line is that a rise in the loan rate will cause excess supply in the loan market. This can only be eliminated by a fall in the spot exchange rate given the expected rate which causes the covered rate of interest to rise making domestic borrowing relatively more attractive to domestic firms but the foreign market relatively more attractive for lending by domestic banks. Note that the substitution effect is assumed to offset the wealth effect (i.e. the reduced demand for loans due to the fall in the exchange rate) so that the excess supply of loans is eliminated. The depreciation of the $ exchange rate is initially caused by banks switching currency from overseas to domestic lending. We have drawn the CM curve to represent this assumption.

The MM curve is derived in a similar manner. Solving (3.27) for RL produces:

$$RL = [(\beta_2-\beta_6)LnS+\beta_7F.S+(\beta_6-\beta_2)(S^*+R^*)-\beta_3\lambda-\beta_4RM$$
$$+\beta_7(H+B^*)]/(\beta_1-\beta_5) \qquad (3.30)$$

Differentiating (3.30) w.r.t. S and defining $v = 1/(\beta_1-\beta_5)$ (>0) provides:

$$\delta RL/\delta S \ \langle MM\rangle = v[(\beta_2-\beta_6)/S]+\beta_7F) \qquad (3.31)$$

Noting that β_7 and v are > 0 whereas β_2 and β_6 are < 0 and given F > 0; $\delta RL/\delta S$ will be > 0 provided that the demand for money is more responsive to changes in the foreign rate of interest than the supply of money (i.e. β_6 > β_2 in absolute value) [5]. In this case the economic interpretation is that a rise in the loan rate, through its effect on the deposit rate, causes excess supply in the money market. Since both the demand for and the supply of money are negatively related to the covered foreign interest rate, it is necessary that the $ spot exchange rate rises so as to eliminate the excess supply of money (i.e. the covered foreign rate of interest falls). In this case the rise in the exchange rate increases wealth which also assists the elimination of excess supply of money by raising demand. The rise in the spot exchange rate comes about through purchase of foreign currency as the demand for domestic currency falls. The MM curves in the following figures are drawn reflecting this assumption. The question now arises whether any firm prediction can be made concerning the slopes of the curves. De Grauwe et al [1985] argue that the loan rate is proximately determined in the credit market and the exchange rate in the money market with the result that the CM curve is flatter than the MM curve. This seems a not-unreasonable assumption given the relative ease of changing domestic monies into foreign currency. It would also be expected that the loan rate of interest will be more directly affected by conditions in the credit market rather than those appertaining to the money market. In terms of equations (3.28) and (3.30) this represents:

i) Relatively large magnitudes for α_1 and α_4 but relatively small values for α_2 and α_5. The assumption of gross substitutability will ensure this condition.

ii) Relatively small values for β_1 and β_5 but relatively large values for β_6 and β_2. The assumption of gross substitutability does nothing to help in this respect

We have also accepted this assumption that the CM curve is flatter than the MM curve.

We now examine the asset market equilibrium to analyse the stability of the model. This is carried out using the phase diagrams depicted in figures 3.2 to 3.4. which reflect the assumptions made earlier that i) the loan rate of interest is proximately determined in the credit market and ii) the exchange rate is proximately determined in the money market. Point A in Figure 3.2 illustrates a position of excess supply in the credit market which will be eliminated by a fall in the loan rate of interest. The converse is true for point B. Turning to figure 3.3 point C demonstrates excess supply in the money markets which will be eliminated by a rise in the exchange rate. The converse is applicable to point D. Combining figures 3.2 and 3.3 produces figure 3.4 demonstrating stability in all four zones of the diagram. In this connection it is instructive to examine the critical nature of the assumption lying behind the negative slope of the CM curve. Reference to (3.29) shows that the slope of the CM curve would be positive if the wealth effect outweighs the substitution effect. Figure 3.5 represents this situation but with the assumption that the slope of the CM curve is steeper than that of the MM curve. Note that now instability is demonstrated in zones 2 and 4. Furthermore, as is well known (see for example

FIGURE 3.2: PHASE DIAGRAM 1

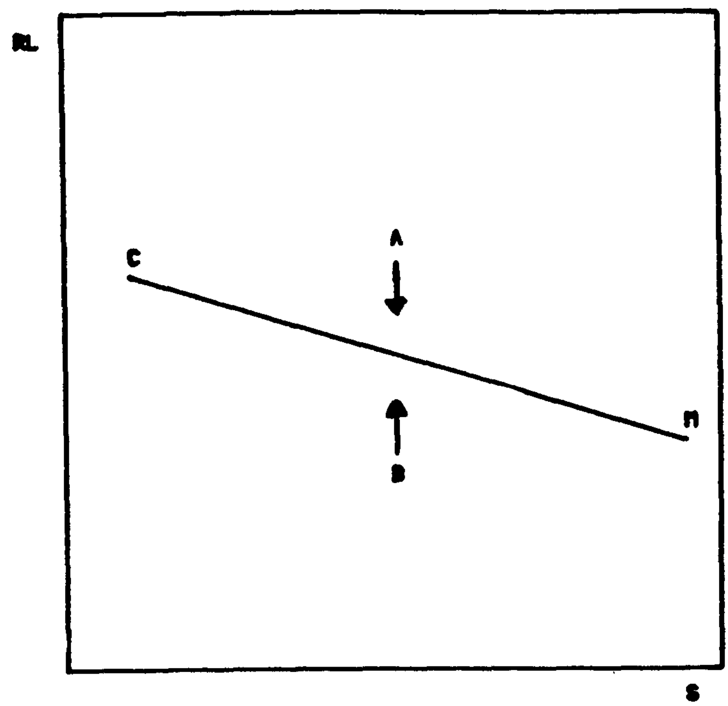


FIGURE 3.3: PHASE DIAGRAM 2

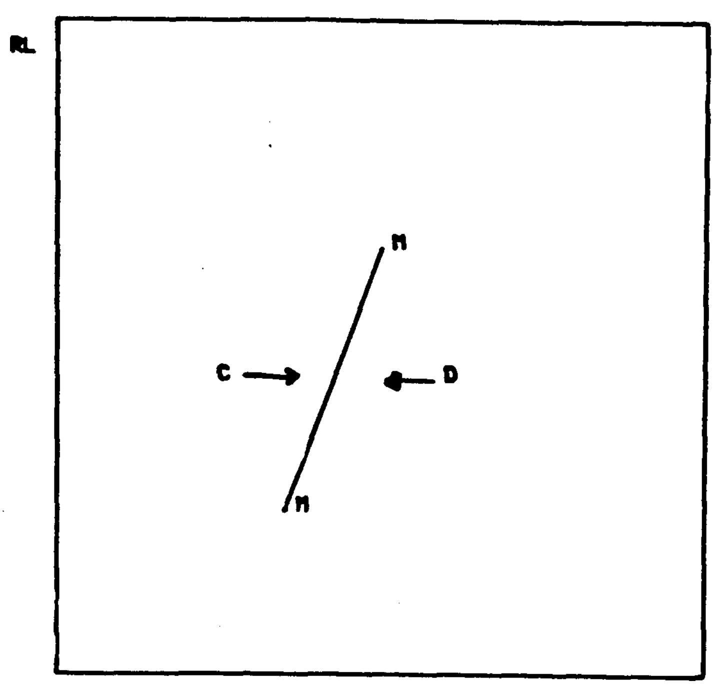


FIGURE 3.4: PHASE DIAGRAM 3

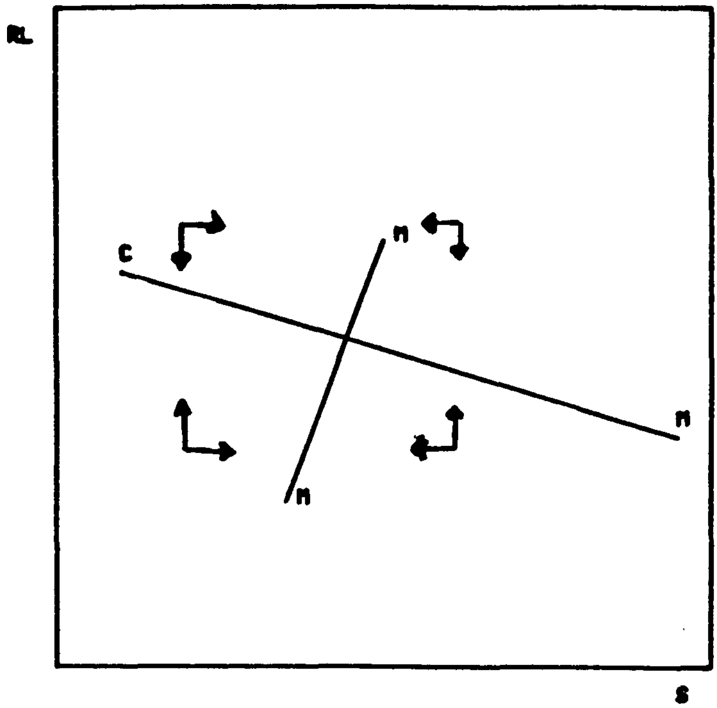
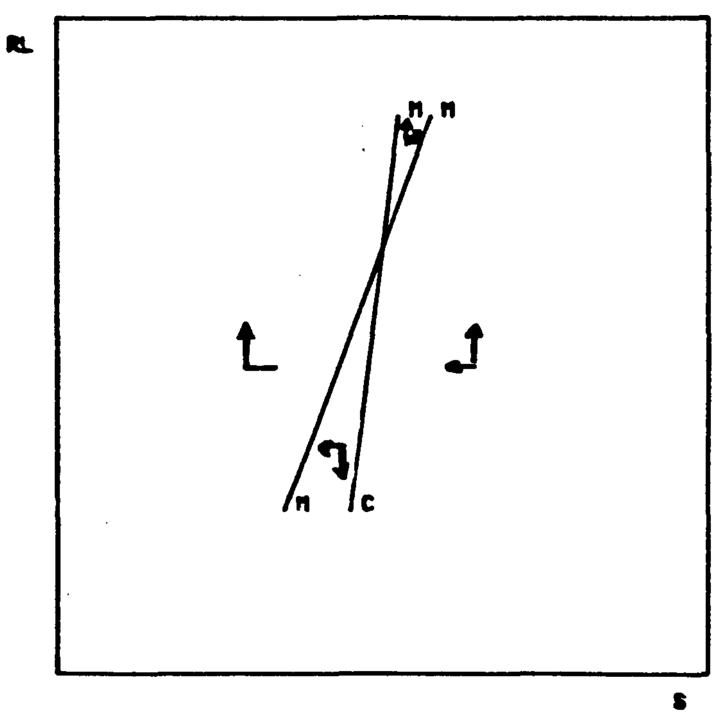


FIGURE 3.5: PHASE DIAGRAM 4



Allen and Kenen [1980], page 205), instability can also be introduced if F is negative as this will reduce the negative slope of the CM curve and similarly for the positive slope of the MM curve

Shifts in the two curves can also be defined with regard to the partial derivatives of the two market clearing equations. For the CM curve these are as follows:

Table 3.2

$\delta RL/\delta S^*$; $\delta RL/\delta R^*$	$Z(\alpha_5-\alpha_2)$	> 0
$\delta RL/\delta\lambda$	$Z\alpha_6$	> 0
$\delta RL/\delta RM$	$Z\alpha_7$	> 0
$\delta RL/\delta B^*$	$-Z(1+\alpha_3)$	> 0
$\delta RL/\delta F$	$-ZS\alpha_3$	> 0

In graphical terms, therefore, the CM curve will shift to the right (upwards) if any of the variables listed above increase. Turning now to the MM function the relevant partial derivatives are as follows:

Table 3.3

$\delta RL/\delta S^*$; $\delta RL/\delta R^*$	$v(\beta_5-\beta_2)$	< 0
$\delta RL/\delta\lambda$	$-v\beta_3$	> 0
$\delta RL/\delta RM$	$-v\beta_4$	> 0
$\delta RL/\delta B^*$	$v\beta_7$	> 0
$\delta RL/\delta F$	$vS\beta_7$	> 0

Note because of our assumptions the magnitude of these partial derivatives will be larger (and therefore produce larger movements downwards or upwards in the MM curve) than those relevant to the CM curve. In graphical terms the MM curve will shift to the right (downwards) if either S_* or R_* increase but to the left (upwards) if any of the other variables listed above increase.

We can now examine diagrammatically the effects of the changes discussed in Table 3.1. These are shown in figures 3.6 to 3.8 inclusive. First the increase in the foreign rate of interest R* creates excess demand in the loan market requiring a rise in the loan rate of interest to restore equilibrium in the credit market. This is represented by an upward shift of the CM curve to C_2M_2. In the money market, both the demand for and supply of domestic money will decrease but given our assumption that the demand for money is more responsive to changes in foreign rates of interest than the supply of money, the net effect is to create excess supply in the money market. Restoration of money market equilibrium needs a rise in the spot exchange rate which reduces the covered return on foreign assets. This is represented in figure 3.6 by a shift of the MM curve to the right to M_2M_2. The relevant partial derivatives in tables 3.2 and 3.3 confirm these shifts. Both shifts point to an appreciation of the exchange rate (defined in £ per $) but the effect on the loan rate of interest (RL) is ambiguous. The upward shift of the CM curve points towards a higher loan rate but the rightward shift of the MM curve to a lower rate. Our assumptions predict i) a steeper MM curve and ii) a smaller shift to the right of the MM curve. Both of these factors predict a probable increase in the loan rate as illustrated in figure 3.6 (i.e. point 1 to point 2). The second shock considered is a rise in the domestic money market rate of interest (RM). Figure 3.7 clearly demonstrates that the domestic rate of interest will rise since both the CM and MM curves shift upwards to C_2M_2 and M_2M_2 respectively. The economic interpretation of the shifts in the two curves is that the rise in the money market rate of interest reduces the supply of both money and credit thus causing excess demand in both the credit and money markets which can only be eliminated by a rise in the domestic loan rate (CM curve shifts upwards) and a fall in the exchange rate (MM curve shifts to the left). This is evidenced by the signs of the partial derivatives contained in tables 3.2 and 3.3. The upward shift in the CM curve produces an increase in the exchange rate whereas the shift to the left of the MM curve tends to lower the exchange rate as is illustrated by the equilibrium point B in figure 3.7. Again the predictions of our assumptions (the smaller shift to the left of the MM curve and its steeper slope) suggest that the $ spot exchange rate will depreciate. The final shock considered is an increase in net foreign wealth (F) attributable to a one-off increase in the current account. As evidenced by the signs of the partial derivatives contained in tables 3.2 and 3.3 both the CM and MM curves shift to the left to C_2M_2 and M_2M_2. As was the case in the previous shock, this is due to the creation of excess demand in both markets. This leads to an unambiguous increase in the

FIGURE 3.6: AN INCREASE IN THE UNCOVERED FOREIGN RATE OF INTEREST

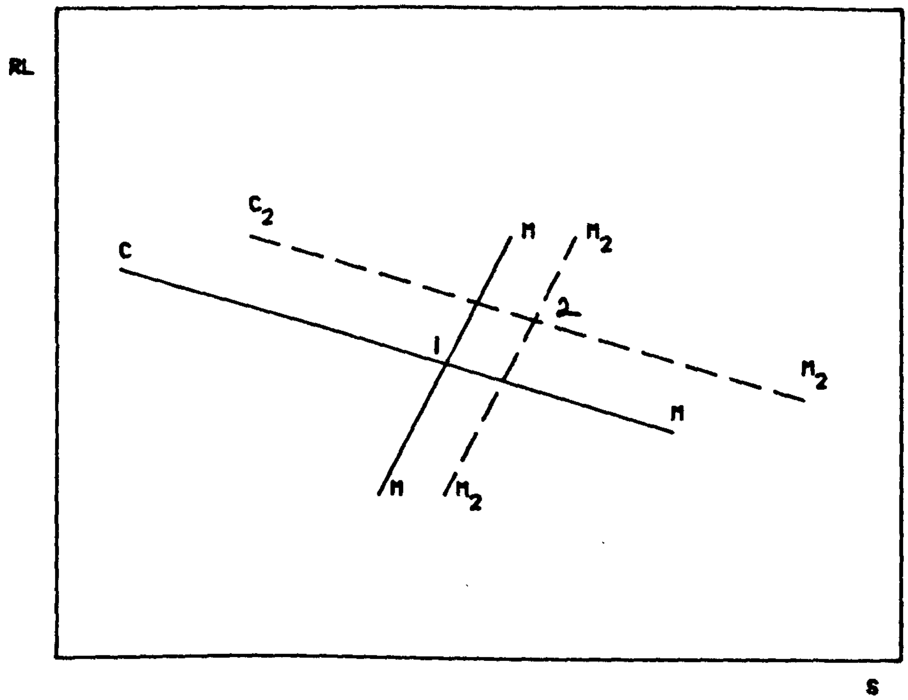


FIGURE 3.7: AN INCREASE IN THE DOMESTIC MONEY MARKET RATE OF INTEREST

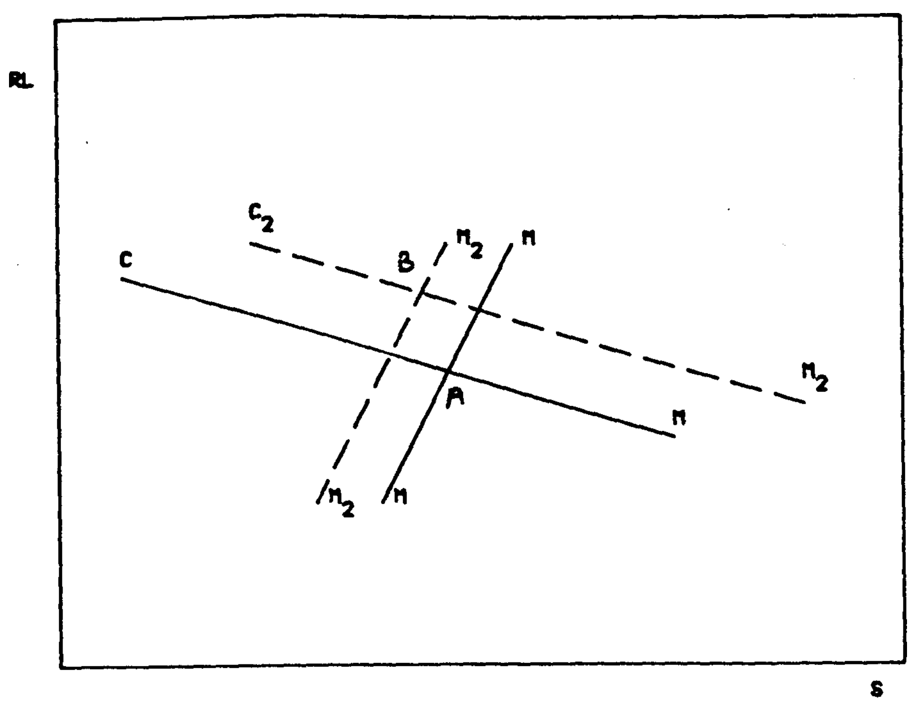
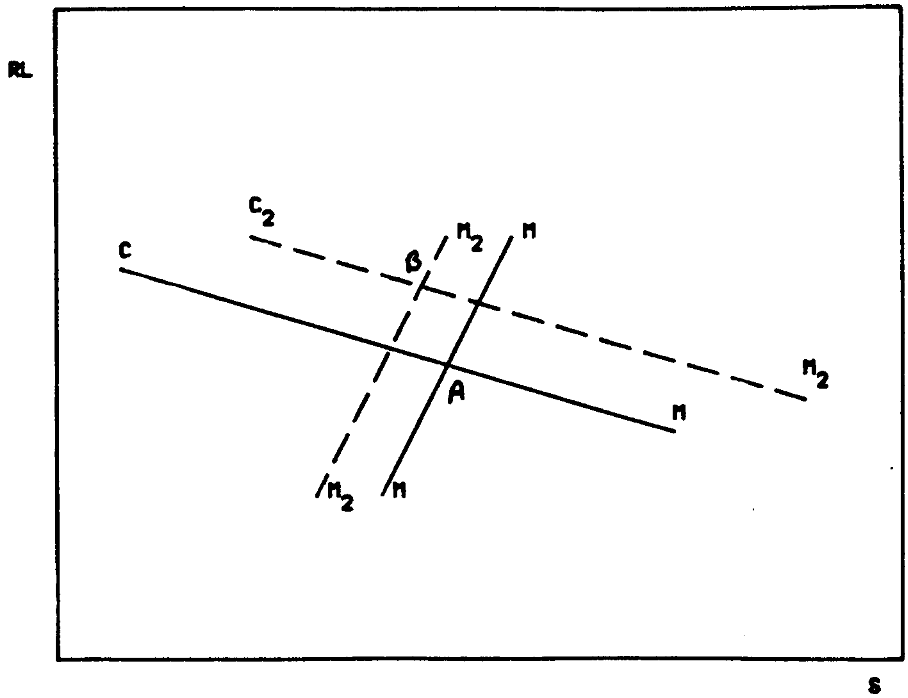


FIGURE 3.8: AN INCREASE IN NET FOREIGN WEALTH



domestic loan rate of interest. The effect on the exchange rate is however not so clear since the upward shift of the CM curve points to a rise in the \$ spot exchange rate but the shift to the left of the MM curve to a depreciation. Again appealing to the assumptions made, it would be anticipated that the \$ spot exchange rate will fall as is demonstrated in figure 3.8.

The changes discussed above assume an unchanged expected exchange rate which, itself is assumed to be determined within the framework of a more general model, and therefore correspond to a shock which is expected to be temporary. A permanent change would require a change in the expected equilibrium exchange. Note that:

$\delta RL/\delta S^{*}$ <CM> > 0

$\delta RL/\delta S^{*}$ <MM> < 0

The first shock, i.e. a rise in the uncovered foreign rate of interest, would lead to an appreciation of the \$, i.e. a fall in the log of the expected exchange rate. This would enhance the initial shifts of both the CM and the MM curves. This leaves the exchange rate as predicted but does nothing to ameliorate (and in fact increases) the ambiguity concerning the direction of the movement in the loan rate. Similarly a permanent increase in the money-market rate would lead to a fall in the expected equilibrium \$ spot exchange rate. This increases the upward shift of the CM curve but reduces that of the MM curve thus reducing the ambiguity concerning the direction of the movement in the exchange rate. With respect to the third shock, the impact of an increase in the current account balance must be temporary since portfolio equilibrium requires a zero balance on the current account as a condition of long-run equilibrium. Hence our conclusions concerning this shock are not moderated in any way.

3.3 Dynamic Properties of the Model

So far we have carried out a partial equilibrium analysis by examining the behaviour of the asset market in isolation. Clearly changes in asset market conditions will also affect the real sector. This is particularly true of the balance of payments. From the identity

$$\Delta RES = CA - \Delta F \tag{3.32}$$

with a pure float $\Delta RES = 0$ so that $CA = +\Delta F$. The long-run adjustment envisaged within Branson type models (see for example Branson and Halttunen [1979]) follows the following scheme:

i) Asset market equilibrium sets the exchange rate on a day-to-day basis given the initial values of credit and net financial assets.

ii) The exchange rate determines the valuation of net exports given the domestic price level.

iii) The current account surplus/deficit leads to a corresponding increase/decrease in net foreign assets.

iv) The change in the net value of foreign assets produces a change in the exchange rate setting off a chain of adjustment which would ultimately involve a change in the domestic price level and net exports.

v) The final equilibrium would be one where $CA = \Delta F = 0$.

To illustrate this mechanism , consider the effect of a rise in the UK domestic rate of interest starting from a position of long-run equilibrium (i.e. where $CA = \Delta F = 0$). This would produce a capital inflow and ceteris paribus a fall in the exchange rate (i.e. an appreciation of the pound) - see figure 3.7. However the new equilibrium depicted in this diagram (i.e. point B) cannot be a long-run equilibrium because of the consequential changes in net financial wealth of the non-bank private sector. This positive inflow will increase non-resident holdings of domestic assets and reduce F. Simultaneously the current account will move into deficit (following 3.32). The fall in F will cause the $ spot exchange rate (S) to appreciate (or equivalently to a depreciation of sterling) which in turn will cause a rise in UK net exports. This offsets the fall in F leading ultimately to a restoration of long-run equilibrium [6]. In terms of figure 3.7 the CM curve will shift downwards to the left (from C_2M_2) and the MM curve downwards to the right (from M_2M_2). Thus the long-run equilibrium will lie between points A and B so that the initial change (from A to B) is partially offset. This adjustment process requires two conditions for stability:

i) The Marshal-Lerner conditions are satisfied so that the current account responds positively to a devaluation of sterling.

ii) The \$ exchange rate reacts negatively to a rise in net foreign assets.

The dynamic response of the exchange rate will be subject to overshooting: a phenomenon which has been subject to fairly widespread discussion in the literature. The reason for this overshooting can be demonstrated quite easily. The return on domestic assets is defined as R and that on foreign assets so as to include the expected appreciation of the exchange rate (i.e. $R^* + \Delta S$ where $\Delta S = S^* - LnS$) [7]. Consequently a rise in the domestic rate of interest must induce a rise in the covered foreign rate of interest ($R^* + \Delta S^*$) to restore portfolio equilibrium. This is brought about by a fall in the spot exchange rate (\$/£) which, given S^* causes ΔS to increase.

3.4 Conclusions

In this chapter we have examined the specification of a theoretical portfolio balance model which we would contend is applicable to the UK economy. The impact of various shocks has been examined resulting in ambiguous predictions in some instances. The use of graphical analysis has sharpened and clarified the various assumptions necessary to produce less ambiguous predictions.

Analysis of the dynamic properties of the model suggests stability and also overshooting of the exchange rate.

We now move on to translate this theoretical framework into an empirical financial model of the UK economy. Chapter 4 examines the portfolio behaviour of the non-bank private sector and we develop a model specified in ratios rather than levels as outlined in this chapter. In fact this procedure is adopted purely to facilitate estimation of the various equations and does not affect in any significant manner the conclusions developed later in this study - see appendix 3A for further development of this point. Chapter 5 then concentrates on that of the banking sector.

Notes

1. More detailed and therefore complicated multipliers can be derived by varying the assumptions but these do not alter the basic thrust of the analysis (see e.g. Brunner and Meltzer [1964] and [1966] also Kortweg and Van Loo [1977]. Note also we are concentrating on domestic assets. The banks will also hold assets and liabilities denominated in foreign currency. However the equation specifying their holdings of net foreign-currency assets may be eliminated through the use of the banks' balance sheet constraint (3.2)given the assumption of zero net worth of the banking sector.

2. Consequently the demand for monetary base determines the market quantity given that the authorities provide the quantity of monetary base demanded at the rate of interest chosen by them.

3. From (3.1)

   $V = NC + D + B + F.S - L$

   noting from (3.2) that

   $L = D - HB - BB$

   and substituting for L produces:

   $V = NC + HB + B + BB + F.S$

   using the definitions of i) $H = NC+HB$ and

ii) $B^{*} = B + BB$ gives:

$V = H + B^{*} + F.S$

4. Note this is the same assumption made earlier to give a negative coefficient α_{12} in equation set (3.25).

5. Note this is the same assumption made earlier to give a positive coefficient β_{22} in equation set (3.25). Of course, if neither are affected, then $\delta RL/\delta S$ will be > 0.

6. Branson and Halttunen [1979] define this equilibrium as being where the sum of net exports plus investment income on net foreign assets sum to zero. In this case stability requires the trade effect to outweigh the investment income effect.

7. If domestic and foreign assets are perfect substitutes then from (3.26) $\alpha_1 = -\alpha_2 = \alpha_4 = -\alpha_5$. Similarly from (3.27) $\beta_1 = -\beta_2 = \beta_5 = -\beta_6$. Consequently this implies that the interest rate parity condition always holds so that:

$RL = RL^{*} + S^{*} - LnS.$

Appendix 3.A: Model Specification

In this appendix we use a simple three asset model (i.e. money, bonds and net foreign assets) to examine the effects of specifying a model in ratio form rather than levels. The supply of bonds, money and nominal wealth are assumed to be exogenous so that the asset market clearing equations may be specified as follows:

$$m = \alpha_1 R + \alpha_2 RC^* + \alpha_3 w \tag{3A.1}$$

$$b = \beta_1 R + \beta_2 RC^* + \beta_3 w \tag{3A.2}$$

$$s+f = \gamma_1 R + \gamma_2 RC^* + \gamma_3 w \tag{3A.3}$$

$$w = \phi_1 m + \phi_2 + z(s+f) \tag{3A.4}$$

using standard notation with small case letters representing logs, ϕ the share of the relevant asset in wealth, $z = (1-\phi_1-\phi_2)$ and $RC^* = R^*+s^*-s$

Denote equations 1 to 4 as model 1. Note this specification is quite general with no presumption that the elasticity of demand of the various assets with respect to wealth is unity.

An alternative specification in ratio form (model 2) is appended below:

$$m - b = \lambda_1 R + \lambda_2 RC^* + \lambda_3 w \tag{3A.5}$$

$$s + f - (\theta_1 m + \theta_2 b) = \Omega_1 R + \Omega_2 RC^* + \Omega_3 w \tag{3A.6}$$

$$w = \phi_1 m + \phi_2 b + z(s+f) \tag{3A.7}$$

where θ represent the share of the asset in gross domestic assets and $\theta_2 = (1-\theta_1)$. Note the term on the LHS of (3A.6) approximates $Ln[SF/(M+B)]$

Clearly equation (3A.5) may be considered as a subtraction of (3A.2) from (3A.1). Likewise equation (3A.6) may be taken to represent equation (3A.3) minus a weighted average of equations (3A.1) and (3A.2). In principle, if accurate estimates of the coefficients in equations (3A.5) and (3A.6) are obtained, it is possible to derive the coefficients for equations (3A.1) to (3A.3) by solving the following set of simultaneous equations - noting that (3A.14) to (3A.16) are given by the portfolio adding up constraints:

$$\lambda_1 = \alpha_1 - \beta_1 \quad (3A.8)$$

$$\lambda_2 = \alpha_2 - \beta_2 \quad (3A.9)$$

$$\lambda_3 = \alpha_3 - b_3 \quad (3A.10)$$

$$\Omega_1 = \gamma_1 - \phi_1\alpha_1 - \phi_2\beta_1 \quad (3A.11)$$

$$\Omega_2 = \gamma_2 - \phi_1\alpha_2 - \phi_2\beta_2 \quad (3A.12)$$

$$\Omega_3 = \gamma_3 - \phi_1\alpha_3 - \phi_2\beta_3 \quad (3A.13)$$

$$\alpha_1 + \beta_1 + \gamma_1 = 0 \quad (3A.14)$$

$$\alpha_2 + \beta_2 + \gamma_2 = 0 \quad (3A.15)$$

$$\alpha_3 + \beta_3 + \gamma_3 = 0 \quad (3A.16)$$

The analysis can be extended further by differentiating totally the two sets of equations in both models and solving for dR and dS. In model 1 one equation is redundant so we can eliminate the bond equation so as to preserve close comparability with model 2. After differentiation it is possible to eliminate the wealth identity in both models by substituting for dw in the other equations. This produces the following equation sets:

Model 1

$$\begin{bmatrix} \alpha_1 & (\alpha_3 z-\alpha_2)/S & dR \\ & & \\ \gamma_1 & (\gamma_3 z-\gamma_2-1)/S & dS \end{bmatrix} = \begin{bmatrix} -\alpha_2 & 1-\alpha_3\phi_1 & -\alpha_3\phi_2 & -\alpha_3 z \\ & & & \\ -\gamma_2 & -\gamma_3\phi_1 & -\gamma_3\phi_2 & 1-\alpha_3 z \end{bmatrix} \begin{bmatrix} dR^*+ds^* \\ dm \\ db \\ df \end{bmatrix}$$

Model 2

$$\begin{bmatrix} \lambda_1 & (\lambda_3 z-\lambda_2)/S & dR \\ & & \\ \Omega_1 & (\Omega_3 z-\Omega_2-1)/S & dS \end{bmatrix} = \begin{bmatrix} -\lambda_2 & 1-\lambda_3\phi_1 & -(1+\lambda_3\phi_2) & -\lambda_3 z \\ & & & \\ -\Omega_2 & -(\theta_1-\Omega_3\phi_1) & -(\theta_2-\theta_3\phi_2 & 1-\Omega_3 z \end{bmatrix} \begin{bmatrix} dR^*+ds^* \\ dm \\ db \\ df \end{bmatrix}$$

It can be seen that the coefficients of the two models are not inconsistent with each other.

CHAPTER 4 NON-BANK PRIVATE SECTOR PORTFOLIO SELECTION

4.1 Introduction

The basis of the analytical framework is the balance sheets of the principal sectors of the economy, i.e. the public sector, the central bank, the non-bank private sector, the banking sector and the overseas sector. It is first of all necessary to examine these balance sheets which are reproduced in table 4.1 with all the items being recorded in nominal terms and denominated in sterling. Note also physical assets are excluded from these balance sheets.

Since the aim of the study is to examine the behaviour of the assets and liabilities of the non-bank private and the banking sectors, we shall treat the assets and liabilities of the public sector (including the central bank) as exogenous. Consequently the size of the PSBR will determine the quantity of the monetary base and of bonds available to the other two sectors.

Table 4.1 Balance Sheets

The Public Sector

Liabilities		Assets	
Net overseas assets	NOSPS	Bank Deposits at:	
Foreign currency		Central Bank	DCB
borrowing from banks	BB$	Banks	DPS
Government debt		Foreign currency	
(B+BB+BSCB+BOS)		bank deposits	DG$
Net worth	NWPS		

Central Bank

Liabilities		Assets	
Notes and coins:		Foreign Currency	
held by banks	NCB	reserves	RES
held by NBPS	NC	Holdings of public	
Banks' deposits		DB sector debt	BSCB
(normal)		Loans to the	
Banks' deposits	SPECD	banking sector	CL
(special)			
Public sector			
deposits	DGCB		
Net worth	NWCB		

Overseas Sector Relative to the UK

Liabilities		Assets	
Net overseas assets:		Public sector debt	BOS
NBPS	F	Sterling bank	
Banks	-FB	deposits	DOS
Public sector	-NOSPS		
Central bank	IR		
Net worth	NWOS		

Non-Bank Private Sector

Liabilities		Assets	
Bank Loans:		Notes and coins	NC
sterling	L	Sight Deposits	DS
Foreign currency	L$	Time deposits	DT
Net financial worth	W	Foreign currency	
		deposits	D$
		Net overseas assets	
			F'
		Public sector debt	
			B

Banking Sector

Liabilities		Assets	
Private sector:		Sterling lending to:	
Sight deposits	DS	Private sector	L
Time deposits	DT	overseas sector	LOS
Public sector deposits	DPS	Foreign currency lending to:	
Overseas sterling deposits	DOS	NBPS	L$
Non-deposit liabilities	NDL	Public sector	BB$
Loans from the central bank	CL	Public sector debt	BB
Foreign currency deposits:		Monetary base (NCB+BD)	HB
NBPS	D$	Special deposits	SPECD
Public sector	DG$		
Net overseas foreign liabilities	FLB		
Net worth	NWB		

Assuming that the net worth of the banking sector is zero the following identities derived from the balance sheets in Table 4.1 hold:

Non-bank Private Sector

$$L + L\$ + W = NC + DS + DT + D\$ + F' + E \qquad (4.1)$$

Banking Sector

$$DS + DT + DG + DOS + FLB + NDL + D\$ + DG\$ + CL = L + LOS + BB + HB + SPECD + L\$ + BB\$ \qquad (4.2)$$

These identities can be further simplified. First, we aggregate, for each sector, overseas assets/liabilities and foreign currency deposits/lending with the domestic banking sector. This assumes that these two categories of assets/liabilities are close substitutes because both are subject to revaluation following exchange rate changes. Second, since our aim is to explain the behaviour of the banking and non-bank private sector, we shall treat public sector sterling deposits with the banking sector (DPS) as exogenous. Similarly central bank lending to the banking sector (CL) and sterling deposits (DOS) from overseas held with the banking sector may also be treated as being outside the immediate control of the banks given the structure of `interest rates. Consequently we combine these items with the banks' non-deposit liabilities (NDL) to produce a new composite exogenous variable, other liabilities (OL) i.e

$$OL = DPS + CL + DOS + NDL$$

These simplifications produce the following balance sheet identities which are used throughout the remainder of the study:

Non-bank Private Sector

$$L + W = NC + DS + DT + B + F \quad (4.3)$$

where $F = F' + D\$ - L\$$

Banking Sector

$$DS + DT + OL = L + BLOS + BB + HB + SPECD + FB \quad (4.4)$$

where $OL = DG + DOS + NDL + CL$

$FB = -FLB - D\$ - DG\$ + L\$ + BB\$$

In this chapter estimation of the portfolio behaviour of the non-bank private sector will be examined (i.e. the variables contained in 4.3) and the behaviour of the banking sector (items contained in 4.4) in chapter 5.

4.2 Theoretical Framework

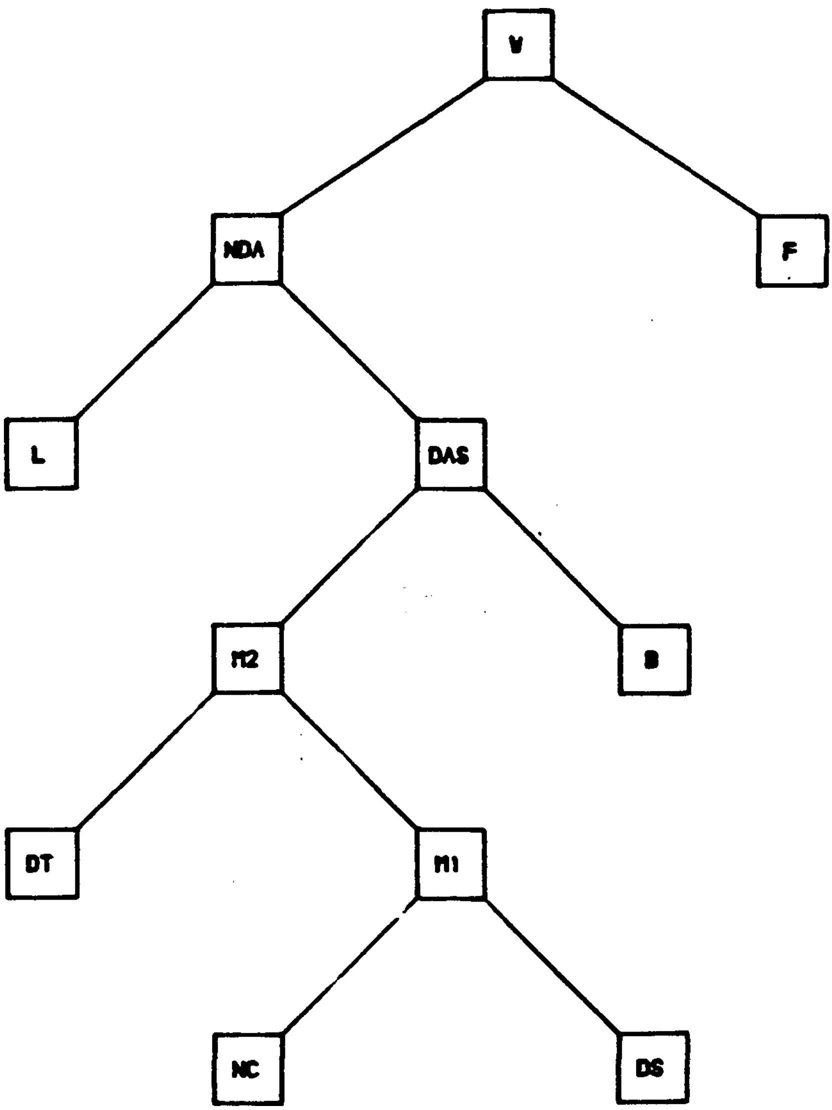
In chapter 2 we reviewed existing studies of the UK financial/monetary sector. Here we outline an alternative approach which in fact follows the methodology adopted in the Liverpool model to explain portfolio behaviour but with a greater degree of disaggregation of financial assets. The detail is also greater than that contained in the Cambridge and London Business School models. It is suggested that the non-bank private sector decision to accumulate assets can be considered to be part of a nesting process, in which closely related assets are nested at different levels so as to represent a multi-level series of sequential decisions. This is illustrated in figure 4.1.

At its highest level the decision to accumulate financial assets is part of the non-bank private sector's consumption/saving decision. Given the history of financial net worth (W) and current flow additions to it, the next decision in the sequence of decision making is at the second level where the non-bank private sector allocates its financial net worth between net domestic (NDA) and net foreign assets (F) and it is at precisely this point that this study commences with financial net worth being treated as exogenous for estimation purposes. Given the level of net domestic assets the third level of decision taking is reached with the division between gross domestic assets (DAS) and liabilities to the banking sector (L). In this way the non-bank private sector proceeds in successive stages to the determination of its portfolio of financial assets/liabilities. Next there is the allocation to liquid assets, i.e broad money (M2) and to illiquid assets (government debt, B i.e. bonds). Within the holding of money there is a further decision to be made concerning the division of money holdings between narrow money (M1) and time deposits (DT). Finally narrow money can be subdivided into holdings of notes and coins and also sight deposits. This hierarchy is, in principle responsive, to the degree of substitution between the respective nested assets. However institutional and theoretical considerations are also relevant. For instance it would be reasonable to assume that notes and coins are more substitutable with sight deposits than with bonds.

FIGURE 4.1

NON-BANK PRIVATE SECTOR

HIERARCHY OF PORTFOLIO DECISIONS



The 'utility tree' depicted in figure 4.1 is that implied by the non-bank private sector utility function in the sense of Strotz [1957]. The actual utility function employed is the 'nested' CES first put forward by Sato [1967] which has the additional advantage of powerfully simplifying the analytical and estimation problems. This utility function in its 'nested' form can be represented by the following series of functions:

$$U = [\alpha_1 (F)^{-\lambda} Z_{1j}^{e_{1j}} + \alpha_2 (NDA)^{-\lambda} Z_{2j}^{e_{2j}}]^{-1/\lambda} \quad (4.5)$$

$$F = [\alpha_3 (L)^{-\mu} Z_{3j}^{e_{3j}} + \alpha_4 (DAS)^{-\mu} Z_{4j}^{e_{4j}}]^{-1/\mu} \quad (4.6)$$

$$DAS = [\alpha_5 (M2)^{-\gamma} Z_{5j}^{e_{5j}} + \alpha_6 (B)^{-\gamma} Z_{6j}^{e_{6j}}]^{-1/\gamma} \quad (4.7)$$

$$M2 = [\alpha_7 (M1)^{-\omega} Z_{7j}^{e_{7j}} + \alpha_8 (DT)^{-\omega} Z_{8j}^{e_{8j}}]^{-1/\omega} \quad (4.8)$$

$$M1 = [\alpha_9 (NC)^{-\tau} Z_{9j}^{e_{9j}} + \alpha_{10} (DS)^{-\tau} Z_{10j}^{e_{10j}}]^{-1/\tau} \quad (4.9)$$

The Z_{ij}s represent the relevant quality variables which capture influences on the composition of portfolios other than the returns on competing assets/liabilities such as the relative riskiness of the assets or exogenous preferences affecting the composition of the portfolio. The Greek letters are parameters. There may be several components of each Z, some common to each asset (e.g. financial wealth) and others not. For example it might be expected that inflation would affect the demand for money but not necessarily the demand for bonds. From this set of utility functions, the following asset demand equations describing the total portfolio structure of the non-bank private sector can be derived [1]:

$$Ln(L/DAS) = f^1(RL-RM;\ Z_{3j}^{e_{3j}};\ Z_{4j}^{e_{4j}}) + \epsilon_1 \quad (4.10)$$

$$Ln(M2/B) = f^2(RD-RG;\ Z_{5j}^{e_{5j}};\ Z_{6j}^{e_{6j}}) + \epsilon_2 \quad (4.11)$$

$$Ln(M1/DT) = f^{3}(RD;\ Z_{7j}e_{7j};\ Z_{8j}e_{8j})+\epsilon_{3} \qquad (4.12)$$

$$Ln(NC/SD) = f^{4}(RD;\ Z_{9j}e_{9j};\ Z_{10j}e_{10j})+\epsilon_{4} \qquad (4.13)$$

$$Ln(F/NDA) = f^{5}(RC^{*}-RG; Z_{10j}; Z_{11j}e_{11j})+\epsilon_{5} \qquad (4.14)$$

where RG is a composite rate of interest on government bonds and is assumed to be the representative rate on domestic assets, RL is the rate of interest on bank lending

Z_is are vectors of relevant quality variables

The advantage of such a process is that each decision level is separated from the ones above it and below it. Therefore at each stage it is not necessary for all assets to have the same speed of adjustment or alternatively to specify a more general adjustment process with the adjustment of each asset depending on lagged values of all other assets. This avoids irksome conditions that are an essential component of the normal demand system portfolio adding up constraints. Within this hierarchy we expect that highly liquid assets have a much faster speed of adjustment than fairly non-liquid assets. As noted appendix 3.A, this procedure is used purely as a tractable modelling framework and none of the predictions of the model depend critically on the precise functional form adopted for the equations.

Table 4.2 gives the expected partial effects of the quality variables on each asset/liability with YEXP and ΔPEXP representing expected permanent real income and expected inflation respectively. Traditionally it would be expected that inflation would act on nominal assets as a tax reducing holdings of such assets. It is also a stylised fact that the variability of inflation is positively correlated with the level of inflation so the higher the level of inflation, the greater is its variability. It would seem, therefore likely that its negative impact would probably be stronger on non-interest bearing assets than on interest bearing ones but we are not dogmatic about this. It may also be true that the impact will be less on variables which are held primarily for transactions purposes than those primarily held as a store of value. It would be expected that bank lending would rise with expected inflation since inflation benefits borrowers and penalises lenders. Real financial wealth (RW = W/P) would be expected to have a positive impact on all assets. It is however by no means clear that the elasticity of asset demand with respect to wealth will always be unity. We allow in the asset demand functions for the possibility that the non-bank private sector will have varying asset preferences as wealth changes.

Table 4.2 Quality Variable Effects

	Asset/Liability					
	NC	DS	DT	B	L	F
ΔPEXP	–	–	–	–	+	+
RW	+	+	+	+	+	+
YEXP	+	+	?	?	?	?

A rise in the foreign rate of interest would be expected to divert asset holdings from domestic to foreign sources. Similarly a rise in the foreign rate of interest also increases the cost of borrowing abroad consequently increases the demand for domestic bank credit. A rise in expected (i.e. permanent income) would in all likelihood raise the demand for all assets and possibly credit.

We now turn to the examination of the relative impact of these quality variables on the ratios specified as dependent variables in (4.10) to (4.14) above. In cases where the direction of the impact of a change in the quality variable is the same for both the numerator and the denominator, the direction of the impact of the quality variable on the asset/liability ratio is ambiguous. This will depend on the relative elasticities of demand for the two variables concerned. A negative (positive) coefficient would indicate that the denominator has a higher (lower) elasticity than the numerator. The 'a priori' relative impact of these quality variables is presented in table 4.3 with question marks indicating the absence of strong priors.

Table 4.3 Relative Impact of Quality Variables

	Asset/Liability Ratios				
	NC/DS	M1/DT	M2/B	L/DAS	F/NDA
ΔPEXP	?	?+	?	+	?
RW	?-	?-	?	?	?
YEXP	?-	-	?	?	?

The effect of changes in financial wealth on the ratios is not clear except that the strength of the impact may vary inversely with the extent to which the asset is held for transaction purposes. Consequently the impact on the NC/DS and M1/DT ratios would, if anything, be expected to be negative. Similarly expected income would be likely to have a negative impact on the NC/DS ratio and the M1/DT ratio. This reflects our prior view and the evidence of much empirical work that suggests a higher income elasticity on time deposits than M1 and on sight deposits as compared with cash. A rise in the foreign rate of interest would unambiguously raise the ratios L/DAS and F/NDA because domestic borrowing and the holding of foreign assets would become more attractive. The effect, if any, on ratios of purely domestic assets is not apparent. Similarly a rise in domestic rates of `interest would lower demand for overseas assets and hence the ratio F/NDA.

Increases in the rate of interest on bank deposits would make time deposits more attractive relative to other assets and hence lower the ratio of M1 to DT but raise that of M2/B. For similar reasons the ratio of M2/B would fall as the return on bonds increases. The direct impact of these interest rates on other ratios is not clear from an 'a priori' view. A rise in the rate of interest charged on bank loans should reduce the demand for bank loans and hence the ratio of bank loans to gross domestic assets subject to the condition that net domestic assets are positive [2].

Having completed the theoretical discussion of the portfolio behaviour of the non-bank private sector, we proceed to discuss the estimation of this model in the following section.

4.3 Estimation

Before proceeding to the presentation of the empirical estimates of the parameters governing the non-bank private sector's portfolio behaviour, it is necessary to make a few comments. First, full details of the data used are provided in chapter 6 but preliminary comments on both the foreign rate of interest and of the expected variables are appropriate at this stage. The 'ex ante' return on foreign assets consists of two components, the known rate of interest and the expected change in the exchange rate. The problem is how to measure the second component, i.e. the expected change in the exchange rate. One method would be to use the observed forward premium but, given our assumption of imperfect substitutability between domestic and foreign assets, we view the forward premium itself as a biased predictor of the future change in the exchange rate [a] - for a review of the empirical evidence regarding the forward rate as a predictor of the expected spot rate see Holden, Peel and Thompson [1985]. Consequently where we use the forward premium as our 'ex ante' estimate of exchange rate movements and therefore the covered foreign rate of interest (R^{*}+FP) as the return on assets denominated in foreign currency, estimation is carried out through the use of instrumental variables to overcome potential bias (see also Bean [1983]). The second point of clarification concerns the two expected variables ΔPEXP and LnYEXP. These were estimated by the McCallum technique and full details of the estimation procedure are reported in the appendix 4.A to this chapter.

The general form of the estimated equations follows the specification contained in (4.10) to (4.14) together with the addition of a time trend to capture the effect of omission of relevant variables such as technology changes. It was decided to restrict the use of the foreign rate of interest in the non-bank private sector portfolio equations to the first portfolio decision (i.e. between domestic and overseas assets) and secondly to the domestic bank borrowing decision. For the purposes of estimation, the rate of interest on gilt-edged securities was treated as exogenous. Appeal to the efficient market hypothesis would suggest that today's price is the best predictor of tomorrow's price. This assumption is also consistent with the view that the 'pivotal' rate of interest, i.e. the money-market rate, can be treated as exogenous for estimation purposes. A full listing of the model together with exogenous and endogenous variables appears as appendix 7.A.

Estimation was carried out using the TSP package. Methods of estimation included ordinary least squares (OLS), instrumental variables (Inst), and seemingly unrelated regression estimates (SURE). Whenever appropriate, the value of the first order autocorrelation coefficient used in the latter two methods of estimation was that obtained by the instrumental variable estimate. The possibility of the existence of higher order autocorrelation is considered in Appendix 4.B to this chapter. Details of estimation are reported in Tables 4.4 to 4.8. In all tables the figures shown in parenthesis represent 't' values. ρ represents the estimated first order serial correlation coefficient. Estimated coefficients for the seasonal dummies are not shown. SSR refers to the sum of the squared residuals, S to the standard error of the regression expressed as a percentage of the mean of the dependent variable. In some cases where the logarithmic ratio used as the dependent variable approaches the value of zero, a quite small absolute error produces a very large relative error. This is particularly true of the details shown in Tables 4.5 and 4.6 for ln(M1/DT) and ln(M2/BA) respectively. DW refers to the Durbin-Watson statistic, the subsequent figure in brackets refers to the Durbin 'h' statistic and b/d indicates this statistic is not defined. The sample period was 1973(1) to 1980(4).

Table 4.4 presents some estimates for the currency to sight deposit ratio for which all estimation methods produce broadly similar results. The positive sign on the interest rate coefficient suggests that sight deposits are a closer substitute to time deposits than currency. This result is highly plausible on the assumption that the interest elasticity of currency demand is less than that of sight deposits. The negative impact of expected income suggests again the wholly plausible result that sight deposits have a higher income elasticity of demand than currency. The speed of adjustment is moderate with a mean lag in the region of two quarters. Expected inflation failed to add to the explanatory power of the equation. The results broadly conform to 'a priori' expectations and appear fairly well determined. Turning to Table 4.5 we present the results of estimating the ratio of M1 to time deposits and yet again the various estimation methods produced broadly similar results which appear to be fairly well determined. The coefficient for LnRW was negative in line with our priors outlined in table 4.3. Expected inflation comes in with a positive sign (significantly different from zero in some estimates only) which suggests that this variable has a stronger impact on time deposits than that on narrow money. This is a fairly surprising result which perhaps reflects our earlier caveat suggesting the view that assets primarily used for transaction purposes may be insensitive to changes in rates of inflation. The speed of adjustment is also disappointingly slow for such a liquid variable. Inclusion of expected income failed to improve the explanatory power of this equation.

Table 4.6 presents results of the estimating equation for the ratio of broad money (M2) to bonds. Early experimentation suggested that the difference between the deposit rate and the gilt-edged rate of interest provided better estimates than that achieved through using them as separate variables. The significance of the estimated coefficients depends on the method of estimation. If this allows for the presence of first order serial correlation, then the coefficient for LnRW is highly significant whereas that for the lagged dependent variable becomes small in value and not statistically significantly different from zero. The interest rate coefficient verges on significance. The negative sign of the coefficient for LnRW suggests that the elasticity of demand for bonds with respect to wealth is higher than that for broad money. In the three functions discussed so far, the estimated coefficients for total wealth all possess negative signs which confirms the intuitive belief that the more illiquid an asset becomes the higher its elasticity with respect to total wealth. Therefore at low levels of wealth a fairly liquid portfolio should be expected and as financial wealth increases a tendency towards a more illiquid portfolio should be observed.

Bank lending to gross domestic assets proved to be problematic in estimation. The results are set out in Table 4.7. Again in

Table 4.4 Ratio of Notes and Coins to Sight Deposits

Dependent Variable Ln(NC/DS); Mean Value = -0.7426

	Constant	RD	LnYEXP	LnRW	T	Lagged Dependent Variable	ρ
OLS	12.27	0.4346	-1.040	-0.2378	0.0038	0.2288	
	(2.73)	(3.87)	(2.39)	(3.50)	(2.00)	(1.24)	
	$\bar{R}^2$ 0.8298, SSR 0.0080, S 2.50, DW 2.454 (b/d)						
OLS	6.962	0.4423	-0.5666	-0.1602	0.0017	0.5127	-0.4444
	(1.78)	(5.84)	(1.51)	(2.86)	(1.05)	(3.14)	(2.47)
	$\bar{R}^2$ 0.9681, SSR 0.0070, S 2.34, DW 2.042 (-0.31)						
INST	12.283	0.4705	-1.043	-0.2361	0.0038	0.2373	
	(2.73)	(3.77)	(2.40)	(3.47)	(1.98)	(1.28)	
	SSR 0.0080, S 2.52, DW 2.455 (b/d)						
INST	7.187	0.4541	-0.5892	-0.1606	0.0018	0.5085	-0.4392
	(1.79)	(5.75)	(1.52)	(2.86)	(1.07)	(3.07)	(2.43)
	SSR 0.0070, S 2.34, DW 2.040 (-0.32)						
SURE	9.380	0.4301	-0.5445	-0.1362	0.0016	0.5786	-0.4392
	(2.35)	(6.78)	(2.09)	(3.02)	(1.39)	(4.63)	
	SSR 0.0071, S 2.01, DW 2.151 (-0.60)						

Instruments: Constant, LnYEXP, LnRW, $Ln(NC/DS)_{t-1}$, RD_{t-1}, Seasonal Binaries.

Table 4.5 Ratio of Narrow Money to Time Deposits
Dependent Variable Ln(M1/DT) Mean Value = -0.164

	Constant	RD	LnRW	ΔPEXP	T	Lagged Dependent Variable	ρ
OLS	1.108	-1.646	-0.1111	0.6305	0.0037	0.8726	
	(0.97)	(5.63)	(1.10)	(2.05)	(2.50)	(11.48)	
	$\bar{R}^2$ 0.9379; SSR 0.0313, S 225.00, DW 2.389 (-1.22)						
OLS	1.735	-1.465	-0.1661	0.5674	0.0028	0.9261	-0.2960
	(1.73)	(5.80)	(1.89)	(2.16)	(2.12)	(14.04)	(1.52)
	$\bar{R}^2$ 0.9736, SSR 0.0291, S 217.07, DW 2.02 (-0.06)						
INST	2.634	-1.053	-0.2200	0.2860	0.0017	0.9355	
	(1.71)	(2.43)	(1.81)	(0.76)	(0.89)	(10.60)	
	SSR 0.0369, S 243.91, DW 2.61 (-1.99)						
INST	2.682	-1.121	-0.2484	0.3534	0.0014	0.9752	-0.3626
	(2.48)	(3.84)	(2.62)	(1.26)	(0.99)	(14.77)	(1.92)
	SSR 0.0313, S 225.00, DW 2.052 (-0.16)						
SURE	2.094	-1.400	-0.1469	0.4662	0.0027	0.9089	-0.3626
	(1.92)	(7.06)	(2.09)	(2.27)	(2.65)	(17.56)	
	SSR 0.0297, S 185.36, DW 1.802 (0.59)						

Instruments: Constant, LnRW, ΔPEXP, $Ln(M1/DT)_{t-1}$, RD_{t-1}, Seasonal Binaries.

this case the assumption of equality of response of the loan ratio to the various rates of interest proved to be helpful. This was achieved by the inclusion of the composite interest rate variable (RL-RG-RC*) as one of the explanatory variables. The sign of the coefficient for this variable was negative, correctly implying a negative effect from the loan rate but a positive effect from the other two interest rates. Inclusion of the expected rate of inflation consistently produced wrongly signed but statistically insignificant coefficients. This variable was therefore omitted from the estimating equation. Again the various methods of estimation produced coefficients of a broadly similar magnitude.

The results of estimating the ratio of net foreign assets to net domestic assets are set out in Table 4.8. The key variable, the difference between the foreign covered rate and the five year gilt rate was always of the right sign and significant at the 5% level suggesting strong substitution effects. The speed of adjustment is also moderate which suggest a strange asymmetry regarding the adjustment of net foreign assets vis a vis adjustment of certain domestic assets (e.g. M1 and time deposits).

Table 4.9 shows long-run estimates of the elasticity of substitution between the nested groups of assets with respect to the various quality variables. The elasticities shown are based on the instrumental variable estimates and in the case of interest

Table 4.6 Ratio of Broad Money to Bonds

Dependent Variable Ln(M2/B); Mean Value = −0.234

	Constant	RD-RG	LnRW	T	Lagged Dependent Variable	ρ
OLS	2.189	1.319	−0.1583	−0.0082	0.5522	
	(1.12)	(1.89)	(0.94)	(2.54)	(3.14)	
	$\bar{R}^2$ 0.9716 SSR 0.0671 S 226.07 DW 1.882 (3.11)					
OLS*	7.935	0.5368	−0.6599	−0.0146	0.0139	0.7811
	(3.72)	(0.67)	(3.47)	(3.80)	(0.08)	(7.06)
	$\bar{R}^2$ 0.4997 SSR 0.0568 S 205.98 DW 1.595 (3.42)					
INST	2.218	1.334	−0.1607	−0.0083	0.5498	
	(0.93)	(1.35)	(0.79)	(2.10)	(12.63)	
	SSR 0.0671 S 226.07 DW 1.880 (b/d)					
INST	7.416	2.753	−0.6026	−0.0165	0.0498	0.4759
	(2.84)	(1.97)	(2.65)	(3.88)	(0.23)	(2.56)
	SSR 0.0725 S 235.04 DW 1.890 (b/d)					
Sure	4.459	2.753	−0.6964	−0.0180	−0.0224	0.4759
	(4.97)	Imposed	(4.50)	(6.20)	(0.15)	
	SSR 0.0734 S 204.70 DW 1.666 (1.81)					

* ρ failed to converge after 20 iterations

Instruments: Constant, LnRW, T, $Ln(M2/B)_{t-1}$, RD_{t-1}, RG_{t-1}, Seasonal Binaries

Table 4.7 Ratio of Bank Lending to Gross Domestic Assets

Dependent Variable Ln(L/DAS) Mean Value = − 1.011

	Constant	RL-RG -RC*	LnRW	T	Lagged Dependent Variable
OLS	-1.979	-0.8763	0.1558	0.0003	0.8295
	(4.95)	(6.25)	(4.09)	(0.69)	(15.30)
	$\bar{R}^2$ 0.9478 SSR 0.0092 S 1.94 DW 2.30 (-0.89)				
INST	-1.998	-1.178	0.1485	0.0004	0.7793
	(4.56)	(4.01)	(3.53)	(0.74)	(10.76)
	SSR 0.0110 S 2.12 DW 2.080 (-0.25)				
SURE	-1.886	-0.8379	0.1485	0.0003	0.8375
	(5.50)	(7.28)	(4.57)	(0.75)	(18.81)
	SSR 0.0093 S 1.68 DW 2.287 (-0.84)				

Instruments: Constant, RL_{t-1}, RG_{t-1}, LnRW, $Ln(L/DAS)_{t-1}$, R*, Seasonal Binaries

Table 4.8 Ratio of Net Overseas Assets to Net Domestic Assets

Dependent Variable Ln(F/NDA) Mean Value = -2.394

	Constant	RC*-RG	LnYEXP	T	Lagged Dependent Variable
OLS	14.647	9.416	-1.565	0.0058	0.6654
	(0.33)	(3.00)	(0.35)	(0.33)	(5.53)
	$\bar{R}^2$ 0.8393, SSR 1.534 S 10.56 DW 2.190 (-0.73)				
SURE	15.305	8.219	-1.626	0.0064	0.6911
	(0.42)	(3.16)	(0.44)	(0.43)	(6.97)
	SSR 1.547 S 9.19 DW 2.184 (-0.63)				
OLS	-0.8648	8.905			0.6820
	(3.43)	(2.62)			(7.66)
	$\bar{R}^2$ 0.8509 SSR 1.542 S 10.18 DW 2.230 (-0.75)				
INST	-1.0980	12.499			0.6025
	(3.33)	(3.03)			(5.24)
	SSR 1.654 S 10.53 DW 2.112 (-0.42)				

Instruments: Constant, R^*, RG, FP_{t-1}, $Ln(F/NDA)_{t-1}$, Seasonal Binaries

Table 4.9 Relative Long-Run Elasticities

	RD	RC*	RL	RG	ΔPEXP	LnRW	LnYEXP
NC/DS	0.11	0	0	0	0	-0.48	-2.12
M1/DT	-5.37	0	0	0	2.01	-10.02	0
M2/B	0.34	0	0	-0.34	0	0.63	0
L/DA	0	0.71	-0.62	0.63	0	0.67	0
F/NDA	0	4.17	0	-3.64	0	0	0

Table 4.10 Single Equation Long-Run Partial Elasticities

	RD	RC*	RL	RG	LnRW
F	0	+4.23	0	-3.37	+5.20
B	-0.16	0	0	+0.16	+5.87
M2	+0.17	0	0	-0.17	+5.62
DT	+2.87	0	0	0	+10.63
DS	-2.55	0	0	0	+0.66
NC	-2.44	0	0	0	+0.55¶
L	0	+0.88	-0.78	+0.78	+6.72

¶ Assumed coefficient

rate coefficients are evaluated at their means. The striking feature of this table are the high elasticities for the M1/DT ratio which are coupled with a very slow adjustment and therefore low elasticities in the short run. Thus for example a 1% rise in RD causes a decrease in the ratio of holdings of M1/DT by 5.37% and similarly a rise in the ratios of NC to DS and of M2 to B of 0.11% and 0.34% respectively. From these relative elasticities it is possible to derive partial elasticities for each of the individual assets and liabilities [4]. These are presented in Table 4.10.

A word of caution is appropriate here with regard to the interpretation of these elasticities. A problem occurs with respect to the ratio Ln(M1/DT). As noted in the previous paragraph the coefficient on the lagged dependent variable implies a low response to current changes in the independent variables, a long lag (average 9 quarters) and therefore a large response in the long run. Because of the method of calculation demonstrated in note 4, the various elasticities are interdependent so that this effect spills over into the estimates of other elasticities.

Turning now to the interest rate elasticities, it is clear that they are signed in accordance with 'a priori' expectations except, perhaps, the slightly positive elasticity for broad money (M2) - a possibility noted with respect to the similar official definition of M3 by Niehans [1981]. Consequently the magnitude and sign of the partial elasticities lead to the prediction that the main effect of raising the level of domestic interest rates would be a switch from non-interest bearing money (M1) to time deposits and hence to interest bearing money (M2). In general the interest elasticities with respect to money shown in table 4.10 are higher than those published in other studies. This is particularly true with respect to those related to monetary variables. For example, Coghlan [1978] reports interest elasticities for M1 in the range between -0.1 and -0.5 for period 1964 to 1976.. Johnston [1984] quotes similar elasticities for notes and coins held by the non-bank private sector for period 1965 to 1982. In a similar manner Artis and Lewis [1976] report interest rate elasticities over the period 1963 to 1973 varying between -0.03 and -0.26 for M1 and -0.24 and -3.00 for M3. Pierce and Tyson [1985] summarise the information on short- term interest rate elasticities of the the demand for money as follows:

Broad Estimates	varying between -0.07 and -0.8
Narrow estimates	varying between -0.06 and -1.2

Turning now to the other interest-rate elasticities it is worth comparing these with those reported in Melitz and Sterdyniak [1979] who followed a similar approach to that adopted in this study - see chapter 2.10. They report elasticities of +0.35 to +0.39 for the ratio of government debt to money (broader definitions than used in this study) compared with -0.34 for the inverse of this relationship reported in table 4.9. Similarly they find own-interest elasticities of -0.35 to -0.45 for the demand for loans in real terms compared with -0.77 reported in table 4.10. Their elasticity of the demand for loans with respect to the foreign rate of interest is lower than that reported in table 4.10 - precise figures are not available because they do not report the average value for this rate.

Regarding the various wealth elasticities, it was first of all necessary to assume a particular value for one variable before it is possible to derive the other figures. Following the work of Baumol [1952] it was assumed that the elasticity of the demand for notes and coins was 0.5. Consequently it may be more correct to regard the various wealth elasticities as an index scaled relative to the assumed value of 0.5. The elasticities appear to be on the high side but it is difficult to make firm comparisons with the results of other studies because of the initial assumed value.

It would be inappropriate to claim that the estimated coefficients represent the precise population coefficients but, nevertheless, we would claim that they are reasonably illustrative of the type of functions estimated within the model. We now turn to the estimation of the portfolio behaviour of the banking sector.

Notes

1. To illustrate the methodology used we shall take the first stage of the sequence of decisions described earlier and maximise utility (U) - as defined in (4.5) - with respect to F and NDA subject to the constraint:

$$RW = F/(1+RC^{*}) + NDA/(1+R) \qquad (4N.1)$$

where RW is the present value of real net worth

RG is a composite domestic rate of interest

RC^{*} is the foreign rate of interest

Setting up the Lagrangean:

$$Lg = [\alpha_1 (F)^{-\lambda} Z_{1j}^{e_{1j}} + \alpha_2 (NDA)-\lambda Z_{2j}^{e_{2j}}]^{-1/\lambda}$$

$$+ x[F/(1+RC^{*}) + NDA/(1+RG) - RW] \qquad (4N.2)$$

and maximising we obtain the first order conditions

$$\delta Lg/\delta F = \alpha_1 U^{(\lambda+1)} F^{-(\lambda+1)} Z_{1j}^{e_{1j}} + x/(1+RC^{*}) = 0 \qquad (4N.3)$$

$$\delta Lg/\delta NDA = \alpha_2 U^{(\lambda+1)} NDA^{-(\lambda+1)} Z_{2j}^{e_{2j}} + x/(1+RG) = 0 \qquad (4N.4)$$

$$\delta Lg/\delta x = F/(1+RC^{*}) + NDA/(1+RG) - RW = 0 \qquad (4N.5)$$

From (4N.3) and (4N.4) we have

$$(F/NDA)^{-(\lambda+1)} = (1+R)[(Z_{2j}^{e_{2j}}/Z_{1j}^{e_{1j}})$$

$$(\alpha_2/\alpha_1)]/(1+RC^{*}) \qquad (4N.6)$$

Taking natural logarithms, assuming a standard lagged adjustment hypothesis and adding a disturbance term we arrive at the first estimating equation:

$$Ln(F/NDA)_t = \psi\tau LnD + \psi\tau(\theta_{2j}LnZ_{2j} - \theta_{1j}LnZ_{1j}) +$$

$$\psi\tau\{Ln(1+RG)_t - Ln(1+RC^{*})_t)\} + (1-\tau)Ln(F/NDA)_{t-1} + \epsilon_t \qquad (4N.7)$$

where $\psi = -1/(1+\lambda)$ and τ is an adjustment coefficient $0 \leq \tau \leq 1$

$$D = Ln(\alpha_2/\alpha_1)$$

Noting that Ln(1+RG) is approximately equal to RG given that RG is a small figure and similarly for RC*, (4N.7) may be written out in purely general terms as:

$$Ln(F/NDA)_t = \beta_0 + \beta_1 LnZ_{2j} - \beta_2 LnZ_{1j} + \beta_3 RG_t$$

$$- \beta_3 RC^*_t + \beta_4 Ln(F/NDA)_{t-1} \qquad (4N.8)$$

or $$Ln(F/NDA)_t = f^n\{Z_{1j};\ Z_{2j};\ RG-RC^*;\ Ln(F/NDA)_{t-1})\} \qquad (4N.9)$$

From the balance sheet constraint and given financial wealth it is possible to obtain at once the absolute level of the non-bank private sectors net foreign asset position and also its domestic asset position. Given the composite asset NDA the procedure can be taken further and subsequently employing the same principles, the series of asset functions.

2. This condition can be easily demonstrated by noting that the ratio BL/DAS may be defined as:

$$\Omega = L/(L + NDA) = f^n(RL;\ ....) \qquad (4N.10)$$

where L = domestic loans

NDA = net domestic assets

differentiating Ω with respect to RL produces:

$$d\Omega/dRL = [(L+NDA)dL/dRL - LdL/dRL]/(L+NDA)^2 \qquad (4N.11)$$

Rearranging

$$d\Omega/dRL = [1/(NDA+L)][(1-\Omega)dL/dRL] \qquad (4N.12)$$

Thus provided Ω is less than 1 (i.e. that NDA is greater than zero) dΩ/dRL is negative since dL/dRL is negative by assumption.

3. To demonstrate this point, it is only necessary to consider a situation where assets denominated in different currencies are considered by economic agents to be imperfect substitutes. Possible reasons for such imperfect substitutability include political risk, governmental regulations, potential or actual capital controls etc. In this situation, market equilibrium would require the return on domestic assets to equal the return on foreign assets plus a risk premium representing compensation for the extra risk involved in holding assets denominated in foreign currency. The relevant market clearing identity may be approximated by:

$$R = R^{*} + E_{t}LnS_{t+1} - LnS_{t} + RP \qquad (4N.13)$$

where R = representative nominal domestic rate of interest

R^{*} = representative foreign nominal rate of interest

S = spot rate (£ per $)

E = expectation operator

RP = risk premium

Terms of R, RF and RP being consistent with each other

Equality in actual or observed market opportunities would be given by:

$$R = R^{*} + FP \qquad (4N.14)$$

where

FP = forward premium or $LnFS_{t} - LnS_{t}$ with FS = forward rate with other variables as before

Substituting (4N.14) into (4N.13) and rearranging gives:

$$FP = E_{t}LnS_{t+1} - LnS_{t} + RP \qquad (4N.15)$$

hence the forward premium is a biased predictor of the expected change in the spot exchange rate given the existence of a risk premium, i.e. provided RP is not equal to zero. Tests of (4N.15) can be undertaken in two ways. First using the definition that FP = LnFS - LnS and adding S_t to both sides of (4A.15) produces:

$$E_t LnS_{t+1} = LnFS_t + RP \qquad (4N.16)$$

Hence running regressions of the form

$$LnS_{t+1} = \alpha_0 + \alpha_1 LnFS_t \qquad (4N.17)$$

should produce values for α_0 and α_1 of 0 and 1 respectively if the forward rate is an unbiased predictor of the future spot rate (i.e. RP = 0). Note in this test LnS_{t+1} is the actual spot rate in period t+1 and FS_t is the forward rate in period t. This equation tests the accuracy of FS as a predictor of the future spot rate. A more stringent test is to examine the accuracy of the forward premium as a predictor of the future change in the spot rate. This can easily be carried out by running a regression of the form:

$$LnS_{t+1} - LnS_t = \alpha_0 + \alpha_1 FP_t \qquad (4N.18)$$

$$\text{or} \quad \Delta S_t = \alpha_0 + \alpha_1 FP_t \qquad (4N.18a)$$

Again the estimated values of α_0 and α_1 should be 0 and 1 respectively. The impression conveyed by the literature is that estimates of (4N.16) are generally satisfactory but that the values of α_0 and α_1 derived from equations of the type of (4N.18a) often do not meet the 'a priori' conditions. Furthermore their explanatory power is low. The results of running regressions of the form of (4N.16) and (4N.16a) are shown below and clearly they are in accord with the general picture described above.

Estimation Period 1973(1) to 1980(4)

	Coefficient	t value
Dependent variable: LnS_{t+1}		
Constant	0.0382	0.72
$LnFS_t$	0.9206	3.70
Durbin-Watson statistic	1.278	
R^2	0.9206	
Dependent variable: ΔS_t		
Constant	-0.0081	0.42
FP_t	-0.5085	0.50
Durbin-Watson statistic	1.473	
R^2	-0.057	

Seasonal Dummies not quoted

4 Long-run partial elasticities for interest rates were calculated in the following way. Starting from the estimated Ln(M2/B) equation:

$$Ln(M2/B) + \alpha_1 RD - \alpha_1 RG + \alpha_2 LnRW + \lambda Ln(M2/B)_{t-1} + \ldots \quad (4N.19)$$

ignoring RG for simplicity of exposition then the long-run coefficients are given by:

$$Ln(M2/B) = \alpha_1/(1-\lambda)RD + \alpha_2/(1-\lambda)LnRW + \ldots. \qquad (4N.20)$$

Assuming RW is constant and abstracting from changes in the composition of wealth (since a change in RD would also alter the value of W due to valuation effects) and differentiating (4N.20) with respect to RD produces:

$$\delta LnM2/\delta RD - \delta LnB/\delta RD = \alpha_1(1-\lambda) \qquad (4N.21)$$

from the wealth identity assuming W is constant:

$$\phi_1\delta LnM2/\delta RD - \phi_2\delta LnB/\delta RD = 0 \qquad (4N.22)$$

where ϕ_1 and ϕ_2 are the respective shares of M2 and B in W

Hence

$$\delta LnM2/\delta RD = -(\phi_2/\phi_1)\delta LnB/\delta RD \qquad (4N.23)$$

Substituting (4N.23) in (4N.21) and rearranging produces:

$$-(\phi_2/\phi_1)\delta LnB/\delta RD - \delta LnB/\delta RD = \alpha_1/(1-\lambda) \qquad (4N.24)$$

Hence a solution for $\delta LnB/\delta RD$ can be obtained, which on multiplying by the average value of RD, provides and estimate of the elasticity of B with respect to RD. It is then possible to calculate the other elasticities of B with respect to interest rates and also for M2.

Turning to the Ln(M1/DT) equation, a similar methodology can be applied in conjunction with the identity:

$$\theta_1\epsilon_{M1,RD} + \theta_2\epsilon_{DT,RD} = \epsilon_{M2,RD} \qquad (4N.25)$$

where θ_1 and θ_2 are shares of M1 and DT in M2

In a similar manner it is possible to derive the remaining interest rate elasticities of the non-bank private sector portfolio assets.

The wealth elasticities can be derived directly from equation (4N.20) and the other estimated equations provided one wealth elasticity is assumed.

Appendix 4.A: The Generation of Expectational Variables

The two expectational variables were generated using the McCallum [1974] technique for obtaining consistent estimates but using a rather longer time period than that used for estimating other coefficients within the model.

For expected output we used the log of expenditure GDP at factor cost in constant 1975 prices so that:

$$E_t LnY_t = E(LnYt/Q_{t-1}) \qquad (4A.1)$$

where Q_{t-1} defines the information set in the previous quarter. In the output case the information set included lagged output values, lagged real balances and a time trend. Summary statistics are set out below:

Table 4A.1

Dependent variable	LnY
Sample period	1967(1) to 1980(4)
Mean	10.04
Standard error as percentage of the mean	0.18
R^2	0.9611
F(7,48)	194.97
Durbin"h"	0.06
n	56

The residual from this regression was further regressed on up to eight lags of itself and the information set to check for "white noise" properties. A χ^2 test supports the null hypothesis that the residuals are information free (see Godfrey [1978]).

Table 4A.2 Simultaneous Lags

k	lag	R^2	nR^2	$\chi^2_L(0.025)$
15	8	.1002	4.81	17.5
14	7	.0996	4.78	16.0
13	6	.0822	3.95	14.4
12	5	.0794	3.81	12.8
11	4	.0776	3.70	11.1
10	3	.0619	2.97	9.4
9	2	.0586	2.81	7.4
8	1	.0316	1.52	5.0

R^2n tends to $\chi^2_{(L)}$ where n = number of observations, k = the number of parameters and L the number of lags.

Generation of the expected inflation rate was more problematic. The variable used was the consumer price index, but this was generated in a forward looking manner so that:

$$E_t\Delta LnP_{t+4} = E_tLnP_{t+4} - LnP_t \qquad (4A.2)$$

$$= E(\Delta LnP_{t+4}/Qt-1) \qquad (4A.3)$$

so that $E_t\Delta LnP_{t+4}$ represents the expected annual inflation rate one year hence. The problem with such an approach is that, as is well known, the residuals from this process (which can only exploit the lagged one quarter information set) could exhibit up to fourth order serial correlation. Consequently any test of "white noise" properties must take this fact into account.

Again using the McCallum technique the dependent variable ΔLnP_{t+4} was regressed on the lagged values of the Consol rate, expansion of the U.S. money supply and the lagged real value of the U.K. money supply. Summary statistics are outlined below:

Table 4A.3

Dependent variable	ΔLnPt+4
Sample	1967(1) to 1980(4)
Mean	0.1111
Standard error as a percentage of the mean	20.52
R2	0.8011
F(10,41)	56.39
Durbin-Watson statistic	0.9438
n	52

The residuals from the expected inflation generation equations were then regressed on their own lags of up to 4 quarters. The residuals from this equation were again retained and tested for information content by regressing them on their own lags of up to eight quarters together with the information set used to generate the expectational series. The table of χ^2 statistics presented below again generally supports the null hypothesis that the residuals are information free.

Table 4A.4 Simultaneous Lags

k	lag	R^2	nR^2	$\chi^2_L(0.025)$
19	8	.4174	16.70	17.5
18	7	.3802	15.21	16.0
17	6	.3078	12.31	14.4
16	5	.2912	11.65	12.8
15	4	.2174	8.70	11.1
14	3	.1797	7.19	9.4
13	2	.1540	6.16	7.4
12	1	.1502	6.00	5.0

R^2n tends to $\chi^2_{(L)}$ where n is the number of observations and L the number of lags.

Appendix 4.B:
Autocorrelation Tests

As discussed in the main body of the text supplementary tests were carried out to check for the existence of serial correlation beyond that for first order as evidenced by the quoted Durbin-Watson statistics. The basis of these tests is the regression of the residuals on their own lagged values and all the explanatory variables (including constants and seasonal binary variables) used in the original estimating equation. In this connection the actual variables were employed rather than the instruments used in the estimation procedure. The estimating equation took the general form:

$$ERR_t = \alpha X + \Sigma \rho_k ERR_{t-k} \qquad (4B.1)$$

where X = Vector of explanatory variables appearing in the original equation

ERR = Actual - Estimated variable

The performance of (4B.1) was then compared with (4B.2)

$$ERR_t = \alpha X + \Sigma \rho_{k-1} ERR_{t-k-1} \qquad (4B.2)$$

using the likelihood ratio test to examine the hypothesis $\rho_k = 0$ against the alternative hypothesis that $\rho_k \neq 0$. These tests were carried out sequentially for each of the non-bank private sector portfolio equations until the final test took the form:

$$ERR_t = \alpha X + \rho_1 ERR_{t-1} \qquad (4B.3)$$

against the performance of the equation:

$$ERR_t = \alpha X \qquad (4B.4)$$

Absence of serial correlation requires the "χ^2" statistic for the ratio $\chi^2 = n*\ln(S^2_r/S^2_u)$ to be less than the critical value according to the level of significance adopted which was a type 1 error equal to 5%. where;

r = number of restrictions

S^2_r = restricted sum of squares

S^2_u = unrestricted sum of squares

n = number of observations

Tests were carried out to check for serial correlation up to fourth order (i.e. k = 4 in (4B.1) and (4B.2) above) and the results of the tests are shown in table 4B.1 below. There is some indication of the continued existence of serial correlation remaining within the equations since two of the tests produce "χ^2" statistics greater than the relevant critical value. One possible explanation of this is that a solution is obtained for only one expectational variable within the model namely the expected exchange rate. Two expectational variables have been estimated by the McCallum technique and are therefore assumed to be fixed. Other expectational variables from the real and overseas sector may be relevant to decisions within the financial sector and these excluded variables may be responsible for the small degree of serial correlation evidenced by the tests.

Table 4B.1 Autocorrelation Tests.

Hypotheses Null	Alternative	LNCD	LMTD	LMBA	LBLA	LDOSA
$\rho_4=0$	$\rho_1\neq0, \rho_2\neq0, \rho_3\neq0, \rho_4\neq0$	0.313	0.652	13.028¶	0.896	0.232
$\rho_3=0$	$\rho_1\neq0, \rho_2\neq0, \rho_3\neq0$	0.209	7.367¶	1.605	0.004	0.541
$\rho_2=0$	$\rho_1\neq0, \rho_2\neq0$	0.002	1.645	0.001	0.467	0.540
$\rho_1=0$	$\rho_1\neq0$	0.000	0.001	1.078	0.374	0.996

¶ indicates significance at the 5% level.

Chapter 5 Banking Sector Portfolio Behaviour

5.1 Introduction

For the purposes of this study the banking sector refers to United Kingdom offices of all banks that have agreed to observe a common ratio and other credit arrangements together with the institutions of the discount market. Unlike the official definition, it excludes the banking sector of the Bank of England. In sections 2 and 3 we examine the environment within which the banks operate and also present estimates of their portfolio behaviour.

5.2 Analytical Environment

In terms of the balance sheet identity

$$DS + DT + OL = L + BLOS + BB + HB + SPECD + FB \qquad (4.4)$$

DT, HB, BB, FB and TBL (= L+BLOS) are treated as endogenous to the banking sector, DS is to be treated as demand determined i.e. perfectly elastic in supply. The remaining two variables OL and SPECD are treated as exogenous.

Specification of the behavioural equations must reflect the institutional environment contained in the system of Competition and Credit Control which was in operation throughout the observation period though with some modifications. This system continued until 1981 and it is therefore necessary to examine briefly how it affected the money supply process. Three features are relevant in this respect. These are i) the reserve base specified for the banks, ii) the ability of the banks to create reserve assets and iii) the conduct of monetary policy.

First with respect to the reserve base, the introduction of the system of Competition and Credit Control entailed the replacement of the then existing reserve requirements (i.e. 8% cash ratio and 28% liquid asset ratio) with a single reserve ratio of 12.5% against banks' eligible liabilities [1]. Within the context of Competition and Credit Control the banks could acquire extra reserve assets either by increasing their share of a given total of such assets or alternatively by maintaining their share but increasing the total volume of reserve assets. The first method entails the banks buying reserve assets from non-bank holders of such assets. In practice the scope for such operations was likely to be limited because non-bank holdings were quite widely scattered and not particularly large relative to banking sector holdings (see e.g. Zawadski [1981]) . Consequently such a purchase operation would probably have been quite expensive. The second method involved interplay between the banks and the discount houses. Two types of transaction can be distinguished; i) operations which did not involve any increase in the scale of the discount houses' business and ii) operations which increased the scale or nature of their business. With regard to the first type of transaction, bank lending to the discount houses took two basic forms; money at call (i.e a reserve asset) and market loans (i.e. a non-reserve asset). Hence when they were short of reserves, the banks could switch their lending from market loans to money at call. This resulted in an increase in the banks' holdings of reserve assets without altering in any significant manner, either their own or the discount houses' operations. As reported by Greenwells Special Monetary Bulletin dated 2/3/79 page 4, the banks took advantage of this method to achieve significant increases in their holdings of reserve assets (£800m in the banking month to mid October 1976, £586m in the banking month to mid August 1977 and £1689m between mid November 1977 and mid February 1978). With respect to the second type of transaction, the banks could arrange a swop of assets exchanging non-reserve assets for reserve assets with the discount houses - for example government debt with more than one year to maturity for debt with less than one year to maturity. Alternatively the banks could sell the discount houses non-reserve assets and provide finance for their purchase by way of money at call or short notice. The scope for this latter type of transaction was in fact restricted by two ratios imposed on the discount houses. First the discount houses had to maintain an 'appropriate relationship' between the scale of their business and the size of their capital and reserves. Secondly there was the 'undefined asset multiple' (i.e. the ratio of assets other than defined public sector debt to capital and reserves) which was restricted to a limit of 20. Furthermore expansion of the scale of their business in times of rising rates of interest could prove expensive to the discount houses because of the fall in capital values of some of their assets such as gilt-edged securities.

Nevertheless, despite these caveats, it is clear that the banks could and did increase their holdings of reserve assets within the context of Competition and Credit Control. Consequently these reserve assets cannot be viewed as a surrogate monetary base. In contrast increased holdings of assets traditionally regarded as the monetary base (i.e. notes and coins and balances at the Bank of England) could only be acquired with the acquiescence of the authorities.

A useful starting point for the discussion of the third point, i.e. the relevance of monetary policy to the determination of the money supply, is contained in the green paper "Monetary Control" (HMSO [1980]). This paper listed the main instruments of control of the money supply as i) fiscal policy, ii) short-term interest rates, iii) gilt-edged funding, iv) special deposits v) quantitative controls. The instrument most relevant to this discussion is number ii). Short-term interest rate control was achieved through the Treasury bill issue and MLR (originally linked to the Treasury bill rate but an administered rate after 1978). The technique adopted was to issue a quantity of Treasury bills in excess of the funds available to the market as estimated by the authorities. Consequently the discount houses were forced 'into the bank' to borrow funds so that the Bank could relieve the resulting shortage of funds at the structure of interest rates desired. In other words the supply of the monetary base became demand determined at the rates of interest desired by the authorities. Alterations in the rate of interest could be engineered by variations in MLR and the support price. Clearly the Treasury bill rate and MLR would have a strong influence on other rates of interest and in particular other short-term rates of interest. Consequently the main method of controlling the growth of the money supply was to change rates of interest rather than to achieve changes in the size of the monetary base. Within this framework, the role of special deposits was generally taken to be a support towards the achievement of the desired structure of interest rates. A dissenting view is expressed by Bewley [1981] who claimed empirical support for the view that calls for special deposits led to a significant reduction in bank deposits. Nevertheless it is true that interest rates were also varied according to the state of the monetary aggregate. Given monetary targets interest rate policy was also a means of achieving these targets so that in practice monetary policy was in all probability a compromise between achieving a desired interest rate structure and the money supply target.

The conclusion reached from the discussion of these three factors is that the 12.5% reserve ratio was not a major determinant of the money supply during the period of Competition and Credit Control. Consequently the general strategy adopted is to assume that the authorities attempted to fix the Treasury bill rate by their daily intervention in the money markets. Given this rate (i.e. it is treated as exogenous to the banking sector for estimation purposes) the banks demand a quantity of base assets which demand is met by the authorities. Similarly the banks demand public sector debt given the structure of interest rates. Consequently the quantity of both the monetary base and also government debt held by the banks is demand determined. This strategy requires the public sector budget constraint to be specified in the following manner:

$$PSBR = \text{Bond sales} + \text{Foreign exchange market intervention} + \Delta H + \text{Government intervention in domestic money markets} \qquad (5.1)$$

Bond sales includes all forms of public sector debt to the non-bank private sector and to the banks. ΔH includes changes in holdings of monetary base by the banks and the non-bank private sector. Government intervention in the domestic money markets is the slack variable which ensured total demand for monetary base and public sector debt is satisfied given the Treasury bill rate of interest and the size of the PSBR. The banks are assumed to have some control over their supply of sterling loans and time deposits. The model will incorporate supply functions for these items by inclusion of equations specifying the rates of interest charged on bank loans and paid on bank deposits. A similar strategy was followed for the rate of interest on bank loans by Melitz and Sterdyniak [1979]. The remaining choice asset FB is given by the balance sheet identity (4.4).

5.3 Estimation

The methodology adopted is similar to that used in the estimation of the non-bank private sector. The functions are estimated in ratio form with banks' net holdings of overseas assets treated as the slack or residual asset in the balance sheet. Estimation was again carried out through the TSP programme using ordinary least squares (OLS), instrumental variables (INST). Estimation results are reported in Tables 5.1 to 5.4. Seasonal binary coefficients are not quoted. The estimation period runs from 1973(1) to 1980(4). Throughout the estimation process the interest rate variables RG and RM (i.e on government debt and the money market rate respectively) were treated as exogenous.

The banks supply of loans as a ratio to total liabilities is hypothesised to be a positive function of the loan rate (i.e., the higher the loan rate the more loans supplied) and a negative function of the return on competing assets (i.e., the higher the bond rate the smaller the quantity of loans supplied). The representative cross rate of interest was taken to be the exogenous Treasury bill rate although other rates of interest were tried as reported below. Consequently the estimating equation took the following form:

$$TBL/(D+OL) = \alpha_0 + \alpha_1 RL + \alpha_2 RM + \epsilon \qquad (5.1)$$

$$\alpha_2 < 0 < \alpha_1$$

where TBL = Total sterling bank lending

RL = Rate of interest on bank loans

RM = Treasury bill interest rate

OL = Other liabilities

ϵ = error term

For purposes of estimation equation (5.1) was inverted to obtain:

$$RL = \beta_0 + \beta_1[TBL/(D+OL)] + \beta_2 RM + \epsilon' \quad (5.2)$$

where $\beta_0 = \alpha_0/\alpha_1$

$\beta_1 = 1/\alpha_1 \quad > 0$

$\beta_2 = -\alpha_2/\alpha_1 \quad > 0$

$\epsilon' = -(1/\alpha_1)\epsilon$

The rationale underlying equation (5.2) may be summarised as that in order to achieve the desired structure of assets within the portfolio, the banks set the interest rate on loans in the light of i) the short term rate of interest fixed by the authorities and ii) the proportion of their portfolio held in the form of loans. This approach differs from that adopted in the macromodels surveyed in Chapter 2 which in general allowed for little scope for the banks' preferences in the determination of the supply of their loans.

Estimation results are reported in Table 5.1 and are generally quite satisfactory. The coefficients are correctly signed and apart from the constant term significantly different from zero at the 5% level of significance. The Durbin-Watson statistic exceeds the upper critical value at the 5% level so that it is possible to accept the null hypothesis of zero autocorrelation. Tests for higher order correlation for this and other estimates are reported in Appendix 5.B.

A number of other variables were also tried as discussed briefly now. First, incorporation of special deposits as an independent variable failed to improve the performance of the equation. Second, it would be interesting to examine whether deposit liabilities and other liabilities have had different influences on the loan rate of interest. Separation of deposits and other liabilities also failed to improve the fit and performance of the equation. Third, the performance of additional/alternative rates of interest was examined. The use of the deposit rate instead of the Treasury bill rate was generally unhelpful since it rendered insignificant the coefficients of the lending variables i.e. TBL/(D+OL) etc. Further the role of the foreign rate of interest was also investigated as an additional variable. In most cases the coefficient on this variable was correctly signed but not significant. This is perhaps due to the high degree of correlation between the two rates of interest (i.e.

Table 5.1 The Supply of Bank Loans

Dependent Variable RL Mean Value = 0.1157

	Constant	RM	LENRAT
OLS	-0.0711	0.8733	0.1207
	(2.83)	(24.71)	(3.31)
	$\bar{R}^2$ 0.9708, SSR 0.0007, S 4.24 DW 1.77		
INST	-0.0611	0.8806	0.1073
	(1.79)	(21.98)	(2.14)
	SSR 0.0007, S 4.24, DW 1.72		

NB Lenrat = L/(D+OL)

Instruments: RM, $LENRAT_{t-1}$, Constant

RM and RC*) as evidenced by a simple correlation coefficient value of 0.829. Further estimates were therefore tried constraining the two coefficients to be equal. Given the consistently high "t" value of the estimated coefficient of RM it was perhaps not surprising that the estimated coefficient for the new synthetic variable (RM+RC*) was correctly signed and significant. However the explanatory performance of the equation deteriorated as evidenced by higher standard errors. For these reasons it was decided to adopt (5.2) as the specification of the equation determining the rate of interest charged on bank loans.

The supply of time deposits as a ratio to total liabilities is hypothesised to be a negative function of the own rate of interest (i.e., the cost of obtaining deposits) and a positive function of the yields on assets held against deposits. The representative own rate of interest was specified to be the London interbank sterling 3 month deposit rate . This rate was chosen as opposed to the more traditional seven day notice deposit rate paid by the London Clearing Banks in view of the growth of liability management by the banks. In this connection it is interesting to note that the London Clearing Banks indicated to the Wilson Committee that 40% of sterling deposits were obtained in the wholesale interbank market. The yield on the corresponding earning assets was assumed to be that earned on the principal asset held i.e. loans in sterling. In addition it may be assumed that banks will be willing to increase their supply of time deposits if the return on foreign currency assets is increased. The resulting equation was therefore:

$$DT/(D+OL) = \alpha_0 + \alpha_1 RD + \alpha_2 RL + \alpha_3 RC^* + \epsilon \quad (5.3)$$

$$\alpha_1 < 0 < \alpha_2, \alpha_3$$

where RD = time deposit interest rate

RC* = covered foreign interest rate

other variables as before

Equation (5.3) was also inverted to obtain the rate of interest on deposits as the dependent variable:

$$RD = \beta_0 + \beta_1[DT/(D+OL)] + \beta_2 RL + \beta_3 RC^* + \epsilon' \quad (5.4)$$

where $\beta_1 = 1/\alpha_1 < 0$

$\beta_2 = -\alpha_2/\alpha_1 > 0$

$\beta_3 = -\alpha_3/\alpha_1 > 0$

$\epsilon' = -(1/\alpha_1)\epsilon$

The rationale underlying the specification of (5.4) may be summarised in a similar manner to that described earlier for the loan rate, that is, in order to achieve the desired structure of liabilities within their portfolio, the banks set the rate of interest on time deposits according to i) the returns on assets held against deposits and ii) the proportion of their liabilities held in the form of interest bearing liabilities. Table 5.2 reports estimation results for the rate of interest on time deposits. Early experimentation revealed that i) seasonal variables did not add to the explanatory power of the the various estimated equations and ii) the performance of the equation was improved when the coefficients β_2 and β_3 were constrained to be equal. The overall impression is that the various methods of

Table 5.2 Supply of Bank Time Deposits

Dependent Variable RD Mean Value = 0.1190

	Constant	RL+RC*	TDRAT	ρ
OLS	0.0146	0.5388	-0.0659	
	(0.88)	(22.3)	(1.73)	
	$\bar{R}^2$ 0.9428	SSR 0.0018	S 6.64	DW 1.33
OLS	0.0100	0.5313	-0.0511	0.3301
	(0.45)	(17.78)	(0.99)	(1.87)
	$\bar{R}^2$ 0.9129	SSR 0.0016	S 6.30	DW 1.81
INST	0.0243	0.5510	-0.0944	
	(1.32)	(18.35)	(2.32)	
	SSR 0.0018	S 6.72	DW 1.34	
INST	0.0268	0.5625	-0.1062	0.3154
	(1.00)	(12.20)	(1.82)	(1.79)
	SSR 0.0017	S 6.47	DW 1.80	

NB TDRAT = DT/(D+OL)

Instruments: Constant, $(RL+RC^*)_{t-1}$, $TDRAT_{t-1}$

estimation produced broadly similar results. There is, however, evidence of first order serial correlation since in the absence of allowing for this in estimation, the Durbin-Watson statistics lie in the indeterminate region. All the coefficients are signed in accordance with "a priori" expectations but it is noticeable that the coefficient for the variable DT/(D+OL) only verges on being significant at the 5% level - and even then only after allowing for the presence of first order serial correlation in the estimation procedure.

The rationale underlying the specification of the banking sector's demand for public sector debt within their portfolio of domestic assets is that the banks desire a normal ratio between their holdings of public sector debt and sterling loans. This ratio will not be a constant but will vary positively according to the gap between the rate of interest on on public sector debt and that on loans (i.e., the more profitable holdings of public sector debt are in relation to loans):

$$BB/TBL = \beta_0 + \beta_1(RG-RL) + \epsilon \qquad (5.5)$$

$\beta_1 > 0$

where BB = banking sector's holdings of public sector debt

other variables as before

Inclusion of the lagged dependent variable may be necessary to allow for lagged adjustment. Early experimentation confirmed that this was so. In addition the use of binary variables to capture seasonal influences was also tested using a standard F test. The null hypothesis that this set of variables did not contribute to the explanatory power of the estimating equation could not be rejected. Nevertheless, the equation performed better in some other respects with rather than without seasonal binaries. First, at least one of the binary variables was always significant at 5% level. Second, without seasonal variables, the constant term assumed what seemed to be an excessively important role. Third, the value of R^2 fell marginally when these additional variables were excluded even though they did not add significantly to the power of the equations. Fourth, the coefficients for the other variables were more likely to be significant if accompanied by seasonal variables. Finally bank holdings of government debt may be expected to follow a seasonal pattern dependent on the flow of payments to the public sector.

The estimation results are reported in Table 5.3. The coefficient for the interest rate gap is always correctly signed and generally verges on being significantly different from zero at the 5% level of significance. The value of the Durbin "h" statistic approaches the critical value of 1.645 for the OLS estimate and just exceeds this figure for the instrumental variable estimate. The purging of first order serial correlation carried out for both estimation methods provides more satisfactory estimates.

The theoretical underpinning of the banking sector's demand for monetary base is, as stated earlier, that the authorities fix the Treasury bill rate of interest by their daily interventions in the money market. During the observation period the Bank of England

Table 5.3 The Demand for Bonds by the Banking Sector

Dependent Variable Ln(BB/TBL) Mean Value = -1.337

	Constant	RG-RL	Lagged Dependent Variable	ρ
OLS	-0.3817	1.636	0.7203	
	(2.20)	(1.77)	(6.83)	
	$\bar{R}^2$ 0.7426 SSR 0.1708 S 6.06 DW 1.56 (1.55)			
OLS	-0.4362	1.981	0.6127	0.3061
	(2.72)	(1.84)	(4.89)	(1.67)
	$\bar{R}^2$ 0.6410 SSR 0.1599 S 5.86 DW 2.14 (-0.56)			
INST	-0.3303	1.825	0.7120	
	(2.20)	(1.62)	(6.52)	
	SSR 0.1710 S 6.07 DW 1.54 (1.65)			
INST	-0.5325	2.839	0.5625	0.3611
	(2.83)	(1.90)	(4.10)	(2.02)
	SSR 0.1631 S 5.92 DW 2.15 (-0.67)			

Instruments: Constant, RM, OL, T, $Ln(BB/TBL)_{t-1}$, Seasonal Binaries operated so as to make the banking system short of cash with this shortage being relieved by the Bank at interest rates of its choosing. Given this framework the quantity of monetary base held by the banking sector was demand determined subject to the minimum ratio imposed by the authorities. It should therefore have been a relatively simple task to estimate a function of the general form:

$$\mathrm{Ln}(HB/D) = \beta_0 + \beta_1 RM + \epsilon \qquad (5.6)$$

$$\beta_1 < 0$$

In fact estimation proved difficult despite Howard's [1982] confident assertion that "in the present British monetary system the banks demand for cash reserves is a well defined and well behaved function of bank liabilities and a few other variables" (page 21). A reworking of Howard's methods applied to our data is shown as an appendix 5.A to this chapter. Two reasons may be perhaps advanced for our difficulties. First, intervention is on a daily basis whereas estimation is based on quarter ends. Second, the change in the system with the introduction of Competition and Credit Control may have meant that the banking system took some time to learn how the system worked. On the other hand it is interesting to note that the Bank of England reported that for the largest component of the monetary base "it has not been possible to find a stable econometric relationship between interest rates and cash balances in this country" (BEQB [1982] page 520). Similarly Johnston [1984], whilst finding support for interest rate responsiveness of i) the total monetary base and ii) cash holdings of the non-bank private sector, found little evidence that banks' holdings of till money or of operational balances at the Bank of England were sensitive to interest rate movements.

Representative estimates are presented in Table 5.4. The general picture is that it is possible to obtain reasonable estimates of the banking sector's demand for monetary base but only at the expense of severe first order serial correlation. When this serial correlation is purged from the estimating equation the coefficient of the Treasury bill rate becomes insignificant. Even then the Durbin-Watson statistic falls within the indeterminate range making it impossible to assert confidently that no first order autocorrelation remains. The same general picture is obtained when a time trend is included or the loan rate of interest substituted for the Treasury bill rate. Incorporation of the lagged dependent variable drastically reduces the significance of the constant term whilst at the same time bearing a coefficient which suggests implausibly long adjustment lags (in the region of 11 quarters). At the same time no real improvement in the performance of the equation is obtained. Consequently it was decided to remain with the specification outlined in (5.6) because of our prior belief that interest rates affect the demand for monetary base by the banks but at that same time noting that this equation is one of the least satisfactory estimates in the model.

Initially it was intended to leave the banks' holdings of foreign assets as the residual element obtained from the balance sheet identity (4.4). Problems arose with this approach with

Table 5.4 The Demand for High-Powered Money by the Banking Sector

Dependent Variable Ln(HB/D) Mean Value = -3.385

	Constant	RM	ρ
OLS	-3.103	-2.112	
	(31.4)	(2.88)	
	$\bar{R}^2$ 0.1487 SSR 0.3876 S 3.54 DW 0.64		
OLS	-3.307	-0.3387	0.8408
	(23.58)	(0.4)	(7.05)
	$\bar{R}^2$ 0.8668, SSR 0.1934, S 2.50, DW 2.697		

respect to simulation of the model because convergence was difficult to obtain (see chapter 7). Consequently it was necessary to estimate an equation specifying the banks' net holdings of overseas assets (FB). Following a similar methodology to that adopted for non-bank private sector net holdings of overseas assets we assume that the banks wish to maintain, within their portfolio, a ratio of net overseas assets to domestic assets (FB/(TBL+BB)). This ratio will not be constant but will vary according to relative rates of return (i.e., positively with the foreign rate of interest and negatively with the domestic rate) so that the estimating equation can be specified as:

$$FB/(TBL+BB) = \beta_0 + \beta_1 R^* + \beta_2 FP + \beta_3 RL + \epsilon \qquad (5.7)$$

$\beta_3 < 0 < \beta_1, \beta_2$

β_1 and β_2 were not constrained to be equal so as to allow for the fact that not all foreign investment is 'covered' against the risk of exchange rate changes. Partial adjustment can be allowed for by incorporating the lagged dependent variable on the right hand side of (5.7).

For period 1973(1) to 1980(4) equation (5.7) proved difficult to estimate since the estimated coefficients of the interest variables were invariably insignificant and also incorrectly signed. It was thought that perhaps these poor results were due to the impact of exchange controls so additional estimates were tried for the period 1980(1) to 1984(4). The ordinary least squares estimate (equation 1 in table 5.5) gave promising results with all variables (except the constant term) significant at the 5%

Table 5.5 The Ratio of Net Overseas Assets to Domestic Assets for the Banking Sector

Dependent Variable FB/(TBL+BB) Mean Value = 0.0222

	Constant	R*	FP	RL	Lagged Dependent Variable	ρ
OLS	0.0116	0.1569	0.2711	-0.2119	0.7448	
	(1.87)	(1.00)	(1.55)	(1.24)	(4.22)	
	$\bar{R}^2$ 0.6611 SSR 0.0023 S 18.92 DW (1.927) (0.28)					
OLS	0.0099	0.2451	0.3613	-0.3207	0.9075	-0.4466
	(2.06)	(1.79)	(2.29)	(2.09)	(6.73)	(1.57)
	$\bar{R}^2$ 0.7322 SSR 0.0002 S 18.47 DW 1.587 (1.20)					
INST	0.0103	0.4836	0.7021	-0.5391	0.07570	
	(1.16)	(0.95)	(1.09)	(1.01)	(3.23)	
	SSR 0.0004 S 25.23 DW 1.7995 (b/d)					
INST	0.0097	0.1357	0.2180	-0.2008	0.8852	-0.3258
	(1.92)	(0.68)	(0.93)	(0.91)	(5.90)	(1.11)
	SSR 0.0002 S 19.37 DW 1.608 (1.24)					

Instruments: Constant, FP_{t-1}, R^*, RM, FB_{t-1}, Seasonal Binaries level or verging on significance. Estimates by the instrumental variable approach tended to remove the significance of the coefficients. Possibly this is attributable to the fact that instrumental variable estimates are in general not efficient and the beneficial property of consistency is asymptotic. However, it was decided to remain with the instrumental variables estimates though the non-logarithmic estimate (equation 4) was used as it tended to assist convergence of the model.

Table 5.6 presents estimated long-run elasticities of the dependent variables with respect to their various determinants.

Table 5.6 Long-Run Elasticities

Dependent Variable	Variable	Elasticity
RL	RM	+0.847
	LENRAT	+0.681
RD	RL	+0.547
	RC*	+0.627
	TDRAT	-0.399
Ln(HB/D)	RM	-0.038
FB/(TBL+BB)	R*	+11.79
	FP	+0.65
	RL	-12.30

Two salient features of this table are worth comment. First, as noted earlier we have not obtained a satisfactory estimate for the high powered money demand function which is in any way sensitive to the rate of interest. Second, our bank supply functions leave a role for bank portfolio preferences over and above that attributable to the change in rates of interest engineered by the authorities. This contrasts with the common procedure adopted in most of the macroeconomic models surveyed in chapter 2 where the lending rate in essence follows a simple mark-up procedure on the "key" short-term rate of interest. It is also instructive to compare the estimates shown in table 5.6 with those obtained by Melitz and Sterdyniak [1979] who followed the same approach. The long-run elasticity of the loan rate of interest with respect to the ratio of loans to (deposits+net worth of the banking sector) was in the region of 0.52 against the figure of 0.68 reported for the similar variable lenrat reported in table 5.6. On the other hand the estimated coefficient for the money-market rate of interest just exceeded unity as against the figure of 0.87 shown in table 5.1 - the average value for the money-market rate of interest over the estimation period was not reported by Melitz and Sterdyniak. The methodology concerning the determination of the rate on time deposits is not the same for the two models so that no comparison is possible. Consequently, as is the case for the coefficients for the non-bank private sector portfolio behaviour, we do not claim that the estimated coefficients represent the precise population coefficients but rather that they are reasonably illustrative of those contained within these types of functions.

Notes

1 Assets classified as reserve assets are detailed below:

i) Balances with the Bank of England (other than special and supplementary special deposits).

ii) British government and Northern Ireland government Treasury bills, local authority and commercial bills eligible for rediscount at the Bank (subject to a maximum of 2 percentage points out of the 12.5% in the case of the latter category).

iii) Money at call with the London money markets - mainly with the discount houses.

iv) British government stocks and government guaranteed nationalised industry stocks with one year or less to final maturity.

Appendix 5.A: The Demand for Monetary Base

Howard [1982] provides a fairly detailed study of the demand for monetary base over a similar period to that in this study (1971/1978 instead of 1973/1980) but using monthly data. The demand for monetary base function was specified to take the form (using our notation rather than that in Howard):

$$HB/D = \alpha + (\psi_0+\psi_1 RM)DS/P + (\gamma_0+\gamma_1 RM)DT/P + \theta LA/P + \mu RHB/P \quad (5A.1)$$

where LA = liquid assets

RHB = required holdings of monetary base

other variables as before

Howard also included additional variables in his initial theoretical specification but these were subsequently excluded on the statistical grounds of insignificance. Rearranging (5A.1) and assuming that $\mu = 1$ produces:

$$XR/D = \alpha(D/P)^{-1} + (\psi_0-\gamma_0)k + (\psi_1-\gamma_1)kRM + \theta LA/P \quad (5A.2)$$

where XR = excess reserve holdings

k = DS/D

other variables as before

Separate designation of liquid assets is not consistent with our classification of bank assets/liabilities as shown in the balance sheet listed in Table 5A.1. Similar remarks apply to the division of monetary base between required and excess holdings. A third minor difference arose from the fact that our equation was specified in nominal terms and this consequently eliminated the price level from (5A.2). These variations resulted in the estimating equation taking the form:

$$HB = \beta_0 + \beta_1 RM + \beta_2 kRM + \beta_3 D^{-1} + \beta_4 k \quad (5A.3)$$

The signs of the partial derivatives of HB/D are shown below:

Variable	Partial Derivative
RM	$\beta_1 + k\beta_2 < 0$
k	$\beta_4 + \beta_2 RM > 0$

Results of estimating this equation using OLS is shown in Table 5A.1. At first sight the coefficients seem well defined. The explanatory power of the equation is high but the Durbin-Watson statistic falls in the indeterminate region (for levels of significance of 5%, 2.5% or 1%) indicating the probable presence of positive autocorrelation. More serious objections concern the signs of the partial derivatives. Evaluation at the mean values of RM and k produce estimates of -0.00034 and -0.011 respectively. The coefficient for k is incorrectly signed with the implication that the higher the ratio of sight deposits to total deposits the less the quantity of monetary base demanded by banks. Similar results occur when estimation follows the instrumental variable approach or allowance is made for first order serial correlation (equations and 2 and 4 in table 5A.1). Introduction of a time trend failed to alter materially the results noted above or produce

Table 5A.1 Demand for High-Powered Money by the Banking Sector (Reworking of Howard's Results)

Dependent Variable Ln(HB/D) Mean Value = 0.0342

	Constant	RM	kRM	k	D_{t-1}	ρ
1 OLS	0.0775	-0.0045	0.0103	-0.1265	471.3	
	(3.4)	(2.4)	(2.4)	(2.5)	(7.9)	
	R^2 0.8864 S 4.97 DW 2.703					
2 OLS	0.0795	-0.0046	0.0103	-0.1288	452.6	-0.4542
	(5.0)	(3.6)	(3.4)	(3.6)	(11.1)	(2.4)
	R^2 0.9411 S 4.39 DW 2.01					
3 INST	-0.0043	-0.0050	0.0115	-0.1425	453.9	
	(4.5)	(1.1)	(1.1)	(1.2)	(4.4)	
	S 4.91 DW 2.703					
4 INST	0.0671	-0.0036	0.0080	-0.1012	466.2	-0.4834
	(3.1)	(2.0)	(1.9)	(2.1)	(10.6)	(2.3)
	S 4.39 DW 1.945					
	(1-k)	(RM-kRM)				
5 OLS	0.0435	-0.0005			443.2	
	(7.6)	(2.0)			(6.7)	
	S 5.85 DW 1.865					
6 INST	0.0436	-0.0005			442.2	
	(7.6)	(2.0)				
	S 6.14 DW 1.845					

Instruments: Time Trend, PSBR, RM, Constant, OL, Seasonal Binaries a statistically significant coefficient. This result contrasts with that obtained by Howard where a statistically negative coefficient was attached to the time trend.

Applying average values of RM and k to the equation estimated by Howard in his study suggests that the partial derivative of excess reserves to k was also negative. Howard fails to discuss the signs of the partial derivatives with respect to the estimation of the initial equation. Instead he goes on to consider the statistical significance of the coefficients (i.e. ψ_0, ψ_1, γ_0 and γ_1 etc). He discovered that only one of the estimated coefficients (i.e. ψ_0) is not significant.

Eliminating ψ_0 alters (5A.3) to:

$$HB = \beta_1 RM + \beta_2 kRM + \beta_3 D^{-1} + \beta_5 (1-k) \qquad (5A.4)$$

with the following partial derivatives:

Variable	Partial Derivative
RM	$\alpha+(\psi_1-\gamma_1)k \quad < \quad 0$
k	$-\gamma_0+(\psi_1-\gamma_1)RM > 0$

The signs for the coefficients for this equation (including those omitted in our simplification noted earlier) were checked by Howard and found to be in accordance with the relevant theory. Our experience is different. Examination of the original estimated coefficients (i.e. ψ_0 etc) from the estimated equation 1 in Table

5A.1 showed that two coefficients (both β_0 and β_1) were insignificant. Eliminating both these variables from (5A.2) produces:

$$HB/D = \beta_6(RM\text{-}kRM) + \beta_3 D^{-1} + \beta_5(1\text{-}k) \quad (5A.5)$$

with the relevant partial derivatives being:

Variable	Partial Derivative
RM	$\beta_6 = \gamma_1 \quad < 0$
k	$-\beta_5 - \beta_6 RM \quad > 0$

The results of estimating equation (5A.5) are shown in Table 5A.1 as equations 5 and 6. Both equations using OLS and instrumental variable estimates yield similar results. The problem of the perverse sign of the partial derivative with respect to k remains (-0.038 for the OLS estimate). Neither equation shows any sign of serial correlation.

One further curiosity in Howard [1982] remains. Although using monthly data, only eleven seasonal variables were incorporated in the reported regression equation. In addition a constant term was tried "to allow fully for seasonal effects". The constant term was not significant. We tried regressions with an additional binary variable (making four in all) without a constant term. This did not solve the problem of the perverse sign of the partial derivative with respect to k. However, the inclusion of the additional seasonal variable did render the coefficients for (1-k) and (RM-kRM) statistically insignificant but left their signs in accordance with the results reported in Table 5A.1. The coefficients for all seasonal binary variables were statistically significant.

The conclusion drawn in this appendix is that reproduction of the results contained in Howard [1982] is difficult using quarterly data over the observation period in this study.

Appendix 5.B: Autocorrelation Tests

The basis of the tests is precisely the same as that outlined in Appendix 4.B for the non-bank private sector. A summary of the tests is presented in Table 5.B1.

As far as first-order serial correlation is concerned the tests replicate the results of the Durbin-Watson statistics. Three of the equations appear to be free of first-order serial correlation whereas, in line with the results noted in the main body of the text, it has not been possible to purge the high powered money equation of serial correlation despite the use of an auto-regressive estimation procedure. Turning now to the higher order statistics, it is not possible to state categorically that there is no evidence of serial correlation in view of the existence of two significant χ^2 statistics; i.e. fourth order for the RIB equation and second order for the RL equation. These blemishes appear to be relatively minor and may be attributable to the same causes as advanced in Appendix 4.B; that is exclusion of other expectational variables arising from the behaviour of the real sector.

Table 5B.1

Hypotheses					
Null	Alternative	RD	LBLL	RL	LBHD
$\rho_4=0$	$\rho_1\neq0, \rho_2\neq0, \rho_3\neq0, \rho_4\neq0$	8.457¶	2.458	1.876	0.001
$\rho_3=0$	$\rho_1\neq0, \rho_2\neq0, \rho_3\neq0$	0.972	0.004	2.636	0.324
$\rho_2=0$	$\rho_1\neq0, \rho_2\neq0$	0.651	3.916	6.512*	0.331
$\rho_1=0$	$\rho_1\neq0$	0.010	0.574	0.007	14.933¶

¶ indicates significance at the the 5% level.

Chapter 6 DATA DESCRIPTION

6.1 Data Sources

The data discussed in this section refer to the items contained in the balance sheets listed in chapter 4 with the same symbols being used. The two key sources of the data are; i) Financial Wealth data for the non-bank private sector - first published in the August 1981 edition of Financial Statistics and ii) Table 6.1 of the Financial Statistics which shows total assets and liabilities of the then-banking sector which was defined as the UK offices of all banks that agreed to observe a common ratio and other credit control arrangements, together with the banking department of the Bank of England and the institutions of the discount market - note that since 1981 this sector has been superceded by the new monetary sector which also includes the Trustee Saving Banks and the National Giro Bank.

The inclusion of the banking department of the Bank of England raises two main problems. First Bank of England holdings of government debt are included in lending to the public sector. It would not seem to be likely that these holdings are subject to the same type of motives that are relevant to those of the other institutions contained within the banking sector. Second, two important items are netted out in the consolidation of the banking sector's balance sheet. These are i) special deposits and ii) banks' balances at the Bank of England. To rectify this situation the Bank of England's holdings of public sector debt was deducted from, and the other two items added to the assets of the banking sector. Note this still leaves holdings of net foreign currency assets by the banking department of the Bank of England in the banking sector's balance sheet. No adjustment has been made in respect of this item. Details of all adjustments to the raw data necessary to produce the data series appearing in the balance sheets described in chapter 4 appear in section 2 of this chapter.

A further caveat is necessary. Although the data refer as near as possible to the end of the quarter, there are some inconsistencies. For example some of the banking statistics refer to the last working day of the quarter whereas others refer to the third Wednesday of the last month of the quarter (except for December when it is the second Wednesday). These inconsistencies have been indicated in the data description which follows. All data is NOT seasonally adjusted.

1 M1

The narrow definition of money includes notes and coins in circulation with the non-bank private sector plus sterling sight deposits held by this sector with the banking sector. Figures were obtained from the Bank of England corrected for the various changes in definitions introduced over the years. The component notes and coins includes public sector holdings. Measurement is at the end of the quarter.

2 Monetary Base and Special Deposits

i	Notes and coins held by the banking sector	NCB
ii	Banks' deposits at the Bank of England	DB
iii	Notes and coins held by the non-bank private sector	NC
iv	Special deposits (including supplementary special deposits) held by banks at the Bank of England	SPECD

These figures were all extracted from the details of the monetary base first published (as a whole rather than as individual components) in an article contained in the March 1981 edition of the Bank of England Quarterly Bulletin (Table B). Measurement is at the close of business on the third Wednesday of the month (second in December). Prior to 1975, coverage of the figures of the breakdown between banks' till money and the residual in circulation with the non-bank public is not fully consistent with other statistics throughout the period but the inconsistencies are not thought to be large. Note the figures will also not be consistent with those included under the heading of money in the financial wealth statistics because public sector holdings of notes and coins are included in the monetary base.

3 Financial Wealth Data - Non-Bank Private Sector

In very broad terms net financial wealth can be defined as the sum of financial assets, i.e. claims against other sectors (currency, bank deposits, government securities, net overseas assets) less liabilities to other sectors (i.e. bank loans). Preliminary estimates of non-bank private sector financial wealth for the UK were published by Grice and Bennett [1980] but these have been superceded by the publication of a more detailed series by the Central Statistical Office. A quarterly series covering period 1966 quarter 4 to 1980 quarter 4 first appeared in the August 1981 edition of Financial Statistics and is used for the purposes of this study.

The individual components of this wealth series are:

i Public Sector Long-Term Debt GILTS

This consists of British government and government guaranteed securities; Northern Ireland government stock; local authorities listed stocks; bonds and long-term borrowing in the form of loans and mortgages; securities issued by public corporations and other long-term debt of public corporations. Valuation is at market prices.

ii Fixed Price Public Sector Debt FPPSD

This second category refers to those assets whose market prices are relatively fixed. These assets are national savings; tax instruments; Treasury bills and local authority temporary deposits.

iii Overseas Assets OSA

Overseas government and municipal securities; debenture and loan stock; ordinary and preference shares; direct investment; property holdings overseas; loans to overseas subsidiaries; advance and progress payments on imports and exports; other overseas trade credit and loans. Valuation is at market prices or book value after allowing for exchange rate changes.

iv Overseas Liabilities OSL

Debenture and loan stock; ordinary and preference shares; direct investment; advances on imports and exports; other overseas trade credit and loans. Valuation is at market prices or book value after allowing for exchange rate changes.

v Bank Loans (L+L$)

This covers domestic bank lending to the non-bank private sector; both in sterling and foreign currencies. The foreign currency lending in sterling reflects exchange rate fluctuations.

vi Money (Sterling plus Foreign Currency) MON

This variable is defined as the non-bank private sector component of the M3 definition but of course excludes public sector deposits. Thus the series includes non-bank private sector holdings of notes and coins together with sterling and foreign currency sight and time deposits (including certificates of deposit) at UK banks except for finance houses' special deposits at the Bank of England.

vii Money (Foreign Currency) MRFC

This refers to holdings of bank deposits denominated in foreign currency. Sterling valuation reflects exchange rate changes.

viii Residual Component RESID

This refers to the additional items which appear in the official series. These are: UK ordinary and preference shares (holdings and issues) Other domestic loans (lending and borrowing); Domestic trade credit (granted and received); Other domestic assets and liabilities; Accruals of taxes, rates and interest (payable and receivable); Public sector loans for house purchase. Valuation of all items is at end of period.

4 Bank Lending to the Public Sector in Sterling BLPUB

Table 6.1 in the Financial Statistics shows total assets and deposits of the banking sector. Total assets are divided into bank lending to the various sectors in sterling and foreign currency. Consequently this variable refers to total bank lending by the banking sector to the public sector in sterling. Valuation is mainly at nominal values.

As noted earlier these figures:

i include public sector debt held by the Bank of England

ii exclude the banking sector's deposits (including special deposits) at the Bank of England. Adjustments have therefore been made to the raw data to exclude (i) and include (ii). Measurement is at the end of the quarter.

Sources of the individual figures are the following tables of the Financial Statistics:

1980(4) to 1981(4	Table 6.1
1979(4) to 1980(3)	Dec. 1980 Table 6.1
1978(4) to 1979(3)	Dec. 1979 Table 6.1
1976(4) to 1978(3)	Dec. 1978 Table 6.3

1974(1) to 1976(3)	Dec. 1977 Table 6.6
1973(1) to 1973(4)	Dec. 1975 Table 38

5 Bank Lending in Foreign Currency to the Public Sector BLPUB$

Source the same as for 4 above. Total sterling value reflects exchange rate changes.

6 Bank Lending to the Non-Bank Private Sector in Foreign Currency L$

Source the same as for 4 above. Total sterling value reflects exchange rate changes.

7 Banking Sector: Foreign Currency Business

i Banking Sector Total Foreign Currency Assets FCA

ii Banking Sector Total Foreign Currency Liabilities FCL

The figures for assets include BLPUB$ and $L. The source is the same as for 4 above. Total sterling value reflects exchange rate changes.

8 Bank Lending in Sterling to the Overseas Sector LOS

Source the same as for 4 above.

9 Sterling Bank Deposits from the Overseas Sector DOS

Source the same as for 4 above.

10 The Covered Foreign Rate of Interest RC*

This consists of two components; i) the foreign rate of interest (R^*) and ii) the forward premium (FP). The representative foreign rate of interest is the three month rate on Eurodollar deposits in London. The rates listed are representative middle market rates as recorded by the Bank of England during the late afternoon of the last working day of the period concerned. The forward premium/discount on dollars (three months) in London - expressed as a percentage per annum - is the middle market rate as recorded by the Bank of England during late afternoon of the last working day of the period concerned. The specific figures were obtained from various issues of the Bank of England Quarterly Bulletin - apart from the period 1973 (1) to 1974 (4) which were obtained from the Bank of England Statistical Abstract vol. 2 :

1980 4	March 1981	Table 18
1980 3	December 1981	Table 20
1980 2	September 1980	Table 18
1979 4 to 1980 1	June 1980	Table 18
1979 3	December 1979	Table 19
1979 2	September 1979	Table 18
1979 1	June 1979	Table 19
1978 4	March 1979	Table 18
1976 1 to 1978 3	December 1978	Table 29
1975 1 to 1976 2	December 1976	Table 28

11 Rate of Interest on Public-Sector Debt RG

The representative rate of interest on public sector debt was taken to be the calculated redemption yield on five-year government stock. Sources of the individual figures were obtained from the same sources as detailed for 10 above.

12 Interest Rate on Bank Lending RL

Since 1971 the rates of interest charged by banks on loans have been linked to their own individually declared base rates. Normally these base rates are the same for each bank due to competitive forces. In some cases, however, different rates have been recorded and in this case the rate selected is the mid point of the range. Measurement is at the end of the period and the source of the individual figures was the 1982 Annual Supplement to Economic Trends

13 Treasury Bill Rate of Interest RM
(Money Market Rate of Interest)

This rate refers to the average rate of allotment at the weekly tender expressed as an annual rate of interest. The sources of the individual figures is the same as for 10 above.

14 Rate of Interest on Time Deposits RD

This rate of interest is taken to be the Inter-Bank sterling 3 month deposit rate. The rate quoted is the mean of the lowest bid and highest offer on the last working day of the period. It was felt that this rate was more appropriate than the traditional 7-day deposit rate in view of the increasing use made by the banks of the inter-bank money market as a source of funds. The source of the data is the same as for 10 above.

15 Holdings of Public Sector Securities by the Bank of England Banking Department. BCB

These figures refer to holdings of government securities by the Banking Department of the Bank of England. Measurement is at close of business on the third Wednesday of the month (second in December). Sources of the data are various issues of Financial Statistics as follows:

1979 2 to 1980 4	May 1981	Table 6.3
1978 3 to 1979 1	October 1979	Table 6.1
1977 2 to 1978 2	December 1978	Table 6.1
1976 4 to 1977 1	December 1977	Table 6.1
1975 4 to 1976 3	December 1976	Table 6.1
1974 4 to 1975 3	December 1975	Table 35
1973 4 to 1974 3	December 1974	Table 35
1973 1 to 1973 3	December 1973	Table 35

16 Consumer Expenditure at Constant and Current Prices

CON75 & CON

This data was used to obtain the implicit price index used in the study to deflate nominal variables wherever appropriate. The source of the data on consumer expenditure was the 1982 annual supplement to Economic Trends

17 US Consumer Price Index

USP

The data were obtained from various issues of International Financial Statistics Item 6L as follows (with the base being converted into 1975 = 100):

1977 1 to 1980 4	March 1981
1975 1 to 1976 4	March 1979
1973 1 to 1974 4	March 1977

18 The Exchange Rate

S^{-1}

The $/£ exchange rate was obtained from the following editions of the BEQB. Measurement was at the close of trade on the last working day of the month

1980 4	March 1981	Table 18
1980 3	December 1981	Table 20
1980 2	September 1981	Table 18
1980 1	June 1980	Table 19
1979 4	March 1980	Table 19

1979 3	December 1980	Table 19
1979 2	September 1979	Table 18
1979 1	June 1979	Table 14
1978 4	March 1979	Table 14
1977 4 to 1978 3	December 1978	Table 29
1975 4 to 1977 3	December 1977	Table 29
1974 1 to 1975 3	December 1975	Table 28
1973 1 to 1973 4	December 1974	Table 29
1972 4	September 1974	Table 28

19 Balance of Payments Statistics

The two main balance of payments statistics series (the current account and changes in reserves) were obtained from Table 126, 1982 Annual Supplement to Economic Trends

6.2 Generation of Data

The following adjustments were necessary to obtain the principal series used in the model described in the balance sheets listed in chapter 4:

i Sight Deposits (DS) were obtained by deducting notes and coins held by the non-bank private sector from M1;

i.e. $DS = M1 - NC$

ii Time deposits are obtained by deducting the non-bank private sector's holdings of money denominated in foreign currency and M1 from their holdings of money;

i.e. DT = MON - MONFRC - M1

Similarly M2 was obtained from the identity:

M2 = M1 + DT

iii Sterling deposits held by the non-bank private sector follow automatically by adding DS and DT;

i.e. D = DS + DT

iv Monetary base held by the banking sector is derived by adding the banking sector's holdings of notes and coins to their deposits at the Bank of England;

i.e. HB = DB + NCB

v Bank lending in sterling to the NBPS is obtained by deducting from total bank lending to the private sector their borrowings in foreign currency;

i.e. L = (L+L$) - L$

vi Total bank lending in sterling refers to the sum of lending to the non-bank private sector and to the overseas sector;

i.e. TBL = L + LOS

vii The definition of bank lending to the public sector used in this study excludes all such lending carried out by the banking department of the Bank of England and also holdings of monetary base by the banking sector. It is therefore equal to total bank lending to the public sector minus i) lending by the banking department of the Bank of England and ii) holdings by the banking sector of notes and coins - it will be recalled that banking sector deposits at the Bank of England have already been netted out;

i.e. BB = BLPUB - BCB - NCB

viii The banking sector's net holdings of foreign currency assets is derived by subtracting total foreign currency liabilities from their total foreign currency assets;

i.e. FB = FCA - FCL

ix Other liabilities of the banking sector is treated as the sum of the residual items of their balance sheets. It therefore consists of non-deposit liabilities and all other components not explained within the model, for example Bank of England lending to the banking sector;

i.e. OL = HB + BB + TBL + FB + SPECD - D

x As far as is possible net overseas assets of the non-bank private sector refer to all holdings of assets and liabilities denominated in foreign currency irrespective of the originating source of the asset or direction of the liability;

i.e. F = OSA + MONFRC - OSL - L$

xi Nominal financial wealth was defined as:

$$W = M2 + B - L + RESID$$

In turn the non-bank private sector's boned holdings were obtained by adding together their holdings of gilt-edged securities and fixed price debt

i.e. B = GILTS + FPPSD

xii The residual element of the balance of payments (Other) was obtained as the gap between identified items within the balance of payments identity

i.e. Other = ΔRes - CA + ΔF + ΔFB

6.3 Data Consistency

In view of the widely different sources of the data, it was considered advisable to check the data for consistency. One such check used was to compare the figures obtained for bank lending from the Financial Statistics with those derived from the wealth series referred to in the previous sector. The two series yielded approximately equal figures and summary statistics of a comparison between the two series is shown below:

Table 6.1

Correlation coefficient	0.9998
Root Mean Square Error	826(2.1%)
Mean Absolute Error	811(2.1%)
Mean Error	811(2.1%)
Fraction of Error due to Bias	0.964
Fraction of Error due to Different Variation	0.001
Fraction of Error due to Different Co-variation	0.034

A second consistency check was carried out by comparing the sterling money series held by the non-bank private sector derived from the wealth series with that obtained from the Financial Statistics by adding notes and coins plus sterling bank deposits (both held by the non-bank private sector). As can be seen from the details shown below in Table 6.2, the equality between the two series was approximately satisfied given timing difference between the two series - notes and coins are as per the banking statistics (i.e generally the third Wednesday of the month) and the other series refer to the end of the period.

Table 6.2

Correlation Coefficient	0.9994
Root Mean Square Error	453(1.1%)
Mean Absolute Error	271(0.6%)
Mean Error	-262(0.6%)
Fraction of Error due to Bias	0.336
Fraction of Error due to Different Variation	0.011
Fraction of Error due to Different Co-variation	0.653

These two consistency checks provide gratifying support for data consistency although, in the case of the first check, the small error is consistently signed in one direction i.e. biased.

6.4 Data

A listing of the raw series of data necessary to derive the variables used in the model now follows:

	M1 £m	NCB £m	DB £m	NC £m	SPECD £m
1973 1	12940	644	202	3948	728
1973 2	13832	685	268	4089	754
1973 3	13520	735	247	4091	1098
1973 4	13967	806	195	4369	1439
1974 1	13382	692	290	4327	1351
1974 2	13801	753	236	4499	884
1974 3	14163	775	290	4639	922
1974 4	15457	872	300	5068	928
1975 1	15426	754	359	5089	943
1975 2	15901	797	297	5305	966
1975 3	16773	786	304	5501	980
1975 4	17483	862	322	5730	989
1976 1	17801	737	265	5809	983
1976 2	18920	768	378	6072	1000
1976 3	19227	785	272	6319	1043
1976 4	19467	814	326	6531	1806
1977 1	19566	741	317	6505	1027
1977 2	20410	867	310	6792	1055
1977 3	22049	774	335	6995	1110
1977 4	23659	952	428	7581	1185
1978 1	24270	778	267	7559	1246
1978 2	24762	835	399	7862	656
1978 3	26046	822	369	8200	641
1978 4	27535	967	423	8731	1009
1979 1	27495	817	426	8725	2
1979 2	27892	917	477	8846	741
1979 3	28957	865	497	9156	772
1979 4	30046	996	462	9714	805
1980 1	29173	868	378	9498	132
1980 2	29743	889	473	9739	242
1980 3	29791	926	676	9882	0
1980 4	31230	1043	487	10255	0

	MON £m	MONFRC £m	BLPUB £m	BCB £m	L$ £m
1973 1	26264	1099	7627	1085	2568
1973 2	27751	1072	7966	1136	2619
1973 3	30150	1320	8513	1455	3029
1973 4	32486	1432	9277	1675	3436
1974 1	32930	1773	7928	1686	3759
1974 2	33977	2180	7502	1101	3984
1974 3	34851	2500	7666	1248	4132
1974 4	36728	2398	8907	1248	4373
1975 1	36413	2519	8055	1418	4332
1975 2	36965	2342	9617	1261	4963
1975 3	38580	2765	11254	1360	5477
1975 4	39231	2939	11966	1405	5605
1976 1	39150	3115	11406	1375	5889
1976 2	40735	3487	11302	1478	6246
1976 3	42934	3966	11908	1548	6879
1976 4	43750	3896	11801	1905	6994
1977 1	42979	4220	10815	1449	7456
1977 2	44849	4583	11316	1599	7630
1977 3	45769	4327	12134	1516	7595
1977 4	47722	4151	13632	1591	7421
1978 1	49255	4469	12954	1797	7870
1978 2	51600	5123	11723	1046	8318
1978 3	52829	4862	12132	1370	8213
1978 4	54999	4800	13478	1848	8088
1979 1	54635	4585	11605	1550	8248
1979 2	57687	5043	12590	1394	8329
1979 3	59115	4737	13409	1477	8297
1979 4	61933	5202	14980	1462	8326
1980 1	62111	5625	12864	615	8847
1980 2	66426	5658	14323	574	9195
1980 3	68874	5646	14546	534	9200
1980 4	73346	6081	17325	446	8852

	L £m	FCA £m	FCL £m	LOS £m	DOS £m
1973 1	20241	28734	28061	1654	2807
1973 2	21541	29713	29040	1744	3035
1973 3	23622	35694	35089	1912	2821
1973 4	25899	40512	39892	1967	2959
1974 1	27073	44957	44329	2072	2902
1974 2	28585	47558	46989	2117	3383
1974 3	29360	48001	47235	2138	3637
1974 4	30250	50319	49397	2256	3686
1975 1	30272	51647	50809	2132	3500
1975 2	30137	57512	56836	3273	3717
1975 3	30122	63611	62824	3275	3723
1975 4	30123	67195	66170	3184	3825
1976 1	30627	72476	71333	3529	3995
1976 2	32122	79890	7881	3795	3721
1976 3	33540	87323	85902	3996	3947
1976 4	34923	92222	90770	3831	3967
1977 1	35678	92655	91521	3746	4170
1977 2	37075	96554	94944	3926	4528
1977 3	37652	98118	96824	4086	4877
1977 4	38499	95062	93833	4237	5606
1978 1	39526	100593	99146	4857	5634
1978 2	41860	103971	101844	5149	5245
1978 3	42591	106927	104779	5176	5458
1978 4	43967	112077	109947	5089	5476
1979 1	46399	111579	109581	5014	6085
1979 2	49155	115122	113555	4999	6632
1979 3	50584	127493	126336	5089	7034
1979 4	52681	134258	132666	5074	8475
1980 1	55501	145823	144478	5497	8914
1980 2	59099	143085	141132	6100	10091
1980 3	61928	143568	141777	6916	10897
1980 4	62833	153318	152027	7879	11477

	RC* %	RG %	RL %	RM %	RD %
1973 1	11.43	10.42	9.50	8.06	9.94
1973 2	10.93	10.33	8.00	7.02	8.13
1973 3	14.94	11.45	11.00	11.20	13.25
1973 4	16.82	12.26	13.00	12.76	15.81
1974 1	19.44	14.69	13.00	12.300	15.50
1974 2	16.43	15.37	12.00	11.50	13.44
1974 3	15.40	15.01	12.00	11.24	11.75
1974 4	18.15	17.45	12.00	11.24	12.56
1975 1	12.08	13.68	10.38	9.55	9.94
1975 2	10.78	14.77	9.50	9.68	9.69
1975 3	11.35	14.17	10.00	10.73	10.62
1975 4	10.91	14.56	11.00	10.89	10.72
1976 1	9.84	13.75	9.50	8.56	8.50
1976 2	14.36	13.68	10.50	11.26	11.22
1976 3	16.89	14.86	12.00	12.74	12.81
1976 4	15.28	13.81	14.00	13.97	14.37
1977 1	9.25	11.64	9.50	9.57	9.12
1977 2	8.96	12.36	8.50	7.60	7.75
1977 3	6.21	9.45	7.00	5.37	5.84
1977 4	6.59	9.58	7.00	6.39	6.66
1978 1	7.60	10.20	6.50	6.08	6.94
1978 2	11.53	11.89	10.00	9.49	10.16
1978 3	13.09	11.50	10.00	9.38	9.69
1978 4	12.58	11.79	12.50	11.91	12.44
1979 1	12.04	10.27	13.00	11.78	12.12
1979 2	14.07	11.18	14.00	13.79	14.07
1979 3	14.15	10.91	14.00	13.82	14.16
1979 4	16.68	12.15	17.00	16.65	17.06
1980 1	16.53	12.20	17.00	16.97	16.57
1980 2	16.77	10.91	17.00	16.32	17.13
1980 3	15.66	11.09	16.00	14.86	15.94
1980 4	14.41	11.56	14.00	13.45	14.84

	RESID £m	GILTS £m	FPPS £m	OSA £m	OSL £m
1973 1	230	15202	9162	21205	11905
1973.2	-149	15930	9526	21303	12472
1973 3	-1057	15431	9607	21122	12749
1973 4	-997	15409	9668	21627	13477
1974 1	-1487	14873	9784	21775	14261
1974 2	-1977	15592	10068	21993	14669
1974 3	-3306	16305	10521	21641	14810
1974 4	-3895	115152	10702	21633	15423
1975 1	-3698	19005	10397	22424	15888
1975 2	-3850	19176	10449	23669	16847
1975 3	-4205	20759	10876	23834	17825
1975 4	-4467	22772	10939	24930	19073
1976 1	-3750	24505	11273	27303	20138
1976 2	-3813	25579	11238	28590	20782
1976 3	-5343	25066	11687	29467	20897
1976 4	-5479	28103	11237	30940	21530
1977 1	-5585	32934	12089	29160	22819
1977 2	-4596	32835	12439	29490	23316
1977 3	-4168	39850	12837	29332	24318
1977 4	-3736	41139	12968	29680	24501
1978 1	-3313	39530	13362	29621	24943
1978 2	-2553	39733	13366	30996	25269
1978 3	-2466	40773	13843	32661	25739
1978 4	-4641	41378	14378	32628	26309
1979 1	-4893	46888	15829	38872	29734
1979 2	-5477	47612	16433	40083	31514
1979 3	-7943	51215	16641	42701	32383
1979 4	-9627	49755	14940	44636	32730
1980 1	-7315	51489	15078	46513	33554
1980 2	-7048	56514	15687	47910	34478
1980 3	-6865	59731	16004	49231	35528
1980 4	-7938	60283	16961	50706	35864

	BLPUB$ £m	CON £m	CON75 £m	USP Index	S^{-1} $ per £
1973 1	91	10560	15925	79.9	2.4377
1973 2	328	11068	16257	81.6	2.5820
1973 3	611	11591	16733	83.4	2.4139
1973 4	909	12540	17417	85.4	2.3235
1974 1	1172	11552	15403	87.7	2.3935
1974 2	1388	12640	15914	90.2	2.3910
1974 3	1488	11820	13501	93.0	2.3325
1974 4	1980	13510	14975	95.7	2.3495
1975 1	2278	14276	15617	97.4	2.4026
1975 2	2509	15872	16073	98.9	2.1845
1975 3	2675	16662	16224	101.1	2.0436
1975 4	2648	17939	16835	102.7	2.0233
1976 1	2793	17063	15456	103.7	1.9158
1976 2	3022	18029	15845	105.0	1.7847
1976 3	3388	19054	16358	106.6	1.6680
1976 4	3530	20806	17156	107.8	1.7020
1977 1	3986	19667	15389	109.7	1.7201
1977 2	3995	20766	15635	112.1	1.7202
1977 3	4188	21949	16247	113.7	1.7475
1977 4	3751	23619	17312	115.0	1.9185
1978 1	3657	22985	16248	116.9	1.8625
1978 2	3431	23743	16458	120.0	1.8605
1978 3	3143	25383	17353	122.8	1.9739
1978 4	3151	26836	18163	125.2	2.0410
1979 1	2967	25892	16828	128.4	2.0665
1979 2	2662	28199	17763	132.8	2.1715
1979 3	2493	30164	17932	137.2	2.2020
1979 4	2325	32462	18886	141.2	2.2250
1980 1	2233	31593	17447	146.7	2.1640
1980 2	2053	32424	17130	152.0	2.3570
1980 3	1621	34661	18041	154.8	2.3883
1980 4	1485	36725	18836	158.9	2.3920

	CA £m	ΔRES £m
1973 1	-376	72
1973 2	-20	380
1973 3	-260	-254
1973 4	-325	30
1974 1	-856	-33
1974 2	-847	116
1974 3	-747	189
1974 4	-823	167
1975 1	-624	142
1975 2	-334	-410
1975 3	-526	-170
1975 4	-37	-217
1976 1	-112	178
1976 2	-339	-354
1976 3	-243	-61
1976 4	-187	-616
1977 1	-635	3197
1977 2	-456	1158
1977 3	570	3227
1977 4	480	2006
1978 1	-439	-46
1978 2	298	-2026
1978 3	441	54
1978 4	639	-311
1979 1	-930	955
1979 2	-181	68
1979 3	384	152
1979 4	-136	-116
1980 1	-225	457
1980 2	-162	140
1980 3	1209	-223
1980 4	2384	-83

CHAPTER 7 THE MODEL AS A WHOLE

We commence by discussing in sections 1, 2 and 3 additional functions imposed on the model namely i) the linkage between the exogenous Treasury bill rate of interest and the rate on government bonds; ii) valuation effects on financial assets due to changes in both rates of interest and also exchange rates and iii) determination of the exchange rate. A complete listing of the model is presented in appendix A. In section 4 we describe the forecasting methodology adopted for the projection of the exogenous variables necessary to obtain the rational expectations solution to the model. The performance of the model is reviewed in section 5 and finally, in view of the large number of charts contained within this chapter, they are presented together in appendix B.

7.1 The Term Structure of Interest Rates

According to the preferred habitat theory of the term structure of interest rates, the long-term interest rate can be described by current and expected future short-term interest rates and liquidity premiums - see Holden, Peel and Thompson [1985]. More precisely assuming one period rates of return with interest rates measured at the beginning of the period:

$$(1+RLR_t)^n = (1+RS_t)(1+E_tRS_{t+1}+L_1)\ldots\ldots(1+E_tRS_{t+n-1}+L_{n-1}) \quad (7.1)$$

where RLR = long-term rate of interest

RS = short-term rate of interest

L_i = liquidity premiums with i = number of years ahead

Provided RL, RS and the various L_i are small fractions (7.1) may be approximated by:

$$RLR_t = (1/n)(RS_t+E_tRS_{t+1}..+E_tRS_{t+n-1}+L_2+L_3+....+L_{n-1}) \quad (7.2)$$

Assuming constant liquidity premiums (7.2) may be further simplified to :

$$RLR_t = (1/n)(RS_t+E_tRS_{t+1}+....+E_tRS_{t+n-1})+L \quad (7.3)$$

In the context of this model the long-term rate of interest is represented by the five year rate on gilt-edged securities (RG) and the short-term rate by the rate on Treasury bills (RM). Hence (7.3) may be written more precisely as:

$$RG_t = (1/20)(RM_t+E_tRM_{t+1}...+E_tRM_{t+19})+L \quad (7.4)$$

Moving (7.4) forward one period produces:

$$RG_{t+1}=(1/20)(RM_{t+1}+E_{t+1}RM_{t+2}+..+E_{t+1}RM_{t+19}+E_{t+1}RM_{t+20})+L \quad (7.5)$$

Subtracting (7.4) from (7.5) and rearranging produces:

$$\Delta RG = (1/20)(\Delta RM+(E_{t+1}RM_{t+2}-E_tRM_{t+2})+.+(E_{t+1}RM_{t+20}-E_tRM_{t+1}) \quad (7.6)$$

It should be noted that apart from the last term all other terms are either actual changes in RM or the change in its expected value. The further simplifying assumption is made that any change in the information set, i.e. news, produces the same quantitative change in all current and expected future rates so that $\Delta RM = (E_{t+1}RM_{t+2} - E_tRM_{t+2})$ etc. Applying this assumption to (7.6) and noting that the effect of the last term (i.e. $E_{t+1}RM_{t+20} - E_tRM_{t+1}$) is likely to be dwarfed by the other terms produces the following term structure equation for simulation purposes:

$$\Delta RG = \Delta RM \qquad (7.7)$$

The starting value for RG is taken to be RM+0.007 where 0.007 represents a constant liquidity premium and is measured by the average excess of RG over RM during the estimation period. Consequently (7.7) may be written in the form used for simulation purposes:

$$RG = RM + 0.007 \qquad (7.7a)$$

7.2 Valuation Effects on Financial Wealth

For estimation purposes the domestic component of the non-bank private sector's wealth was valued at market prices and therefore included valuation effects arising from the impact of changes in the rates of interest on the market price of securities. Similarly the foreign component (F) also incorporates the effects of exchange rate changes. In contrast the banking sector's holdings of public sector debt are valued at acquisition cost for balance sheet purposes - in line with the valuation of the other items of their balance sheet such as bank lending. Simulation of the response of the endogenous variables to external shocks requires valuation effects to be incorporated within the model since these provide a potentially interesting component of the transmission mechanism.

This can be achieved by changing W into an endogenous variable for simulation purposes. A simple way of achieving this is to determine W according to its lagged value plus the valuation effects due to interest and exchange rate changes and the additions arising from the public sector borrowing account and the current account of the balance of payments. For the domestic component this was simply specified as:

$$VALD = \lambda(NDA_{t-1} * ((RG_t - RG_{t-1})/RG_{t-1})) \qquad (7.8)$$

where λ is a fraction representing i) the proportion of DAS held in non-fixed price debt and ii) the average maturity of outstanding debt.

It is not likely that the fraction λ would remain constant over time but, on the other hand, it is unlikely that a violent distortion of the truth will occur by assuming a constant λ. A variety of values of λ were experimented with and ultimately a value of 0.15 was selected.

For the original data the balance of payments was closed through the construction of a new synthetic exogenous variable "OTHER" which reflected the gap between the official financing component and the sum of the current account and the other two capital flows endogenous to the model i.e. F and FB. The balance of payments identity now becomes:

$$\Delta F = CA - \Delta RES - \Delta FB + OTHER \quad (7.9)$$

The procedure adopted was to incorporate a valuation effect which ensured equality between the original series for F and this new synthetic series which incorporated the valuation effect by simultaneously making a corresponding adjustment to the variable OTHER. The valuation effect itself was estimated as:

$$VALF = \mu*(F_{t-1}*(LnS_t-LnS_{t-1})) \quad (7.10)$$

where μ is a fraction representing the fact that not all overseas assets/liabilities are denominated in foreign currency. The value of μ was arbitrarily fixed at 0.5.

Using (7.8) and (7.9) the definition of net financial wealth becomes:

$$V = V_{t-1} + PSBR + CA - \Delta RES - \Delta FB + OTHER$$
$$-0.15*((RG_t-RG_{t-1})/RG_{t-1})*NDA_{t-1}) +$$
$$0.5*(LnS_t-LnS_{t-1})*F_{t-1}) \quad (7.11)$$

7.3 The Exchange Rate

The exchange rate in this model is determined by interaction between i) the definition of the forward premium, ii) the non-bank private sector's demand for net overseas assets and iii) the balance of payments identity. First, as noted in chapter 4.2, the forward premium is defined as the gap between the expected and current spot exchange rates so that:

$$FP = 4*(E_t LnS_{t+1} - LnS_t) \quad (7.12)$$

where FP is expressed at an annual rate.

This permits the current spot exchange rate to be specified as:

$$LnS_t = E_t LnS_{t+1} - FP/4 \quad (7.13)$$

A function to determine FP can be obtained by using the definition that $RC^* = R^* + FP$ and then inverting the estimated demand equation (i.e equation (4.14) for which the estimation results are reported in Table 4.8) for net overseas assets by the non-bank private sector so that:

$$FP = \beta_0 - (RG_t - R^*_t) + \beta_1 Ln(F/NDA)_t - \beta_2 Ln(F/NDA)_{t-1} \quad (7.14)$$

Finally it is possible to obtain the change in the non-bank private sector's holdings of net overseas assets from i) the flow addition due to the current account surplus and ii) the stock valuation effects attributable to exchange rate changes. Rearranging (7.9) produces:

$$F = F_{t-1} + CA_t - \Delta RES_t - \Delta FB_t + OTHER_t \quad (7.15)$$

The specification in (7.13) to (7.15) ensures that the exchange rate is determined by the interaction of all the asset market equations not just by the balance of payments capital flows [1] and hence is consistent with the asset market approach to exchange rate determination and the main thrust of Melitz [1984].

7.4 Generation of Exogenous Variables

Eighteen exogenous variables are used in the model. Of these variables, one consists of a time trend and three are seasonal binary variables. Generating processes for these variables are purely mechanical, i.e. $1 + T_{t-1}$ for the time trend and D_{t-4} for the seasonal binary variables. Special Deposits is a government policy variable and it was decided to represent this variable by a random walk. One other variable needs further comment. In the model PEXP is treated as exogenous. As far as forecasting exogenous variables is concerned, it is only necessary to forecast either the price level or the rate of inflation since the forecast for one implies values for the other. We provide below a process for the generation of forecasts of the price level which imply a forecast for PEXP given by:

$$\Delta PEXP = LnCPI_{t+4} - LnCPI_t \qquad (7.16)$$

For the remaining thirteen variables predicted values were obtained using ARIMA processes (see for example Box and Jenkins [1970]). Graphs of the original series together with details of the autocorrelation (ACF) and partial autocorrelation functions (PACF) are shown in figures 7.1 to 7.32. By examining the graphs of the series (to observe any change of mean or variance) and checking the ACF and PACF's to see if they decline for long lags, a decision can be made on whether each series is stationary. It appears that RM (see figures 7.12 and 7.24), OTHER (see figures 7.7 and 7.19), BOF(=ΔRES) (see figures 7.8 and 7.20), PSBR (see figures 7.10 and 7.22) and CA (see figures 7.9 and 7.21) are stationary. The remaining series, R^* (see figures 7.1 and 7.13), LnYEXP (see figures 7.2 and 7.14), P (see figures 7.3 and 7.15), LOS (see figures 7.4 and 7.16), OL (see figures 7.5 and 7.17) RESID (see figures 7.6 and 7.18) and USP (see figures 7.11 and 7.23) are non-stationary and so are differenced to remove the trend. This appears to make R* (see figure 7.25), LnYEXP (see figure 7.26), P (see figure 7.27), LOS (see figure 7.28), OL (see figure 7.29) and RESID (see figure 7.30) all stationary, but in the case of USP (figure 7.31) the ACF implies there is still a trend. Second differencing gives stationarity (see figure 7.32).

Subsequently a search was made for an appropriate ARIMA process of the order (p d q). Various combinations of p and q were tried with values ranging from 0 to 2 inclusive so as to ascertain the "best fit". The selection criteria were i) the smallest value of the residual sum of squares; ii) the significance of the estimated autoregressive or moving average coefficients; iii) the lack of significance of the autocorrelation and partial autocorrelation coefficients of the residuals and iv) parsimony. The third criteria is necessary to ensure the residuals are free from information content so that the correlation coefficients should not be significantly different from zero.

The selected processes are shown in Table 7.1 with the relevant autocorrelation and partial autocorrelation coefficients of the residuals being shown in tables 7.2 and 7.3 respectively. Estimation was achieved through use of the MINITAB computer package. For the uncovered foreign rate of interest (R*), the best

Table 7.1 Exogenous Variables Generating Processes

Variable	ARIMA Process	MA(1)	AR(1)	Constant	SSR	RMS of of SSR as a % of Mean Value
RF	0 1 1	0.4411 (2.58)			0.02	26.0
LnYEXP (4th difference)	0 1 1	0.3837 (2.09)			0.01	1.3
CPI	1 1 0		0.8567 (8.87)		188.14	2.0
LOS	1 1 0		0.5330 (2.94)		3389431	8.6
OL	1 1 1	0.8746 (5.58)	1.0015 (22.59)		14215740	5.6
RESID	0 1 1	-0.3001 (1.66)			921397	22.7
PSBR	1 0 1	-0.9299 (4.78)	-0.6121 (2.19)	176.5 (0.45)	29134848	60.6
USCPI	0 2 1	0.3876 (2.25)			17.36	6.9
CA	0 0 1	0.3876		163.9	9845851	536.8

Processes for RM, OTHER, and BF are modelled as random walks

TABLE 7.2 AUTOCORRELATION COEFFICIENT OF RESIDUALS

	COEFFICIENTS															standard error 1/ n	degrees freedom	critical t value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
HF	-0.019	-0.133	0.120	0.239	0.124	-0.112	0.008	0.023	-0.017	-0.049	-0.114	-0.097	-0.051	-0.040	-0.129	0.180	30	0.367
LRYEYP	0.169	-0.133	-0.133	-0.355	0.169	0.392	0.088	-0.030	-0.164	-0.394	0.003	0.035	0.141	0.153	-0.264	0.192	26	0.390
CPI	-0.402*	.032	-0.175	.232	-0.104	-0.099	-0.179	.219	.069	-0.211	.065	.095	.097	-0.222	.021	0.180	30	0.367
LOS	-0.206	-0.008	.107	-0.082	.035	-0.220	-0.071	.107	-0.307	-0.067	.267	-0.012	-0.053	-0.065	-0.103	0.180	30	0.367
OL	-0.367	.286	-0.109	0.246	-0.283	.327	-0.407*	.222	-0.194	.176	-0.264	.332	-0.244	.094	-0.092	0.180	30	0.367
RESID	-0.079	-0.180	-0.034	.126	-0.192	-0.171	-0.028	.067	.124	-0.058	-0.048	.100	.074	-0.264	-0.118	0.180	30	0.367
PSBR	-0.011	-0.041	-0.090	-0.390*	.045	-0.147	.141	.183	.157	-0.101	-0.112	-0.079	-0.234	.267	-0.025	0.189	27	0.387
US CPI	.060	-0.369	.211	.212	.213	-0.168	.168	.001	-0.289	-0.067	.214	.051	-0.318	-0.107	.106	0.183	29	0.375
LA	.103	.098	-0.017	.202	.067	-0.097	-0.080	.215	.053	.108	-0.091	.162	.015	-0.062	-0.167	0.177	31	0.362

* Indicates coefficient significantly different from zero. (Type I error = 0.05)

TABLE 7.3 PARTIAL AUTOCORRELATION COEFFICIENTS OF RESIDUALS

FUNCTION	COEFFICIENTS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	standard error 1/ n	degrees freedom	critical t value
RF	-0.019	-0.133	0.117	0.232	0.179	-0.062	-0.030	-0.104	-0.080	-0.047	-0.098	-0.109	-0.057	-0.016	-0.066	0.180	30	0.367
LRYEYP	0.169	-0.167	-0.084	-0.358	0.312	0.238	-0.018	-0.104	0.045	-0.282	-0.005	-0.249	0.238	-0.129	-0.102	0.192	26	0.396
CPI	-0.402*	-0.155	-0.272	.056	-0.008	-0.180	-0.350	-0.123	.072	-0.220	-0.094	-0.012	.011	-0.176	-0.124	0.180	30	0.367
LOS	-0.206	-0.052	.099	-0.041	.015	-0.235	-0.167	.048	.050	-0.073	.235	.054	-0.094	-0.155	-0.140	0.180	30	0.367
OL	-0.367	.175	.050	.211	-0.178	.143	-0.269	-0.043	-0.005	.069	-0.056	.137	.034	-0.199	-0.011	0.180	30	0.367
RESID	-0.079	-0.187	-0.068	.086	-0.199	-0.187	-0.137	-0.058	0.121	-0.054	-0.089	.019	.027	-0.207	-0.146	0.180	30	0.367
PSBR	-0.011	-0.041	-0.091	-0.398*	.014	-0.231	.071	.006	.224	-0.260	.081	-0.116	-0.097	.163	-0.048	0.189	27	0.387
US CPI	.060	-0.374	.309	.005	.073	-0.122	.064	-0.090	-0.151	-0.087	.089	.092	-0.251	-0.131	-0.173	0.183	29	0.375
CA	.103	.089	-0.035	.202	-0.034	-0.152	-0.054	.236	-0.011	.102	-0.063	.079	-0.048	-0.091	-0.100	0.177	31	0.362

* Indicates coefficient significantly different from zero. (Type 1 error = 0.05)

process was an ARIMA (0 1 1). Alternative representations using autoregressive functions failed to obtain estimates of the relevant coefficients which were significantly different from zero at the 5% level. An exception to this occurred in the case of an ARIMA (2 1 2) process but this was rejected on the grounds of parsimony in view of the fact that the additional restrictions failed to improve significantly the fit as evidenced by an observed χ^2 of 5.87 against the critical 5% value of 7.815 using the test:

$$\chi^2_{(r)} = n*\ln(S^2_r/S^2_u) \qquad (7.17)$$

where r = number of restrictions

S^2_r = restricted sum of squares

S^2_u = unrestricted sum of squares

n = number of observations

There is no evidence of exploitable information in the residuals since none of the relevant coefficients listed in Tables 7.2 and 7.3 approach the critical value. Nevertheless the representation is not completely satisfactory given the rather high value of the relative root-mean square of the residuals shown in the last column of Table 7.1.

In the case of LnYEXP. it was necessary to fourth difference the original series prior to seeking out the best ARIMA process in order to eliminate the seasonal influence. Again an ARIMA (0 1 1) process provided the best fit. The relative root-mean square of the residuals is very satisfactory. None of the coefficients listed in Tables 7.2 and 7.3 are significantly different from zero for LnYEXP but a few coefficients do approach the critical value.

The position with the P series is that the ARIMA (1 1 0) process meets all the criteria with the exception that the first order autocorrelation coefficient is significantly different from zero. Consequently it is not possible to assume that the residuals are pure white noise and information free. An ARIMA (0 1 1) process also yielded a significant estimate of the relevant coefficient but with a higher sum of squares of the residuals. Other processes failed to converge after twenty five iterations.

The selected best fit model for LOS is (1 1 0) which provides a satisfactory estimate. The estimated coefficient is significantly different from zero with a reasonably low relative root-mean square of the residuals. The appropriate correlation coefficients displayed in Tables 7.2 and 7.3 provide no indication of any remaining information content within the residuals. ARIMA (0 1 1) and (1 1 1) processes also provided estimates of the relevant coefficients which were significantly different from zero. In the case of the moving average process, the sum of the squares of the residuals was greater than that achieved through the use of the first order autoregressive process. The use of the additional restriction in the (1 1 1) process failed to provide a significant reduction in the value of the sum of squares as evidenced by the χ^2 test. Turning now to the other liabilities of the banks (OL) the selected process is an ARIMA (1 1 1). Both coefficients are statistically significant and the degree of fit, as evidenced by the relative root-mean square of the residuals, is good. Values of p and q higher or lower than 1 produce coefficients which are not significantly different from zero. However examination of the relevant autocorrelation coefficients contained in Tables 7.2 and 7.3 suggest that the residuals may not be pure white noise. Several coefficients verge on significance at the 5% level and one coefficient exceeds the critical "t" value. Estimation of the process for RESID proved to be more problematic. Examination of the time profile of the series exhibited in figure 7.6 suggests a non-stationary series with a negative time trend. The evidence from the autocorrelations depicted in figure 7.18 is less clear cut but nevertheless first differencing does seem to be necessary (see figure 7.30). Difficulty was experienced in estimating a satisfactory ARIMA process and it was pertinent to note that the estimated moving average (1) coefficient is not statistically different from zero. In addition the quite high relative root-mean square of the residuals indicates a not-very high explanatory power. In contrast the residuals appeared to be white noise. The performance of the other ARIMA processes were even less satisfactory with either coefficients with a lower degree of significance or the estimation process failing to converge within twenty five iterations. On balance therefore, given the revealed time profile of the series, it seems preferable to use an ARIMA (0 1 1) process as compared with the alternative of a random walk which implies a constant value throughout the forecast period.

The series for PSBR exhibits a strong seasonal pattern so that as for LnYEXP it was necessary to fourth difference the series prior to seeking out an appropriate ARIMA process. The best process turned out to be an ARIMA (1 0 1). The estimated coefficient is significantly different from zero and the residuals are largely free from information content - one autocorrelation and one partial autocorrelation coefficient are significantly different from zero. The major drawback is the high relative root-mean square error of the series. In part this is due to the presence of positive and negative values which produces a relatively low mean value with a high variability (mean 1779 and standard deviation 1043). An ARIMA (1 0 0) process produced similar results but with a marginally higher sum of squares of the residuals. Other processes failed to converge within twenty five iterations or resulted in non-significant coefficients.

Turning now to the US consumer price index, as noted earlier it was necessary to twice difference the series and an ARIMA (0 2 1) process produced the best results. The moving average coefficient was significant at the 5% level and the explanatory power of the process was high as evidenced by the low relative root-mean square of the residuals. None of the two sets of autocorrelation coefficients for this variable contained in Tables 7.2 and 7.3 are significantly different from zero at the 5% level but two coefficients are only very slightly below the critical "t" value. Therefore it is not possible to say with complete certainty that the residuals are free of information content. Other processes yielded at least one estimated coefficient which was not significantly different from zero or alternatively failed to converge within twenty five iterations. The explanatory power of the estimated generating process for CA was extremely low as evidenced by the very high relative root-mean square of the residuals. As is the case for PSBR this is partly due to a series with positive and negative values resulting in a low mean but with high variability (mean 106 standard deviation 671). In other respects the estimated process was satisfactory. The estimated coefficient was significantly different from zero at the 5% level. Examination of the various correlation coefficients in Tables 7.2 and 7.3 yields no evidence of information content. An ARIMA (1 0 0) process also produced a significant coefficient but with a marginally higher sum of squares of the residuals. Combinations of autoregressive and moving average processes produced at least one insignificant coefficient.

Finally it was not possible to derive satisfactory ARIMA processes for the variables RM, OTHER and BOF. In no cases were the coefficients near an acceptable level of significance. Consequently it was decided to model these processes as random walks.

7.5 Evaluation of the Model

Within the relevant literature, there are no clear and unambiguous criteria according to which macroeconomic models can be evaluated. Criteria often used include:

i) Comparison with Time Series Models

ii) Ex Post Forecasts

iii) Ex Ante Forecasts

Methods (ii) and (iii) can be employed within the sample period and outside the sample period. As Matthews [1985] notes evaluation of ex post forecasts can be criticised on the grounds that the degree of exogeneity varies between models whereas ex ante forecasts reflect not only the character of the model but also the ability of the model user. Evaluation of models using within period sample period data runs the risk of over-using sample period data. Fair [1979] notes a further difficulty with regard to outside sample period forecasts in that "it is an unfortunate characteristic of macroeconomic models that the coefficients can change substantially as the sample period changes ...."(page 705).

'Ex Ante' tracking exercises are subject to further difficulties. The first concerns the projection of the exogenous variables. As is customary, in this model these processes were estimated by ARIMA methods. Clearly market operators would have additional knowledge to that revealed by the time series analysis so as to forecast the future path of the exogenous variables. In other words, ARIMA processes on their own are unlikely to provide 'best' forecasts of the exogenous variables. A more subtle difficulty with respect to the forecasts arises from the fact that the ARIMA processes themselves were estimated over the whole sample period and may therefore not have been known to market operators.

More correctly these processes should have been estimated over a period prior to the sample period and therefore the implied assumption is made that we are estimating processes which were already in existence and known to market operators. A second problem occurs because our forecasts ignore the stochastic component of the time series estimates. Hendry and Richard [1982] point out that if the model is stationary, such forecasts would simply tend to the mean of the relevant series unless the series of exogenous variables was continuously updated. Consequently, in the absence of such updating, the historic track will explain none of the variance of the observed series even if the model is the true data generating mechanism. Finally Hendry and Richard [1982] demonstrate also that an examination of historic tracking errors may not substantiate the validity of the model even if it is the 'true' model generated by the data because the accuracy of the simulation track depends on "the extent to which the selected model attributes data variance to factors which are outside the model irrespective of whether or not such factors really are strongly exogenous in practice" (page 29).

Nevertheless, provided these defects are kept in mind, it is argued that tracking exercises still provide some indication of the validity of the model as a whole as distinct from that of the individual equations examined in chapters 4 and 5. The following exercises were carried out using the 'RATEXP' computer package - see for example Matthews, Marwaha and Pierse [1981]:

i) Simulation using actual values of exogenous variables and actual subsequent observations of the expected variables (i.e perfect foresight)

ii) True rational expectations forecasts

In the case of (ii) above the method adopted was similar to that outlined in Matthews [1985]. The projections of the exogenous variables were used to produce a four-period ahead forecast in the following manner:

$$E_{t-1}X_{t+i} = E(X_{t+i}/Q_{t-1}) \tag{7.18}$$

$$E_{t-1}Y_{t+i} = f^{n}(E_{t-1}X_{t+i};\ E_{t-i}Y_{t+i+1}) \tag{7.19}$$

$$i = 1,2,3,4$$

where Q = the information set

Y = endogenous variables

X = exogenous variables

The process was then repeated for the whole sample period with the information on the exogenous variables being updated at each forecast. This also requires specification of the terminal condition [2]. The procedure adopted was to use the definition of the real exchange rate and to forecast the future real exchange rate by way of a simple time trend and using the forecasts of the domestic and US price levels derived from the ARIMA forecasts discussed earlier. The actual equations used were:

$$E_{t}LnS_{t+1} = LnUSP_{t+1} - LnP_{t+1} - RealLnS_{t+1} \tag{7.20}$$

with RealLnS being defined as:

$$RealLnS = LnUSP - LnP - LnS \tag{7.21}$$

The precise version of the model used was that listed in appendix 7.A. This involves one alteration to the estimated equations as discussed in chapters 4 and 5. As noted earlier the assumption of equality between domestic and foreign rates of interest facilitated the estimation of the bank lending equation. It was felt, however, that the own rate of interest should have a stronger impact on the demand for bank loans than that for the competing source of loans. Consequently this assumption was imposed on the relevant equation by adjusting the two estimated coefficients but it should be noted that the adjusted coefficients still lie within a 95% confidence interval of their original (equal) estimates.

Examination of the tracking errors concentrated on variables considered to be of significance within the context of the theoretical model discussed in chapter 3. These are i) notes and coins (NC); ii) two definitions of money (M1 and M2); iii) domestic bank lending to the non-bank private sector in sterling (L) iv) the rate of interest on bank loans (RL) and the exchange rate (LS). Figures 7.33 to 7.62 show the behaviour of the actual and model forecasts of these variables. Further examination of the tracking errors concentrated on the following summary statistics comparing the actual and model predicted values of key variables:

i) The Root Mean Square Error

i.e. $\{\Sigma(P_i-A_i)/n\}^{1/2}$

ii) The Mean Absolute Error

$\{\Sigma|P_i-A_i|/n\}$

iii) The Mean Error

$\{\Sigma(P_i-A_i)/n\}$

iv) The Theil Inequality Coefficient

$(\Sigma(P_i - A_i)^2 / \Sigma A_i^2)$

v) The correlation coefficient between the actual and model predicted variables.

where P_i and A_i refer to predicted and actual values respectively Greater importance was attached to measures (i), (ii) and (iv) as opposed to (iii) since the latter can be quite small due to negative and positive errors offsetting each other by chance. Similarly a high value for the correlation coefficient can be recorded even if the prediction is biased. The Theil inequality coefficient has a minimum value of 0 but no upper limit. The relevant statistics are shown in Tables 7.4 to 7.8.

We now examine the results of simulations of the model. These results are reported in Tables 7.4 to 7.8. The first simulation uses actual observed values of both the exogenous variables and LnS_{t+1} noting that this experiment represents perfect foresight. The statistics incorporated in Table 7.4 seem satisfactory with relatively low forecast errors. The tracking performance of the model is depicted in Figures 7.33 to 7.38 inclusive. Again the results seem to be adequate. The second set of simulation results reported in Tables 7.5 to 7.8 cover dynamic rational expectations solutions of the model with the terminal condition for the expected exchange rate being given by (7.20) and (7.21). Thus these simulations test not only the performance of the model but also, in addition, the ability to forecast values of the expected exchange rate used as terminal conditions. For the quantity variables the summary statistics reported in Tables 7.5 to 7.8 seem satisfactory. As would be expected the errors tend to become larger as the forecasting horizon increases. In general higher order forecasts induce higher order serial correlation. Thus forecast errors will be correlated up to the length of the forecasting horizon-1. This will lead to higher variances and, therefore, forecast errors.

A similar pattern is revealed in Figures 7.39 to 7.42, 7.45 to 7.46, 7.51 to 7.54 and 7.57 to 7.60 for one period, two period, three period and four period ahead forecasts but it is noteworthy that the prediction for bank lending produced one outlier for each of the simulations when substantial under-prediction occurred. Charts 7.41, 7.47, 7.53 and 7.59 reveal a similar, if less pronounced, picture for M2. These errors occur in the one/four period ahead forecasts starting from 1977 quarter 1 when the model failed to converge. These were the only simulations where convergence was not achieved so little weight should be attached to these errors. The results for the bank lending rate of interest are less satisfactory and relatively high forecasting errors are recorded in Tables 7.5 to 7.8. A similar picture is revealed in Figures 7.43, 7.49, 7.55 and 7.61.

Table 7.4 Static Simulation: Actual Exogenous Variables 1974 Quarter 3 to 1979 Quarter 4

	r	% RMS	%MAS	%ME	TIC
NC	0.996	2.4	2.0	-1.4	0.0006
M1	0.996	2.6	2.2	-1.5	0.0007
M2	0.993	2.8	2.6	-1.8	0.0008
L	0.993	3.1	2.6	-1.3	0.0010
RL	0.979	4.8	3.9	-0.6	0.0022
LnS	0.890	7.3	6.1	-0.9	0.0053

where r = correlation coefficient between actual and predicted values

%RMS = % Root Mean Square Error

%MAS = % Mean Absolute Error

%ME = % Mean Error

TIC = Theil's Inequality Coefficient

Table 7.5 Static Simulation: Rational Expectations

One period Ahead Forecasts

1974 Quarter 3 to 1979 Quarter 4

	r	% RMS	%MAS	%ME	TIC
NC	0.987	3.4	2.8	0.6	0.0011
M1	0.986	3.7	2.9	0.1	0.0013
M2	0.978	3.7	3.2	-0.8	0.0013
L	0.971	5.0	3.7	-0.4	0.0024
RL	0.796	14.2	10.9	1.6	0.0194
LnS	-0.540	26.9	22.9	-7.1	0.0766

where r = correlation coefficient between actual and predicted values

%RMS = % Root Mean Square Error

%MAS = % Mean Absolute Error

%ME = % Mean Error

TIC = Theil's Inequality Coefficient

Table 7.6 Static Simulation: Rational Expectations

Two Period Ahead Forecasts

1974 Quarter 3 to 1980 Quarter 1

	r	% RMS	%MAS	%ME	TIC
NC	0.981	4.6	3.5	2.4	0.0002
M1	0.982	4.5	3.7	1.8	0.0002
M2	0.974	4.1	3.3	-0.5	0.0017
L	0.959	7.3	4.9	-0.8	0.0051
RL	0.641	19.4	16.9	3.1	0.0384
LnS	-0.692	27.2	23.7	-7.0	0.0721

where r = correlation coefficient between actual and predicted values

%RMS = % Root Mean Square Error

%MAS = % Mean Absolute Error

%ME = % Mean Error

TIC = Theil's Inequality Coefficient

Table 7.7 Static Simulation: Rational Expectations

Three Period Ahead Forecasts

1974 Quarter 3 to 1980 Quarter 2

	r	% RMS	%MAS	%ME	TIC
NC	0.964	6.87	5.3	4.2	0.0045
M1	0.970	6.3	5.1	3.5	0.0038
M2	0.973	4.3	3.6	-0.1	0.0018
L	0.955	8.8	6.4	-1.3	0.0074
RL	0.432	26.5	22.1	5.2	0.0654
LnS	-0.675	26.4	23.5	5.9	0.0680

where r = correlation coefficient between actual and predicted values

%RMS = % Root Mean Square Error

%MAS = % Mean Absolute Error

%ME = % Mean Error

TIC = Theil's Inequality Coefficient

Table 7.8 Static Simulation: Rational Expectations

Four Period Ahead Forecasts

1974 Quarter 3 to 1980 Quarter 3

	r	% RMS	%MAS	%ME	TIC
BC	0.930	9.7	8.1	6.6	0.0091
M1	0.951	8.3	6.5	5.3	0.0066
M2	0.969	4.7	4.1	0.6	0.0021
L	0.947	10.3	8.3	-1.9	0.0099
RL	0.340	29.0	24.8	6.8	0.0781
LnS	-0.768	26.6	23.3	-4.8	0.0685

where r = correlation coefficient between actual and predicted values

%RMS = % Root Mean Square Error

%MAS = % Mean Absolute Error

%ME = % Mean Error

TIC = Theil's Inequality Coefficient

Finally turning to the forecast errors for the exchange rate which can only be described as poor (see Tables 7.5 to 7.8 and also figures 7.44, 7.50, 7.56 and 7.62). It should however be remembered that this variable is forecast by the equation:

$$LnS_t = E_t LnS_{t+1} - FP/4 \qquad (7.13)$$

and no doubt the inadequate performance reflects to a large extent the inability to forecast the required terminal conditions for $E_t LnS_{t+1}$ with any degree of precision. It will be recalled that the predicted value of the expected real exchange rate is obtained by a simple time trend and we show below summary statistics for the relationship between the actual and predicted values during the observation period:

R^2	0.504
RMS	0.170(25%)
MAS	0.146(17%)
ME	-0.187(27%)

where the same abbreviations are used as in Tables 7.4 to 7.8 and the figures in brackets represent percentage errors

A second reason for this deficiency is that the simulations were carried out under the assumption of a pure float whereas the authorities intervened in the markets during this period [3]. This view is substantiated by comparing these errors with those obtained using actual values for $E_t LnS_{t+1}$ described in table 7.4.

The tentative conclusion drawn from this analysis is that the model gives a reasonable representation of the UK financial system during the relevant observation period.

Notes

1 This arises because of the ratio log(F/NDA) used as the dependent variable in the original equation for holdings of net overseas assets held by the non-bank private sector. For example a once-and-for-all increase in domestic wealth due to a rise in the PSBR causes the exchange rate ($ per £) to rise as foreign assets and domestic money are substituted for bonds in portfolios.

2 Fuller discussion of terminal conditions is contained in chapter 8.2.

3 Kearney and MacDonald [1985] also note the poor fit of a rational expectations simulation over approximately the same time period. They argue that the actual rate would have followed the path of the rational expectations simulation if the "information about the Thatcher experiment been known in advance"(page 20).

Appendix 7.A

The instrumental variable estimates are used with the sole exception of the banks' demand for monetary base for which estimation was by ordinary least squares only. The entire model was re-estimated by the full information maximum likelihood method with all the slope parameters contained in the information set so as to obtain new estimates of the constant terms. As noted in the main body of the text, the non-bank private sector net overseas asset equation was inverted to obtain the forward premium as the dependent variable with the actual net holdings of overseas assets being obtained from the balance of payments identity. Variables are as defined before with the exception of the seasonal binaries D1, D2 and D3. Full details of the abbreviations used follow the listing of the equations/identities.

Non-Bank Private Sector Portfolio Equations

E.1 $LNCD = 10.342 + 0.4541RD_t - 0.5892LnYEXP - 0.1606LnRV_t + 0.5085LNCD_{t-1} + 0.0018T - 0.0417D1 - 0.0277D2 - 0.0290D3$

$\rho = -0.4392$

E.2 $LMTD = 3.658 - 1.121RD_t - 0.2484LnRV_t + 0.3534\Delta PEXP_t + 0.0014T + 0.9752LMD_{t-1} - 0.0302D1 - 0.0407D2 - 0.0196D3$

$\rho = -0.3626$

E.3 $LMBA = 3.887 + 2.753(RD-RG)_t - 0.6026LnRV_t - 0.0165T + 0.0498LMBA_{t-1} - 0.0697D1 - - 0.0373D2 - 0.0351D3$

$\rho = 0.4759$

E.4 $LBLA=-1.9979 - 1.456RL_t¶ + 0.900RC_t¶ + 0.1485LnRV_t + 0.0004T + 0.7793LBLA_{t-1} +0.0115D1 + 0.0131D2 - 0.0123D3$

E.5 $FP= -1.0979 - (R^*_t - RG_t) + 0.0800Ln(F/NDA)_t - 0.0482Ln(F/NDA)_{t-1} - 0.0056D1+ 0.0037D2 - 0.0120D3$

¶ = imposed coefficient

Banking Sector Portfolio Equations

E.6 $RL = -0.0611 + 0.8806RM_t + 0.1073LENRAT_t$

E.7 $RD = 0.0183 + 0.5625(RL+RC^*)_t - 0.1062TDRAT_t$

$\rho = 0.3154$

E.8 $LBHD=-0.5953 - 0.3387RM_t - 0.1019D1 - 0.0392D2 - 0.0562D3$

$\rho = 0.8408$

E.9 $FB_t/(TBL+BB)_t = -0.0049 + 0.4836R^*_t + 0.7021FP_t -0.5391RL_t + 0.7570(FB/(TBL+BB))_{t-1} + 0.0020D1 + 0.0052D2 + 0.0001D3$

Term Structure

E.10 $RG= RM + 0.007$

Valuation Effect

E.11 $W = NDA_{t-1} + PSBR_t - 0.15*((RG_t-RG_{t-1})/RG_{t-1}) *NDA_{t-1} + F_{t-1} + CA_t - BF_t+ OTHER_t - (FB_t-FB_{t-1}) + 0.5*(LnS_t-LnS_{t-1})*F_{t-1}$

Log of the Exchange Rate

E.12 $LnS_t = E_t LnS_{t+1} - FP/4$

Identities

I.1	$NC = \{Exp(LNCD)\}DS$	Notes and coins
I.2	$M1 = \{Exp(LMTD)\}DT$	Narrow money
I.3	$DS = M1 - NC$	Sight Deposits
I.4	$M2 = (Exp(LMBA))B$	Broad Money
I.5	$DT = M2 - M1$	Time Deposits
I.6	$L=\{Exp(LBLA)\}DAS$	$ Bank lending to nbps
I.7	$D=DS + DT$	Total £ bank deposits
I.8	$TBL = L + LOS$	Total £ bank lending
I.9	$HB=\{Exp((LBHD)\}D$	Bank's monetary base
I.10	$BB=OL+D-HB-FB-SPECD$	Bank's holdings of bonds
I.11	$F=CA-BF+OTHER-(FB_t-FB_{t-1})+F_{t-1} + 0.5*(LnS_t-LnS_{t-1})*F_{t-1}$	Inverted balance of payments identity
I.12	$DAS = B + M2$	nbps gross domestic assets
I.13	$B= W - M2 - F - RESID + BL$	nbps bond holdings
I.14	$LnRW = Ln(W/P)$	nbps real financial wealth
I.15	$RC^* = R^* + FP$	covered foreign rate of interest

I.16 NDA = DAS - L — nbps net domestic assets

I.17 LENRAT = TBL/(D+OL) — banks lending ratio

I.18 TDRAT=DT(D+OL) — banks time deposit ratio

Endogenous Variables

B	bonds held by the nbps
BB	bonds held by the banking sector
DAS	nbps gross domestic assets
D	total sterling bank deposits
DS	sight deposits held by the nbps
DT	time deposits held by the nbps
F	net overseas assets of the nbps
FB	net overseas assets of the banks
FP	forward premium on $
HB	monetary base held by banking sector
L	sterling bank lending to the nbps
LBHD	Ln(HB/D)
LBLA	Ln(L/DAS)
LBLL	Ln(BB/TBL)
LMBA	Ln(M2/B)
LMTD	Ln(M1/DT)
LNCD	Ln(NC/DS)
LnS	Ln spot exchange rate (£ per $)
M1	narrow money held by nbps

M2	broad money held by nbps
NC	notes and coins (i.e. monetary base) held by nbps
NDA	net domestic assets held by nbps
P	General price level based on consumer prices
RC^*	covered foreign rate of interest
RD	rate of interest paid on time deposits
RL	rate of interest charged on sterling bank loans
RG	5 year gilt rate of interest
TBL	total sterling bank lending by banking sector
W	Net financial wealth of the nbps

Exogenous Variables

BOF	official financing balance of payments also depicted by ΔRES
B^*	total supply of government bonds
LOS	bank lending in sterling to overseas sector
CA	current account balance of payments
CPI	consumer price index
D_i	seasonal binary variables
LRYEXP	Ln real expected GDP at factor cost
OL	other liabilities of the banking sector
OTHER	residual of the balance of payments identity
ΔPEXP	expected inflation
R^*	uncovered Eurodollar rate of interest
RESID	residual item in the definition of FIN
RM	treasury bill (money market) rate
SPECD	special deposits

T Time in units of 1 quarter

USP US consumer price index

Predetermined Variables

$LMTD_{t-1}$	FB_{t-1}	$LBHD_{t-1}$
RC^*_{t-1}	$LBLA_{t-1}$	$LNCD_{t-1}$
RD_{t-1}	$LBLL_{t-1}$	$LNCD_{t-2}$
RL_{t-1}	LRY_{t-1}	RG_{t-1}
$LMBA_{t-1}$	$LnRW_{t-1}$	DT_{t-1}
NDA_{t-1}	F_{t-1}	LnS_{t-1}
LnS_{t-2}	B_{t-1}	

Appendix 7.B: Graphs

FIGURE 7.1 THE UNCOVERED FOREIGN RATE OF INTEREST (R*)

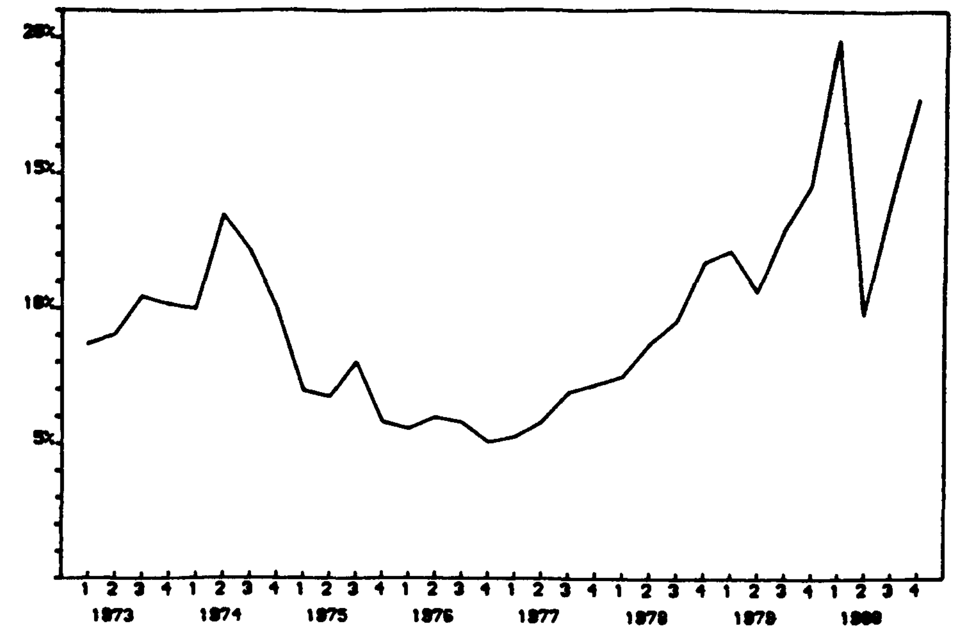


FIGURE 7.2: LOG EXPECTED REAL GNP (LYEXP)

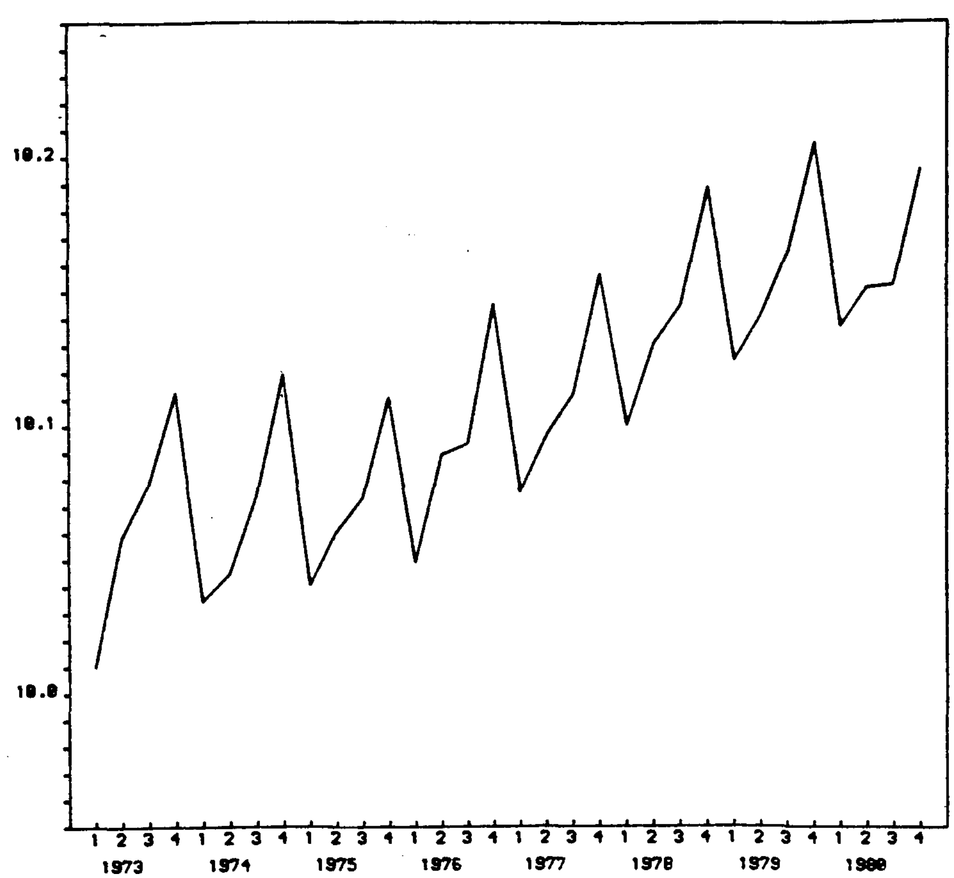


FIGURE 7.3: CONSUMER PRICE INDEX (P)

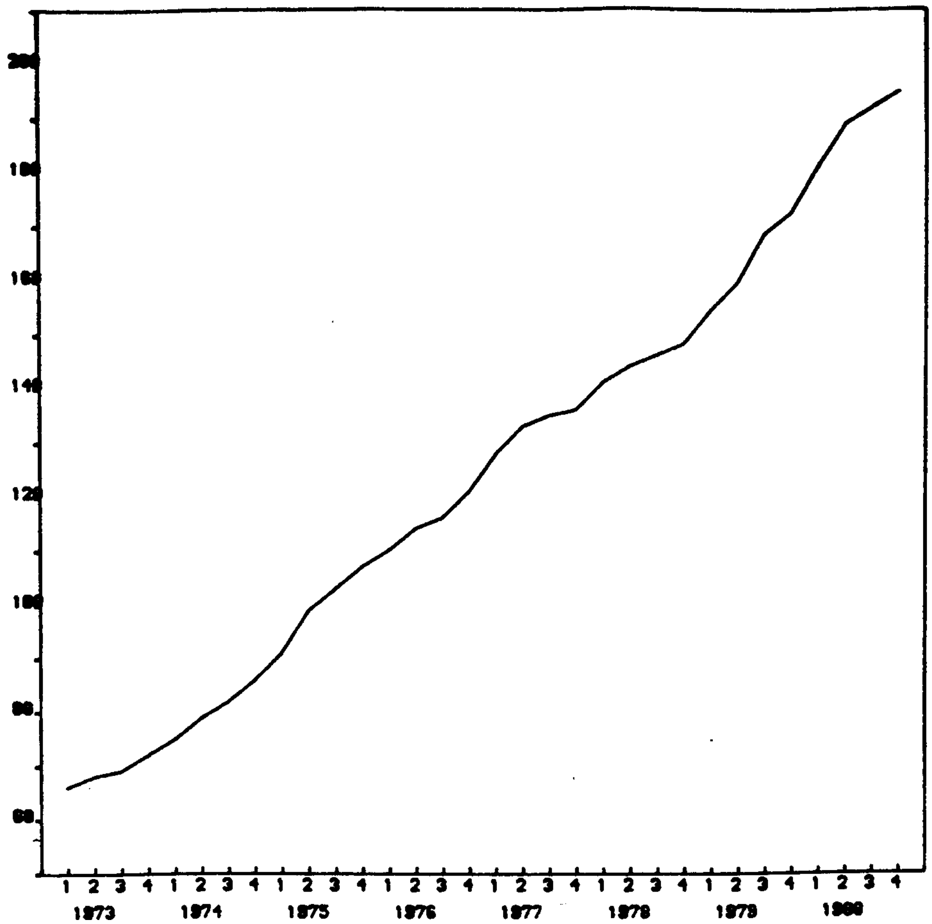


FIGURE 7.4: STERLING BANK LENDING OVERSEAS (LOS)

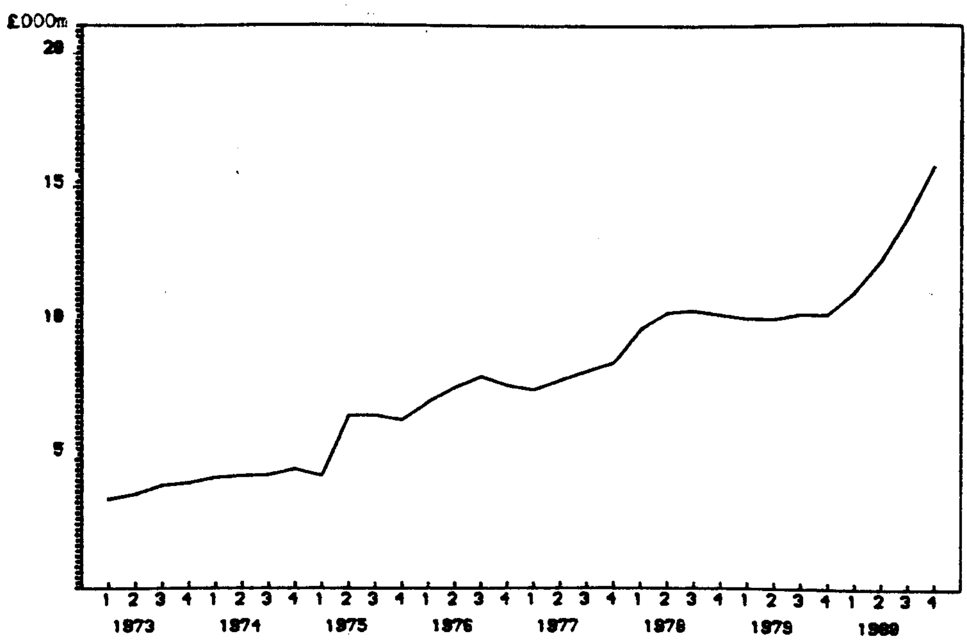


FIGURE 7.5: OTHER LIABILITIES OF THE BANKING SECTOR (OL)

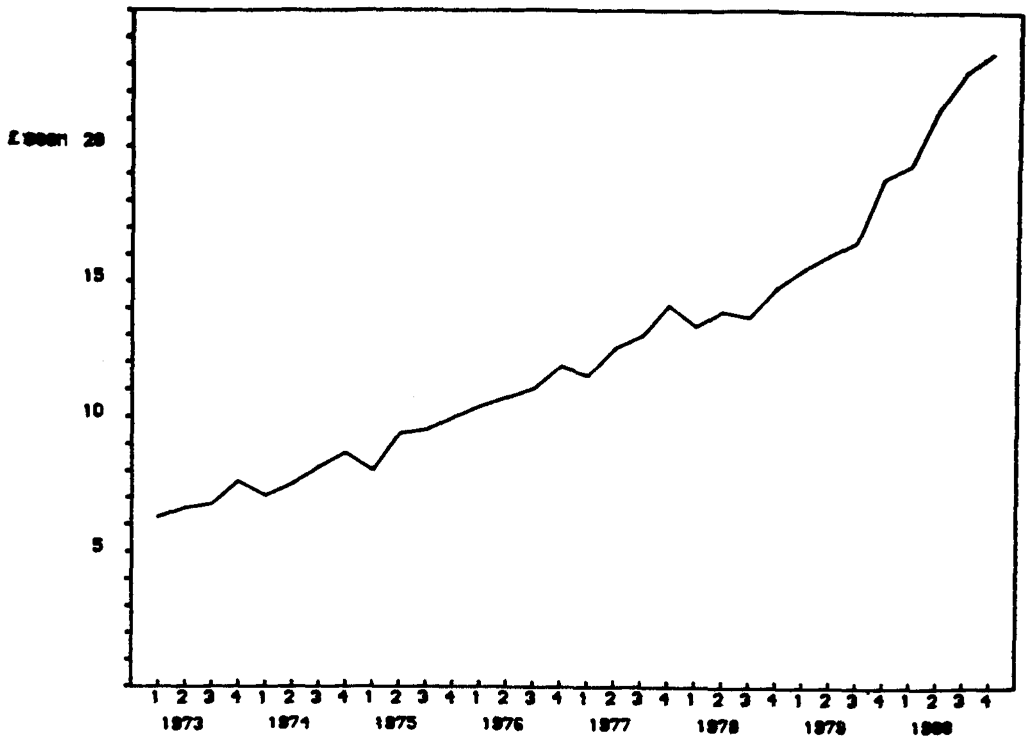


FIGURE 7.6:
RESIDUAL ELEMENT OF NON-BANK PRIVATE SECTOR FINANCIAL WEALTH (RESID)

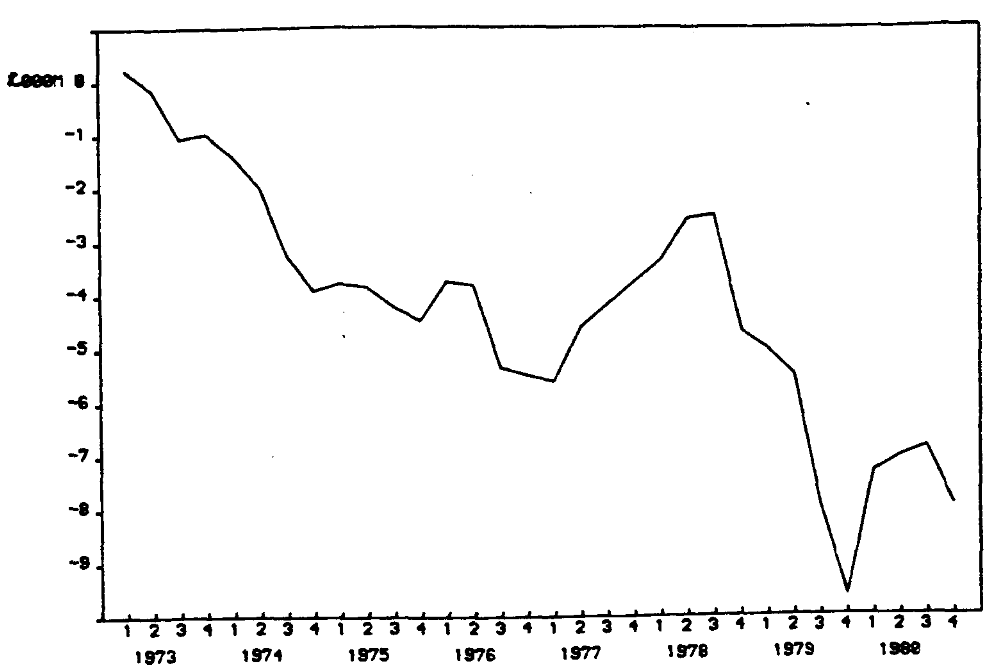


FIGURE 7.7: RESIDUAL FROM THE BALANCE OF PAYMENTS (OTHER)

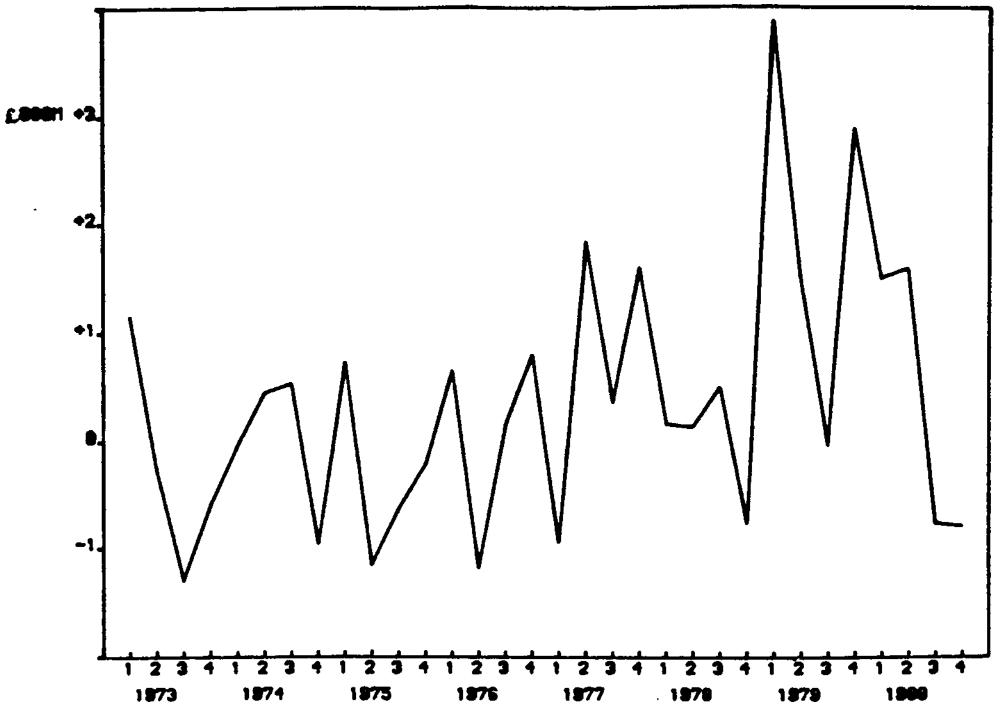


FIGURE 7.8: BALANCE OF PAYMENTS - CHANGE IN RESERVES (BOF)

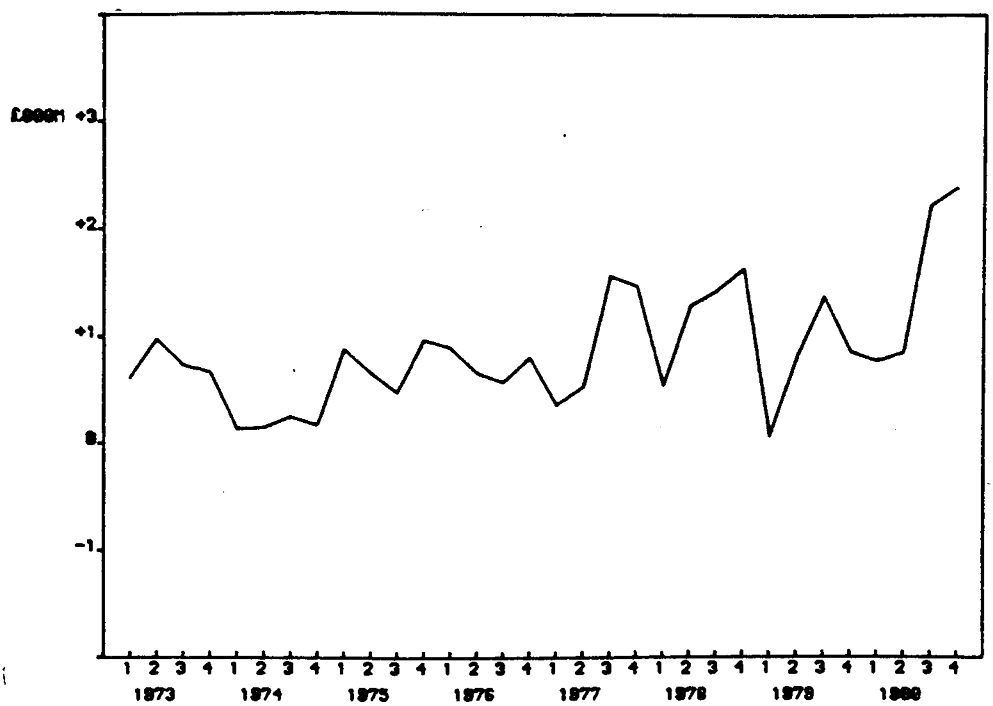


FIGURE 7.9: CURRENT ACCOUNT BALANCE OF PAYMENTS (CA)

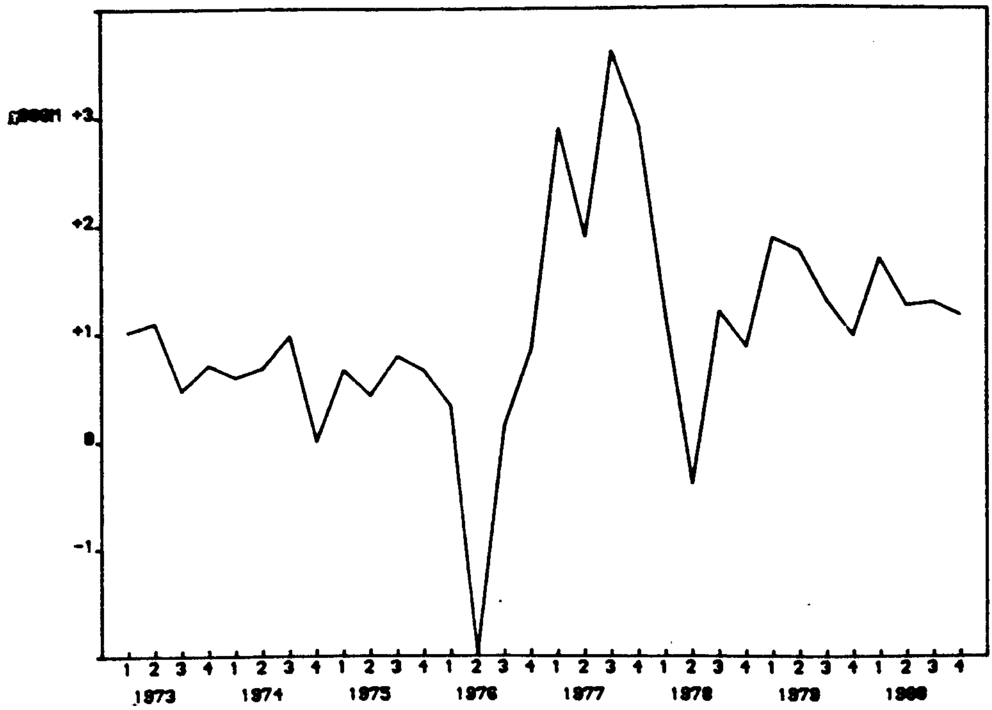


FIGURE 7.10 COMPONENT OF THE PSBR FINANCED BY THE NON-BANK PRIVATE SECTOR (PSBR)

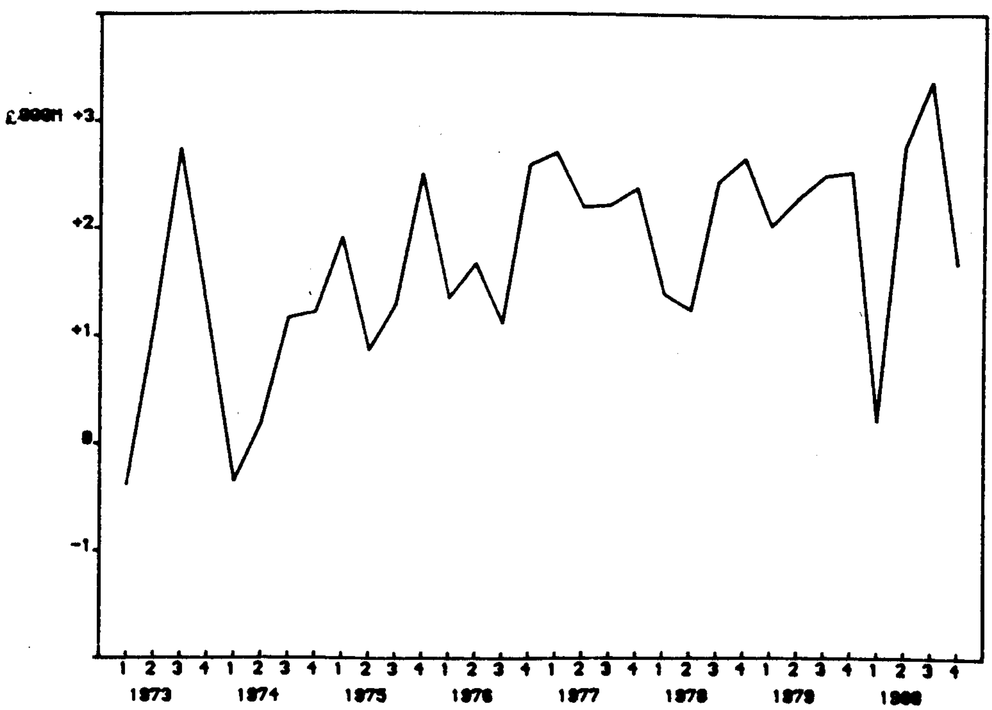


FIGURE 7.11: US CONSUMER PRICE INDEX (USP)

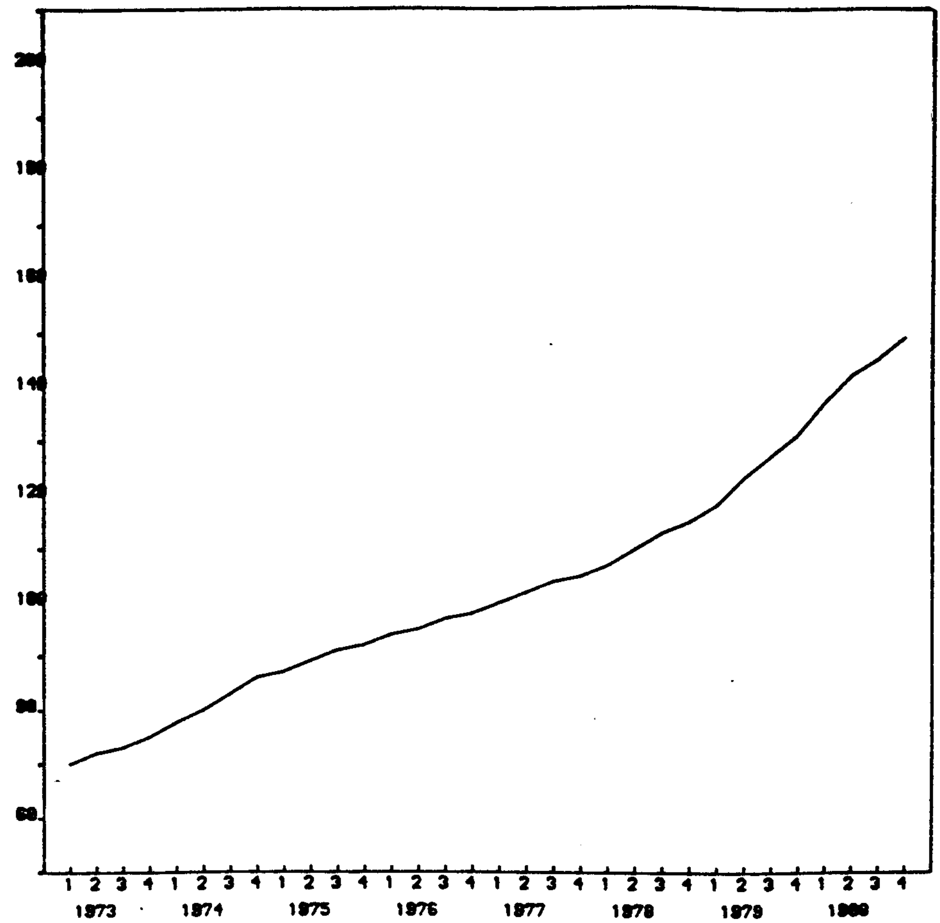
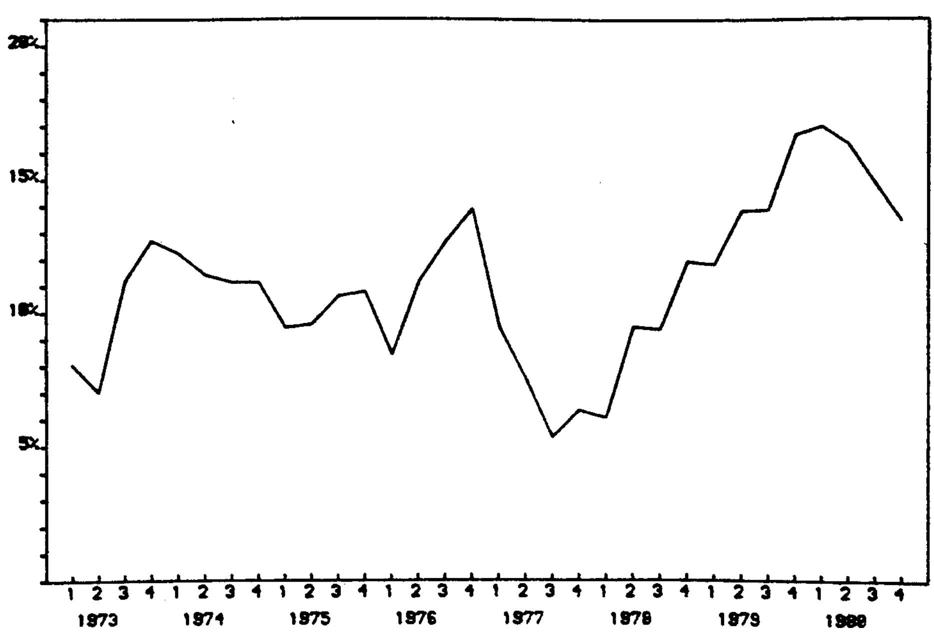


FIGURE 7.12 THE MONEY MARKET RATE OF INTEREST (R m)



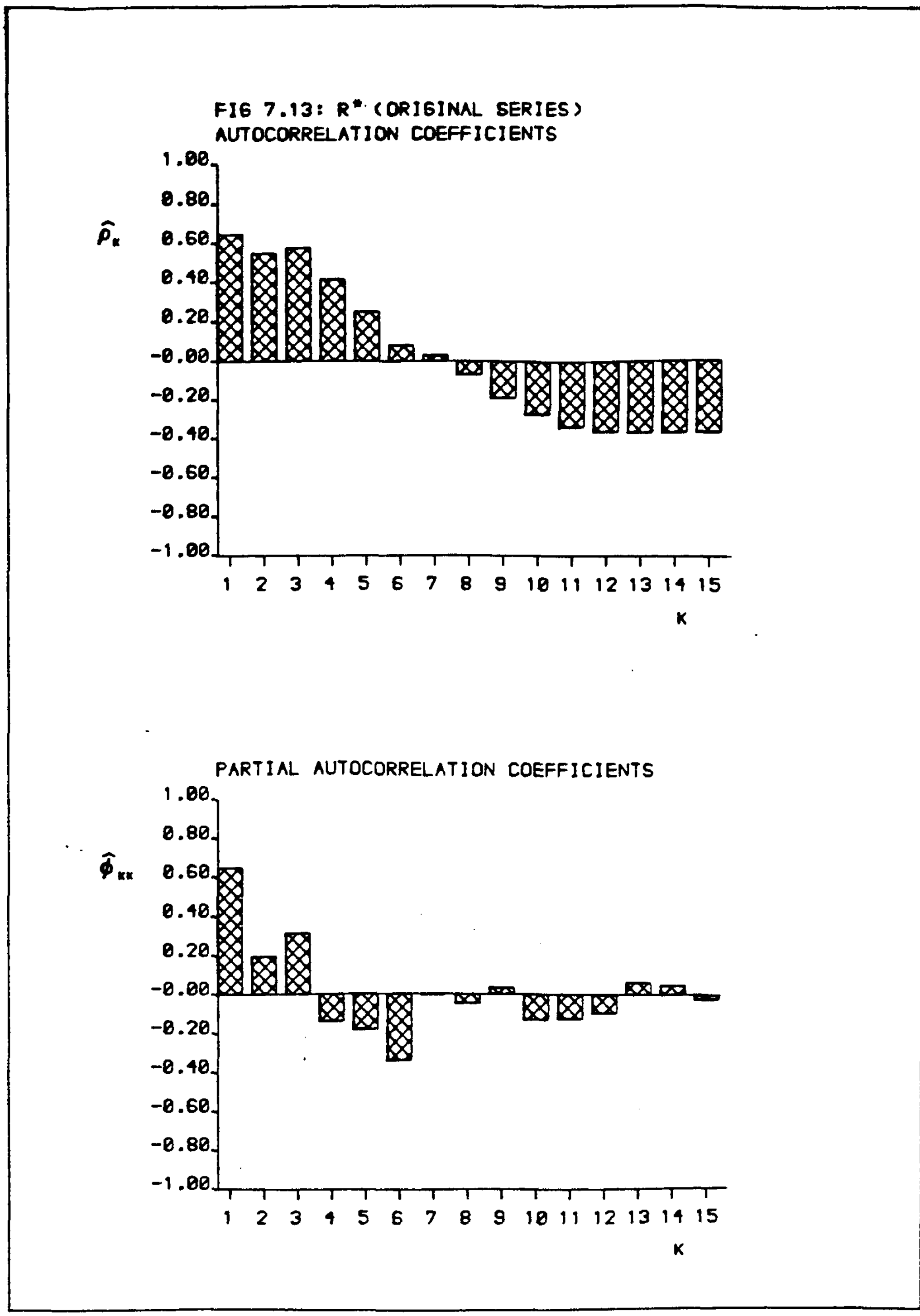
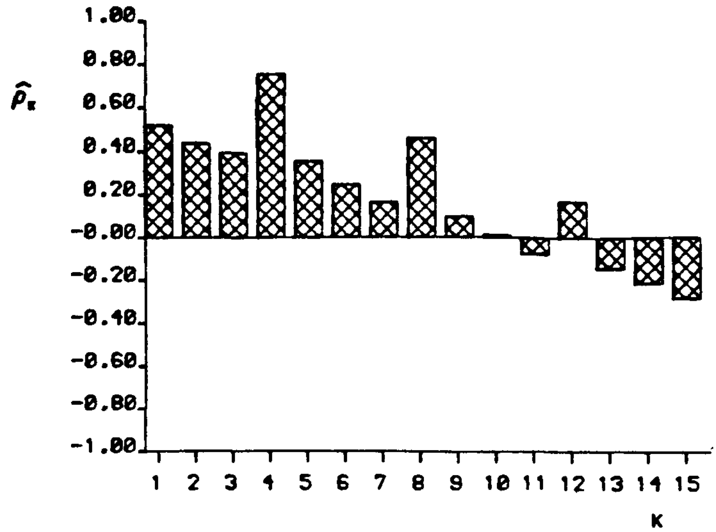
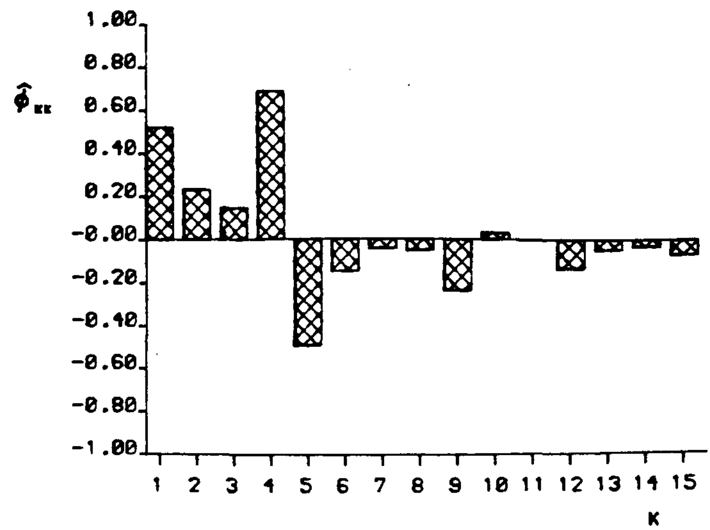


FIG 7.13: R* (ORIGINAL SERIES)
AUTOCORRELATION COEFFICIENTS
$\hat{\rho}_k$
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.60
-0.80
-1.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
K
PARTIAL AUTOCORRELATION COEFFICIENTS
$\hat{\phi}_{kk}$
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.60
-0.80
-1.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
K

FIG 7.14: LnYEXP (ORIGINAL SERIES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS



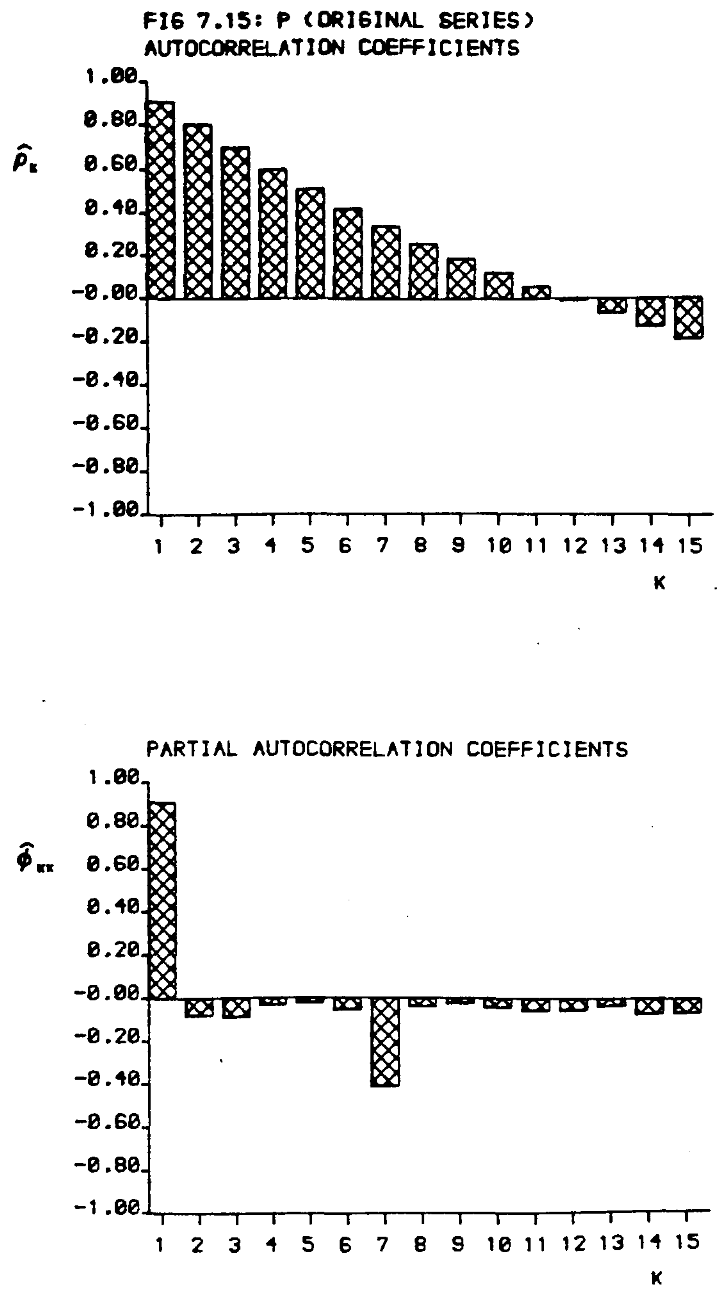
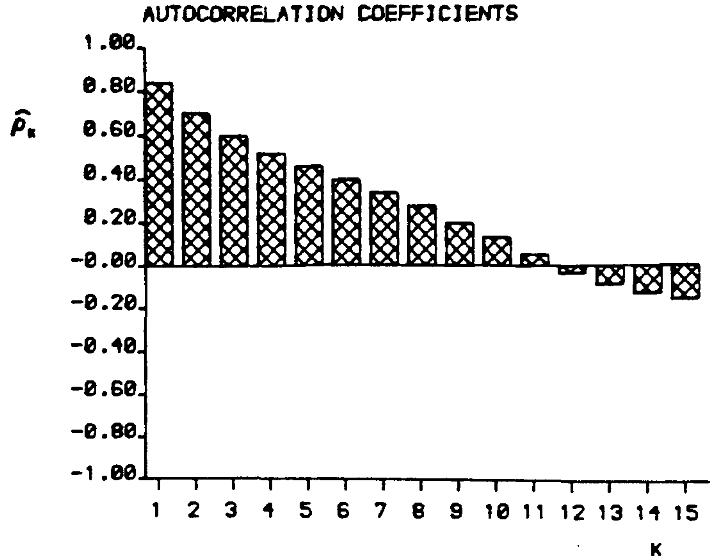


FIG 7.15: P (ORIGINAL SERIES)
AUTOCORRELATION COEFFICIENTS
$\hat{\rho}_k$
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.60
-0.80
-1.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
K
PARTIAL AUTOCORRELATION COEFFICIENTS
$\hat{\phi}_{kk}$
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.60
-0.80
-1.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
K

FIG 7.16: LOS (ORIGINAL SERIES)



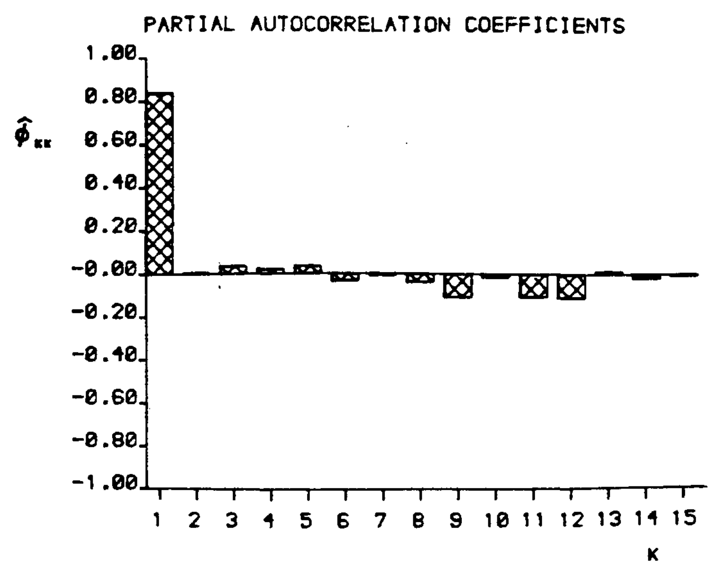


FIG 7.17: OL (ORIGINAL SERIES)

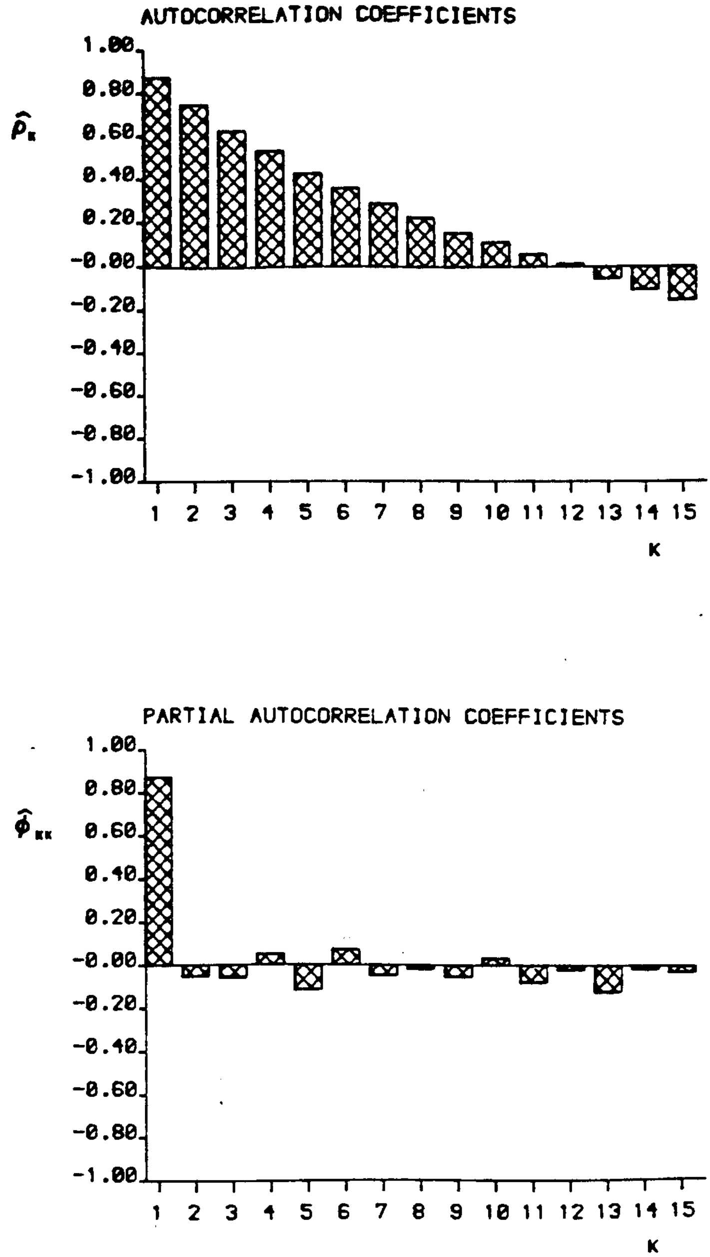
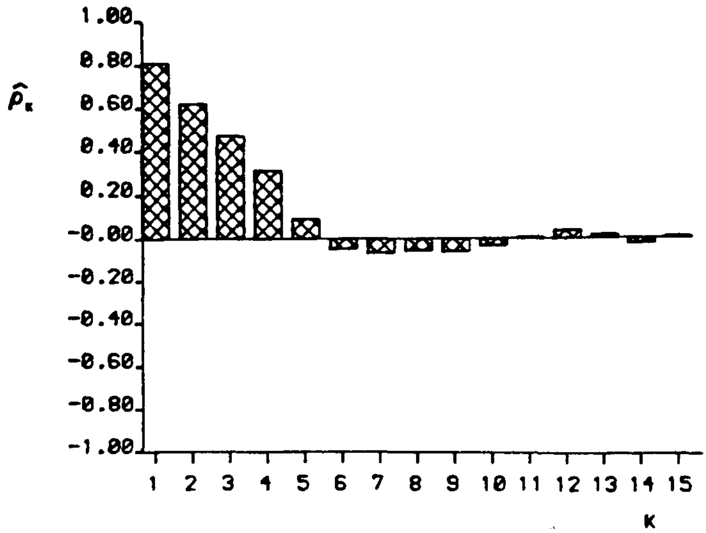


FIG 7.18: RESID (ORIGINAL SERIES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

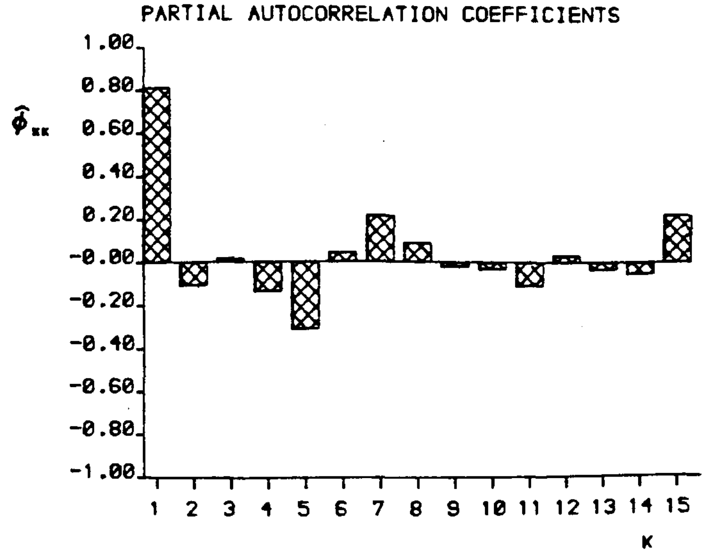
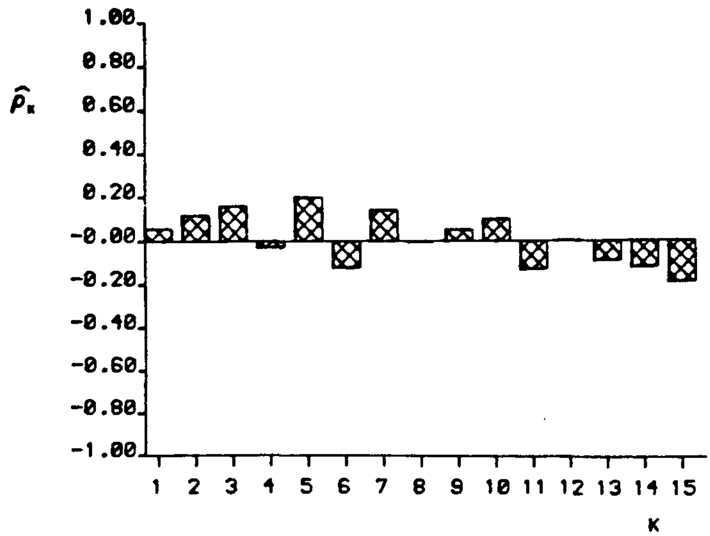


FIG 7.19: OTHER (ORIGINAL SERIES)

AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

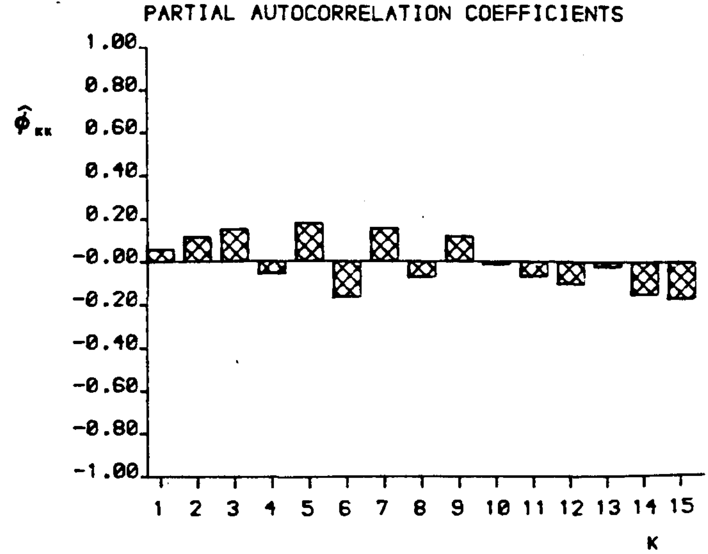


FIG 7.20: Bof (ORIGINAL SERIES)

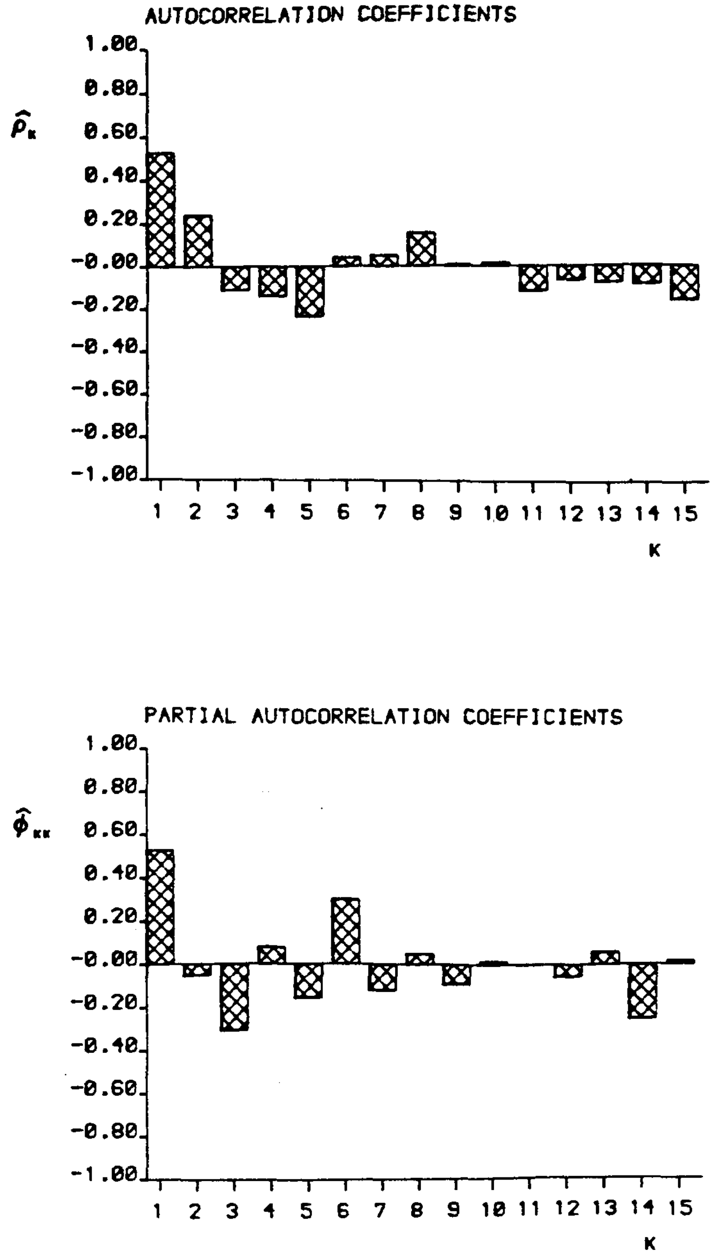


FIG 7.21: CA (ORIGINAL SERIES)

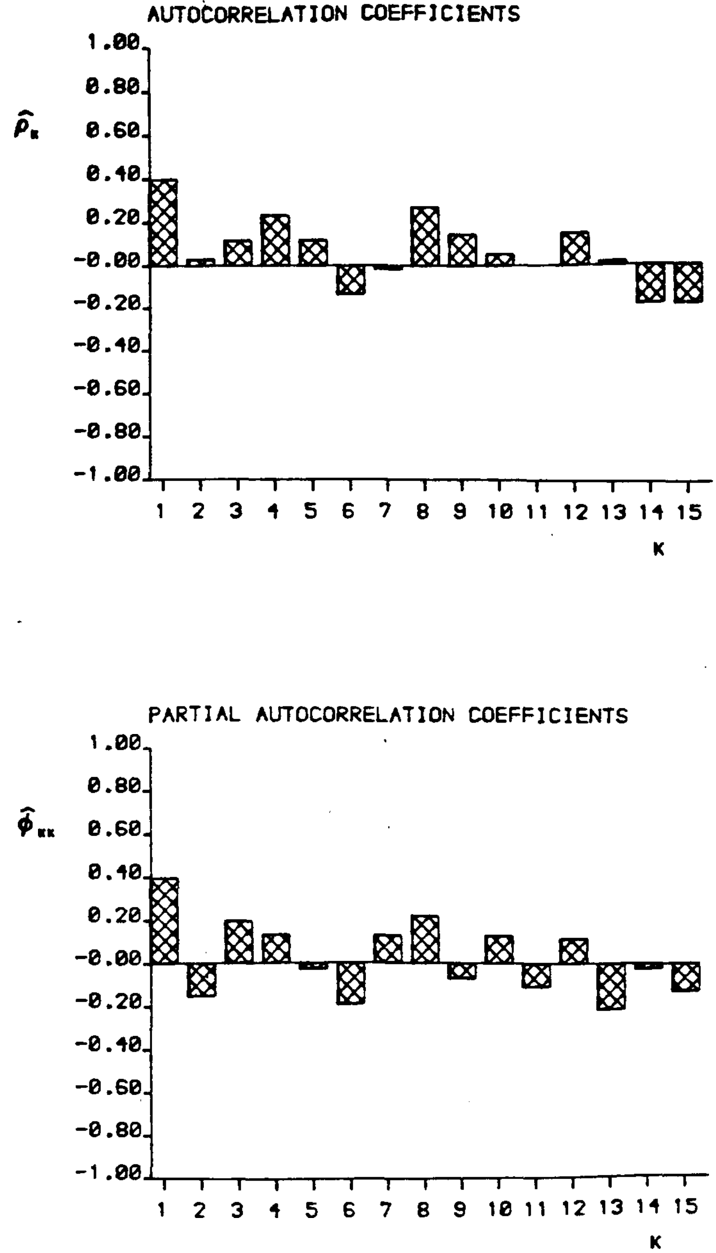


FIG 7.22: PSBR (PSBR(T)-PSBR(T-4))

AUTOCORRELATION COEFFICIENTS

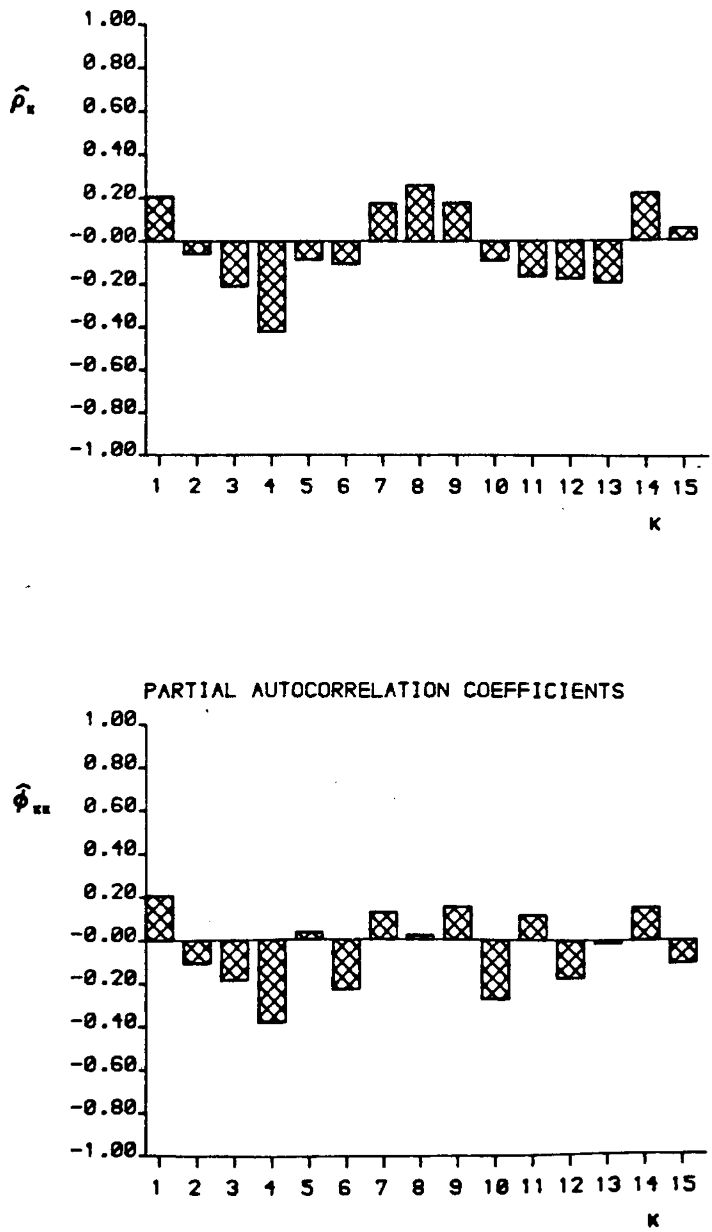


FIG 7.23: USP (ORIGINAL SERIES)

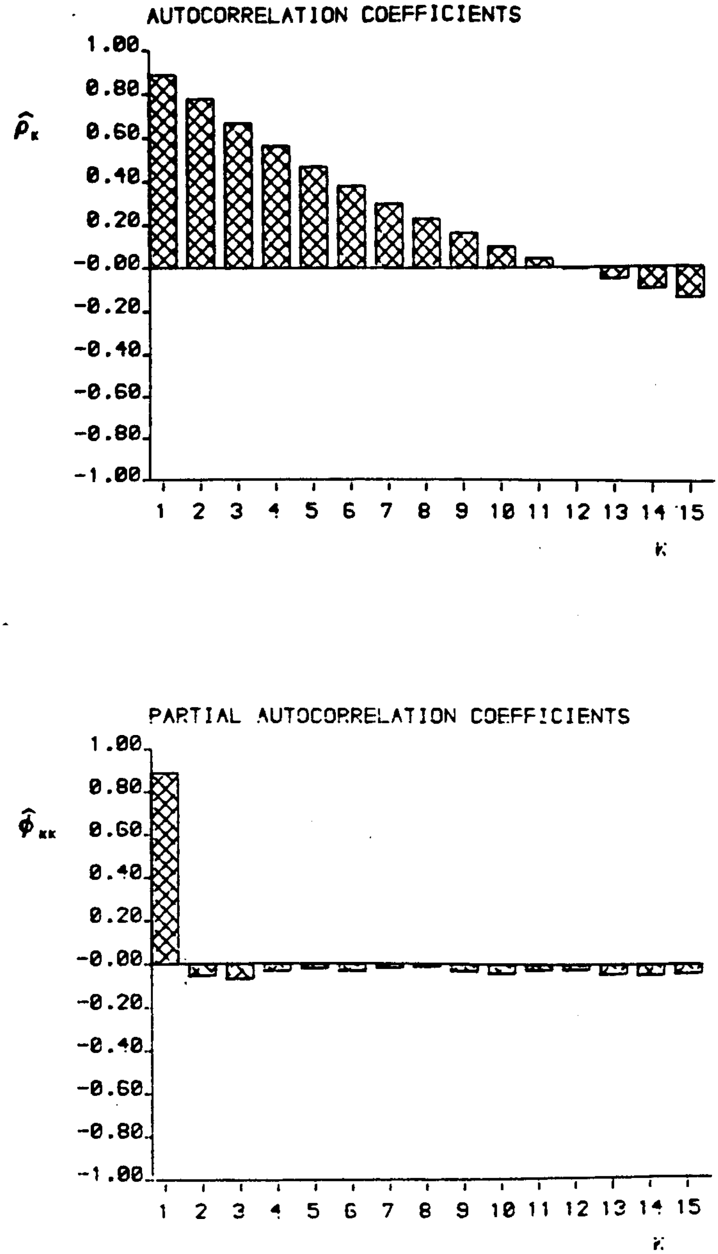


FIG 7.24: RM (ORIGINAL SERIES)

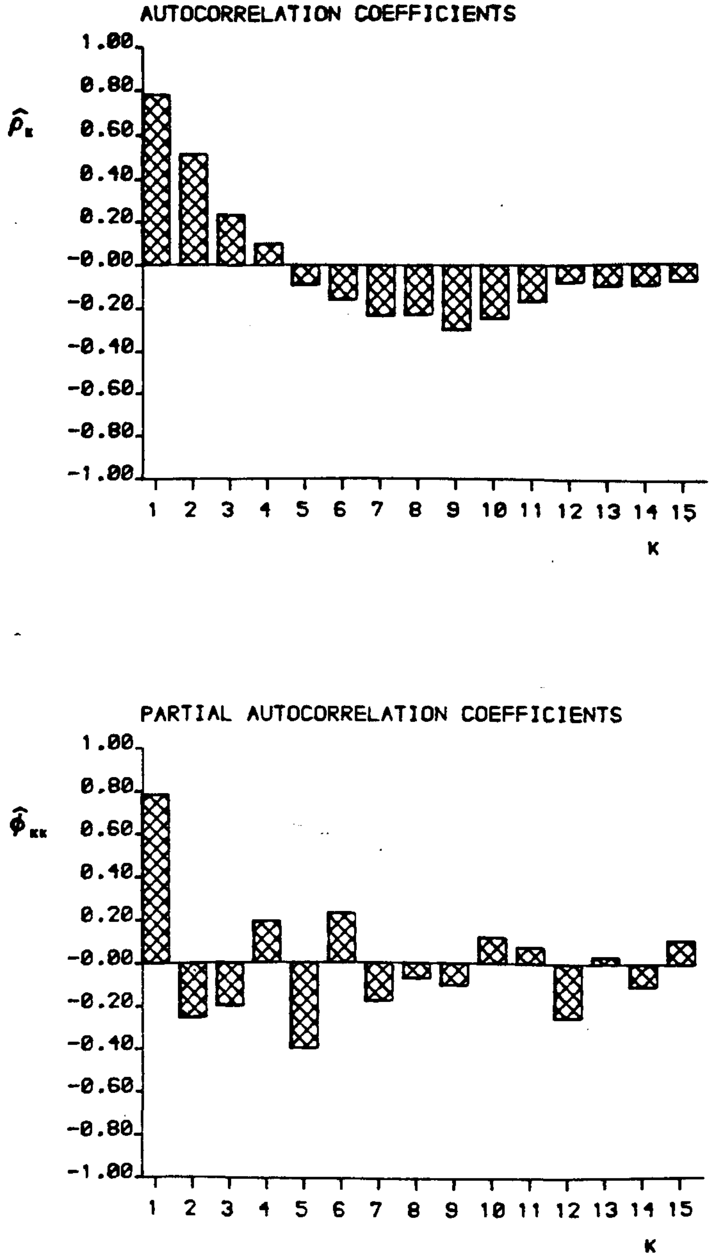
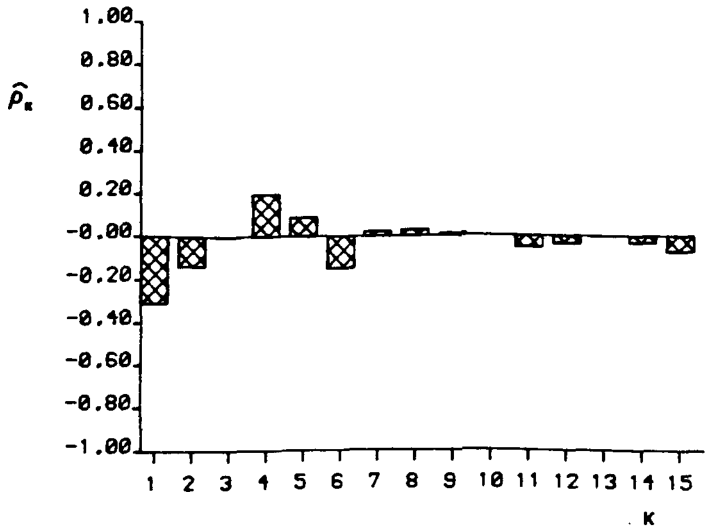


FIG 7.25: R* (FIRST DIFFERENCES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

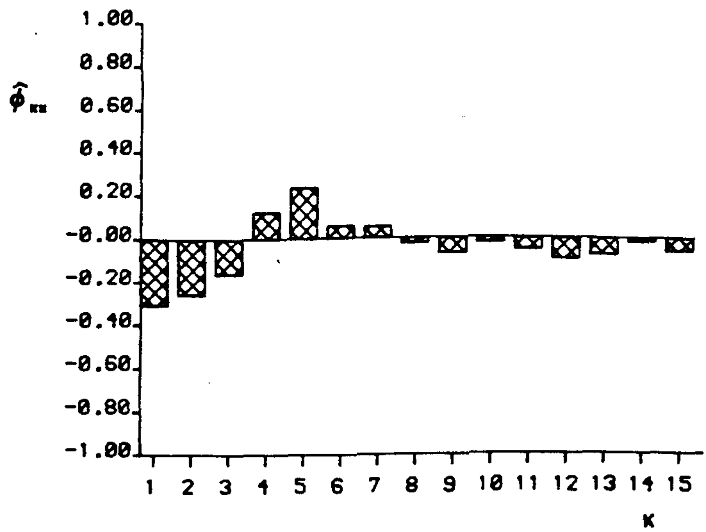
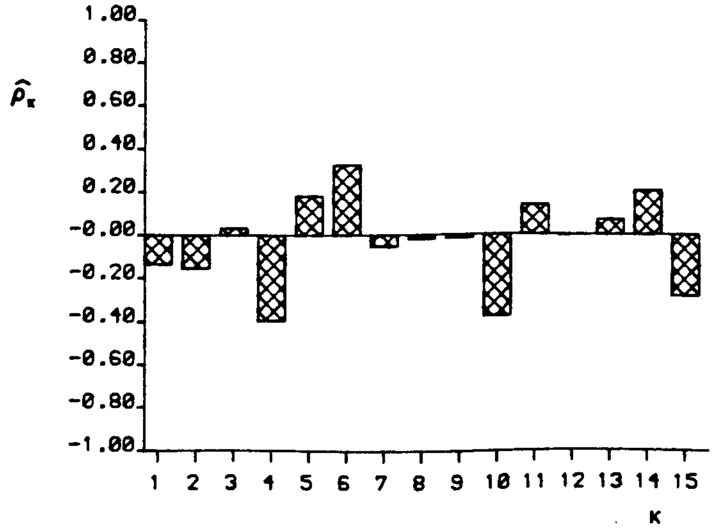


FIG 7.26: LnYEXP (LRYEXP(T)-LRYEXP(T-4))
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

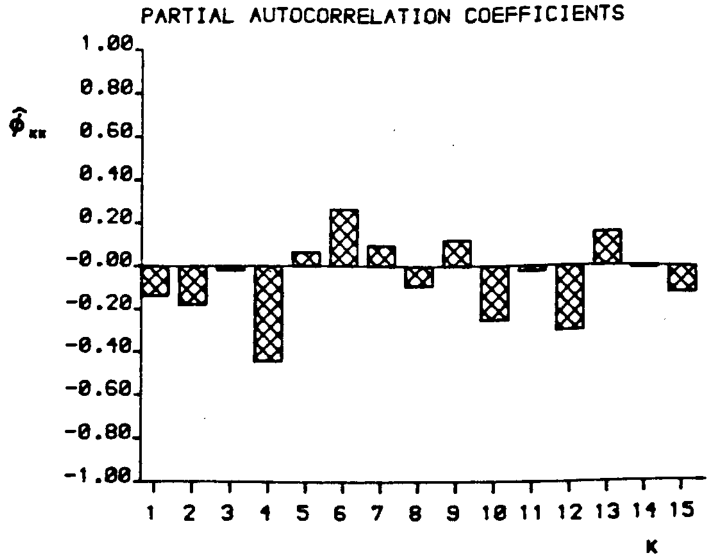
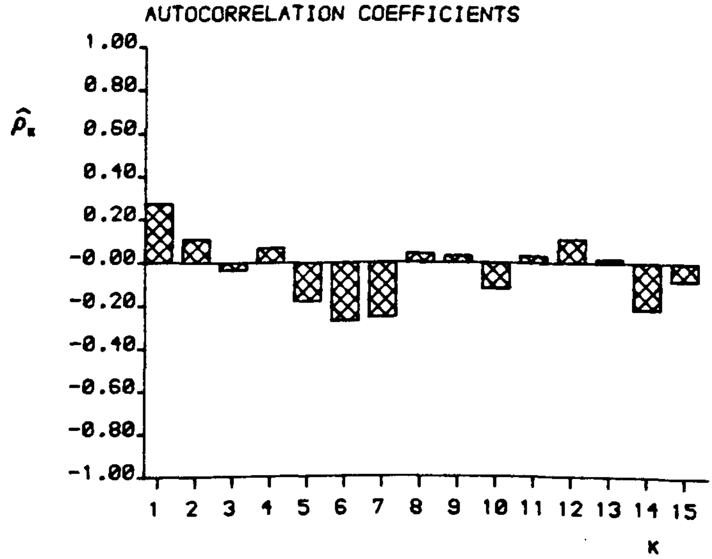


FIG 7.27: P (FIRST DIFFERENCES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

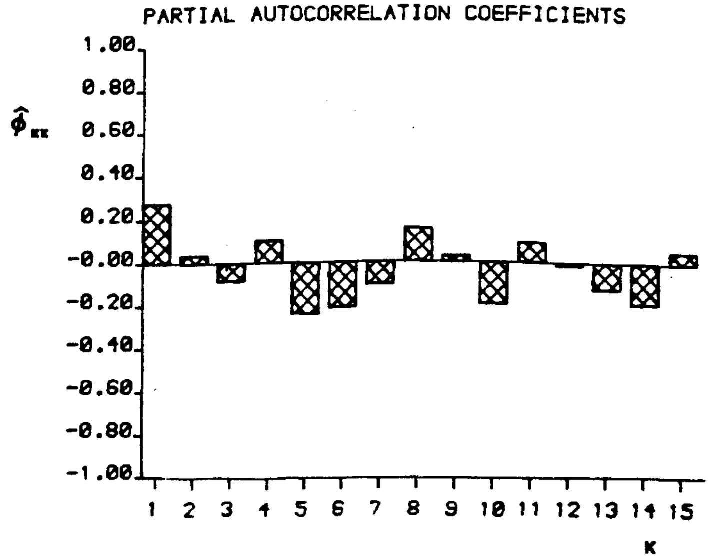


FIG 7.28: LOS (FIRST DIFFERENCES)
AUTOCORRELATION COEFFICIENTS

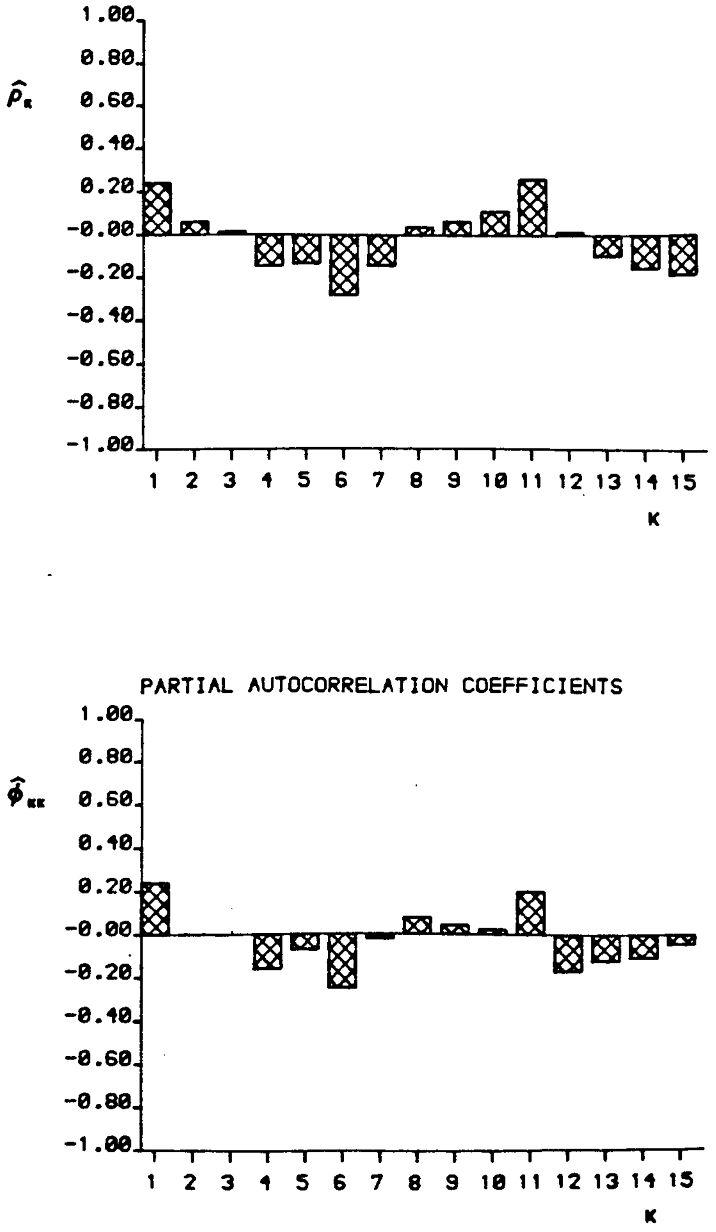
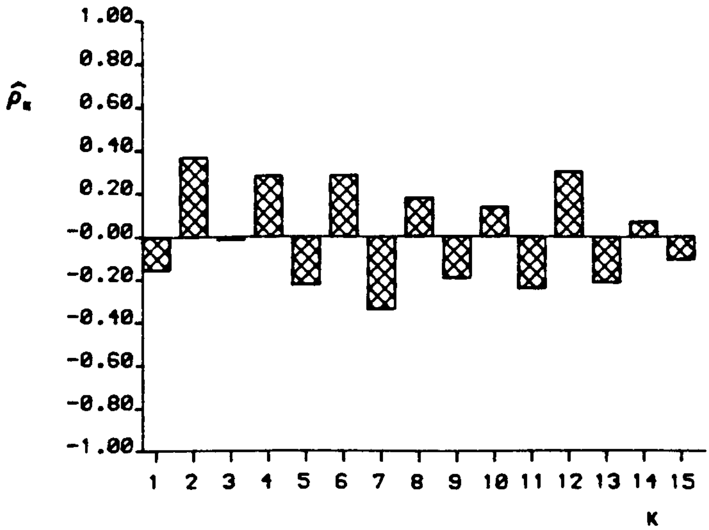


FIG 7.29: OL (FIRST DIFFERENCES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

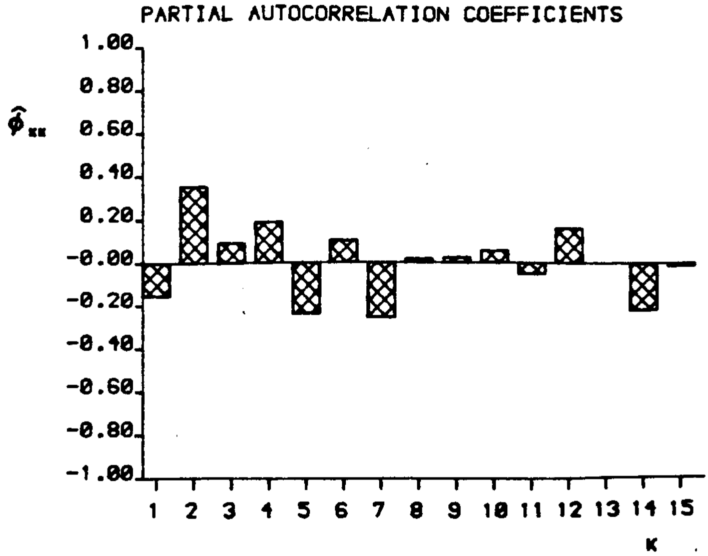
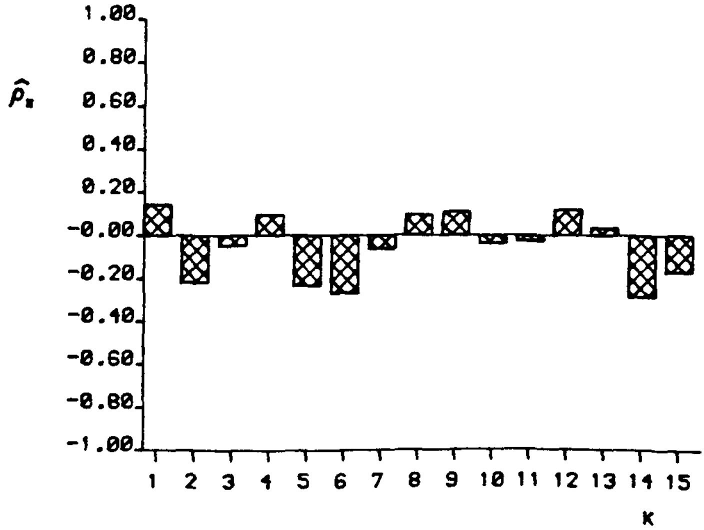


FIG 7.30: RESID (FIRST DIFFERENCES)
AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS

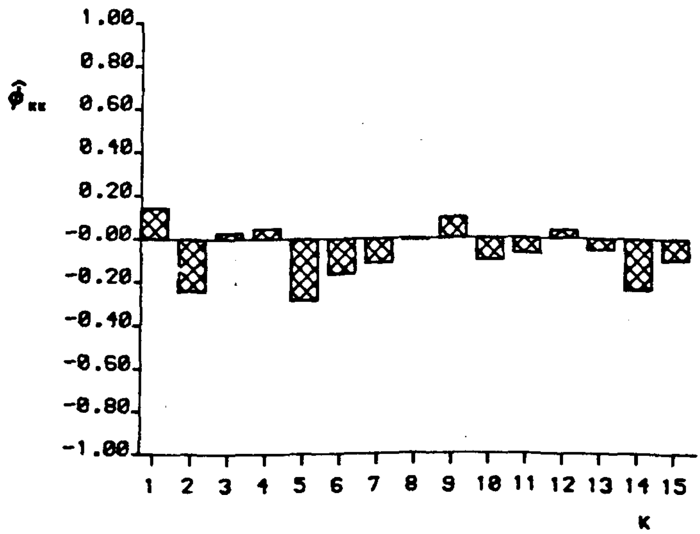
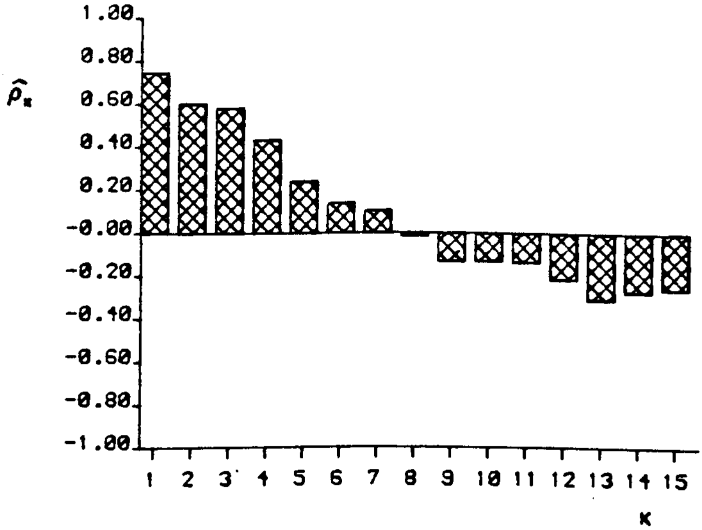
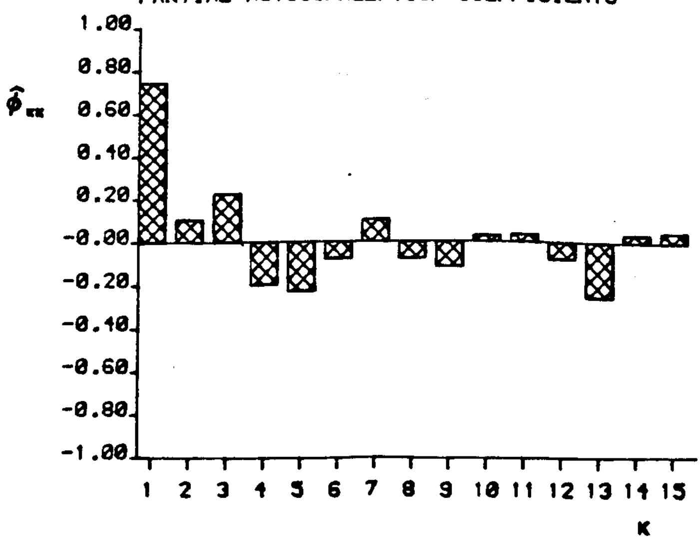


FIG 7.31: USP (FIRST DIFFERENCES)

AUTOCORRELATION COEFFICIENTS



PARTIAL AUTOCORRELATION COEFFICIENTS



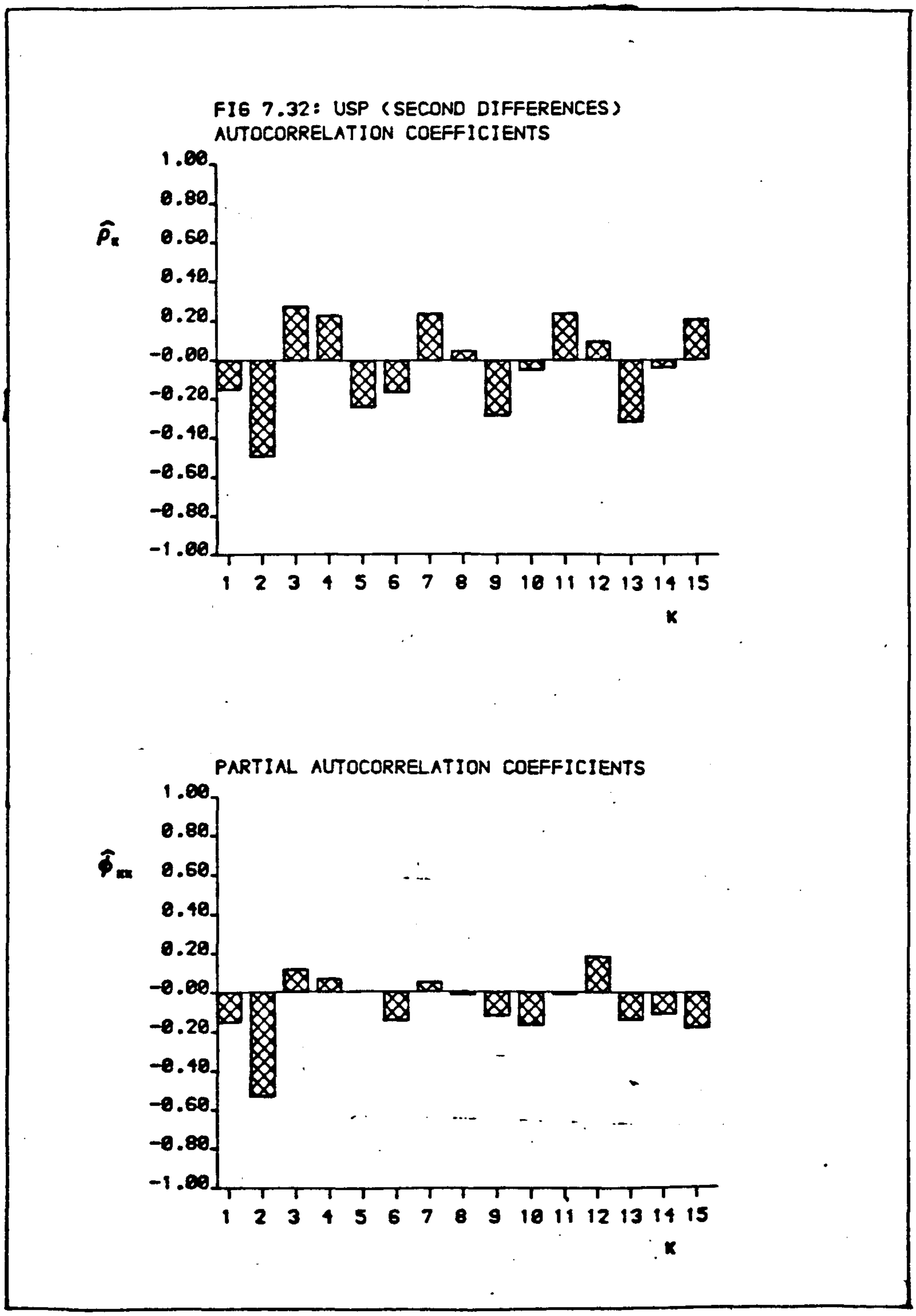


FIG 7.32: USP (SECOND DIFFERENCES)
AUTOCORRELATION COEFFICIENTS
1.00
0.80
0.60
0.40
0.20
-0.00
-0.20
-0.40
-0.60
-0.80
-1.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
K
PARTIAL AUTOCORRELATION COEFFICIENTS
K

FIGURE 7.33: TRACKING PERFORMANCE - NOTES AND COINS
ACTUAL EXOGENOUS VARIABLES

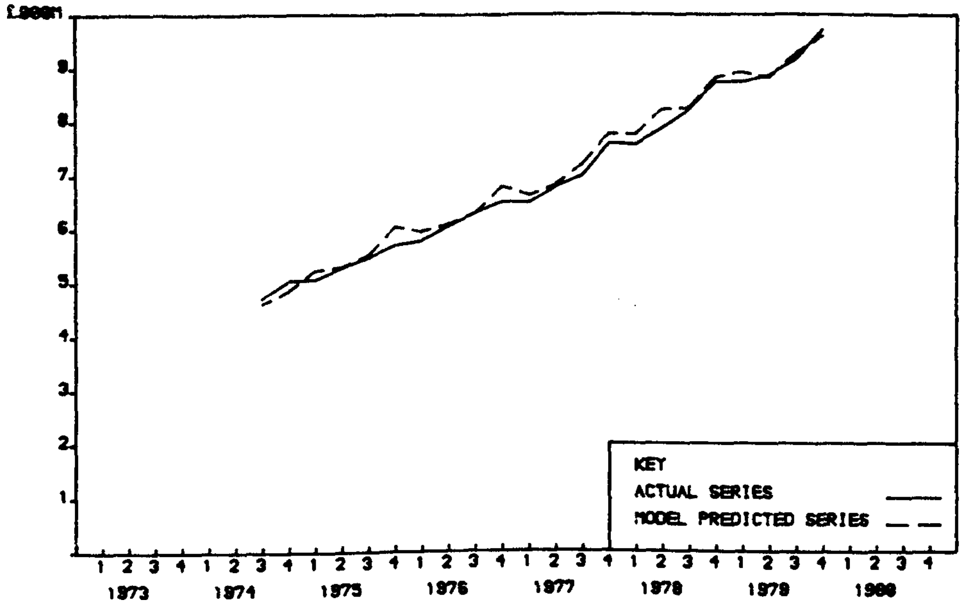


FIGURE 7.34: TRACKING PERFORMANCE - M1
ACTUAL EXOGENOUS VARIABLES

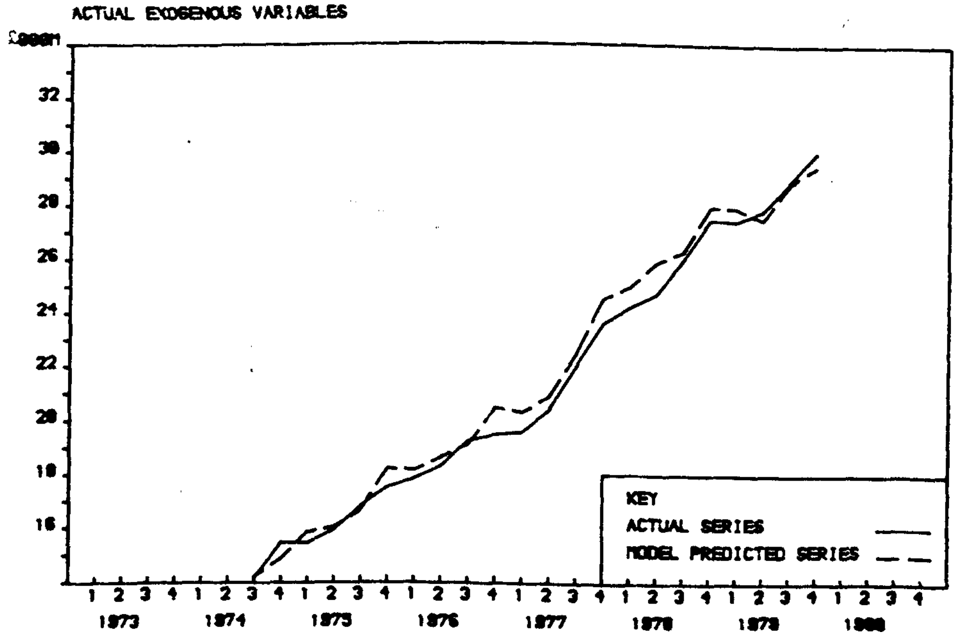


FIGURE 7.35: TRACKING PERFORMANCE - M2
ACTUAL EXOGENOUS VARIABLES

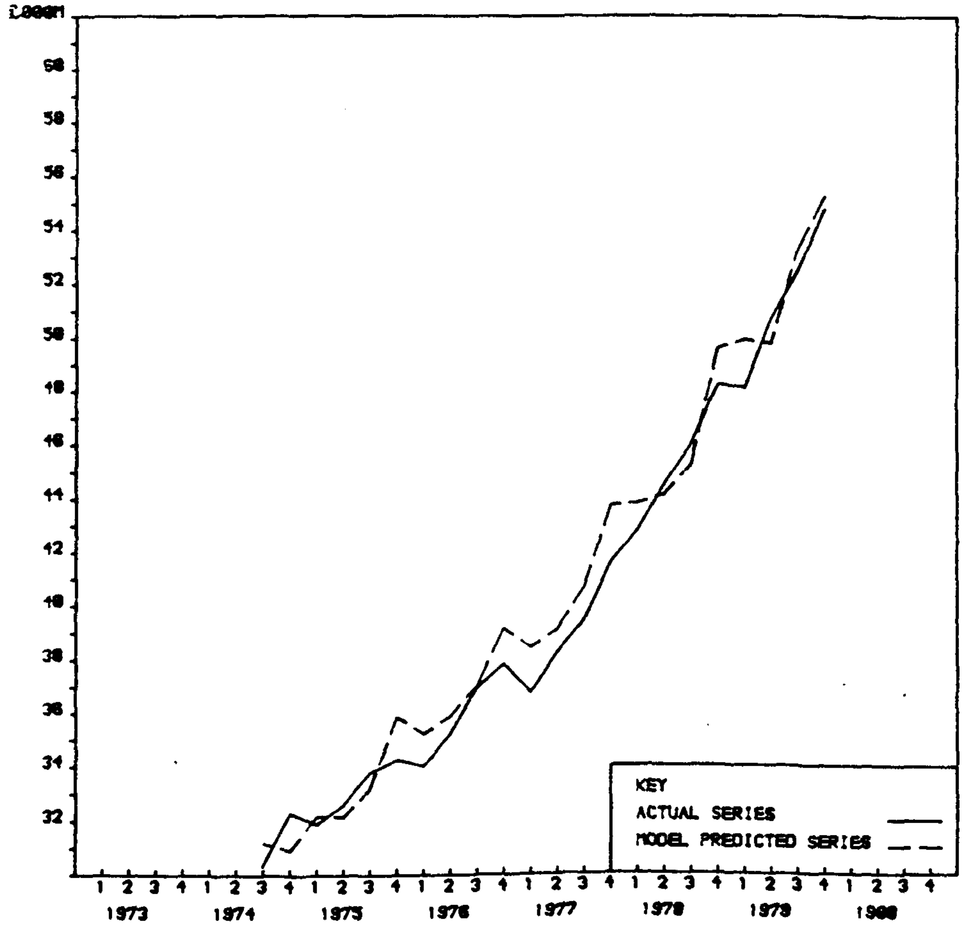


FIGURE 7.36: TRACKING PERFORMANCE - BANK LOANS
ACTUAL EXOGENOUS VARIABLES

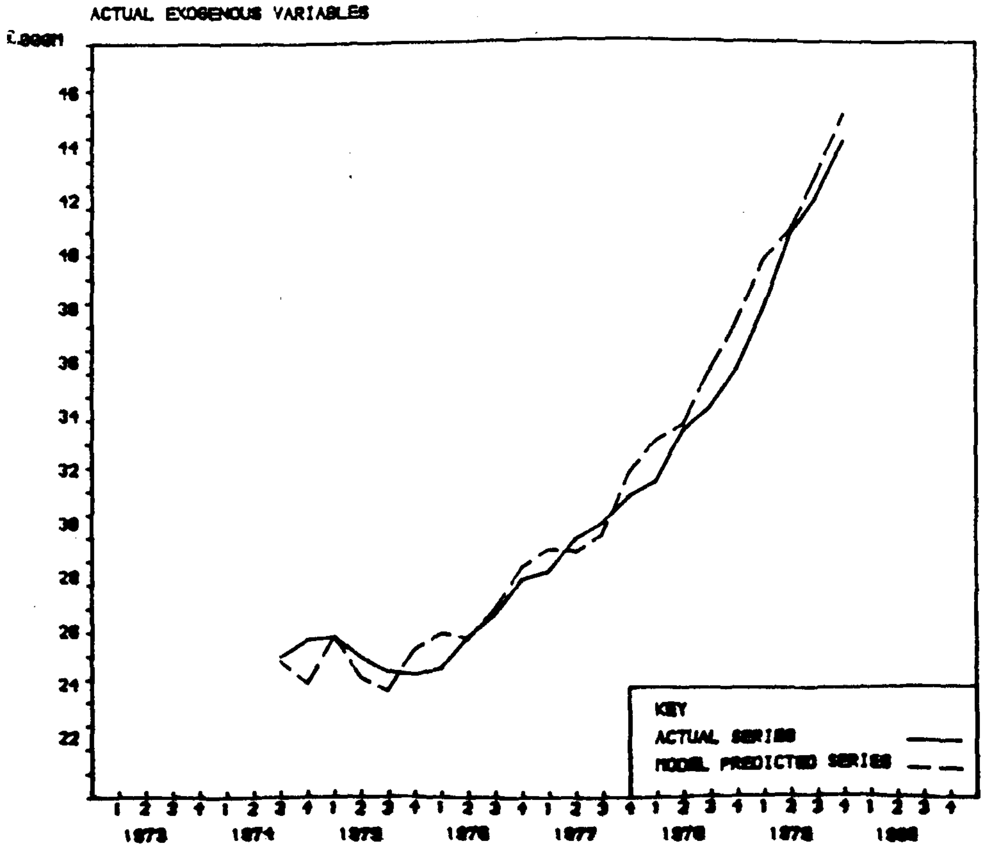


FIGURE 7.37: TRACKING PERFORMANCE - LOAN RATE
ACTUAL EXOGENOUS VARIABLES

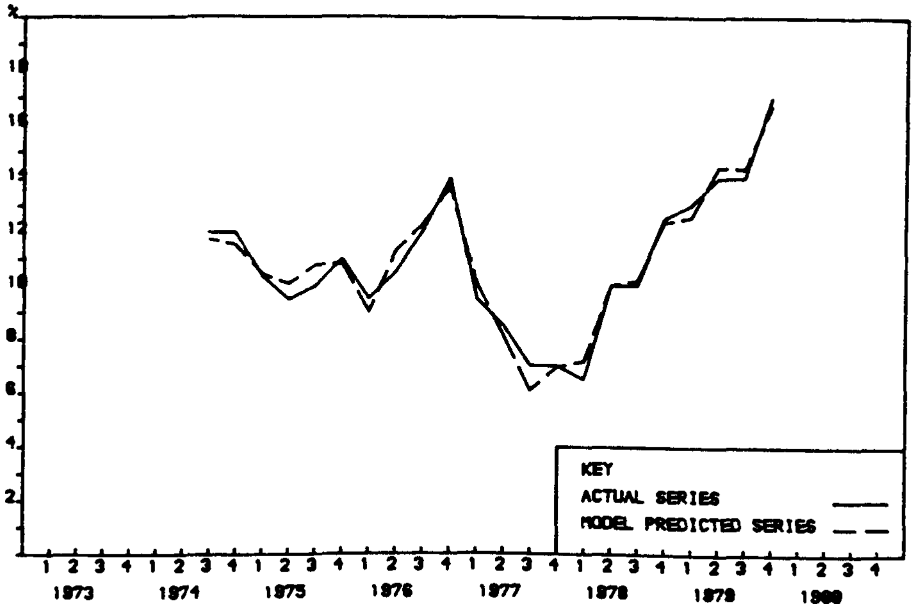


FIGURE 7.38: TRACKING PERFORMANCE - LOG EXCHANGE RATE (DOLLARS/POUNDS)
ACTUAL EXOGENOUS VARIABLES

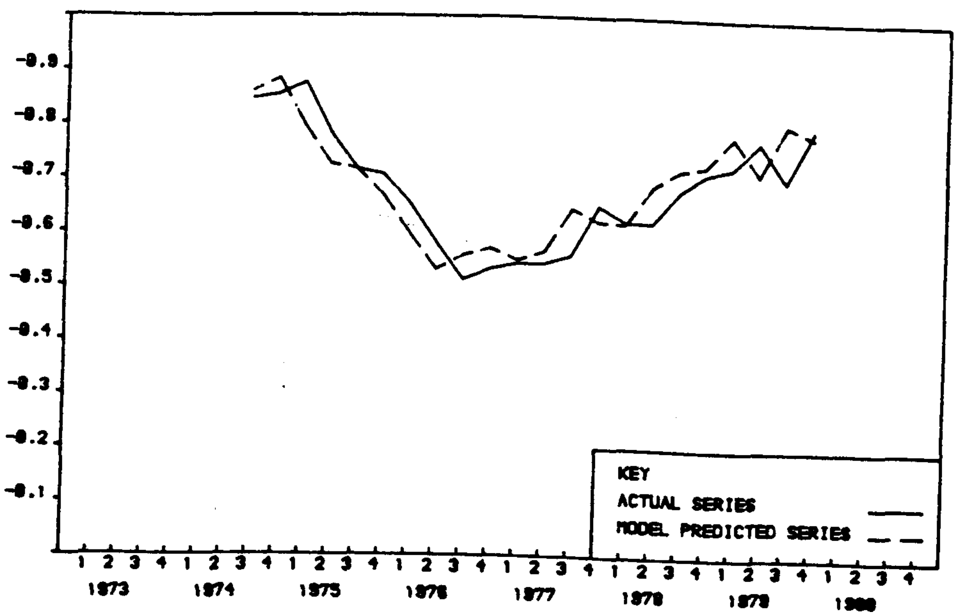


FIGURE 7.39: TRACKING PERFORMANCE - NOTES AND COINS
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

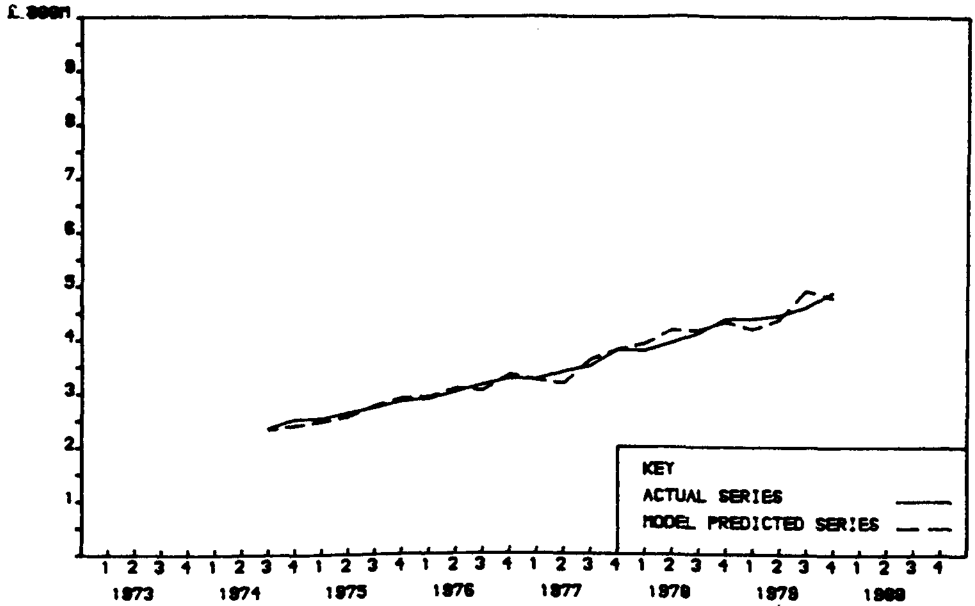


FIGURE 7.40: TRACKING PERFORMANCE - M1
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

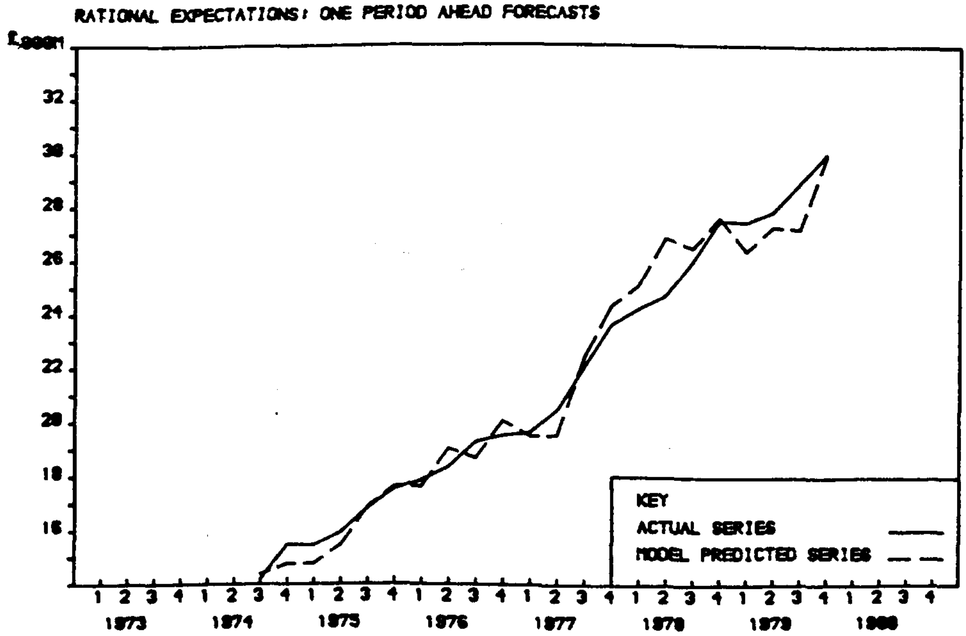


FIGURE 7.41: TRACKING PERFORMANCE - M2
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

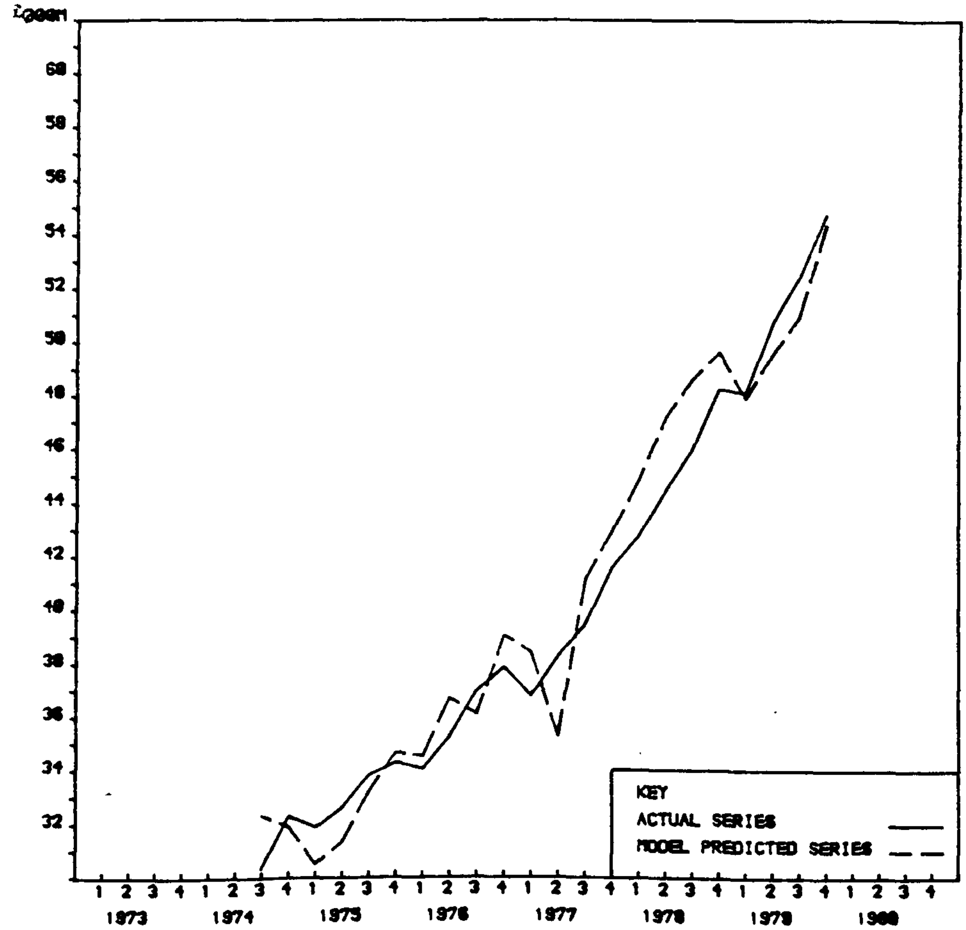


FIGURE 7.42: TRACKING PERFORMANCE - BANK LOANS
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

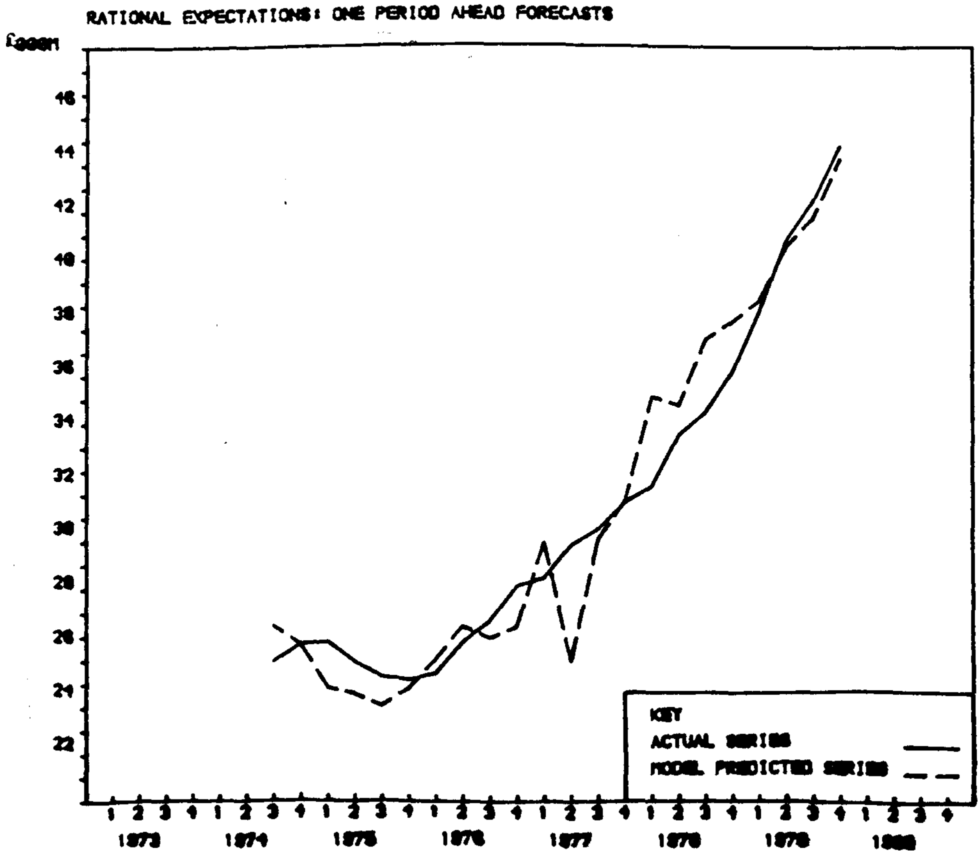


FIGURE 7.43: TRACKING PERFORMANCE - LOAN RATE
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

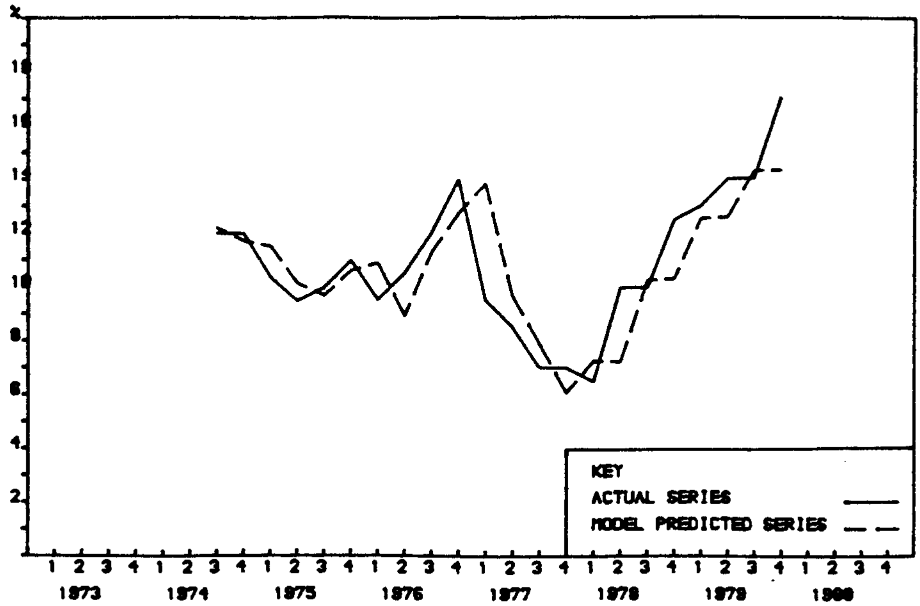


FIGURE 7.44: TRACKING PERFORMANCE - LOG EXCHANGE RATE (DOLLARS/POUNDS)
RATIONAL EXPECTATIONS: ONE PERIOD AHEAD FORECASTS

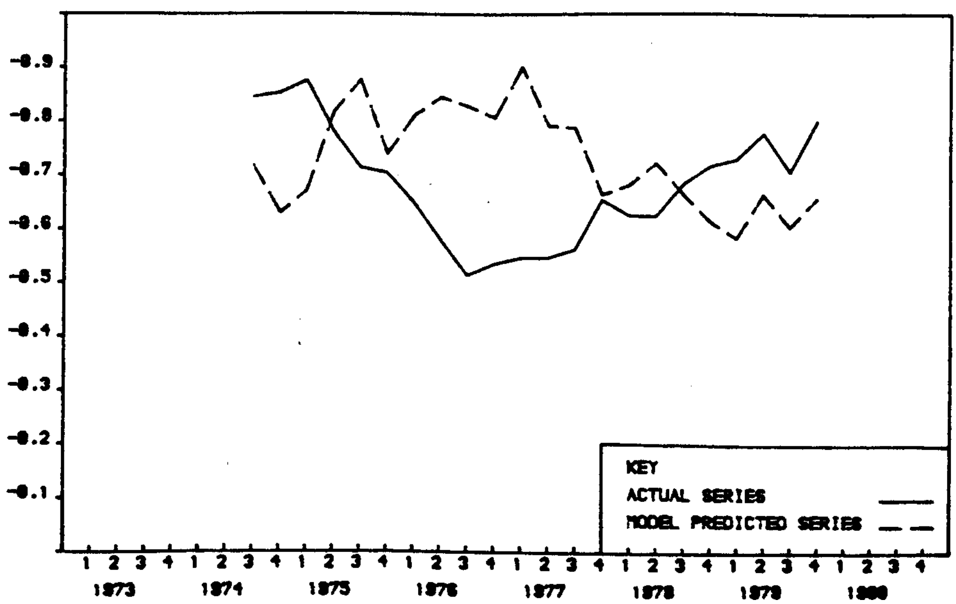


FIGURE 7.45: TRACKING PERFORMANCE - NOTES AND COINS
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

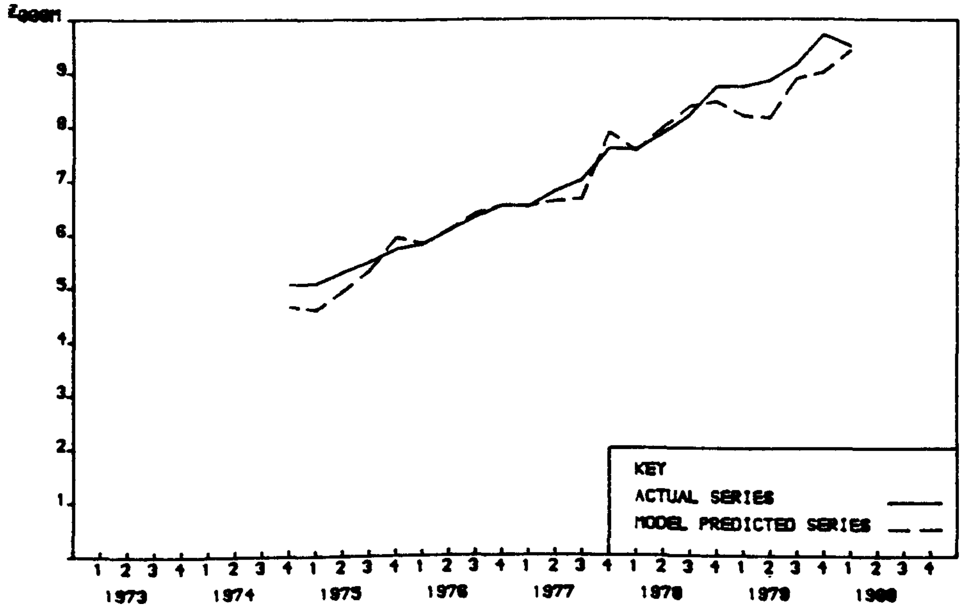


FIGURE 7.46: TRACKING PERFORMANCE - M1
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

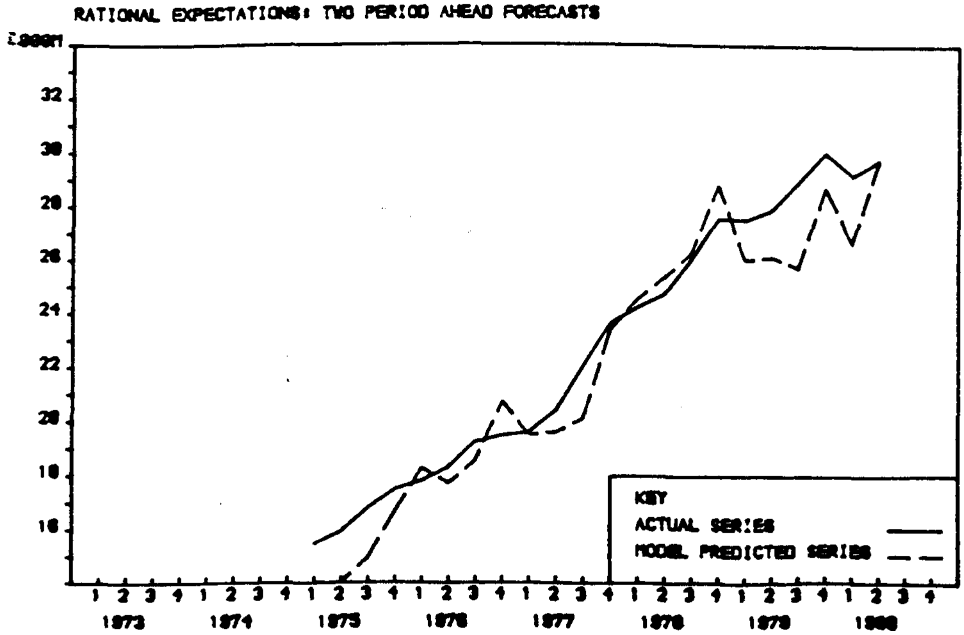


FIGURE 7.47: TRACKING PERFORMANCE - M2
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

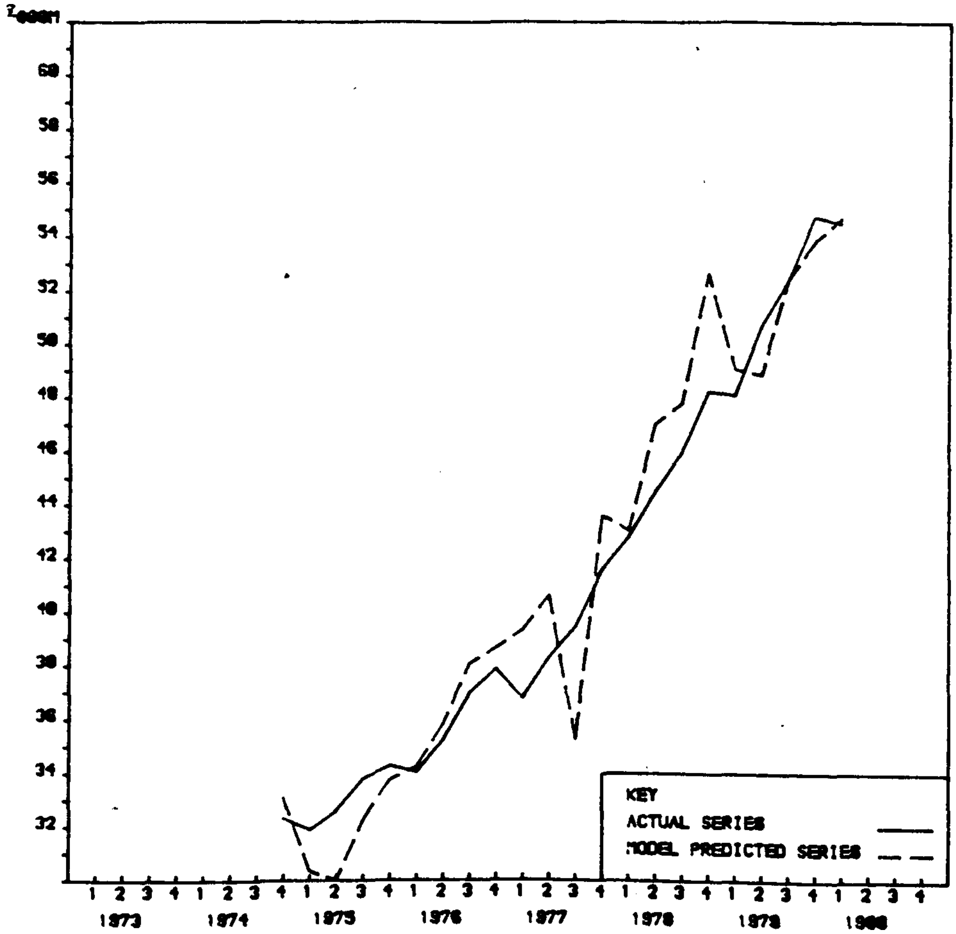


FIGURE 7.48: TRACKING PERFORMANCE - BANK LOANS
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

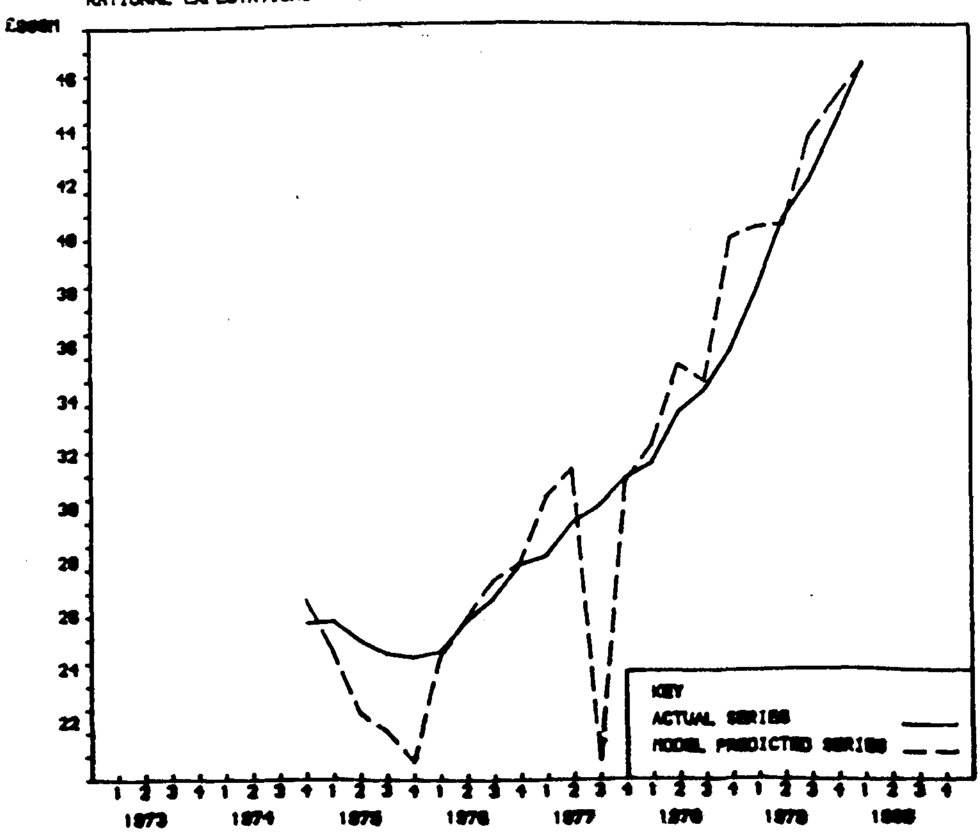


FIGURE 7.49: TRACKING PERFORMANCE - LOAN RATE
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

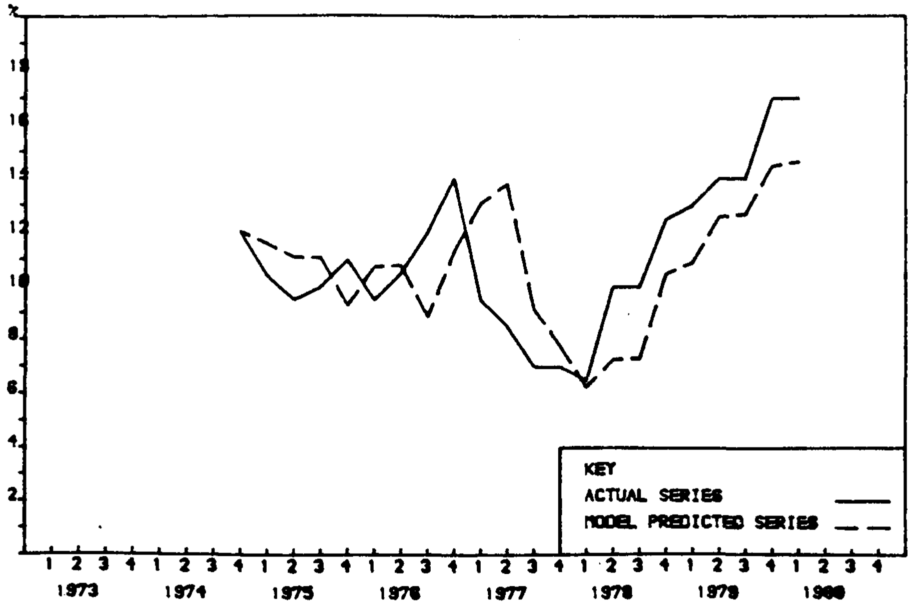


FIGURE 7.50: TRACKING PERFORMANCE - LOG EXCHANGE RATE (DOLLARS/POUNDS)
RATIONAL EXPECTATIONS: TWO PERIOD AHEAD FORECASTS

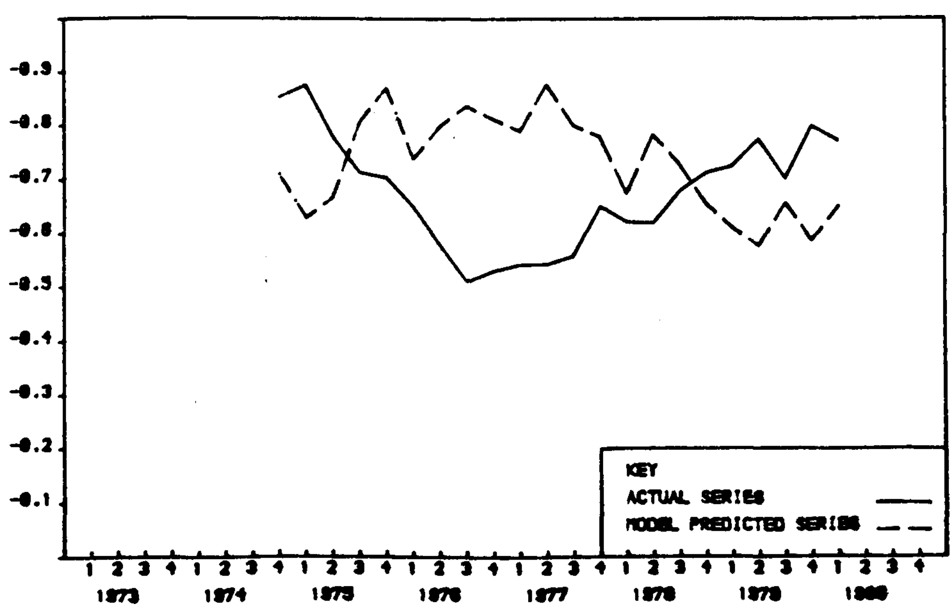


FIGURE 7.51: TRACKING PERFORMANCE - NOTES AND COINS
RATIONAL EXPECTATIONS: THREE PERIOD AHEAD FORECASTS

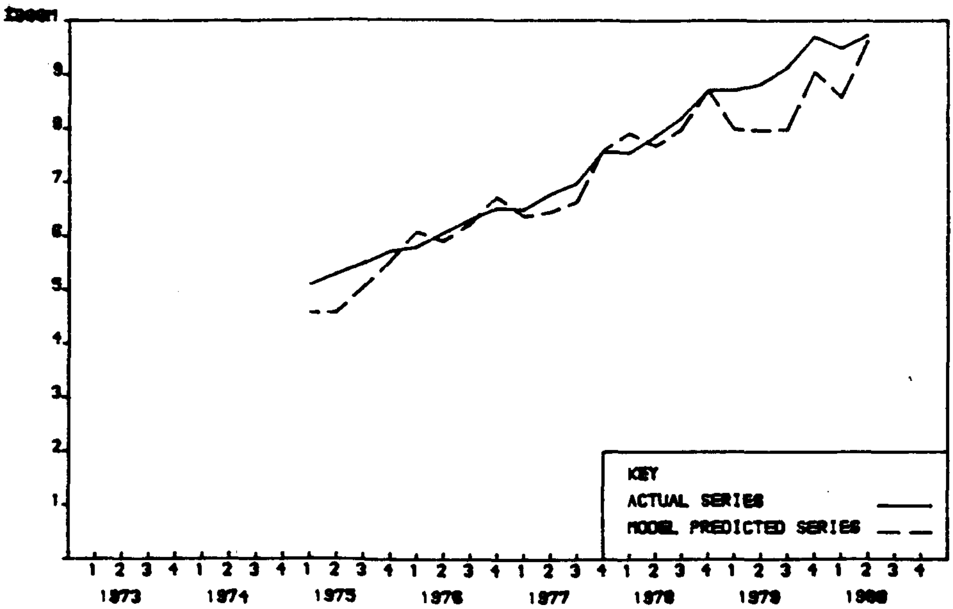


FIGURE 7.52: TRACKING PERFORMANCE - M1
RATIONAL EXPECTATIONS: THREE PERIOD AHEAD FORECASTS

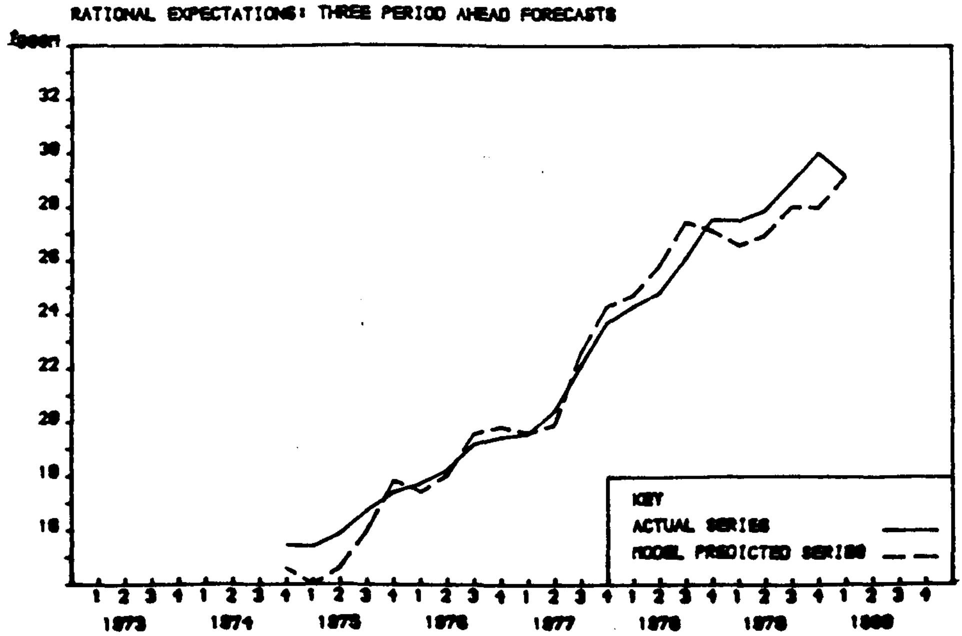


FIGURE 7.53: TRACKING PERFORMANCE - M2
RATIONAL EXPECTATIONS: THREE PERIOD AHEAD FORECASTS

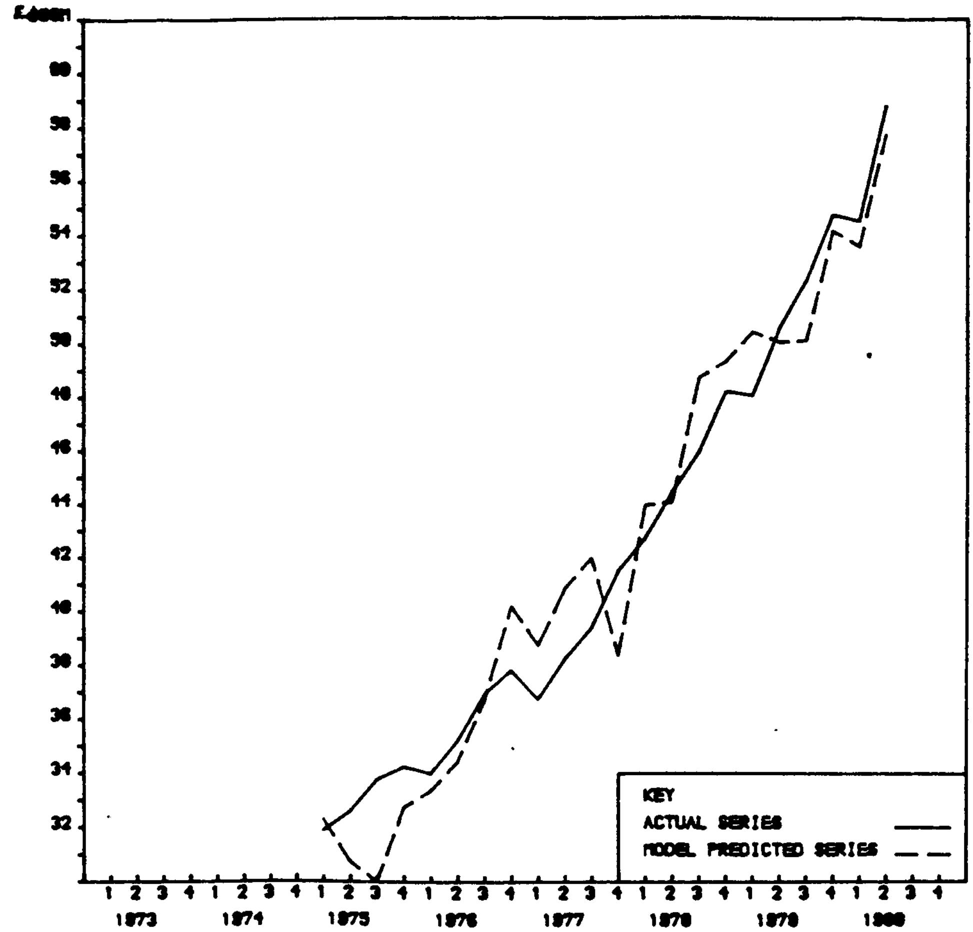


FIGURE 7.54: TRACKING PERFORMANCE - BANK LOANS
RATIONAL EXPECTATIONS: THREEPERIOD AHEAD FORECASTS

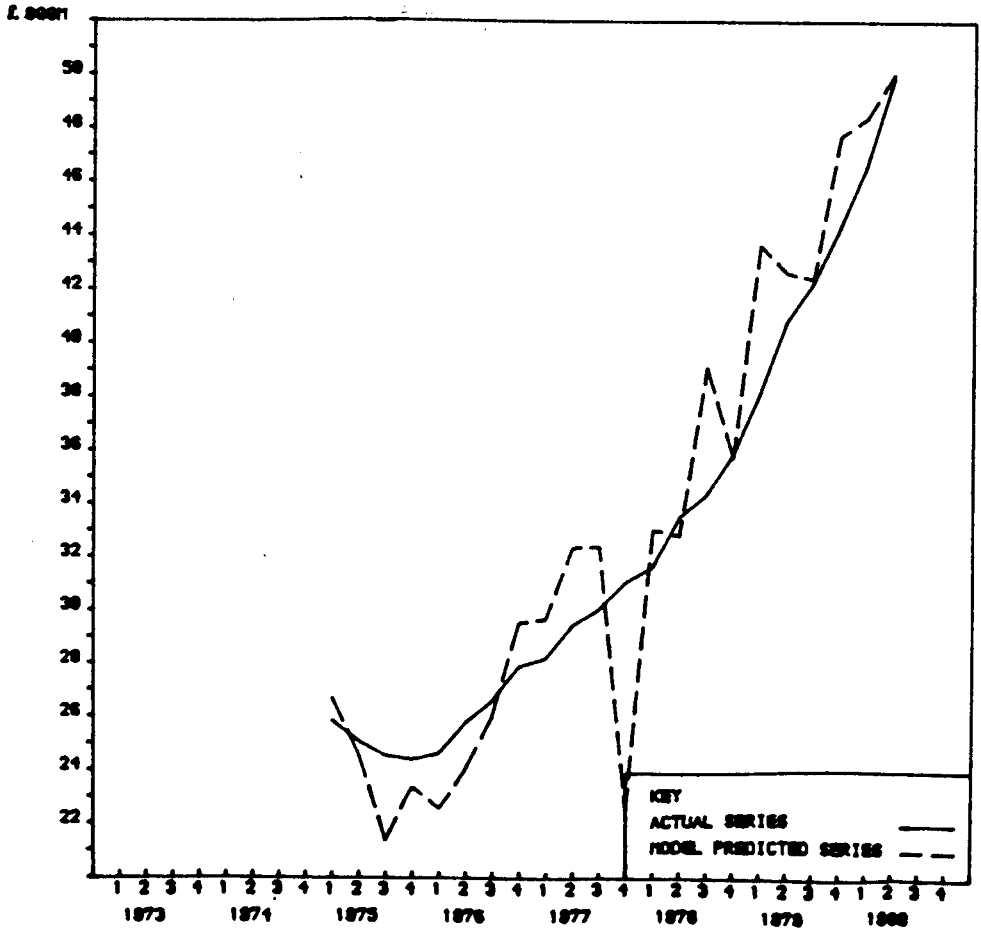


FIGURE 7.55: TRACKING PERFORMANCE - LOAN RATE
RATIONAL EXPECTATIONS: THREE PERIOD AHEAD FORECASTS

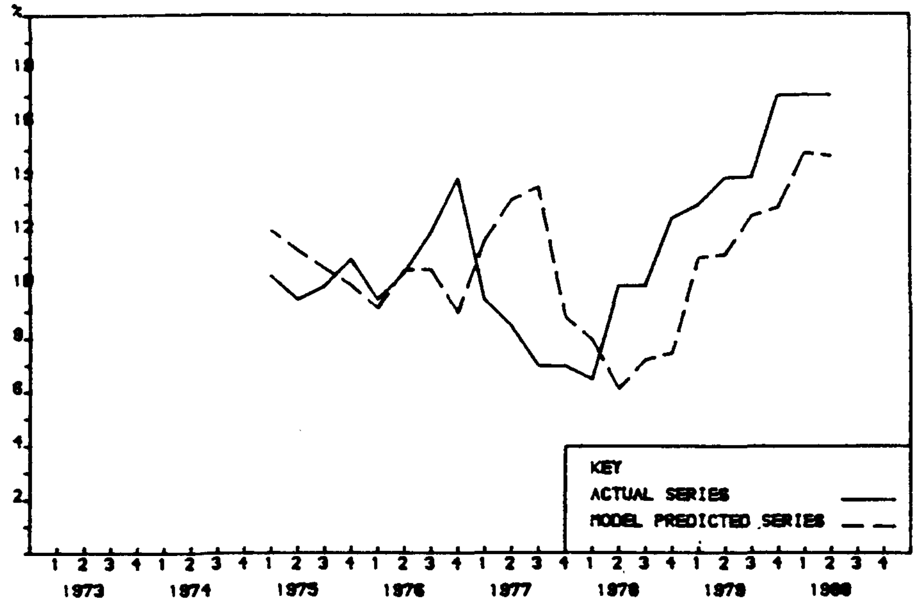


FIGURE 7.56: TRACKING PERFORMANCE - LOG EXCHANGE RATE (DOLLARS/POUNDS)
RATIONAL EXPECTATIONS: THREE PERIOD AHEAD FORECASTS

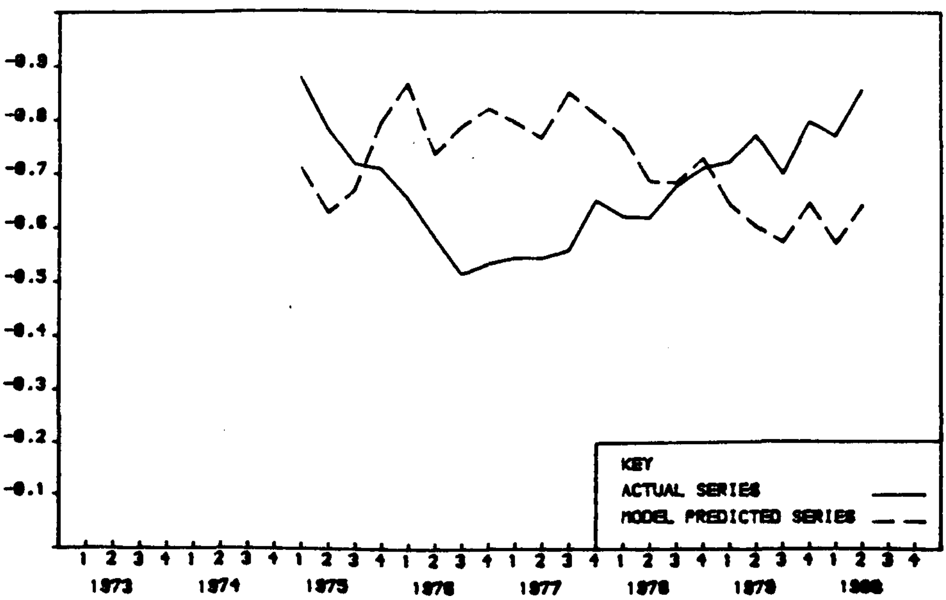


FIGURE 7.37: TRACKING PERFORMANCE - NOTES AND COINS
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS

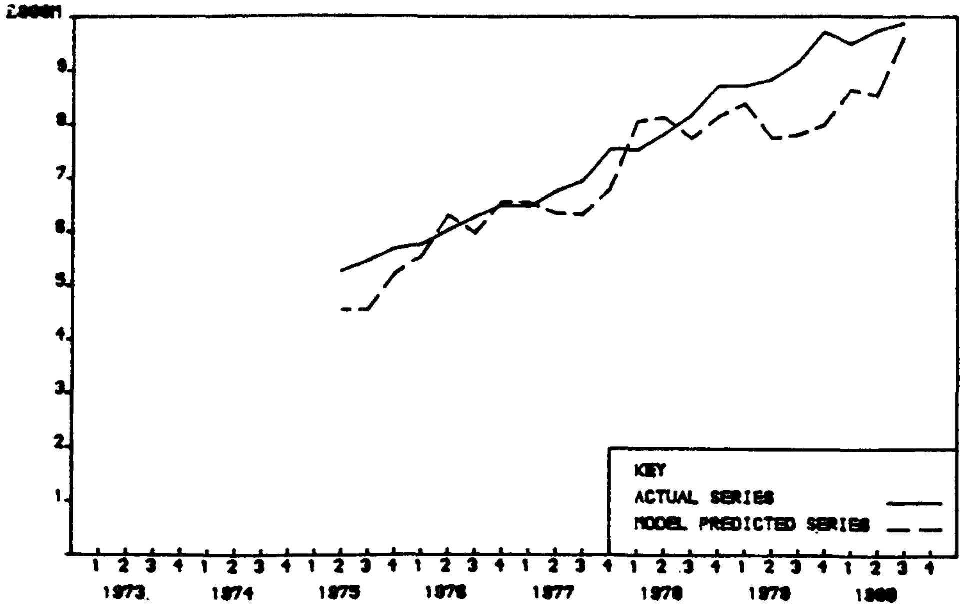


FIGURE 7.38: TRACKING PERFORMANCE - M1
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS

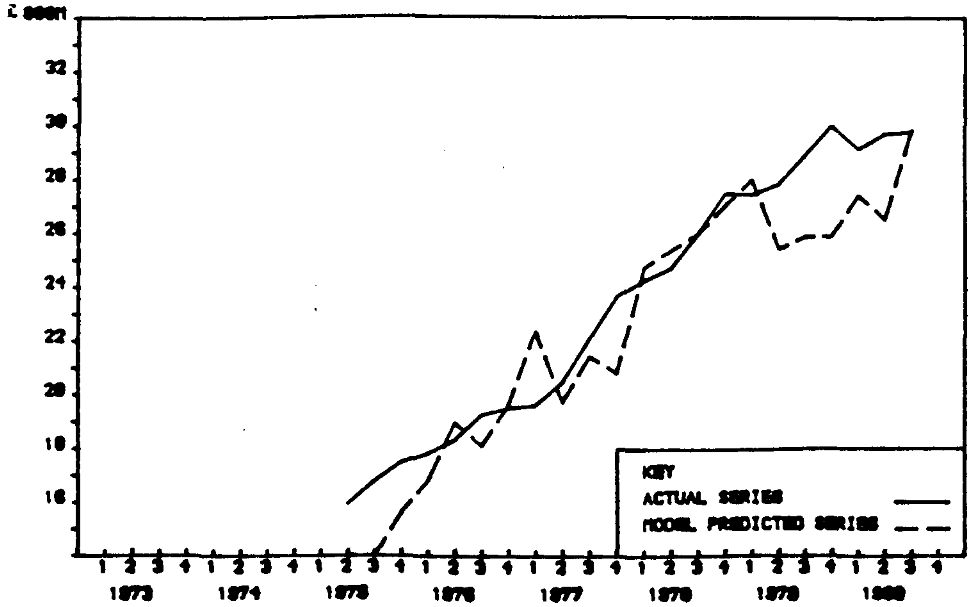


FIGURE 7.59: TRACKING PERFORMANCE - M2
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS

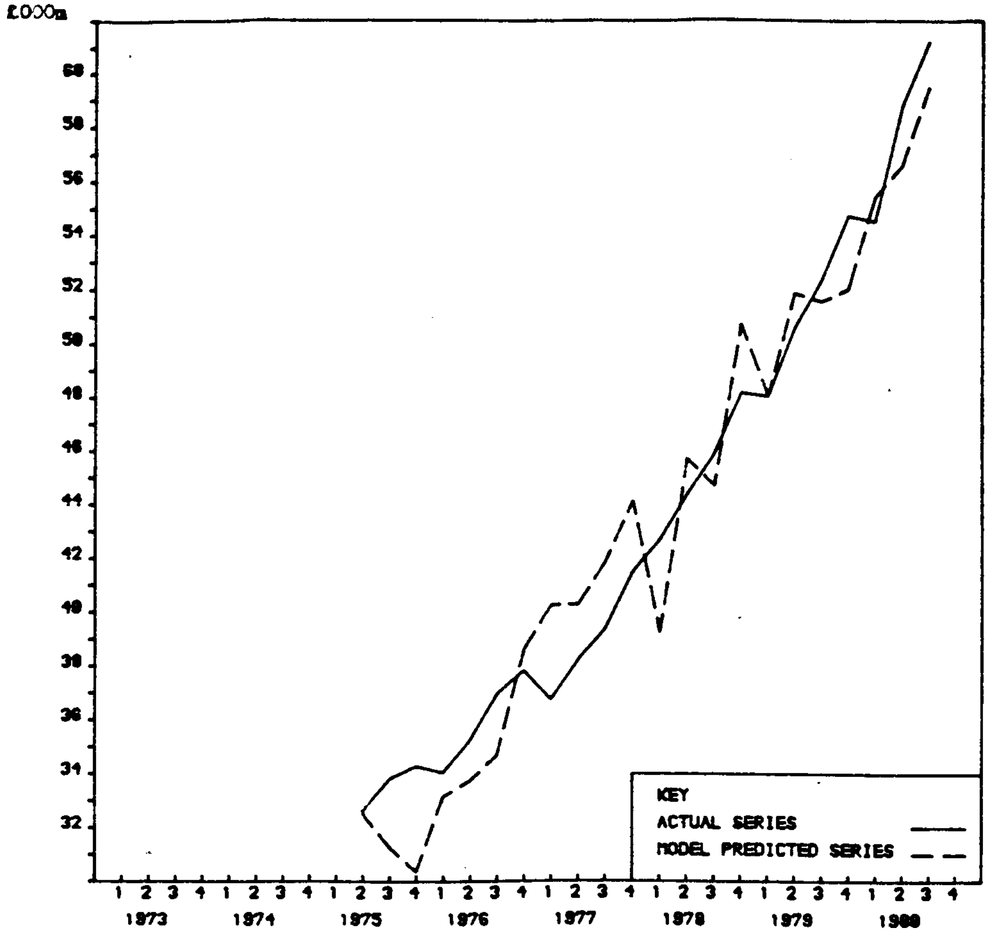


FIGURE 7.60: TRACKING PERFORMANCE - BANK LOANS
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS

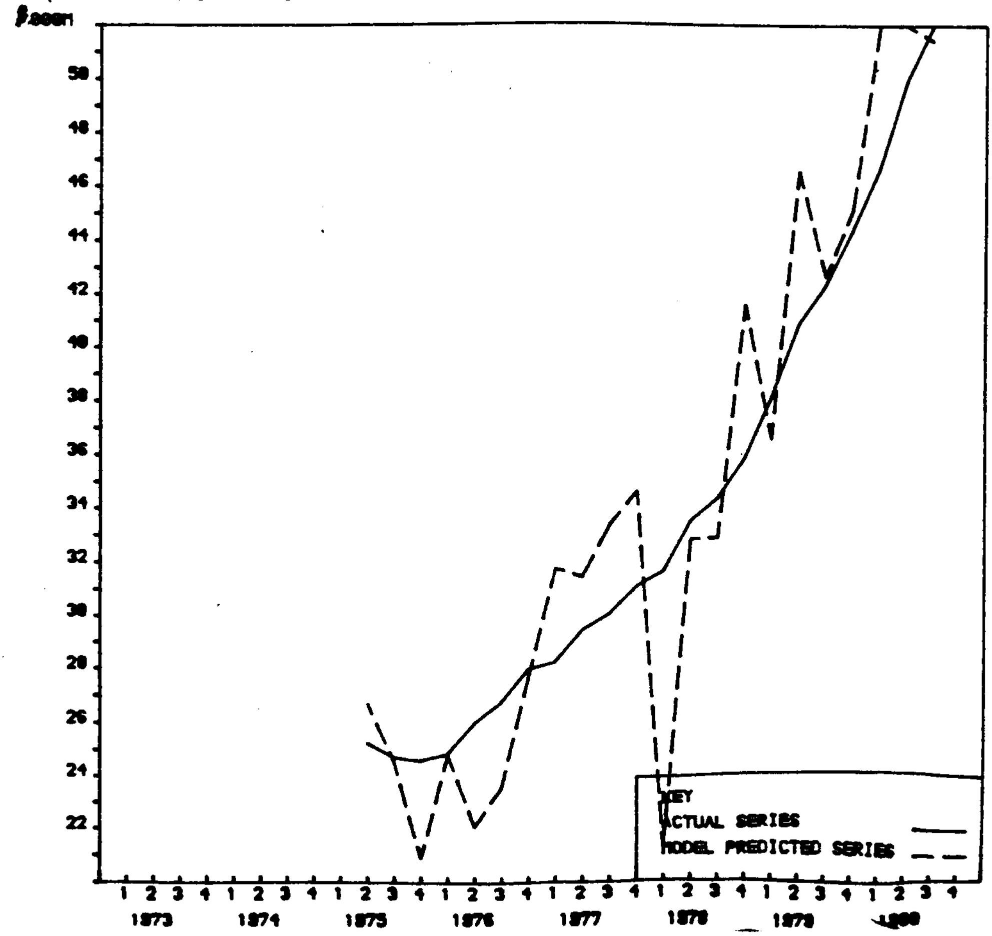


FIGURE 7.61: TRACKING PERFORMANCE - LOAN RATE
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS

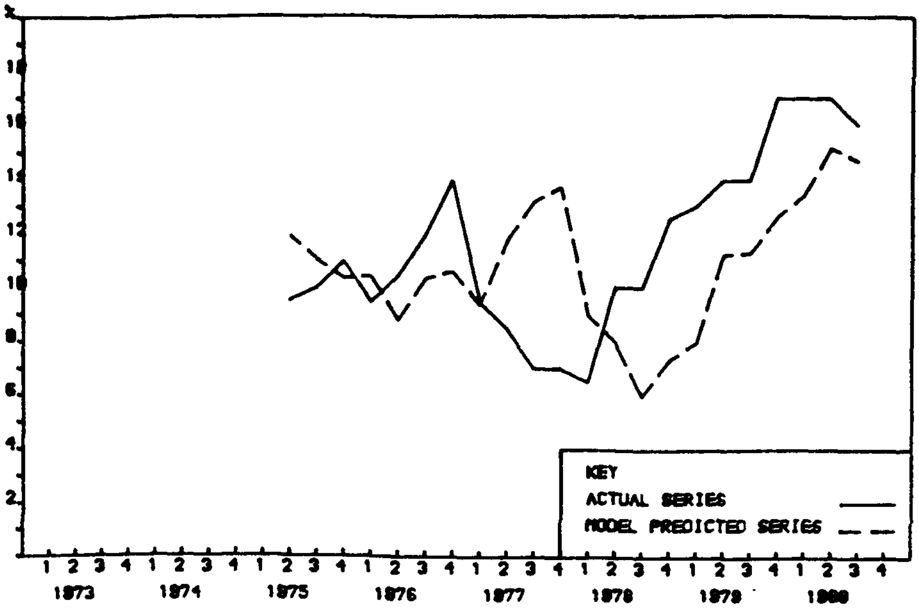
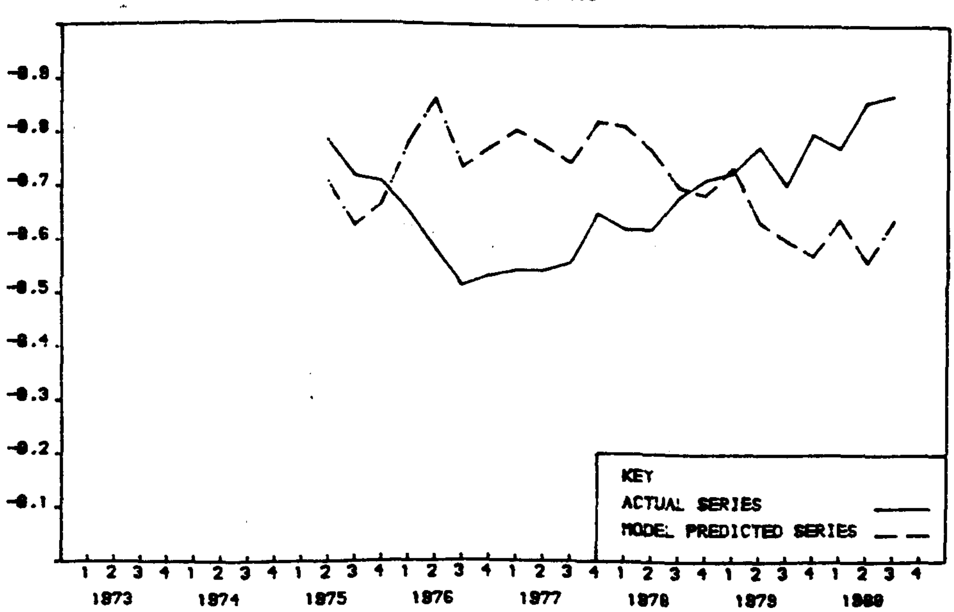


FIGURE 7.62: TRACKING PERFORMANCE - LOG EXCHANGE RATE (DOLLARS/POUNDS)
RATIONAL EXPECTATIONS: FOUR PERIOD AHEAD FORECASTS



CHAPTER 8 SIMULATION STUDIES: PURE FLOAT

8.1 Introduction

In this chapter we report the results of various simulation exercises dealing with shocks to i) the domestic money market rate of interest, ii) the uncovered foreign rate of interest and iii) net overseas assets held by the non-bank private sector. The general procedure adopted attempted to replicate as far as possible the theoretical experiments reported in chapter 3. Consequently, throughout the simulations the following variables were held constant:

i) Long-run expected income (LnYEXP)

ii) Nominal financial wealth (V). This implies zero balances for the PSBR and also the current account. Note this still permits financial wealth to vary due to the valuation effects discussed in chapter 7. This assumption is relaxed for the current account balance in section 4.

These adjustments left the price index rising but at an approximately constant rate so that expected inflation remains roughly constant. The plan of the chapter is as follows. In section 2 we discuss the imposition of the terminal condition. In section 3 the impact of the shocks discussed above are examined under conditions of a pure float so that the change in foreign currency reserves is zero. It is realised that a pure float is unlikely to occur in the real world but the results obtained using the assumption of a pure float provide a yardstick against which the results of intervention by the authorities may be considered. These simulations show the impact of shocks on the financial sector with no feedback from changes in the real sector. It was felt to be beyond the scope of this study to specify and estimate the real sector in addition to the financial sector but in section 4 we impose an equation which allows for some adjustment via the current account balance. Intervention by the authorities in the foreign exchange markets is considered in chapter 9.

8.2 Terminal Conditions

It is well known that rational expectations models involving future expectations typically involve non-unique solutions. The method adopted in this study to overcome this problem is to impose a terminal condition whereby agents anticipate that the model will reach an equilibrium value at some date in the future (see for example Minford and Peel [1983a] chapter 3) [1]. Imposition of a terminal condition requires two decisions to be made; i) the actual terminal condition itself and ii) the time horizon envisaged before the model returns to its equilibrium value. Dealing with the first problem, it was decided to impose the exchange rate ruling at the commencement of the simulation period as the terminal condition rather than any value suggested by purchasing power parity (PPP). Apart from the dubious relevance of PPP theory to short-term movements in the exchange rate, there was the additional problem that the sterling exchange rate appreciated during the later part of the simulation period even though the rate of inflation was higher in the UK than that experienced in the USA. Two (not necessarily competing) reasons have been offered in the literature for this phenomenon namely i) the onflow of North Sea oil production and ii) UK monetary policy. It was felt, therefore, that the use of an actual value of the exchange rate would approximate the then-ruling conditions more closely and facilitate evaluation of the results of the simulation experiments.

The second decision was approached from two angles. First the dynamic properties of a simplified version of the model were examined analytically [2]. Second, we also simulated changes in the domestic money market rate of interest against differing time horizons. The analysis concentrates on the portfolio behaviour of the non-bank private sector and the relevant equations are recorded below using a slightly different notation in order to facilitate the algebraic manipulation:

Demand for money

$$(1-\theta L)(m-b) = \alpha R \qquad \alpha < 0 \qquad (8.1)$$

Gross domestic assets (source)

$$g = \ln(\Sigma PSBR_{t-1}) \qquad (8.2)$$

Net domestic assets

$$d = \gamma g - \tau c \qquad (8.3)$$

where $\gamma = 1+\tau$ and τ is the share of bank credit in gross domestic assets

Net overseas assets

$$(1-\lambda L)(f-d) = \beta(R^*+s^*-s-R) \qquad 0 < \beta \qquad (8.4)$$

Demand for bank loans

$$(1-\phi L)(c-g) = \mu(R-R^*-s^*+s) \qquad \mu < 0 \qquad (8.5)$$

Gross domestic assets (shares)

$$g = \psi m + (1-\psi)b \qquad (8.6)$$

Valuation effect

$$(1-L)F = (\pi s(1-L))F_{t-1} \qquad \pi < 0 \qquad (8.7)$$

The smaller case variables represent logarithmic variables defined by the standard abbreviations. Thus $m = LnM$, $b = LnB$, $c = LnC$, $s = LnS$, $d = NDA$ and $f = LnF$. The capital L in this case represents the lag operator with C representing bank lending to the non-bank private sector. ψ is the share of money in net financial wealth. Endogenous variables are m,b,d,f,c and s with equation (8.2) merely describing the source of g in terms of an exogenous variable. Equation (8.7) can be transformed by dividing throughout by F_{t-1} to obtain:

$$((1-L)F)/F_{t-1} = \pi s(1-L)$$

or approximately

$$(1-L)f = (1-L)\pi s \qquad (8.7a)$$

Note that the solution of the model for the exchange rate (s) requires solution of equations (8.3), (8.4), (8.5) and (8.7a) only. Given a solution for s the remaining equations can be solved sequentially.

From (8.4) we obtain:

$$s^*-s = R-R^* + \{(1-\lambda L)(f-d)\}/\beta \qquad (8.8)$$

From (8.7a):

$$f = \pi s + k \qquad (8.9)$$

From (8.5):

$$c = \mu\{R-R^*-s^*+s)/(1-\phi L) + g \qquad (8.10)$$

Substituting (8.10) into (8.3) produces:

$$d = \gamma g-\tau\{\mu(R-R^*-s^*+s)/(1-\phi L)+g\} \qquad (8.11)$$

Substituting (8.9) and (8.11) into (8.8) gives:

$$s^*-s = R-R^*+\{\pi s+k-[\gamma g-\tau\mu(R-R^*-s^*+s)/(1-\phi L)-\tau g]\}\{(1-\lambda L)/\beta\} \qquad (8.12)$$

In order to simplify the algebra it is assumed that $1-\phi L$ approximately equals [3] $1-\lambda L$. Writing

$Z = \{k-\gamma g(1-\lambda L))+\gamma g(1-\lambda L))/\beta$ and simplifying (8.12) produces:

$$s^*-s = R-R^*+Z+(\pi s-\pi\lambda s_{t-1})/\beta+\tau\mu(R-R^*)/\beta-(\tau\mu s^*-\tau\mu s)/\beta \qquad (8.13)$$

Collecting like terms and rearranging gives:

$$(1+\tau\mu/\beta)s^*-(1+\pi/\beta+\tau\mu/\beta)s+(\lambda\pi/\beta)s_{t-1} = (R-R^*)(1+\tau\mu/\beta) + Z \qquad (8.14)$$

Using the estimated values for μ, β and λ (taken from Tables 4.7 and 4.8), the average value for τ over the estimation period and the value for π used in the valuation effect produces:

$$0.9914s^* - 1.0409s + 0.0241s_{t-1} = R-R^* + Z \qquad (8.15)$$

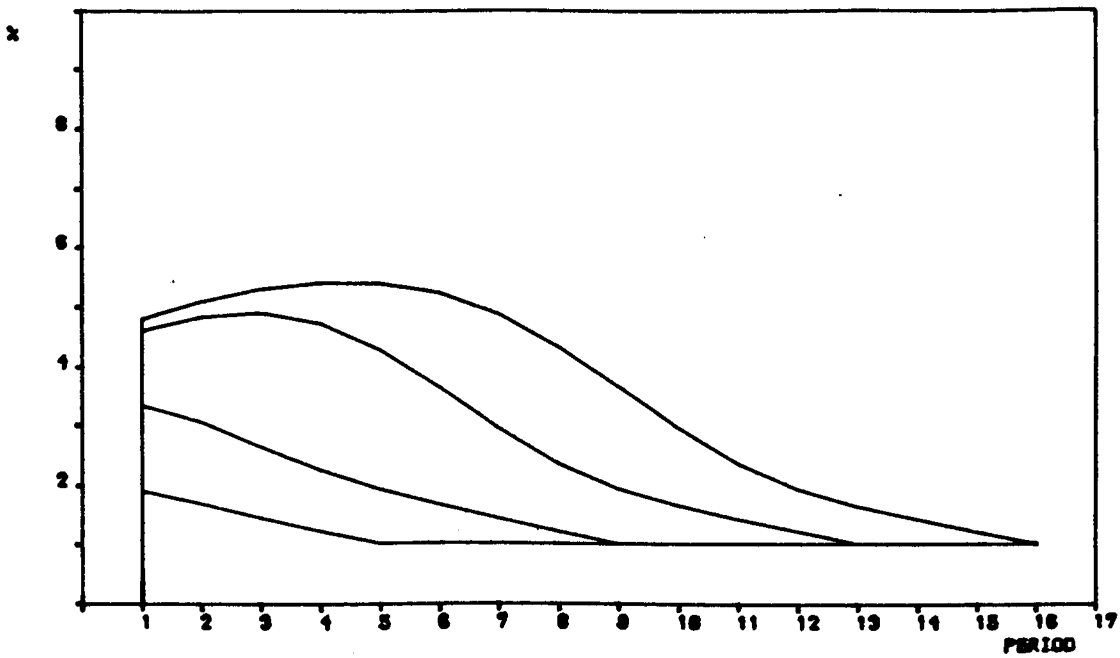
Assuming rational expectations so that $s^* = s_{t+1}$ and normalising (8.15) produces:

$$s_{t+1} - 1.05s + 0.0243s_{t-1} = R - R^* + 1.007Z \qquad (8.16)$$

The solution of the characteristic equation of (8.16) gives roots of 0.0238 and 1.026. Following standard practice we disregard the non-stable root and concentrate on 0.0238. The small size of this root suggests that the equilibrium exchange rate should be quickly restored following any external shock.

As a further check on the relevant time horizon, we simulated the effect of a permanent [4] increase in the domestic money market rate of interest of 1% for differing time horizons. The results of this experiment are shown in figure 8.1. The salient feature revealed by this chart is the change in the time path followed by the exchange rate as the period is extended. For periods of 4 and 8 quarters the exchange rate jumps immediately and then gradually returns to its terminal condition. For the 12 quarter time horizon, the adjustment path of the exchange rate assumes an inverted V pattern which is further accentuated for the 15 quarter period. Given the quick adjustment revealed in the analytical solution of the simplified version of the model, the probable reason for this behaviour is that we are forcing the adjustment path away from that inherent in the structure of the estimated model. Consequently for the simulation experiments reported in section 3 we use an eight quarter time horizon.

FIGURE 8.1 POUND/DOLLAR EXCHANGE RATE
SIMULATION : PERMANENT RM + 0.01
PURE FLOAT



8.3 Simulation of Exogenous Shocks: Pure Float

In this section we examine the effect of the three exogenous shocks considered theoretically in Chapter 3. These simulations are non-stochastic and are carried out for the time period 1975 quarter 3 to 1977 quarter 2 under the hypothesis of rational expectations so that the shocks are unanticipated. The terminal condition is imposed on the first quarter beyond the simulation period, i.e. 1977 quarter 3. Two types of shock are considered: permanent and temporary. For a permanent shock, the variable concerned was maintained at the new level throughout the simulation period. In addition the terminal condition is adjusted to reflect the effect on the equilibrium level of the exchange rate. Thus, for example, a 1% rise in the foreign uncovered rate of interest is assumed to raise the dollar/pound exchange rate by the same amount (in terms of logs, from -0.7814 to -0.7714). A temporary shock on the other hand is applied to the first two quarters of the simulation period only and the terminal condition is left unchanged.

The effect of a permanent rise in the uncovered foreign rate of interest (R*) is examined first of all. The comparative static analysis pursued in chapter 3 (Figure 3.6) suggests that both the exchange rate and the loan rate of interest (RL) will rise. This is confirmed by the model simulation as illustrated in Table 8.1

below which shows the impact on the same variables used in chapter 7 to assess the performance of the model. As would be expected under conditions of a pure float, the impact on the quantity variables is quite small. This comment also applies to the effect on RL. The assumption of imperfect substitutability between domestic and foreign assets means that the forward premium on dollars is reduced but by less than the 1% rise in R*. Consequently, the cost of borrowing abroad rises and this results in the rise in sterling bank loans (L) revealed in the table. Similarly, the money supply rises - the effect is more marked for M2 than M1 because the rate of interest on time deposits also increases following the rise in R*. Note also the loan rate also rises following the increase in loans in the banks' asset portfolio so that the profitability of banking operations is only marginally affected (i.e. the gap between the rate charged on loans and that paid on deposits decreases by 0.16%.)The adjustment path for the exchange rate is shown in Figure 8.2. As predicted in chapter 3, overshooting occurs with a gradual adjustment back towards the terminal condition after the initial jump. The general features described above are similar to those reported in De Grauwe et al [1985] for a foreign rate of interest shock applied to financial models of the German and French economy. The main difference lies with regard to the size of the initial jump (approximately 6% compared with the 2.8% described above). This difference seems to arise from their assumption of the much longer time horizon of sixteen quarters. Reference to Figure 8.1 also shows that if the time horizon is extended, the size of the initial jump in the exchange rate increases.

In contrast to the case of a permanent shock, a temporary shock to R* produces minimal effects on all variables including the exchange rate. Examination of Figure 8.2 shows that the exchange rate jumps by only 0.4% and then quickly returns to its original value. The effect on the other variables is also minute as evidenced by the details of Table 8.2. Note also there is no growth in bank lending in this case. The small magnitude of the effects of the temporary rise in R* contrasts with the results obtained for a permanent rise discussed above and suggests that the significance of the impact of interest rate changes on exchange rates will vary according to whether the markets perceive the changes to be permanent or temporary. This may help to explain why the impact of interest rate changes on the foreign exchange markets appears to be unpredictable since the advent of general floating. The same point has been made by De Grauwe et al [1985] and Brunner, Cukierman and Meltzer [1980].

We now turn to examine the effect of a rise in the domestic money market rate of interest (RM) caused by the implementation of a restrictive monetary policy. The effects are similar in magnitude but opposite in direction to those analysed above for a rise in R*. Again the effect on the quantity variables is quite small. There is a decline in the quantity of notes and coins held but a greater decline in holdings of M1 which implies a decline in

FIGURE 6.2 DOLLAR/POUND EXCHANGE RATE
SIMULATION : R^* +0.01.
PURE FLOAT

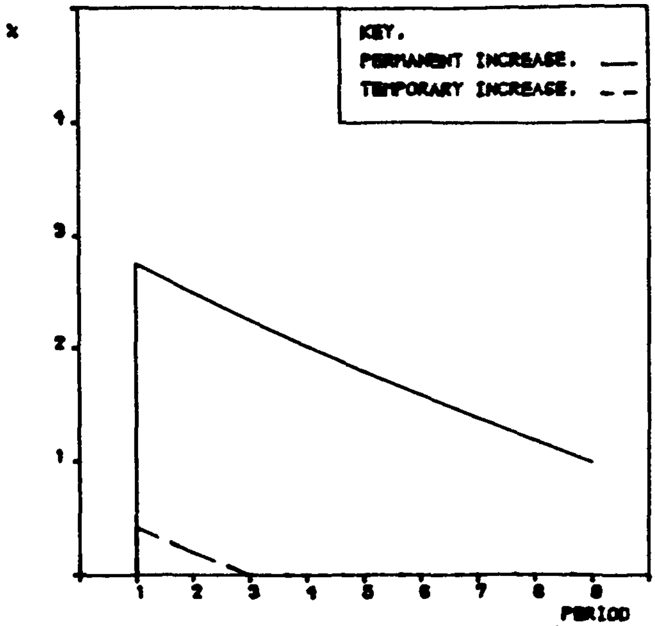


FIGURE 6.3 DOLLAR/POUND EXCHANGE RATE
SIMULATION : RM +0.01.

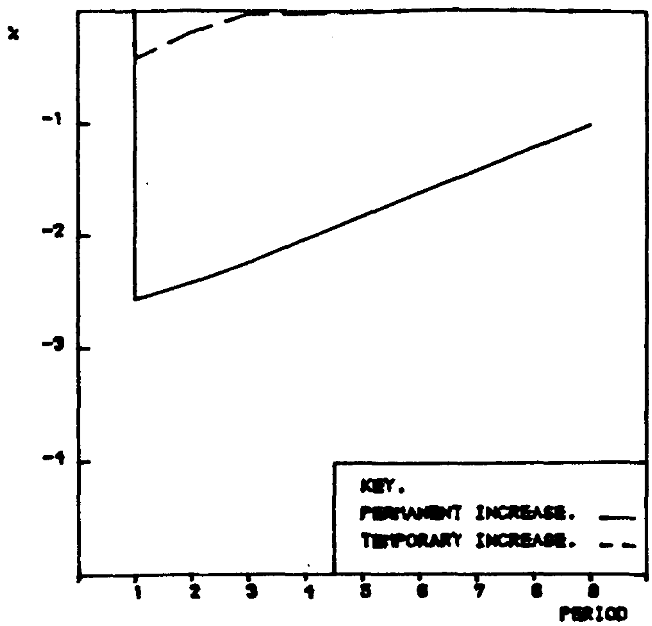


Table 8.1

Effects of A Permanent Increase of 1% in the Uncovered Foreign Rate of Interest (free Float)

Variable	Impact Effect	Effect after 4 quarters	End-of-Period Effect
	£m	£m	£m
NC	-3.4	+2.4	-2.9
M1	-3.5	+12.5	+6.1
M2	-10.5	+86.5	+106.5
L	+64.6	+145.7	+174.1
	%	%	%
RL	+0.02	+0.03	+0.03
LnS	+2.76	+2.02	+1.20

Table 8.2

Effects of A Temporary Increase of 1% in the Uncovered Foreign Rate of Interest (Free Float)

Variable	Impact Effect	Effect after 4 quarters	End-of-Period Effect
	£m	£m	£m
NC	+3.6	-6.1	-5.1
M1	+11.1	-9.2	-3.6
M2	+46.2	+19.2	+11.2
L	+49.1	+54.9	+25.6
	%	%	%
RL	+0.01	+0.01	0.0
LnS	+0.42	-0.01	0.0

Table 8.3

Effects of A Permanent Increase of 1% in the Domestic Money Market Rate of Interest (Free Float)

Variable	Impact Effect	Effect after 4 Quarters	End-of-Period Effect
	£m	£m	£m
NC	-39.0	-61.4	-102.3
M1	-194.0	-340.3	-470.7
M2	-275.2	-239.4	-272.5
L	-225.4	-130.2	-116.6
	%	%	%
RL	+0.86	+0.87	+0.87
LnS	-2.56	-2.01	-1.20

Table 8.4

Effects of A Temporary Increase of 1% in the Domestic Money Market Rate of Interest (Free Float)

Variable	Impact Effect	Effect after 4 Quarters	End-of-Period Effect
	£m	£m	£m
NC	-37.4	-18.2	-25.4
M1	-188.7	-85.3	-59.4
M2	-251.0	+23.5	+4.3
L	-199.0	+41.7	+7.9
	%	%	%
RL	+0.87	0.00	0.00
LnS	-0.42	0.02	0.00

sight deposits. Holdings of M2 have also decreased but by a smaller amount thus indicating a switch from non-interest bearing sight deposits towards interest bearing time deposits. This, of course, reflects the rise in other domestic interest rates which are directly related to RM. Similarly bank lending has also declined following the rise in the loan rate - note, however, the rise in the loan rate is less than 1% given the elasticity of 0.85 recorded in table 5.6. At the same time the rate paid on deposits rises by the same amount so that there is no change in the interest rate spread. The initial fall in the exchange rate is approximately equal in magnitude to the rise following the increase in R* discussed earlier. Again it is relevant to note that the direction of these effects is in accordance with the theoretical analysis carried out in chapter 3 (Figure 3.7). The pattern of adjustment in the exchange rate for both the temporary and permanent increase in RM is shown in figure 8.3. The comments made above with regard to a temporary increase in R* apply with equal force to a temporary increase in RM as evidenced by the detail contained in Tables 8.3 and 8.4.

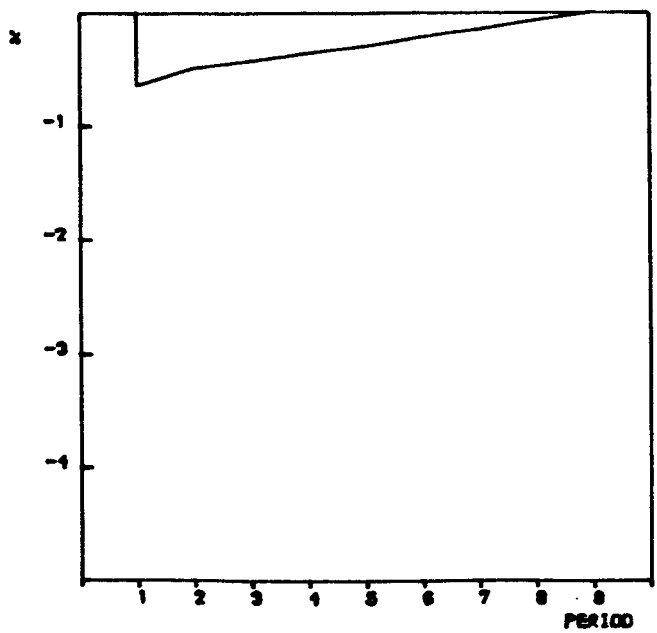
Finally, in this section, we examine the impact of a rise in holdings of net overseas assets by the non-bank private sector. This was achieved by imposing a one period positive balance of £500m on the current account of the balance of payments. No change was made to the terminal condition. The effect of this change on the exchange rate is shown in Figure 8.4 and on all variables in Table 8.5. The rise in both the exchange rate and the loan rate of interest are in accordance with the analysis presented in chapter 3 (Figure 3.8). The changes in the quantity variables reflect rises in domestic rates of interest and the forward premium on the dollar which is not offset by any decline in the uncovered foreign rate of interest thus making foreign borrowing more expensive. Note also there is a small shift from non-interest bearing to interest bearing money. We note that the reaction to these shocks involves 'overshooting' defined as the movement of the actual spot rate

Table 8.5

Effects of A Permanent Increase of £500m in Net Overseas Assets held by the Non-Bank Private Sector (Free Float)

Variable	Impact Effect	Effect after 4 Quarters	End-of-Period Effect
	£m	£m	£m
NC	+19.7	-16.8	-27.6
M1	+54.0	-36.8	-49.9
M2	+221.9	+162.0	+162.8
L	+249.5	+293.5	+272.3
	%	%	%
RL	+0.03	+0.05	+0.04
LnS	-0.64	-0.35	-0.07

FIGURE 8.1 DOLLAR/POUND EXCHANGE RATE
SIMULATION : CA +£500 m
PURE FLOAT



beyond the rational expectation of the equilibrium rate as imposed in these simulations by the terminal condition. The feature of 'overshooting' has been extensively reviewed in the literature [5] with perhaps a general consensus being that overshooting results from the specification of the model rather than being a universal phenomenon. Driskill [1980] comments that "Furthermore, one of the striking implications of existing asset equilibrium models, that of overshooting, is seen to be not a general result but one closely tied to rather special assumptions" (page 783). One might counter that the absence of overshooting also depends on rather special assumptions such as i) instantaneous adjustment of the trade balance (Driskill [1980]), ii) absence of interest bearing domestic assets (Niehans [1977]) etc. One particular restrictive assumption in this model is that we have not allowed any feedback via the current account of the balance of payments from the real sector. This is partially rectified in the following section.

8.4 Extension of the Model to Incorporate the Current Account of the Balance of Payments

The various simulations reported in the previous section suffer from one major defect since the channels of adjustment are restricted to the financial sector. This contrasts with the mechanism envisaged by Branson and Halttunen [1979] where the long-term adjustment involves changes in the current account of the balance of payments which, in turn, lead to changes in private wealth. Since, as is already noted, the object of this study is to model the financial sector of the UK economy, we have imposed the following simple current account function on the model.

Abstracting from income flows derived from overseas investment, exchange rate changes affect the current account in two ways; i) a valuation effect and ii) a volume effect. This can easily be seen by differentiating the current account identity using the simplifying assumption that both the foreign currency price of imports and the sterling price of exports remains unchanged. Similarly no allowance is made for domestic income changes. Consequently:

$$\Delta CA = P(\delta X/\delta S)dS - SP_m(\delta IM/\delta S)dS - P_m IMdS \qquad (8.17)$$

where CA is the nominal current account, X and IM are exports and imports in real terms, P and Pm are the domestic and foreign price level and S the spot exchange rate (units of domestic currency per unit of foreign currency).The last term is the valuation effect and the first two terms the volume effect. Ignoring lags (8.17) can be approximated by:

$$CA = X\epsilon_x \Delta LnS - IM\epsilon_m \Delta LnS - IM\Delta LnS \qquad (8.18)$$

where ϵ_x and ϵ_m are relevant price elasticities for exports and imports respectively, LnS the log of the exchange rate. A further simplification is achieved by using mean values of exports and imports for X and IM and imposing a zero balance on the period before the shock. This specification is quite general and a J curve would arise from making two assumptions: i) the Marshal/Lerner conditions are satisfied with respect to the elasticities in the long run and ii) the adjustment from the volume effect is slower than that from the valuation effect.

This leaves two factors to be determined. These are the size of the two elasticities and the appropriate lag structure. Reverting to the first factor, Thirlwall [1980] considers the question of the elasticities and concludes that the evidence regarding the significance of changes in relative prices on the volume of imports is very mixed. In contrast he argues that there would seem to be a general consensus among investigators that the short run elasticity of exports with respect to relative price changes is quite low but that after two years the elasticity is probably of the order of 1.5 to 2.0. We have imposed coefficients of 0.5 and 1.75 for imports and exports respectively which seem to be roughly of the right order. With regard to the appropriate lag structure, we have assumed a total lag of eight quarters with imposed weights that follow an inverted V pattern peaking after 4 quarters. The actual lags were as follows:

t 0.0; t-1 0.05; t-2 0.10; t-3 0.20;

t-4 0.30 t-5 0.20; t-6 0.10; t-7 0.05;

This contrasts with Minford [1978] who identifies a six year lag as being appropriate for UK manufactured exports [6]. The combination of the two assumptions regarding the elasticities produces a J curve effect with a one-off 1% appreciation in the dollar exchange rate producing an impact effect of -£79m in period t but an overall improvement of £99m after 8 quarters. The break even point occurs after 4 quarters.

We now examine the effects of introducing the current account into the model on the simulation of a rise in the domestic money market rate of interest reported in section 3 above. The rise in this rate of interest causes the $/£ exchange rate to depreciate in the period immediately following the shock but, thereafter to appreciate gradually towards the long-term equilibrium value. The introduction of adjustment via wealth effects through current account changes should alter this pattern in three directions:

a. The initial jump in the exchange rate should cause the current account balance to increase leading to a corresponding increase in private wealth.
b. The long-term effect of the initial jump would be to reverse this effect and cause the current account (and therefore private wealth) to decrease.
c. The subsequent depreciation of the exchange rate towards the terminal condition would produce the opposite effects to those discussed in (a) and (b) above.

In contrast, if we assume immediate adjustment of the current account to exchange rate changes, all the adjustment would take place in period t. Consequently, the depreciation of the dollar would lead to an immediate reduction in private wealth reducing the size of the overshooting.

Examination of the simulation of the shock to net overseas assets discussed in the previous sections suggests that the impact of these changes on other variables within the model should be quite small. In the case of lagged adjustment, the time horizon of the terminal condition should, in theory, be extended. However in view of the relatively small magnitude of these effects we decided to leave it at eight quarters. The results of a simulation of a 1% increase in the domestic money market rate of interest against the base run of no current account effect confirmed the above prognosis. The impact of these changes as against the model which excluded current account adjustments were as follows:

a Immediate adjustment of the Current Account

Initial jump in the exchange rate reduced from 2.56% to 2.26%

b Lagged Adjustment of the Current Account

Initial jump in the exchange rate increased from 2.56% to 2.69%

Both these impacts are relatively small and have therefore little effect on the results discussed earlier. Similar results would be obtained if the shock had taken the form of an increase in the uncovered foreign rate of interest in view of the symmetry of the results discussed in section 3 above.

8.5 Conclusions

In this chapter we have examined the effects of shocks arising from changes in domestic and foreign rates of interest as well as net foreign assets. We have imposed a function to represent changes in the current account induced by movements in the exchange rate. These effects seem to have quite a small impact so that using foreign asset markets alone provides a useful approximation to the results derived from the use of the more complete model. The simulations show that the effect of interest rate shocks depends critically on whether the changes are perceived to be permanent or temporary. In the following chapter we examine the potential for official intervention in the foreign exchange markets.

Notes

1 Alternative methods of solving the model include i) ruling out unstable roots (though see Burmeister [1980] for a criticism of this approach), ii) adopt the root which minimises the deviations of the endogenous variables (Taylor [1977]).

2. The model is mainly simplified by i) the incorporation of a composite variable M to replace four monetary variables, ii) the omission of the banking sector supply functions - in this latter case the exchange rate appears in the equation explaining their demand for overseas assets.

3. The estimated values of ϕ and λ were 0.7793 and 0.6820 respectively.

4. The distinction between temporary and permanent shocks is defined in section 8.3

5 For example see Phylaktis and Wood [1983], Driskill [1980], Dornbusch [1976], Ethier [1979], Minford and Peel [1983b].

6. Driskill [1981] reports that, for Swiss/US data for period 1973/1977, after 11 quarters about 75% of the exchange rate adjustment has taken place and, for the price level, about 97% of the total adjustment.

CHAPTER 9 INTERVENTION BY THE AUTHORITIES IN THE FOREIGN EXCHANGE MARKETS

9.1 Introduction

Justification of official intervention in the foreign exchange markets is usually directed towards the potential for the reduction of fluctuations in exchange rates - see, for example, Mayer and Taguchi [1983]. It is argued that uncertainty in respect of the equilibrium exchange rate given changing domestic circumstances will inevitably lead to excessive volatility in the spot market which will interact with the domestic economic environment but with a lag due to the J curve. This may exaggerate the inherent volatility of the exchange rate with detrimental effects on the growth of world trade and economic growth. Such volatility may, in principle be allievated by private speculation but it is often argued that private speculators take an essentially short-term position rather than the medium-term view necessary to even out swings in the exchange rate. Consequently, there is a need for official intervention. On the other hand, it is not always accepted that intervention by the authorities will influence the exchange rate in the desired manner. For example, Bockelmann

[1983] suggests that intervention by the authorities may change the nature of the market so that the desired results are not obtained. In particular:

> "when the central bank is buying foreign currency the message of the signal might be 'don't expect a drop in the exchange rate because the authorities are set against it'. In actual fact, the message nowadays invariably seems to be 'this may be the best price you can get for your foreign currency for some time, therefore hurry if you wish to sell'. So additional supply may be provoked by the intervention that more than matches the additional demand and effects opposite to those intended cannot be ruled out" (page 191).

Nevertheless he accepts that situations of very short--lived movements in the exchange rate often occur and this may be offset by official intervention.

The following examination of intervention by the authorities in the foreign exchange markets is carried out within the context of the model incorporating lagged adjustment to the current account of the balance of payments. Also, given the symmetry of the responses of the exchange rate to shocks arising from changes in both the foreign and domestic rates of interest, we concentrate on the response of the model to a 1% increase in the uncovered foreign rate of interest. Furthermore, before we can move on to the simulations two decisions are required concerning the intervention behaviour of the authorities. The first concerns the actual intervention rule(s) followed and the second the type of intervention followed. Argy [1982] distinguishes two types of intervention rules. The first is 'leaning against the wind' and the second the target approach. Leaning against the wind requires the authorities to intervene so as to resist partially market forces with the objective of reducing swings in the exchange rate. The target approach is assumed to entail the authorities moving the exchange rate towards a desired target rate. Although it is generally agreed that most intervention in the foreign exchange markets by the authorities takes the form of leaning against the wind, we shall examine the efficacy of both approaches and in the case of target intervention assume that the target adopted by the authorities is the rational expectation of the equilibrium exchange rate, that is the terminal condition imposed on the model.

Two types of intervention have been distinguished in the literature, sterilised and non-sterilised intervention. The precise distinction between sterilised and non-sterilised intervention is ambiguous. De Grauwe et al [1985] define sterilised intervention as intervention in the foreign exchange markets which does not affect the domestic monetary base. Genburg [1981] defines sterilised intervention as intervention which leaves the domestic money supply unaltered. In contrast Wonnacott [1982] implies the much more constrained definition of sterilised intervention as that which leaves "money stock, interest rates, prices and competitiveness unchanged so that the long-run equilibrium exchange rate is likewise unaffected" (page 11). In the model specified in chapter 7, the monetary base is demand determined and monetary policy is exercised through variations in interest rates so that our definition of sterilised intervention must lie outside a constant quantity of money or other monetary variables. Thus we have defined sterilised intervention as one which leaves the domestic money market rate of interest unchanged and a non-sterilised intervention as one that allows that rate of interest to change [1].

Within the literature controversy exists over the potency of sterilised intervention and we return to this topic in chapter 9. For the moment it is sufficient to note that Argy [1982] argues that sterilised intervention by the authorities will be effective in a number of situations included in which are i) the authorities follow a policy of leaning against the wind ii) the spot exchange rate is flexible and iii) imperfect substitutability exists between domestic and foreign currency assets. These conditions apply in the model described in chapter 7 and we would, therefore, expect sterilised intervention to alter the adjustment path of the exchange rate following a shock to the uncovered foreign rate of interest.

We also have to decide on the statistics necessary to describe the impact of the methods of intervention. At this stage three statistics are used:

i) The cut in the initial overshoot compared with a pure float.

ii) The mean value of appreciation.

iii) The cumulative cost in reserves.

It is important to recognise that the base run or benchmark, against which a policy intervention is assessed also incorporates the intervention rule. We are not comparing intervention against a base run of a pure float. Thus, for example, the rise in the exchange rate following an increase in the foreign rate of interest is measured against a base run which also incorporates the same intervention rule. One important feature to note about these simulations is the fact that we have left the terminal condition unchanged. This is equivalent to assuming that the market believes that no long-run effects on the exchange rate result from sterilised intervention by the authorities. Note, however, intervention does alter marginally the path of transition towards the long-run equilibrium (i.e. the terminal condition)

9.2 Sterilised Intervention

In order to represent intervention within the model, it is necessary to specify a reaction function linking reserve changes to changes in the exchange rate. Artis [1978] surveys the evidence on reaction functions for the UK economy over the period from the mid 1950s to 1970. He finds that the main objectives included the quantity of reserves, unemployment and the price level with instruments including bank rate, special deposits, hire purchase controls and bank advances requests. It is noteable that, in these studies, the target was the quantity of reserves rather than the exchange rate but this is, no doubt, attributable to the fact that the period covered was one of a fixed exchange rate. Haache and Townend [1981] examined the period 1972 to 1980 (i.e. a period of floating exchange rates) and find that the main intermediate targets for a reaction function with reserve changes as the dependent variable included exchange rate changes and interest rates. However the explanatory power of the estimated equations was generally not particularly high though it improved towards the end of the period. As far as interest rates were concerned, they find very little evidence of the relationship between exchange rate pressure and interest rate changes. More generally some studies (see for example Wonnacott [1982], Quirk [1977] and Artus [1976]) find explanatory variables additional to changes in the exchange rate, such as the lagged values of the dependent variable, considerably improved the explanatory power of the equation explaining intervention in the foreign exchange markets. Since our aim is to examine the effects of intervention rather than explaining why intervention takes place, we have restricted the explanatory variable in the reaction function to exchange rate changes. It is argued that this is a sufficiently close approximation to reality to provide a sensible prediction of the results of intervention in the foreign exchange markets by the authorities. Thus the method of including sterilised intervention in the model is to specify a function of the general form:

$$\Delta RES = \alpha(LS_t - LS_{t-1}) \qquad (9.1)$$

$\alpha < 0$

where ΔRES (=BF) represents the change in reserves. The precise value of the coefficient a will depend on two factors. The first is a scaling factor linking (LS_t-LS_{t-1}) to the quantity of reserves. The second reflects the intensity of intervention. We adopt three alternative rules in ascending order of intensity of intervention. This function will operate via equations specified in Appendix 7A in the following manner. First the change in reserves will alter the net quantity of overseas assets held by the non-bank private sector via identity (I.11). This alters the forward premium via equation (E.5) and hence the exchange rate given the expected exchange rate via equation (E.12). Given the adjustment path shown in Figure 8.2, it would be expected that intervention by the authorities in the form of leaning against the wind would lead to an immediate loss of reserves as the initial jump in the exchange rate is modified. Subsequently the authorities would gain reserves as the dollar/pound exchange rate depreciates towards the long-term equilibrium given by the terminal condition.

Three intervention rules were tried. These are designated (a), (b) and (c) in Table 9.1 in increasing order of intensity of intervention - i.e. larger values of α^2 in (9.1) above. As can be seen from the results shown in that table sterilised intervention produces a stabilisation of the exchange rate compared with a pure float but at a cost in the form of loss of reserves. The same information is also shown in figures 9.1 and 9.2. The pattern of reserve loss followed the expected pattern discussed earlier with an immediate heavy loss but subsequent gains as the authorities tried to modify the subsequent depreciation of the dollar (or equivalently the appreciation of the pound). This is depicted in Figure 9.2. Note the benchmark for these simulations assumes that the same intervention rules were applicable to the base run as simulation of the shock.

Table 9.1

Effect of Sterilised Intervention

Leaning Against the Wind

Intervention Rule	Reduction in Initial Jump in the Exchange Rate	Mean Appreciation	Cost in Reserves £m
a	0.77	1.5	337
b	0.94	1.46	450
c	1.15	1.38	559

FIGURE 9.1 DOLLAR/POUND EXCHANGE RATE
SIMULATION : R^* +0.01.
STERILISED INTERVENTION: LEANING AGAINST THE WIND

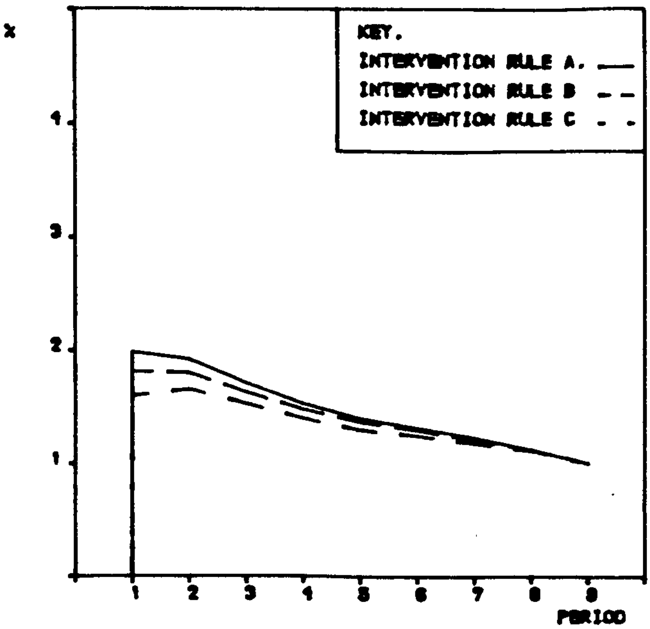
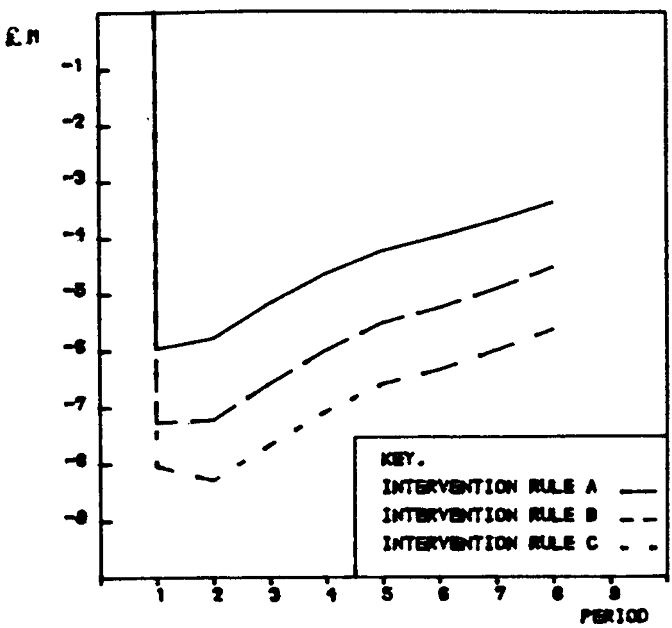


FIGURE 9.2 RESERVE LOSS
SIMULATION R^* + 0.01
STERILISED INTERVENTION: LEANING AGAINST THE WIND



For the target approach, we assumed that the target held by the authorities was the long-run equilibrium exchange rate, i.e. the terminal condition we imposed on the model. Consequently it was necessary to modify (9.1) to:

$$\Delta RES = \alpha(LnS_t - LnS^*) \qquad (9.1a)$$

$$\alpha < 0$$

The results of the simulations corresponding to those for the leaning-against-the-wind intervention are shown in Table 9.2 and figures 9.3 and 9.4. As can be seen from the details contained in table 9.2, the effects of sterilised target intervention are quite different from those obtained by leaning-against-the-wind intervention

Table 9.2

Effect of Sterilised Intervention

Target Intervention

Intervention Rule	Reduction in Initial Jump in the Exchange Rate	Mean Appreciation	Cost in Reserves £m
a	1.14	1.24	592
b	0.99	1.23	737
c	1.32	1.16	655

FIGURE 8.3 DOLLAR/POUND EXCHANGE RATE
SIMULATION : R* +0.01.
STERILISED INTERVENTION: TARGET INTERVENTION

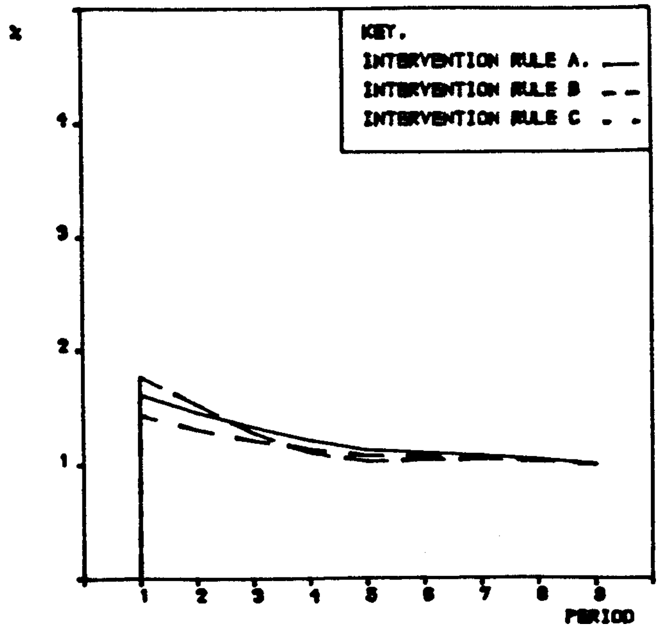
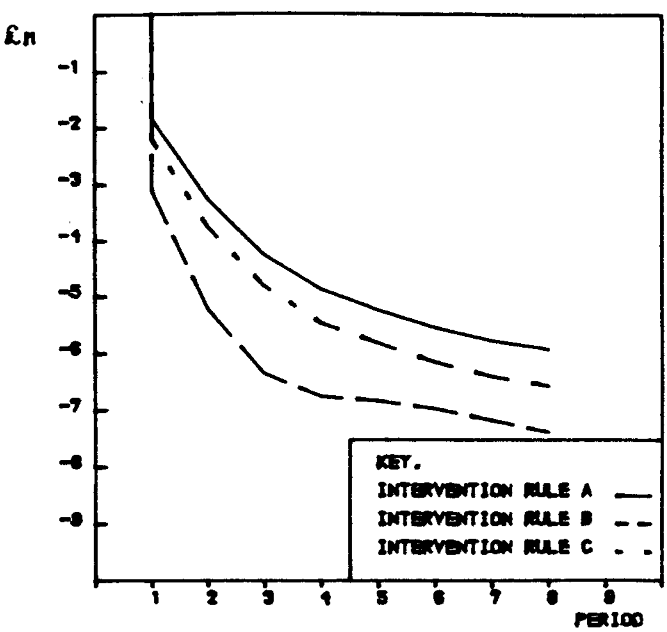


FIGURE 8.4 RESERVE LOSS
SIMULATION R* + 0.01
NON-STERILISED INTERVENTION: TARGET INTERVENTION



In general both the mean appreciation and the initial overshoot are reduced compared with the leaning-against-the-wind intervention. However this improvement is not without cost since the loss of reserves is increased. This occurs because target intervention is directed continually towards deviations of the exchange rate from the long-run equilibrium level characterised by the terminal condition. Consequently the authorities are continually purchasing sterling throughout the simulation period. This arises because the market exchange rate ($/£) is always above the equilibrium (terminal condition) rate. This contrasts with the position for LAW intervention where, after the initial overshoot, the authorities are gaining reserves as they moderate the depreciation of the $ (i.e. appreciation of the £). There are also some other interesting results. Increasing intervention (from rule a to rule b) alters the path of adjustment rather than total effect. In addition rule c dominates rule b

The simulations for target intervention assume that the authorities correctly identify the long-run equilibrium exchange rate (i.e. the terminal condition) as appropriate target for intervention. It is therefore akin to an assumption of perfect foresight. We have also simulated sterilised target intervention against the background of an inappropriate target exchange rate. So as to restrict the proliferation of simulations we concentrate on intervention rule a in Table 9.2 and consider two possibilities. The first is the authorities fix their target above the long-run equilibrium value for the £/$ exchange rate. In this case it would be expected that intervention would be less effective in smoothing the path of the exchange rate towards its equilibrium value but also less costly in terms of reserves as the authorities intervene towards an undervalued £. The second possibility is that the authorities intervene towards a target of an $/£ exchange rate below the long-run equilibrium. This case approximates a situation of defending an over-valued £ and would be expected to be costly in terms of reserves but would speed up the adjustment process. The simulations reported below in Table 9.3 refer to an error in the target of 1% either side of the long-run equilibrium rate with result 1 referring to the first case discussed above. As a base run we have used the correct target, i.e. intervention is directed towards the long-run equilibrium rate so that the error only occurs in the response to the external shock.

Table 9.3

Effect of Sterilised Intervention

Target Intervention: Incorrect Targets.

Case	Reduction in Initial	Mean Appreciation	Cost in Reserves £m
1	0.16	1.85	362
2	1.91	0.66	1573

Comparison of the figures shown in Table 9.3 with the corresponding figures in Table 9.2 (i.e. line 1 of that table) substantiates our earlier comments. Case 2 shows a much higher reserve loss. This suggests that target intervention is a much riskier policy than leaning against the wind where the knowledge requirement for the authorities is much less onerous.

9.3 Non-Sterilised Intervention

We now turn to the question of non-sterilised intervention. In this case an extra function is required linking adjustments in the domestic money market rate of interest to changes in reserves. In particular an increase in this rate of interest follows from a loss of reserves. The function adopted takes the following general form:

$$RM = RM_{t-1} - \beta \Delta RES \qquad (9.2)$$

Changes in the domestic rate of interest will, as we have already seen from the simulations reported in chapter 8.3, tend to offset the initial rise in the uncovered foreign rate of interest. There is, however, a timing difference. The rise in the foreign rate of interest applies from the beginning of the simulation period whereas the rise in the domestic rate of interest operates at the end of the first quarter following the reserve loss. Again in order to avoid proliferation of simulations we restrict our analysis to intervention rule a in Tables 9.1 and 9.2 coupled with a value for β in equation (9.2) which produces a reasonable rise in the domestic money market rate of interest [3]. A further difficulty arises with respect to the specification of the simulation. It seems inconsistent to assume that the terminal condition is not influenced by intervention when this is accompanied by a rise in the domestic money market rate of interest. If this rate was increased on its own and the market perceived this change to be permanent, then the terminal condition would be altered for simulation purposes. Therefore it may be reasonable to assume that the markets expect that monetary policy leading to a rise in the domestic money market rate of interest will alter the long-run equilibrium exchange rate and hence a change in the terminal condition would be appropriate. The question then arises by how much should the terminal condition be changed. We show the result of two simulations representing polar views. The first (assumption A) shows the result when the terminal condition adjusts only to the change in the uncovered foreign rate of interest. The second (assumption B) shows the effect of the terminal condition returning to its original value i.e. the value prior to the increase in the foreign rate of interest. This second assumption is equivalent to believing that the markets perceive that intervention by the authorities will completely offset the rise in foreign interest rates if domestic interest rates are changed at the time of intervention.

The results of these simulations are shown in Table 9.4 and Figures 9.5 and 9.6 Again it should be noted that the base run benchmark incorporates both the reserve and interest intervention rules. With no change in the terminal condition, the results for non-sterilised intervention correspond closely with those obtained for sterilised intervention using the corresponding intervention rule (a in Table 9.2). The initial overshoot is reduced but otherwise the results are almost identical. In the case of assumption B, the result is completely different. A considerable degree of stabilisation is achieved at a relatively low cost of reserve loss. This demonstrates the importance of the assessment by the market of the potency of intervention by the authorities. A similar picture in respect of Target intervention is revealed in Table 9.5 and Figures 9.7 and 9.8 ; very effective amelioration in the rise in the exchange rate but at a high cost in reserves which is not relieved by the market's perception of the effectiveness of intervention.

Table 9.4

Effect of Non-Sterilised Intervention

Leaning Against the Wind

Assumption	Reduction in Initial Jump in the Exchange Rate	Mean Appreciation	Cost in Reserves £m
A	0.43	1.55	341
B	1.11	0.78	63

FIGURE 9.5 DOLLAR/POUND EXCHANGE RATE
SIMULATION : R^* +0.01.
NON-STERILISED INTERVENTION
LEANING AGAINST THE WIND

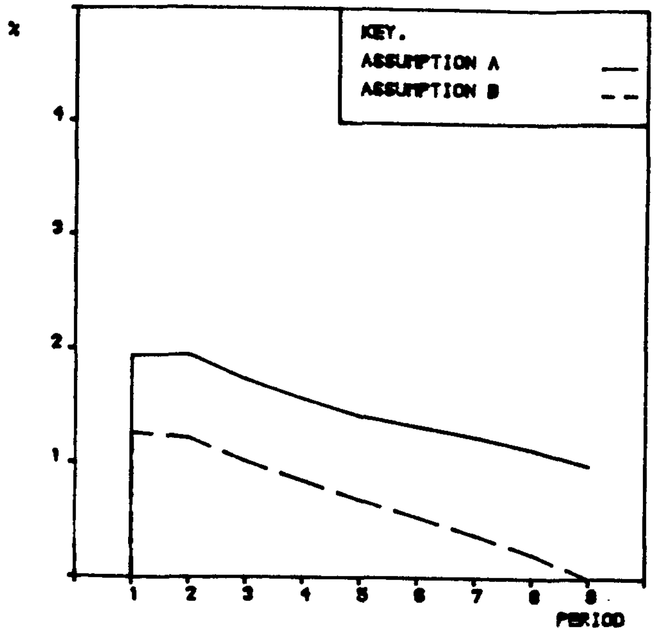


FIGURE 9.6 RESERVE LOSS
SIMULATION R^* + 0.01
NON-STERILISED INTERVENTION
LEANING AGAINST THE WIND

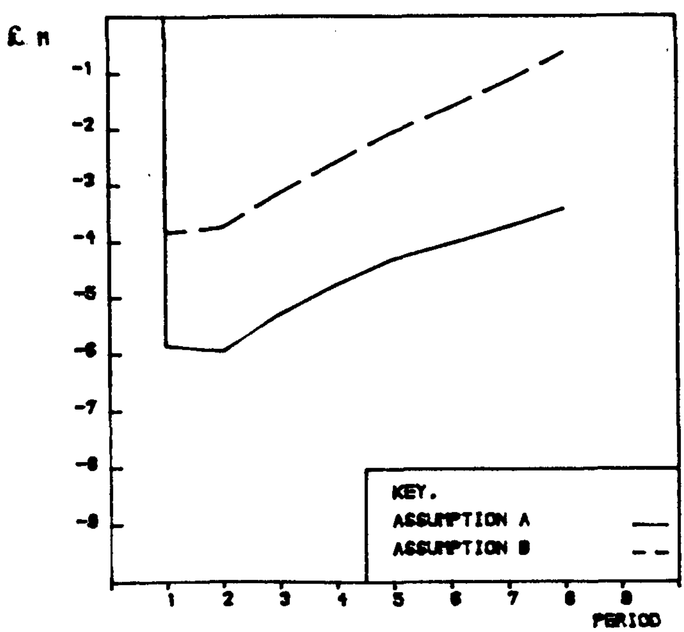


FIGURE 8.7 DOLLAR/POUND EXCHANGE RATE
SIMULATION : R^* +0.01.
NON-STERILISED INTERVENTION
TARGET INTERVENTION

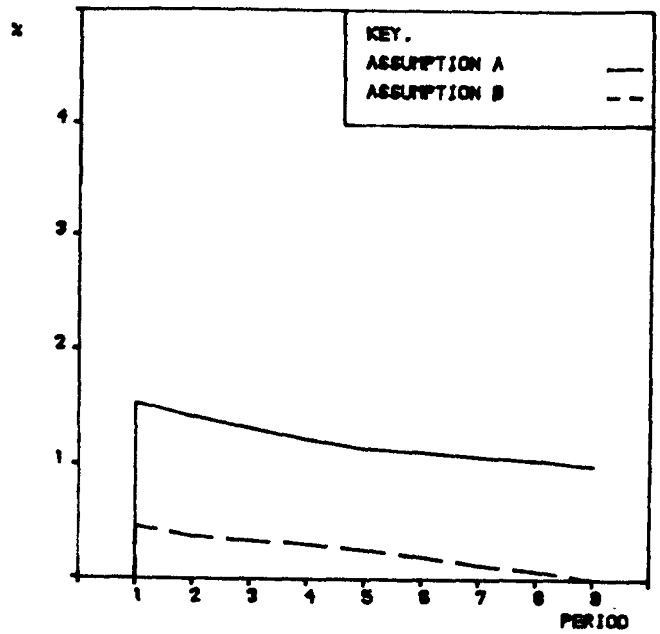


FIGURE 8.8 RESERVE LOSS
SIMULATION R^* + 0.01
NON-STERILISED INTERVENTION
TARGET INTERVENTION

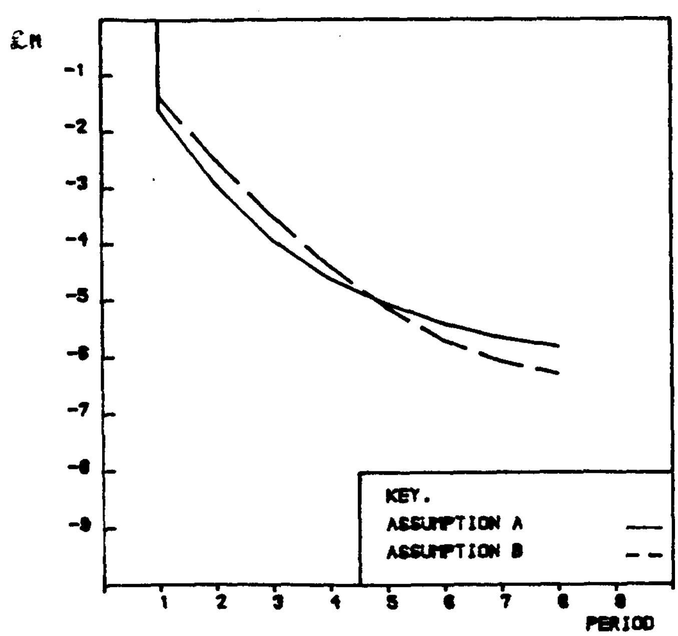


Table 9.5

Effect of Non-Sterilised Intervention

Target Intervention

Assumption	Reduction in Initial Jump in the Exchange Rate	Mean Appreciation	Cost in Reserves £m
A	1.36	1.18	637
B	2.40	0.19	689

9.4 An Assessment of Intervention

So far we have established that intervention can influence the path of the exchange rate but at a cost in terms of changes in official holdings of foreign exchange reserves. This poses the question of against what criteria must the efficacy of intervention be judged. Friedman [1953] suggests a single criteria - the profitability of intervention. This arises because stabilisation would seem to imply the authorities buying below the equilibrium rate and selling above the equilibrium rate. Mayer and Taguchi [1983] demonstrate that this criteria has only limited application due to the fact that the only available information with which to evaluate the activities of the authorities is 'ex post' data rather than a series indicating what the exchange rate would have been in the absence of intervention. Similarly if the exchange rate is subject to a trend, intervention may be unprofitable but stabilising in the sense that the market rate is moved towards the equilibrium adjustment path - that is unless a 'unique' interest rate differential equals the slope of the underlying trend of this equilibrium adjustment path.

More recently a variety of methods have been employed to examine whether intervention - and in particular sterilised intervention [4] - has been effective. Three broad approaches can be distinguished: First, the use of reduced form models, second, examination of periods of actual intervention to see whether the exchange rate was moved towards its equilibrium path and third, simulation of models of the financial sectors of different economies. Clearly this model falls into the third category. In order to indicate their nature a highly selective survey of studies within these three categories now follows.

With respect to the first category the general procedure is to estimate a reduced form equation of the following general form:

$$\Delta CAP = \alpha_0 = \alpha_1 \Delta DCE + \alpha_2 R^* + \ldots\ldots \qquad (9.3)$$

where CAP = the capital account, balance of payments

DCE = domestic credit expansion

The coefficient α_1 is designated the 'offset coefficient' as it measures the fraction of domestic credit expansion reversed by subsequent foreign exchange losses. A value of -1 indicates a complete offset and consequently the inability of the authorities to pursue a domestically orientated monetary policy or equivalently the inability to sterilise intervention. Using the reduced form approach, Argy and Kouri [1974] estimated capital flow equations for Germany, Netherlands and Italy over the period 1964 to 1970. They reached the tentative conclusion that the effect of changes in the domestic component of the monetary base had been partially offset by private capital movements. Similarly Quirk [1977] using data for Japan over the period March 1973 to October 1976, found that regression of the yen on a variety of variables failed to establish a significant role for the intervention variable in the determination of the spot exchange rate.

Studies following the second approach include Mayer and Taguchi [1983] (period 1974 to 1982 using monthly data for the Yen, Dmark and the £) and Wonnacott [1982] (period 1977 to 1979 using daily data for the Dmark versus the $). In both cases the approach involved estimating the adjustment path through the use of moving averages and, subsequently, ascertaining whether the intervention would move the exchange towards rather than away from this path. In both studies the broad conclusion was that intervention was stabilising in this sense. It should also be noted that this approach blurs the distinction between sterilised and non-sterilised intervention

Examples of the third approach are Obstfeld [1983], Kearney and MacDonald [1985] and of course De Grauwe et al [1985]. Obstfeld [1983] presents a four equation model of the financial sector of the German economy using monthly data for the period 1979(1) to

1981(6). The equations comprise a money demand function, a money supply function, a domestic and foreign demand for German bonds. The model was simulated using the rational expectations hypothesis that expected inflation reflected the model predictions of future exchange rates. The base run [5] was obtained using historical values of the monetary base and outside debt supply. Two simulations were carried out representing transitory intervention which was reversed after nine months. The first simulation represented monetary intervention involving a reduction of 10% in the monetary base. In the second simulation the effect on the monetary base was sterilised through the issue of a corresponding amount of government debt. The effect of intervention was to cause a much sharper appreciation of the currency in the case of monetary intervention rather than sterilised intervention. Kearney and MacDonald employ a similar methodology with respect to UK data using essentially the same model as was presented in Kearney and MacDonald [1984] - see chapter 2 section 10. They consider two different types of environment: static expectations and 'perfect foresight' when expectations are formed in accordance with model predictions. The interventions, which involve selling foreign exchange (equivalent to £1 billion) are unanticipated and continue for three months starting from 1976(1). Intervention is more powerful in the case of 'perfect foresight'. The results of the simulation show a curious dichotomy. Monetary intervention causes the exchange rate ($) to appreciate by nearly 8% whereas sterilised intervention causes it to depreciate by just over 3%. No explanation is given for this differential impact. Furthermore the cost of intervention seems excessive in relation to the stock of reserves held by the UK at that time (approximately £2800m at the start of the simulation period). As noted in chapter 8 our methodology is different. We simulated a shock in the form of an unanticipated rise in the uncovered foreign rate of interest and examined the extent to which official intervention in the foreign exchange markets would moderate the rise in the $ exchange rate [6].

We contend that the criteria involved in concentration on exchange rate changes is too narrow to assess the efficacy of official intervention in the foreign exchange markets. For example no consideration is given to the possibility that stabilisation of the exchange rate is attained at the expense of destabilisation in domestic financial markets. Since we are interested in the interaction of exchange rate changes and domestic financial markets it is logical to examine the effects of intervention against a wider background. Hence we propose to use, as the relevant criteria against which to judge the efficacy of intervention, a loss function which the authorities are assumed to wish to minimise. This loss function should contain as its arguments indicators which reflect both price and quantity conditions in the various financial markets. The indicators we have chosen are: the exchange rate (S), changes in reserves (ΔRES), the loan rate (RL) and the money supply - Narrow definition (M1) as well as the broad definition (M2). We use two definitions of the money supply in order to capture any switches between M1 and M2 following changes in domestic interest rates. In order to carry out this assessment we have imposed the following loss function:

$$LF = \Sigma_i \alpha_i \{(\Delta X_i / X_i) * 100)^2 \qquad (9.4)$$

where ΔX_i represents the change in the indicator as compared with the base run

X_i represents the value of the indicator in the base run

$\Sigma\alpha_i = 1$

Specification of the variable representing reserves merits further discussion. It was necessary to build up a notional value of reserves for each simulation. This was done by starting from the actual figure for the start of the simulation period and adding/subtracting the changes implied by the particular intervention rule applicable to that simulation. Thus the variable ΔX refers to the change (i.e. the current flow change not the cumulative change as shown in the Figures 9.2, 9.4, 9.6 and 9.8) in the notional series of reserves relevant to a particular intervention rule. A further difficulty arose from the fact that foreign currency reserves are denominated in $s and are therefore immune to changes in the exchange rate whereas intervention in the model is denominated in £s. Consequently the change in reserves was converted into $s using the the exchange rate produced by the model solution

It should be noted that the precise form of the loss function adopted in (9.4) has several important implications. First, any fluctuation compared with the 'base run' is bad. Thus, for example, a gain in reserves is given equal weight to a loss in reserves. This is particularly relevant to the assessment of leaning-against-the-wind intervention (LAW) since the authorities are involved in a heavy loss in reserves in the period of the shock which is partially offset by subsequent gains. These changes in reserves are all considered a loss and increase the value of the loss function. Second, because the function is in terms of squares, it is very sensitive to large numbers. Again this prejudices the function against LAW intervention in view of the heavy loss in reserves in the first period. Third, the function is in ratio form which not only permits comparison between the indicators adopted but also implies that it is relative changes which matter. Finally we have to decide on the relative importance of the various indicators within the overall function, i.e. the values for the α_is. In the absence of any strong 'a priori' views we decided to assume equality.

In addition to the simulations carried out in this chapter, the authorities could react to a change in the foreign rate of interest by adjusting the money market rate by precisely the same amount. This would leave the exchange rate virtually unaltered so passing the burden of adjustment entirely on to domestic variables. In order to evaluate the various policy options we show in Table 9.6 the values of this loss function for each of the major simulations carried out in chapters 8 and 9 together with the interest rate option discussed above. For sterilised intervention, all intervention rules show that intervention is costly in terms of reserve losses. The values for LAV intervention reflect the caveat mentioned earlier concerning the high values allocated to large changes. Consequently, although the cumulative loss of reserves is greater in the case of target intervention than in LAV, the latter dominates the former within the context of the loss function specified in (9.4). It should also be noted that intervention rule b for target intervention involves a relatively high reserve loss. Turning to non-sterilised intervention, we distinguish between the two assumptions made in this chapter concerning the market's belief in the effectiveness of intervention. 'A' reflects the assumption that the market believes intervention is completely ineffective with respect to influencing the long-term equilibrium rate. 'B' is the opposite assumption that intervention prevents the long-run equilibrium rate responding to the shock so that the terminal condition is the same as that for the base run. In both instances this form of non-sterilised intervention (i.e. 'active') is more powerful than non-sterilised intervention. Note, however, in this case stability of the exchange rate is obtained at the expense of fluctuations in other variables such as the money supply and domestic rates of interest. This again illustrates the vital role of the market's assessment of the effectiveness of intervention by the authorities in the foreign exchange market. Finally complete stabilisation of the exchange rate at zero cost in reserves is obtained if the authorities match any rise in the uncovered foreign rate of interest by a corresponding change in the domestic money-market rate of interest ('Interest Rate Option' in Table 9.5).

Table 9.6

Losses due to a Rise of 1% in the Uncovered Foreign Rate of Interest

	S	ΔRES	RL	M2	M1	Overall Index
Pure Float	24.9	0	1.5	1.6	0.3	5.6
Sterilised Intervention						
LAW (rule a)	19.4	171.4	6.8	5.3	0.2	40.6
(rule b)	17.7	209.7	8.7	7.8	0.4	48.7
(rule c)	15.5	221.1	9.8	9.8	0.7	51.4
TGT (rule a)	12.7	36.6	7.5	9.3	0.9	13.4
(rule b)	12.6	80.8	9.8	16.1	2.2	24.3
(rule c)	11.0	42.4	8.4	11.0	1.1	14.8
Non-Sterilised Intervention						
LAW (A)	19.9	167.2	39.3	12.1	0.4	47.8
(B)	5.8	80.2	13.4	5.7	0.3	21.1
TGT (A)	12.5	33.6	21.5	8.8	0.5	15.4
(B)	0.7	29.4	19.9	8.4	0.7	11.8
Interest Rate Option	0.0	0.0	927.0	2.2	24.1	190.7

LAW refers to Leaning-Against-The Wind Intervention
TGT refers to Target intervention
Rules (a) and (b) refer to the intensity of intervention as discussed in chapter 8
(A),(B) refer to the assumptions concerning the terminal conditions.

However, the details contained in Table 9.6 suggest that the cost of this option is high in terms of the effect on domestic financial markets. The change in M1 is more pronounced than that in M2 reflecting the substitution of time deposits for sight deposits as well as that of bonds for money. This contrasts with the results for the other simulations where interest rate effects were smaller and larger wealth effects resulted from the changes in reserves.

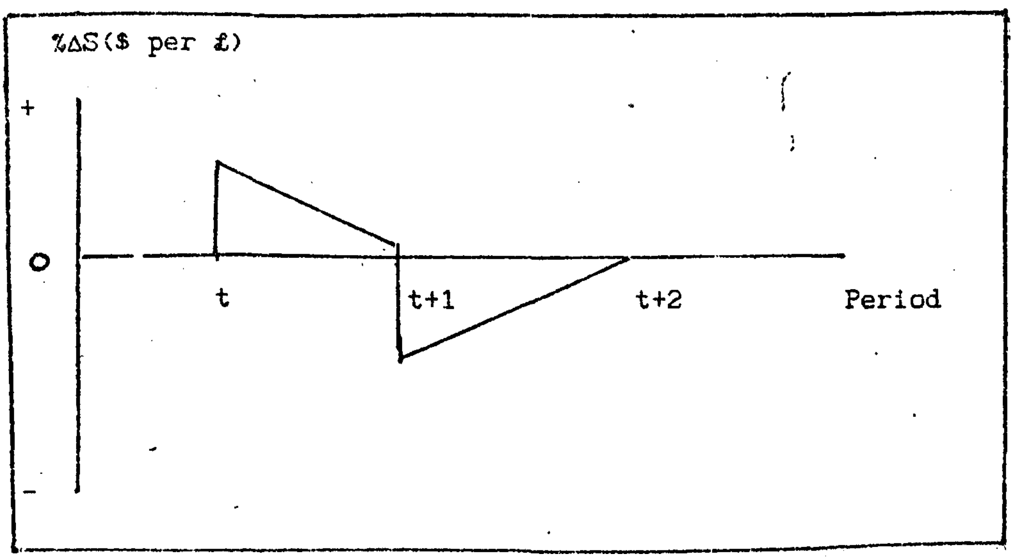
Intervention is costly and in terms of the loss function the pure float dominates the other discussed policy options open to the authorities. On the other hand it must be remembered that we have allocated an equal importance to changes in all the indicators in the loss function. If a weighted average was applied then active non-sterilised intervention could be considered an acceptable alternative - particularly if the authorities can convince the public at large that intervention is successful so that the long-run equilibrium value of the exchange rate is altered (i.e the terminal condition is changed). This would, however, require a large change in the weights. For example, if (in the case of leaning against the wind, assumption B) the weight attached to exchange rate fluctuations rose to 0.6 and that for each of the other indicators fell to 0.01, then the value of the overall index would fall to 6.3 - still higher than the value for a pure float.

9.5 Conclusions

We have found that intervention can influence the adjustment path of the exchange rate but at quite a high cost in reserve loss (or gain if movements are in the opposite direction as for example would occur if the uncovered foreign rate of interest fell). In the case of non-sterilised intervention the efficacy of intervention was dramatically increased and the corresponding cost reduced when intervention was perceived by the markets to be completely effective. Turning now to the narrower question of profitability of intervention in the foreign exchange markets, it is apparent that it is costly in terms of reserve losses for the authorities to intervene in the foreign exchange markets in order to moderate the depreciation of the pound following a rise in the foreign rate of interest. However, as we have already noted, movements in the exchange rate are roughly symmetrical to both domestic and foreign shocks. Consequently it might be expected that, over a sufficiently long time period, the authorities would achieve a net gain in reserves since they would be buying sterling at a lower rate than that at which subsequent sales were made. We illustrate this point in Figure 9.9 over a two-period cycle noting that all the changes are unanticipated because of our assumption of the rational expectations hypothesis. The uncovered foreign rate of interest rises by 1% at time t so that the $/£ exchange rate immediately increases but subsequently declines to the long-run equilibrium at time t+1 (note this coincides with the terminal condition). At this point the uncovered foreign rate of interest falls again to its original level so that there is an immediate drop in the exchange rate which then gradually climbs back to its original level. Thus in the period t to t+1, the authorities are selling $ to moderate the rise in the price of the $ on the foreign exchange markets. Conversely during period t+1 to t+2 the authorities are buying $ to moderate the depreciation of the $. It is apparent that the selling price of the $ exceeds the buying price so that this gap provides the authorities with an increase in reserves. The existence of this profit is independent of the terminal horizon but its magnitude does depend on this horizon since the size of the initial movement in the exchange rate increases as the terminal condition is extended into the future - see Figure 8.1 for a demonstration of this point.

We examine further this possibility by converting the flow losses/gains in reserves into a $ valuation at the exchange rate ruling at the end of the period in which intervention takes place. We then constructed an artifical cycle of 16 quarters consisting of two sub periods. The first quarter saw a rise of 1% in the uncovered foreign rate of interest and the 9th quarter a fall of 1% in that rate. As an illustrative example, intervention followed leaning against the wind (sterilised) according to rule a in Figure 9.1. As would be expected the authorities acquired a net gain in reserves over the cycle but one which only amounted to 19m$. According to the profitability criteria then, foreign exchange intervention is efficient but note that we have not met any of the objections to the profit criteria discussed by Mayer and Taguchi [1983] - see page 307. In fact another real problem facing the UK authorities is the scale of intervention necessary to move the exchange rate. Thus, for example, the cost of leaning-against-the-wind intervention following assumption A in Table 9.4 entails a loss of reserves amounting to £585m in the period following the shock which represents just over 20% of the stock of foreign currency reserves at that time. In the case of target intervention, the initial cost is lower but the cumulative loss of reserves is higher (e.g. £578m for Assumption A in Table 9.5). The sole exception to this cost occurs for leaning-against-the-wind intervention where the market believes that intervention will be successful (i.e. assumption B in Table 9.4). The cumulative reserve loss falls to £63m though the first period loss still remains high at £381m. The existence of modest profits attributable to intervention over the long run does not therefore modify the earlier conclusions following from the detail incorporated in Table 9.6

Figure 9.9: Intervention over the Cycle



Notes

1 In the terminology of De Grauwe et al [1985] this is "active non-sterilised intervention" (page 156). The rise in the domestic money market rate of interest causes a corresponding rise in the rate of interest on government securities (RG) leading to substitution of government securities for other assets in the portfolio of the non-bank private sector. This can be verified from the change in the market value of government bonds held by the non-bank private sector in the following way. The total change in holdings of government securities within the portfolio is attributable to two components: i) the negative valuation effect due to the rise in interest rates and ii) the positive substitution effect. The period following the rise in domestic interest rate saw the total market value of bond holdings fall by £232m out of which £392m can be explained by the negative valuation effect. Consequently non-bank private sector holdings of government bonds increased by £160m due to the rise in interest rates.

2 The values of α in (8.19) are 30,000, 40,000 and 50,000 for intervention rules a,b and c respectively. As noted in the main body of the text these figures represent the intensity of intervention and a scaling factor.

3 The value of β in (8.10) is 0.0001

4 Bockelmann [1983] questions the practical value of the distinction between sterilised and non-sterilised intervention. He argues that adjustment of shortages/surpluses in the domestic money markets depends on the overall situation not on whether or not the imbalance is due to intervention in the foreign exchange markets.

5 Obstfeld noted that the 'benchmark' simulation did not correspond closely the historical path. He also attributed this lack of conformity to "unanticipated" events (page 183).

6 This methodology is similar to that adopted by De Grauwe et al [1985].

CHAPTER 10 CONCLUSIONS

The object of this study is to construct an empirical portfolio balance model of the UK financial system with a view to the examination of the interaction between the various returns on assets, the quantities of assets and the exchange rate. The analysis and investigation described in the previous chapters support the view that this objective has been achieved to a reasonable extent

In contrast to many other theoretical and empirical studies, we have incorporated a richer menu of asset choice within the non-bank private sector. In particular bank lending appears as a major component of the portfolio. In this respect, Kearney and MacDonald [1984] and [1985] are similar but with a more limited portfolio choice since the quantities of assets are given in their models. We have also included a supply side function in the form of the specification of the portfolio behaviour of the banking sector (chapter 5). Furthermore, again in contrast to other studies of the UK financial system (except that by Kearney and MacDonald [1985]) we have assumed that expectations of future exchange rates are formed in accordance with the rational expectations hypothesis. In this and other respects the methodology is similar to that adopted by De Grauwe et al [1985].

It is not claimed that the specification of the various functions, or for that matter, the values of the coefficients estimated represent precisely the population coefficients. We would, however, claim that they are reasonably representative of the behaviour of the financial sector given the assumption of this type of portfolio balance model. It is against this background that our assessment of shocks and intervention by the authorities in the foreign exchange markets must be evaluated.

Before summing up the conclusions of this study, it is appropriate to note some limitations of the analysis. These limitations can be divided into two categories. The first category concerns the estimation of the model and the second the extent of the theoretical specification of the model. Dealing with the first category, no use was made of sequential tests to assess the structure of the equations or the lag structure in the manner suggested by Mizon [1976]. We advance three reasons for this. First the observation period yielded insufficient data to provide for the use of what are essentially asymptotic tests. Second, we commenced with an 'a priori' structure with the intention of analysing the properties of such a framework. Third, the observation period (1972/1980) was a period of considerable structural change so that a more empirical approach seemed inappropriate. For similar reasons we have not tested the stability of the parameters over the estimation period. Turning now to the second category of limitations, first the model includes no links between changes in the financial sector and the subsequent reactions within the real sector. Consequently real expected income is held constant throughout the simulations. Second, and similar to the first point, there is no link between changes in the exchange rate and the expected price level so that expected inflation is also held constant throughout the simulations. Third, the act of intervention by the authorities is assumed not to influence the behaviour of the markets as compared with a pure float [1]. On the other hand expectations are not static and are assumed to vary in response to the foreign interest rate shock. Furthermore, wealth holdings are subject to valuation effects from changes in both interest rates and exchange rates thus meeting the point made by Frenkel [1983]. Perhaps more controversially we have assumed that government debt is perceived by the non-bank private sector as wealth and is not offset by the discounted value of future tax payments necessary to service the debt.

It should also be noted that whilst the intervention analysis is conducted in terms of a rise in the uncovered foreign rate of interest, the analysis is of general application in view of the symmetry of the model response to other shocks described in chapter 8.3

Our conclusions concerning the practicality of successful intervention by the authorities in the foreign exchange markets tend towards pessimism. This is due to a number of reasons. First, the assessment by the market of the permanence of the shock is of critical importance. If the shock is viewed as temporary, then the exchange rate is affected only to a small extent and there is little need for intervention by the authorities. Second, when the shock is perceived as permanent, intervention appears to be costly in terms of reserves lost by the authorities. This is so even when the intervention target is the long-run equilibrium exchange rate and the market believes that intervention will completely offset any movement in the exchange rate. However a qualification to this conclusion concerns the existing stock of reserves held by the UK. The loss function (9.4) is specified in terms of percentage changes so that an increased stock of reserves would reduce the percentage change given the absolute quantity of reserve loss/gain. Consequently higher stocks of reserves could make intervention a less costly and, therefore, more attractive policy. Even so the figures contained in Table 9.6 suggest that stability of the exchange rates is gained at the expense of greater volatility in domestic financial markets. In other words a pure float seems to be the most appropriate exchange rate policy in the absence of stringent controls on capital movements. Our findings also suggest that a policy of changing domestic interest rates to match movements in the exchange rate is inappropriate because of its high cost in the form of the disturbances created in other financial markets. Finally our simulations suggest that the authorities could make net gains in reserves in the long run by intervening in the foreign exchange markets but that the scale of intervention necessary to achieve only modest increases in reserves tends to make such a policy unattractive given the disturbances to the other financial markets.

Consequently our findings are rather pessimistic about the practicality, let alone desirability, of intervention by a single country on the foreign exchange markets.. Finally we would like to draw attention to the fact that our conclusions relate to short/medium term intervention rather than to day-to-day smoothing operations.

Notes

1 Mussa [1981] discusses the possibility that intervention may convey new information to the market about future monetary growth.

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