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Citation: Warburton, P.J. (1987). The application of modern econometric techniques to the analysis of UK labour market and international relationships. (Unpublished Doctoral thesis, City University London)

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THE APPLICATION OF MODERN ECONOMETRIC TECHNIQUES TO THE ANALYSIS OF UK LABOUR MARKET AND INTERNATIONAL RELATIONSHIPS

by

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A submission of thesis and published papers for the

DEGREE OF DOCTOR OF PHILOSOPHY

of

THE CITY UNIVERSITY

based upon research conducted primarily in the

BUSINESS SCHOOL

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ACKNOWLEDGEMENTS

Almost all of the research represented in the collection of articles which constitute my PhD submission has arisen from a close working relationship with Professor Michael Beenstock of The City University Business School. From 1978 until the early part of 1981 we worked together in the Centre for Economic Forecasting at the London Graduate School of Business Studies. Between November 1981 until my departure in April 1986 our partnership continued at The City University Business School. Without his enthusiasm and encouragement I doubt whether this submission would have been possible. Although a PhD by published articles requires no formal supervisor, it is logical to regard Professor Beenstock as the de facto supervisor of the research which I have carried out. I also owe a debt of gratitude to three other colleagues, who have permitted me to include our joint work in this submission, namely Professor Alan Budd, Alan Dalziel and Paul Lewington.

Finally, this thesis would not have been completed without the constant support and encouragement of my parents and my wife.

Mea culpa. Deo gloria.

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ABSTRACT

The published papers and accompanying essay which constitute this doctoral thesis examine a number of key UK macroeconomic relationships using modern econometric methods. Aggregate labour demand and supply schedules are estimated on both inter-war and post-war UK data. The use of a consistent theoretical structure enables comparisons of parameter estimates to be made between the two periods. Labour participation data are analysed by sex and age in the context of the retirement decision. The determination of multilateral exchange rates and UK imports are also investigated. In each area of application, the empirical model was identified using dynamic econometric methods and with the aid of various specification tests. In general, the resulting models offer a superior explanation of the relevant economic data than was previously available. In certain cases, this has implications for the conduct of national economic policy.

PART ONE

THE APPLICATION OF MODERN ECONOMETRIC TECHNIQUES TO THE ANALYSIS OF UK LABOUR MARKET AND INTERNATIONAL RELATIONSHIPS: AN INTEGRATIVE ESSAY

CHAPTER 1 INTRODUCTION

The main objectives of this introduction are first, to define the areas in which it may be contended that this research is original and second, to identify my own contribution. After discussing these in more detail, the structure of this essay will be mapped out.

The most persuasive argument for the originality of the body of the research submitted is that seven of the nine papers have been published in reputable journals or in book form. Of these seven, Papers 7 and 8 were invited papers, the others being anonymously refereed. Of the two, as yet unpublished papers, Paper 6 has been refereed for the Journal of Economic History and approved subject to changes in the style of the paper. The remaining paper entitled "Estimates of a 3-sector model of the UK labour market" was being prepared for submission to a journal in 1982. Unfortunately, a very similar but entirely separate paper, written at the Centre for Labour Economics at the London School of Economics reached publication stage first. Paper 2 is included only because it complements the earlier labour market paper.

Turning to the content of the papers, one general point is in order. Many of the papers employ a simplistic neo-classical demand-supply framework, sometimes referred to as a "textbook" framework. This choice is deliberate and fundamental to the nature of the aggregate empirical research. The most obvious example is with regard to the labour market and in particular the model defined on pages 255 and 256 of the article in Oxford Economic Papers. It is plain that the originality of this paper and of several others lies not in its theoretical content but in the application of the model to the data. This is not to say that originality may not be identified in the use of supplementary arguments within simple models. The use of the female participation ratio and a measure of other employment costs are possible examples of this in the 1982 article. Nevertheless such enhancements to the textbook model would scarcely qualify for publication in their own right. In all the papers on the labour market, excluding the book chapter on labour supply incentives, it is arguable that their originality, as well as most of the effort, lies predominantly in the empirical work.

Arguably, the element of original thought is greater in the papers concerning the theoretical monetary model of exchange rate. In the 1981 Oxford Economic Papers article, the integration of various theories of sterling behaviour into a coherent framework is highly innovative and particularly so in its specification of the effects of North Sea oil on the exchange rate. Once again, the empirical dimension is necessary to attempt to evaluate the strength of the various arguments.

The longest paper in the submission is the chapter on labour supply incentives published as Chapter 6 of "Work, welfare and taxation". This paper, although containing econometric estimates like the others, differs from them in character. Developing the concept of the budget line to the individual's years of work decision and constructing elaborate computer programs to enable the relevant decision paths to be evaluated represented a considerable departure from my other empirical research. On a conservative estimate, over twelve months' effort was dedicated to this piece of work alone.

It is in the nature of model-related research that much of the work is jointly prepared. This submission contains seven such papers. I have approached all the individuals concerned and they have agreed the following percentages as my shares of the relevant papers. All the empirical work contained in the shared papers was my sole responsibility except in the case of Paper 3, for which further explanation is given below. For the four papers shared only with Professor Beenstock

(Papers 1, 5, 6 and 9) the empirical work represents approximately 75% of the total effort. Regarding Paper 7, Professor Budd has estimated my percentage of the work at 60%. For Paper 8, I contributed about 40%. Paper 3 was the culmination of over three years of ongoing research. Whilst the proportion of the paper which could be directly attributable to me is probably less than 25%, I would claim a much larger share of the underlying effort over the life of the project.

The remaining part of this essay concerns the methods of empirical investigation used (Chapter 2), three chapters on the key areas of the empirical applications and a summarising chapter (Chapter 6). The contributions relating to the post-war labour market and the inter-war labour market are grouped separately in Chapters 3 and 4. Chapter 5 contains the work on exchange rates and UK imports.

CHAPTER 2 MODERN METHODS OF EMPIRICAL INVESTIGATION

In this chapter some of the landmarks in the development of econometrics must be chronicled in order to place the empirical work in the published papers in its proper context. We may loosely define econometrics as the art or science of applying statistical methods to the analysis of economic data with a view to verifying or falsifying economic hypotheses. By comparison with most branches of economic thought, the subject of econometrics is still in its adolescence. This was illustrated quite neatly by the recent publication of a paper entitled "The development of British econometrics* 1945 -1985", by Gilbert (1986). Before 1945 it may be reasonably asserted that econometrics consisted almost entirely of items stolen from Biometrika and The Journal of the Royal Statistical Society. The closing date, 1985, is likely to signify no more than a staging post in the development of a subject which has a burgeoning literature. During the eight years which span the work described in the research submitted here, econometrics has received many important contributions. Interestingly, the majority of these have emanated from the United Kingdom rather than from across the Atlantic. Gilbert's paper highlights the contributions of the Department of Applied Economics at Cambridge in the 1950s and 1960s and, more recently, the ascendancy of the London School of Economics.

My own interest in economics stems from the taught MA course at Warwick Universtiy from which I graduated in 1975. As a part of my MA thesis I examined for the first time a macroeconomic model (that of the London Business School). One of the striking features was the apparent disregard of severe econometric problems such as autocorrelation and multilinearity in a large number of the equations. During the three years which followed, dissatisfaction with the conduct of empirical research became widespread, and reached a crescendo in 1978 when the Social Science Research Council insisted that the major modelling teams engage econometric consultants to advise them. The London Business

*chiefly, time-series econometrics

School approached David Hendry, then of the London School of Economics. He attended regular sessions and gave instruction in what might now be termed the "modern methods of empirical investigation". These techniques will be summarised below, where only the main references to the literature will be given. It is convenient to describe the methodology under four headings. First, general to specific modelling; second, dynamic econometrics; third, the treatment of serial correlation; and fourth, other diagnostic tests.

2.1 General to specific modelling

Mizon (1977), in a contribution entitled "Model selection procedures", contrasted two extreme approaches to testing an economic hypothesis. The first, which was widely used at that time, is to model an econometric relationship beginning from a specific dynamic form. Then the investigator would test for the valid inclusion of other lagged variables until, on some arbitrary criteria, the model could not be improved by further addition or removal of variables. The beauty of this approach, to those who used it, is that the initial specification of the model is not particularly important; its deficiencies are revealed through the process of experimentation. The drawback to this method is that the significance of a newly introduced variable in the multiple regression is conditional on the set of previously included variables. Thus the same variable may be deemed worthy or unworthy of inclusion depending on the particular sequence of experiments undertaken. By definition, this introduces a large degree of ambiguity to the "specific to general" modelling selection method.

The diammetrically opposite modelling strategy is the "general to specific" method in which the largest number of potential regressors that can be accommodated are included at the outset. However, once selected, no additional variables are included in the general regression. The model selection procedure is simplified enormously as successive coefficient restrictions may be tested, individually and serially, proceeding from those most likely to be admissable on some benchmark condition (for example, a t-statistic equal to unity), to those least likely. Whilst it is not strictly correct to say that each general specification yields a unique optimal form, the scope for ambiguity in the model selection procedure is greatly reduced. Hendry and Mizon (1980) have advocated the "general to specific" approach not only for this reason, but also in reaction to the criticism, made by Leamer (1974, 1978), of the protracted specification searches inherent in the other approach.

One problem that has arisen, especially in relation to annual data, is the paucity of degrees of freedom, and hence the restrictiveness of the initial general form. In such circumstances, a certain eclecticism may be justified, and a combination of the two polar methods used.

2.2 Dynamic econometrics

In Davidson, Hendry, Srba and Yeo (1978), Hendry (1979), Hendry, Pagan and Sargan (1984) and, most recently, Hendry (1986), can be found all the central ideas of dynamic time-series econometrics. This methodology is appealing to economists because it permits statements about the relationship between variables in equilibrium to be embedded in dynamic equations without implying instantaneous adjustment to that equilibrium. This introduces the notion of an error correction mechanism, that is, one in which outstanding disequilibrium is progressively eliminated, and is inherited from control theory. Salmon (1982) catalogues the characteristics of error control mechanisms. The use of error correction methodology has aroused some controversy with regard to the interpretation of the resulting static and steady states. Currie (1981) has argued that restrictions must be placed on the dynamic structure of equations to prevent high order difference terms entering the steady state. In reply, Patterson and Ryding (1984) show that the application of such restrictions results in markedly inferior estimated equations and conclude that such restrictions are undesirable. In his later contributions, Hendry is at pains to re-establish predictive failure as a key criterion for model selection. No matter how plausible or implausible is the dynamic structure of an equation, if its performance outside its sample period is incongruent with its performance within, then the model should be rejected.

2.3 Treatment of serial correlation

It is probably no exaggeration to say that serial correlation was the scourge of empirical time series modelling until the mid-1970s. The typical investigator of that period quoted a Durbin-Watson statistic for first order autocorrelation and breathed a sigh of relief if its value was tolerably close to 2. If it were not, then a Cochrane-Orcutt correction or first-difference operation might be applied as a token gesture. Hendry and Mizon (1978), following Sargan (1964), cast the problem in a new light by demonstrating how autocorrelation was often a sign of misspecification, and the adoption of a more general dynamic form would usually eliminate the problem and enable more reliable perameter estimates to be obtained. As more attention was paid to residual autocorrelation, so better diagnostic tests emerged, of which the most stringent has proved to be the Lagrange multiplier test statistic, developed by Godfrey (1978). As such tests have been included in popular econometric software packages, so their use has grown, and with it the understanding that the first element in the correlogram is not the only one that should be checked. In the context of modern empirical work, it is now quite rare to see equations estimated with Cochrane-Orcutt corrections, giving encouragement to the view that most of its early use was necessitated by dynamic model misspecification. In all uses of single equation time-series regressions in the submitted papers, tests for autocorrelation are carried out.

2.4 Other diagnostic tests

Whilst residual randomness is the most frequently violated assumption of the general linear model, the application of other assumptions should be verified, namely, homoscedasticity and statistical normality. Hendry (1986) includes a list of five specification tests, other than for autocorrelation, which constitute a thorough examination of the data coherence and durability of a single equation. Some of these tests have not yet won universal acceptance and, since some are relatively new, neither are they to be found in the econometric estimates reported in the submitted papers. However they constitute an example of the rigorous multidemensional approach which characterises the modern methodology.

i) F-test of functional form mis-specification heteroscedasticity, White (1980)
ii) F-test for Autoregressive Conditional Hetero-scedasticity (ARCH) of a given order, Engle (1982)
iii) Chi-squared test for residual normality, Jarque and Bera (1980)
iv) Chow-test of perameter constancy over a given number of extra-sample observations, Chow (1960)
v) F-test of a restricted against the general unrestricted model.

Gilbert (1986) attempts to summarise the current state of the art (or science) although he acknowledges the inherent dangers of defining a concensus position. His five postulates provide a succinct summary of what I have dubbed in this essay the "modern methods of empirical investigation".

i) The data generating process underlying a data set is never known. Applied econometrics is therefore in part a process of discovery, and all proposed models must be presumed to be misspecified.

ii) Applied economists should aim to provide structural models which may be taken as approximations to the unknown data generating process.

iii) Restrictions derived from economic theory will typically relate to the equilibrium solutions to these models, rather than to the short term dynamics. Such restrictions may frequently be imposed and tested within an error correction framework.

iv) Any proposed model must be tested within and outside the sample. One needs to ask whether the model adequately characterizes the data, and also whether this characterization is superior to that provided by a rival specification.

v) Equation specification should be conducted by testing alternative simplifications against a common nesting maintained hypothesis. Tests may be carried out using standard classical statistical procedures, or straightforward generalization of these procedures. "

Gilbert (1986) pp40,41.

In the next three chapters, varying vintages of this methodology have been applied to the UK labour market, the determination of multinational exchange rates and UK imports of goods.

CHAPTER 3 APPLICATIONS TO THE POST-WAR UK LABOUR MARKET

Four of the nine submitted papers fall into this category. "An aggregative model of the UK labour market", for which work began in 1978, was accepted for publication without revision in 1980 but was not published until 1982. This paper derives reduced form econometric estimates for the aggregative non-government sector of the UK economy on annual data. The next paper to be written analysed a three-sector model of the UK labour market, in analogous fashion to the aggregate model, but using quarterly time series data. Most of the work was carried out in 1981 and the final draft was prepared in early 1982.

During the period January 1982 to April 1986, Professor Beenstock and I were engaged in an innovative macroeconomic modelling project which gained the support of the (then) Social Science Research Council from October 1983. The novelty of the model was to be the inclusion of a production function for the business* sector of the economy. This required a consistent and simultaneous framework of structural equations to be estimated for the constituent factor markets. Our first attempt at a structural empirical analysis of the UK labour market was Beenstock and Warburton (1984), a paper which was presented to the Association of University Teachers of Economics (AUTE) conference of that year. From the critical comments which were received it was apparent that this paper would require substantial revision before it would be ready for publication. A truncated and revised version of the labour market analysis is presented within the third submitted paper, "A macroeconomic model of aggregate supply and demand for the UK", published in Economic Modelling in October 1986. Ironically, to find a detailed published description of our labour market model, one must look to the analysis of UK econometric models by the Economic and Social Research Council (ESRC) Macroeconomic Bureau at

*the business sector is defined here as the private sector plus elements of the public sector which sell goods and services on a pseudo-commercial basis.

Warwick University. Andrews and Whitley (1984) and Andrews, Bell, Fisher, Wallis and Whitley (1984) provide the best examples.

The fourth submitted paper, the chapter from the book "Work, welfare and taxation", contains an empirical section on labour market participation by age and sex using annual UK data from 1966. These estimates complement the sex-dissaggregated labour supply equations which are contained in Beenstock and Warburton (1984). The substance of the fourth paper pursues detailed microeconomic issues relating to the work-retirement trade-off for men aged 50 and above. A discussion of this microeconomic work would be out of place in this unifying essay for obvious reasons. As stated in the introduction to this essay, this portion of work is different in character and should be judged on its own merits.

In the remainder of this chapter, I shall attempt to synthesise the results from all the empirical work on the post-war UK labour market, drawing on some other unpublished work as well as from the four submitted papers. The two reduced form studies will be discussed together and afterwards, the various structural estimates.

3.1 <u>Reduced form estimates</u>

Table 1 summarises the main results from the two earlier papers on the UK labour market, in terms of their reduced form stationary states. The equations in part A of the table satisfy the theoretical requirement that the set of arguments should be common to both the quantity and price specifications. The first appealing feature of the aggregate model is the sign conformity of the implied static coefficients. Whilst output, other employment costs and the proxy for the real cost of capital, RRD, represent demand shocks and therefore disturb both employment and real wages in the same direction, the

Table 1: Reduced-form stationary state solutions for employment and real wages

A. Beenstock and Warburton (1982): UK non-government sector, annual data 1948-1977.

$$L = 0.47\,Q + 0.28\,POP + 0.62\,FEM - 1.57\,OEC + 0.14\,RRD - 0.015\,T + 9.91$$

$$RW = 2.15\,Q - 3.68\,POP - 2.93\,FEM - 2.29\,OEC + 0.15\,RRD + 0.018\,T + 17.90$$

Source: Table 2, equations 5L and 5W.

B. Warburton (1982): UK three sectors, quarterly data 1963-1981

(i) Manufacturing

$$L_m = 0.47\,Q_m + 1.0\,POP - 0.24\,RER_m - 0.18\,RW_m - 0.021\,T - 3.28$$

$$RW_m = 1.0\,Q_m - 1.0\,POP - 0.08\,RER_m + 0.009\,T + 5.20$$

(ii) Primary and private tertiary

$$L_r = 0.24\,Q_r + 1.0\,POP - 0.004\,RIR_r - 0.17\,BEN - 1.76$$

$$RW_r = 0.28(W_m/P_r) + 1.23\,Q_r - 0.004\,RIR_r - 2.37$$

(iii) General government

$$L_g = 1.0\,C_g + 1.0\,POP - 0.10u + 0.004\,T - 10.03$$

$$W_g = 1.0\,W_m - 0.05\,OEC - 0.12$$

Source: Tables 2, 3, 4B, 5, 6 and 7.

KEY:
- L : Employees in employment
- Q : Output index
- POP . Population of working age
- FEM : Female participation ratio
- OEC : Index of other (non-wage) employment costs
- RRD : Real rate of interest allowing for depreciation
- T : Time trend
- RW : Real wage index
- RER : Real exchange rate
- RIR : Real interest rate
- BEN : Real rate of unemployment / supplementary benefit
- C : Real general government expenditure on wages and pensions
- u : Unemployment percentage rate
- W : Nominal wage index
- P_r : Retail price index

Subscripts m, r and g refer to manufacturing, primary and private tertiary and general government, respectively. All variables are expressed in logarithmic form except the time trend.

two demographic variables correspond to supply shocks and induce opposite movements in employment and real wages. What is particularly pleasing is that if (expected) output were 1% higher, ceteris paribus, the real wage bill would also be (0.47)(2.15)=1.01% higher, implying stable factor shares. The two chief objections to this reduced form model are first, that output, Q, can only be regarded as exogenous in the very short run and second, that the model is under-identified in terms of the underlying structural parameters. The first objection points to the need for some form of instrumental variable or simultaneous equations approach and the second towards direct structural estimation. These aspects will be taken up in the context of the third submitted paper.

The task attempted in the three-sector model was rather more difficult than in the aggregate model. By contrast the estimates in Part B of Table 1 are less descriptive and correspond less closely to the theoretical blueprint. However, a number of similarities between the two can be observed. Output, understood in the sense of demand, is an important factor in each sector. The output effects on wages are transmitted through the manufacturing sector equation to general government wages. Population effects are present throughout, but coefficients have been constrained to unity in the employment equations due to the lack of independent variation of the demographic variable in the shorter sample period. Confirmation of the importance of real exchange rate movements for manufacturing and real interest rates for distributive and service industries was encouraging. These results were obtained without the aid of the dramatic exchange and interest rate changes during 1980 and 1981. Unfortunately, as the paper notes, the degree of employment loss was so large in this period, relative to the previous fifteen years, that the parameter estimates are subject to a large increase in their absolute magnitudes when these data are included. This episode of predictive failure has caused enormous difficulty to all modellers of the labour market and the problem has only properly been overcome with the benefit of hindsight and three or four more years of information.

Three main conclusions emerge from the reduced form estimates. Firstly, that the evolution of employment and real wages in the post-war period cannot be understood solely in terms of the arguments of the demand for labour schedule. Demographic and other supply factors have also exerted important influences. Secondly, that it is unfeasible to characterise the labour market as being in continuous equilibrium. Thirdly, that the decision to exclude general government from the aggregate model appears to be vindicated. Whilst government wage behaviour may mimic that of the private sector over the longer term, there is no doubt that public sector pay is far more vulnerable to manipulation in the form of explicit or implicit incomes policy. Public sector employment appears to be almost completely unresponsive to private sector influences. This conclusion may go a long way to explain the differences between our own work and that of Professor Stephen Nickell and Martyn Andrews, both then of the London School of Economics. This issue will be developed below.

3.2 Structural estimates

In theoretical terms, structural estimation is strongly preferred to reduced-form estimation by the applied economist. The identification of structural parameters, together with their estimated significance levels, and the freedom to test the various mechanisms of price adjustment are high on the list of advantages. The age-old problem of identifying demand curves and supply curves when only the actual prices and quantities are available prevents structural estimation from being an easy option.

The economists in the Centre for Labour Economics have adopted a halfway house position in their analysis of the labour market. They regard the wage as the outcome of some form of bargaining model in which a variety of demand and supply arguments are admissible as proxies for unobservable theoretical constructs . Hence the wage equation can be regarded as a quasi-reduced form. Conditional on the wage bargain, employers are deemed able to choose their desired level of employment for a particular time period in relatively unconstrained manner. The observed level of employment can therefore be regarded as equivalent to the demand for labour and econometric estimation can proceed. Labour supply is invariant to changes in tax and wage rates, and hence the unemployment in their model arises largely as a result of deficient labour demand.

The insight gained from our experiments with the reduced forms guided us towards a different theoretical framework from that used by Nickell, Andrews and Layard. Rather than a sequential decision-making process, and eapecially since these models were to be estimated using annual data, it was felt over-restrictive to disallow an interaction within a given year between labour demand, labour supply and the real wage. The framework which has been used in the City University Business School (CUBS) model paper and elsewhere, permits the issue of the speed with which unemployment disequilibrium is eliminated to be determined empirically. In order to define unemployment disequilibrium, it is obviously necessary to employ some notion of a "natural" or "equilibrium" unemployment rate. This is a highly emotive concept and one which, sadly, has created obstacles to the publication of this work in the UK. In our model, a natural, but not fixed, unemployment rate is implicit in the wage equation. The dynamics of the labour market system may be understood in the following way. Independent labour demand and supply schedules combined with the embedded natural rate function implies a steady state growth path for real wages conditional of the levels and growth paths of all the constituent arguments of the model. When the observed unemployment rate exceeds the natural rate, the form of the wage adjustment equation allows the actual growth of real wages to fall, stimulating faster demand growth and lower supply growth. With an unspecified lag length, the observed unemployment rate falls back to its natural rate and the real wage returns to its steady state growth path. The empirical model consists of three behavioural equations which are jointly estimated using Three-Stage Least squares. The results for each will be discussed briefly below.

As far as the labour demand equation is concerned, qualitatively similar results to those obtained by Symons (1985) for manufacturing and Nickell and Andrews (1983) for the whole economy were achieved. A real wage elasticity close to (minus) unity is the most notable feature. Our results differ from Symons' in that we were unable to accept the restriction that the coefficient on energy costs was equal to that of other input costs. Energy costs, deflated by factor cost output prices, exerted a powerful negative effect on labour demand in our work. The major departure from the most recent estimates by Layard and Nickell (1985) occurs with regard to the introduction of additional indicators of demand in the specification under the banner of "imperfect competition". Specifically, aggregate demand indicators were found to offer a means of avoiding the predictive failure of the model in 1979-1981. Quite apart from the methodological objections concerning the use of additional measures of demand, such as the real exchange rate and the adjusted budget deficit, there appears to be an element of tautology in using the budget deficit to explain the fall in employment. As mentioned above, Nickell and Andrews' results must also be viewed with caution in relation to the inclusion of the unresponsive government sector in their aggregates. When their aggregate demand indicators were added to our model, covering the business sector of the economy, only their world trade variable proved significant.

The supply equation, defining supply as total employment plus registered unemployment, is aggregative in the CUBS model paper, but our preference is for the disaggregation by sex, as in Beenstock and Warburton (1984). There, the dichotomy between the male and female real post-tax wage elasticities is explicit. Whereas the male elasticity was found to be insignificantly different from zero, for females an elasticity of between 0.3 and 0.5 was estimated. The average elasticity of 0.097 on page 254 of the CUBS model paper masks this dichotomy. There is also an age dimension to labour supply real wage elasticities. On page 194 of "Work, welfare and taxation", the addition of the parameters α_3 and α_4 represents the term in real wages for males and females aged over 45. Whilst the coefficients are generally much more significant for women than for men, there is a tendency for the wage incentive to weaken as age rises.

Finally, the wage adjustment equation revealed a markedly slow speed of elimination of the difference between the actual and natural rates of unemployment. This is unsurprising to the extent that many other studies have suggested that the labour market reacts only slowly to price shocks. It may alternatively indicate misspecification of the implicit natural rate function which contains a real benefit term and a proxy for structural change. However, a wide variety of other suggestions have been unsuccessfully incorporated, and no effort has been spared in seeking to ensure that all important variables have been included.

In conclusion, the application of modern econometric techniques to UK post-war labour market data has yielded new insights and given rise to the "real wage debate" at national policy-making level. The Treasury's working paper (1985) was unprecedented in its forthright acknowledgement of a relationship between real wage costs and future employment levels. However, various problems remain. The instability of parameter estimates, particularly in the labour demand equation, continues to cause concern. The recent sharp fall in the cost of energy, between November 1985 and April 1986, will ultimately provide a good test of the repairs made to the specification following the oil price rises of 1979 and 1980. Measurement problems are another area in which the usefulness of quantitative research has been diluted. The repeated revisions to employment and especially self-employment, the numerous changes of definition for unemployment and the difficulty of making proper allowance for the increase in part-time working, all require detailed consideration in future work.

CHAPTER 4 APPLICATIONS TO THE INTER-WAR UK LABOUR MARKET

The background to the two contributions which relate to the inter-war period lies to some extent in the remit received from the Economic and Social Science Research Council. It was agreed with them that, given the shortage of degrees of freedom in the post-war period alone, it would be a useful exercise to attempt to validate the post-war labour market model using a larger data set. It was soon discovered that the inter-war period, despite the wide availability of the relevant data, suffered from its own shortcomings. The most annoying of these was the absence of a consistently defined wholesale output price index throughout the period 1921-1938. An appropriately defined series for wholesale prices was not published until 1930. A further limitation of the data was the disruption to the data for 1921 and 1922 caused by the post-war inflation. This rendered the effective sample period extremely short, and this lack casts a long shadow over the reliability of all inter-war econometric work.

"Wages and unemployment in inter-war Britain" was written in 1985 after a paper by Beenstock, Capie and Griffiths (1984) had rekindled an old debate regarding the causes of the economic recovery which began in 1932. Dimsdale (1984) was particularly dismissive of the Beenstock et al (1984) argument that the behaviour of real wages played a critical role in the recovery. Beenstock and Warburton (1986a) was written originally to examine the data more rigorously, following Dimsdale's article,and to present econometric estimates for the first time. The first paper stopped short of describing a justification for the real wage behaviour in the inter-war period. It merely analysed the respective roles of aggregate demand variables on one hand, and real wages and the rate of capital accumulation on the other. A second, as yet unpublished paper, entitled "The market for labour in inter-war Britain" includes estimates of real wage behaviour and integrates this with the evidence from Beenstock and Warburton (1986a).

To a very large extent the data are modelled in an analogous fashion to those of the post-war period.

The remainder of this chapter is devoted to highlighting the similarities and contrasts between the inter-war and post-war econometric estimates and to a brief summary of the conclusions from the whole of the inter-war research.

Part A of Table 2 reveals unit wage elasticities for inter-war manufacturing employment and post-war business sector employment, but much lower elasticities for the inter-war whole economy. The discrepancy may be attributed to the unresponsiveness of the included government sector, but it is more likely that the price deflator is deficient as a measure of the cost of output. Estimates of the capital stock for manufacturing are based on somewhat cavalier assumptions in the inter-war period and this may explain why a time trend performs better. Otherwise the capital coefficients are of a similar order. Whilst real energy prices display the anticipated negative sign both pre-war and post-war, a persistent positive effect is estimated for real non-energy materials prices. The most likely explanation for the sign arises from the predominance of domestically produced intermediate products over imported raw materials within the category. Insofaras intermediate products embody domestic value added, substitution of own labour for bought-in labour is feasible. Opportunities for energy or raw material substitution, on the other hand, are negligible. The addition of the real money supply and world trade variables, reflecting an imperfectly competitive characterisation of the economy, improved specifications of labour demand in both time periods.

The comparison of the labour participation equations for the pre-war and post-war years, shown in Part B of Table 2, reveals similar real wage elasticities. The functional form adopted in both studies provides for the real wage elasticity to attentuate as participation rises. Labour

Table 2: Comparison of estimated elasticities from inter-war and post-war labour market models

A Labour demand (proxied by actual employment)

	Inter-war			Post-war	
	(1)	(2)	(3)	(4)	(5)
Real wage	-1.10	-0.37	-0.17	-0.92	-1.16
Capital stock	*	1.17	0.69	0.65	0.80
Real energy prices	-0.30	-	-	-0.16	-0.08
Real materials prices	0.39	-	-	0.47	0.34
Real money stock	-	-	0.21	-	-
World trade index	-	-	0.11	-	0.20

*The capital stock is approximated by a time trend in this equation

Sources: (1) Beenstock and Warburton (1986a) Table 1 col.3, manufacturing sector
(2) Beenstock and Warburton (1986a) Table 2 col.2, whole economy
(3) Beenstock and Warburton (1986b) Table 2 whole economy
(4) Beenstock et al (1986) p252, business sector
(5) Unpublished estimates by Ordinary Least Squares, business sector

B Labour supply

	Inter-war		Post-war
	(6)	(7)**	(8)
Real post-tax wage	0.52	0.19	0.10
Population of working age	1.00	1.00	1.00
Unemployment rate	-0.36	-0.26	-0.92

**Equation (7) includes the "burden of proof" dummy variable, whereas equation (6) does not

Sources: (6) Beenstock and Warburton (1986a) Table 3 col.2
(7) Beenstock and Warburton (1986b) Table 2
(8) Beenstock et al (1986) p254

C Implicit natural rate of unemployment

	Inter-war	Post-war
	(9)	(10)
Real benefit rates	0.13	0.13
Structural change proxy	2.49	1.73
Inflation***	-1.23	-0.78

***Inflation is measured using an output price index in the inter-war estimated, but using a nominal wage index for the post-war period

Sources: (9) Beenstock and Warburton (1986b) Table 2
(10) Beenstock et al (1986) p252

participation, particularly of females has recorded much higher levels in the post-war period. Charts of labour participation for certain age-groups are shown on pages 191 and 192 of "Work, welfare and taxation". The larger "discouraged worker" effect in the post-war estimate suggests either a change of attitudes to unemployment or that the crude unemployment rate is not capturing the effect properly.

Perhaps the most surprising result appears in Part C of Table 2 where the similarities of the parameters of the implicit natural unemployment rate function are remarkable, considering its tentative foundations. The structural change proxy, which standardises changes in the employment share of the industrial sector relative to the whole economy, performs the valuable task of sterilising the effects of rapid employment change on real wages. It recognises that labour cannot move freely or quickly from heavy industrial occupations to white-collar clerical ones. The adjustment period is likely to be protracted and during this time real wages may be relatively unaffected by unemployment of a structural nature.

That real wage growth appears not to be homogeneous of degree zero with respect to inflation, is to be expected in the inter-war period. To observe a similar result for the post-war period provokes a certain amount of dismay, although the parameter estimate was very well established. The favoured interpretation is that high inflation rates carry with them greater risk of negative real wage growth, and this induces risk-averse workers to accept wage offers more readily when inflation is high. In other words, the inflation rate can be viewed as a proxy for the variability of inflation, with which it tends to be strongly and positively correlated. Time series data on the variability of inflation is not directly observable. Such estimates as can be made are always out of date.

These findings reinforce the conclusions reached from the post-war applications. In the context of the inter-war period the main conclusions are as follows: For various reasons, which include the bahaviour of real out-of-work benefits and the pattern of industrial employment, real wages increased at an excessive rate during the second half of the 1920s and can provide a significant part of the explanation for the emergence of high unemployment at the end of that decade. Real wage growth moderated after 1932 and employment, particularly in manufacturing, accelerated in precisely the manner that a neoclassical labour demand function would suggest. However, no single variable can explain the behaviour of unemployment throughout this period. The roles of world trade and monetary policy were also significant in the recovery period, but the best explanation is offered, we believe, by the comprehensive model developed in Beenstock and Warburton (1986b). In particular, this model suggests that when distortions to the unemployment rate are removed, the rate which would have prevailed immediately prior to the second world war is not inconsistent with that observed after the war. Finally, the labour supply or participation schedule does appear to be responsive to post-tax real wage movements and to the prevailing rate of unemployment. The common usage of an analytical framework in which labour participation is assumed exogenous appears inconsistent with the properties of the data sets which we have examined.

CHAPTER 5 APPLICATIONS TO EXCHANGE RATES AND UK IMPORTS

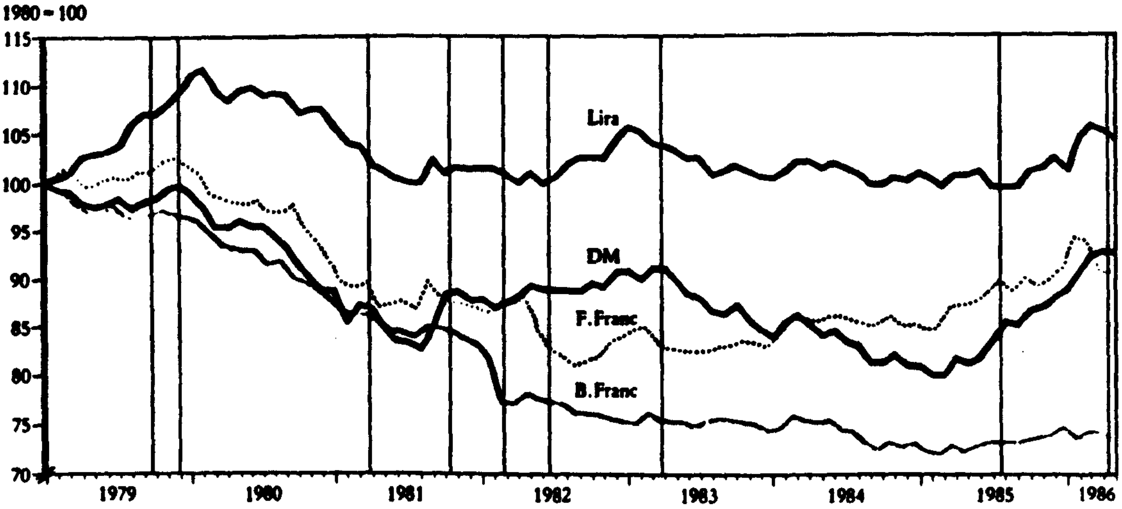
The econometric techniques described in Chapter 2 have also been applied to the monetary theory of the exchange rate and to the determination of UK imports of goods. As in earlier chapters, the diagnostic test statistics quoted in each paper differ due to the extended time scale over which the papers were written. However, tests against residual non-randomness and of predictive failure are generally provided, the only exception being Budd and Warburton (1979).

This paper was an early attempt at integrating the roles of both trade flows and capital flows in an exchange rate model. In Beenstock, Budd and Warburton (1981), this approach was generalised in a number of respects but tested only on UK data. An accompanying discussion paper, Warburton and Beenstock (1980), supplies the econometric details underlying the results. The third paper, Beenstock and Warburton (1982), examines the behaviour of UK import volumes in the light of world-wide trade liberalisation and, particularly, following UK entry into the European Economic Community. This chapter continues with a summary of the main results and outstanding difficulties in these two areas of international economics.

The advent of flexible exchange rates after 1971 presented the need for a comprehensive theory of exchange rate determination. In the 1960s, international capital flows were still highly regulated in most developed countries. Thus, trade flows assumed great importance in the fixed exchange rate era, giving rise to the familiar "stop-go" economic policy cycle. When a domestic economy became overheated, import volumes would rise, the balance of payments would fall into deficit and, to prevent devaluation, the government would be forced to dampen demand through raising the burden of taxation or by similar measures. After the Smithsonian agreement of late 1971, exchange rates became free to appreciate and depreciate within margins set only by governments' desire to stabilise short-term movements by the use of foreign exchange intervention. Private sector capital flows immediately became more influential in the new exchange rate regime. Relaxation of restrictions on capital flows combined with the evasive ingenuity of multinational enterprises guaranteed that expectations of currency values in future time periods would dominate trade flows in establishing exchange rates. The monetary theory of the exchange rate, whose origin is to be found in the work of Johnson (1964) and Frenkel (1976) is sketched out in Appendix 1 of Budd and Warburton (1979). This lays the foundation for long-run exchange rate expectations. In essence, a nation with faster monetary growth but the same GDP growth as another will tend to suffer progressive currency depreciation against the other and a higher rate of inflation. Many factors complicate this basic model, such as varying income elasticities of money demand, varying trends in income velocity, varying degrees of international openness and varying growth rates of industrial productivity.

The purpose of Budd and Warburton (1979) was to examine the degree to which the exchange rate movements of the UK, France, Germany and Italy could be understood within this structure of exchange rate determination. Current account balances, both as flows and accumulated stocks (since 1963), were also included in the specification. Despite the ambition inherent in the model, which was estimated using quarterly data, correctly signed parameters were obtained in all cases although the coefficients for Germany were not well determined. The error correction term, whose parameter is α_{10} in the table of results, was very well determined for France and Italy and moderately so for UK and Germany. Relative income (represented by industrial output) elasticities varied greatly across countries, as did trade flow responses, but were almost always statistically significant at the 95% level. Remarkably, around half the variance of quarterly movements in the exchange rate was explained by the model. These results suggested that the European Monetary System would be forced into frequent realignments of currencies unless the member countries subordinated their monetary policies to those of the dominant currency, namely Germany. In retrospect, this interpretation has proved quite accurate and on ten separate occasions between 1979 and 1986, realignments were necessary, as shown in Chart 1. Furthermore, had the UK joined the system at its inception, even more frequent adjustments would have been required.

Chart 1: **Real exchange rates of EMS countries, 1979-85***



* MERM-weighted effective rates deflated by wholesale prices, nine major countries
Note: Vertical lines indicate dates of realignments.

Sources: International Financial Statistics, IMF; *Main Economic Indicators*, OECD

The particular position of the UK as an oil producer distinguishes it from the other major European currencies and this issue was addressed in the second paper, Beenstock, Budd and Warburton (1981). The effect of supplementing a theoretical model which could already be regarded as ambitious, was to exacerbate the problem of identifying the parameter estimates. On Table 2 of the paper the long-run coefficients are presented for four distinct classes of exchange rate model. In the first, only asset (money and bonds) stocks and real incomes are used. Capital account effects in the form of interest rates were also incorporated in the second block of equations and, separately, oil effects in the third. The final block attempted to integrate all three effects. The detailed econometric equations underlying these static reduced forms are contained in Warburton and Beenstock (1980) which is reproduced in this submission as the Appendix. Whereas Budd and Warburton (1979) allowed own and world income and current balance elasticities to differ, these were constrained in the later paper in order to save degrees of freedom.

The diagnostic test statistics reveal that almost all the equations failed a Chow test for the period 1978Q1 to 1980Q2. The sharp appreciation of sterling during this time proved a very severe test of the models and underlined the inadequacy of the information set. In particular, the current account effects of North Sea oil were only just becoming apparent in 1978, the final year of the estimation period, and were not to reach a peak until 1985. The poor predictive performance was inevitable from this standpoint. The worst examples of predictive failure were provided by the equations which included interest rate effects, standing for capital account changes. Whether because of simultaneity bias, which is probable, or some other form of mis-specification, the interest rate effects, though correctly signed, were extremely erratic and generated appalling post-sample errors.

A measure of success was achieved, despite the difficulties, concerning the estimated effects of North Sea oil. In addition to the income effect (since real oil incomes are a part of real national output), a current account effect (whereby the real exchange rate is raised to allow the non-oil account to deteriorate) and a capital account effect (whereby oil discoveries raise national wealth, leading to a reassessment of the exchange rate) were also identified. The estimate of a 14% real exchange rate premium by mid-1980 on account of North Sea oil does not seem too ridiculous in retrospect. Furthermore, the abrupt depreciation of sterling in 1986 following the collapse of the oil price gives credence to the oil effects on the exchange rate.

However, extended periods of exchange rate instability have made talk of long-run or fundamental exchange rates appear anachronistic. And the examination of quarterly exchange rates is also open to question when the timing of capital switches between international financial centres is defined in minutes rather than months. The modeller is presented with two courses of action in such circumstances. Either to use a high volume of high frequency data and employ a sophisticated dynamic model, or to use low frequency data, as we have done, and look only for broad brush, robust, data representations.

The future of exchange rate modelling seems destined to travel along the route of low frequency data and to provide generalisations of behaviour across time and countries from which to deduce tentative conclusions. The abundance of competing explanations for a particular episode of exchange rate movement is evidence of the underlying problem. In any environment where, for every new data observation, another two relevant explanatory variables may be suggested, it is unlikely that the "true" model will ever be identified.

The final submitted article, concerning the post-war behaviour of the volume of imports of UK goods, was estimated using annual data from 1950. The essence of the exercise was to investigate whether UK import propensities were disproportionately large (as other authors have argued) when changes in the degree of openness of the international trading environment were taken into account. In Beenstock and Warburton (1982), a novel import equation was advanced, in which the liberalisation of world trade and the effects of EEC entry were proxied by the relevant import to GDP ratios of the external nations and these terms added to the conventional model. For total goods imports, the results indicated that UK behaviour could be well understood in these terms. Consumers in the UK were simply mimicking the worldwide pattern of spending a greater proportion of their expenditure on imported goods as these were released from tariff and quota restrictions by, for example, the Kennedy Round. A fuller discussion of the background to this work may be found in Beenstock and Warburton (1980).

According to our thesis, EEC entry caused a surge in UK import propensities because the average import to GDP ratio of the original six EEC members was substantially higher than for the OECD world in general. By giving and receiving preferential trading rights through entering the EEC customs union, the UK began the transition to a higher average import propensity. The more general of the two models, EEC model 2, indicated that the UK import to GDP ratio would rise to about 39% from a pre-entry base of 23%. In 1985 the actual ratio was 32%.

Separate results for manufactured import volumes were also estimated, using quarterly data, and evidence of a small degree of autonomous import growth was observed. However, the central thesis was maintained for manufactured goods, namely, that rising import penetration is an international phenomenon, and not peculiar to the UK. Econometric tests were performed against autocorrelation and predictive failure, but all our equations registered test statistics which were comfortably within the usual 5% significance levels.

Writing in the latter part of 1986, the UK balance of payments is set to fall into deficit after six years of surpluses totalling £22 billions, and again the forecasters at the National Institute are projecting a massive £5 or £6 billions deficit in 1987. These forecasts typically derive from import equations in which no allowance has been made for the international movement towards free trade. In interpreting these historical developments as exogenous and time trended, the future growth of imports is likely to be seriously overestimated. If, as we suspect, the trade liberalisation wagon has ground to a halt (and fears are growing of a more protectionist stance in the US) then extrapolation of the time trends is inappropriate. Imports will grow more conservatively and the balance of payments will deteriorate by a much smaller margin.

In conclusion, the application of modern econometric methods has provided us with new insights into the determination of imports. The high income elasticities and unexplained time trends have been accommodated within a dynamic equation which provides for a more plausible long-run theory of UK imports. The verdict on the empirical work with respect to the exchange rate is less encouraging. Except for the naive monetary model, the information set available in 1980 appeared insufficient to enable coefficients to be reliably determined. As more sophisticated and realistic theoretical structures were adopted, the data deficiency became more apparent. Recent experiments with the data set suggest that the monetary model can still provide a good description of the data, although parameter instability remains as much of a problem as it was in 1979-1980.

CHAPTER 6 CONCLUSIONS

This essay has attempted to draw together the various strands of argument and evidence contained in the published papers. In this final chapter, the objective is merely to emphasise the key areas in which it is believed that an original contribution has been made to the existing body of knowledge. Two general and five specific conclusions will be drawn.

6.1 General conclusions

6.1.1 Short-run dynamics and long-run properties of economic models

Modern econometric methods acknowledge the need to combine plausible short-run dynamics with sensible long-run properties in model building. The empirical relationships which had dominated the literature until the mid-1970s tended to model either the short-run dynamics or the long-run properties, but not both. Examples of the former are the short-run demand for labour, popularised by Ball and St Cyr (1966) and Brechling (1965), and the short-run demand for imports, described in Rees and Layard (1971). The static consumption function of Keynesian origin provides an illustration of the latter. Whilst Professor Hendry has demonstrated the superiority of a consumption function modelled using error correction mechanisms in Davidson and Hendry (1981) and elsewhere, the empirical work contained herein generalises the short-run labour and import demand functions. The generalisation of these specifications to possess long-run properties has required the adoption of more complex theoretical models. In accordance with modern methods, additional lagged variables were also included enabling a fuller description of model dynamics. The resulting models encompass and outperform their predecessors in almost all cases. Thus, for example, the explanation of labour demand now includes long-run arguments such as changes in the net capital stock, real energy and real materials prices. In the case of the import demand equation, short-run income elasticities of 1.5 or 2 can now be reconciled with a more sustainable long-run elasticity of unity. However, the net gain in precision and in predictive accuracy obtained by these methods should not obscure the fact that error margins will remain uncomfortably wide as long as sample sizes remain so small.

6.1.2 Diagnostic testing as an aid to identifying appropriate models

Heightened awareness of autocorrelation and other sources of violation of the assumptions on which OLS regression is based, has led to more carefully specified equations. By conducting experiments with generalised forms, it is possible to deduce whether or not the omitted variables are lags of existing arguments. This technique was applied in the analysis of labour supply and of real wage adjustment for the post-war period. It is of particular significance in the latter case because of the embedded unemployment function which lies at the heart of the labour market analysis. Whilst many other arguments have been tested, for example, measures of union power, a deterioration in the residual correlogram was invariably the result. This has led to the important conclusion that, both in the inter-war and post-war periods, the "equilibrium" unemployment rate has shifted primarily because of three factors. First, the real value of out-of-work benefits, second, the degree of industrial dislocation or structural change in economy and third, the variability of inflation. In other words, a rise in unemployment due to demographic influences can be distinguished in its labour market effects from a rise in unemployment due to accelerated structural change. The former can be expected to reduce real wages and raise employment whilst the latter may have no discernible effect on either.

6.2 Specific conclusions

6.2.1 Time-series labour participation behaviour

The assumption of fixed labour participation rates pervades the literature of aggregate labour market analysis. In the research reported in this submission, this characterisation of behaviour holds up only for prime-age males. Males over 45 are only slightly responsive to changes in remuneration differentials (between work and retirement), but female labour participation in all age-groups appears real wage sensitive. Therefore, even in aggregate empirical work, it is concluded that real post-tax wages and labour participation rates should be allowed to interact.

6.2.2 Retirement analysis

A series of conclusions from the optimum retirement age model were listed on pages 227 and 228 of "Work, welfare and taxation". They relate to males aged 50 years old and possessing the other characteristics detailed on page 218. In particular, it was concluded that the most important influences on the retirement decision were the individual's work-leisure preferences, earnings (if below-average) and life expectancy. High earnings were found to have an ambiguous effect on the optimal age of retirement.

6.2.3 Re-interpretation of the inter-war period

Any conclusions reached concerning this period must be regarded as tentative, since the quality of some of the data is questionable. However, after a comprehensive study of the arguments which have been advanced to explain wages and unemployment behaviour, it is believed that the following statements hold true. First, that the equilibrium rate of unemployment was increased because of the increased generosity of unemployment benefits. The relaxation of the "work test" requirements in 1930 also worsened unemployment. Second, that real wages responded to both demand and supply shocks during the inter-war period. The flexibility of the labour market enabled the economic recovery to gather pace before faster productivity growth was absorbed by higher wage payments.

6.2.4 Exchange rate modelling in the context of North Sea oil

In Beenstock, Budd and Warburton (1981), and Warburton and Beenstock (1980), an ambitious model of UK multilateral exchange rate behaviour was advanced and estimated. An integrated equation of the type described in those papers remained in use in the London Business School model long after the author departed. In respect of the treatment of North Sea oil, the analysis was innovative. The estimate of the size of the effect of North Sea oil on the real exchange rate, at 14%, seems realistic in retrospect. Exchange rate modelling is fraught with difficulty but it is contended that, on its own, the long-run implied purchasing power parity model offers an inadequate explanation of UK data. Real shocks, such as North Sea oil discovery and exploitation and differential productivity growth in the traded goods sector, play an important role in exchange rate determination.

6.2.5 UK imports and the international trading order

As, perhaps, one of the first studies to apply modern econometric methods to the determination of UK imports of goods, Beenstock and Warburton (1982) reached several important conclusions. Remembering that the data period ended in 1979, the inclusion of oil imports, for which the paper has been criticised, is not important. The key conclusions regarding visible goods imports were that the time trend, used in previous studies, offered an inferior explanation to that provided by the international trade ratio, denoted R_w. Furthermore, the high income elasticities found by earlier researchers applied only in the short-run. The long-run elasticity was discovered to be insignificantly different from unity. Finally, the hypothesis that EEC entry was responsible for increased trade could not be rejected.

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PART TWO

THE PUBLISHED PAPERS

PAGE/PAGES EXCLUDED UNDER INSTRUCTION FROM UNIVERSITY

PAPER 2

ESTIMATES OF A 3-SECTOR MODEL OF THE U.K. LABOUR MARKET

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JANUARY 1982

Introduction

This discussion paper aims to provide a satisfactory explanation of the movement in UK earnings and employment since the early 1960s in the context of the full LBS model. The approach should therefore be labelled structural rather than reduced form. Reliance is placed on the existence of the appropriate transmission mechanisms from fiscal and monetary variables to domestic output and prices elsewhere in the model. A non-instantaneous market clearing characterisation of the UK labour market is adopted. Following our earlier study using annual data (Beenstock and Warburton (1980)), we regard the inclusion of the determinants of the supply of labour as extremely important in our explanation of labour market movements. The reader will notice that we do not emphasise the effects of instruments of labour market control, for example, incomes policies. This is not to deny that incomes policies and other pay legislation have affected the path of earnings and employment, but rather to interpret them as the means by which temporary market adjustments have been made. The contention of this paper is that, in most cases, an adequate description of the data can be found without reference to incomes policies.

The economy is divided into three sectors for the purpose of this exercise. This can be regarded as the minimum degree of disaggregation necessary to enable the structural arguments to find expression in the model. The three sectors are total manufacturing (both private and public), public administration and the residual category, which combines primary and private tertiary activities. In essence we have an internationally exposed sector (manufacturing), a largely administered sector (public administration), and an internationally insulated but market responsive sector. The biggest challenge is generally provided by the latter sector, partly because of its heterogeneity and partly because of its size, accounting for 45 per cent of all employees in 1975.

The paper is organised into four sections. The first section sets out the theoretical considerations of the model, identifying both supply and demand factors where appropriate. The second section contains a visual description of the main data series and recognises the difficulties in distinguishing the separate influences of variables which have moved similarly. A third section presents some empirical estimates in which the modelling strategy has been directed towards the fullest representation of the theoretical model. Some concluding remarks and suggestions for further research are given in the final section.

I Theoretical Considerations

As there appears to be little common ground between the sectors concerning the applicability of labour market theory I shall analyse each sector as if it were isolated from the other two. However it is recognised that such a trichotomy is not valid in the real economy and linkages are introduced into the sectoral specifications before proceeding to estimation. In adopting a bottom-up approach to the modelling of total wages and employment, expressing the sectors in relation to the total would be a luxury. Each sector is too large as a proportion of the total to allow such a strategy to obviate serious simultaneity problems in a full model context.

a) Manufacturing

This sector permits the most extensive theoretical specification because of its international openness and because output and productivity are meaningful and measurable concepts. The demand function for manufacturing employment may be written as:

$$L_m^d = F_{m1}(\overset{+}{Q}_m, \overset{-}{w}_m, \overset{+}{\rho}_m, \overset{-}{oc}_m, \overset{-}{\left(\frac{pi_m}{po_m}\right)}, \overset{+}{\left(\frac{po_m e}{pow_m}\right)}, \overset{-}{t}) \qquad (1)$$

where the signs above the arguments refer to the respective partial derivatives and where L denotes employment, Q is output, W, the earnings index divided by the output price index for manufacturing, ρ is the real interest rate, oc is other employment costs in real terms, pi and po are, respectively, the manufacturing input and output prices, the penultimate term describes the international competitiveness of UK manufacturing prices and t is a time trend. The subscript m represents manufacturing.

If one interprets ρ_m as a proxy for the user cost of capital, then the first three terms in the brackets are derived from the assumptions of entrepreneurial cost minimisation and a putty-clay CES production function. The terms oc_m and (pi_m/po_m) are modifications to the factor price w_m. The former is defined as the real cost of employer's national insurance and superannuation contributions per manufacturing employee and attempts to take account of the non-wage additional cost to the employer of hiring the marginal employee. The relative input-output price of manufacturing goods enters the specification because the employer is sensitive to changes in value added as a proportion of the final price. The employer's reaction to a higher relative price of his non-labour inputs, especially when his output price is fixed (i.e. he is a price-taker), is to seek to reduce his labour input costs and thereby restore his profitability. International wholesale price competitiveness enters the specification as a proxy for expected UK manufacturing output. Finally, the time trend reflects technical progress and net capital accumulation.

The supply curve is postulated as:

$$L_m^s = F_{m2}\ (\overset{+}{P},\ \overset{+}{w}_m,\ \bar{b},\ (1\overset{+}{-}t_1),\ (1\overset{-}{+}t_2),\ \bar{u}) \qquad (2)$$

where P represents the total population of working age, b is the average income replacement ratio for Earnings Related Supplement recipients in real terms, t_1 is a measure of the direct marginal tax rate and t_2 a measure of the indirect tax rate.

Over long periods of time (e.g. decades) there is a close relationship between total employment and the population of working age. In order to embed this long-run relationship in the model, it must be present in each labour supply function. The real income replacement ratio is considered to affect the work/leisure choice and also the optimal length of job search time. Higher tax rates, direct or indirect, it is usually assumed will have disincentive effects on labour supply. It is also possible that people may be prepared to work harder or longer in order to restore their post-tax standard of living. In other words, they may be willing to sacrifice some of their leisure time in order to buy more petrol, alcohol or tobacco. The percentage rate of unemployment for the whole economy, acting as a barometer of excess labour supply at current factor price ratios, may exert a separate discouragement to potential suppliers of labour. Whether or not these people register as unemployed is another question, but it is pertinent to the decision of the potential new entrant to the labour force who has no unemployment benefit entitlement what proportion of the existing working population is without work.

Combining (1) and (2) with a market clearing condition we can express steady state real earnings per employee and numbers employed as functions of the following variables:

$$L_m^e = F_{m3}(Q_m, \rho_m, oc_m, (\frac{pi_m}{po_m}), t, P, b, (1-t_1), (1+t_2), u, \overline{w_m}) \quad (3)$$

$$w_m^e = F_{m4}(Q_m, \rho_m, oc_m, (\frac{pi_m}{po_m}), t, P, b, (1-t_1)(1+t_2), u, \overline{L_m}) \quad (4)$$

where the bars over w_m and L_m denote that only lagged values of these variables should enter into the regression specification. It is clear that this model for manufacturing employment will be overdetermined in terms of the structural parameters.

b) Public Administration

It would be wrong to think of this sector as suffering no market pressures at all, despite its highly centralised and administered nature. Under a fixed exchange rate regime or a fixed money supply growth regime, the public sector cannot pay its employees what it likes, not can it employ however many people it likes. The external undesirability of a high budget deficit has internal implications for public expenditure control. In the wage equation we draw the distinction between central government and local authority employees, on the grounds that most of the expansion has taken place in the employment of the latter, who, typically, are the lower paid of the two.

The demand function for public administration employees may be written as:

$$L_g^d = F_{gl} \left(\overset{-}{w}_g, \overset{-}{BRGMA}\ \overset{+}{\Delta}^2{}_u, \overset{-}{oc}_g \right) \qquad (5)$$

where BRGMA is the public sector borrowing requirement as a percentage of cyclically adjusted GDP at current market prices and $\Delta^2 u$ is the rate of acceleration of the unemployment rate.

The terms w_g (the relative price effect) and oc_g require no further explanation as they are analogous to w_m and oc_m in (1). Since statistically, output in this sector is identical to the volume of expenditure (which is mainly wages), clearly it would be double counting to include the national accounts measure of government output. Two terms have been added which constitute a reaction function. When the borrowing requirement has been high in relation to the economic cycle, it is supposed that in an effort to restrain its expenditure, the number of jobs will be cut. Similarly if unemployment begins to rise at an increasing rate the government may attempt to stem the tide by offering more public sector jobs. Obviously both the latter arguments are highly tentative, but so, I suspect, is the idea of a demand function for government employees.

In considering the supply of labour in this sector, it is important to bear in mind that the average public administration employee receives a lower salary than the average manufacturing employee. It is assumed in this study that the premium that manufacturing enjoys arises from the greater risks of injury and dismissal in that sector. It may also be partly explained by public sector employees' preference for a higher retirement pension. We write the supply function as follows:

$$L_g^s = F_{g2}\,(\overset{+}{P},\ \overset{+}{w}_g,\ \overset{-}{b},\ \overset{+}{F},\ \overset{-}{u}) \qquad (6)$$

where F is the female participation rate. This argument has been added to the list which appeared for manufacturing on the grounds that public administration has increased the proportion of female employees in the total over the estimation period. The equal opportunities legislation has probably contributed to this trend in the later years. The tax rate terms have been dropped from the earlier list because most public administration employment is either salaried or conducted on the basis of a fixed working week with few overtime opportunities. Disincentive or incentive effects are likely to be absent.

The resulting regression specifications for real earnings per employee and employment are presented below, again on the basis of (5), (6) and an equilibrium condition.

$$L_g^e = F_{g3}(\text{BRGMA},\ \Delta^2 u,\ oc_g,\ P,\ b,\ F,\ u,\ \overline{w_g}) \qquad (7)$$

$$w_g^e = F_{g4}(\text{BRGMA},\Delta^2 u,\ oc_g,\ P,\ b,\ F,\ u,\ (\overline{\frac{L_{cg}}{L_g}}),\overline{L_g}) \qquad (8)$$

The term in (L_{cg}/L_g) is the differential 'quality' effect of central government employees referred to on page 6.

c) Primary and Residual Tertiary

As this sector is much more diverse than the other two, we begin by defining the various categories which it contains in Table 1.

Table 1 Constituents of the Residual Sector

		Percentage of Total in 1975
Agriculture, Forestry, Fishing		3.8
Petroleum and Natural Gas	Primary	0.4
Mining and Quarrying		3.5
Construction		12.7
Public Utilities		3.5
Transport		14.9
Communication	Tertiary	
Distributive Trades		27.2
Insurance, Banking, Finance		10.8
Other Services		23.2

In specifying the demand function for labour in this sector, it is clear that output is a meaningful concept only in the case of the primary sector, construction and public utilities, and possibly transport. Retail sales serve as a good proxy for the volume of activity in the distributive trades, but no independent estimate of output for the service sector exists.

It is possible to identify a number of interpretations of the real rate of interest in this sector's labour demand function. As well as reflecting the cost of capital (albeit in a crude fashion) large movements in ρ_r will influence the demand for labour in the distribution and retailing sectors through their effect on the cost of holding stocks. It is also possible that as the real returns to investment rise, financial companies take on more staff. The resulting coefficient on ρ_r can theoretically take either a positive or negative sign, according to whichever effect dominates. We may write the demand function as follows:

$$L_r^d = F_{r1}(\overset{+}{Q}_{NMIA}, \overset{+}{RSV}, \overset{-}{w}_r, \overset{?+}{\rho}_r, \overset{-}{oc}_r) \qquad (9)$$

where Q_{NMIA} is a composite output index for non-manufacturing industrial activities plus agriculture and RSV is retail sales volume. The subscript r represents the residual sectors. The variable oc_r contains an additional term in the numerator, namely net Selective Employment Tax payments. The non-manufacturing sector was liable to make these payments during the period 1967-1972.

The labour supply function has no additional characteristics to those in L_m^s and L_g^s and is postulated as:

$$L_r^s = F_{r2}(\overset{+}{P}, \overset{+}{w}_r, \overset{-}{b}, (1-\overset{+}{t}_1), (1+\overset{-}{t}_2), \overset{+}{F}, \overset{-}{u}) \qquad (10)$$

Since employment in the residual sector has been the most stable relative to its size of all three sectors, we are perhaps being too ambitious in specifying such an elaborate supply function. However, all the arguments are theoretically applicable and we rely on the empirical section to discriminate in favour of the few really important supply influences.

The market clearing solutions for employment and real earnings per employee in the residual category are:

$$L_r^e = F_{r3}\ (Q_{NMIA}, RSV, \rho_r, oc_r, P, b, (1-t_1), (1+t_2), F, u, \overline{w_r}) \qquad (11)$$

$$w_r^e = F_{r4}\ (Q_{NMIA}, RSV, \rho_r, oc_r, P, b, (1-t_1), (1+t_2), F, u, \overline{L_r}) \qquad (12)$$

<u>d) Cross-equation linkages</u>

The case for introducing cross-equation linkages is probably more persuasive for real earnings than for employment. It is proposed, therefore, to add terms in the sectoral real earnings relativities to the existing market clearing specifications, (4), (8) and (12). Although sectoral relativities may follow secular trends, in the short-term, significant gains by any one sector are likely to be unsustainable.

If to manufacturing is assigned the role of the leading sector in wage negotiations, then specifications (8) and (12) may be augmented by lagged terms in $\frac{W_g}{W_m}$ and $\frac{W_r}{W_m}$, respectively, adding time trends in both cases. There is some doubt as to whether cumulative error correction terms should be present. The argument against the use of such terms in this context is that whilst employees may have a perception of their relative earnings compared to employees in other sectors, they are much less likely to perceive differences in their relative wealth.

In Section II, the data required for estimation of the relationships above are examined graphically.

II Data-based Considerations

A preliminary visual examination of the data to be used in any empirical work is usually well rewarded. In this short section charts of the specified variables from Section I are presented. The main points to emerge from this examination are:

(i) The diversity of performance of the three sectors over the period 1963-1981. This helps to establish the usefulness of disaggregation.

(ii) The different degress of volatility of the proposed regressors. The coefficient on a regressor which displays little variation relative to the dependent variable, (having allowed for trend and seasonal influences) is not likely to be well determined. For example, over this period the population of working age on Chart 6 is barely discernible from a constant.

(iii) The likely areas of conflict where different arguments in the specification, being highly collinear, are competing for statistical significance. As examples of this, the traces of other employment costs shown on Chart 3 are highly correlated with the time trend. Again, coefficients on regressors which are non-orthogonal tend to have exaggerated standard errors and therefore apparently low levels of significance. Economic time series variables are prone to this latter defect and perhaps this helps to explain why so many researchers have reached different conclusions on the basis of regression analysis performed on the same available data set. The different results must each have been compatible with their owners' expectation of coefficient signs and magnitudes.

Having specified the model and indicated the anticipated direction of each effect, an examination of the data and particularly of the correlation matrix of the regressors often identifies areas of difficulty before any estimation is carried out.

The arguments of the labour demand function (1) display a large degree of independence from each other, with the exception, cited above, of other employment costs and the time trend. Manufacturing output, Qm on Chart 1, has the expected cyclical pattern, until the massive decline at the end of the period; manufacturing real wages, w_m on Chart 2, has a definite kink in its growth rate which occurs in the early seventies; and the real interest rate, ρ_m on Chart 4, and relative input-output prices, (pi_m/po_m) on Chart 5 each display systematic independent variation in the mid-seventies. On a cursory examination, one would not expect great collinearity problems from this data set.

The arguments of labour supply, listed in equation (2) appear much less independent. The invariability of P has already been mentioned, but it is also clear from Chart 8 that the direct and indirect tax ratios bear an inverse relationship with each other. When one interprets this phenomenon in terms of government preferences for one type of tax or another it makes good sense that reductions in the direct tax burden should be compensated elsewhere. However, if the ratios are added together then the problem is far from solved, for again the series is virtually a constant. The real benefit rate, b on Chart 7 is a redeeming feature of the specification, as is the behaviour of u on Chart 11. Nevertheless it becomes a little easier to understand how difficult it has been to establish the independent influence of labour supply variables by use of time series regressions.

For the regression specifications (3) and (4), it is also necessary that the elements of the demand function are individually discernible in a statistical sense from those of the supply function. If u is included as a logarithmic term then there is the likelihood of a high correlation between ln(u) and the time trend. The information we can glean about these specifications from the data is that the coefficients on oc_m, ln(u) and t may display remarkable fluctuations in significance depending upon the presence or absence of one of the others, and secondly, that it is unnecessary to include more than one term in the population of working age, P.

In carrying out a similar exercise for employment in the public sector, the problem areas appear to be the correlations of oc_g and F and of BRGMA and w_g (see Charts 10 and 4 respectively). The rapid growth of real public sector wages in 1974/5 was associated with the largest proportional government deficit (on a cyclically adjusted basis). The introduction of (L_{cg}/L_g) in (8) also has its problems as shown in Chart 12, to the extent that it too does not contribute much original variation to the regression specification.

Finally, the arguments of specifications (11) and (12) must be considered. The regressors QNMIA and RSV on Chart 1 have behaved differently only since 1973 and this casts doubt on the feasibility of including them both in the specification. A further problem can be anticipated in the estimation of the employment equation (11). Chart 9 reveals that, relative to the other categories, employment in the residual category has exhibited very little variation. Indeed if the period 1967-72, when SET adversely affected employment, is omitted, there appears to be very little left to explain.

This emphasises the point that however numerous are the candidates for inclusion in the equation specification, one can only estimate as many parameters as the data will allow. If there is no variance to explain then the best theory in the world cannot be distinguished on statistical grounds from the worst. Consequently, it is suspected that some of the richness of the specifications in section I will be lost as soon as the equations are confronted with the economic data. The only effective answer to this problem is to widen the experience covered by the empirical analysis. For example if the data set had begun in 1958 then rather more variation in P, the population of working age, would have been observed and perhaps more reliable estimates of its effect, especially on wages, would have been obtained.

In Section III, empirical estimates of the six functions are provided.

III Empirical Results
Econometric Methodology and Modelling Strategy

Leamer (1978) has drawn attention to some of the contradictions which exist between the theoretical statistical conditions under which econometric tests are validly performed and the typical modelling environment in which practical research is carried out. To caricature the situation in an ideal world, the student would be closeted in a data-free environment until the day he or she had their first original idea which was both precisely specified with regard to functional form and capable of empirical verification, (or died, whichever was the sooner). On this day the student would be handed a sealed envelope containing the data on only the variables he had selected, and a copy of a TSP instruction manual. Having successfully submitted his job, the student would be escorted back to his cell where, under sedation, he would be shown his results. Having written up his project the student would then think of his next idea, being careful not to include any of the variables for which he had seen the data. The point of all this is to demonstrate that awareness of the data and the formulation of hypotheses is an interactive process in real life. Most researchers are in a position to discriminate between those hypotheses which are likely to be data supported and those which are not on the basis of their broad knowledge of the available data set. However, in statistical terms the process of repeated sampling of the same data set nullifies the original validity of tests of individual variable significance. Leamer gives some indication of the progressive strictness of the test criteria necessary when repeated sampling takes place.

An appealing solution to this problem is suggested by Mizon (1977), who recommended data-based specification search as a means of model selection. In theory, since all regressions after the first are generic only one original sampling of the data has taken place. This can take two forms; either moving from a specific model to a general one or vice-versa. The former has the advantage that the specific model used as the starting point is not of great importance. Tests for the inclusion of existing ones are performed until the model cannot be significantly improved by further addition or removal. The main disadvantage is that there is no guidance as to the order in which the tests should be carried out.

The latter form, general to specific model selection, has become widely used over the last three years. Contingent on the "correct" set of independent variables being chosen initially, the modeller follows a set procedure for testing coefficient restrictions, estimating common factors and monitoring the autocorrelation and predictive performance of the model, step by step. At what stage the procedure is terminated is an arbitrary decision but the final restricted form will always be a direct descendant of the general form. Tests for inclusion of previously excluded variables will almost always confirm the prior decision.

A parallel development to these model selection procedures has been the application of engineering control methodology to economic systems and, lately, to individual equations. The language of integral, proportional and derivative control has permeated the applied economist's vocabulary and lent theoretical support to techniques previously considered arbitrary.

These developments, together with an increasing battery of rigorous tests for non-randomness of the residual correlogram, heteroscedasticity, out of sample performance, coefficient instability and implausible dynamic response have created a multi-dimensional function for model selection. The nature of the trade offs between criteria obviously differ greatly between data sets. The inclusion of a given variable may significantly lower the equation standard error, make no significant difference to the autocorrelation properties or the forecasting performance but may result in dramatic changes in the size of the other coefficients. On what basis should one decide to include or exclude it?

A further set of problems arise when independently estimated equations are inserted into a macroeconomic model. New sources of dynamic instability and inconsistent coefficient restrictions may arise, and non-zero correlations between cross-equation residuals may jeopardise the ability of the model to track data in a dynamic simulation. Given the size and computational problems of systems estimation in a large model, these do not supply a practicable answer.

In this study, single equation methods are used without apology, and although the parameters of the model selection "objective" function are not defined, systems or whole-model considerations have a larger weight attached to them in the selection of individual equations than is usually the case. Although the modelling approach is eclectic, specification tests have been carried out and these are reported alongside each regression. The predictive performance of the equations over the period 1980 first quarter to 1981 first quarter is often unsatisfactory, but it must be acknowledged that this period is untypical of the experience of the sixties and seventies, if only in the severity of the recession.

Empirical Results

The results presented in tables 2 to 7 are the preferred regression estimates of the specifications set out in section I. These regressions were selected, subject to satisfactory performance in terms of the single equation tests mentioned in section III, on the basis of their closeness of correspondence to the original model. The warnings given earlier concerning the limited amount of information contained in the data set and the constraints on estimation which may arise from the assembling of the single equation estimates both proved relevant.

Manufacturing

a) Employment

The employment equation in Table 2 combines a number of desirable features with respect to specification (3) outlined in section I. On the supply side, the population of working age appears in a one-for-one relationship with employment and there is a temporary but highly significant "discouraged worker" effect of the percentage unemployment rate. Demand effects, as expected, have exerted a more powerful influence over employment in manufacturing. Of particular interest, in addition to the term in actual output, is the proxy term for expected output. Wholesale price competiveness is highly significant despite the exclusion from the sample of the most recent data. Lagged real wages also enter negatively, reflecting the adverse effect of "too high" wage levels on employment. The time trend of 2% per year can be interpreted as the secular result of the installation of labour saving capital investment. Finally, there is a temporary and very small boost to employment of a higher real cost of capital to manufacturing.

Where the equation falls down is in its failure to predict the severity of the decline in manufacturing employment in the second half of 1980 and beyond. None of the specifications were able to track the data closely, and when this particular equation was estimated over the full sample, evidence of coefficient instability emerged. The long-run implied coefficient on competitiveness fell from -0.24 to -0.42; the real wages coefficient from -0.18 to -0.36 and the output coefficient rose from 0.42 to 0.72. On the face of it, the parameter estimates should have much wider confidence

Manufacturing

Table 2

a) Employment

$$\Delta \ln L_{mt} = \underset{(3.2)}{-0.356} + \underset{(1.7)}{0.164}\Delta \ln L_{mt-1} - \underset{(3.6)}{0.0269}\Delta \ln u_t$$

$$+ \underset{(2.6)}{0.00029}\left[\tfrac{1}{2}\left(\rho_{mt-2} + \rho_{mt-3}\right) - \rho_{mt-4}\right]$$

$$- \underset{(3.8)}{0.1085}\ln (L_m/P)_{t-3} + \underset{(2.7)}{0.0513}\ln Q_{mt}$$

$$- \underset{(3.1)}{0.0259}\ln\left(\frac{po_m \cdot e}{poW_m}\right)_{t-2} - \underset{(2.1)}{0.0198}\ln W_{mt-1}$$

$$- \underset{(3.7)}{0.000552}\ t$$

R^2 = 0.87

SE = 0.22%*

DF = 47

65Q1 - 78Q4

* 17,200 people (at the mean)

$z_1(5)$ = 13.0 (11.1)

$z_2(6)$ = 7.0 (12.6)

$z_2(9)$ = 57.2 (16.9)

$z_3(9,47)$ = 2.66 (2.15)

$z_4(9)$ = 14.3 (16.9)

$z_5(13)$ = 19.1 (22.4)

Stationary State Solution

$$\ln L_m = 0.47\ln Q_m + 1.0 \ln P - 0.24\ln\left(\frac{po_m \cdot e}{poW_m}\right)$$

$$- 0.18 \ln W_m - (2.05\% \text{ per annum}) - 3.278$$

intervals attached to them than the in-sample standard errors would suggest. However, it should be stressed that the experience of 1980/81 is very dissimilar to that of 1963/79 to the extent that 60% of the total sums of squares of the dependent variable is accounted for by the final six quarters.

In other respects, autocorrelation and heteroscedasticity for example, the performance of the equation is satisfactory.

b) Earnings

Earlier we assigned to manufacturing the role of 'leading sector' in pay determination. In linking the other sectors' earnings indices to that of manufacturing, it is clear that the selection of a well-behaved equation for the latter has great importance. The link also has its advantages, the foremost being that the richness of the specification employed in the manufacturing earnings equation is borrowed by the equations for the public and residual sectors' earnings.

However, the estimation of this equation proved problematic, not least because the author had addressed this particular task on a number of previous occasions. An innovation in the specification was the term in the relative input to output wholesale price index. The results in respect of this variable were disappointing, as were attempts to include the "other employment costs" variable. The failure of the former modification to the real factor price can be attributed to the dominating effect of output in the regression. If manufacturing output was reduced by the increase in the relative price of non-labour inputs, as seems plausible, then the introduction of this variable into the earnings equation could be considered double-counting. A similar argument could be made in the case of real other employment costs per employee but it is more likely that the econometric problem of collinearity was the telling factor in its insignificance.

b) **Earnings** **Table 3**

$$\Delta \ln W_{mt} = \underset{(4.2)}{1.002} + \underset{(4.0)}{0.249}\, \Delta_2 \ln W_{mt-1}$$

$$- \underset{(3.3)}{0.461}\, \Delta \ln po_{mt} + \underset{(1.7)}{0.327}\, \Delta \ln po_{mt-1}$$

$$+ \underset{(2.0)}{0.393}\, \Delta \ln pc_{t-1} + \underset{(4.6)}{0.187}\, \Delta\Delta \ln (Q_m/P)_t$$

$$- \underset{(2.6)}{0.112}\, \Delta \ln \left(\frac{pi_m}{po_m}\right) + \underset{(4.2)}{0.110}\, \Delta_3 \ln \left(\frac{pi_m}{po_m}\right)_{t-1}$$

$$- \underset{(4.4)}{0.102}\, \Delta \ln u + \underset{(2.7)}{0.055}\, \Delta \ln u_{t-3}$$

$$- \underset{(1.5)}{0.491}\, \Delta \ln L_{mt-1} - \underset{(4.9)}{0.193} \ln \left(\frac{W_{mt-3}}{po_{mt-2}} \cdot \frac{P_{t-3}}{Q_{mt-3}}\right)$$

$$- \underset{(0.9)}{0.0152} \ln \left(\frac{pi_m}{po_m}\right)_{t-4} + \underset{(3.7)}{0.00044}\, t$$

R^2	=	0.773	$Z_1(5)$	=	5.4 (11.1)
SE	=	0.82%	$Z_2(5)$	=	10.6 (11.1)
DF	=	50	$Z_3(5,50)$	=	1.7 (2.41)
64Q1 - 79Q4			$Z_4(15)$	=	23.9 (25.0)
			$Z_5(13)$	=	14.6 (22.4)

Stationary State Solution

$$\ln W_m = 1.0(\ln po_m + \ln Q_m - \ln P) - 0.08 \ln \left(\frac{pi_m}{po_m}\right) + 0.93\%\text{p.a.} + 5.20$$

The equation reported in Table 3 is rich in dynamic terms, but all that influences earnings in the end is the value of manufacturing output, from which is deducted a small relative input price effect, and an effect of the population of working age. Whilst the latter term is important in the very long run for total employment, it bears little relationship to the behaviour of manufacturing employment over this short period. Consequently, a time trend is required to represent the additional effect of labour-saving productivity gains.

In the short-run the dynamics are very complicated with two difference terms each of output prices, output per head of population of working age, percentage unemployment and relative non-labour input prices. There are also transitory effects of lagged consumer prices and lagged manufacturing employment on earnings. One abvious area of concern is whether the complicated dynamic structure is real or induced by failure to take account of simultaneous relationships between earnings, prices and output. The tests necessary to establish this have yet to be carried out, but one factor which runs counter to the simultaneity explanation is the perverse sign of the current term in output price inflation. If simultaneity were a problem, one would expect this term to carry a strong positive coefficient. However, there is no convincing explanation of the negative sign either.

The autocorrelation, heteroscedasticity and forecast tests all proved satisfactory. This presents the dilemma that on a single equation basis the equation cannot easily be rejected. However, in a full model context, problems arise on account of the implausibly large reduction in earnings growth which is predicted for the immediate future.

Public Administration

a) Employment

The first regression in Table 4 contains the controversial term in the female participation rate, F. Although significant, to be included properly it must also be exogenously determined. In other words, to defend its inclusion in this equation, the theory must adduce, for example, sociological and demographic reasons for the increase in female participation. If the true cause of the significant effect implies a tautology, such as that the government was anxious to comply with equal pay and opportunity legislation, then the complete model must be specified.

In the second regression the problem is sidestepped by excluding F altogether and adopting a different specification. The new variable, C_g, represents general government expenditure on labour at constant wage and pension rates. One would expect a very close relationship between C_g and L_g even that there might be a fixed coefficient identity between them, but this is not the case. In fact, changes in composition of the public administration (and local authority) labour force has guaranteed significant divergences between the two series and the long-run adjustment term is poorly determined.

The advantage of a specification which includes C_g is that it allows the government to directly influence the level of employment in public administration. The earlier regression does not, and instead regards the volume of expenditure as being better approximated by a time trend over the period 1963-1975, and by a constant thereafter. The argument underlying this alternative is that the pre-1975 period contained legislation which had definite employment consequences (e.g. equal pay, reorganisation of local government), whilst the emphasis of later years has been to economise on the cost of the public sector. On balance, the inclusion of C_g, a recognised

Public Administration   Table 4A

a) Employment

(i) $$\Delta \ln L_{gt} = -\underset{(4.6)}{0.306} + \underset{(3.7)}{0.346}\, \Delta \ln L_{gt-1} + \underset{(3.7)}{0.267}\, \Delta \ln L_{gt-3}$$

$$+ \underset{(2.9)}{0.034}\, \Delta_2 \ln W_{gt-2} + \underset{(5.4)}{0.0096}\, \Delta DUMMY\ 74Q3$$

$$- \underset{(4.7)}{0.1007} \ln\left(L_g/P\right)_{t-2} + \underset{(3.2)}{0.1314}\, F_t$$

$$+ \underset{(4.0)}{0.00055}\, (t - t75)$$

R^2 = 0.749

SE = 0.23%*

DF = 56

64Q1 - 79Q4

$z_1(5)$ = 1.0 (11.1)

$z_2(5)$ = 17.1 (11.1)

$z_3(5,56)$ = 2.59 (2.38)

$z_4(8)$ = 7.6 (15.5

$z_5(14)$ = 9.9 (23.7)

* 10,000 people (at the mean)

Stationary State Solution

$$\ln L_g = 1.0 \ln P + 1.305 F - 3.04$$

Table 4B

$$\text{(ii)} \quad \Delta \ln L_{gt} = -\underset{(1.3)}{0.374} + \underset{(6.6)}{0.582}\,\Delta \ln L_{gt-1}$$

$$+ \underset{(1.7)}{0.132}\,\Delta \ln L_{gt} + \underset{(4.0)}{0.154}\,\Delta \ln C_{gt}$$

$$- \underset{(2.2)}{0.036}\,\Delta \ln W_{gt-4} + \underset{(6.6)}{0.0121}\,\Delta\,\text{DUMMY 74Q3}$$

$$- \underset{(1.3)}{0.0373} \ln \left(\frac{L_g}{P.C_g}\right)_{t-2} - \underset{(2.0)}{0.00368} \ln u_{t-1}$$

$$+ \underset{(1.3)}{0.00005}\; t^{\cdot} + 0.002\; Q1 + 0.0013 Q3$$

$R^2 = 0.738$

SE $= 0.23\%$*

DF $= 52$

64Q2 - 79Q4

$z_1(5) = 1.5\ (11.1)$

$z_2(5) = 14.3(11.1)$

$z_3(5,52) = 2.2(2.40)$

$z_4(11) = 9.1(19.7)$

$z_5(12) = 12.1(23,7)$

* 10,000 people (at the mean)

Stationary State Solution

$$\ln L_g = 1.0 \ln C_g + 1.0 \ln P - 0.099 \ln u$$

$$+ \text{(0.44\% per annum)}$$

where C_g = CCGE(1 - RYECPA) + CLAE(1 - RYECHE) control or policy variable, is a much more attractive option from a full-model perspective. The other advantages of the second regression are that the forecast performance is rather better, with the Chow test at least being accepted at the 95% level, and that the unemployment term enters significantly, representing the "discouraged worker" effect. What is also interesting is that the lagged difference term in real public earnings carries the expected negative sign in the second regression.

b) Earnings

Although the full set of arguments contained in specification (8) were entered in the unrestricted regression, most of these were insignificant and were deleted in the course of successive coefficient restriction tests. The regression gives overwhelming importance to the behaviour of manufacturing earnings and any further work on this equation would probably restrict the dependent variable to be the ratio of public administration to manufacturing earnings, given the instantaneous response profile implied by the lagged ratio terms in conjunction with the dynamic terms. The only other significant effects were the other employment costs terms, in both changes and levels, and a perverse effect of the change in unemployment. The only justification for the latter term would seem to be the reasoning that increasing unemployment puts pressure on the government to relax fiscal and monetary policy, thus permitting faster growth of nominal wages. One of the disappointing aspects of this equation is the failure to identify any evidence of a reaction function in terms either of unemployment or the cyclically-adjusted borrowing requirement. The forecasting performance of the equation is adequate although both tests were narrowly failed. In any further work, more effort would be applied to the detection of incomes-policy induced deviations of public sector earnings from manufacturing, and also to the hypothesis that both tertiary and manufacturing earnings influence public sector earnings.

b) Earnings   Table 5

$$\Delta \ln W_{gt} = \underset{(3.4)}{-0.0494} + \underset{(1.3)}{0.4456}\, \Delta \ln W_{mt-1}$$
$$+ \underset{(2.2)}{0.4567}\, \Delta_2 \ln W_{mt-1} + \underset{(2.7)}{0.1029}\, \Delta \ln u_{t-1}$$
$$- \underset{(1.9)}{0.2069}\, \Delta \ln oc_{gt} + \underset{(0.7)}{0.0217}\, \Delta \ln b_t$$
$$+ \underset{(1.4)}{1.1008}\, \Delta \ln (L_{cg}/L_g)_t - \underset{(2.8)}{0.2709} \ln \left(\frac{W_g}{W_m}\right)_{t-1}$$
$$- \underset{(1.8)}{0.1399} \ln \left(\frac{W_g}{W_m}\right)_{t-4} - \underset{(2.3)}{0.02098} \ln oc_{gt-4}$$
$$+ \underset{(5.1)}{0.0823}\, \Delta\, \text{DUMMY 1975 Q1} - \underset{(1.3)}{0.0081}\, Q1 + \underset{(1.2)}{0.0077}\, Q3$$

$\bar{R}^2 = 0.687$

SE = 1.87%

DF = 51

64Q1 - 79Q4

$Z_1(5) = 1.33$ (11.07)

$Z_2(5) = 13.83$ (11.07)

$Z_3(5,51) = 2.49$ (2.41)

$Z_4(13) = 18.5$ (22.4)

$Z_5(12) = 8.0$ (21.0)

Stationary State Solution

$$\ln W_g = 1.0 \ln W_m - 0.051 \ln oc_g - 0.120$$

Primary and Residual Tertiary

a) Employment

The equation in Table 6 was one of the most encouraging of all the results in that despite the lack of variability of the series for residual sector employment, several well-determined coefficients were estimated. In the 'steady state', employment is determined by population, in common with each of the other categories, retail sales volume, the real interest rate and the real level of unemployment benefit. In the short run, the female participation ratio and the unemployment rate each have the expected signs, but other employment costs does not. The forecasting and autocorrelation properties of this equation are good and the Breusch-Pagan test is also passed satisfactorily.

The sign of the real interest rate suggests that the dominant effect on this sector amongst those raised in Section I is that implied by stockholding behaviour. Although the effect is not numerically large, there is evidence that as the cost of holding stocks rises, so employment in distributive and service industries is reduced.

The significance of the real benefit level, b, came as a surprise and one must be wary of placing too much confidence in the size of the estimated coefficient. The equation implies that a 20% reduction in benefit, such as that produced by the abolition of Earnings Related Supplement, would eventually increase employment in the residual sector by over 3%, or over 300,000 people.

The combination of the three preferred employment equations in Tables 2, 4B and 6 provides a fairly comprehensive representation of the arguments forwarded in section I. Tax and benefit rates are poorly represented but it is questionable whether one should expect to observe significant aggregate

Primary & Residual Tertiary — Table 6

a) Employment

$$\Delta \ln L_{rt} = \underset{(4.5)}{-0.202} + \underset{(1.3)}{0.118}\,\Delta \ln L_{rt-1}$$

$$+ \underset{(5.5)}{0.513}\,\Delta \ln F_t + \underset{(2.6)}{0.0296}\,\Delta \ln oc_{rt}$$

$$- \underset{(3.2)}{0.032}\,\Delta \ln u_t - \underset{4.2)}{0.115} \ln \left(L_r/P\right)_{t-2}$$

$$- \underset{(3.7)}{0.00044}\left[\tfrac{1}{2}(\rho_{rt} + \rho_{rt-1})\right]$$

$$+ 0.0277 \ln RSV_{t-1} - \underset{(4.7)}{0.0198} \ln b_t$$

R^2 = 0.708	$Z_1(5)$ = 6.1(11.1)
SE = 0.33%*	$Z_2(4)$ = 1.8(9.5)
DF = 54	$Z_3(4,54$ = 0.4(2.6)
64Q2 - 79Q4	$Z_4(9)$ = 9.4(16.9)
	$Z_5(14)$ = 22.0(23.7)

* 33,800 people (at the mean)

Stationary State Solution

$$\ln L_r = 1.0 \ln P + 0.24 \ln RSV - 0.0038\,\rho_r$$

$$- 0.173 \ln b - 1.76$$

effects given the microeconomic nature of labour supply decisions.

A final observation is to record the disparity between the speeds of adjustment to the steady state implied by private and public sector employment equations. It is true that equation 4A has a larger absolute adjustment coefficient, but the doubt over that specification obviously carries over to all the coefficients.

b) Earnings

Residual sector earnings follow manufacturing earnings much less closely than public sector earnings. Instead the regression in Table 7 attaches greater weight to consumer prices in the determination of the earnings of the mostly private tertiary sector. The volume of retail sales has an extraordinarily large impact on earnings, but as the index only applies to a part of the sector, it is possible to reconcile this with a stable model. It would be preferable, however, if there were some counterbalancing effect from another constituent activity. Finally, the negative real interest rate effect observed for employment is encountered again but with little quantitative importance. A five percent real interest rate (ex post) implies a level of real earnings 1.8% lower than a zero real rate of interest. The single equation tests were passed easily, and whilst there is plenty of room for improvement the equation is judged satisfactory.

b) **Earnings** **Table 7**

$$\Delta \ln W_{rt} = -\underset{(5.9)}{1.653} + \underset{(1.3)}{0.116}\,\Delta_3 \ln W_{rt-1}$$

$$-\underset{(1.8)}{0.74}\,\Delta \ln L_{rt-2} - \underset{(2.3)}{1.056}\,\Delta \ln F_t$$

$$-\underset{(4.1)}{0.506} \ln\left(\frac{W_r}{pc}\right)_{t-1} - \underset{(1.3)}{0.193} \ln\left(\frac{W_r}{W_m}\right)_{t-1}$$

$$+\underset{(3.0)}{0.476} \ln RSV_t + \underset{(2.4)}{0.386} \ln RSV_{t-1}$$

$$-\underset{(3.1)}{0.00253}\,\rho_{rt} + \underset{(1.4)}{0.0072}\ Q1$$

$R^2 = 0.432$	$z_1(5) = 3.6\ (11.1)$
$SE = 1.76\%$	$z_2(5) = 5.3\ (11.1)$
$DF = 54$	$z_3(5,54) = 0.7\ (2.4)$
64Q1 - 79Q4	$z_4(10) = 11.6\ (18.3)$
	$z_5(12) = 17.0\ (21.0)$

Stationary State Solution

$$\ln W_r = 0.724 \ln pc + 0.276 \ln W_m + 1.23\ RSV - 0.00363\rho_r - 2.368$$

IV Concluding Remarks

The objective of this paper was to explore the reduced form neoclassical labour market model at a less aggregative level than in Beenstock and Warburton (1980). The advantage of using quarterly data lies in the additional degrees of freedom, but this does not necessarily imply much of a gain if this is not accompanied by extra data variability. Any straight line can be used to derive an explanation of another straight line.

As far as the empirical results are concerned, most of the original hypotheses have gained a measure of support. In addition to indicators of demand, competitiveness effects were observed for manufacturing, demographic effects for public administration and real interest rate and real benefit effects for the primary and private tertiary sector.

The next step in the research would be to incorporate the six-equation system into a full econometric model. At this stage, one tentative attempt has been made to do this in the context of the London Business School model. However, rather than proceed with detailed simulations it was felt that a re-examination of at least two of the original equations was called for. The weaknesses that emerged from the whole model analysis stemmed from two sources. Firstly the drastic decrease in real earnings growth that was implied by the low levels of output at the end of the estimation period and secondly, some ambiguities concerning the role of the female participation variable in the model. The latter problem is rather deep-seated, in that it is not clear whether the public sector expanded its employment of women in the early seventies as a deliberate policy, or whether women increased their participation because of the higher differential earnings that were offered following the legislation of 1970. The resolution of this problem requires that both phenomena be explained, not just the rise in public employment.

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APPENDIX A

Data Definitions and Sources

L	:	Employees in employment, UK in thousands; Deparyment of Employment Gazette and H.M. Treasury. (Subscript denotes the sector concerned)
u	:	Percentage unemployment rate, UK, seasonally adjusted excluding school leavers; Department of Employment Gazette.
ρ	:	Real interest rate defined by the formula: $(\frac{r\%}{100} - \Delta_4 \ln \rho.)$ Interest rate used was the minimum Lending Rate (% p.a.); Bank of England Quarterly Bulletin.
P	:	UK population of working age, thousands; Interpolated from Annual Abstract of Statistics.
Q	:	Output index, 1975 = 100; Economic Trends Annual Supplement. (Subscript denotes the sector).
po_m	:	Price index of manufactured output, UK, 1975 = 100; Economic Trends Annual Supplement.
poW_m	:	World price index of manufactures expressed in world currency, 1975=100; Constructed as an 18-country trade-weighted average of OECD country price indices.
W	:	Nominal earnings per employee index, 1975=100; Economic Trends Annual Supplement and H.M. Treasury (Subscript denotes the sector).
w_m	:	Real Wage index for manufacturing, 1975 = 100; Constructed as (W_m/po_m).
t	:	Linear time trend, 1955Q1 = 1, etc.
e	:	UK effective rate, 1975 = 1; Economic Trends Annual Supplement and LBS calculations using period average data from International Financial Statistics
pc	:	Consumers' Expenditure Deflator, UK, 1975= 1; Economic TRends (by calculation).
pi_m	:	Price index of inputs to UK manufacturing industry, 1975 = 1.0; Economic Trends Annual Supplement.
F	:	Female Participation Ratio, proportion; Department of Employment Gazette and Annual Abstract of Statistics.

t75	:	Linear time trend, 1975Q1 = 1, etc.
C_g	:	General government expenditure on employment and pension incomes at constant wage and pension levels; constructed from the Blue Book and data supplied by H.M. Tresury as follows: C_g = CCGE(1 - RYECPA) + CLAE(1 - RYECHE) where CCGE and CLAE are 1975 volume expenditures on wages abd other employment costs for central government and local authority; RYECPA and RYECHE are the corresponding fractions of total employment income attributable to pensions for Central government and local authorities.
Q1,Q2,Q3	:	Quarterly dummies.
oc_r	:	Other employment costs per employee index for residual sector, 1975 = 1; constructed from Economic Trends Annual Supplement.
RSV	:	Retail Sales Volume index, 1975 = 100; Economic Trends Annual Supplement.
b	:	Real benefit entitlement including Earnings Related Supplement of a married man with no children, 1975 per week; Social Security Statistics.
DUMMY 74Q3	:	Dummy variable for 1974 Q3.

Subscripts

m	:	Manufacturing
g	:	Public Administration and the Health and Education functions of Local Authorities.
r	:	Primary and Residual Tertiary Sector
t	:	Time in quarters

Operators

ln	:	Natural logarithm
Δ	:	First difference
Δn	:	n-period difference

APPENDIX B

Econometric diagnostic tests

$Z_1(p)$: Lagrange Multiplier test against significant auto-correlation to degree p.

$Z_2(q)$: Chi-squared forecast test over the succeeding q quarters.

$Z_3(r,s)$: Chow test for model constancy over the full period (r+s) against the restricted period (r)

$Z_4(t)$: Breusch -Pagan heteroscedasticy test with t regressors (including the constant).

$Z_5(u)$: Ljung-Box test * for autocorrelated residuals to degree u.

* adjusted for small samples.

Chart 1 : Output Indices

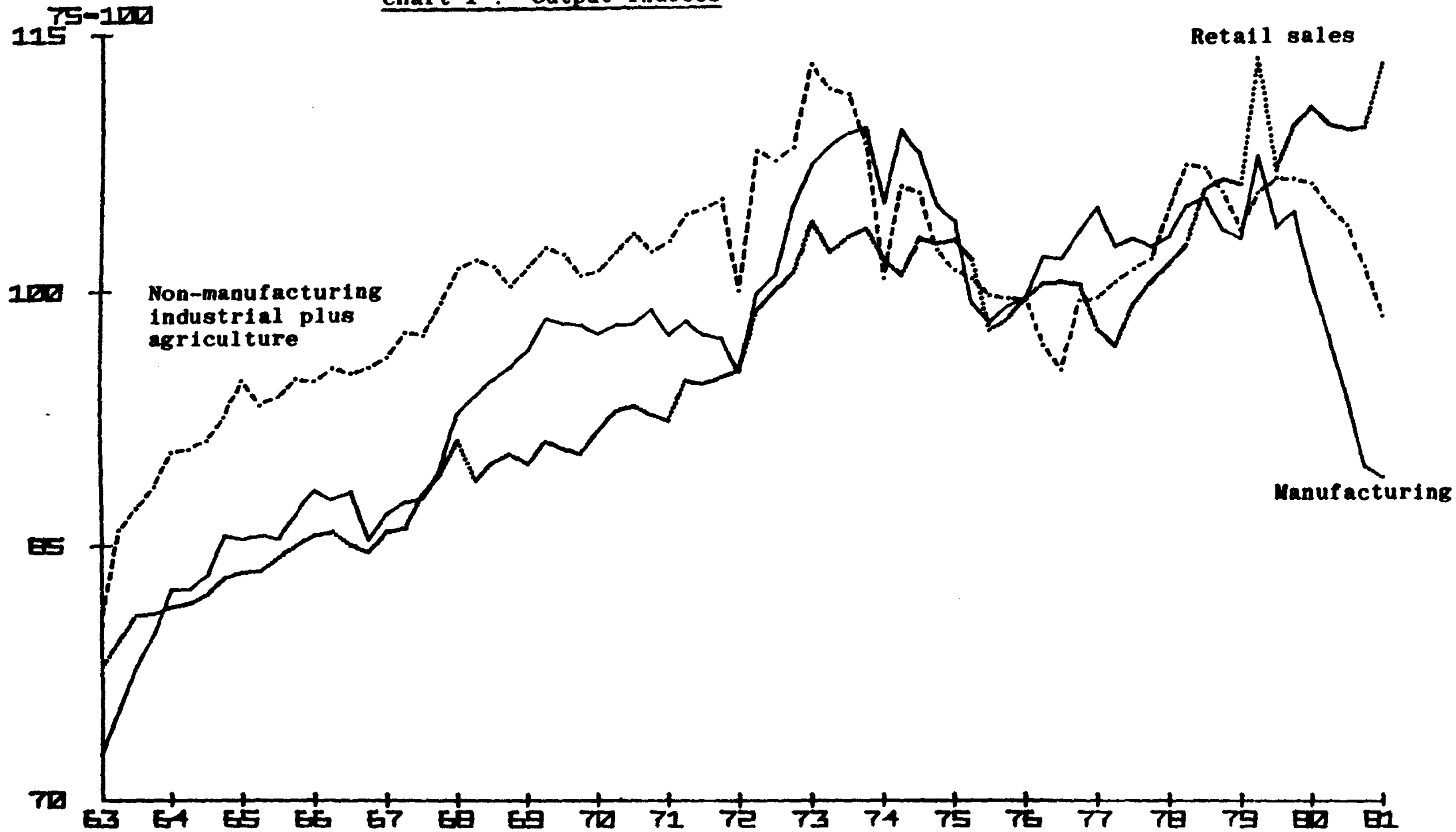


Chart 2 : Real earnings indices

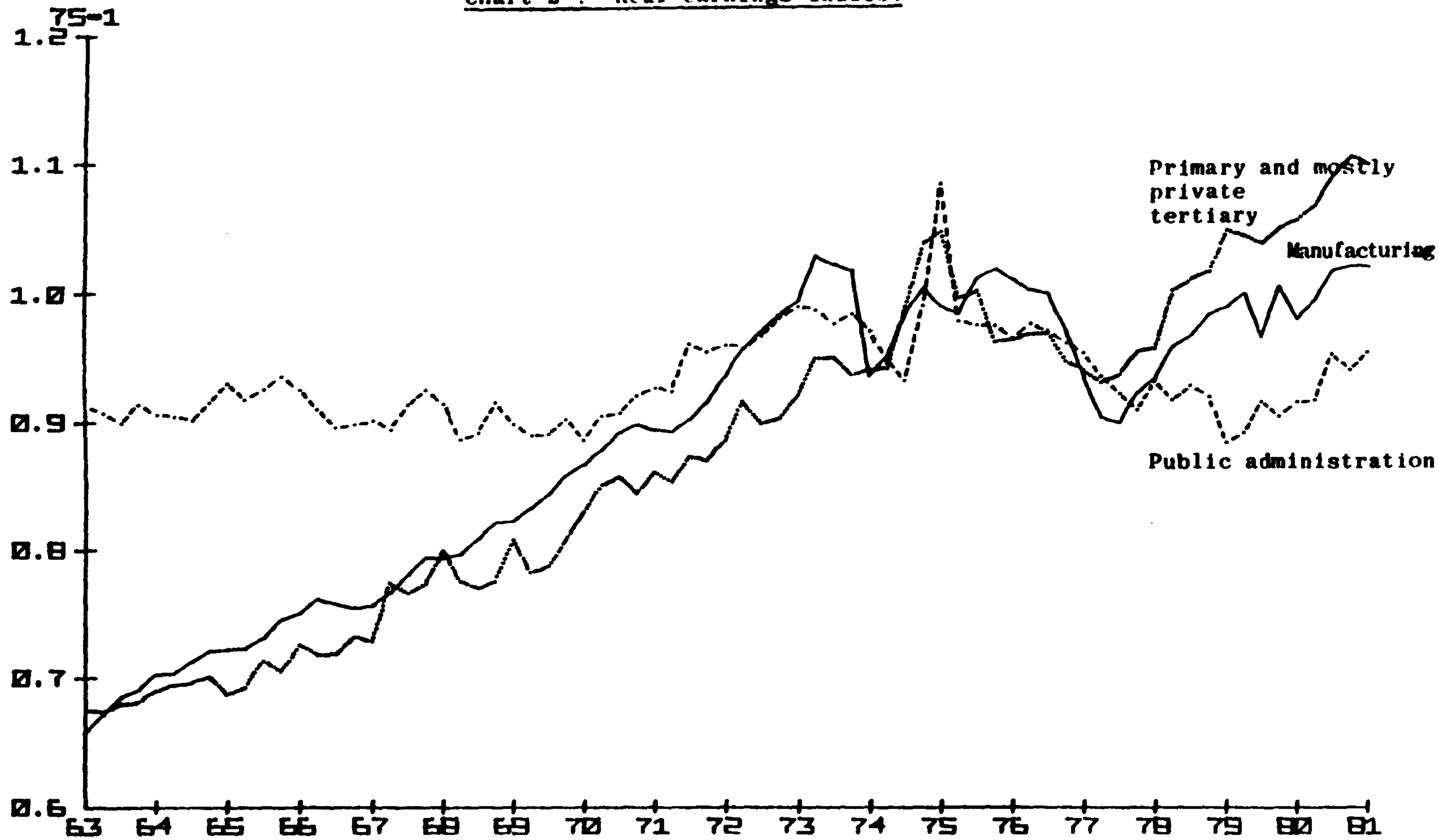


Chart 3 : Other Employment Costs indices

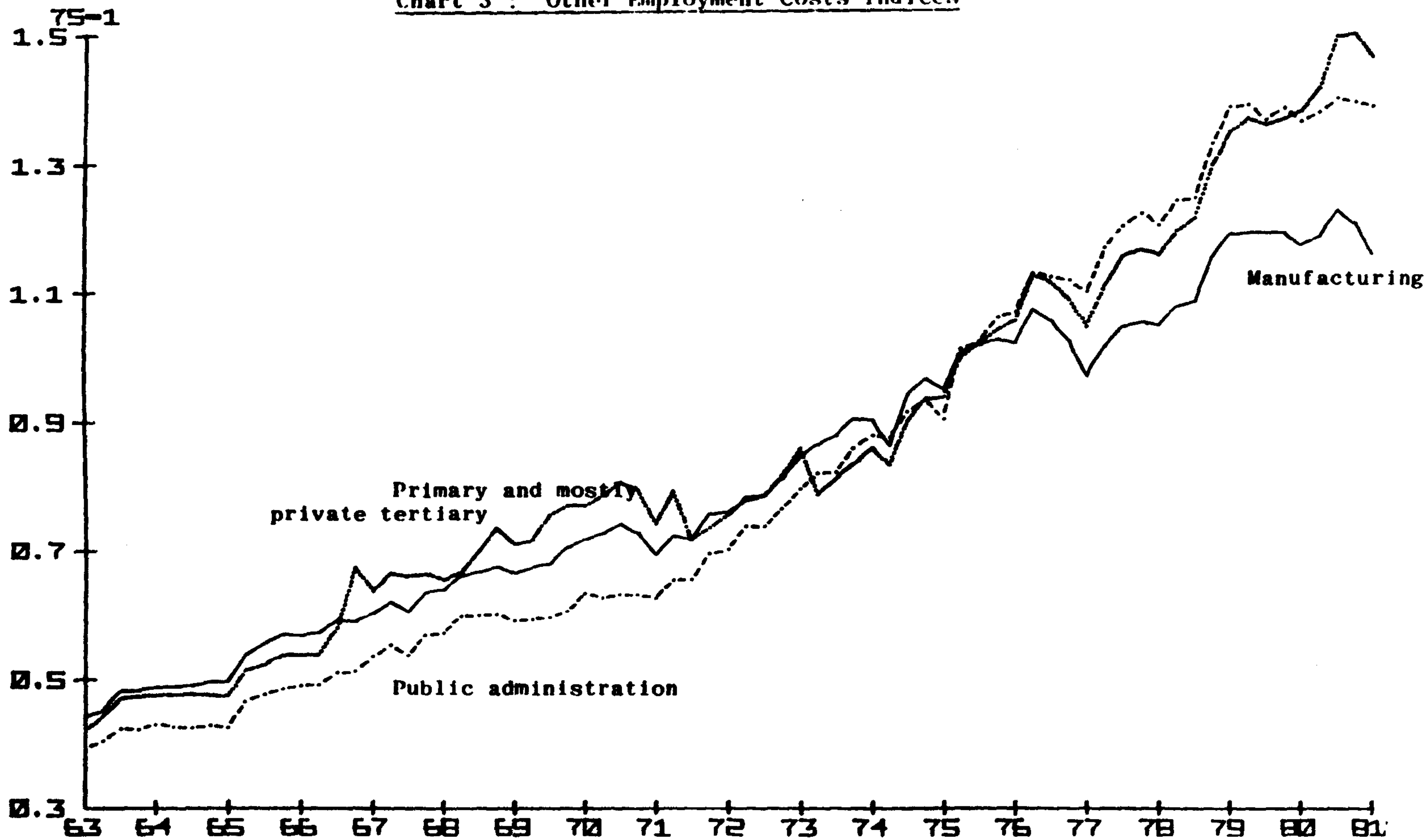


Chart 5 : Wholesale input-output price ratio for manufacturing

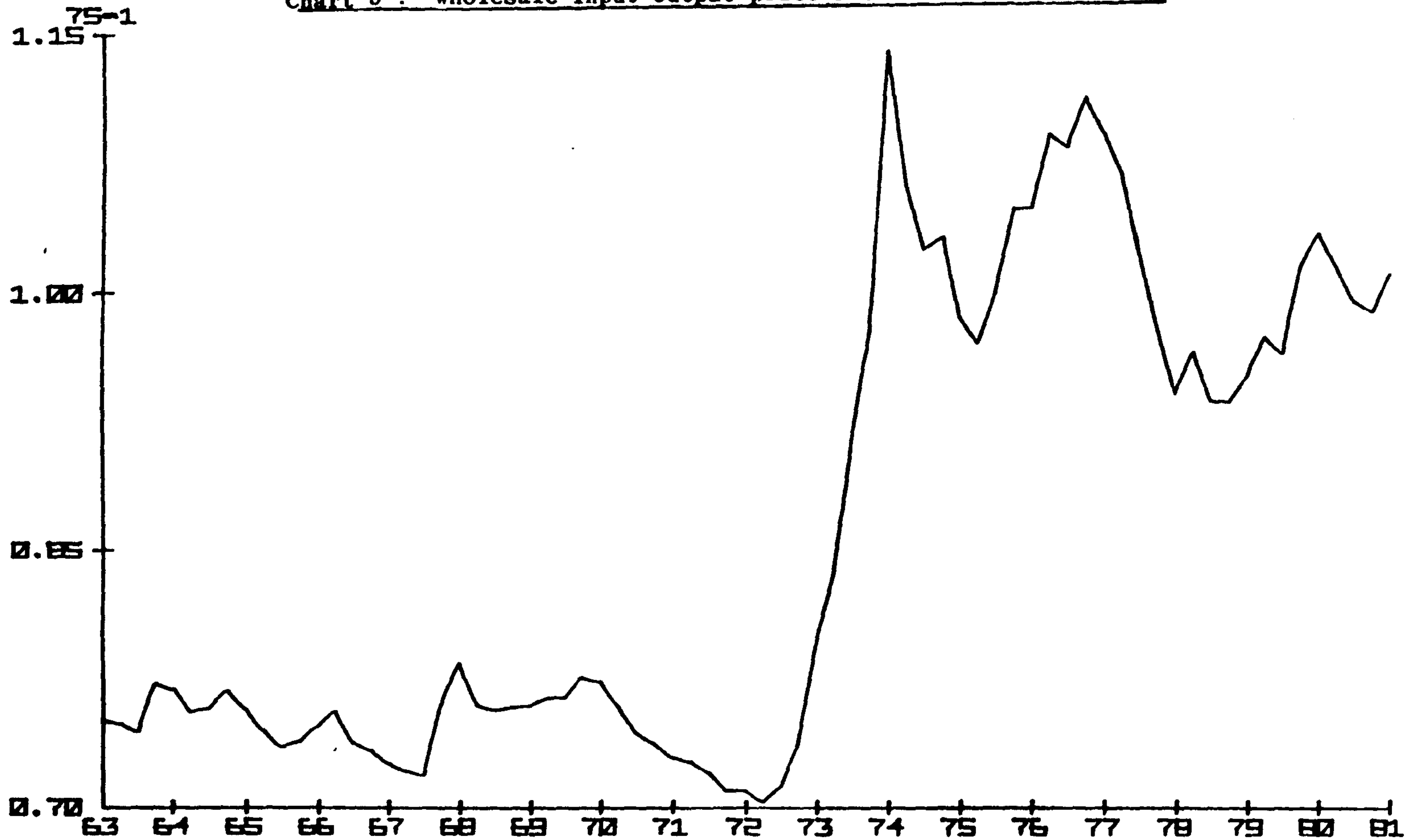


Chart 6 : Indices of population of working age and female participation

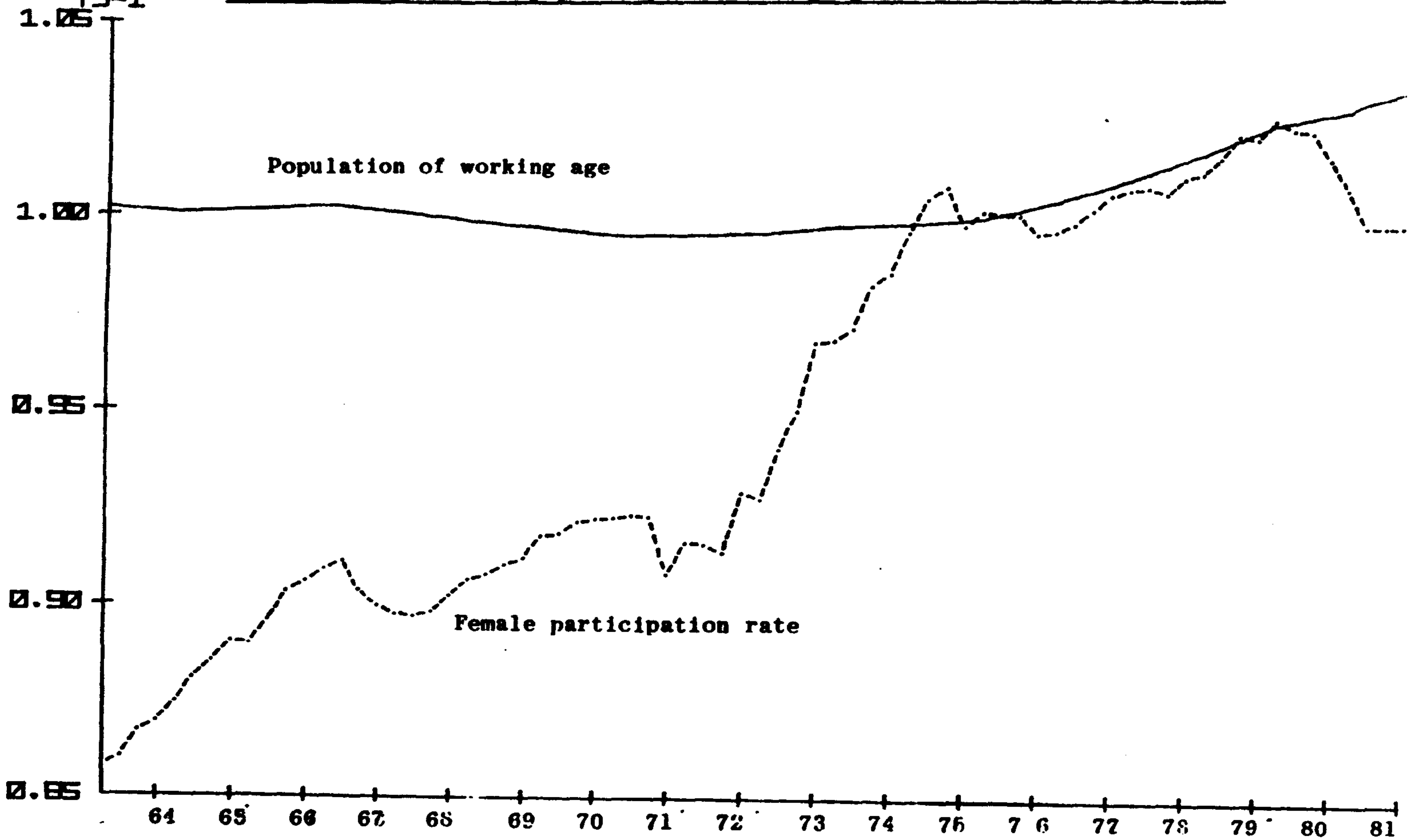


Chart 7 : Real unemployment benefit for Earnings Related Supplement receipients (£ per week in 1975 prices)

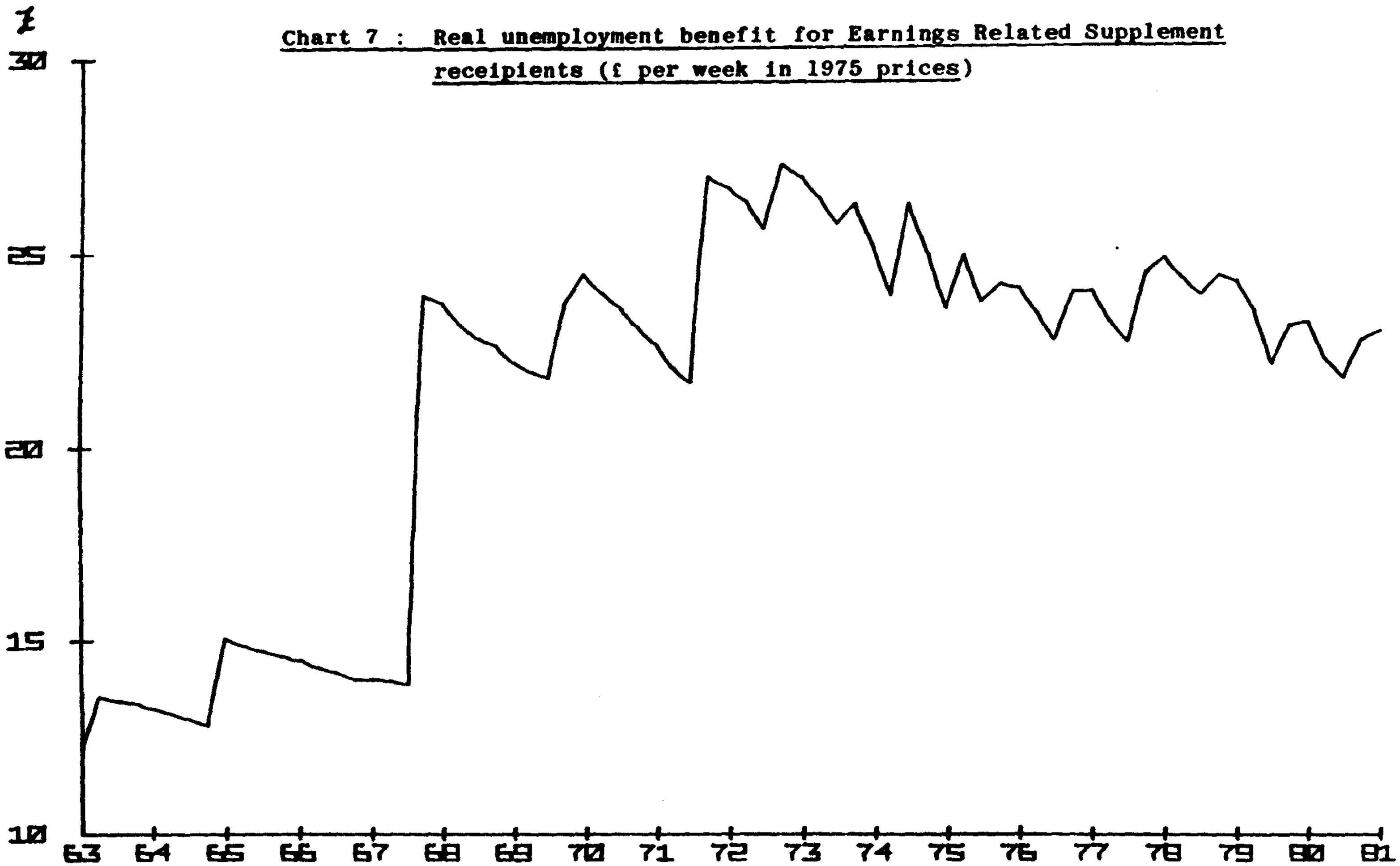


Chart 8 : Tax ratios

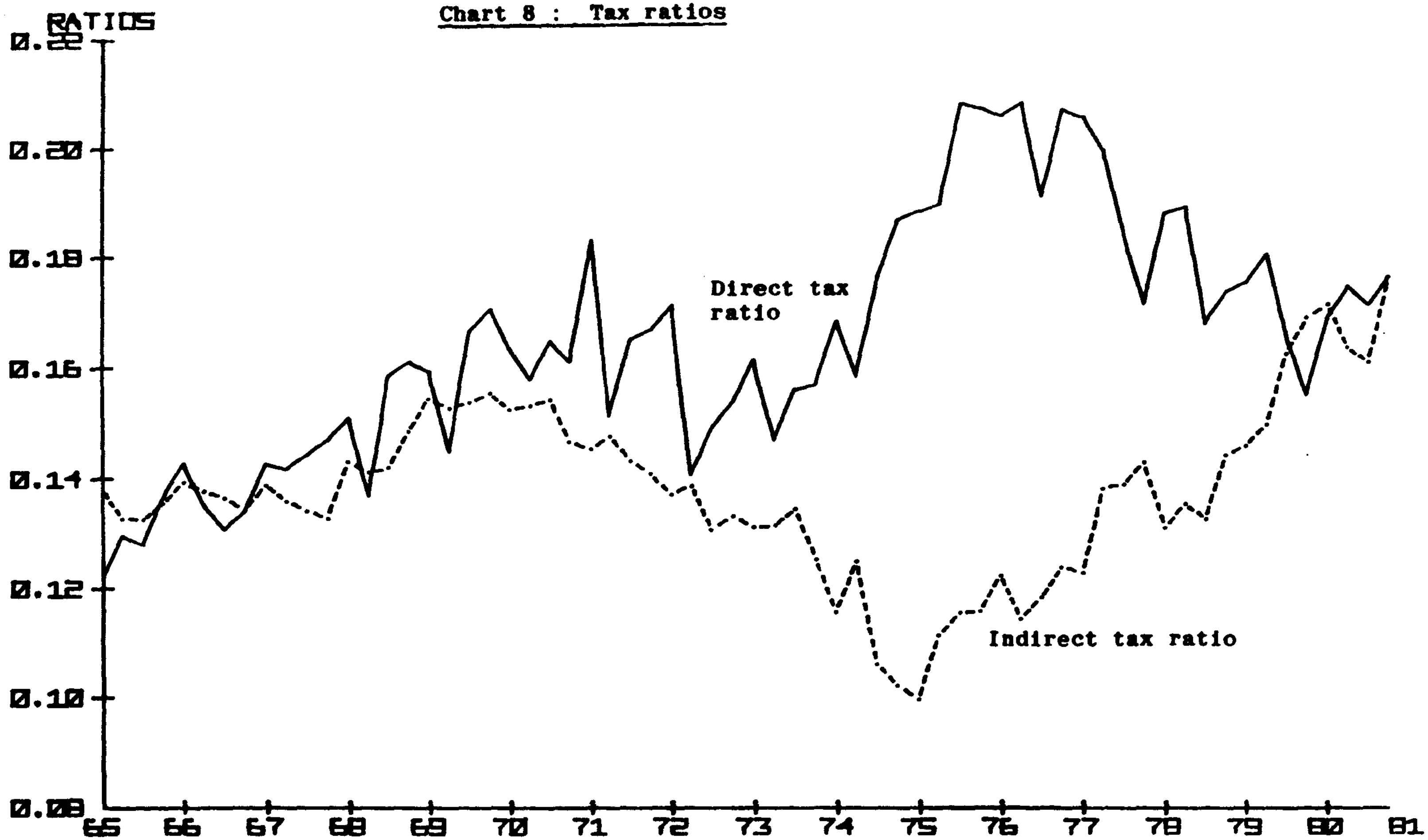


Chart 9 : Indices of Employment

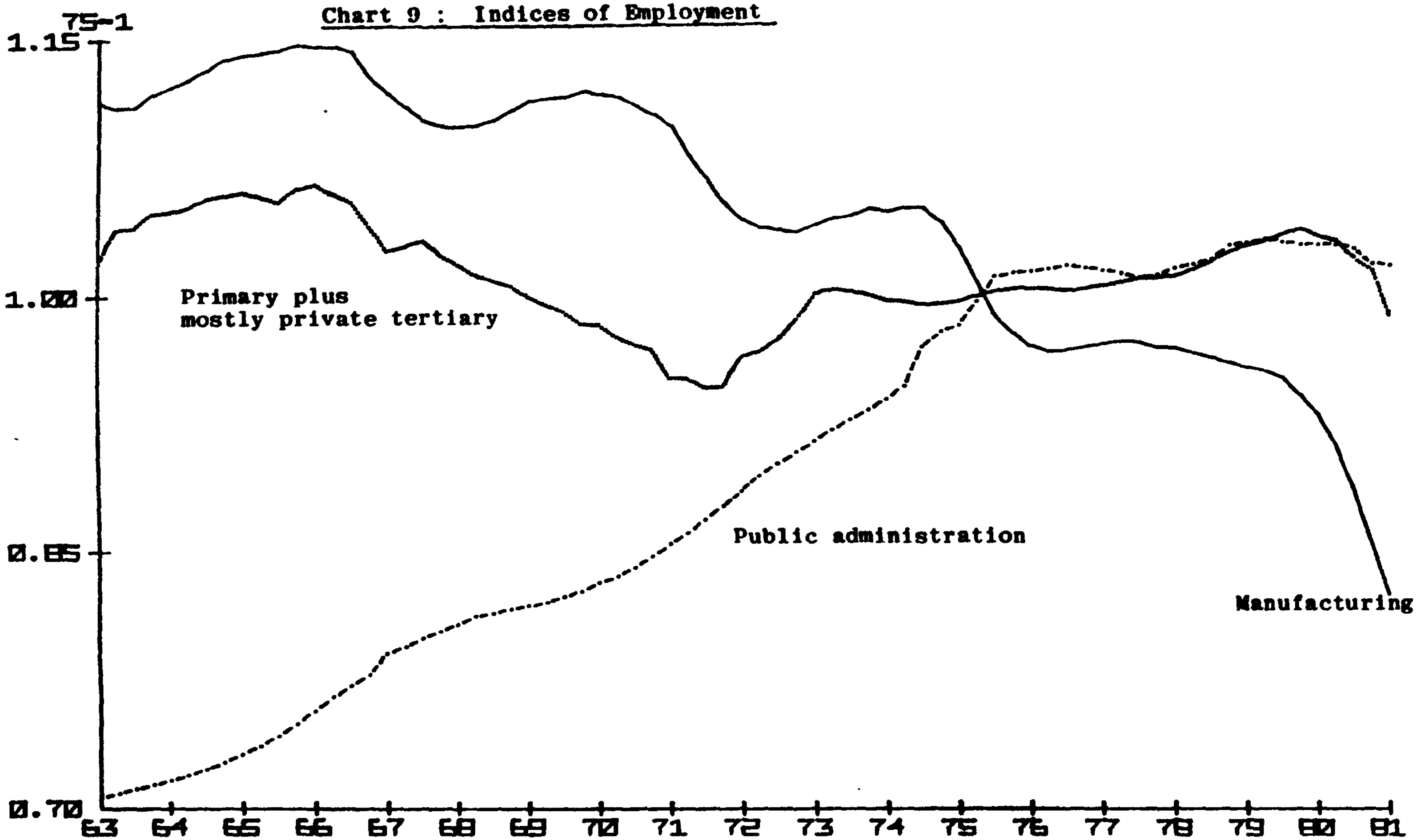


Chart 10 : Government employment reaction function variables

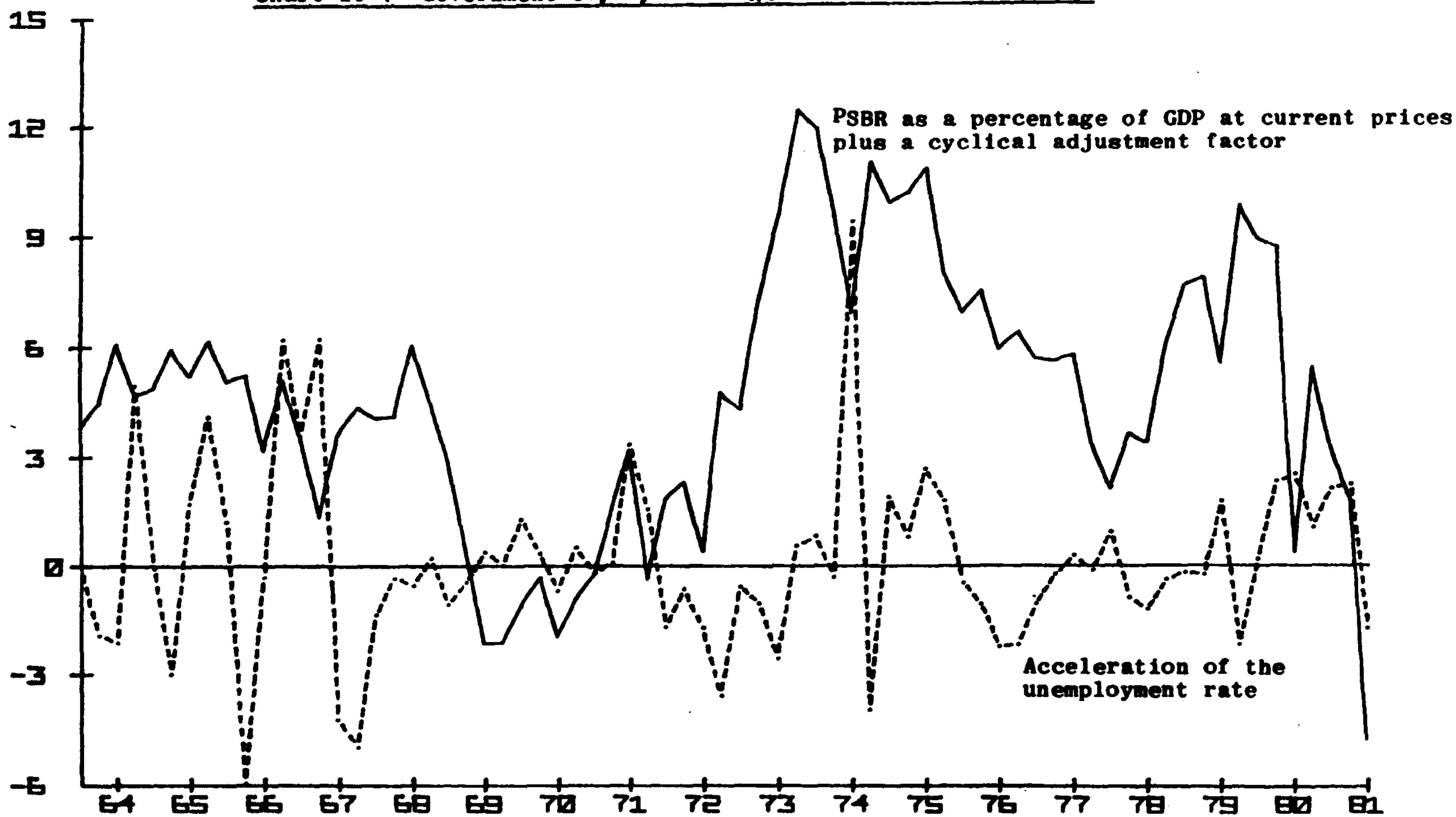


Chart 11 Percentage rate of unemployment

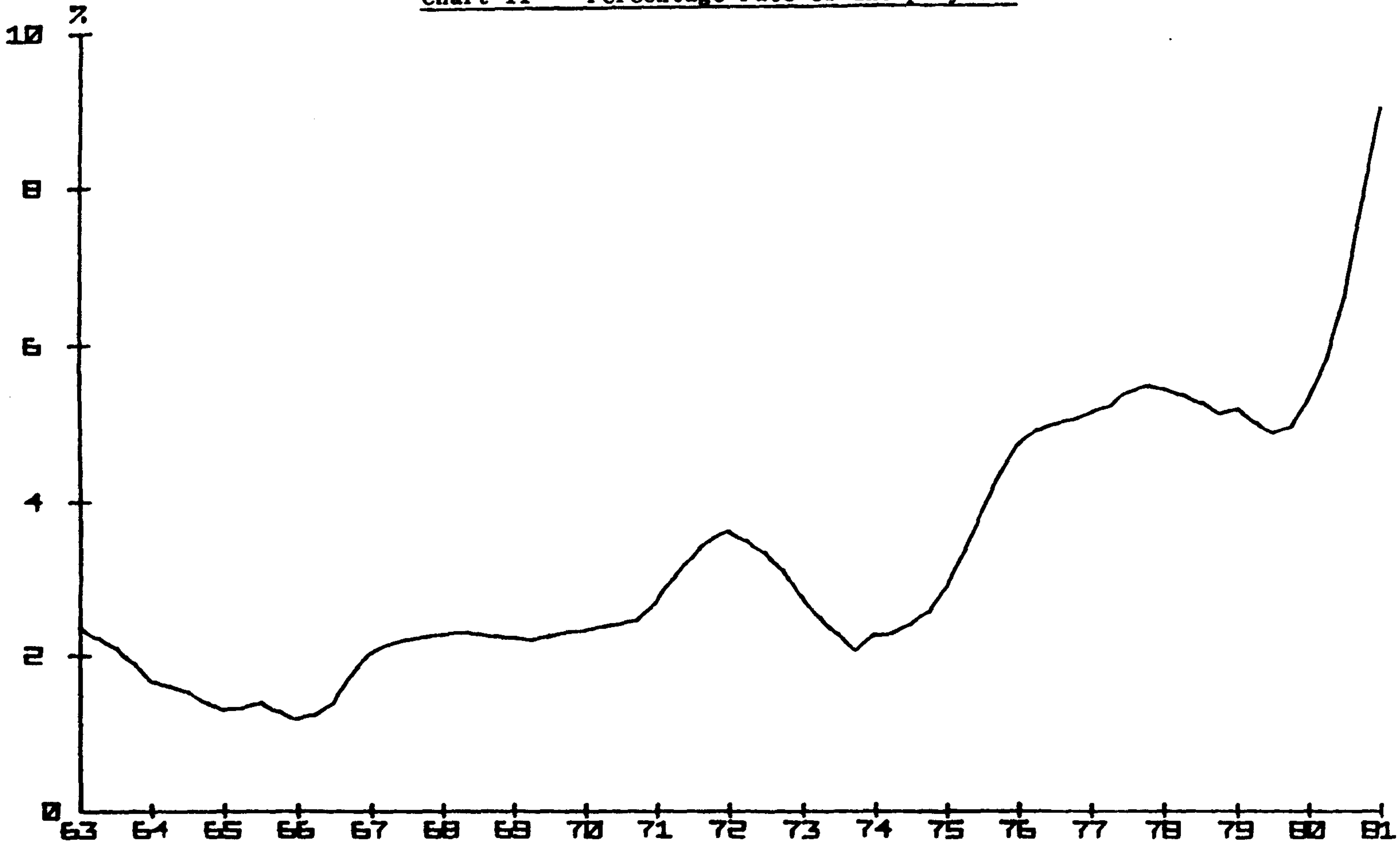
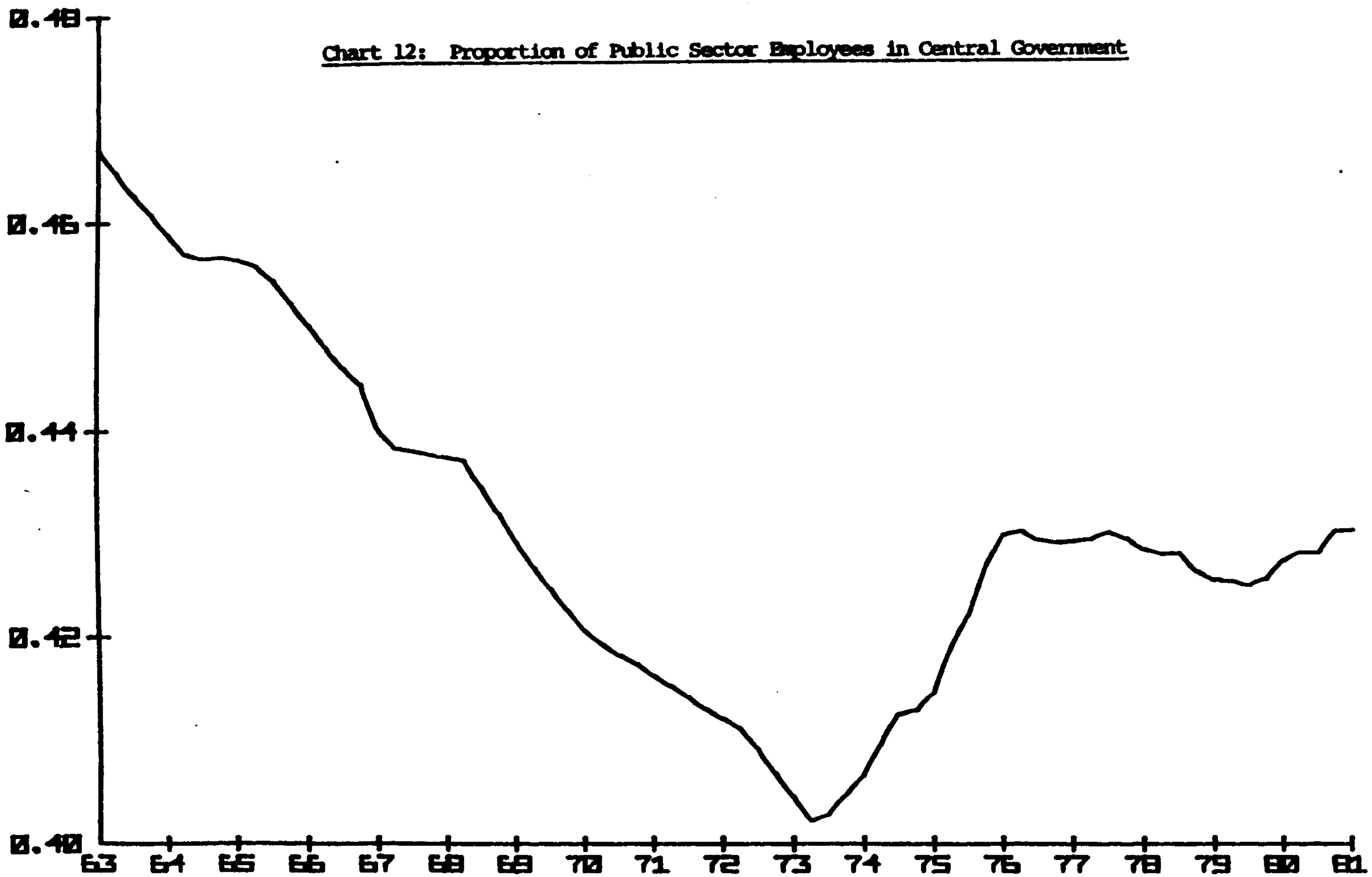


Chart 12: Proportion of Public Sector Employees in Central Government



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APPENDIX

APPENDIX

AN INTEGRATED ANALYSIS OF THE EFFECTIVE EXCHANGE RATE FOR STERLING

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DISCUSSION PAPER NUMBER 88

December 1980

I Introduction*

The central objective of this paper is to analyse empirically the determinants of the effective exchange rate for sterling. In previous work, e.g. Ball, Burns and Warburton (1980), the long run real exchange rate was determined by relative productivity between the traded and non-traded goods sectors at home and abroad, while the nominal exchange rate was determined in the light of the monetary theory. In this paper we extend this approach in two directions. First, we consider the effects of N. Sea oil on the real exchange rate. Secondly, we explore the portfolio balance approach to the nominal exchange rate in which capital flows and relative asset supplies affect the exchange rate.

The analysis is necessarily a retrospective one. In attempting to isolate the economic factors which have been the most important influences on sterling over the period 1970-1978, we do not presume that these factors will be similarly relevant for prediction. Indeed the dynamic instability of the estimated equations argues forcibly against this application. In particular this paper does not specify an explicit expectations generating mechanism. However, the estimated equations implicitly contain both expectational variables and elements of the data generation process. We regard it as an aspect of the econometric problem of identification that the two cannot be disentangled.

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*This paper was originally prepared as a section of a more general paper entitled "Monetary Policy, Expectations and Real Exchange Rate Dynamics" by Alan Budd and ourselves. to be published in a special edition of Oxford Economic Papers in 1981. As the original effort assumed gigantic proportions, we decided to summarise the contents of the empirical section.
As a result both papers hold the theoretical section in common. In particular pages 3-8 are almost a direct transcript of Beenstock, Budd and Warburton (1981).
We wish to thank Alan Budd and all the other members of the CEF Research Discussion Group, financed by the SSRC, for their helpful comments in the preparation of this draft.

We have chosen to persevere with single equation estimation techniques rather than, with one exception, utilise systems estimation methods. The econometric problems of estimating the exchange rate specification which we postulate are discussed at some length and we do not pretend that they have all been satisfactorily resolved. However, within the confines of a small data sample and many uncompeting hypotheses we have attempted to steer clear of the worst manifestations of autocorrelation and overparameterisation. Diagnostic statistics are provided to allow the reader to make his own judgement as to the worthiness of the results obtained.

The main conclusions of the paper are as follows. The inclusion of the stock of privately-held government bonds in addition to the money stock as the implied determinant of the domestic price level yielded significant improvements in standard error in some models. However the contribution of bonds was not usually greater than 0.2 and the autocorrelation properties were worsened.

In the light of the current interest in the Dornbusch (1976a) model in which an efficient foreign exchange market is placed alongside inefficient labour and goods markets, and which assumes that the interest parity condition holds ex ante and ex post, we have simulated a couple of our basic equations in order to examine whether Dornbusch-type effects could be observed for sterling. The overshooting phenomenon appears to hold in only the extremely short-run on our evidence.

The estimation of the effects of North Sea oil on the exchange rate showed that a combination of current and capital account arguments could significantly improve our explanation of why sterling has maintained its higher level through 1980. We estimate that by the second quarter of 1980 the exchange rate would have been between 13 and 20 per cent lower had it not been for North Sea oil.

II Theoretical Considerations

The Nominal Exchange Rate

In what follows we seek to develop a theory about the long run determinants of the real and nominal exchange rates. The temporary equilibrium condition in the foreign exchange market is that the flow demand for foreign exchange must equal its flow supply.

We assume that the UK is a small open economy in the sense that it is affected by the world but is too small to significantly affect the rest of the world.* The world demand for money function is assumed to vary inversely with the world interest rate, or

$$\ln M_w = \alpha_1 \ln Y_w - \alpha_2 \ln R_w + \ln P_w \qquad (1)$$

while the world demand for bonds varies directly with the world interest rate, or

$$\ln B_w = \beta_1 \ln Y_w + \beta_2 \ln R_w + \ln P_w \qquad (2)$$

Both of these equations imply that asset demand functions are homogenous of degree one in prices.

Assuming that the world monetary authorities determine M_w and B_w we may solve equations (1) and (2) for P_w and R_w respectively as

$$\ln P_w = [\beta_2 \ln M_w + \alpha_2 \ln B_w - (\beta_2\alpha_1 + \beta_1\alpha_2) \ln Y_w] / (\alpha_2 + \beta_2) \qquad (3)$$

$$\ln R_w = [\ln B_w - \ln M_w + (\alpha_1 - \beta_1) \ln Y_w] / (\alpha_2 + \beta_2) \qquad (4)$$

The respective UK asset demand functions are written as

$$\ln M = \gamma_1 \ln Y - \gamma_2 \ln R + \ln P \qquad (5)$$

$$\ln B = \delta_1 \ln Y + \delta_2 \ln R - \delta_3 \ln R_w + \ln P \qquad (6)$$

i.e. external assets compete with domestic assets in portfolios.

---

* Variable definitions are provided in Appendix I.

The theory of Purchasing Power Parity (PPP), when applied to traded goods, implies that in the long run the real exchange rate is a constant, k. We shall defer consideration of the reasons why k may vary until the discussion below of the theory of the real exchange rate. Thus we define

$$\ln P + \ln S^* - \ln P_W = k \qquad (7)$$

We may now solve this system for the long-run equilibrium exchange rate; for given values of nominal asset stocks. Although in equilibrium Y and Y_W will be growing at their respective natural rates we must take account of their disparate levels. The equilibrium is thus defined as

$$\begin{aligned} \ln S^* = k \; & + \left[\frac{\beta_2 \ln M_W + \alpha_2 \ln B_W}{(\alpha_2+\beta_2)}\right] - \left[\frac{\delta_2 \ln M + \gamma_2 \ln B}{(\delta_2+\gamma_2)}\right] \\ & - \left[\frac{\delta_3\gamma_2(\ln B_W - \ln M_W)}{(\alpha_2+\beta_2)(\delta_2+\gamma_2)}\right] + \left[\frac{(\delta_1\gamma_2+\delta_2\gamma_1)}{(\delta_2+\gamma_2)}\right]\ln Y \\ & - \left[\frac{(\delta_2+\gamma_2)(\alpha_1\beta_2+\alpha_2\beta_1) + (\alpha_1-\beta_1)\delta_3\gamma_2}{(\alpha_2+\beta_2)(\delta_2+\gamma_2)}\right]\ln Y_W \end{aligned} \qquad (8)$$

S^* varies inversely with M and B since the latter raise P. M_W raises S^* since it raises P_W as well as lowering R_W. However, the effects of B_W are ambiguous since it raises P_W and R_W. In the long run, S* depends positively on Y and negatively on Y_W.

Equation (8) represents the long-run portfolio balance theory of the exchange rate since the exchange rate is generated by the balancing of portfolios in terms of money and bonds at home and abroad. However, when the demand for money is interest inelastic, i.e. when $\alpha_2 = \gamma_2 = 0$, it has a very familiar solution;

$$\ln S^* = k + \ln M_W - \ln M + \gamma_1 \ln Y - \alpha_1 \ln Y_W \qquad (9)$$

which is the relative money supply theory of the exchange rate. Thus the relative money theory is a special case of the portfolio balance theory.

Another special case arises when there is perfect capital mobility i.e. when $\delta_2 = \delta_3 = \infty$. In this case equation (8) simplifies to (ignoring terms in Y and Y_W) :-

$$\ln S^* = k + \frac{\beta_2 \ln M_W + \alpha_2 \ln B_W}{\alpha_2 + \beta_2} - \ln M - \gamma_2 \ln R_W \qquad (9a)$$

i.e. the elasticity with respect to the domestic money stock is minus one and the domestic bond supply no longer affects the equilibrium exchange rate. However, external interest rates identify the domestic interest elasticity of the demand for money.

Therefore equation (8) may be used to test a number of hypotheses, including the monetary theory, the portfolio balance theory and the interest parity theory. If lnB enters the solution and the coefficient of lnM is less than unity the monetary and interest parity theories must be rejected in favour of the less restrictive portfolio balance theory.

The Real Exchange Rate

Equation (8) describes a theory of the long run nominal exchange rate. We now turn to the determinants of the real exchange rate in the long run. We propose to derive these determinants using the balance of payments flow equilibrium identity

$$CA + IK - BOF = 0 \qquad (10)$$

where BOF (balance for official financing) represents the government's spot market intervention. The current account depends on the real exchange rate but it also depends in the UK on exogenous factors such as the production of N. Sea oil (NSO). In principle NSO need not affect the current account since UK beneficiaries might spend all their income on traded goods. In practice, however, this seems unlikely since they will wish to increase their consumption of non-tradeables which by definition cannot be provided through the balance of payments.

Whilst it is clear that an increase in domestic demand for goods will worsen the UK current account and that an increase in foreign demand for goods will have the opposite effect, it is unclear whether these effects will be permanent.

A more permanent influence on the current account is thought to be the differences in the supply characteristics of aggregate production at home and abroad which result in differential rates of productivity growth in the respective traded goods sectors. This phenomenon has been widely discussed since the contribution of Balassa (1964). In the absence of a series for world employment we approximate this productivity bias effect by relative GDP, thereby making the assumption that the ratio of UK employment to world is constant around a trend.

Since we observe neither the demand nor the supply of goods, we must regard the sign of the long-run relative output effect on the real exchange rate, through the current balance, as an empirical matter. However, our theory suggests that a short-run negative relative output effect may be followed by a positive long-run effect.

Hence

$$CA = CA \left[\overset{-}{E}, \overset{\pm}{NSO}, \overset{-}{\Delta Y}, \Delta \overset{\pm}{Y}_w, \overset{\pm}{Y}, \overset{-}{Y}_w \right] \qquad (11)$$

where the signs above the variables refer to partial derivatives.

As noted in the appendix, capital flows depend on changes in the uncovered interest rate differential and changes in the expected rate of exchange rate appreciation. There are particular factors which affect UK exchange rate expectations. For example when a North Sea oil discovery is made, or when the estimated existing stock of oil is revalued by an increase in the real price of oil, there is an expectation of a higher exchange rate underpinned by the larger implied value of future oil production. The variable which we use in the empirical section which follows is slightly more complicated than the basic concept of discoveries and deserves explanation. Its definition is given below.

$$\Delta OILRES/_t = \frac{(DISC_t - NSO_t).PNSO_t}{GDP\pounds_t} \qquad (11a)$$

Thus current production of oil (in millions of tonnes) is subtracted from current discoveries of oil (DISC) before valuing the difference at current prices and dividing through by the nominal value of GDP. It is important to realise that ΔOILRES/ will actually fall if there are no discoveries and also if the relative price of oil in terms of other goods falls. It should be noted that the capital account effect of a discovery is shortlived; in order to cause a sustained capital account inflow, it would be necessary for the pace of discovery of new oil resources to increase. A further source of capital account disturbance is the demand for sterling denominated assets by OPEC, following large current account surpluses as a result of crude oil price increases. Again, the effect is expected to be temporary, and it would require the investment of some proportion of sustained OPEC surpluses to have a permanent affect on the UK capital account and thence the exchange rate. However, it is equally possible that, by depositing larger quantities of short-term money in other financial centres, sterling may effectively depreciate, and therefore the sign on BALOPEC, suitably normalised, is indeterminate. Hence we may write

$$IK = IK(\Delta \overset{+}{RS},\ \Delta \overset{-}{RS}_w,\ \Delta({}_tS^{e}{}^{+}_{t+1} - S_t)) \qquad (12)$$

Combining equations (10) to (12) we can write a composite real exchange rate specification

$$k = \left[\overset{+}{NSO}, \Delta Y, \Delta \overset{+}{I}_w, \overset{+}{Y}, Y_w,\ \Delta \overset{+}{RS}, \Delta RS_w\ \Delta({}_tS^{e}{}^{+}_{t+1} - S_t),\ \overset{-}{BCF/} \right] \qquad (13)$$

where BCF/ is defined as BCF divided by the value of total exports. The principal determinants of $\Delta RS, \Delta RS_w$ and $\dot{S}^{e*}$ are the relative asset stock growth rates while $\dot{S}^{e}$ will also depend upon changes in the expected rate of production of N. Sea oil (reflecting depletion policy) and upon the pace of discoveries of new oil reserves. Thus,

$$\dot{S}^{e} = S(\Delta M, \Delta B, \Delta M_w, \Delta B_w, \Delta NSO, \Delta^2 OILRES/, BALOPEC) \qquad (13a)$$

* For convenience we refer to $({}_tS^{e}_{t+1} - S_t)$ as $\dot{S}^{e}$ in the text.

Integrating the arguments of equations (8) and (13) yields a rich theory of the determination of the equilibrium exchange rate which is represented below as a regression specification.

$$\ln S^{*} = a_0 + a_1 \ln M_w + a_2 \ln B_w + a_3 \ln M + a_4 \ln B + a_5 \ln Y + a_6 \ln Y_w + a_7 \ln NSO + a_8 \Delta \ln Y + a_9 \Delta \ln Y_w + a_{10} \Delta nRS + a_{11} \Delta nRS_w + a_{12} \Delta^2 OILRES / + a_{13} BALOPEC / + a_{14} BOF / \quad (14)$$

The determinants of $\dot{S}^{e}$ are omitted from this list but they consist of higher order difference terms in the asset stocks and North Sea oil variables. The actual effective exchange rate at time t , S_t, is assumed to adjust to S^{*} in equilibrium but its path to equilibrium will be disturbed by movements in ${}_{t-1}S^{e}_{t}$ reflecting new information available to the market. The adjustment function can be written

$$\Delta \ln S_t = \lambda_1 \Delta \ln_t S^{e}_{t+1} - \lambda_2 \ln\left(\frac{S}{S^*}\right)_{t-1} + \epsilon_t . \quad (15)$$

where ϵ_t is normally and independently distributed with zero mean and constant variance.

When equations (3.13a), (3.14) and (3.15) are combined, a dynamic version of (3.14) is obtained with differences and double differences of the asset stocks appearing. Since our model already contains a large number of parameters, we decline to write out the full theoretical dynamic specification. However, in the estimation section that follows we employ the dynamic estimation methodology popularised by Davidson et al (1978) and some of these difference terms appear as a result of the process of parameter rationalisation. To summarise, the equilibrium properties of the theoretical specification are such that even if relative asset supplies are fixed, the exchange rate will appreciate when new oil discoveries are announced, or when N. S. oil production itself increases.

An interesting juxtaposition between the long run steady state and short term dynamics is the case of an increase in the quantity of bonds. When B rises equation (3.8) suggests that the exchange rate will fall in the steady state. However, in the short term the exchange rate may rise as inward capital flows are induced by the increase in domestic interest rates. On the other hand the expectation that eventually the exchange rate is going to fall may cause speculative capital outflows in the short term. Therefore the impulse response of the exchange rate to a shock to bonds may be quite complicated.

III Empirical Results

The estimation was carried out using single equation techniques for the quarterly data over the period 1970 Q1 to 1978 Q4, reserving the succeeding six quarters for post sample testing. Details of the definitions and sources of the data can be found in the Appendix. The estimation period was lengthened to include observations from 1970 and 1971, before sterling was actually floating, on the grounds that cracks in the Bretton Woods system were already evident and the effective rate for sterling was not constant over these two years. Beginning with only 36 data points, it seemed sensible to try for no more than a dozen parameters of the model. Given that the static specification, (14) required the estimation of 15 parameters, clearly the dynamic model form would require that all the degrees of freedom be used up. Even so, the data generation process alone does not provide enough information to distinguish the independent effects of highly collinear competing time series regressors such as relative asset stocks and real incomes.

In seeking to make defensible parameter restrictions on the model, our attention inevitably turned to the implications of empirical studies of asset demand functions. The balance of evidence from the post-war period suggests a long-run homogenous relationship between asset stocks and prices and between asset stocks and real income. We translate these suggested results into appropriate combinations of variables. This permits us to test directly the hypotheses that the exchange rate is homogenous with respect to relative asset stocks and that the income elasticities of money and bonds at home and abroad are equal. We note that Bilson (1978), in the context of a static bilateral exchange rate specification, embodied similar restrictions using a Bayesian analysis which allowed flexible probability limits around the prior parameter values. A further a priori parameter constraint we apply is that, apart from in the current period, the interest rate effects of money and bonds on the exchange rate are assumed to be equal for domestic and foreign assets. Occasionally an opportunity arises for the relaxation of these parameter restrictions, but in the majority of the reported regressions the own and world parameters have not been freely estimated.

An area in which published studies give far less guidance is on the question of the maximum lag length that should be considered in estimating the reaction of exchange rates and prices to asset stocks. At the risk of protracting the adjustment period we have preferred to include lags of 1 year in the case of the exchange rate, interest rates and real incomes and up to 2 years in the case of relative asset stocks in the generalised regression forms. In the context of the lag-generalised regressions, we examine the steady state properties of the equation and, following Mizon and Hendry (1980), allow the data to determine the dynamic structure of the model. Often these data-determined difference terms are quite complicated and difficult to justify on a priori grounds. For example, a long difference term on relative money stocks appears in most equations carrying a "perverse" positive sign. However, it would be wrong to dismiss such an effect without establishing firstly, the shape of the implied impulse response path, taking all references to the variables concerned into account, and secondly, testing whether the equation dynamics are sensitive to the sample period chosen. It must, however, be conceded that on occasions, and especially in small samples, modifiers act as dummy variables, "mopping up" what would otherwise be large equation residuals.

Long-Run Portfolio Balance

In Table 1 we present estimates of three versions of equation (8) in which the only real variables to be included are relative real incomes. The variants derive from allowing a mixture of money and bonds to determine the implicit UK long-run price level, rather than money only, and from substituting the actual world price level for the world money stock (per unit of GDP) on the assumption that one could regard world prices as exogenous to the determination of the UK exchange rate. The results are interesting in four respects. Firstly, in each regression lagged dependent variables enter with significant positive coefficients. We resist the temptation of attempting to identify this autoregressive behaviour with any particular method of expectations formation. In seeking to establish the constituents of the relevant agents' information set we are not at liberty to distinguish between terms in our equation which are backward looking, and therefore part of the data generation process, and those which are forward looking, that is, part of the expectation generating process. Secondly, that the homogeneity restriction between the exchange rate and relative asset supplies per unit of GDP is strongly accepted in every case. Thirdly that relative real incomes carry the anticipated signs in both short and long-run in all cases and finally that the inclusion of the domestic bond supply contributes significantly to the power of equation 1B over 1A, carrying an implied weight of 12% in the reduced form UK price level.

Table 1 : Basic Forms of Equation Specification (8) with Corresponding Steady State Properties

Equation 1A :

$$\begin{aligned}\Delta \ln S_t = {} & \underset{(5.0)}{-0.042} + \underset{(1.6)}{0.153}\, \Delta_3 \ln S_{t-1} + \underset{(1.0)}{0.173}\, \Delta \ln S_{t-2} \\ & + \underset{(3.6)}{0.449}\, \Delta_5 \ln\left(\frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-2} + \underset{(1.1)}{0.231}\, \Delta \ln\left(\frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-5} \\ & - \underset{(1.4)}{0.507}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} - \underset{(4.9)}{0.416}\, \ln\left(S \cdot \frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-1} \\ & + \underset{(4.4)}{0.996}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3}\end{aligned}$$

$\bar{R}^2 = 0.358$
$SE = 0.0234$
$Q(8) = 10.4(15.5)$
$LM(5) = 7.34(11.1)$
$Chow(6,28) = 3.8(3.6)$

Equation 1A S :

$$\begin{aligned}\ln S = {} & -\ln\left(\frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right) + 2.4 \ln\left(\frac{Y}{Y_w}\right) - 0.1 \\ & - 1.219\, \Delta \ln\left(\frac{Y}{Y_w}\right)\end{aligned}$$

Equation 1B :

$$\begin{aligned}\Delta \ln S_t = {} & \underset{(3.1)}{-0.038} + \underset{(2.5)}{0.259}\, \Delta_4 \ln S_{t-1} + \underset{(2.4)}{0.371}\, \Delta \ln S_{t-4} \\ & + \underset{(4.6)}{0.49}\, \Delta_6 \ln\left(\frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-2} + \underset{(2.8)}{0.488}\, \Delta \ln\left(\frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-5} \\ & + \underset{(2.4)}{0.207}\, \Delta \ln\left(\frac{M}{B}\right)_t - \underset{(2.0)}{0.619}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} \\ & - \underset{(5.1)}{0.712}\, \ln\left(S \cdot \frac{M}{M_w} \Big/ \frac{Y}{Y_w}\right)_{t-1} + \underset{(1.2)}{0.083}\, \ln\left(\frac{M}{B}\right)_{t-1} \\ & + \underset{(5.6)}{1.476}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3}\end{aligned}$$

$\bar{R}^2 = 0.57$
$SE = 0.0191$
$Q(8) = 11.8(15.5)$
$LM(5) = 8.9(11.1)$
$Chow(6,26) = 4.2(3.6)$

Equation 1B S :

$$\begin{aligned}\ln S = {} & -0.88 \ln\left(\frac{M}{Y}\right) - 0.12 \ln\left(\frac{B}{Y}\right) + \ln\left(\frac{M_w}{Y_w}\right) \\ & + 2.07 \ln\left(\frac{Y}{Y_w}\right) - 0.05 - 0.869\, \Delta \ln\left(\frac{Y}{Y_w}\right)\end{aligned}$$

Equation 1C :

$$\begin{aligned}
\Delta \ln S_t = & \underset{(0.9)}{-0.027} + \underset{(2.6)}{0.379}\, \Delta_4 \ln S_{t-1} + \underset{(2.0)}{0.344}\, \Delta \ln S_{t-4} \\
& \underset{(4.8)}{+0.76} \left[\ln\left(\tfrac{M}{Y}/P_W\right)_{t-2} - \tfrac{1}{2}\ln\left(\tfrac{M}{Y}/P_W\right)_{t-6} - \tfrac{1}{2}\ln\left(\tfrac{M}{Y}/P_W\right)_{t-8} \right] \\
& \underset{(1.5)}{-0.21}\, \Delta_2 \ln\left(\tfrac{M}{Y}/P_W\right)_{t-3} + \underset{(2.2)}{0.299}\, \Delta \ln\left(\tfrac{M}{B}\right)_t \\
& \underset{(2.4)}{-0.885}\, \Delta \ln\left(\tfrac{Y}{Y_W}\right)_{t-1} + \underset{(1.0)}{0.636}\, \Delta \ln P_{W\,t-3} \\
& \underset{(4.2)}{-0.817}\, \ln\left(\tfrac{S}{P_W} \cdot \tfrac{M}{Y}\right)_{t-1} + \underset{(2.0)}{0.265}\, \ln\left(\tfrac{M}{B}\right)_{t-1} \\
& \underset{(5.0)}{+1.097}\, \ln\left(\tfrac{Y}{Y_W}\right)_{t-3}
\end{aligned}$$

$\bar{R}^2 = 0.46$
SE = 0.0214
Q(8) = 8.0(15.5)
LM(5) = 11.5(11.1)
Chow(6,25) = 4.1(3.6)

Equation 1C S :

$$\begin{aligned}
\ln S = & -0.68 \ln\left(\tfrac{M}{Y}\right) - 0.32 \ln\left(\tfrac{B}{Y}\right) + \ln P_W \\
& +1.34 \ln\left(\tfrac{Y}{Y_W}\right) - 0.03 - 1.083\, \Delta \ln\left(\tfrac{Y}{Y_W}\right)
\end{aligned}$$

The version of the model which uses world prices (1C) is surprisingly inferior in standard error terms to 1B, and the reason appears to be the lack of precision attached to the coefficient of the world price level in the lag-generalised regression. The predictive performance of all three equations over the period 1979 Q1 to 1980 Q2 is abysmal, with strong evidence of a structural break at the end of the sample period suggested by a comparison of the Chow test with the relevant 99% F-statistic. The degree to which these models would have underpredicted the prevailing exchange rate in mid-1980 on the basis of all other equation information given is contained in Table 1A. It is worth pointing out that what we should really like to test is whether the steady states of equations exhibit post sample stability. In the work that follows it is clear that dynamic instability is present at virtually every stage in the estimation process, and that there is good reason to expect that the Chow tests will be failed. We await a comparable test of the stability of steady state properties.

Before discussing the interest rate results in Table 2 more fully, a point of econometric methodology is necessary. Whilst the nested equations 1A to 1C were derived from unrestricted forms, the dimensions of the degrees of freedom problem prevented us from repeating the exercise for the more complicated models. In consequence, we nest the interest rate dynamics from a partially unrestricted form in which the restricted variable combinations from Table 1 are used. In adopting this procedure we make the assumption that the dynamic structure of the first model is independent of the dynamic structure of the additional variables with respect to the dependent variable.

Table 1A : Prediction errors from the equations

Equation	% prediction error* in the level of of the exchange rate in 1980Q2**	variables included
1A	-11.1	Relative Asset Stocks
1B	-13.8	Relative Real Incomes
1C	-11.9	
2A	- 8.4	As table 1 equations but including relative short and long interest rates
2B	-11.9	
3A	+ 8.0	As table 1 equations but including real effects of North Sea oil
3B	- 0.1	
4A	+11.1	Relative Asset Stocks
4B	+ 6.7	Relative Real Incomes
4C	+ 6.7	Interest rates
		North Sea oil effects

*A negative sign indicates underprediction

**These forecasts were made assuming the lagged value of the exchange rate known as well as the actual values of the variables on the right-hand side of the equation.

Interest Rate Effects

In Table 2 we present estimates of the basic form of regression augmented by both short- and long-term interest rate effects. The former represent arguments of the capital account of the balance of payments, while the latter derive from the inclusion of the opportunity cost of holding money from equation (5). It is recognised that during the estimation period the own rate of interest on the sterling M3 stock was non-zero and therefore to some extent the effects are confused. Equation 2A contains four references to interest rates. In the first place the current period change in world short interest rates (taken as exogenous to the UK exchange rate) carries a negative sign, which is consistent with the capital account argument. What is interesting is that the two higher order interest rate effects both at lag one, have opposite signs. This result is interpreted as support for the hypothesis that the determinants of short and long-run interest rates and, implicitly, expected inflation rates, differ. The response of the exchange rate to long interest rates is consistent with the portfolio balance analysis, in which the opportunity cost of holding money carries a negative sign in individual asset demand functions. The behaviour of short-term interest rates is quite different implying that the capital account responds much more readily to new information and takes account of the institutional stickiness of price inflation in the short-run.

Table 2 : Estimates of Equation Specification (8)
Augmented by interest rate effects

Equation 2A :

$$\begin{aligned}\Delta \ln S_t = & \underset{(3.8)}{-0.046} + \underset{(3.6)}{0.417}\,\Delta \ln S_{t-2} - \underset{(3.4)}{1.006}\,\Delta \ln \left(\frac{Y}{Y_w}\right)_{t-1} \\ & + \underset{(6.5)}{0.865}\,\Delta_5 \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-2} - \underset{(2.9)}{1.473}\,\Delta n RS_{w_t} \\ & + \underset{(3.1)}{0.986}\,\Delta^2 (RS-RS_w)_{t-1} - \underset{(3.9)}{1.793}\,\Delta^2 n(RL-RL_w)_{t-1} \\ & - \underset{(7.4)}{0.489}\,\ln\left(S \cdot \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1} - \underset{(1.0)}{0.247}\, n(RL-RL_w)_{t-4} \\ & + \underset{(5.5)}{1.036}\,\ln\left(\frac{Y}{Y_w}\right)_{t-3}\end{aligned}$$

$\bar{R}^2 = 0.652$
SE = 0.0172
Q(8) = 10.4(15.5)
LM(5)=10.7(11.1)
Chow(6,26) = 8.2(3.6)

Equation 2A S :

$$\begin{aligned}\ln S = & - \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right) + 2.12 \ln\left(\frac{Y}{Y_w}\right) - 3.10\,\Delta n RS_w \\ & - 0.51\, n(RL-RL_w) - 2.06\,\Delta \ln\left(\frac{Y}{Y_w}\right) - 0.094\end{aligned}$$

Equation 2B :

$$\Delta \ln S_t = \underset{(7.3)}{-0.06} + \underset{(3.4)}{0.426}\, \Delta \ln S_{t-4} + \underset{(6.0)}{0.693}\, \Delta_6 \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-2}$$

$$+ \underset{(2.1)}{0.342}\, \Delta \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-5} + \underset{(2.7)}{0.184}\, \Delta \ln\left(\frac{M}{B}\right)_t$$

$$- \underset{(3.5)}{1.131}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} - \underset{(1.5)}{0.425}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-2}$$

$$- \underset{(2.9)}{1.448}\, \Delta n RS_{w_t} - \underset{(8.0)}{0.668}\, \ln\left(S \cdot \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1}$$

$$+ \underset{(6.6)}{1.274}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3} - \underset{(3.0)}{0.526}\, n(RS - RS_w)_{t-1}$$

$\bar{R}^2 = 0.651$
SE = 0.0172
Q(8)=13.2(15.5)
LM(5)=14.9(11.1)
Chow(6,25)=10.8(3.6)

Equation 2B S :

$$\ln S = -\ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right) + 1.91 \ln\left(\frac{Y}{Y_w}\right) - 0.79\, n(RS - RS_w)$$

$$- 2.17\, \Delta n RS_w - 2.33\, \Delta \ln\left(\frac{Y}{Y_w}\right) - 0.09$$

Equation 2C : (Two stage least squares)

$$\Delta \ln S_t = \underset{(1.8)}{-0.03} - \underset{(1.9)}{0.234}\, \Delta_3 \ln S_{t-1} + \underset{(5.9)}{0.433}\, \Delta_5 \ln\left(\frac{\dot{M}}{M_w} / \frac{Y}{Y_w}\right)_{t-2}$$

$$- \underset{(4.2)}{0.841}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} + \underset{(4.0)}{1.142}\, \Delta n RS_{t-1}$$

$$- \underset{(2.4)}{0.513}\, \Delta_2 n RS_{w\,t-1} - \underset{(6.4)}{0.354}\, \ln\left(S \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1}$$

$$+ \underset{(1.5)}{0.326}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3} - \underset{(3.9)}{1.746}\, n \hat{RS}_t$$

$$+ \underset{(5.1)}{1.841}\, n RS_{w\,t-1}$$

$\bar{R}^2 = 0.83$
SE = 0.0120
Q(8)=8.7(15.5)
LM(5) = 8.7(11.1)
Chow(6,26)=20.1(3.6)

where ^ denotes the endogenous variable on the right-hand side

Equation 2C S :

$$\ln S = -\ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right) + 0.92 \ln\left(\frac{Y}{Y_w}\right) - 4.93\, n RS$$

$$+ 5.19\, n RS_w - 2.373\, \Delta \ln\left(\frac{Y}{Y_w}\right) + 3.22\, \Delta n RS$$

$$- 1.45\, \Delta n RS_w - 0.085$$

In equation 2B, where bonds are included, we find only a short run response in this equation. By contrast with equation 2A, it is only short-interest rates that matter in both the short and long-run. However it should be noted that the current period $\Delta\ln(\frac{M}{B})$ effect could be interpreted as a domestic interest rate differential effect. Since their long-run determinants are similar, it is not surprising that equations 2A and 2B have identical standard errors. On its superior autocorrelation properties, equation 2A is preferred, although the constancy of the model outside the sample period is rejected in both cases.

Simultaneous Equation Estimation

We have made only a token attempt at simultaneous equation estimation of the interaction between interest rates and the exchange rate. This took the form of two stage least squares estimation of the current period domestic interest rate effects where the government's borrowing requirement as a proportion of national income and the rate of growth of privately held bonds were the arguments in the first stage. The results (represented here by equation 2C) were good in statistical terms but the implied interest elasticity of demand for money at home and abroad was extremely high at -4.9 for UK interest rates and 5.2 for world interest rates. A comparison with the results from explicit studies of UK demand for money functions, as summarised on pp 136-8 of Coghlan (1980), revealed a wide discrepancy between the two. An explanation for this may be attempted in terms of the dissimilarities of econometric techniques used and of the data samples selected. However, in the light of the smallness of the interest elasticities obtained from equations 2A and 2B we must regard the two-stage least squares result with caution, especially as the hypothesis of model constancy over the period 1979Q1 to 1980Q2 is over-whelmingly rejected.

One of the problems of simultaneity in small sample estimation is that, since there is no test of statistical consistency, we can have little idea as to the extent to which estimates are affected by omitted simultaneous relationships. As an attempt to minimise the problem we avoid the use of current dated variables on the right-hand side wherever possible.

Simulations of Overshooting

We use the simple monetary model implied by equation 1A to illustrate the impulse response profile of the nominal exchange rate with respect to the UK money stock, shown as the solid line in chart 1. There appear to be two distinct phases of response. At first there is an anticipatory appreciation following the news of a cut in the money stock but this effect is quickly cancelled out.

The second phase of response begins in period six when the indirect effect of money on the exchange rate via the domestic price level becomes very powerful.

In order to test this interpretation, we combined this nominal exchange rate profile with the impulse responses from an independently estimated equation*, reported in Beenstock and Longbottom (1980), of the dynamic effects of money on the price level in a closed economy. The result, assuming the world price level is unaffected by the domestic money stock, is the "real" response profile on chart 1.

In confirming our interpretation we find that "overshooting" of the real exchange rate in the short-run is extremely mild giving way to more substantial undershooting in quarters 4 to 8 and overshooting in the third and fourth years.** It is conceded that we are not allowing interest rates an explicit role in the model implied by equation 1A, a mechanism on which Dornbusch (1976b)*** places great emphasis. To analyse how much difference this is likely to make we repeat the exercise for equation 2A in combination with the same money/price profile, on the assumption that the domestic short interest rate rises by 2% and declines geometrically to its starting value after 6 years, in response to the 1% reduction of the money stock. The result is shown on chart 2. Whilst the overshooting phenomena finds support in the very short-run, it vanishes very rapidly and the response profile is little changed from before by period 6. (Although the level of the long interest rate differential has a permanent effect it responds *negatively* in both short and long run to an increase in domestic money).

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*equation (10) on p 12

**In terms of the discussion of the real exchange rate rise in the UK, it is difficult to see how the announcement of the cut in UK money growth could be attributed to any significant extent, to overshooting.

***e.g. p 1167

Chart 1 : Impulse Response of the Nominal and Real Effective Exchange Rate
Following a permanent 1% cut in the UK money stock

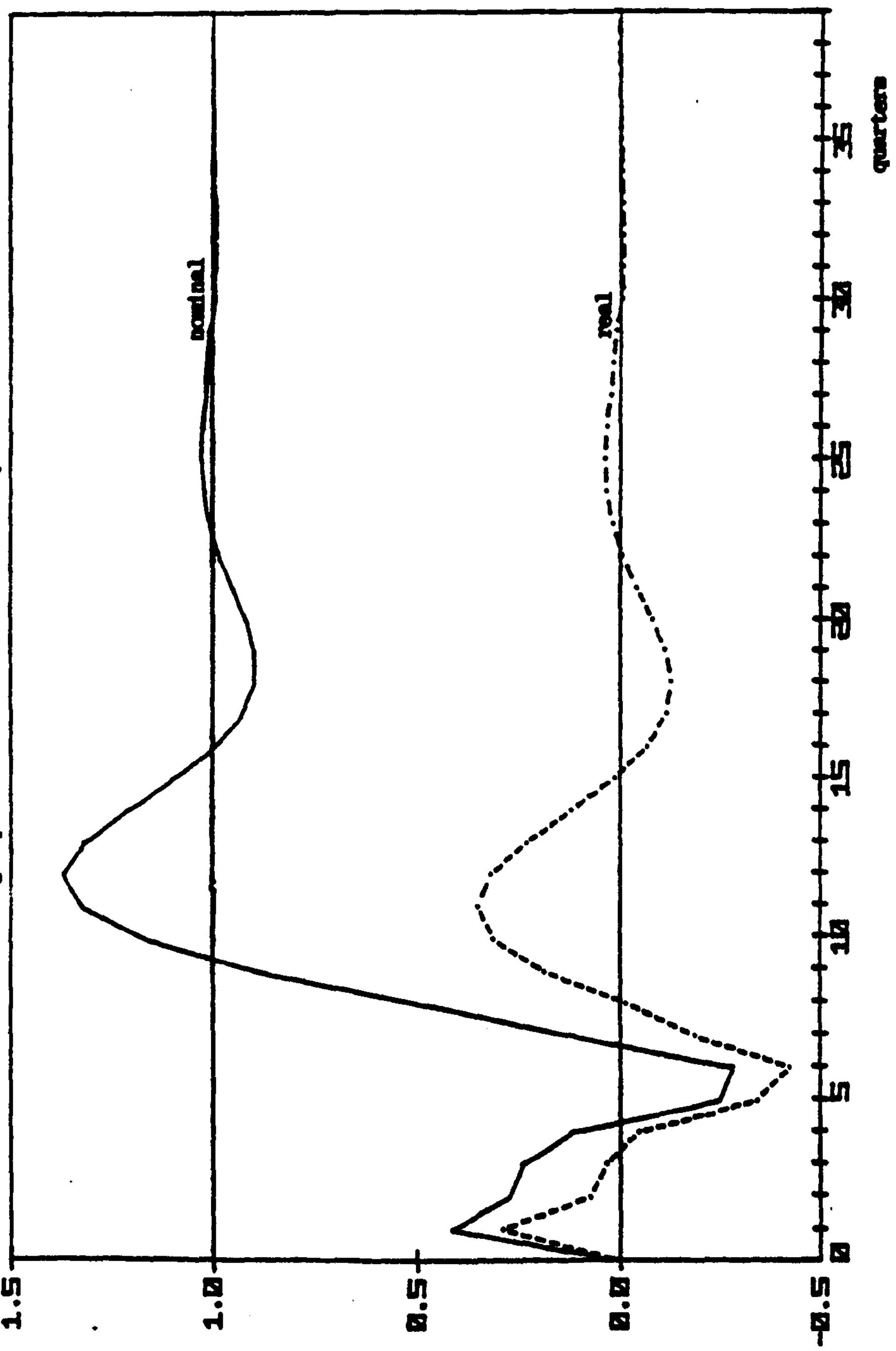
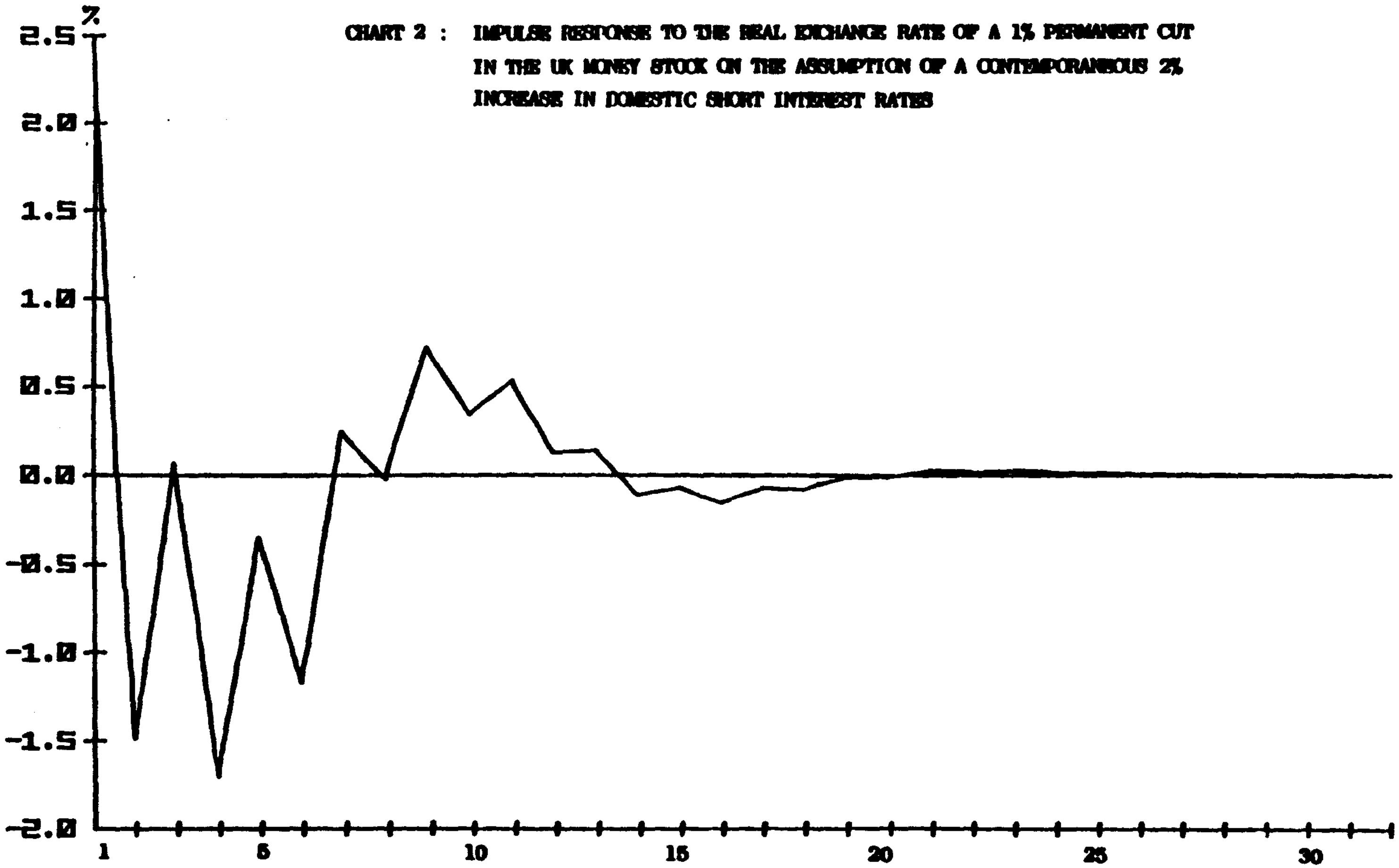


CHART 2 : IMPULSE RESPONSE TO THE REAL EXCHANGE RATE OF A 1% PERMANENT CUT IN THE UK MONEY STOCK ON THE ASSUMPTION OF A CONTEMPORANEOUS 2% INCREASE IN DOMESTIC SHORT INTEREST RATES



<u>Effects of N. S. Oil</u>

The results set out in Table 3 attempt to capture the real effects of North Sea oil discovery and exploitation on the UK effective exchange rate, in addition to the basic arguments of equation (8)
The two variables which represent oil effects in the exchange rate equation are the annual* change in the real value of oil in the ground expressed as a proportion of GDP (as defined on p. 5 .) and the current account effect of oil production, scaled by total exports at current prices (NSO£/X£). The former variable captures the one-off effect of the discovery and/or the revaluation of existing reserves by a change in the real oil price whilst the latter variable picks up the effect of the current account improvement on the exchange rate and remains as a steady state argument. To the extent that a proportion of the known oil reserves has become regarded as a permanent increase in income and consumption, this is already reflected in the real GDP terms in the regression.

It should be emphasised that there is an inevitable vulnerability associated with the parameter estimates of the North Sea oil levels variable, (NSO£/X£), on account of the fact that it takes zero values up to the middle of 1975 and the sample period closes at the end of 1978, leaving only a few degrees of freedom with which to estimate the parameter. Thus the major build up of production occurs outside the sample period. When the estimation period is extended to the end of 1979, much better determined parameter estimates are obtained for the oil effect, but unfortunately, the whole dynamic structure of the equation experiences change after 1978 and one should really begin the modelling exercise again from scratch over the longer data period. However the equations presented in Table 3 give an illustration of the way in which the oil effect enters the empirical analysis. Conforming to the earlier pattern, the only differences between 3A and 3B derive from the use of only money in the former and both money and bonds in the latter. On standard error grounds equation 3B is clearly superior and carries much more plausible steady state properties than 3A, although 3B now fails both autocorrelation tests. Again we have evidence that the inclusion of the stock of bonds provides a gain in equation efficiency. However, the Chow model constancy statistic now passes the F-test for equation 3A whilst failing in the case of 3B, as a result of the reduction of in-sample variance relative to outside-sample variance. The conclusion to be drawn from this, considering that Table 1A confirms the improvement in

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*This form of change is preferred because the estimates of possible oil reserves are published annually in the Department of Energy Brown Book.

Table 3 : Estimates of Equation Specification (3.8) including North Sea oil variables

Equation 3A :

$$\Delta \ln S_t = \underset{(7.3)}{-0.06} + \underset{(2.0)}{.199}\, \Delta_5 \ln\left(\frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-2} + \underset{(1.4)}{.277}\, \Delta \ln\left(\frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-5}$$

$$+ \underset{(2.6)}{3.232}\, \Delta^2 n\left(\frac{NSO\pounds}{Y\pounds}\right)_{t-1} - \underset{(1.8)}{3.218}\, \Delta n\left(\frac{NSO\pounds}{Y\pounds}\right)_{t-1}$$

$$+ \underset{(2.9)}{0.0084}\, \Delta_4\left(\frac{OILRES}{GDP\pounds E}\right)_{t-1} - \underset{(2.4)}{0.243}\, \ln\left(S \cdot \frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-1}$$

$$+ \underset{(5.8)}{1.167}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3} + \underset{(4.0)}{1.735}\, n\left(\frac{NSO\pounds}{Y\pounds}\right)_{t-1}$$

$\bar{R}^2 = 0.529$
SE = 0.0200
Q(8)=9.2 (15.5)
LM(5)=9.5(11.1)
Chow(6,27)=1.9(3.6)

Equation 3A S :

$$\ln S_t = -\ln\left(\frac{M}{M_w}/\frac{Y}{Y_w}\right) + 4.8 \ln\left(\frac{Y}{Y_w}\right)$$

$$+ 7.13\, n\left(\frac{NSO\pounds}{Y\pounds}\right) - 0.244$$

Equation 3B :

$$\Delta \ln S_t = \underset{(5.7)}{-0.045} + \underset{(1.8)}{0.153}\, \Delta_4 \ln S_{t-1} + \underset{(4.7)}{0.585}\, \Delta \ln S_{t-4}$$

$$+ \underset{(3.4)}{0.301}\, \Delta_6 \ln\left(\frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-2} + \underset{(2.7)}{0.342}\, \Delta \ln\left(\frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-5}$$

$$\underset{(1.4)}{-0.386}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} + \underset{(3.6)}{0.224}\, \Delta \ln\left(\frac{M}{B}\right)_t$$

$$+ \underset{(5.7)}{0.00966}\, \Delta_4\left(\frac{OILRES}{GDP\pounds E}\right)_{t-1} - \underset{(4.8)}{0.56}\, \ln\left(S \cdot \frac{M}{M_w}/\frac{Y}{Y_w}\right)_{t-1}$$

$$+ \underset{(8.5)}{1.469}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3} + \underset{(1.7)}{0.955}\, n\left(\frac{NSO\pounds}{Y\pounds}\right)_{t-1}$$

$$+ \underset{(2.0)}{0.090}\, \ln\left(\frac{M}{B}\right)_{t-1} - \underset{(2.4)}{0.372}\, u_{t-1}$$

$\bar{R}^2 = 0.788$
SE = 0.0134
Q(8)=19.8(15.5)
LM(5)=18.1(11.1)
Chow(6,24)=4.5(3.6)

Equation 3B S :

$$\ln S_t = -0.839 \ln\left(\frac{M}{Y}\right) - 0.161 \ln\left(\frac{B}{Y}\right) + \ln\left(\frac{M_w}{Y_w}\right)$$

$$+ 2.625 \ln\left(\frac{Y}{Y_w}\right) + 1.706\, n\left(\frac{NSO\pounds}{Y\pounds}\right) - 0.69\, \Delta \ln\left(\frac{Y}{Y_w}\right) - 0.081$$

the predictive accuracy of the model when N.S. oil variables are included, is that it is the instability of the dynamic structure of the equation which is primarily responsible for the failure of prediction tests, rather than the steady state properties.

Identification of the Structural Parameters

It is interesting at this point to note that the framework developed earlier in this section, whilst overdetermined in terms of the parameters of the nominal exchange rate model and the equation dynamics, is nearly identified in the case of the steady states of the real variables.

Rewriting equations (10) to (12) as parametric functions and making certain simplifying assumptions we may write :

$$\frac{CA}{Y\pounds} = -\alpha_1 \ln(S^{*}\frac{P}{P_w}) + \alpha_2 \ln(\frac{Y}{Y_w}) + \alpha_3 (\frac{NSO\pounds}{Y\pounds}) \qquad (16)$$

$$\frac{DK}{Y\pounds} = \beta_1 \Delta n(RS-RS_w) + \beta_2 \Delta^2 \frac{OILRES}{GDP\pounds} + \beta_3 \text{ BALOPEC}/ \qquad (17)$$

Thence :

$$k = \ln(S^{*}\frac{P}{P_w}) = \frac{\alpha_2}{\alpha_1}\ln(\frac{Y}{Y_w}) + \frac{\alpha_3}{\alpha_1}(\frac{NSO\pounds}{Y\pounds}) + \frac{\beta_1}{\alpha_1}\Delta n(RS-RS_w) \qquad (18)$$

$$+ \frac{\beta_2}{\alpha_1}\Delta^2(\frac{OILRES}{GDP\pounds}) + \frac{\beta_3}{\alpha_1} \text{ BALOPEC}/$$

In order to identify the structural parameters of (18) an assumption about α_3 is necessary. The parameter α_3 represents the proportion of N.S. oil production (and therefore income) that is not offset by expenditure on traded goods, in other words, α_3 is the net effect of N.S. oil on the current balance of payments. Using the analysis and assumptions of Forsyth and Kay (1980) we can deduce an implicit value of α_3, if we make the extra assumption that no more than half of UK primary production is exported. Thus the addition of £10b to net output results in an additional £3.7b of Imports implying $\alpha_3 = 0.63$.

The Complete Specification

It is always a hazardous exercise to combine several strands of theoretical analysis into a single estimated equation, and the problem is often made acute by the smallness of the available data sample. However the modelling exercise would be incomplete if we did not attempt to integrate, in particular, the effects of interest rates and N.S. oil variables into equation specification (14). Equations 4A and 4B are the resulting estimated equations, the distinction between them being in the choice of the implicit determinants of the UK price level, as before. The comparison between the "money only" and "money-bonds" models becomes extremely important viewed against the theoretical framework developed above. In particular, equation 4A has a steady state which excludes long-run interest rate effects, and is therefore representative of model (9), whilst equation 4B identifies an effect of the domestic stock of bonds on the exchange rate, a result which is indicative of the generalised portfolio balance model of (8). Both equations reject the interest parity model as described by equation (9a).

In attempting to reach a conclusion, one must take account of the implied values of the structural parameters as well as the tests of autocorrelation and predictive performance. Such a multi-criteria comparison is unlikely to yield an unambiguous result and this is confirmed below. In terms of the implied parameter values of the structural model contained in (18), we find the following results.

Table 3A Long Run Structural Parameters

Symbol	Meaning	Equation 4A	Equation 4B
α_1	Elasticity of the current account with respect to the real exchange rate	0.10	0.14
α_2	Effect of relative real GDP on the current account (Implied productivity bias effect	0.47 -0.85%p.a.	0.50 -0.91%p.a.)
α_3	Net effect of N.S. oil production on the current account	0.63*	0.63*
β_1	Elasticity of the capital account with respect to the interest rate differential	0.33	0.11
β_2	Elasticity of the capital account to the pace of N.S. oil discoveries per unit of nominal GDP	0.0025**	0.0036**

* Assumed value

** This coefficient applies to a temporary, not a sustained capital inflow. The precise definition of (OILRES/GDPIE) is given on p. 7 , equation 11a.

Table 4 : Estimates of Equation Specification (14)

Equation 4A

$$\Delta \ln S_t = \underset{(10.9)}{0.072} + \underset{(4.5)}{0.441}\, \Delta_5\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-2}$$

$$-\underset{(2.3)}{0.568}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1} - \underset{(2.0)}{0.896}\, \Delta n RS_{wt}$$

$$+\underset{(3.7)}{1.063}\, \Delta^2 n(RS-RS_w)_{t-1} - \underset{(4.0)}{1.464}\, \Delta^2 n(RL-RL_w)_{t-1}$$

$$+\underset{(2.1)}{2.132}\, \Delta n\left(\frac{NSO\pounds}{X\pounds}\right)_{t-1} + \underset{(3.2)}{0.00696}\, \Delta_4\left(\frac{OILRES}{GDP\pounds}\right)_{t-1}$$

$$-\underset{(4.0)}{0.278}\, \ln\left(S \cdot \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1} + \underset{(8.6)}{1.289}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3}$$

$$+\underset{(5.6)}{1.714}\, n\left(\frac{NSO\pounds}{X\pounds}\right)_{t-3}$$

$\bar{R}^2 = 0.761$
SE = 0.0143
Q(8) = 7.9(15.5)
LM(5)=8.3(11.1)
Chow(6,25)=4.7(3.6)

Equation 4A S :

$$\ln S = -\ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right) + 4.63 \ln\left(\frac{Y}{Y_w}\right)$$

$$+ 6.155\, n\left(\frac{NSO\pounds}{X\pounds}\right) - 3.219\, \Delta n RS_w - 2.04\, \Delta \ln\left(\frac{Y}{Y_w}\right) - 0.258$$

Equation 4B

$$\Delta \ln S_t = -\underset{(8.3)}{0.062} + \underset{(3.7)}{0.464}\, \Delta \ln S_{t-4} + \underset{(2.3)}{0.205}\, \Delta_6 \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)$$

$$+\underset{(3.1)}{0.394}\, \Delta \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-5} - \underset{(0.9)}{0.195}\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1}$$

$$+\underset{(4.1)}{0.265}\, \Delta \ln\left(\frac{M}{B}\right)_t + \underset{(1.5)}{0.383}\, \Delta n(RS-RS_w)_{t-1}$$

$$+\underset{(1.6)}{1.513}\, \Delta n\left(\frac{NSO\pounds}{X\pounds}\right)_{t-1} + \underset{(5.3)}{0.0124}\, \Delta_4\left(\frac{OILRES}{GDP\pounds}\right)_{t-1}$$

$$-\underset{(5.9)}{0.484}\, \ln\left(S\, \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1} + \underset{(2.0)}{0.0996}\, \ln\left(\frac{M}{B}\right)_{t-1}$$

$$+\underset{(8.2)}{1.695}\, \ln\left(\frac{Y}{Y_w}\right)_{t-3} + \underset{(4.6)}{2.144}\, n\left(\frac{NSO\pounds}{X\pounds}\right)_{t-3}$$

$\bar{R}^2 = 0.781$
SE = 0.0137
Q(8)=13.3(15.5)
LM(5)=14.3(11.1)
Chow(6,23)=4.1(3.6)

Equation 4B S :

$$\ln S = -0.794 \ln\left(\frac{M}{Y}\right) - 0.206 \ln\left(\frac{B}{Y}\right) + \ln\left(\frac{M_w}{Y_w}\right)$$

$$+3.506 \ln\left(\frac{Y}{Y_w}\right) + 4.434\, n\left(\frac{NSO\pounds}{X\pounds}\right) + 0.792\, \Delta n(RS-RS_w) - 0.128$$

Equation 4C

$$\Delta \ln S_t = -0.081 + 0.347\, \Delta \ln S_{t-4} + 0.49\, \Delta_6 \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-2}$$
(11.0) (3.2) (5.6)

$$+0.318\, \Delta \ln\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-5} - 0.683\, \Delta \ln\left(\frac{Y}{Y_w}\right)_{t-1}$$
(2.7) (3.1)

$$+0.198\, \Delta \ln(E)_t - 1.199\, \Delta nRS_{wt} + 1.626\, \Delta^2 n\left(\frac{NSO£}{X£}\right)_{t-1}$$
(4.0) (3.2) (2.9)

$$+0.0094\, \Delta_4\left(\frac{OILRES}{GDP£E}\right)_{t-1} - 0.0243\, \Delta\left(\frac{BOF£}{X£}\right)_t - 0.0386\left(\frac{BOF£}{X£}\right)_{t-2}$$
(4.9) (1.3) (1.7)

$$-0.5405\, \ln\left(S \cdot \frac{M}{M_w} / \frac{Y}{Y_w}\right)_{t-1} + 1.751\, \ln\left(\frac{Y}{Y_w}\right)_{t-3}$$
(9.1) (9.9)

$$+1.747\, n\left(\frac{NSO£}{X£}\right)_{t-3}$$
(5.4)

$\bar{R}^2 = 0.83$
SE = 0.0121
Q(8)=19.8(15.5)
LM(5)=14.9(11.1)
Chow(6,22)=7.3(3.6)

Equation 4C S :

$$\ln S = -\left(\frac{M}{M_w} / \frac{Y}{Y_w}\right) + 3.239\, \ln\left(\frac{Y}{Y_w}\right) + 3.232\, n\left(\frac{NSO£}{X£}\right)$$
$$- 2.219\, \Delta nRS_w - 1.264\, \Delta \ln\left(\frac{Y}{Y_w}\right) - 0.15$$

A casualty of integrating the N.S. oil variable into the specification used in Table 3 is the fall in the estimated size of a_1, the elasticity of non-oil trade with respect to the real exchange rate. If $a_1 = 0.14$, we can deduce that the absolute value of the sum of the export and import real exchange rate elasticities is 1.14. This implies rather smaller overall trade elasticities than empirical studies from the 1950's and 1960's indicated, although more recent studies have found import elasticities of about a half, e.g. Whitley (1977). Since our entire estimation period spans only the 1970's, if the relative price elasticities of export and import demand functions have in fact declined then the estimate above seems quite plausible.

A value of 0.11 for $\hat{\beta}_1$ implies that a one per cent increase in the uncovered interest rate differential would generate a meagre capital inflow of £18 millions. Even allowing for a large degree of underestimation of $\hat{a}_1$, the capital account response is unlikely to exceed £100 millions. Either way the interest elasticity is low and much removed from the estimates implied by perfect capital mobility.

The "money only" model, contained in 4A, passes both the small sample Box-Pierce and the Lagrange Multiplier tests against autocorrelation, whereas 4B passes only the former. This pattern has prevailed throughout with the exception of specification 1B. On efficiency grounds 4B is much to be preferred in the case of the simple model and the N.S. oil model, but on both occasions where interest rates are explicitly included, both models perform similarly in terms of standard error. Equation 4B has a marginally smaller standard error than 4A. Finally, on the grounds of dynamic post sample stability both models perform badly, although we would argue that the test is a stern one. In attempting to predict the quarter to quarter movement of the sterling effective exchange rate during 1979 and the first half of 1980, there was considerable unavailable external information. In so far as the election of a Conservative government, the announcement of a more restrictive monetary stance and medium-term strategy in the UK, the abandonment of outward UK exchange controls and the Volcker measures in the US are items of information which are not adequately contained in the explanatory variable set, then dynamic equation instability could be said to be inevitable. In terms of the stability of the steady state prediction of the exchange rate, both equations overpredict 1980Q2 (see Table 1A). In view of the further appreciation of sterling since the summer, neither result can be disregarded.

The Role of Official Intervention

The estimated equations prior to 4C exclude the intervention variable, BOF/Xt, and since it is a policy variable of some interest we seek to remedy this omission. Girton and Roper (1977) estimated an exchange rate pressure model for the Canadian dollar, in which they performed constrained canonical regressions of the form

$$\frac{BOF}{M_{-1}} + \Delta \ln S = F [\quad] \qquad (19)$$

Such a model has the advantages that it allows estimation over both fixed and flexible exchange rate regimes to be carried out (although one would probably still include some allowance for institutional structural breaks) and that it avoids the problem of trying to obtain correctly-signed effects on BOF/M_{-1} when it appears on the right-hand side of the specification. The main disadvantage of the Girton-Roper model is that whilst agents may form systematic exchange rate expectations they are unlikely to have any idea about the behaviour of BOF in the short run. Thus in one sense the inclusion of BOF in this way is a handicap to efficient exchange rate estimation, since the BOF component of pressure adds considerably to the equation variance to be explained.

A second approach is to estimate BOF and exchange rate equations as a system. There is an unavoidable simultaneity here as intervention in both spot and forward exchange markets is necessarily spontaneous. Work has proceeded along this line of enquiry at the Bank of England carried out by Haache and Townend (1980). Although identifying a plausible specification for the BOF equation the authors found the BOF term in the exchange rate equation to be insignificantly different from zero.

The simplistic approach we adopt in equation 4C, (which is to emphasise that we do not regard efficient estimation of the intervention coefficient as a principal objective in this paper) is to enter BOF/Xt directly into the equation. The term enters as a current period difference followed by a levels effect with a two quarter lag, but neither coefficient, although correctly signed, is very significant.

The implied response of the exchange rate to efficient intervention in the spot market is necessarily a short-run response as our theory suggests that the government cannot permanently alter the level of sterling without the help of infinite reserves of gold and foreign currency. The estimated short-run effect of a £1bn sale of foreign currency is a sterling appreciation of less than 0.4%. It should be noted, however, that equation 4C with its deteriorated autocorrelation properties is most probably over-fitted.

IV Summary and Conclusions

In the context of the most basic form of portfolio balance model, our first conclusion was that the inclusion of bonds into the specification was a significant improvement over the simple monetary model, although in both cases there was strong evidence of dynamic post-sample instability. Moreover the implicit steady states of the equations yielded levels predictions for the exchange rate in 1980Q2 which were over 10% too low.

When interest rate variables were explicitly included, another significant improvement in equation efficiency occurred, especially in the case of the simple monetary model. At this stage we simulated the effects of a permanent cut in the money stock on the nominal and real exchange rate to examine whether the Dornbusch overshooting phenomenon was observed. This effect appeared to be extremely shortlived and was followed by more substantial periods of undershooting. The interest rate-augmented models underestimated the level of the exchange rate by only 2-3% less than in the original case.

The addition of variables to proxy the current and capital account effects of the discovery and exploitation of N.S. oil further enhanced the within sample precision of the money-bonds equation in particular. More dramatically, the levels prediction of the exchange rate is in the range 13-20% higher by the end of the period than when N.S. variables are excluded, implying that the impact of the North Sea on the exchange rate is primarily responsible for the rapid appreciation of sterling since 1977.

In the estimation of the complete specification we draw attention to the dangers of overfitting the equation and the implied structural parameters indicate that this problem has become serious at this stage. On the balance of the evidence we conclude that the portfolio balance model is to be preferred to the simple monetary model because of its generality, although the coefficient on UK bonds is probably no larger than 0.2. It is also acknowledged that the inclusion of bonds appears to induce more autocorrelation into the model, and for this reason the only-money model cannot be rejected on the basis of this evidence. Finally we examined in a simplistic way the sensitivity of the exchange rate to intervention by the authorities. Our results suggested that the disturbance to the exchange rate by way of these flows was of both minor and temporary importance.

Appendix

a) Data Definitions and Sources

B	:	Total non-bank private domestic holdings of British government securities at nominal value, £m. Source : Bank of England Quarterly Bulletin annual article on the composition of the national debt. Quarterly values were obtained by interpolation using the net acquisitions data as a guide to the quarterly pattern.
BALOPEC	:	Exports (f.o.b) minus imports (c.i.f.) of the oil exporting countries expressed in billions of US $. Source : IMF International Financial Statistics
BOF	:	Balance for official financing, £m. Source : Financial Statistics
DISC	:	The annual change in the Estimated Possible Reserves of North Sea oil in millions of tonnes. Source : Department of Energy Brown Books
GDP£E	:	Gross Domestic Expenditure at Current Prices £m, SA Source : Economic Trends
M	:	Sterling M3 money stock index (1975=1) derived from the series provided in the Bank of England Quarterly Bulletin
M_w	:	Index of World* M3 money stock (1975=1) constructed from 17 individual country indices using geometric trade weights
NSO	:	Production of North Sea oil in millions of tonnes per quarter. Source : Oilfacts (Hoare Govett) and Department of Energy Press Notices
NSO£	:	The value of North Sea oil production at current prices £m, derived as the product of NSO and PNSO£
OILRES/	:	The value of estimated N.S. oil reserves in the ground at current prices expressed in terms of quarters' worth of annual expenditure, constructed using the definition on page 7.
P_w	:	Index of World* Wholesale Prices in World currency (1975=1) Constructed from 17 individual country indices using geometric trade weighting.
PNSO£	:	Price of a typical tonne of North Sea oil in £. Constructed from the dollar series contained in Oilfacts using period average exchange rates.

RS	:	Short term rate of interest (91 day Treasury Bill Rate) in % per annum. Source : Bank of England Quarterly Bulletin
RS_w	:	World* short term interest rate, % per annum, constructed as a weighted average of US, Japan, Germany and France
RL	:	Redemption yield on medium dated UK government stocks, % per annum Source : Bank of England Quarterly Bulletin
RL_w	:	World* long term interest rate, derived as a weighted average of secondary market yields of securities of maturity greater than 10 years for US, Japan, Germany and France.
S	:	Effective Exchange Rate Index (1975=1) in foreign currency per £ Source : Bank of England Quarterly Bulletin
X£	:	Total UK exports of goods and services at current prices, £m Source : Economic Trends
Y	:	Index of UK Gross Domestic Product at constant 1975 prices (1975=1) Source : Economic Trends
Y_w	:	Index of World* Gross National Product. 1975=1. Constructed as a weighted average of the six largest non-UK countries' GNP

*excluding UK

(b) Syntax of symbols used

Δ : First difference operator

Δ^2 : First difference of a first difference operator

lnx : Natural logarithm of x

n(x) : $\ln\left[1 + (\frac{x}{100})\right]$

c) Explanation of diagnostic statistics used

$\bar{R}^2$: Multiple correlation coefficient adjusted for degrees of freedom

SE : Estimated equation standard error

Q(X) : Small sample Box-Pierce statistic testing the null hypothesis of randomness of the residual correlogram to degree X. If the Chi-squared value in parenthesis (e.g. 15.5) is exceeded by the test statistic value which precedes it, then the null hypothesis may be rejected at the 95% confidence level

LM(Y) : A Lagrange-Multiplier test for the joint significance of the first Y autocorrelation coefficients. A test statistic which exceeds the bracketed chi-squared value indicates the presence of significant autocorrelation

Chow(Z_1,Z_2): The Chow statistic tests the hypothesis that the residual sum of squares from the equation estimated over an additional Z_1 observations belongs to the same population as the residual sum of squares from the original equation estimated with Z_2 degrees of freedom. This statistic has an F-distribution and the 99% critical value is given in brackets. Again if this value is exceeded, the test fails.

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