A PLURALIST MODEL OF TAX-BENEFIT POLICY

By Philip Truscott

Dx77539
ACKNOWLEDGEMENTS

I would like to express my affection and gratitude to Sara Arber and Nigel Gilbert for reading countless drafts of this thesis and supplying copious comments and corrections. I would also like to thank Bea and Gloria for providing moral support and material sustenance in spite of my often cheerless and unsociable behaviour.
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A.1 Summary of POM's Commands
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ABBREVIATIONS

CIO  Central Information Office
CSO  Central Statistical Office
DIG  Disablement Income Group
DHSS Department of Health and Social Security
DOE Department of the Environment
ESRC Economic and Social Research Council
FES  Family Expenditure Survey
GHS  General Household Survey
HMSO Her Majesty's Stationary Office
ICERD International Centre for Economics and Related Disciplines
IFS  Institute for Fiscal Studies
LSE  London School of Economics
NIT  Negative Income Tax
OECD Organisation for Economic Co-operation and Development
PAYE Pay As You Earn
POM  Policy Option Model
PSI  Policy Studies Institute
PSL  Policy Simulation Language
SPI  Survey of Personal Incomes
SSRC Social Science Research Council
UCL University College London
UK  United Kingdom
US  United States
ABSTRACT
In order for a pluralist democracy to function well it is necessary that the means to bring forward policy proposals should be dispersed widely among a variety of political parties, pressure groups, and institutions. The goal of this thesis is to define and solve the problems of creating a computer model of tax-benefit policy suitable for a pluralist society. Computer modelling of tax-benefit policies poses two serious problems. Firstly, can such computer models be sufficiently easy to use so that non-experts can use them without the need for computer specialists? Secondly, can they be flexible enough so that truly innovative policies can be simulated, or must the user be restricted to a narrow set of policy options?

The first section of the thesis defines the major dilemmas involved in creating a tax-benefit model. Chapter 1 outlines the problems inherent in solving the aforesaid problems of usability and flexibility. Chapter 2 shows how far these problems have been solved already by describing the features of eleven existing models of the British tax-benefit system.

The second section of the thesis examines the store of knowledge on which an ideal tax-benefit model should be based. Chapter 3 discusses the various principles which have been advanced as yardsticks by which to measure tax-benefit policy. Chapter 4 examines four case histories of major changes to the tax-
benefit system in the past. Chapter 5 makes a detailed examination of the form of behavioural response to tax-benefit policy which has been most frequently explored by policy researchers: the extent to which work incentives are affected by tax-benefit policy.

The third section describes the characteristics of a new computer model and a new computer language which have been constructed for this thesis which attempt to deal with the problems of tax-benefit modelling in a pluralist society. Chapter 6 outlines the general features of the data, the new computer language, the Policy Simulation Language, and the new model the Policy Option Model which have been created. Chapter 7 gives a detailed explanation of how the features of the Policy Simulation Language and the Policy Option Model have been implemented. Chapter 8 describes the characteristics of the Policy Option Model's user interface. Chapter 9 gives examples of the output from the Policy Option Model. In order to collect the data for chapter 10 the Policy Option Model was demonstrated to a number of people in the field of tax-benefit modelling who use other models. Chapter 10 contains a selection of the comments of these people after these demonstrations. Chapter 11 outlines possible future developments of the Policy Option Model and discusses the extent to which it has succeeded in solving the problems of tax-benefit modelling in a pluralist society.
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

1. Introduction
This chapter is arranged in four sections. Section 1.1 explains the importance of tax-benefit modelling in British society. Section 1.2 outlines the conceptual arguments for a new tax-benefit model based on a discussion of the nature of power. Section 1.3 deals with the practical arguments for a new tax-benefit model based on three case studies of power relationships which highlight the inequalities in the access to tax-benefit policy making resources. Section 1.4 explains the dilemma which faces the designers of the type of tax-benefit model which would solve the problems outlined in sections 1.2 and 1.3.

1.1 The Importance of Tax-Benefit Modelling
Taxation has often been a matter of passionate debate. Such debates have sometimes changed the course of history. An excessive tax burden may have contributed to the fall of the Roman Empire (Coffield, 1970:58). Henry IV's Poll Tax was the direct cause of the great Peasant's Revolt of 1381. It was a "Cause Celebre" of the American Revolutionary War when James Otis declared that "Taxation without representation is Tyranny". In more recent times the fate of elected governments has often been linked to the issue of taxation. Governments have to do a complex balancing act to raise enough money on the one hand, while maintaining the support of the governed on the other. Leaders failing to keep this balance have sometimes toppled into political oblivion like Henry IV's Treasurer Sudbury who was lynched by objectors to the Poll Tax.

Avoiding mistakes in fiscal policy is therefore a matter of political importance. Indeed, it is even more crucial today than in the great taxation debates of the past because of the sheer scale of the current system.
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Currently 34 per cent of Britain's National Income is taken in taxation. Of this figure (some 122 bn pounds of a gross domestic product of 354 bn pounds) (CSO, 1987) the state spends some £44 bn per annum on state benefits to individuals (CIO, 1989). This is easily the single largest item of government spending. In no previous century was so large a proportion of national wealth consumed by taxation, nor was there ever such a highly developed social welfare system.

Policy-making in the area of taxation and social security is made more complex because of the public's contradictory expectations. For example, it was found in 1985 that 61 per cent of the British public said they thought it was "very important" or "quite important" to cut the standard rate of Income Tax to 25 per cent, while 86 per cent agreed that the government should spend more money to get rid of poverty (Heald & Wybrow, 1986: 128). Similarly, 66 per cent said they thought that high income tax makes people work less hard (Heald & Wybrow, 1986), while the British Social Attitudes Survey found that 59 per cent of respondents agreed with the proposition that "it is the responsibility of government to reduce the difference between people with high incomes and people with low incomes" (Brook, Jowell, and Witherspoon, 1987). Balancing the requirements of equality and incentives is all the more difficult because of this lack of clarity about what the system is intended to achieve.

If policy-making only involved decisions about the aggregate levels of taxation and benefit spending, then it would be relatively easy. Unfortunately for the policy analyst, it is necessary to weigh up the effect of a policy on millions of individuals - who may be affected in unexpected and sometimes contradictory ways by different elements of the tax and social security system. For example, consider a hypothetical man:-
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with a two child family ... [who] earned £35.00 per week in July 1977. He would be paying Income Tax and National Insurance Contributions, receiving family income supplementation, receiving a rent rebate, and entitled to free school meals. Each involves a separate form and different criteria. Incidentally, if the father were so exasperated with all this form filling that he assaulted one of the officials, he would then be eligible for legal aid. (IFS, 1978:82)

Here we see a case where the taxes and benefits affect an individual in conflicting ways. In this case the state acknowledges that the man's income is too low to pay his rent and raise his children, yet at the same time that it offers him benefits to increase his income it makes him pay Income Tax and National Insurance Contributions. The policy analyst must therefore take into account the conflicting effects of uncoordinated tax-benefit policies. This complexity is increased by the fact that one cannot know with certainty whether the man described above would actually claim the rent rebate and family income supplement.

Policy analysts have to assess how a change will affect millions of such cases. The tax-benefit system has grown into a structure of such labyrinthine complexity that pencil and paper methods of assessing changes in policy are no longer adequate. Computer models have become an unavoidable necessity. Computers can analyse the effects of a policy change on a large number of cases to give policy predictions which are far more detailed than is possible with other methods. The type of information which can be generated by a computer includes:-
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(i) showing how net incomes of different groups will be affected by a policy change;
(ii) estimating the incentive or disincentive effects of a policy;
(iii) calculating a breakdown of gainers and losers by family type and level of income;
(iv) estimating the global Exchequer costs of a policy;
(v) calculating the "take-up rate" of a given benefit;
(vi) showing who bears the burden of a particular tax;
(vii) predicting the behavioural responses to a given policy.

It should be stressed that this is not an exhaustive list. It is merely shown to give an impression of the range of different policy issues which must be considered. [A fuller discussion of the issues which need to be included in the assessment of tax-benefit policy is given in chapter 3.]

Computer models have thus become a vital feature in determining how the burden of tax and the benefit of welfare are to be distributed. Given the large proportion of national income which is channeled through the tax-benefit system, these computer models are of undeniable importance as they help to shape opinions about whether or how the current system should be changed.

1.2 The Need for a new Tax-Benefit Model
   - The Conceptual Arguments

Given that tax-benefit modelling is an inevitable feature of policy-making, is the current pattern of access to
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such models appropriate for the efficient working of democracy?

This thesis accepts a prescriptive view that in a democracy a pluralist pattern of access to tax-benefit models is desirable; it is necessary for effective policy-making abilities to be available to a range of pressure groups, opposition parties, and groups within parties, rather than simply to the dominant faction within the governing party. This prescriptive view accepts that the propagation of a series of alternative policies is useful to ensure that the optimum policy will be adopted. Even if the constant questioning of a government's policies does not lead to their rejection, it may lead to modifications which would not have been made if a vigorous alternative case had not been put. This prescriptive view was asserted eloquently by Laski:

We prefer a state where sovereignty is distributed, where the richness of corporate lives is insurance against ... sterility of outlook ... There can be no servility in a state which divides its effective governance. The necessity of balancing interests, the need for combining opinions, results in a wealth of thought such as no man can attain. The price of liberty is exactly the divergence of opinion on fundamental questions ... No man, and even more, no state can ever be so right as not to need doubts about its rightness.

(Laski, 1917:273-274)

In the field of tax-benefit policy, these essential "doubts", which Laski considered so important, can best be supplied by groups with views which differ from the government. Such groups may exist both inside and
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outside the governing party. Groups outside the governing party would include pressure groups and the opposition parties. Examples of intra-party groups would include such bodies as the Monday Club and the Tory Reform Group within the Conservative Party, or the Campaign for a Labour Victory and the Tribune Group within the Labour Party. It is all the more important for alternative views to be expressed within the British political system because it has no distribution of power between levels of government as in federal systems, or between branches of government as in the USA where there is a constitutional separation of powers between the legislature, the executive, and the judiciary. The lack of checks and balances within the British polity is so marked that a former Lord Chancellor has described it as a system of "elective dictatorship" (Hailsham, 1978:9).

How far does the pattern of access to tax-benefit models parallel the concentration of political power? Who owns and has access to the existing tax-benefit models?

There are eleven major models of the UK tax-benefit system. Four of these were developed inside government departments. These are the DHSS tax-benefit Model table program (which shows the net income and implied tax rates of hypothetical families); the Inland Revenue Personal Income Tax Model (which uses a sample of 55,000 tax returns to predict the revenue costs and distributional effects of Income Tax changes); the DHSS Policy Simulation Model and the Inter-Departmental Group on Tax-Benefit Modelling program which both use the Family Expenditure Survey (FES) to predict the effects of general tax-benefit changes. The government have a monopoly of the use of these programs, except for the facility afforded to MPs to ask parliamentary questions. However, the government can refuse to answer a question on grounds of cost. In practice, this means questions
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about policies which are a relatively minor deviation from the status quo (and which are therefore cheap to simulate) will be answered, whereas questions about more complex policies will not be.

Apart from the four models in government departments, there are two in the quasi-governmental sector. The Policy Studies Institute (PSI) has a model. Though the PSI is independent, the overwhelming majority of the contracts for its work come from government or quasi-governmental bodies. There is no evidence that an opposition party or pressure group has paid the PSI to do tax-benefit simulations on its behalf. The other quasi-governmental model is the Alvey DHSS Policy Demonstrator. This is a joint project between government, private industry, and higher education. It is not clear that the Policy Demonstrator will be made available to opposition parties after its completion. Even if it is, non-governmental organisations would have difficulty in affording the extremely expensive computers that the Demonstrator is designed to run on.

Five of the eleven models are not owned directly by government. For example, the City University Business School Model (CUBS) was developed primarily to demonstrate the effect of the tax-benefit system on labour supply. Its structure displays a keen concern for possible disincentives in the tax-benefit system, and its authors (such as Michael Beenstock) are associated with the ideological right. It has not been used by any pressure groups or opposition parties.

The Tax Reform Analysis Package (TRAP) has been developed by academics at the London School of Economics. Like the CUBS model it is chiefly concerned with the labour supply effects of policy. The users of this package would have to supply their own data and spend considerable amounts
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of time in becoming familiar with it. It has not been used by any opposition parties or pressure groups in the U.K.

Two models have emerged from the Suntory-Toyota International Centre for Economics and Related Disciplines (STICERD) at the London School of Economics. TAXEXP is like the DHSS Tax Benefit Model Table program in that it is based on hypothetical families. TAXMOD is based on a sample of actual cases from the FES, but it does not include cases of people who are unemployed or retired. TAXMOD has been supplied to a number of pressure groups such as the Low Pay Unit, however there are limitations on the type of output it can produce, and there is no evidence that it is regularly used by any opposition parties. It has been used to assess the former Liberal Party's Tax Credit Proposals, but not by the Liberal Party itself but rather by researchers at the LSE. Thus it was not used during the process of policy formulation, but afterwards to criticise the policy.

The Institute for Fiscal Studies (IFS) model has been used regularly by the government and by the Social Democratic Party (SDP). Indeed the SDP's use of the IFS model is the only example in the 1980s of an opposition party actually commissioning research to be done on a tax-benefit model.

The different characteristics of the eleven models are summarised in figure 1.1. It will be seen from this that there is no model available to opposition parties and pressure groups which can simulate the effect of policies on the full population. By far the best of the publicly accessible tax-benefit models is the LSE TAXMOD package but as it excludes the unemployed and retired it only covers 51 per cent of the population.
<table>
<thead>
<tr>
<th>Level of Analysis</th>
<th>House-</th>
<th>Household/ Tax Unit/ Tax/Benefit Rule</th>
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<td>Major Exclusions</td>
<td>Investm't</td>
<td>Sick,</td>
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<td>From Population</td>
<td>Pensioner</td>
<td>Jobless</td>
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<td>Proportion of Population Covered</td>
<td>under 50%</td>
<td>above 95%</td>
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<td>No. of Cases</td>
<td>Not</td>
<td>Not</td>
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<tr>
<td>Based on Hypothetical Examples</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Based on Actual Survey Data</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Survey Data Used</td>
<td>Not</td>
<td>F.E.S.</td>
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<tr>
<td>Simulation of Behaviour Responses</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Computer Language</td>
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<td>FORTRAN77</td>
</tr>
<tr>
<td>Availability</td>
<td>General</td>
<td>Not Meant!</td>
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<td>£20.00</td>
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<td>No</td>
<td>No</td>
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<tr>
<td>Standard Deviation</td>
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<td>Applic.</td>
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<tr>
<td>Assessment of User-friendliness</td>
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<td>Medium</td>
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<td>Date Written</td>
<td>Late 60's</td>
<td>1982</td>
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<td>Documentation</td>
<td>None</td>
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* Trap can be used with a variety of data sets, these figures refer to...
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It should be stressed that access to these models is not the only factor affecting the ability to do tax-benefit policy analysis. The ability to use some of these models also necessitates the employment of people with specialist computer skills. This problem could be solved by producing more models like TAXMOD which are extremely easy to use, but such programs are the exception rather than the rule. When the availability of skilled labour is considered, in addition, to the accessability of the models themselves, it is clear that opposition parties, pressure groups, and groups inside the governing party (other than the dominant faction), are all at a serious disadvantage in comparison with government.

Tax-Benefit models can make a difference to the balance of political power. By predicting the likely effects of a policy, tax-benefit models can help to show whether a particular policy is viable or not. The ability to determine the viability of different options is important in influencing opinions. Clearly if one group in society has the resources to show that a particular policy option can be implemented without serious disadvantages, then that group will be more powerful than another group without the same ability.

Does this matter? Is the British political system sufficiently diverse that alternative policies may be brought forward and implemented within the existing structure anyway? These questions involve a conceptual debate about the nature of power itself. Is power concentrated in the hands of an elite, or does it exist in a distributed form in a variety of different power centres? This debate involves the use of the word "pluralist" in both a prescriptive sense (to explain, by those who support the concept of pluralism, what the political system ought to be) and a descriptive sense (to explain how the political system actually is). In order
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to avoid this confusion, the term will be used in the following discussion purely in its descriptive sense.

Among the recent contributions to the academic discussion is a debate which has become a classic study for students of political science. This is the dispute between Dahl who argued that power is distributed in a pluralist manner, and Bachrach and Baratz who argue that it is concentrated. Dahl’s (1961) argument was based on an empirical study of political conflicts within New Haven, Connecticut. Dahl concluded that there were several centres of power, because no single group appeared to win all (or even a large majority) these disputes.

Commenting on Dahl’s research Bachrach and Baratz (1970) pointed out that the assumption of a pluralist power structure was incorrect because an elite could have manipulated the political debate so that only minor issues were brought into the political arena while the major ones were never allowed to be contested. Thus even though observed conflicts did not show a monopoly or even a hegemony of power by a single group, an elite could have prevented significant conflicts from being observed. Bachrach and Baratz argued that the control of the political agenda meant that issues such as poverty and racism, which were of major concern to significant numbers of people in New Haven, were not raised.

Lukes (1974) has termed Dahl’s perspective on power relationships the "One Dimensional View" because it only takes into account power relationships from a single narrow perspective: that of visible actualised conflicts. Conducting empirical research at this one dimensional level involves a risk that the researcher will conclude that the distribution of power is more dispersed than it actually is because, as Bachrach and Baratz (1970) have shown, the conflicts which succeed in rising to the
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surface of the political maelstrom, may only be of an inconsequential nature. This echoes Schattschneider’s view that "some issues are organised into politics while others are organised out" (Schattscheider, 1960:34).

Lukes (1974) categorised Bachrach and Baratz’s methodological perspective as the "Two Dimensional View". This view is capable of explaining more power relationships than the one dimensional view by taking into account suppressed conflicts. Power relationships may be illustrated not only by decisions but also by "non-decisions". However in Lukes’ view there is a crucial flaw in Bachrach and Baratz’s methodology because they insist on only taking into account observable non-decisions. Bachrach and Baratz write that if "there is no conflict, overt or covert, the presumption must be that there is consensus on the prevailing allocation of values, in which case nondecision-making is impossible" (Bachrach & Baratz, 1970: 49). Lukes suggests that power may be manifested in forms so subtle that it cannot be measured in terms of conflict, either overt or covert. Bachrach and Baratz seem at times to dismiss this more subtle view of power simply because it might defy the power of social scientists to measure it. This seems to involve sacrificing the accuracy of social theory on the altar of empirical methodology.

Lukes argues that a "three dimensional view" should be taken so as to explain the structure of power fully. This view would make it possible to take into account forms of power which do not express themselves either in open or suppressed conflict.

The bias of the system is not sustained simply by a series of individually chosen acts, but also, most importantly, by the socially structured and culturally patterned behaviour
of groups and practices of institutions, which may indeed be manifested by individuals' inaction.

(Lukes, 1974:21-22)

These structures, practices, and patterned behaviours can prevent issues from being raised at all so that they never reach the point at which they could be suppressed. Not only does Lukes maintain that the three dimensional view of power helps better to explain the structure of power, but he refutes the Bachrach and Baratz view that it is impossible to measure the forces which lead to politically significant inaction. The patterned behaviours which Lukes mentions could help to support Poulantzas' (1986) case that a social class's objective interests could differ from the way those interests are represented. Thus if the way a class's interests are represented so as to confine the class's goals to a narrow range of "safe" issues, its real interests can be ignored.

As a paradigm for the type of research methodology which could help to assess power relationships using the three dimensional view Lukes takes a study by Crenson (1971) which seeks to explain the reason why different cities in the USA tackled their air pollution problems at different points in time.

Crenson conducted a detailed case study of two American cities, and also completed a survey of the opinions of community leaders in 51 American cities, to try to determine why certain cities dealt with their air pollution problems years or even decades earlier than others. Crenson's data indicated that a strong reputation for power by local industry and strong party organisation in a given city made it less likely that the pollution issue would be dealt with quickly. For
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example, East Chicago which lacked strong party organisation and whose commercial power was split between a number of companies succeeded in enacting local clean air legislation in 1949. In contrast Gary, Indiana, had a strong party organisation and was seen as a "one company town". The company, U.S.Steel, was a major air polluter and therefore had a vested interest in the status quo. The existence of party organisations tended to impede progress, because the parties provided a mechanism by which the companies could give local politicians inducements not to take action on the clean air issue. Thus Gary did not institute air pollution controls until 1962. To understand Crenson's research and Lukes' three dimensional view of power it is crucial to understand that these commercial and political obstructions to change do not need to take active steps to exert power. The fact that institutions merely have a reputation for being powerful is sufficient to discourage potential reformers from entering the political fray and trying to change a policy.

It has been argued here that undemocratic restrictions on the scope of local political activity are the products of indirect influence. They are not the result of suppressive acts or directly applied pressure but are responses to the power reputations of various local groups, organizations, and individuals.

(Crenson, 1971 : 181)

Foucault's research would also tend to support Lukes' concept of power, in that he concentrated on the underlying assumptions of societies which could be gauged from their patterns of speech. Foucault is concerned with the question "What rules of right are implemented by the relations of power in the productions of discourses of
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truth?" (Foucault, 1986: 229). It should be stressed that the words "right" and "truth" are used here in an existentialist sense. "Right" and "Truth" are not absolute concepts with an independent existence for Foucault. They are "right" and "truth" in a relative sense as they are defined by a particular society. This is the basis of Foucault’s studies of "discourse/practice" in which he shows how in certain situations the language of societies has shaped what behaviour is acceptable, and therefore it has acted as an invisible form of control. This control exerts itself purely by shaping the underlying values of society, and never through overt conflict. It is, par excellence, an example of power exertion which can only be measured if one accepts Lukes’ three dimensional view of power. Arendt’s definition of "authority" is similar to Foucault’s and Lukes’ concept of power "Authority ... Its hallmark is unquestioning recognition by those who are called to obey; neither coercion nor persuasion is needed" (Arendt, 1986: 65).

If the dominant position of the ruling groups in a society depends on this preservation of underlying values, then it is necessary for the values of the status quo to go unquestioned. Alternative policies and systems must be excluded from regular discussion. Lukes and Foucault imply that there is an invisible dictatorship of the mind which is kept in force without the overt exercise of power. For such mind control to exist alternatives must be suppressed. Thus if status quo is to be altered then different ideas must be promulgated. In order to make possible this dissemination of different ideas it is necessary to have information transfer mechanisms to undermine the consensus of the status quo. Thus writing, ink, paper, printing, literacy, and independent broadcasting all tend to undermine power concentration. The dissemination of a generally usable
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tax-benefit model would also be a tiny step forward in this process of knowledge dispersal. Some adherants of Lukes’ radical view of power might argue that it would be hopelessly idealistic to suggest that mechanisms of information transfer could alter the structure of power. But this would be to expose a weakness of the radical view of power, because it only furnishes a theory about how domination is maintained; it does not provide a theory about how domination is undermined. The radical view cannot explain how monarchies become oligarchies and how oligarchies become democracies.

Lukes (1974) locates his various conceptions of power within different categories, which represent different outlooks on politics. He implies that the one-dimensional view is best applied to liberals, the two-dimensional view best fits those who are reformists, and that the three dimensional view is best suited to radicals. There would seem to be various political persuasions which are not covered by this typology. Would a true conservative only be interested in maintaining the status quo and so take a zero-dimensional view of power? Where would Marxists fit into Lukes’ schema?

Some of Marx’s arguments about the distribution of power and control of the mode of production have parallels with the debate over information technology. To understand this argument it is important to understand how some Marxist concepts have been adapted by writers like Foucault. Marx argued that the capitalist class maintained its power through its monopoly ownership of the mode of production (Marx, 1976). However economic developments since Marx have made the mode of production a much less useful yardstick by which to measure the distribution of power. When Marx wrote the vast majority of the working population were employed in the secondary (industrial) sector of the economy, rather than the
primary sector (agriculture). However, in the last quarter of the twentieth century many countries have an entirely different pattern of employment. In the United States the majority of workers are now in the tertiary (service) sector. As Poster puts it, the fact that fewer people are employed producing material objects means that:

labor now takes the form of men and women acting on other men and women, or, more significantly, people acting on information and information acting on people. Especially in the advanced sectors of the economy, the manipulation of information tends to characterize human activity... The creation, transformation, and movement of information are the objects of most of the important new technologies that are introduced into the economy. We are told that very soon movement in the social field will involve information (electronically processed), not men or commodities. People will stay put while information will flow through social space.

(Poster, 1984: 53)

In order to signify this transition, Foucault's writings concentrate on the "mode of information", a deliberate modern parallel of Marx's concept of the mode of production. Thus it could be argued that the government's dominant access to the tools for making tax-benefit policy parallels Marx's theory about the capitalist class's monopoly ownership of the means of production. In the Marxist era ownership of capital was the litmus test of power; in the late twentieth century it is the control of information.

As an example of the potential effect of control and use
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of information Burnham (1983) points to a referendum
campaign in Missouri in 1978. This resulted in a victory
for trade unionists supporting the retention of the
"closed shop" principle, even though the opinion polls
had shown Missouri residents were against the closed
shop. The trade unionists' campaign had involved massive
use of demographic and opinion poll data to devise a
highly selective information campaign which allowed the
forces in favour of the "closed shop" to tell different
groups of voters the types of argument that were most
likely to be effective. This resulted in a last minute
swing in favour of the closed shop. Burnham (1983)
commented that this method of using computers is normally
only accessible to the richest and most powerful
institutions in society because it requires a large
amount of sophisticated expertise and equipment.

Burnham's assessment of the power-concentrating impact of
computers was echoed by Downs who made an empirical
investigation of the effect of information on local
government in the USA - "The government bureaucracy as a
whole gains power at the expense of city and state
legislators, the general electorate, and non-governmental
groups" Downs (1971 : 331). The development of
expensive main frame computers up to 1971 made it easy to
believe that computers would lead to a monopoly of
information in the same way that nineteenth century
industry lead to a monopoly of capital. The computers of
that era were bulky, difficult to use, and extremely
expensive. By their very nature they could only be
purchased and used by organisations with substantial
monetary resources.

However the threat the computers would concentrate
political power was swept away with the advent of
silicon-chip based micro-circuitry. This made it
possible for computer circuits of considerable complexity
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to be reproduced very cheaply. The machines based on this technology were called micro-computers and because of their relative cheapness and availability it is probable that they will lead to a dispersal rather than a concentration of power. While main frame computers were produced in the thousands or tens of thousands, micro-computers have been produced in the millions. A logical result of this dissemination of information power would be to alter societies in the direction of greater pluralism.

The spread of cheap, universal computer power will result in a gradual loosening of the restraints on the movement of information within a society. The world of the 1980s and 90s will be dominated not only by cheap electronic data processing, but also virtually infinite data transmission. This kind of development will encourage lateral communication - the spread of information from human being to human being across the base of the social pyramid.

(Evans, 1983: 208)

The arrival of cheap micro-computers had a profound effect on the way information technology was to be used. In the case of large main frame computers there was a general practice that the large investment in capital to buy the equipment would be matched by a large investment in labour. The machines were so expensive that "experts" were needed to get the most cost-effective use out of them. Then the silicon chip shattered the specialist's monopoly and threw open the doors of computing to the generalist. Millions of people who were not primarily programmers found computers in their everyday use. This created a market for computer programs which could perform complex tasks and yet still
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be operable by "non-experts". Spurred on by this profit motive the greatest improvements in human-computer interactions came from companies in the field of micro-computing: TV games, calculating programs like Visicalc, business graphics, writing systems like Wang's word-processing (Martin, 1984). Thus the silicon chip has improved not only the accessibility of the computer equipment itself but also of the method of using it.

It might be assumed that the decentralising potential of micro-computers would inevitably lead to pluralism in areas where policy-making can be facilitated by information technology, such as tax-benefit modelling. Sieghart disputes the logic of such an assumption "technology is not neutral. It does not develop according to the laws of some technological determinism, breeding clinically according to some inner logic of development." (Sieghart, 1982:147). Experience has shown that the availability of computers to non-governmental groups has greatly increased, but their use for tax-benefit modelling has not. One micro-computer based program, TAXMOD, is used by several pressure groups. None of the opposition parties makes regular use of a tax-benefit model (see below). Though the potential for developing a pluralist tax-benefit model exists, it is not clear that one has yet been constructed. Section 1.4 outlines the reason why such a model has not be developed. Though the silicon chip has broken the barrier of equipment costs, the barrier of usability stands firm.

1.3 The Need for a new tax-benefit model

The Practical Arguments

The discussion now turns from the theoretical arguments about tax-benefit models and the structure of power to an examination of tax-benefit policy making in practice. This examination is arranged in the form of case studies
of three areas where there is potential for conflict over tax-benefit policy. Such conflicts or potential conflicts are likely to arise in the relations between politicians and civil servants, between pressure groups and the government, and between opposition parties and the government. This is intended to be an illustrative rather than exhaustive list of relationships in which tax-benefit modeling could be significant.

1.3.1 1st Case Study - Politicians vs Civil Servants

The conventional theory of representative democracy is that the many are able to exercise power through the ballot box by choosing from among two or more political parties to form the government. It is necessary for the alternative parties to present policies at the election which are significantly different from each other. However popular electoral power is undermined if political parties do not follow their manifestos once they become the government. Political parties may fail to carry out their policies because they have a greater incentive to promise change before an election than they do to effect change after an election. Pareto developed a theory that power is wielded by elites which often promise significant changes on their accession to power only to reneg on them when their position is secure:-

The new elite ... assumes the leadership of the oppressed, declares that it will pursue not its own interests but those of the many ... Of course, once victory is won, it subjugates the erstwhile allies, or at best offers them some formal concessions.

(Pareto, 1968: 36)

One example of this was the Conservative Party's promise to spend 30 million pounds on increasing Family Allowances prior to the 1970 election (Brown, 1984: 54) -
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a commitment extracted by the Child Poverty Action Group. This promise was not fulfilled as the rate of Family Allowance remained the same when the Heath government went out of office in 1974 (which represents a substantial decline in value when inflation is taken into account).

A similar volte face nearly happened in 1977 when the Callaghan government contemplated deferring the introduction of Child Benefit because of fears about trade union opposition to the reduction in father’s take home pay which would be caused by the abolition of child tax allowances (Barnett, 1982).

Such changes of policy are probably less the result of deliberate dishonesty than the intervention of political forces which were unforeseen when the original policy commitment was made. Politicians and their advisers have sometimes claimed that civil servants have prevented political promises from being implemented. Williams is one of the most outspoken critics of the civil service:—

It is undemocratic, particularly at the top; exclusive; and with a strange personality of its own, half reminiscent of the Army, half of a masonic society. Certainly many members of the Administrative Class seem unrelated to the outside world.

(Williams, 1972: 346)

Williams complains that the obstructiveness of the civil service prevented the implementation of a number of radical policies by the first Wilson government, and that the higher Civil Service is biased towards the Conservative Party (Williams, 1972). Haines has argued a slightly different case. He maintains that the higher civil service does try to influence policy, but not in a
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way which demonstrates a bias to a particular party. In Haines' view, the civil servants in a particular department tend to favour a specific set of policies which becomes part of that department's unspoken ideology. Thus, according to Haines, the Treasury in the 1960s and 70s had a bias towards incomes policy regardless of which party was in power. It is significant that between 1964 and 1979 every incoming government opposed incomes policy, and each government ended up adopting one. In Haines' view the civil service's favoured policies tended to be pragmatic and centrist (Haines, 1977). This view has been echoed by Tony Benn (Sampson, 1983:203), who also complains of higher civil servants' bias to consensus politics. In contrast Hurd (1979) asserts that civil servants positively need strong direction from their ministers to operate, and that it would be against their nature to try to initiate policy themselves. It should be noted, however, that Hurd was commenting on his experience as a political insider during the Heath government. As many of Heath's policies happened to coincide with the civil service's own policies, Hurd would not have had the opportunity to observe the bureaucracy trying to obstruct government policy.

One case where the Heath government's policies did not coincide with the preferences of the civil service was its support for the introduction of tax credits. Under this scheme a number of tax reliefs were to be converted from allowances of tax free income into positive cash payments, so that lower paid workers below the tax threshold would benefit from them. It also involved abolishing the cumulative system under which unused tax allowances from one week would be carried forward to a future week. These changes were such a radical departure from the existing P.A.Y.E. system that the Inland Revenue was very antagonistic to it. Antony
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

Barber and Sir Keith Joseph commented that they had to face the opposition of civil servants who continually said that implementing tax credits simply could not be done (DHSS, 1972). This bureaucratic delay had important consequences. Although the Heath government was elected in the summer of 1970, it was 1972 before it even published a consultative Green Paper on the scheme. Legislation for tax credits was to be incorporated in the 1974 Budget, however the Heath government lost the February 1974 election and so the tax credit policy was lost. The failure of the tax credit policy was only partly due to civil service obstruction. However it is notable that it was possible for the civil service to draw up an extremely detailed statutory incomes policy in 1972 at very short notice, while it took nearly four years for legislation to be prepared on tax credits.

To understand how access to tax-benefit models may affect the implementation of policies like tax credits, it is necessary to understand how they are used. Tax-Benefit models exist in several departments of government, notably the Treasury, the Department of the Environment, and the Department of Social Security. In addition there is a model which can be accessed by any department, IGOTM. Such models tend to be used by civil servants at many levels of seniority below those who come into personal contact with government ministers. Thus it is possible for higher civil servants to manage the flow of information to their political masters. This could be used extremely effectively in a situation where a civil servant was attempting to prevent the adoption of a particular tax-benefit policy. The permanent secretary would be responsible for ordering the tax-benefit modellers to produce tables to illustrate the effects of several different versions of a given policy. He or she could choose to show those tables which indicated that the policy would seriously change the distribution of
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

income, and suppress those which predicted a minor change. Thus it would be possible to reduce the chance that the policy would be adopted.

It should be stressed that this is described as a possible scenario. By the very nature of such an action, no civil servant would have an incentive to preserve evidence of it. If the memoires of Benn and Williams are accurate then civil servants certainly have the motive to behave in this way. What evidence there is about the inter-actions between civil servants and politicians comes from political memoires, a source which may be prone to serious bias. However, it is true to say that such a scenario would not be possible if an accurate and widely accessible computer model existed outside government. In this case politicians would be able to work out their policies in detail while in opposition, and when they were in government detailed options could be put forward by officials from within the governing party itself or by political advisers to government ministers.

1.3.2 2nd Case Study - Pressure Groups vs Government Ministers

If a society is to have a pluralist structure then it is necessary for influence to be exercised by groups other than the government. It has long been recognised that organisations independent of the state tend to undermine the concentration of power. Aristotle's Politics contained the following advice to a tyrant who wants to maintain his power base - "don't allow the getting together in clubs or education or anything of that kind; these things are breeding grounds of independence and confidence, two things a tyrant must guard against" (Saunders, 1981: 344-345).

In the field of tax-benefit policy a special category of
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

such associations are particularly important - pressure groups. The term "pressure groups" probably arose out of the writing of Bentley:–

All phenomena of Government are phenomena of groups pressing one another, forming one another, and pushing out new groups. (Cit. Mann, 1983)

A number of groups interested in tax-benefit policy apply pressure on government directly through political lobbying. In the field of social security policy a plethora of groups exist to further the interests of people with similar concerns. "Age Concern" and "Help the Aged" have a special interest in state pensions, old age tax allowances, and income support for the elderly. The National Association of Widows, Cruse, and the War Widows Association of Great Britain are concerned with National Insurance widows benefits and Industrial Death Benefit. Gingerbread and the National Council for One Parent Families are interested in single parent’s benefits, while the Child Poverty Action Group is concerned with family benefits in general. The Disablement Income Group, the Disability Alliance, and the Royal Association for Disability and Rehabilitation are concerned with a range of benefits including Attendance Allowance, Mobility Allowance, benefits for the industrially injured, and non-contributory benefits for the handicapped. Some groups exist to further a specific benefit policy such as the National Maternity Grant Campaign. Others fall outside this categorisation. The Basic Income Research Group exists to promote the provision of a universal cash benefit at subsistence level to replace personal tax allowances and unemployment benefit. It thus exists to serve an idea rather than a specific client group.
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It is difficult to assess how successful these groups have been. Two of the major groups to champion the cause of the disabled were set up in the late 1960s - the Disability Alliance, and the Disability Income Group (DIG). DIG has the specific aim of persuading governments to introduce a unified national disability benefit payable regardless of contribution conditions or the cause of the disability. This national disability income concept is now also supported by the Disability Alliance and the Spastics Society. In the late 1960s and '70s several major benefits for the disabled were either planned or introduced. In 1970 Attendance Allowance was introduced; in 1971 Invalidity Benefit and Allowances; in 1975 the Invalid Care Allowance, Non-Contributory Invalidity Pensions, and Mobility Allowances; in 1979 the Vaccine Damage Fund. It is likely that these pressure groups were at least a contributory cause of these changes. However, although the government did take action on disability benefits, it is worth noting how far this departed from the main policy supported by the disability pressure groups. At no time since DIG was set up, has a government seriously planned the introduction of a National Disability Income. Indeed there has been a one sided debate between the government and pressure groups over the feasibility of introducing such a scheme - "one-sided" because of the superior resources which the government has to conduct such a debate. Brown writes:-

The government throughout has cited the cost [of a national disability income] as between two and three billion pounds. The disability organisations have attempted to cost their proposals, though they have had the disadvantage of not having full access to the data.

(Brown, 1984: 388)
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This estimate was similar to one by the Spastics Society of 2,012 million pounds based on 1982-83 benefit rates (Spastics Society, 1983). However Wilson (1981) estimated that a National Disability Income could be introduced at a cost of 1640 million pounds (at 1980-81). However if this was to be limited solely to those deemed to be 100 per cent disabled then the cost would be only 120 million pounds. (All figures are "net costs" over and above the expenditure on existing disability benefits which would be replaced).

For the debate over benefit policy to be genuinely pluralist it would be necessary for the information on benefit policy to be available to the various participants in the debate. In the case of the pressure groups with an interest in social security policy, this is not the case. There are restrictions both on the data itself (generally large government surveys of the population) and on computer programs to manipulate the data into a form which is useful for policy predictions.

In the case of the data there are some sources which it is very difficult for pressure groups to gain access to. The most important set of data about benefit claimants is the DHSS Annual Statistical Enquiry (DHSS, 1987). This gives the fullest possible detail about the circumstances of those on benefit. Unfortunately, it is not available to extra-governmental researchers. Some other major data sets may be acquired for the purposes of academic research namely the General Household Survey (GHS), the Family Expenditure Survey (FES), and the Inland Revenue Survey of Personal Incomes (SPI). Even if the government allowed the pressure groups access to all of this data (they do not in the case of the Annual Statistical Enquiry) it is only available in a form which makes it virtually unusable by a pressure group of insubstantial means. The data is supplied in the form of large...
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Computer tapes of the kind normally used by large main frame computers or minicomputers, rather than the microcomputers which are often owned by pressure groups. It is reasonable to expect that an increasing number of pressure groups will have access to micro-computers costing in the range of 400-3000 pounds. It is extremely unlikely that any pressure group is likely to spend (or be able to spend) the tens of thousands necessary to acquire a main frame or a mini-computer.

Even if a pressure group had access to the data and to a suitable computer, there would still be serious difficulties in using the data to produce meaningful predictions about the tax-benefit system.

The pressure group would have two choices. One option would be to purchase one of the existing menu-driven tax-benefit programs like TAXMOD, however this type of program restricts the user to a narrow range of policy options (see section 1.4 below).

The other option would be to design a new tax-benefit model from scratch. This would be a labour of hercules. It would involve writing a computer program to represent the existing tax-benefit system, and to represent an alternative system which the group wanted to simulate. If a group wanted to pay for a computer programmer to undertake such work from a commercial software agency it could be extremely expensive. One such agency recently quoted 400 pounds per day as the price to supply a programmer familiar with the computer language Scientific Information Retrieval (SIR) - the language the FES data is compatible with. Assume that it would take at least four weeks to correct for missing values and response bias and to write equations representing the tax-benefit system (an optimistically low estimate). This means that one would need to have access to 8,000 pounds worth of
computing resources. In practice, a pressure group would probably have to depend on people (probably academics) giving their time voluntarily, but the figure of 8,000 pounds is useful in showing the value of the skills that would be needed to produce a tax-benefit model. It should be stressed that these figures are illustrative minima. The actual effort in workhours which has gone into the existing tax-benefit models vastly exceeds this.

In conclusion, it should be noted that the pressure groups have an important role to play in advocating policies for sections of society with specific needs. Their effectiveness in performing this role would be increased by access to computer data on the circumstances of the groups they campaign for combined with a facility for analysing this data in such a way as to assess the feasibility and cost of alternative policies.

1.3.3 3rd Case Study - Opposition Parties vs Government
In addition to the discussion between pressure groups and government there is also a vigorous debate between the governing party and opposition parties. For a country to have a pluralist structure of power it is necessary that information resources should be dispersed. For an opposition to be constructive and effective it must not be limited to purely negative criticisms of the government’s policies; it should be able to put forward its own practical alternatives, otherwise electors are not offered two or more credible options to choose from. This propogation of credible alternatives is hampered by the imbalance of policy-making resources which operates to the advantage of the government.

The only case of a political party actually commissioning the use of a tax-benefit model in the 1980s occurred in the case of the SDP. Dick Taverne was the chairman of the SDP panel on tax-benefit policy, and had close links
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

with the IFS. He had been one of its founders. In 1986 the SDP commissioned a report by the IFS on the SDP's Basic Benefit policy. The IFS report indicated that people on incomes higher than 15,000 pounds per annum would be worse off. This figure was a matter of considerable controversy at the SDP's 1986 conference. Some Social Democrats were concerned that such a policy would seriously reduce their electoral support among those on incomes of more than £15,000. Some leading Social Democrats disputed the accuracy of the IFS findings.

However at least the SDP had some access to a detailed assessment of the implications of their tax-benefit policies. In the case of the Liberal Party there was a consistent dearth of authoritative information about its tax credit policy. In the early 1950s the Liberal Party proposed a tax credit scheme involving the merging of National Insurance Contributions (NICs) with Income Tax and the payment of a universal credit of 10/- per week to all adults. In spite of the considerable outlay on these payments the Liberal Party calculated that the net result of the policy would be a surplus of funds. In 1951, Professor Hicks made the following comment about the Liberal submission to the Royal Commission on the Distribution of Profits and Income:-

I think one is right in saying that there are not enough minuses to balance the pluses ... and something therefore needs to be explained, because this is essentially a redistributive scheme ... and therefore somebody must lose for somebody else to gain.

(Royal Commission, 1951)

Lady Juliet Rhys-Williams, the author of the scheme, explained that this was because the National Insurance
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Fund was running at a surplus during this period, and that the merging of Income Tax and NICs would release money to be used for general government spending. The Liberal Party had a similar experience in the 1980s with their document "To Each According ..." (Vince, 1983). Like the earlier policy in the 1950s, there were proposals to introduce a universal system of tax credits and to merge Income Tax and NICs. The paper concluded that this policy could be financed if this combined tax were set at a standard rate of 44 per cent (Vince, 1983:41). However, the Vince proposals were examined by Atkinson using a version of the LSE TAXMOD program. Atkinson concluded that a tax rate of at least 47 per cent would be required (Atkinson, 1984: 28).

This use of tax-benefit models is significant, in that the models are used to expose deficiencies in the policies of opposition parties after they have been published (rather than being used to advise policy-makers before they are published). During the 1987 general election Independent Television News commissioned a report on the Labour Party's tax-benefit policies, and was able to confront the shadow Chancellor, Roy Hattersley, with the finding that on average people with annual incomes over 15,000 pounds would be worse off under Labour's policies. The relative weakness of the Labour Party's research resources was exposed on April 15th 1985 when Micheal Meacher, M.P., held a press conference to launch a Labour Party consultative document on the reform of the social security system. The scheme included controversial plans such as the phasing out of mortgage interest tax relief. The correspondent for the Times (1985a) commented that "Mr Meacher could not provide any details of the impact of his proposals on individual families." It is difficult to advocate such policies effectively if there is an absence of knowledge about their effects.
Ranged against this paucity of research resources is the government, with four of its own tax-benefit models, full rights to use the IFS model, and the status of a virtual monopoly buyer of the output from the PSI model. It also has large numbers of expert staff to operate these models. One example of the government’s superior skills was the research which was used to produce the Green Paper "Paying for Local Government" (DOE, 1986). This outlined a controversial scheme for the replacement of domestic rates with a community charge. It analysed the effects of the scheme with the IFS model using four entire years of FES data combined. Thus a detailed simulation was performed using a sample of 27,000 families. The Green Paper showed the numbers of gainers and losers broken down by family type, gross household income, and net household income. No opposition party could hope to match this research effort.

In spite of the apparent thoroughness of the Green Paper’s analyses of the community charge, there was one major weakness in the government’s methodology. This flowed from the fact that the IFS model is based on tax units rather than individuals. This meant that although the basis for the community charge was to be the individual rather than the tax unit or the household, the Green Paper was unable to present the effects of the community charge at the individual level. Though the Green Paper showed large income gains by low income tax units, it was unable to show large income losses by low income individuals because of the basis which had been chosen for the analysis. For example, economically inactive household members such as students and non-working wives were to be subjected to local taxation for the first time. In almost every case these people would be poorer than the head of household. Thus the distributional effects of the charge are likely to be
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extremely regressive when examined on an individual basis. The paucity of the opposition parties' research resources meant that they were unable to point this out. It was left to a researcher in higher education to publish tables showing the income losses of individuals (Truscott, 1986).

1.3.4 Conclusion
The experience of recent years indicates that the research resources available to the dominant faction of the governing party greatly exceeds those of opposition parties and pressure groups. On occasions even the representatives of the governing party, the ministers, may find themselves at a disadvantage compared to civil servants. However, as the next section will show, the remedy for this situation depends not only on access to survey data and computer programs to analyse it.

These case studies help to show that the access to effective tax-benefit modelling resources is extremely limited. This tilts the balance of power in favour of those with access to these resources. Government becomes more powerful at the expense of pressure groups and opposition parties.

How could this concentration of power be altered? It would be necessary to have a tax-benefit model for pressure groups and opposition parties to simulate their policies which would be as effective as those available to the government. This model will be referred to as a pluralist tax-benefit model as it is intended to promote that dispersal of information resources which is necessary for a pluralist democracy to be effective.

A pluralist tax-benefit model must have two main characteristics. Firstly, it must be sufficiently easy to operate so that it is not restricted to a small number
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of experts. This ease of operation will be referred to as usability. Secondly, it must not restrict the user to a narrow range of policy options; it must be flexible. The following section analyses these twin problems of usability and flexibility.

1.4 Tax-Benefit Models: Usability and Flexibility

In order to assess the problems of usability and flexibility it is useful at this point to undertake a brief review of some of the characteristics of the existing tax-benefit models. Figure 1.1 shows 16 characteristics of the 11 tax-benefit models reviewed in chapter 2 (a fuller description of the terms in figure 1.1 is given in chapter 2). The row labelled "user-friendliness" provides an assessment of each model’s ease of use. Inevitably, this is a subjective assessment. The problem of usability in tax-benefit modelling stems from a conflict between the goals of flexibility and comprehensibility.

To understand one of the problems of flexibility it is necessary to grasp the difference between "source code" and "object code" in computer programming. All of the computer models have been created with the aid of a programming language. These languages allow the user to express concepts in a way which may be more or less similar to the English language. For example, a programmer might use a statement like:

"If Age > 60 then Entitled_To_Pension := True".

(This kind of statement would be acceptable in the language PASCAL). Once the programmer has created a series of these statements, they are then used by a compiler which checks for errors and then translates the kind of "human readable" statement shown above into a series of binary numbers which can be understood by a
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computer. The "human readable" statement is referred to as the "source code" in computer programming, and the resulting binary numbers are the "object code". It should be stressed that the "source code" of programs is comparatively easy for human beings to alter and adapt; however if a person only has access to the binary object code it is very difficult to change it.

Some of the models shown in figure 1.1 are only supplied in object code form: TAXEXP, TAXMOD, IGOTM, and the Inland Revenue Personal Income Tax Model. This means that the user cannot alter the basic structure of the program. However, some of the other models have been supplied with both the source and the object code. The Department of the Environment, for example, purchased the Institute for Fiscal Studies Model in this way.

Where a model is supplied in object code form the user cannot alter its structure or underlying assumptions. In order to test different policy assumptions with these models the user is only allowed to alter numbers which help to define the tax-benefit system. Such numbers would, for example, be the rates of Income Tax, National Insurance Contributions and the main social security benefits. These numbers hold the same value throughout any particular analysis of a tax-benefit system so they will be referred to as "constants". Figure 1.2 shows a computer screen image produced by the Inland Revenue Personal Income Tax Model.

The user of the program is given a "menu" of options to change tax rates and tax bands. For each option the user has the ability to alter the numerical value associated with the tax or tax band. This method has many advantages. It is simple for a non-expert user to understand. It is difficult to input policy assumptions in such a way that a novice user could produce misleading
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results. Thus it is relatively 'fool proof'.

Figure 1.2 Computer Screen Image produced by Inland Revenue Personal Income Tax Model showing constants to define the tax schedule

<table>
<thead>
<tr>
<th>NUMBER OF TAX RATES</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1ST RATE</td>
<td>30</td>
</tr>
<tr>
<td>2ND RATE</td>
<td>40</td>
</tr>
<tr>
<td>3RD RATE</td>
<td>45</td>
</tr>
<tr>
<td>4TH RATE</td>
<td>50</td>
</tr>
<tr>
<td>5TH RATE</td>
<td>55</td>
</tr>
<tr>
<td>6TH RATE</td>
<td>60</td>
</tr>
<tr>
<td>7TH RATE</td>
<td>70</td>
</tr>
<tr>
<td>8TH RATE</td>
<td>0</td>
</tr>
<tr>
<td>1ST BAND</td>
<td>14600</td>
</tr>
<tr>
<td>2ND BAND</td>
<td>2600</td>
</tr>
<tr>
<td>3RD BAND</td>
<td>4600</td>
</tr>
<tr>
<td>4TH BAND</td>
<td>7100</td>
</tr>
<tr>
<td>5TH BAND</td>
<td>7100</td>
</tr>
<tr>
<td>6TH BAND</td>
<td>8000</td>
</tr>
<tr>
<td>7TH BAND</td>
<td>0</td>
</tr>
<tr>
<td>8TH BAND</td>
<td>0</td>
</tr>
</tbody>
</table>

ALL RATES ARE TWO DIGIT INTEGERS
THERE MUST BE 1 LESS BAND THAN THERE ARE RATES

There is also a major disadvantage, inflexibility. No one can use a model supplied in object code form to simulate a policy which the creator of the model did not allow for. This means that such models tend to concentrate on small departures from the status quo. Such models cannot cope with major policy changes. The menus make the program very simple to use but they place the user in a form of policy straight-jacket. Minor alterations to existing policies can be simulated; but not totally new policies. For example, in January 1986 the British government announced its intention to abolish the local property tax, domestic rates, and replace it with a flat rate poll tax on all adults. At the time none of the object code models could have simulated this because there was simply no "menu option" to allow it to
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be done. The IFS model was used to predict the effects of the poll tax because the Department of Environment were able to purchase the source code of the program. This meant that the model could be adapted to the specific requirements of simulating the poll tax.

Figure 1.3 Fragment of Source Code from the DHSS Tax-Benefit Model

```
8230 FIS=(FISPA-EA)/2
8240 FIS=FIS/100
8250 FIS=INT(FIS+.9)
8260 FIS=FIS*100
8280 IF EA>FISPA THEN FIS=0
8290 IF FIS<7 THEN FIS=0
8300 IF FIS>FISMAX THEN FIS=FISMAX
8310 IF EA=EB AND FIS=0 THEN FSMNOTE=2
8320 REM
8399 RETURN
```

Because the Department of Environment was able to adapt the source code, it could simulate the effects of an entirely new policy while retaining all the work which had been done on the other aspects of the tax-benefit system. However breaking out of the policy straight-jacket imposed by object code models carries with it a heavy cost. The source code is often written in language which appears incomprehensible to the non-expert. To illustrate this figure 1.3 shows a typical fragment of source code written in the computer language BASIC. Even for an expert computer programmer, it is very time-consuming to alter a program of this type, because each
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

time a program is written the programmer creates a set of names which is specific to that particular program. For example, in the top line of figure 1.3 the term "FIS" stands for "Family Income Supplement" and "EA" stands for "Earnings". These may hold different values at different times as a program is running and so are referred to as "variables". Someone attempting to alter a program must be thoroughly familiar with all the variable names in the program. To alter a program's source code it is necessary to have a thorough working knowledge of the entire program. Serious errors may result if a new user alters a small section of a program without understanding the importance of that section to the program as a whole. A full scale model of the tax-benefit system like the IFS model now exceeds 8,000 lines in length. Clearly, learning to understand a program of this size is a major task, especially as it involves learning a new vocabulary of cryptic variable names.

The great problem with the current programming approaches in tax-benefit modelling is this tendency to create a new set of variable names for each model. There is no technical reason why the vocabulary cannot be standardised between one model and another. The most logical course of action would be to define tax-benefit equations in a language as close to English as possible. As figure 1.3 shows, the existing tax-benefit models are a long way from achieving this.

However the unfamiliarity of variable names is not the only cause of the inaccessibility of tax-benefit programming to non-experts. In any program it is necessary to have devices to ensure that different actions are taken in different circumstances. For example, if a family contains children and there is only one parent it will have a one parent benefit entitlement; otherwise there will be no such entitlement. It would be
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Possible to express this concept as follows:

\[
\text{If Family-Type = Single-Parent} \\
\text{then One-Parent-Benefit = £ 4.55} \\
\text{Else One-Parent-Benefit=0.} \quad [1]
\]

An empirical study of the process of learning computer languages indicates that this kind of construct (known as an "If...Then...Else" statement) is relatively easy for novices to use (Allen, 1982:10). The process of choosing between alternatives (known as branching) is often accomplished by programming devices which are much further removed from English language concepts. The following case statement in the language PASCAL could be used to express the one-parent-benefit equation shown above (as follows):

\[
\text{Case Family-Type of :} \quad \text{Single-Parent : One-Parent-Benefit := 4.55;} \\
\text{else} \quad \text{One-Parent-Benefit := 0;} \\
\text{end;} \quad [2]
\]

For a language to be comprehensible to the non-expert it would be better to use only the type of "If...Then...Else" statement shown in equation 1.

Working with computer languages could also be made easier by the sensitive treatment of errors. At the compilation stage of computer programming any errors in the source code are indicated. Some compilers show the user exactly where in their source code they have made the error, and give a clear explanation of the cause of the error. However, most compilers fall short of this ideal. They often give incomprehensible error messages, make the computer emit an angry beeping noise, and do not show clearly where the error occurred. This is particularly
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

ture of computer languages on mainframe computers, which are often designed with "expert" users in mind. Schneiderman has pointed out that errors can be dealt with in such a way as to reassure, inform, and encourage the user:

The phone company long used to dealing with non-technical users, offers this tolerant message: "We're sorry but we were unable to complete your call as dialled. Please hang up and check your number". [A computer programmer would probably have written this error message as follows] ... "Illegal phone number. Call aborted. Error number 583-2R6.9. Consult your user's manual for further information."

(Scheiderman, 1982:59)

It would be a gross understatement to suggest that the designers of some compilers lack the human touch. They bombard novice users, already lacking in confidence, with statements like "Fatal Error: Program Aborted", "Disastrous String Overflow" (Schneiderman, 1982). When the messages do not contain suggestions of the apocalyptic nature of the user's offence, they are often unsettling by their sheer incomprehensibility. "Stack Overflow" and "Floating Point Underflow" (Borland, 1987:629-630) are two messages produced by Turbo Pascal, the popularity of which suggests it is probably one of the most easily usable of computer languages.

The problems of unfamiliar variable names, difficult control structures, and unfriendly error messages, are not the only problems facing a non-expert trying to adapt a tax-benefit program. Various developments in the technology of computer languages could overcome these. All but one of the existing tax-benefit models are written in what are called "third generation languages".
1. THE NEED FOR A NEW TAX-BENEFIT MODEL

These are vastly easier to use than programming in the binary numbers understood by the computers, but still suffer from the drawbacks described above. In recent years fourth generation languages have been developed to try to improve on the usability and comprehensibility of the third generation languages. Some of them have attempted to create a syntax closer to the English language. More recently still, fifth generation languages like PROLOG and LISP have tried to combine these aspects of usability with an ability to process logical statements in a more flexible and powerful way. The creators of these languages have tried to develop features which mimic some of the thinking power of the human brain, which has given rise to the term "Artificial Intelligence". Some of these developments can doubtless be used to enhance tax-benefit modelling. The distinctions between the various types of language and their implications for tax-benefit modelling are explored more fully in chapter 2.

1.5 Conclusion

Though there are at least eleven tax-benefit models, the non-expert user is still impaled on the horns of an uncomfortable dilemma — whether to choose between the inflexibility of object code or the incomprehensibility of source code. In chapter 2 the existing computer models are described in greater detail. The extent to which the existing models have dealt with the twin problems of usability and flexibility will be explored more thoroughly. It is crucial that these problems should be solved if opposition parties and pressure groups are to make an informed contribution to the debate on tax-benefit policy. If they are not the effect of computers on tax-benefit policy-making will be to increase the concentration of power, rather than to help create a more genuinely democratic pluralist society.
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

2.1 Introduction

This chapter is intended to give an overview of the models of the UK tax-benefit system as they existed in 1986. The characteristics are summarised in figure 1.1. Eleven models are covered. These are certainly the eleven most significant models in terms of published research. It is possible that some smaller models in some universities or institutions have not been included because they have not been publicised widely enough, or because they do not deal with the tax-benefit system as a whole (several models exist within the DHSS, for example, which model the effects of a single benefit in isolation).

In order to undertake each review a visit was made to the institution or government department responsible for the model being reviewed. In all cases there was a demonstration of the model and an interview - either with the creators of the model or with the staff members who currently have to use it professionally. In each of the reviews there has been an attempt to give a general overview of the model, and also to assess the model according to the criteria of usability and flexibility outlined in chapter 1.

In order to examine the problem of "usability" there is a section on "user interface issues" for each model. In this context the "user interface" refers to the part of the computer program which the user actually sees on the screen (this has given rise to the term "front end" of a program which some people use as an alternative to the user interface). What makes a good user interface is inevitably a value judgement. The review seeks to define the quality of the user interface according to the following criteria. Can a novice operate the program easily by reading the information displayed on the
screen, or is it necessary to refer constantly to documentation or to seek expert help? Is it easy to input policy options, to go back and correct mistakes, and to make slight alterations to a set of parameters without typing them in anew for each run of the program? Can the user understand what is going on at all times during the execution of the program? The flexibility of the user interface is also assessed.

2.1.1 Programming Approach
The potential flexibility of the program is also assessed by exploring the programming environment of the model. In some cases it was possible to see fragments of the source code of the model. Where it was not possible to view the source code, the characteristics of the computer language it was based on have been reviewed in order to give a flavour of how difficult it would be to alter the source code.

This section also attempts to show some of the underlying assumptions on which the model is based. For example, some models such as the DHSS tax-benefit model table program make very simple assumptions about the claiming of benefits (i.e. it assumes that all of the people entitled to a specific benefit actually claim it). TAXMOD on the other hand assumes that only a proportion of eligible people will claim Housing Benefit and Family Income Supplement.

2.1.2 Objectives & Knowledge Base
The objectives of the model are outlined in order to give the reasons why the model was written, which helps to explain its current structure. In order to give an idea of how each model makes its predictions the "Knowledge Base" section shows whether a model is based on hypothetical cases or on actual survey data, and if so it describes the characteristics of the survey. It also
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

shows whether the model concentrates on or is limited to any particular part of the population (i.e. whether the model excludes the elderly or the unemployed etc).

2.1.3 Output from the Model
This section attempts to show how detailed and clear the output from the model is. In some cases the output is easily comprehensible, in other cases it would be impossible to interpret without frequent reference to explanatory documents. The clarity of the output is no less important in producing a usable model, than creating an easy mechanism for entering policy options.

Finally each review seeks to give an overall assessment of the strengths and weaknesses of each program.

Eleven models are reviewed below. In general the ordering of the reviews introduces the reader to the simplest models first and continues to consider the more complex and sophisticated ones. The first three reviews cover those programs which were originally developed as models based on hypothetical cases - The DHSS Tax-Benefit Model, the "CUBS" model, and the "TAXEXP" package. Next the reviews consider a special case - the Alvey DHSS Demonstrator Project. This is intended to produce a model which is neither based on survey data nor on hypothetical households. It is intended to show the implications of changing some tax-benefit rules on other rules. The remaining seven models are those which are based on sets of survey data: the Tax Reform Analysis Package (TRAP), TAXMOD, the DHSS Policy Simulation Model, the IFS Tax-Benefit Program, the Inland Revenue Personal Income Tax model, the Policy Studies Institute Model, and the IGOTM model. As the models based on hypothetical cases are less complicated than those based on survey data, this ordering of the models represents a gradual progress from the simplest tax-benefit packages to the
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

most sophisticated ones.

2.2 DHSS TAX-BENEFIT MODEL

2.2.1 Objectives of the Model
The purpose of the DHSS Tax-Benefit Model Tables is to show the gross and net incomes of a series of household types under the existing tax-benefit regime. These objectives deliberately exclude the estimation of the numbers of people in each income band or household type, and the calculation of the number of gainers and losers. The effect of changing the existing system on families of a supposedly typical category is the sole aim of the model tables.

The model has existed in some form since the 1960s. The output from the model was used to answer occasional parliamentary questions and internal inquiries from within the ministry. In the early 1970s the output from the model started to be used for tables published in "Social Trends". In April 1979, the model tables were first released as a separate publication.

2.2.2 Knowledge Base
The knowledge incorporated in the model is a set of basic facts about the tax-benefit system. It includes:
(i) the rate schedule for Income Tax, the amounts of the three main tax allowances (single person’s, married man’s and wife’s earned income relief);
(ii) the rate schedule for National Insurance contributions;
(iii) the Child Benefit rate;
(iv) the rules of entitlement and rates of Family Income Supplement, Housing Benefit, Free School Meals and milk.

Travel to work costs are also included in the model, but
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

unlike the "CUBS" model (see below) the model does not assume that the individual will alter the number of journeys to work in response to differing numbers of work hours per week. Furthermore the model assumes a full working week in each case - which has implications for eligibility for Family Income Supplement (which cannot be claimed by one of a couple where the weekly hours are under 30, or under 24 in the case of a single parent).

2.2.3 Programming Approach
The knowledge within the program is represented in the computer language BASIC. The programming approach used suffers from the disadvantage that it is difficult for some one unfamiliar with the program to understand it. The use of very short variable and array names requires the new programmer to search through the program to find the meaning of a variable. Because the language is not self-explanatory it would be unwise for a programmer unfamiliar with the whole program to alter it. Changing one part of the program might have unforeseen and unwelcome consequences for other parts of the program. To give an impression of the flavour of programming within the DHSS Tax-Benefit program a fragment of it is shown in figure 1.3, which defines Family Income Supplement.

The model assumes that there is 100% take up of benefits among the hypothetical families and that there is no tax evasion. The equations lead inexorably from data about the family's composition, earnings, and housing costs to an exact calculation of its net income. There is no need for error terms or probability factors, as there are no unknowns in the equations.

2.2.4 User Interface Issues
The user is guided through a series of questions to define a particular type of family. The user is asked in
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

turn to answer questions on whether the family unit is a single adult, or a couple; the number and ages of any children; whether or not the family unit is also a household; the type of housing tenure; and the amount of rates, rent or mortgage payments. Alternatively the user may choose to run the model using one of 10 pre-defined family types (which are the types used for the published model tables).

The user cannot alter any of the parameters of the tax-benefit system through the interface. The only question connected with this requests the user to select a "budget file" containing parameters about the tax-benefit system. So to simulate a different tax-benefit regime one must first produce a file of the same structure as the existing budget file, but with different tax-benefit rates.

The model calculates the "total income support" payable to the family, which is the total value of all the state benefits it receives. The user can choose to see total income support displayed in cash terms, or it can be adjusted for inflation so that the income support is comparable with a specific date in the past. The user can also choose to see the ratio between the family's actual net income and its supplementary benefit scale rate. For example, the supplementary benefit scale rate of a single householder is taken to be 86% of the net income the person would receive with gross earnings of 50.00 pounds per week. Furthermore the user can specify the earnings levels which the tables are to be based on.

2.2.5 Output from the Model
For each household type the tables show the net incomes for people on different levels of earnings. The tables show the net income after tax has been deducted and after the receipt of various benefits for various types of
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

Figure 2.1 Example of output from DHSS Tax-Benefit Model showing gross and net incomes of a family with three children aged 4, 7, and 15 with a non-working wife.

<table>
<thead>
<tr>
<th>EARNINGS HEAD</th>
<th>TAX</th>
<th>NI</th>
<th>FIS</th>
<th>CHILD BENEFIT</th>
<th>RENT</th>
<th>RENT REBATE</th>
<th>RATES</th>
<th>RA RE</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.00</td>
<td>0.21</td>
<td>4.97</td>
<td>26.00</td>
<td>21.30</td>
<td>15.00</td>
<td>12.41</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>72.00</td>
<td>0.50</td>
<td>5.04</td>
<td>25.50</td>
<td>21.30</td>
<td>15.00</td>
<td>12.29</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>73.00</td>
<td>0.79</td>
<td>5.11</td>
<td>25.00</td>
<td>21.30</td>
<td>15.00</td>
<td>12.16</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>74.00</td>
<td>1.00</td>
<td>5.18</td>
<td>24.50</td>
<td>21.30</td>
<td>15.00</td>
<td>12.04</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>75.00</td>
<td>1.37</td>
<td>5.25</td>
<td>24.00</td>
<td>21.30</td>
<td>15.00</td>
<td>11.91</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>76.00</td>
<td>1.66</td>
<td>5.32</td>
<td>23.50</td>
<td>21.30</td>
<td>15.00</td>
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<td>9.50</td>
<td>5.</td>
</tr>
<tr>
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<td>21.30</td>
<td>15.00</td>
<td>11.66</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>78.00</td>
<td>2.24</td>
<td>5.46</td>
<td>22.50</td>
<td>21.30</td>
<td>15.00</td>
<td>11.54</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>79.00</td>
<td>2.53</td>
<td>5.53</td>
<td>22.00</td>
<td>21.30</td>
<td>15.00</td>
<td>11.41</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>80.00</td>
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<td>5.60</td>
<td>21.50</td>
<td>21.30</td>
<td>15.00</td>
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<td>9.50</td>
<td>5.</td>
</tr>
<tr>
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<td>21.30</td>
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</tr>
<tr>
<td>82.00</td>
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<td>5.74</td>
<td>20.50</td>
<td>21.30</td>
<td>15.00</td>
<td>11.04</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>83.00</td>
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<td>5.81</td>
<td>20.00</td>
<td>21.30</td>
<td>15.00</td>
<td>10.91</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>84.00</td>
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<td>19.50</td>
<td>21.30</td>
<td>15.00</td>
<td>10.79</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>85.00</td>
<td>4.27</td>
<td>5.95</td>
<td>19.00</td>
<td>21.30</td>
<td>15.00</td>
<td>10.66</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>86.00</td>
<td>4.56</td>
<td>6.02</td>
<td>18.50</td>
<td>21.30</td>
<td>15.00</td>
<td>10.54</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>87.00</td>
<td>4.85</td>
<td>6.07</td>
<td>18.00</td>
<td>21.30</td>
<td>15.00</td>
<td>10.41</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>88.00</td>
<td>5.14</td>
<td>6.16</td>
<td>17.50</td>
<td>21.30</td>
<td>15.00</td>
<td>10.29</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>89.00</td>
<td>5.43</td>
<td>6.23</td>
<td>17.00</td>
<td>21.30</td>
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<td>10.16</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>90.00</td>
<td>5.72</td>
<td>6.30</td>
<td>16.50</td>
<td>21.30</td>
<td>15.00</td>
<td>10.04</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>91.00</td>
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<td>6.37</td>
<td>16.00</td>
<td>21.30</td>
<td>15.00</td>
<td>9.91</td>
<td>9.50</td>
<td>5.</td>
</tr>
<tr>
<td>92.00</td>
<td>6.30</td>
<td>6.44</td>
<td>15.50</td>
<td>21.30</td>
<td>15.00</td>
<td>9.79</td>
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</tr>
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<td>6.51</td>
<td>15.00</td>
<td>21.30</td>
<td>15.00</td>
<td>9.66</td>
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<td>5.</td>
</tr>
<tr>
<td>94.00</td>
<td>6.88</td>
<td>6.58</td>
<td>14.50</td>
<td>21.30</td>
<td>15.00</td>
<td>9.54</td>
<td>9.50</td>
<td>4.</td>
</tr>
</tbody>
</table>
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

family. The example shown in figure 2.1 concerns a family with three children aged 4, 7, and 15 with a non-working wife.

2.2.6 General Merits and Problems
The most serious limitation of the DHSS tax/benefit tables is that the choice of family types the user is given excludes large numbers of people. The choice of family types excludes those whose heads are retired, unemployed, or in receipt of investment income. In 1983, the model also excluded non-householders and owner-occupiers. It was argued that the model tables applied to less than 4% of the population. (Atkinson, King, & Sutherland, 1983:64). However since then the program has been updated to allow for the modelling of a wider variety of family and household types. At the time of the interview with the relevant DHSS staff for this review the program had just been altered so that output tables could be produced which would model the effect of policies on owner-occupiers.

2.3 CITY UNIVERSITY BUSINESS SCHOOL MODEL

2.3.1 Objectives of the Model
The main object of the City University Business School Model (CUBS) is to show marginal tax rates faced by people working different numbers of hours per week. The intention is to demonstrate the economic gains and losses people face if they work more or less. It was written in order to answer questions such as whether a particular policy would cause more or less unemployment. It is thus more of a labour supply model, than a tax-benefit model. However the output produced by the model shows taxes paid and benefits received. The CUBS model is unique among the models based on hypothetical families in
that it bases its analysis on the number of hours worked rather than on the level of income. The model therefore gives a graphic illustration of the individual's labour force participation decision. The net financial gain from working is shown after the withdrawal of benefits and the deduction of taxes and travel to work costs.

There are two versions of the CUBS model. The original version was based solely on hypothetical cases (which is why it has been considered at this point in the reviews). The most recent developments in the evolution of the CUBS model have involved the addition of the "batch mode", which analyses the effects of tax-benefit policies on a sample of actual families drawn from the FES. This form of the model calculates the net incomes of a large number of cases and makes a prediction of how many hours they are likely to work as a result of the modelled tax-benefit system. This prediction is based on a labour supply theory, of the type described below in the review of the TRAP model. These predictions of individual labour supply effects are intended to give an indication of the effects of tax-benefit policy on gross domestic product and labour supply on a national scale.

2.3.2 Knowledge Base
The data incorporated in the CUBS model are in some areas more detailed than those in the DHSS model tables. Like the DHSS model tables, the CUBS model simulates Income Tax and National Insurance liabilities, and entitlements to supplementary benefit and housing benefit. However the CUBS model goes further by including other calculations, based on user-specified characteristics of the hypothetical family. The user may specify the daily travel to work costs and the model will calculate the weekly travel costs based on the number of hours worked. The user can state whether the primary earner's job is subject to superannuation contributions and (if it is)
whether the pension scheme is contracted out of SERPS. The CUBS model uses this information to work out a hypothetical superannuation contribution. The user can specify whether F.I.S. is claimed. The user is asked if the amount of capital held by the family exceeds 3000 pounds; if it does the entitlement to Supplementary Benefit will be removed accordingly. If the earner receives an occupational pension then the amount of the pension can be calculated from the earner's leaving salary and the length of time in the scheme (this routine is based on the University Superannuation Scheme for purely illustrative purposes).

2.3.3 Programming Approach
The model is programmed in FORTRAN66. It was not possible to analyse the source code of the model for the purposes of this review. However FORTRAN66 has many of the same characteristics as BASIC (and was developed not long after it). The short variable names required by FORTRAN66 probably means that it suffers many of the same disadvantages as the DHSS Tax-Benefit Model described above.

Results are inferred from the data in a straightforward manner - with exact values calculated from user supplied input values. Unlike the models based on large data sets, there are few unknowns in the models based on hypothetical families, so the more complex issues of how to deal with non-take-up of benefits and behavioural responses do not arise.

These issues do arise when considering the "batch" version of the model which assesses the labour supply effects on a selection of tax units from the FES. The batch version uses the information in the FES to simulate take-up rates (i.e. if the FES shows that a given family surveyed did not claim Family Income Supplement the CUBS
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

model will also assume that it is not claimed by that family in any simulations). There are no special adjustments for response bias or unrepresentativeness of the FES. The model predicts how the family’s work behaviour will be influenced by tax-benefit policy on the basis of a labour supply function which attempts to predict whether a given person will be in or out of work.

Figure 2.2 Example of user interface session with City University Business School Model

WHICH OF THE FOLLOWING FAMILY TYPES APPLIES?
1=C0UPLE, MAN ONLY WORKING 2=C0UPLE, BOTH WORKING
3=SINGLE PERSON, NOT A PENSIONER, NO DEPENDANTS
4=SINGLE PERSON, NOT A PENSIONER, WITH DEPENDANTS
5=WIDOW, 6=PENSIONER COUPLE, 7=SINGLE PENSIONER

HOW MANY ADULTS (EXCLUDING SPOUSES) AND HOW MANY CHILDREN ARE DEPENDANT ON THE PRIMARY EARNER?

WHAT ARE THE AGES OF THE DEPENDANT ADULTS?

IS THE PRIMARY EARNER MALE (=1) OR FEMALE (=2)?

HOW MUCH TAXABLE INCOME DO YOU HAVE ANNUALLY EXCLUDING EARNINGS ALL SPOUSE EARNINGS AND ALL SOCIAL SEC. BENEFITS?

=6000

FROM YOUR MAIN OCC.

WHICH TYPE OF TENURE APPLIES?: RENTED (=1)

OWNER OCCUPIED (=2) OR OWNED OUTRIGHT (=3)

WHAT IS YOUR MONTHLY MORTGAGE INTEREST PAYMENT?

WHAT ARE THE RATES PAYABLE ANNUALLY ON YOUR ACCOMM.?

IS THE P.E. RETIRED?

BEFORE RETIREMENT, WAS THE P.E.'S JOB SUPERANNUABLE?

Therefore the CUBS model gives a prediction of how a particular measure is likely to affect the overall level of unemployment. This approach differs from the type of labour supply function used in the TRAP model (see below)
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

which generally predicts changes in the number of working hours (as well as whether a person will move in or out of employment).

2.3.4 User Interface Issues
In the hypothetical case version the user interface prompts the user to answer a series of questions which describe the family circumstances, income, and expenditure of the hypothetical case. Certain questions will only be asked if a response to a previous question implies that they need to be asked. For example, questions about occupational pensions will only be asked if the individual was in a pensionable job before retirement.

If a mistake is made then the user is required to go back to the first question of the series. The answers given to one series of questions are not saved so that the same responses cannot be used again with minor alterations. For example one cannot define a particular family and then make a minor change to a saved definition (as is possible with the TAXEXP package). The answers have to be input anew. Only the family circumstances can be altered through prompted questions. If one wanted to change a tax rate or the amount of a benefit, then the user would have to alter the program itself. An example of the type of question which the user is prompted to answer is given in figure 2.2. In the batch version of the model, actual families from the FES are used so this definition of individual circumstances is unnecessary.

2.3.5 Output from the Model
A table of output from the model showing a range of taxes paid and benefits received over a range of work hours per week (the range of working hours may be specified by the user) is shown in figure 2.3. Net incomes and the total marginal tax rates are also shown. A routine which
### Figure 2.3 Output from City University Business School Model

<table>
<thead>
<tr>
<th>HRS</th>
<th>ACTUAL OCCUP HRS</th>
<th>TAX HATINS SUP HRS TRAV NET CHILD &amp; FIJ</th>
<th>UNEMP. BENEFIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRKD</td>
<td>PAY PENSION</td>
<td>PAID</td>
</tr>
<tr>
<td>0</td>
<td>0.</td>
<td>0.</td>
<td>0.</td>
</tr>
<tr>
<td>1</td>
<td>2.50</td>
<td>0.</td>
<td>0.</td>
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<td>100.00</td>
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<td>0.</td>
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</tbody>
</table>
2. REVIEW OF EXISTING TAX-BENEFIT MODELS

translates this information into a graph is available. Figure 2.3 gives an example of the output from the CUBS model. The column headings could be improved. The third column from the left labelled HBS is presumably Housing Benefit Supplement (but as the case shown does not claim it this cannot be verified without consulting the authors of the program). The rightmost two columns the marginal tax rate and the total disposable income and are also difficult to interpret.

2.3.6 General Merits and Problems

The chief merit of the model is the clarity with which it represents the incentive/disincentive effects of the current tax-benefit system. The range of items, such as travel to work costs and pension contributions is clearly an advantage in that there is great flexibility in specifying the characteristics of the hypothetical family. This is only to be expected since the main function of the CUBS model is to demonstrate labour supply decisions and for this purpose it is more useful than any of the other hypothetical case models. CUBS was not intended to do anything more than demonstrate these labour supply issues - and its authors stress that it should not be assessed as a full blown tax-benefit model. CUBS is fairly user-friendly in the specification of hypothetical cases but it does not allow the user to specify new tax-benefit policies. It is not possible to specify changes in tax-benefit rates without altering the program itself.

To make CUBS more generally useful as a tax-benefit model it would be necessary to have a menu-driven system for altering tax rates, benefits, tax allowances, and benefit tapers. This issue has been tackled by the authors of TAXEXP described below.
2. EXISTING TAX-BENEFIT MODELS

2.4 LSE TAXEXP PACKAGE

2.4.1 Objectives of the Model
The objective of the TAXEXP program is to simulate the effects of a given tax-benefit system on hypothetical families. In this respect the goals of TAXEXP are similar to those of the DHSS tax-benefit model tables. TAXEXP was originally called "TAXBEN" and was first written by A.B. Atkinson. Since then it has been added to and improved – principally by Holly Sutherland. The authors of TAXEXP deliberately set out to ensure that it could apply to the large sections of the population excluded by the DHSS model tables (e.g. owner-occupiers, non-householder tax units, and those with investment income). The model-builders thus set out to demonstrate the contribution which can be made by simulations based on hypothetical cases, without the more obvious defects of the existing methods. TAXEXP is used for teaching at the London School of Economics. It is used in conjunction with an excellent manual (Sutherland, 1985), illustrating the uses of the model.

2.4.2 Knowledge Base
The store of knowledge within the model is basically a representation of the existing tax and benefit system. Specifically the user can alter the rates, thresholds, and tapers of Family Income Supplement, Child Benefit, One Parent Benefit, Housing Benefit, National Insurance Contributions, and Income Tax. The major exclusions from the model are benefits which do not affect the working population: supplementary benefit, unemployment benefit, and retirement pensions. In addition, the model also incorporates information about some of the better known proposals for changing the tax-benefit system – for example the user is able to model the effects of a "Basic Benefit system" of the type supported by the SDP (1981).
2. EXISTING TAX-BENEFIT MODELS

2.4.3 Programming Approach
The model is written in BBC BASIC, so the facts and rules about the tax-benefit system are represented in the form of BASIC language statements. The source code is not supplied to the user, and it has not been possible to examine it for this review. In general it can be said that the programming problems are probably very similar to those of the DHSS tax-benefit model. However it should be mentioned that the BBC version of BASIC is comparatively easy to use when compared to other versions which is probably a result of its intended use by schools and home computer users.

The model shows the marginal tax rates and net incomes of a family type defined by the user. The model accomplishes this by applying the parameters describing the tax-benefit system to the household with the particular circumstances the user has specified.

2.4.4 User Interface Issues
The interface is very easy to use. When the program is invoked the user is first prompted to key in a set of details to describe the hypothetical family which the model will carry out its simulations on. The user will be asked to describe a number of characteristics about the intended family by answering a series of yes or no questions. The user will state in turn whether or not the head of the family concerned is a householder, an owner-occupier, a claimant of FIS, and a claimant of Housing Benefit. In addition the user will be asked to enter certain numerical information to describe the person's rent/mortgage payments, rates, earnings, taxable income other than earnings, whether the person is contracted out of SERPS, and the numbers of any children and their ages. If the head of tax unit is married then there will also be income questions about the head's
2. EXISTING TAX-BENEFIT MODELS

spouse. When all of this data has been entered, a "FAMILY SUMMARY" is shown on the screen (see figure 2.4).

Figure 2.4 Computer Screen Image produced by TAXEXP program to summarise family characteristics

<table>
<thead>
<tr>
<th>FAMILY SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-holder Y</td>
</tr>
<tr>
<td>Owner N</td>
</tr>
<tr>
<td>Claim FIS Y</td>
</tr>
<tr>
<td>HB Y</td>
</tr>
<tr>
<td>Rent/Mortgage 15.00</td>
</tr>
<tr>
<td>Rates 6.00</td>
</tr>
<tr>
<td>Married Y</td>
</tr>
<tr>
<td>Non-dependents in hshld 0</td>
</tr>
<tr>
<td>Children ages: under 5 5-10 11-15 16+</td>
</tr>
<tr>
<td>Total: 2 1 1 0 0</td>
</tr>
<tr>
<td>Head earns 90.00</td>
</tr>
<tr>
<td>Contracted out Y</td>
</tr>
<tr>
<td>Wife earns 0.00</td>
</tr>
<tr>
<td>Contracted cut N</td>
</tr>
<tr>
<td>Other income: taxable</td>
</tr>
<tr>
<td>Of head 0.00</td>
</tr>
<tr>
<td>Of wife 0.00</td>
</tr>
<tr>
<td>Non-taxable 0.00</td>
</tr>
</tbody>
</table>

If the user wishes to alter any of these answers, then he or she can simply move the cursor key up to the relevant position on the screen in order to make a change. If the "return" key is pressed when the cursor is over the answer to be changed then the user is able to enter a new value in place of the old one. This greatly enhances the program's operation as the user would otherwise have to return to the first question and key in all the data again. This "FAMILY SUMMARY" table allows the user to see all the data at one time, and to check that the combination of family circumstances was what he or she intended.
After entering family details a table of output is shown indicating the net incomes, tax paid, and benefits received by the chosen family type - before and after a user-supplied policy change.

After this table is produced the user is presented with a menu of options which include changing family details, or making policy changes. If family details are to be altered then the user is shown the "FAMILY SUMMARY" screen and is invited to make changes through it. An example of this is shown in figure 2.4. Each of the terms which is underlined contains a number which the user is able to alter. If the user selects the option to make a policy change then a menu appears which invites the user to specify one of five policy areas:– Child Benefit & FIS, National Insurance Contributions, Income Tax, Housing Benefit, or a New Benefit system. In each of these areas of policy the user is able to alter the various tax rates, tapers, thresholds, and cash amounts associated with each tax or benefit. Furthermore once output tables have been produced by the model, the user is able to start a new enquiry session either from the state of the tax-benefit system which was input during the previous enquiry or from the existing "real world" tax-benefit system (i.e. the model is returned to the state it was in before the user started altering any of the policy parameters). Coupled with the ease with which family details can be simulated this makes TAXEXP an extremely user-friendly package.

2.4.5 Output from the Model
There are four main types of output from the model. One type of output is produced whenever the model is run. This is a table showing (for both the current and the proposed system) the gross income, income tax, National Insurance Contributions, FIS, Child Benefit, Housing
2. EXISTING TAX-BENEFIT MODELS

Rebates, and levels of a new proposed benefit of the family specified by the user. This can show the changes in income of this family before and after a policy change.

There are three further types of output from the model: tables of marginal tax rates, tables of net incomes with varying earnings, and graphs of net incomes with varying earnings. The marginal tax rate table calculates the total marginal tax rate by totalling the National Insurance Contribution rate and Income Tax rate the earner is subject to, combined with the taper for any relevant means-tested benefits. Thus if a person was subject to a 30 per cent Income Tax rate, 6.85% National Insurance, and Housing Benefit was withdrawn at 38%, then the marginal tax rate would be 74.85%. These marginal tax rates are shown for increases in earnings of 1.00, 10.00, and 25.00 pounds for both husbands and wives.

The tables showing net incomes with varying earnings give results for a range of income levels specified by the user. For example, the user can choose to see the net income of people earning between 0 and 500 pounds per week rising in 25 pound steps. For each income level the table shows the total gross earnings, tax plus National Insurance Contributions, FIS plus any new benefits, Housing Benefit and net income. The same tables can be produced for husbands and wives. If the graph is based on the varying earnings of the wife, then the husband’s income is constant. The reverse is true if the graph is based on the husband’s income.

The option to plot the net incomes against gross incomes allows the user to request that a graph should be drawn showing how an increase in gross income will affect the net income of a specified family (see figure 2.5). Thus the model is able to depict graphically such issues as
2. EXISTING TAX-BENEFIT MODELS

the poverty trap.

Figure 2.5 Computer Screen Image produced by TAXEXP which shows a graph of Gross Tax Unit Income on the Horizontal Axis against Net Income on the Vertical Axis.

2.4.6 General Merits and Problems
TAXEXP is the best simulator of policy changes based on hypothetical families. It is very user-friendly allowing parameters to be entered and altered easily. It produces a wide selection of output tables. TAXEXP has developed analysis based on hypothetical families further than any other model. If one were to attempt to improve on "TAXEXP" one would need to give the user a larger selection of policy parameters to alter. TAXEXP’s user-
friendliness extends only as far as the options which its authors have seen fit to provide. For example, if one were to model the Liberal Party's tax credit proposals it would be necessary to simulate a flat rate credit for all adults plus a variable credit which would be withdrawn as income rises. One cannot simulate this option with TAXEXP as it exists at present. Ideally the menu driven part of TAXEXP should give a much wider variety of policies to choose from. This could be done by increasing the number of menu questions within TAXEXP. The problem with this approach is that no matter how many options one included among the menu options a new scheme could always be proposed which the designers of the menu system had not thought of.

The alternative to this would be to adopt a programming language approach. This would mean that there would be less of a dividing line between the program itself and the questions asked by the user. A model based on LISP or PROLOG might allow this kind of flexibility. Even if artificial intelligence techniques are not used, the minimum requirement for a truly flexible interface is a system which allows the user to gain access to the individual variables within the data. An ideal tax-benefit model would have the flexibility of a programming language without requiring the massive investment of time needed to learn one. The Alvey DHSS demonstrator project described below goes some of the way to providing this flexibility.

The crucial defect of any model based on hypothetical families is that the diversity of family circumstances in the real population is so great that it cannot be represented by hypothetical cases. The overall number of gainers and losers from a policy, and the global exchequer costs of a policy cannot be predicted from hypothetical cases. Thus the designers of TAXEXP felt it
2. EXISTING TAX-BENEFIT MODELS

necessary to produce a model based on survey data, TAXMOD.

2.5 ALVEY DHSS DEMONSTRATOR PROJECT

2.5.1 Objectives of the Model

The DHSS Policy Demonstrator is part of a programme of research which is intended to put Britain in the forefront of artificial intelligence. The term "artificial intelligence" is used to refer to computer systems which attempt to mimic some of the flexibility and sensitivity of the human brain. This contrasts with the more traditional use of computers to manipulate numbers and perform repetitive tasks. The ultimate goal of the DHSS Policy Demonstrator is to produce a facility for policy makers which will be capable of making inferences which one might expect of a human adviser rather than a computer. For example, if one wished to ask the model the consequences of making supplementary benefit available to a new group of people, the existing models might tell you how this would affect the incomes of a hypothetical family within this group, or how much the policy might cost the national exchequer. The Policy Demonstrator could be able to give qualitative rather than quantitative information - such as the fact that this change would make passport benefits like Free School Meals available to this group. Thus the model is intended to make connections of considerable subtlety. Another goal of the project is to design a system which will be so simple to use that it will be accessible to people without special computing skills. Most of the existing models do require such expertise. At best the user will be invited to select options from a series of highly structured menus. At worst the user has to use a programming language to specify a change.
The flexibility offered by artificial intelligence could make it possible not only to make inferences which mimic human thought processes, but also to interpret the sort of questions which a human inquirer might wish to ask. For example, if one were consulting a human adviser one might pose a question like: "How do you solve the problem that people on Invalidity Benefit never become eligible for the long-term rate of Supplementary Benefit?" (this problem has not applied since April 1983 when Invalidity Benefit could also count towards entitlement to long term Supplementary Benefit). One of the properties of Artificial Intelligence is its potential for interpreting English language sentences. In theory a system could understand the structure of English questions, and so allow the user far greater flexibility in using the model (though the interpretation of natural language is theoretically achievable through artificial intelligence it is not one of the goals of the DHSS Demonstrator Project). Using artificial intelligence to maximise user-friendliness is thus a major concern of the DHSS Demonstrator Project.

It should be stressed that the Demonstrator is not a tax-benefit model in the same sense as the other models reviewed here. To date those developing the Demonstrator have concentrated on building a model to produce qualitative rather than quantitative information. For example, the Demonstrator is likely to be able to predict the effect of a social security rule change on other social security rules (and any consequent inconsistencies in the system). This search for inconsistencies is one of the most promising areas for the use of artificial intelligence, and has been a central goal of the demonstrator project. The Demonstrator does not currently produce statistics such as the Exchequer costs of a policy change.
2. EXISTING TAX-BENEFIT MODELS

2.5.2 Knowledge Base
The knowledge incorporated into the model is a subset of rules about the social security system. The various characteristics that give rise to a benefit entitlement such as the age at which certain benefits are payable, family circumstances, the level of earnings, the amount of capital that may be held are all included. The type of knowledge is thus very different from that included in other models. The majority of the knowledge incorporated in TAXMOD and the IFS Model (reviewed below) is a set of data about actual tax units. These models do contain facts about the existing tax-benefit system but these are the minimum that are required for the measurement of net incomes and cost effects. The vast majority of the Demonstrator's domain knowledge is a set of rules which describes the social security system. The interaction of different parts of the social security system have thus been described in far more detail than in any of the other models.

2.5.3 Programming Approach
Knowledge is represented in the Demonstrator in a way which is very different from the other models. The programs based on survey data such as TAXMOD and the IFS Model are based on a set of data which is arranged in a simple array with a fixed number of variables. Each record within the array is identical in form for each case. The database used by the Demonstrator could not be more different. The Demonstrator's database consists of a set of rules of differing lengths, structures, and complexity. There is no requirement for there to be a single structure for each rule within the database. The model can operate on both simple and complex rules.

At the time of writing, the procedures for making inferences from the data and outputting the results from
2. EXISTING TAX-BENEFIT MODELS

the model were still in the development stage, so it is not possible to comment on the inference mechanisms within the model. The model is being written in the Artificial Intelligence language LISP. LISP requires the programmer to design his or her own mechanisms for drawing conclusions from the data in the model. The mechanism (termed an "inference engine") is thus being tailor-made for the Demonstrator.

2.5.4 User Interface Issues
The method of asking questions of the Policy Demonstrator is simpler and friendlier, than it is with any of the existing models. The system is being developed on a Xerox Dandelion, which has an extremely clear and detailed display screen. All of the communication with the computer is through a "mouse" (a hand held pointer which is rolled around the desktop in order to move a corresponding pointer around the display screen). When the pointer is resting on an option the user wants to select he or she clicks a button on the top of the mouse in order to make the choice. To help the user realise which choices are available a black line surrounds the phrase or word the pointer is resting on.

Unlike any of the other models reviewed here the Demonstrator makes extensive use of "windows" on the computer's display screen. When a choice is selected which makes information on the screen change not all of the previous information on the screen disappears. Thus if one selects the option to input a numerical characteristic, a "window" of such characteristics appears on part of the screen allowing the users to see those parts of the screen not covered by the window.

The Demonstrator works by inviting the user to input a policy, and then printing the consequences which flow from that policy. An example of the sort of policy the
2. EXISTING TAX-BENEFIT MODELS

user might enter is:-

"Underlying title to Retirement Pension" "Is" "True" "If" "Age" "Greater Than" "55".

The term "Underlying title to Retirement Pension" means the right to claim retirement pension. The inverted commas indicate which parts of the sentence are selected as entire units. To state the policy above one would move the mouse so that the pointer was resting over the option to select a menu of symbolic terms. The mouse would then be clicked, and a window of symbolic terms would appear on the upper half of the screen. The user would move the mouse around the window till it was resting on the phrase "Underlying Title to Retirement Pension". The mouse would then be clicked and this phrase would be written on a "scratch-pad" area of the screen where new sentences are built up. The user is continually shown a menu of standard words like "is", and "true", and "greater than". The user would thus point to the options "is", "true", and "if" in turn and click the mouse to add them to the sentence. To select the word "age" one calls up a window of numeric terms and moves the pointer to it. "Greater Than" is selected from the menu of standard words. To input the number 55, a numeric keypad is called up on a window in the screen and the numeral "5" is clicked twice.

This procedure allows the user to build up a potentially complex question in a matter of seconds, with little training.

It should be stressed that the preceding description of the interface applied to the Demonstrator as it existed in 1986. It has been substantially changed since.

2.5.5 Output from the Model
At the time of writing the mechanisms for outputting answers from the model were still being developed so it is not possible to comment on them.

2.5.6 General Merits and Problems
It would be inappropriate (if not impossible) to give an overview of the Demonstrator's strengths and weaknesses at the current stage of its development. The Policy Demonstrator will have an extremely friendly user interface, and will allow for a wide range of policy options to be simulated. Policy makers should be able to use it with very little training. The combination of extremely fast graphics, clear menus, windows, and the hand held pointer make it very quick to input policy changes. Unless the Demonstrator includes data from sample surveys it is likely that it will produce answers very quickly. Its method of inputting policy questions is an ideal which the other tax-benefit models should aim for if models are to be usable by non-experts. To improve on the Demonstrator it would be necessary to produce output tables which are as clear as the method for inputting policies. The output should be displayed with the full use of windows, bar charts, tree diagrams, and sentences in clear English. If the output matches the sophistication of the input, then the DHSS Demonstrator will be an extremely impressive model.

2.6 TRAP (TAX REFORM ANALYSIS PACKAGE)

2.6.1 Objectives of the Model
The main objective of the Tax Reform Analysis Package is to simulate the effect of behavioural responses to tax-benefit policy. The other tax-benefit models reviewed assume that if there is a tax cut or increase that it will not have an effect on how much people work. However
2. EXISTING TAX-BENEFIT MODELS

some economists would argue that some policies will have a significant impact on labour supply. For example, it is postulated that a massive rise in taxation would cause people to work less which in turn would lead to a reduction in National Income. As this type of theory cannot be simulated by the other models (with the exception of CUBS), they implicitly assume that tax-benefit policy cannot have an impact on National Income. The *raison d'etre* of TRAP is to simulate the effect of tax-benefit policies while incorporating a theory about how tax rates affect people's labour participation decisions. (The term "tax rate" used here is held to include taxes such as Income Tax and National Insurance Contributions together with the withdrawal rate of means-tested benefits).

It is important to stress that TRAP does not assume that any particular theory of behavioural responses applies. The user must make an explicit choice to accept a theory. If no such choice is made then TRAP will perform like all the other models in that it will assume that the Gross National Product will not be affected by a tax change. The most commonly used example of these theories is the effect of alternative treatments of the income of husbands and wives. It is thought that the work incentives of women with working husbands are particularly sensitive to tax rates. In most such cases the husband earns more than the wife and it is often possible for the wife to choose not to work. Thus the wife's labour participation is highly dependent on the net income she receives for each hour of work. The output from the TRAP model was used for a paper "On the reform of the taxation of Husband and Wife: Are Incentives Important?" (Blundell, Meghir, Symons, and Walker, 1985). This paper examined three possible reforms:

(a) Reducing the Married Man's Allowance to the level of
2. EXISTING TAX-BENEFIT MODELS

the Single Allowance, and using the revenue saved to increase Child Benefit;
(b) Reducing the Married Man’s Allowance to the level of the Single Allowance, and introducing a transferable allowance which could either be used by the wife (generally this would be used where the wife is working) or transferred to the husband (generally this would be done where the wife was not working);
(c) Reducing the Married Man’s Tax Allowance to the level of the Single Allowance and using the revenue saved to fund a Home Responsibility Payment to non-working wives who care for children.

In each case TRAP was used to predict whether married women were more or less likely to work, assuming that a user-specified theory of labour supply was true.

2.6.2 Knowledge Base
TRAP itself is designed to allow users to specify their own theories about the way people respond to tax-benefit policy. It does not include a list of such policies to choose from.

Furthermore unlike most of the other models reviewed it does not incorporate a specific sample of data. The user can configure the program to accept a number of data sets. TRAP has been sent abroad to the USA and Belgium where it has been operated by researchers using data sets from their own countries. The British researchers who have used it have done so with the Family Expenditure Survey, though it could also be used in conjunction with other survey data such as the General Household Survey.

There is almost no knowledge incorporated into TRAP in the sense that knowledge has been incorporated into the other models. There are no facts and rules about the tax-benefit system itself, there are no data about
individual cases, and there are no theories about behavioural responses to tax-benefit policy. TRAP is a utility program designed to make it easy for these things to be added by the user.

2.6.3 Programming Approach
The source code of the program has not been supplied for the purposes of this review. It uses the language FORTRAN77 which is an improvement on early versions such as FORTRAN66.

The model infers results from the data by calculating the marginal tax rate faced by the individual at his or her level of income and number of hours worked per week. The model then applies to this person an equation which attempts to define how many hours of work the person will do for a given rate of net pay per hour. Thus when a tax-benefit change alters this pay rate the model is able to calculate the new number of work hours. The theories about behavioural responses to tax-benefit policy (referred to as "Labour Supply Functions") may be extremely complicated. The theories are based on the relative importance the individual places on money and leisure time.

The diagram in figure 2.6 shows the hypothetical "trade-off" between goods and leisure for a range of income levels and numbers of work hours. At the top left hand corner of the diagram the curved line indicates the highest possible income which can be earned (which is achieved by having almost no leisure time). At the far left of the diagram, the curve dips down to the lowest possible level of income (presumably provided by state benefits) which is achieved at the maximum number of "leisure" hours (i.e. when people are out of work). The curved line represents different combinations of income and work hours which people find equally satisfactory.
2. EXISTING TAX-BENEFIT MODELS

The relationship is definitely curved, not linear. Thus while the point on the curve "H2-G1" might represent 160 pounds for a forty hour week, the point at the top left might represent 500 pounds for an eighty hour week. Notice that as the number of leisure hours decreases to very small numbers that the pay rate has to rise disproportionately in order for people to be equally satisfied. This is why the lines are curved - because people will require disproportionately high incomes to be satisfied with low levels of leisure and disproportionately high levels of leisure to be equally satisfied with low incomes. When a tax-benefit policy changes a person's net income, TRAP in effect takes the
2. EXISTING TAX-BENEFIT MODELS

new net income and plots the new number of work-hours on a graph similar to the one shown above. In practice the problem is solved mathematically, but the effect is the same. Determining the exact shape of these indifference curves is extremely difficult, and there is no theory which is universally accepted. Therefore TRAP requires the users to specify their own theories, so that there is always an explicit choice about whether or not to include a theory of behavioural responses in the simulation.

2.6.4 User Interface Issues

It was not possible to assess the user interface for the purposes of the current review as there was no working demonstration of the model available. The use of the model is explained in a manual (King, M.A., Ramsay, P., 1983), which is somewhat more technical than the manuals of the other models reviewed here because the potential user must be instructed about how to feed data into TRAP. The use of the model is illustrated in two articles by King: - "Welfare analysis of tax reforms using Household Data" (King, 1983a), and "An index of inequality: with applications to horizontal equity and social mobility" (King, 1983).

2.6.5 Output From the Model

The output from the model is badly labelled and cannot be interpreted by a user who is not familiar with the program. The table shown in figure 2.7 was supplied without a key to the abbreviations used for the columns and rows. There is also a table used for error checking which determines whether there are any households with highly improbable numbers of work-hours. (Households working zero hours would not be possible for the data set using this analysis as the unemployed have been excluded from it).

2.6.6 General Merits and Problems
2. EXISTING TAX-BENEFIT MODELS

The main advantage of TRAP is its facility for simulating behavioural responses to tax-benefit policy. It must however be recognised that there is a genuine debate on the question of whether accuracy is enhanced by simulating labour supply responses.

Figure 2.7 Sample Output From TRAP

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Ave</th>
<th>Max</th>
<th>Pos</th>
<th>Zero</th>
<th>Neg</th>
<th>SD</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>YO</td>
<td>22.400</td>
<td>407.178</td>
<td>2081.409</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>197.598</td>
<td>.485</td>
</tr>
<tr>
<td>WO</td>
<td>.039</td>
<td>3.231</td>
<td>18.382</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>1.712</td>
<td>.530</td>
</tr>
<tr>
<td>PCO</td>
<td>1.084</td>
<td>1.084</td>
<td>1.084</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>.004</td>
<td>.004</td>
</tr>
<tr>
<td>WP</td>
<td>22.400</td>
<td>410.289</td>
<td>2081.409</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>199.918</td>
<td>.487</td>
</tr>
<tr>
<td>WP</td>
<td>.039</td>
<td>3.261</td>
<td>18.382</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>1.734</td>
<td>.532</td>
</tr>
<tr>
<td>PCP</td>
<td>1.084</td>
<td>1.084</td>
<td>1.084</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>.004</td>
<td>.004</td>
</tr>
<tr>
<td>YEO</td>
<td>221.298</td>
<td>406.211</td>
<td>915.841</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>80.231</td>
<td>.198</td>
</tr>
<tr>
<td>YEP</td>
<td>221.298</td>
<td>407.153</td>
<td>915.841</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>80.946</td>
<td>.199</td>
</tr>
<tr>
<td>RTP</td>
<td>-29.362</td>
<td>3.023</td>
<td>222.765</td>
<td>914</td>
<td>1046</td>
<td>1035</td>
<td>16.027</td>
<td></td>
</tr>
<tr>
<td>WG</td>
<td>.000</td>
<td>1.020</td>
<td>127.499</td>
<td>1198</td>
<td>952</td>
<td>845</td>
<td>6.877</td>
<td>6.740</td>
</tr>
<tr>
<td>LO</td>
<td>24.000</td>
<td>42.271</td>
<td>109.000</td>
<td>2995</td>
<td>0</td>
<td>0</td>
<td>8.085</td>
<td>.191</td>
</tr>
<tr>
<td>LP</td>
<td>-7.778</td>
<td>41.080</td>
<td>109.000</td>
<td>2984</td>
<td>0</td>
<td>11</td>
<td>10.070</td>
<td>.245</td>
</tr>
<tr>
<td>DL</td>
<td>-41.515</td>
<td>-1.191</td>
<td>22.614</td>
<td>91</td>
<td>2709</td>
<td>195</td>
<td>6.044</td>
<td>-5.075</td>
</tr>
<tr>
<td>SOS</td>
<td>.000</td>
<td>.004</td>
<td>.225</td>
<td>2741</td>
<td>254</td>
<td>0</td>
<td>.014</td>
<td>3.266</td>
</tr>
</tbody>
</table>

75
2. EXISTING TAX-BENEFIT MODELS

To its credit, TRAP produces indicators of accuracy such as standard deviations in its output tables. However this only shows the variability of the results, when one assumes that the particular behavioural response theory is correct. It would be useful if the model was able to display indicators of the accuracy of the labour supply theory itself - based on the original research which gave rise to it. These accuracy indicators would not be calculated by the model itself, but would be taken from published research findings about the relevant theory. Often extremely complex labour supply theories are put forward without the backing of convincing empirical justification (see chapter 6 below). It is argued that one cannot make inferences about behavioural responses unless one uses data which has information about the same people at different points in time (one could thus measure the number of work hours before and after a tax-cut for example). However there is little of this longitudinal data available. The two exceptions to this, the panel element of the Labour Force Survey and the matched cases in the New Earnings Survey have not been used for the estimation of labour supply responses to policy changes. Almost all of the existing British research is based on cross-sectional data which gives a snap-shot of a population at one point in time. It is thus extremely difficult to work out the incentive effects of tax-benefit changes, and it is not possible to prove that any one of the more popular theories is effective in explaining real world events. It is hard to prove that small changes in marginal tax rates have any effect on work effort. The main disadvantage of TRAP is its extreme user-hostility. It is difficult to set up. It takes a great deal of time to modify the program. The execution is slow and the output almost incomprehensible. It is only really suitable for people with expertise in both computing and labour supply economics.
2.7 LSE TAXMOD PACKAGE

2.7.1 Objectives of the Model
TAXMOD is a close relative of TAXEXP described above. The same people were involved in designing both packages. It was written by A.B. Atkinson and H. Sutherland at the International Centre for Economics and Related Disciplines (ICERD) at the London School of Economics. The package was first produced in 1984 and has been continually up-dated since. The difference between TAXMOD and TAXEXP is that TAXEXP carries out simulations on hypothetical families, whereas TAXMOD uses survey data about actual families in order to give some idea of the real world effect of policy changes. Such effects might include the number of people likely to gain or lose from a policy change, the proportion of people whose marginal tax rate will increase or decrease, and the overall Exchequer costs of a policy for the groups covered in the survey. In the "Analysis of Taxation" it was shown that the supposedly representative household with a husband and wife, two children, without investment income occupying a council house accounted for only 4% of all tax units (Atkinson, Sutherland, & King, 1983:64). The emphasis on the use of data on actual households is an attempt to get round this problem of unrepresentativeness.

Another objective of the model is to make policy analysis based on large sets of survey data available to non-expert users. At the time of writing TAXMOD is in use in over 20 charitable and academic institutions. Without a specially designed package like TAXMOD it is very difficult for people without main frame computers and specialist computing skills to use surveys like the FES. In general extensive training and expensive computers are needed. The objective of trying to make the FES easy to
2. EXISTING TAX-BENEFIT MODELS

use on a micro-computer is thus a very important one.

2.7.2 Knowledge Base

There are two types of knowledge which have been incorporated in the model. One is a store of knowledge about the existing tax and social security system, and certain well known proposals for changing it. The other is a large array of data about 3276 tax units taken from the 1982 FES. Benefits, housing costs, and incomes have been scaled up to 1986 levels. The model builders have in effect taken the raw data from the FES and have created a new data set of transformed and combined variables. This work includes calculating grossing up factors to adjust for the fact that certain income groups and types of family are under-represented in the FES sample. Corrections are also made for under-reporting (as when people claim they drink and smoke less than they do) and non-response (as when people cannot remember what their mortgage interest payments are). Where values are missing then imputed values are used. These variables have been constructed specifically for the purposes of modelling the tax and benefit system and are sufficiently far removed from the raw FES data for the program to be distributed to third parties without specific approval in each case from the Department of Employment (though users are cautioned not to use the results of the model for publication).

The cases included in the model are only those where the head of tax unit is under the retirement age and works sufficient hours to qualify for Family Credit. The designers of TAXMOD have also excluded those families who work sufficient hours for Family Credit but are headed by a married woman. This means that roughly 45% of tax units are excluded by TAXMOD.

The rules dealt with include those defining Income Tax,
2. EXISTING TAX-BENEFIT MODELS

National Insurance, Child Benefit, Family Income Supplement, Housing Benefit, the SDP Basic Benefit system, and certain features of the Fowler Review System such as Family Credit and the new Housing Benefit. With some of the benefits the user is allowed to alter virtually all the numerical constants which are associated with them. For example, if the user elects to alter housing benefit then the user may alter over ten different parameters which define housing benefit entitlements. In general, when dealing with most of the menu options the user is only able to alter numerical values which describe the existing tax-benefit system. However the user is able to make some minor structural alterations. For example, in the National Insurance Contribution section the user can make the rates of contribution more smoothly progressive by stipulating that only income above a certain limit should be taxed. Under the current system one’s NI payments rise from zero to 3.20 pounds, when weekly earnings exceed 35.50 pounds (this is because the first 3.50 becomes taxable all at once). Certain other well known reforms can also be explored such as the tax treatment of husbands and wives (the model allows the user to select the present system, fully independent taxation of husband and wife, and fully transferable personal allowances). Furthermore the user can simulate the introduction of several features of the social security system proposed in the Fowler Social Security Reviews such as the new Housing Benefit, and Family Credit to replace Family Income Supplement.

The option termed "specify a new benefit" allows the user the option to specify a specific benefit reform proposal. It should be stressed therefore that this option refers to a particular benefit; it does not allow the user to create any benefit he or she chooses. The options the user is given allow the simulation of a "Basic Benefit" system similar to that proposed by the SDP in their
2. EXISTING TAX-BENEFIT MODELS

"Attacking Poverty" paper (SDP, 1981). It would not, for example, be able to simulate the Liberal Party's Tax Credit system as described in "To Each According ..." (Vince, 1983). One of the most distinctive features of this part of the program is that the simulated Basic Benefits are withdrawn by a single taper (under the present system a household could have its FIS withdrawn by 50% and its Housing Benefit withdrawn by 26%, leading to a cumulative taper of 76%. With this system, the basic benefits are all subject to a single taper). The combined basic benefit taper may be set at a different rate for single people with and without children, and for couples with and without children.

2.7.3 Programming Approach

Knowledge representation is difficult to assess due to the fact that the model is supplied in the form of a compiled BASIC program. The source code is not available. It has to be assumed that a relatively simple structural equation approach has been used.

Results are inferred from the data by calculating the tax liability and benefit entitlement of each case within the data set, based on the recorded family circumstances, incomes, housing costs, etc. Assumptions about benefit take-up rates have been made (the model assumes a take-up rate of 50% for those entitled to FIS, and 75% for those entitled to Housing Benefit). Extrapolations have been made from the test data set to the general population, by multiplying each case by a grossing up factor which varies according to the type of household. These different factors are an attempt to make up for the known biasses within the FES. However, it should be remembered that even when fully grossed up the sample used by TAXMOD represents only 15.5 million out of a possible 27 million tax units, because it does not include tax units where the head is off work due to sickness, is a part-timer, is
2. EXISTING TAX-BENEFIT MODELS

retired, unemployed, or a married woman.

2.7.4 User Interface Issues
TAXMOD is operated through a series of menus which makes it very easy for beginners to use. The user is furnished with a 43 page manual. This helps in understanding the structure of the program, and warns the user that there may be long waiting periods while the program is processing individual cases. Someone running the model on an Apricot micro-computer will find that the initial reading of the FES data takes 27 minutes, the calculations for the standard output tables take 7 minutes, and the optional tables each take 5-8 minutes. However the user is able to control the execution time on test runs, by specifying that only a fraction of the cases will be considered. For example, if the user wants to limit the reading in of raw data to 2.7 minutes he or she can opt to take a one in ten sample. If the result looks interesting the user can then use the full data set to achieve greater accuracy. When the user alters the parameters for a tax or benefit the screen will show which value has been entered, and this value can be altered easily after it has been typed in. Unlike the CUBS model there is no standard sequence of questions. Backtracking to correct mistakes is possible up to the moment that the program starts to read in the data. When all the tables on a particular policy have been output, the user is then given the choice of inputting new policies from the starting point of the tax benefit system specified in the previous session or go back to the original state of the system (based on 1986 tax and benefit rates). The interface is in general the most usable of any of the models based on survey data.

2.7.5 Output from the Model
The output from the model is based on a number of standard formats. For example, whenever the model is run
2. EXISTING TAX-BENEFIT MODELS

Figure 2.8 Output from TAXMOD showing the percentage of people in different income bands before and after a policy change

<table>
<thead>
<tr>
<th>Upper end</th>
<th>% Before change</th>
<th>% Cumul</th>
<th>% Before change</th>
<th>% Cumul</th>
<th>Average gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.00</td>
<td>14.66</td>
<td>14.66</td>
<td>14.24</td>
<td>14.24</td>
<td>5.84</td>
</tr>
<tr>
<td>100.00</td>
<td>11.85</td>
<td>26.51</td>
<td>13.01</td>
<td>27.25</td>
<td>0.69</td>
</tr>
<tr>
<td>125.00</td>
<td>12.18</td>
<td>38.69</td>
<td>8.31</td>
<td>35.56</td>
<td>6.02</td>
</tr>
<tr>
<td>150.00</td>
<td>12.18</td>
<td>50.86</td>
<td>11.16</td>
<td>46.72</td>
<td>8.35</td>
</tr>
<tr>
<td>175.00</td>
<td>10.80</td>
<td>61.67</td>
<td>13.80</td>
<td>60.53</td>
<td>3.84</td>
</tr>
<tr>
<td>200.00</td>
<td>9.73</td>
<td>71.40</td>
<td>13.80</td>
<td>73.82</td>
<td>-1.78</td>
</tr>
<tr>
<td>225.00</td>
<td>8.21</td>
<td>79.61</td>
<td>9.16</td>
<td>82.99</td>
<td>-10.03</td>
</tr>
<tr>
<td>250.00</td>
<td>5.15</td>
<td>84.75</td>
<td>6.10</td>
<td>89.09</td>
<td>-16.20</td>
</tr>
<tr>
<td>275.00</td>
<td>4.08</td>
<td>88.83</td>
<td>3.58</td>
<td>92.67</td>
<td>-26.83</td>
</tr>
<tr>
<td>100.00</td>
<td>11.17</td>
<td>100.00</td>
<td>7.33</td>
<td>100.00</td>
<td>-45.85</td>
</tr>
</tbody>
</table>

Figure 2.9 Output from TAXMOD showing the percentage of people gaining or losing cash amounts by income bands and by amounts of income gain or loss

<table>
<thead>
<tr>
<th>Range</th>
<th>&lt; -15</th>
<th>-5/-15</th>
<th>0/-5</th>
<th>0/5</th>
<th>5/15</th>
<th>&gt;15</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>6.79</td>
<td>57.39</td>
<td>29.81</td>
<td>5.08</td>
</tr>
<tr>
<td>1</td>
<td>0.00</td>
<td>18.86</td>
<td>57.76</td>
<td>7.41</td>
<td>3.50</td>
<td>11.32</td>
</tr>
<tr>
<td>2</td>
<td>2.48</td>
<td>42.95</td>
<td>2.44</td>
<td>3.16</td>
<td>13.86</td>
<td>35.11</td>
</tr>
<tr>
<td>3</td>
<td>13.84</td>
<td>13.28</td>
<td>8.33</td>
<td>8.06</td>
<td>17.73</td>
<td>38.53</td>
</tr>
<tr>
<td>4</td>
<td>13.60</td>
<td>21.56</td>
<td>5.03</td>
<td>10.14</td>
<td>22.10</td>
<td>27.04</td>
</tr>
<tr>
<td>5</td>
<td>24.43</td>
<td>22.73</td>
<td>10.18</td>
<td>13.05</td>
<td>15.04</td>
<td>14.58</td>
</tr>
<tr>
<td>6</td>
<td>46.99</td>
<td>17.14</td>
<td>10.64</td>
<td>6.85</td>
<td>10.68</td>
<td>5.91</td>
</tr>
<tr>
<td>7</td>
<td>56.61</td>
<td>22.86</td>
<td>6.51</td>
<td>3.22</td>
<td>7.69</td>
<td>3.11</td>
</tr>
<tr>
<td>8</td>
<td>84.65</td>
<td>10.36</td>
<td>0.61</td>
<td>0.61</td>
<td>2.35</td>
<td>1.42</td>
</tr>
<tr>
<td>9</td>
<td>94.50</td>
<td>3.20</td>
<td>1.48</td>
<td>0.00</td>
<td>0.55</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Omitted category is 'no change'

it shows the number of people covered by the analysis,
2. EXISTING TAX-BENEFIT MODELS

and the yearly revenue cost of the proposal in millions of pounds.

Figure 2.10 Output from TAXMOD showing details of an individual case

Married couple

with 4.00 children

Tenant: housing costs of 20.47

Gross earnings of head are 105.20
Other income of 70.12
Net income before is 156.94
After is 177.12

Change is 20.18

Marginal tax rate before : head 36.85
After 36.85

This last table also shows the average marginal tax rate for all cases before and after the change, and the percentage of cases where the rates have increased/decreased. For each of these standard tables the user has considerable freedom in specifying the precise format. For example, when income bands are considered the user can stipulate the lowest and highest income level to be considered in the analysis, and the width of each band in between (e.g. one could select a table of incomes from 0 to 500 pounds per week rising by 20 pound increments). Similarly the cash amounts of income gains and losses can be determined by the user up to cash changes of 20 pounds per week. Because these parameters can be varied by the user after the initial reading of the FES data, a second pass through the FES data is required when the format of the standard tables
2. EXISTING TAX-BENEFIT MODELS

has been chosen (this takes 7 minutes on an Apricot). The user may also choose whether the tables are to be based on net incomes or net resources (which is net income less housing costs). There is a rough method of comparing the income of families of different sizes. This can be done by dividing income by the number of "equivalent adults" (defined as 1 for a single person, 1.6 for a couple, and 0.4 for each child).

Optional tables include:-
(a) Percentages of families in different bands of income gain and loss by characteristic of family (householder/non-householder; owner-occupier/tenant; head married/head single; with children/without children; wife working/wife not working);
(b) Percentage of families in different bands of income gain and loss by type of family; average income of husband and wife by band of income gain and loss;
(c) Percentage of tax units in different ranges of increase/decrease of marginal tax rate by tax unit characteristic;
(d) display of individual cases with large income gains or losses;
(e) display of individual cases with large changes in marginal tax rates;
(f) Percentage of total income of all cases by decile level of income (Lorenz curves).

The last three tables which are unique among tax-benefit models are extremely useful. When tables (d) and (e) are shown the individual cases are displayed on the screen with their estimated benefits and tax bills. These individual calculations are useful in determining whether the model is accurate as they allow the user to see some of the raw variables in the array. It is very important to be able to check these case by case calculations, so that the user can have confidence in the overall
conclusions of the model. The last of the optional tables allows the user to gain a reasonably concise measure of how the policy change affects the level of income equality among the sample group.

2.7.6 General Merits and Problems
When considering the problems of TAXMOD it is necessary to stress that the sample on which the model is based only includes non-pensionable households where the head is a full-time employee. When grossed up this means that the model only applies to 15.5 million out of a possible 27 million tax units. It is not clear why tax units with non-working heads are excluded in this way. This may be because the research at the LSE has focussed heavily on labour supply issues such as whether a policy change will cause people to work more or less. For this type of analysis the unemployed and retired are irrelevant, but to predict the overall number of gainers and losers it is very important to have a fully representative sample. This is a substantial drawback to the model, but its authors have not claimed that TAXMOD is a substitute for analyses based on the full FES.

The chief merit of TAXMOD is the contribution it has made in increasing the accessibility of a large sample survey to tax-benefit policy makers. Policy makers who wish to do their own research on the FES normally have to cross a mine-field of computer hardware problems, invalid data, and unfriendly programming languages. The designers of TAXMOD have tamed this unfriendly data into a compact form, which can be stored on a micro-computer, and analysed by an easily understood computer program.

The main disadvantages of TAXMOD flow from the constraints placed on the user to try to make the model user-friendly. The user cannot use the model to analyse a tax-benefit policy which is not contained in the menus
which have already been set up. This is due to the conflict between usability and flexibility outlined in chapter 1. However this should not detract from TAXMOD's undeniable achievements. It is undoubtedly the only model which is sufficiently flexible and user-friendly to be used by a wide range of non-experts.

2.8 IFS TAX AND BENEFIT MODEL

2.8.1 Objectives of the Model
The objective of the Institute for Fiscal Studies Tax and Benefit Model was to provide a method of simulating the effect of the widest possible range of tax and benefit policies. It was developed principally by Andrew Dilnot and Graham Stark (who has added a menu-driven interface). The IFS model has succeeded in using the data from the FES more effectively than most of the other models. It uses roughly 97% of the cases from the FES (whereas TAXMOD, for example, only uses 52%). Furthermore the IFS has made extensive use of the FES to model the indirect tax system which is not touched by the other models. The authors have constructed a system to measure the spending on VAT liable goods. One can not only simulate the effect of varying the existing rate of VAT but also model the introduction of new sales taxes on up to fifteen different categories of spending. The aim of the IFS model was to use the full scope of the data within the FES, and so maximise the accuracy and variety of the tax-benefit policies which could be simulated.

2.8.2 Knowledge Base
The data is derived from the 7,000 households surveyed for the 1982 FES. The model can use any FES data tape which has been processed by the IFS. 1982 data is used by default, though a system based on 1984 data should be in use in the near future. The data are attached to tax units, though where there are several tax units at the
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same address it is possible to combine the data to reconstruct data about the entire household. The program carries out operations on the data file, and works out the tax and benefit entitlement of each case. The cumulative values of these tax and benefit amounts can be used to estimate the Exchequer cost of various policy options. As a result of recent research the IFS model has what is probably the most sophisticated adjustment for non-take-up of benefits. The DHSS commissioned research on take-up rates during the summer of 1986. In the course of this research the probability of claiming benefits was estimated for a range of family types and income levels. These probability factors were estimated after a thorough study of data from the FES for the years 1980-1982, and 1984. For each tax unit there was an assessment of the entitlement to benefit, and this was compared to data on receipt of benefits to see if the benefit was actually claimed. This research has been incorporated in the model; if the probability factors indicate that the chances are less than 50% that a given family will claim, then the model assumes that the benefit is not claimed. This is particularly important because some methods of adjusting for non-take up will tend to under-estimate the Exchequer costs of a given benefit. For example, take the case of a model which assumes that only 75% of families entitled to Housing Benefit will claim it, and which randomly assumes that every fourth entitled household will not claim. (75% is the housing benefit take-up rate which is assumed by the LSE TAXMOD program). This approach ignores the research evidence which indicates that those people with a large benefit entitlement are more likely to claim than those with a small entitlement. A random adjustment will under-estimate the costs of the benefit because it fails to recognise that most of those who don't claim a means-tested benefit will not be entitled to much anyway.
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2.8.3 Programming Approach
The knowledge about the tax and benefit system has been stored in the model in the form of FORTRAN equations. There are few equations which include probability factors or error terms. The results of the equations are conditional on facts which are in almost every case included in the model. The unknowns and probability factors which are included in some of the other models have thus not been needed for the IFS model.

There are good reasons to believe that the results inferred from the IFS model are likely to be superior to those produced by other models, if one is trying to simulate the effects of a change on the population as a whole. The fact that only a tiny proportion of cases from the FES have been excluded means that the results from the IFS model are likely to be more accurate than those from TAXMOD. The programming approach used in this case implies that there is a straightforward relationship between the individual's circumstances and his or her tax bill and benefit entitlement.

2.8.4 User Interface Issues
The IFS model has, in effect, two user interfaces. For changing simple features of the existing tax-benefit regime, such as tax rates, thresholds, amounts of benefit, and tapers there is a system of menus which invite the user to key in the appropriate values. If a more complex change is required then the user must alter the FORTRAN code within the program itself. In most cases the model is supplied in a compiled form so users will not have access to the source code. This helps to make the model "idiot-proof" as far as the end user is concerned and helps assure the IFS that the model cannot be used to produce invalid results. In at least one case the end user has been allowed to alter the source code but only in close consultation with the IFS - as when the
2. EXISTING TAX-BENEFIT MODELS

Department of the Environment used it to produce the Green Paper on the Abolition of Domestic Rates (Department of the Environment, 1986). At the menu-driven level the interface is very user-friendly; to dispense with the menus a knowledge of FORTRAN is required. If the user does have the ability to alter the source code then an Aladdin’s cave of policy options is opened up. This is because each time the model has been used for a new piece of research a new section of the program has been written for the policy area concerned. The routines have been preserved within the program, but in most cases cannot be invoked from the menu-driven front end of the model. When the model is first invoked an "action menu" with seven options appears (see figure 2.11).

If the user selects option 3 to alter the tax and benefit system, a further menu appears, shown in figure 2.14.

If the user decides to alter a complex benefit like housing benefit, the user has to adjust a large number of...

Figure 2.11 Computer screen display produced by IFS model showing initial menu of options

```
Change default Tax and Benefit systems ?(Y/N)--n

Action Menu

<table>
<thead>
<tr>
<th>Pick</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Print all tax + benefit parameters to screen</td>
</tr>
<tr>
<td>2</td>
<td>Print a subset of tax + benefit parameters</td>
</tr>
<tr>
<td>3</td>
<td>Alter the tax + benefit system</td>
</tr>
<tr>
<td>4</td>
<td>Alter the output defaults</td>
</tr>
<tr>
<td>5</td>
<td>Alter the run defaults</td>
</tr>
<tr>
<td>6</td>
<td>Run the model</td>
</tr>
<tr>
<td>7</td>
<td>Abandon the session</td>
</tr>
</tbody>
</table>
```
2. EXISTING TAX-BENEFIT MODELS

parameters and frequently refer to the manual as the labels are far from self-explanatory. The housing benefit menu is shown in figure 2.13.

Figure 2.12 Computer Screen Menu produced by IFS model showing options for altering tax and benefit system

```
enter a number (1 ... 7)—> j

1/ pick 1 from the following list:
1/ tax system
2/ national insurance
3/ family income supplement
4/ housing benefit
5/ state pensions
6/ supplementary benefit
7/ unemployment benefit
8/ child benefit
9/ vat
10/ excise duty
11/ update all allowances + benefits!
by x (system 2 only)
```

enter a number (1 .. 11)—> y

Figure 2.13 Computer Screen Menu produced by IFS model showing housing benefit menu

```
Housing Benefit

<table>
<thead>
<tr>
<th>sys 1</th>
<th>xms</th>
<th>xnu</th>
<th>xnh</th>
<th>xnl3</th>
<th>xndsw</th>
<th>xlin</th>
<th>xlinw</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47.70</td>
<td>70.20</td>
<td>14.50</td>
<td>17.00</td>
<td>5.00</td>
<td>999.99</td>
<td>999.99</td>
</tr>
<tr>
<td>sys 2</td>
<td>47.70</td>
<td>70.20</td>
<td>14.50</td>
<td>17.00</td>
<td>5.00</td>
<td>999.99</td>
<td>999.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sys 1</th>
<th>xhbsys</th>
<th>xrnlx</th>
<th>xooc</th>
<th>xbbv1</th>
<th>xbbv2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>sys 2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sys 1</th>
<th>x1</th>
<th>x2</th>
<th>x12</th>
<th>xrp1</th>
<th>xrp2</th>
<th>xwp2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25.00</td>
<td>25.00</td>
<td>8.00</td>
<td>12.00</td>
<td>50.00</td>
<td>20.00</td>
</tr>
<tr>
<td>sys 2</td>
<td>25.00</td>
<td>29.00</td>
<td>8.00</td>
<td>13.00</td>
<td>50.00</td>
<td>20.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>sys 1</th>
<th>xrrpp</th>
<th>remain</th>
<th>xatmin</th>
<th>xzodd</th>
<th>xnl1</th>
<th>xnl2</th>
<th>xnl3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60.00</td>
<td>0.20</td>
<td>0.25</td>
<td>0.00</td>
<td>6.60</td>
<td>6.60</td>
<td>2.35</td>
</tr>
<tr>
<td>sys 2</td>
<td>60.00</td>
<td>0.20</td>
<td>0.25</td>
<td>0.00</td>
<td>6.60</td>
<td>6.60</td>
<td>2.35</td>
</tr>
</tbody>
</table>
```

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The model has been used to simulate the existing direct tax-benefit system, the incidence of indirect taxes, the SDP Basic Benefit system, the Liberal Tax Credit proposals, and the Fowler Review system. If the user could call up these options and alter the benefit amount and tax rates which are associated with them through the menu driven part of the system, then the IFS model would have an extremely powerful user interface. However it should be stressed that there are also substantial advantages in allowing the user to gain access to the raw variables through a programming language. The merit is that the user retains the freedom to simulate a tax-benefit system which the model-builder has not thought of. The ideal would be to have a more highly developed menu system for the IFS model while allowing the user to access the raw variables in the model.

Figure 2.14 Output from IFS model showing number of people paying/receiving various taxes and benefits

<table>
<thead>
<tr>
<th>tax</th>
<th>bd al</th>
<th>df al</th>
<th>fis</th>
<th>sh</th>
<th>rent reb</th>
<th>rate/al</th>
<th>chen</th>
<th>b/dep</th>
<th>sho</th>
<th>w/dep tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>734.1</td>
<td>294.7</td>
<td>0.0</td>
<td>0.0</td>
<td>18.0</td>
<td>75.0</td>
<td>44.0</td>
<td>15.0</td>
<td>0.0</td>
<td>171.8</td>
</tr>
<tr>
<td>CPF</td>
<td>790.5</td>
<td>92.7</td>
<td>0.0</td>
<td>27.1</td>
<td>537.8</td>
<td>64.8</td>
<td>25.0</td>
<td>374.9</td>
<td>15.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Couple</td>
<td>1101.7</td>
<td>371.9</td>
<td>0.0</td>
<td>141.6</td>
<td>9.0</td>
<td>13.0</td>
<td>15.0</td>
<td>153.2</td>
<td>0.0</td>
<td>171.8</td>
</tr>
<tr>
<td>C + 1</td>
<td>1528.9</td>
<td>374.5</td>
<td>0.0</td>
<td>25.8</td>
<td>462.7</td>
<td>25.0</td>
<td>15.0</td>
<td>374.9</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 2</td>
<td>1813.2</td>
<td>374.5</td>
<td>0.0</td>
<td>25.8</td>
<td>462.7</td>
<td>25.0</td>
<td>0.0</td>
<td>474.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 3</td>
<td>2278.5</td>
<td>374.5</td>
<td>0.0</td>
<td>25.8</td>
<td>462.7</td>
<td>25.0</td>
<td>0.0</td>
<td>674.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 4</td>
<td>2636.8</td>
<td>374.5</td>
<td>0.0</td>
<td>25.8</td>
<td>462.7</td>
<td>25.0</td>
<td>0.0</td>
<td>874.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Single</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>CPF</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Couple</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 1</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 3</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C + 4</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total</td>
<td>1481.4</td>
<td>651.6</td>
<td>141.8</td>
<td>3141.9</td>
<td>437.8</td>
<td>274.3</td>
<td>3653.1</td>
<td>124.6</td>
<td>6472.4</td>
<td>154.0</td>
</tr>
</tbody>
</table>
2. EXISTING TAX-BENEFIT MODELS

2.8.5 Output from the Model
The IFS model is designed to show, for a given tax-benefit change, the following statistics:

(a) the number of people paying/receiving various taxes and benefits (see figure 2.14).
(b) the number of heads of household, and wives facing various marginal tax rates (see figure 2.15).

2.8.6 General Merits and Problems
In terms of the questions which it allows the user to answer, the IFS model is the most powerful of the existing tax-benefit models. The range of policy options which can be simulated and the fullness with which different types of family have been represented makes the

Figure 2.15 Output from the IFS model showing number of people in different ranges of marginal tax rate

<table>
<thead>
<tr>
<th>Table 19</th>
<th>1. Type of tax unit</th>
<th>2. Head or earned, system 1</th>
<th>Average</th>
<th>Old</th>
<th>New</th>
<th>Num</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range thresholds</td>
<td>.50</td>
<td>.60</td>
<td>.70</td>
<td>.80</td>
<td>.90</td>
<td>1.40</td>
</tr>
<tr>
<td>Single</td>
<td>90.41</td>
<td>.60</td>
<td>.77</td>
<td>.84</td>
<td>.91</td>
<td>2.34</td>
</tr>
<tr>
<td>Opp</td>
<td>97.50</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>Couple</td>
<td>95.45</td>
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<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>C + 1</td>
<td>95.32</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>C + 2</td>
<td>93.82</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>C + 3</td>
<td>91.52</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>C + 4</td>
<td>87.50</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>Sin Pea</td>
<td>108.66</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>Cou pea</td>
<td>105.52</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
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<td>16.74</td>
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<tr>
<td>Couple</td>
<td>108.66</td>
<td>.60</td>
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<td>.67</td>
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<td>16.74</td>
</tr>
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<td>103.22</td>
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<td>16.74</td>
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<td>.67</td>
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<td>.60</td>
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<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>Zeds</td>
<td>3.68</td>
<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
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<tr>
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<td>.60</td>
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<td>.67</td>
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<td>16.74</td>
</tr>
<tr>
<td>3 pitch</td>
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<td>.60</td>
<td>4.17</td>
<td>.67</td>
<td>4.17</td>
<td>16.74</td>
</tr>
<tr>
<td>Total</td>
<td>95.63</td>
<td>.60</td>
<td>1.94</td>
<td>.49</td>
<td>.47</td>
<td>.45</td>
</tr>
</tbody>
</table>
2. EXISTING TAX-BENEFIT MODELS

IFS model the most effective. It is significant that when the government introduced its plans for introducing a per capita community charge it did not base its calculations on one of its own models; it used a copy of the IFS model (Department of the Environment, 1986).

In terms of the range of tax and social security policies that the package has been used to assess, the IFS model is clearly the most successful. To improve on the existing version, it would be necessary to create menus which gave access to the various routines and modules which have been written for research projects in the past and which have been retained within the model, such as the routines dealing with indirect taxation.

2.9 INLAND REVENUE PERSONAL INCOME TAX MODEL

2.9.1 Objectives of the Model

The objectives of the Personal Income Tax (PIT) model is to simulate the effect of changing the Income Tax or National Insurance systems. M.P.s have indirect use of the model through the tabling of parliamentary questions, and the Treasury whose ministers and senior civil servants request information about the effect of possible tax changes. There is a greater emphasis on calculating the global Exchequer costs of a policy than there is with any other model. A typical parliamentary question might be "Will the Chancellor of the Exchequer show the revenue which would be lost if a reduced rate of income tax of 20% were levied on the first 3000 pounds of taxable income?" The Model is also capable of creating tables to show how much tax is paid by people in different income groups, and by a limited number of tax unit types.
2. EXISTING TAX-BENEFIT MODELS

2.9.2 Knowledge Base
The knowledge incorporated into the model includes a set of rules about the Income Tax and National Insurance Contribution system. The program allows the modification of tax rates, tax bands, tax allowances, the spouse's earnings election, and a possible investment income surcharge.

The raw data used by the model is the Inland Revenue Survey of Personal Incomes (SPI), which is collected annually. PIT's data is thus updated annually. The Survey of Personal Incomes is a sample of 67,000 Income Tax return forms. The tax-payers selected for the survey are not required to fill out any extra forms. The Inland Revenue requires local tax offices to fill out a survey form based on information that has already been collected for the preceding tax year. In most cases this involves the local tax officials filling out a survey questionnaire form by referring to existing PAYE records. In the case of those who fill out their own tax returns, then these self-completed forms are used. The SPI is designed so that there is a higher percentage sample of people with large incomes, than there is of people with lower incomes. The SPI was designed specifically as a data source for the PIT model and this model is the only one which uses it. However during April 1986, the SPI started to become available in the form of a public user tape available from the ESRC data archive so that other bodies could make use of it.

It is important to note that the SPI is purely concerned with the tax unit and not the household or the individual. There is no way to aggregate the information in the survey to reconstruct entire households as the sampling is based on tax units in the first place and not on whole households. The SPI omits all persons who are not liable for Income Tax. It would be theoretically
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possible to reconstruct data about individuals by separating information about husbands and wives.

2.9.3 Programming Approach
Though it was possible to view the output from the program and the user interface it has not been possible to view the source code of the program itself.

The method of extrapolating from the results based on the survey data to the general population involves multiplying each case within the sample by the inverse of the sampling fraction used when selecting it from the population. These multipliers are different for different types tax-payer, since the SPI samples a much higher proportion of richer tax-payers than it does of poorer tax-payers.

2.9.4 User Interface Issues
The Personal Income Tax model’s user interface is the second most usable interface of any of the Tax-Benefit Models, after TAXMOD. The model was intended to be used by generalist civil servants and not just by technical computer operators. The user is prompted to input new policy parameters through a system of easily understood menus. There is no need to resort to programming in order to answer most parliamentary and ministerial questions.

When the user first invokes the model a general menu of options is shown (see Figure 2.16).

Some of the options shown in figure 2.16 are not in fact connected with the Personal Income Tax model itself. One of them, for example, gives the user access to the inter-departmental model "IGOTM". Another allows the user to access the Inland Revenue model which shows how the tax system has developed over time. To simulate a change to
2. EXISTING TAX-BENEFIT MODELS

the tax system the user should select the option to set up an income change parameter file. The file selection panel shown in figure 2.16 is one of the few menus which requires the user to have specialist knowledge about the tax benefit system.

Figure 2.16 Computer Screen Image produced by Personal Income Tax model showing the initial menu of options

The first question shown in figure 2.16 asks the user to specify a file containing information about the existing tax and benefit system. The next question asks the user if he or she wishes to over-write the existing file of information, or to create a new temporary file of tax information. The user is then asked to give a name to the new output file to be created. The user then states whether the file containing information about the tax system is to be an existing system file or one created by the user. As the user wishes to model a new tax policy the file must be a user-created file. The user in the example shown is then asked whether he or she wishes to set up a parameter file or to have the parameters printed out on to paper. In the example shown in figure 2.17 neither is requested.
2. EXISTING TAX-BENEFIT MODELS

The user is then given a menu of four options, each specifying an area of tax policy which may be modelled. The user is invited to type "yes" or "no" to examine or change tax allowances, tax rates, investment income surcharge, and reduced rate tax bands.

The first screen to appear allows the user to change the tax rate schedule. The menu in figure 2.18 shows how easy it is to understand the options. The existing tax rate and the width of the associated tax band is shown beside it. The user may specify between one and 24 tax rates.

The investment income surcharge schedule may be altered in a similar way (see figure 2.19).

Before performing the analysis users are asked if they wish to have calculations performed on the full data set, or whether a fraction of cases should be sampled. As the model takes only five minutes to run on the full data set, this sampling facility is rarely used. (The model is run on an extremely powerful main frame based in Worthing, Sussex. This computer is linked directly to the Inland Revenue as Somerset House.)
2. EXISTING TAX-BENEFIT MODELS

Figure 2.18 Computer Screen Menu produced by the Personal Income Tax Model showing the menu to change tax rates and tax bands

<table>
<thead>
<tr>
<th>ENTER/VERIFY PARAMETERS BELOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBER OF TAX RATES ———&gt; 7</td>
</tr>
<tr>
<td>1ST RATE ———&gt; 30 1ST BAND ———&gt; 14600</td>
</tr>
<tr>
<td>2ND RATE ———&gt; 40 2ND BAND ———&gt; 2600</td>
</tr>
<tr>
<td>3RD RATE ———&gt; 45 3RD BAND ———&gt; 4600</td>
</tr>
<tr>
<td>4TH RATE ———&gt; 50 4TH BAND ———&gt; 7100</td>
</tr>
<tr>
<td>5TH RATE ———&gt; 55 5TH BAND ———&gt; 7100</td>
</tr>
<tr>
<td>6TH RATE ———&gt; 60 6TH BAND ———&gt; 8000</td>
</tr>
<tr>
<td>7TH RATE ———&gt; 70 7TH BAND ———&gt; 0</td>
</tr>
<tr>
<td>8TH RATE ———&gt; 0 8TH BAND ———&gt; 0</td>
</tr>
</tbody>
</table>

ALL RATES ARE TWO DIGIT INTEGERS
THERE MUST BE 1 LESS BAND THAN THERE ARE RATES

2.9.5 Output from the Model
A final screen of information is displayed which allows the user to determine the form that the output is to take. After specifying the files containing the raw data and the tax policy to be modelled, the user is asked to state whether the income of husbands and wives should be taxed separately or jointly (or whether separate taxation should occur only in those cases where the couple can reduce their tax burden by opting for separate taxation). The user is asked whether tax allowances are to be granted at the higher rates of tax. The user may also specify a tolerance level which indicates the amount of income gains and losses which are significant in the production of the output tables. If the tolerance level is five pounds, for example, then the output tables will
2. EXISTING TAX-BENEFIT MODELS

show the number of people facing tax increases/decreases of more

Figure 2.19 Computer Screen Image produced by the PIT model showing menu to alter investment income surcharge

<table>
<thead>
<tr>
<th>ENTER/VERIFY PARAMETERS BELOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>NON-AGED</td>
</tr>
<tr>
<td>EXEMPTION LIMIT ➞ 0</td>
</tr>
<tr>
<td>NO. OF RATES ➞ 1</td>
</tr>
<tr>
<td>RATES</td>
</tr>
<tr>
<td>1ST ➞ 15 ➞ 0</td>
</tr>
<tr>
<td>2ND ➞ 0 ➞ 0</td>
</tr>
<tr>
<td>3RD ➞ 0 ➞ 0</td>
</tr>
<tr>
<td>4TH ➞ 0 ➞ 0</td>
</tr>
<tr>
<td>5TH ➞ 0</td>
</tr>
</tbody>
</table>

Figure 2.20 Computer Screen Image produced by the Personal Income Tax model showing options for reduced rate tax bands

<table>
<thead>
<tr>
<th>ENTER/VERIFY PARAMETERS BELOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUSBANDS AND SINGLES</td>
</tr>
<tr>
<td>NO. OF RATES ➞ 0 (0-3)</td>
</tr>
<tr>
<td>RATES</td>
</tr>
<tr>
<td>1ST ➞ 0 ➞ 0</td>
</tr>
<tr>
<td>2ND ➞ 0 ➞ 0</td>
</tr>
<tr>
<td>3RD ➞ 0 ➞ 0</td>
</tr>
</tbody>
</table>
than five pounds per week, and the numbers of people facing tax changes of more than five pounds per week. The user may select the ranges of annual income incorporated into the existing model. The user may also select output tables broken down into aged/non-aged, single/married, totals for all tax units (or all of these).

Figure 2.21 Computer Screen Image produced by the Personal Income Tax model showing options for the tax treatment of couples

The table in figure 2.22 shows a typical output table from the model showing the numbers paying more or less tax according to their income level and whether their income gain/loss was more than the tolerance level of five pounds. As is typical of the Personal Income Tax model the emphasis is on the total amount of tax raised and the number of tax-payers in each income band. There is no attempt to show the output so as to assess the output in terms of how it will affect different types of family. The model does not output the average weekly income of different family types, or by the average income gain or loss - which would be the easiest way to assess such facts.

2.9.6 General Merits and Problems
The main disadvantage of PIT is the exclusion of people
2. EXISTING TAX-BENEFIT MODELS

below the tax threshold. As the majority of the recipients of state benefits are below the tax threshold, this means that the SPI can never be used for the analysis of benefit policy. However it would be extremely useful to take advantage of the wealth of information in the SPI about upper income groups. The SPI's one in three sample of incomes over 55,000 pounds per year could provide data on upper incomes which is very scant in the FES. The ideal data set would be one based on the FES but with adjustments so that the distribution of upper incomes was made to resemble the income distribution in the SPI. Though there are dangers in using two data sets in this way, it should be possible to control for certain variables to make it more likely that the results based on one data set can be made applicable to another. The fact that the SPI is now provided as a public user tape should make it easier for this type of research to be undertaken. In its current implementation the PIT model is very fast and user-friendly. However, it suffers from the same defect as all the other friendly menu-driven systems that if the user wishes to simulate a policy which was not thought of by the designers of the program then it simply cannot be done. The other main drawback of the model is its exclusion of low income groups. Because it is based on tax records it automatically excludes people below the tax threshold. This means that of a possible twenty-seven million tax units (counting husbands and wives as one unit) only 20 million are included in the data base used by the model. Because all of these excluded cases of income are below the threshold it is impossible to model benefits with the PIT model - and no attempt has been made to do so. For the purposes for which it was designed it is adequate - as it is usable by a large number of non-expert civil servants, and gives easily comprehensible answers about the revenue implications of changing the tax system.
## 2. EXISTING TAX-BENEFIT MODELS

Figure 2.22 Output from the Personal Income Tax Model showing gainers and losers from a policy change by income groups

<table>
<thead>
<tr>
<th>Income Range</th>
<th>CASES PAYING LESS TAX</th>
<th>TAX DECREASE (TOTAL)</th>
<th>CASES PAYING MORE TAX</th>
<th>WITHIN TOLERANCE</th>
<th>OUTSIDE TOLERANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2000</td>
<td>677</td>
<td>26</td>
<td>46.9</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>2000-4500</td>
<td>2642</td>
<td>22</td>
<td>191.9</td>
<td>178</td>
<td>52</td>
</tr>
<tr>
<td>4500-6000</td>
<td>840</td>
<td>1</td>
<td>61.3</td>
<td>154</td>
<td>14</td>
</tr>
<tr>
<td>6000-7000</td>
<td>926</td>
<td>0</td>
<td>46.6</td>
<td>111</td>
<td>3</td>
</tr>
<tr>
<td>7000-8000</td>
<td>1536</td>
<td>2</td>
<td>122.5</td>
<td>226</td>
<td>5</td>
</tr>
<tr>
<td>8000-9000</td>
<td>1486</td>
<td>3</td>
<td>122.7</td>
<td>210</td>
<td>5</td>
</tr>
<tr>
<td>9000-10000</td>
<td>1353</td>
<td>3</td>
<td>122.8</td>
<td>173</td>
<td>4</td>
</tr>
<tr>
<td>10000-12000</td>
<td>1073</td>
<td>3</td>
<td>108.2</td>
<td>131</td>
<td>6</td>
</tr>
<tr>
<td>12000-15000</td>
<td>1607</td>
<td>6</td>
<td>191.6</td>
<td>223</td>
<td>4</td>
</tr>
<tr>
<td>15000-20000</td>
<td>814</td>
<td>4</td>
<td>98.2</td>
<td>280</td>
<td>2</td>
</tr>
<tr>
<td>20000-30000</td>
<td>238</td>
<td>4</td>
<td>26.9</td>
<td>373</td>
<td>6</td>
</tr>
<tr>
<td>30000+</td>
<td>44</td>
<td>0</td>
<td>4.3</td>
<td>169</td>
<td>6</td>
</tr>
<tr>
<td>&lt; 30000</td>
<td>4410</td>
<td>48</td>
<td>277.1</td>
<td>871</td>
<td>81</td>
</tr>
<tr>
<td>30000+</td>
<td>11453</td>
<td>32</td>
<td>1107.9</td>
<td>2437</td>
<td>81</td>
</tr>
<tr>
<td>100000+</td>
<td>4347</td>
<td>19</td>
<td>495.5</td>
<td>1360</td>
<td>52</td>
</tr>
<tr>
<td>133000+</td>
<td>1180</td>
<td>7</td>
<td>131.5</td>
<td>866</td>
<td>20</td>
</tr>
<tr>
<td>200000+</td>
<td>212</td>
<td>3</td>
<td>37.2</td>
<td>52</td>
<td>15</td>
</tr>
<tr>
<td>ALL</td>
<td>14263</td>
<td>60</td>
<td>1405.0</td>
<td>3426</td>
<td>133</td>
</tr>
</tbody>
</table>
2. EXISTING TAX-BENEFIT MODELS

2.10 POLICY STUDIES INSTITUTE MODEL

2.10.1 Objectives of the Model
The PSI model was developed as part of a program of research sponsored by the Joseph Rowntree Memorial Trust to examine the implications of alternative systems for family income and housing support (Berthoud & Ermisch, 1985). The model has been applied to the analysis of the proposed reforms of social security arising out of the Fowler Reviews.

2.10.2 Knowledge Base
The model incorporates equations to calculate the following taxes and benefits (with variants/alternatives to each):

- National Insurance Benefits
- Statutory Sick Pay
- National Insurance Contributions
- Child Benefit
- Family Income Supplement/ Family Credit
- Income Tax
- Supplementary Benefit/ Income Support
- Housing Benefit
- Free School Meals

The raw data about incomes and expenditures is taken from the 1980 FES. There is one major exclusion from the data used by the PSI model. Households and family units with a head over the pensionable age have been excluded (Berthoud, Ermisch, 1985). This meant that of the original 8,000 or so households only 5,145 were incorporated in the model.

The raw data from the 1980 FES has been modified in a number of important ways. Inflation between 1980 and
2. EXISTING TAX-BENEFIT MODELS

1984 has been simulated by using four different factors to represent increases in:

(i) incomes;
(ii) rent and rates;
(iii) mortgage interest payments;
(iv) house prices.

The latest version of the model allows differential inflation factors as a function of wage levels. The increase in unemployment between 1980 and 1984 was represented by separate weighting factors for those who had been unemployed for over a year (who were given a weighting to increase the factor threefold), and the short term unemployed (who were given a weighting of 1.5) (Berthoud, & Ermisch, 1985).

2.10.3 Programming Approach

The raw data from the FES is manipulated by a hierarchical data management package, Quantum. The data is stored in such a way that it is entirely feasible to undertake accurate simulations regardless of whether the unit of analysis is the household, the tax unit, or the individual. The data about individuals (or rather adults) is stored as complete and separable records - this data is then linked to the appropriate tax unit. These tax units are then linked up to the appropriate household unit. The distinction between the head of household and other household members is preserved. In cases where there are more than one family unit within the household the head of household's family is recorded within the household. This allows the head of household's benefit entitlements to be calculated on the basis of the "non-dependent" contributions of the other tax units (which is important in the modelling of such things as the non-dependants contributions towards rent).
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Figure 2.23 Example of Output from Policy Studies Model

<table>
<thead>
<tr>
<th>FAMILY COMPOSITION</th>
<th>All</th>
<th>Couple</th>
<th>Couple</th>
<th>Lone</th>
<th>All</th>
<th>Single</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAMILIES</td>
<td>with</td>
<td>1-2</td>
<td>3+</td>
<td>par</td>
<td>no</td>
<td>per</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kids</td>
<td>kids</td>
<td>kids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL FAMILIES</td>
<td>18343</td>
<td>7503</td>
<td>5220</td>
<td>1356</td>
<td>927</td>
<td>10839</td>
</tr>
</tbody>
</table>

SOURCE AND AMOUNT OF INCOME UNDER NEW SCHEME

<table>
<thead>
<tr>
<th></th>
<th>Numbers of families</th>
<th>Source and Amount of Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NI benefits or SSP</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Child benefit</td>
<td>7503</td>
</tr>
<tr>
<td></td>
<td>FIS</td>
<td>554</td>
</tr>
<tr>
<td></td>
<td>Housing benefit</td>
<td>2919</td>
</tr>
<tr>
<td></td>
<td>Supplementary benefit</td>
<td>2269</td>
</tr>
<tr>
<td></td>
<td>Any Means test</td>
<td>3951</td>
</tr>
<tr>
<td></td>
<td>Income tax</td>
<td>15051</td>
</tr>
</tbody>
</table>

- Child benefit
- FIS
- Housing benefit
- Supplementary benefit
- Income tax

<table>
<thead>
<tr>
<th></th>
<th>Average amounts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NI benefits + SSP</td>
</tr>
<tr>
<td></td>
<td>Child benefit</td>
</tr>
<tr>
<td></td>
<td>F.I.S.</td>
</tr>
<tr>
<td></td>
<td>Housing benefit</td>
</tr>
<tr>
<td></td>
<td>Supplementary benefit</td>
</tr>
<tr>
<td></td>
<td>Income tax</td>
</tr>
</tbody>
</table>

|                      | Gainer families | 1437 | 904 | 325 | 177 | 402 | 533 | 385 |
|                      | Loser families  | 978 | 416 | 136 | 49 | 211 | 562 | 328 |
|                      | Mean gain among families | 0.21 | 0.54 | 0.17 | 0.68 | 2.46 | -0.02 | 0.08 |

2.10.4 User Interface Issues

When the Policy Studies Institute model was designed it was not intended to be a model for general distribution. Understandably the interface is not suitable for non-expert users. The Quantum analysis package has, in effect, its own programming language. Users have to familiarise themselves with this language in order to be able to modify the program; they would also have to be very familiar with the program itself.

There is no interactive mode for the program. It
2. EXISTING TAX-BENEFIT MODELS

operates in batch mode. A complete run of simulations and tables takes four hours to execute on the Policy Studies Institute mini-computer system.

2.10.5 Output from the Model
The features built into the Quantum Analysis Package allow a wide range of user-friendly output to be produced. The tables produced by the model are well labelled. One distinctive feature of the tables is that the categories on a table need not be mutually exclusive. It would thus be possible to have a table which included the category "single pensioner householders", who would in turn be included in a larger category of "single householders". Several different output parameters and alternative analyses can all be summarised clearly on one page, as is shown in figure 2.23.

2.10.6 General Merits and Problems
The main problem of the Policy Studies Institute model is one it shares with the LSE TAXMOD program - namely that it excludes a large proportion of the population (though while TAXMOD excludes tax units where the head is a pensioner or unemployed, the PSI model only excludes those where the head is a pensioner). Because of the exclusion of pensioner tax units the model is therefore better at predicting the effect of policy changes on specific types of household than it is at forecasting the Exchequer costs of a policy.

The programming is not particularly user-friendly. However, the output tables are very clear, and there are numerous options for output. Many different tax-benefit systems can be tested on the same run, which makes it easier to compare different policies.

The way that the data have been set up means that it is possible to analyse relationships between household
2. EXISTING TAX-BENEFIT MODELS

members more effectively than with any of the other models. For example, with the Institute for Fiscal Studies Model, it is not possible to distinguish between a head of household and adult non-dependants in the same home. (The IFS Model is based on tax units, which can, if necessary, be linked together to re-construct the original households. However there is then no way to discern which of the various heads of tax unit is the head of household). The method adopted by the Policy Studies Institute allows the head of the household to be identified - as well as preserving the identity of all the family units within the household. This feature of the model means that there are a number of policies which it simulates more accurately than any of the other models. A recent change to the benefit system has concerned the levels of rent which it is assumed that non-dependent adults contribute to the household. The effect of this kind of policy clearly cannot be modelled unless the non-dependants can be identified. Similarly the income gains and losses which will be caused by the replacement of local rates by the community charge cannot be adequately modelled unless the head of household can be clearly distinguished from other members. Without this facility Housing Benefit cannot be accurately modelled where there are several unrelated adults in the household. These advantages all flow from the way the cases have been arranged within the data set, and from the hierarchical nature of the data file structure.

2.11 The IGOTM Model

2.11.1 Objectives of the Model
IGOTM is an acronym for the Inter-Governmental working group on Tax Modelling. This group is chaired by representatives of the Treasury and includes civil servants from the Inland Revenue, the Customs and Excise,
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the Department of Health and Social Security, the Department of Employment and the Central Statistical Office. The objective has been to produce a broad model covering indirect taxes as well as direct taxes and benefits, which can be used by a wide range of officials from different departments. There was also a need to assess policies more accurately than is possible with the aid of hypothetical families. The IGOTM model produces tables based on nearly all of the households within the FES and is thus potentially a very representative model.

One of the reasons for the development of IGOTM was that the only other model capable of simulating both the tax and benefit systems was the DHSS's Policy Simulation Model (PSM) which is discussed below in section 2.12. The Inland Revenue's Personal Income Tax Model excludes low incomes, and therefore cannot simulate the benefit system. This meant that departments other than the DHSS were required to submit their policy proposals to the DHSS which would undertake the research on their behalf. This process was becoming unacceptably slow to the other departments and it was impractical for ministries other than the DHSS to use the PSM themselves, because the PSM has to be used by technical programming staff who have a thorough knowledge of it. Therefore one of the main objectives of the IGOTM model was to provide a program simple enough to be used by a wide range of civil servants from various departments.

2.11.2 Domain Knowledge

The knowledge incorporated in the model includes data about the tax and benefit system. There are routines which simulate Child Benefit, One Parent Benefit, Family Income Supplement, Housing Benefit, Supplementary Benefit, Income Tax (including optional transferable allowances and lower rate bands), National Insurance Contributions, and some of the Fowler Benefit proposals.

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2. EXISTING TAX-BENEFIT MODELS

(including Income Support and Family Credit).

The model includes a broad brush treatment of indirect taxes, though this is an area where further development work is planned. The raw data for the IGOTM model is taken from the FES. In 1984 this covered 7081 households; of these a small number have been excluded. Specifically the exclusions were:-

34 households containing a married adult whose spouse is absent;
16 households containing a foster child;
and 11 households containing more than 5 children.

Therefore over 99% of the households from the Family Expenditure Survey are included in the model. This means that IGOTM has the fullest coverage of the FES of any of the models which use it.

2.11.3 Programming Approach

The model is written in FORTRAN77. However, the source code was not available for the purposes of undertaking the current review so it is not possible to comment in detail on the equations which describe the tax-benefit system.

However, it is possible to comment on the method of storing the data from the FES. The storage has been done in a very sophisticated and effective way. The array of variables from the FES has been altered so that instead of reading into the computer's memory the information about an entire household, it reads in the data about an entire variable. Thus the data does not consist of information stored case by case but rather variable by variable. The array has thus been turned on its side, which gives rise to the term "inverted" or "transposed" matrix. By storing the data in this form it is possible
2. EXISTING TAX-BENEFIT MODELS

to save storage space by summarising the data about a particular variable. The CSO estimate that this process reduces the requisite disk storage space by 60-65%. To illustrate how this reduction in storage space is achieved take the example of an income variable where the first 22 values are:

0 0 0 0 0 0 89.92 0 0 0 0 0 0 0 0 0 0 0 0 122.10 0 0.

One could store the information as:

0 x 6, 89.92, 0 x 12, 122.1, 0 x 2.

It is possible to avoid recording long sequences of the same value by storing them as a "run mark". This consists of a number representing a sequence of values (i.e. a run marker), a number representing how many times a value is repeated, and a third number showing the value itself. In this way storage space can be dramatically reduced. The IGOTM model demonstrated at the Central Statistical Office on a Sperry main frame was able to produce tables almost instantaneously, even when they were based on an entire year of FES data. The variables first had to be read into a "work-file". The time required to read the data into the workfile can be up to fifteen minutes (depending on the number of variables required and the number of the other users on the same computer system). The program which accesses the variables from the transposed matrix is called the "Tabulator", an in-house package within the Central Statistical Office, which was originally written in the late 1970s by Geoff Stevenson.

The IGOTM model itself has been written as part of the Tabulator, and cannot be run independently of it. To summarise, the most distinctive feature of knowledge
2. EXISTING TAX-BENEFIT MODELS

representation within the IGOTM model is the transposed matrix concept which allows for such large savings of storage space and execution speed.

2.11.4 User Interface Issues

IGOTM's interface takes the user through a series of questions about the tax-benefit system. The questions are arranged in sections according to types of benefit and tax. When the model is first invoked the first question asked is "Do you wish to call National Insurance Contributions?" (which gives the user the opportunity to answer the 12 questions about National Insurance Contributions). If the user responds by typing "Y", the series of questions in figure 2.24 is asked.

Figure 2.24 Computer Screen Image produced by IGOTM showing questions about National Insurance Contributions

If the user types in "N" (indicating that National Insurance questions should not be asked) then the program will skip on to questions about Child Benefit, Family Income Supplement, Housing Benefit, Supplementary Benefit, and Income Tax (see figure 2.25).

This part of the interface is friendly enough. However when the user wants to extract information through the
2. EXISTING TAX-BENEFIT MODELS

The tabulator then a less understandable series of prompts is shown. The tabulator has a set of command names such as 2FR (for a frequency distribution), 2BR (for a breakdown of average values), and 2XT (for a two-way frequency table).

Figure 2.25 Questions posed by IGOTM model

```
Entering Child benefit module
Do you wish to alter CBl Current level = £7.10 per week
> Y
Enter new benefit in £ per week
> 10.0
Do you wish to alter OFU ? Current level = £4.60/week
> Y
Enter new one parent benefit in £ per week
> 5.0
Do you wish to model further versions of child benefit?
> H
Do you wish to call Family Income Supplement?
> Y
Entering F.I.S. module
Do you wish to change the income limits?
> H
Do you wish to change maximum amounts payable?
> H
Do you wish to change the withdrawal rate?
> H
Do you wish to model further versions of family income supplement?
> H
Entering housing benefit module
Do you wish to change any parameters?
> Y
Do you wish to change the needs allowances?
> H
Do you wish to change earnings disregards?
> H
Do you wish to change starting rate?
> H
Do you wish to change pensioner withdrawal rate?
> H
Do you wish to change non-pensioner withdrawal rate?
> H
Do you wish to change non-dependant deduction (rent)?
> H
Do you wish to change non-dependant deduction (rate)?
> H
Entering Supplementary Benefit (part 1)
Do you wish to change any parameters?
> Y
```
2. EXISTING TAX-BENEFIT MODELS

2.11.5 Output from the Model
The output available from the model is dependent on the capabilities of the C.S.O. Tabulator, rather than IGOTM. IGOTM has calculation routines, so any output tables are a feature of the tabulator rather than IGOTM itself. The statistics available through the tabulator include frequency tables, cross-tabulations, breakdowns, breakdowns and cross-tabulations by quantile groups, gini co-efficients, and the regression of two variables. At the time this review was undertaken an expanded version of the tabulator was being developed which would display full variable labels. An example of the output from IGOTM is produced below in figure 2.26.

2.11.6 General Merits and Problems
The IGOTM model can be used relatively easily by non-expert staff. The interface which requires the user to input changes to the tax-benefit system is user-friendly (however as is the case with all such menu systems, there is no way of modelling major changes to the tax-benefit system not represented by the menus without altering the program itself). However the tabulator commands

Figure 2.26 Output table produced by IGOTM Model

<table>
<thead>
<tr>
<th>Code</th>
<th>DHSSTU</th>
<th>Count</th>
<th>Percent</th>
<th>Cumsum</th>
<th>CUM %</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>SINGLE NON-PENSIONERS</td>
<td>2883</td>
<td>32.14</td>
<td>2883</td>
<td>32.14</td>
</tr>
<tr>
<td>02</td>
<td>MARRIED COUPLES</td>
<td>3779</td>
<td>42.12</td>
<td>6662</td>
<td>74.26</td>
</tr>
<tr>
<td>03</td>
<td>LONE PARENTS</td>
<td>360</td>
<td>4.01</td>
<td>7022</td>
<td>78.27</td>
</tr>
<tr>
<td>04</td>
<td>PENSIONERS</td>
<td>1949</td>
<td>21.73</td>
<td>8971</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>8971</strong></td>
<td><strong>100.00</strong></td>
<td><strong>8971</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>
2. EXISTING TAX-BENEFIT MODELS

take slightly longer to learn. The output mechanisms could not be considered easily comprehensible. They are however extremely fast. Speed of execution is one of the great merits of IGOTM.

The main disadvantage of IGOTM is its lack of portability. It cannot be used independently of the tabulator program, (which is itself not available outside the CSO). The output from the program makes it difficult to compare one tax-benefit system with another (though changes in net income between two systems can be stored). This problem is handled much better by the IFS model which is based on the comparison of one type of system with another (generally the existing system is compared to some proposed reform).

2.12 DHSS POLICY SIMULATION MODEL

2.12.1 Objectives of the Model

The main objective of the DHSS Policy Simulation Model (PSM) was to provide a way of analysing tax-benefit policy in a more sophisticated way than was possible with an analysis of hypothetical families. Policy-makers needed to know statistics such as the overall number of gainers and losers from a particular policy change. It was, of course, possible for the DHSS to produce such statistics by using the FES in conjunction with a statistical analysis package such as SPSS (which is still used by the DHSS for tax-benefit modelling). The advantage of producing an integrated tax-benefit model is that a number of different tax-benefit policies can be analysed using the same model. The first version of PSM was written in 1978 by Nick Morris who was then working in the Economic Advisers Office of the DHSS. Nick Morris later moved to the IFS. The PSM was used extensively for research connected with the Fowler Social Security
2. EXISTING TAX-BENEFIT MODELS

Reviews, and has also been used to simulate some of the effects of the proposals in the Green Paper on Personal Taxation - though the main thrust of the PSM is to simulate the social security system rather than the tax system.

2.12.2 Domain Knowledge

The PSM operates using a database which includes nearly all the cases from the FES. Of the 7,081 households from the 1984 FES only 200 were rejected. The reasons for rejecting a household were as follows:

(i) that it had more than three tax units (77 cases);
(ii) that it has a young dependent adult (84 cases);
(iii) that there was a husband or wife who was not present in the household;
(iv) that it had a child as the head of the tax unit (12 cases).

As with most of the models based on survey data the computer files are held in a simple rectangularised (rather than hierarchical format). All the main features of the tax and benefit system are incorporated in the model. The Income Support rules are described in considerable detail within the model - reflecting the DHSS's specific policy concerns.

2.12.3 Programming Approach

The model is a collection of 5 different programs each of which is concerned with different stages of processing the FES data, validating it, and applying tax-benefit policies to the resulting data. Of the five programs in the suite, four are written in Algol-68R. The command module which provides the only user-friendly features of the PSM is written in FORTRAN. The variable names in Algol are anything but self-explanatory and it is necessary to refer back frequently to a set of coding
2. EXISTING TAX-BENEFIT MODELS

notes in order to interpret a particular tax-benefit formula.

The method of calculating results within the PSM is relatively simple. Unlike TAXMOD and the IFS model,

Figure 2.27 Computer Screen Image produced by the DHSS Policy Simulation Model showing commands for using the model

PLEASE TYPE :-

A TO INPUT A NEW FILE
B TO UPDATE AN EXISTING FILE
C TO AMEND AN OLD FILE TO A NEW FILE
Q TO TERMINATE THE PROGRAM

PLEASE INPUT FILE-TYPE CODE.
DO YOU WISH TO SEE A LIST OF FILE-TYPES?
FILE TYPES

1. MAIN (NATIONAL INSURANCE - PUST 1985)
2. FISY (FAMILY INCOME SUPPLEMENT)
3. CHIB (CHILD BENEFIT)
4. RENT (REBATE)
5. RATE (REBATE)
6. MILK (FREE WELFARE MILK)
7. MEAL (FREE SCHOOL MEALS)
8. TACY (INCOME TAX)
9. NTAX (TRANSFER TAX)
10. GECB (GENERALISED CHILD BENEFIT)

PROPORTION RENT ALLOWED IN H.B FORMULA, (PENS) ?

PRB (.MMMM)
REDUCTION TAPER USED IF INC > HOUSING NEEDS ALLOW
PRC (.MMMM)
INCREASE TAPER USED IF HOUSING NEEDS ALLOW > INC
DISRH (NN.MMM)
EARNINGS DISREGARD : HEAD OF H/HOLD?
DISRS (NN.MMM)
EARNINGS DISREGARD : SPOUSE?
DSB (NN.MMM)
BENEFIT DEDUCTION FOR PERSON ON SB?
DPENS (NN.MMM)
BENEFIT DEDUCTION FOR A PENSIONER?
D1820 (NN.MMM)
2. EXISTING TAX-BENEFIT MODELS

there is no correction for response bias within the PSM so to some extent there will be an under-representation of upper income groups and some family types in its calculations. The model incorporates certain internal DHSS data on the take-up of benefits. The model is "calibrated" by comparing its predictions of the Exchequer cost of certain benefits to the actual data on benefit costs. This is an excellent way of testing the accuracy of the model because it makes use of data on benefit costs which is collected separately from the FES. However as there is no correction for response bias within the model, this method may have unforeseen consequences. For example, if the model predicted that the Exchequer cost of Family Income Supplement was higher than the administrative data suggests, this may either be because the data on take-up rates is faulty or because there is a higher proportion of families with children in the FES than there is in the population.

2.12.4 User Interface Issues

Of the five programs which make up the PSM four are mainly concerned with file manipulation. If the user had to grapple with these programs on their own, the PSM would be extremely difficult to use. Fortunately there has been an attempt to provide a more readily usable interface which prompts the user to key in the names of appropriate files and make other responses in the correct sequence. A sample of the type of prompt displayed by the command module is shown in figure 2.27.

Though there is some terminology which is specific to the PSM, this command module makes it moderately user-friendly. The user may select a verbose interface in which a self-explanatory prompt is displayed such as: "Housing Needs Allowance for a Single Adult?" If the user does not select the verbose mode a cryptic variable label is shown such as "WEA" (Wife's Earned Income
2. EXISTING TAX-BENEFIT MODELS

Allowance). While these prompts are not quite as good as those of the Personal Income Tax model - they are better than those of the IFS model (which prompt with variable names only and not with an English Language description). The PSM is still not as user-friendly as the IGOTM model which does not require the user to learn the PSM's complex file manipulation commands.

2.12.5 Output from the Model

The tables produced by the PSM have extremely obscure value labels. For example one is meant to refer to a legend on a table to translate "[197]=1" into "single person, non pensioner head working". Some of the tables seem to be labelled entirely with Algol array descriptions. For example the table showing the receipt of benefits by family type is labelled entirely by code numbers and no legend was produced to show which number corresponded to housing benefit, FIS, etc. One of the more intelligible tables is produced in figure 2.28 which shows total income support by ranges of annual gross income.

2.12.6 General Merits and Problems

The PSM meets its main objectives, in that it provides a way of analysing the FES to show statistics such as the overall number of gainers and losers, changes in the total amount of income support, and the average amounts of benefits received. The PSM incorporates over 97% of the households from the FES, so it has a very high coverage of the real world population.

On the debit side however, the structure of the program must make it very difficult for newcomers to update and alter the PSM. The Algol program lines are full of array descriptions like "[193]=2", which are less likely to be understood than mnemonic variable labels like "CHBEN" (which is IGOTM's variable name for Child Benefit).
2. EXISTING TAX-BENEFIT MODELS

must make it more difficult to re-program the PSM to incorporate new taxes and benefits. It also increases the risk that errors will go undetected within the program. The failure to try to correct for response bias within the PSM is a significant drawback.

The "verbose" prompts given by the command module help to make the PSM moderately user-friendly. However, if the user wishes to model a completely new policy it would be necessary to grapple with the extremely user-hostile Algol source code. Any program like the PSM which has to be used and modified by a number of different people, should be based on a programming approach which is as

Figure 2.28 Sample of the output from the PSM

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>FREQUENCY TABLE</th>
<th>PART 1 OF 1</th>
<th>TIS IN 2 Pw WEEK. COLS ARE 2000</th>
<th>UF ANNUAL GROSS INCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-2</td>
<td>3-5</td>
<td>5-7.5</td>
<td>7.5-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1977)1</td>
<td>346</td>
<td>1018</td>
<td>1606</td>
<td>1011</td>
</tr>
<tr>
<td>(1977)2</td>
<td>16</td>
<td>22</td>
<td>121</td>
<td>326</td>
</tr>
<tr>
<td>(1977)3</td>
<td>3</td>
<td>6</td>
<td>96</td>
<td>221</td>
</tr>
<tr>
<td>(1977)4</td>
<td>16</td>
<td>54</td>
<td>246</td>
<td>621</td>
</tr>
<tr>
<td>(1977)5</td>
<td>0</td>
<td>1</td>
<td>70</td>
<td>288</td>
</tr>
<tr>
<td>(1977)6</td>
<td>0</td>
<td>22</td>
<td>109</td>
<td>90</td>
</tr>
<tr>
<td>(1977)7</td>
<td>371</td>
<td>1136</td>
<td>2259</td>
<td>2257</td>
</tr>
<tr>
<td>(1977)8</td>
<td>2118</td>
<td>2114</td>
<td>95</td>
<td>45</td>
</tr>
<tr>
<td>(1977)9</td>
<td>266</td>
<td>185</td>
<td>125</td>
<td>74</td>
</tr>
<tr>
<td>(1978)1</td>
<td>72</td>
<td>48</td>
<td>115</td>
<td>106</td>
</tr>
<tr>
<td>(1978)2</td>
<td>503</td>
<td>123</td>
<td>64</td>
<td>3</td>
</tr>
<tr>
<td>(1978)3</td>
<td>56</td>
<td>52</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>(1978)4</td>
<td>608</td>
<td>106</td>
<td>53</td>
<td>3</td>
</tr>
<tr>
<td>(1978)5</td>
<td>2584</td>
<td>714</td>
<td>443</td>
<td>285</td>
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<td>2597</td>
<td>850</td>
<td>346</td>
<td>128</td>
</tr>
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<td>(1978)7</td>
<td>6</td>
<td>1200</td>
<td>576</td>
<td>272</td>
</tr>
<tr>
<td>(1978)8</td>
<td>2595</td>
<td>2259</td>
<td>922</td>
<td>403</td>
</tr>
<tr>
<td>(1978)9</td>
<td>536</td>
<td>226</td>
<td>70</td>
<td>54</td>
</tr>
<tr>
<td>(1979)1</td>
<td>2253</td>
<td>1894</td>
<td>1104</td>
<td>675</td>
</tr>
<tr>
<td>(1979)2</td>
<td>157</td>
<td>124</td>
<td>102</td>
<td>54</td>
</tr>
<tr>
<td>(1979)3</td>
<td>0</td>
<td>23</td>
<td>109</td>
<td>90</td>
</tr>
<tr>
<td>(1979)4</td>
<td>605</td>
<td>83</td>
<td>48</td>
<td>3</td>
</tr>
<tr>
<td>(1979)5</td>
<td>10</td>
<td>64</td>
<td>246</td>
<td>950</td>
</tr>
<tr>
<td>(1979)6</td>
<td>544</td>
<td>118</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>(1979)7</td>
<td>258</td>
<td>1063</td>
<td>1789</td>
<td>1370</td>
</tr>
<tr>
<td>(1979)8</td>
<td>2047</td>
<td>152</td>
<td>61</td>
<td>36</td>
</tr>
<tr>
<td>(1979)9</td>
<td>657</td>
<td>288</td>
<td>364</td>
<td>324</td>
</tr>
<tr>
<td>TOTAL</td>
<td>26208</td>
<td>15552</td>
<td>14656</td>
<td>12977</td>
</tr>
</tbody>
</table>
simple and self-explanatory as possible. The complexity of the PSM must make it very expensive to use in terms of staff time. This is doubtless what has given rise to the development of IGOTM so that there would be a more usable facility which could be employed by a number of different departments.

2.13 Conclusion
Have any of the eleven models described above achieved an effective combination of usability and flexibility? This combination is crucial if a model is to succeed as a pluralist model. A pluralist model must be sufficiently easy to understand that it can be used by a layman, without restricting the user to a narrow range of predetermined policy options selected by the model-builder.

In general those models which are most accessible to non-experts are those which feature a well-designed menu system. Ideally such menu systems display an English language question on the screen and invite the user to type in the answer at the computer keyboard. For example, the IGOTM model displays the question:- "Do you wish to change CB [Child Benefit]? Current Level = 7.10 pounds per week." Of the eleven models described above, TRAP and the PSI model have no interface of this type. To use these models the user would have to edit the source code, in the case of TRAP, or a file of Quantum commands in the case of the PSI model. The Alvey DHSS Demonstrator has no standard template of questions - the user is invited to build up a question from a series of standard terms. The quality of the menu systems varies greatly in the other eight models. The IFS model and the DHSS Policy Simulation Model have menu prompts which are based on variable names rather than English language terms - as such they are more difficult to use than the menu systems in other six models (DHSS Tax-Benefit Model,
2. EXISTING TAX-BENEFIT MODELS

CUBS, TAXEXP, TAXMOD, Inland Revenue PIT, and IGOTM). Of the six menu systems with good English prompts, the usability varies according to how easy it is to move the cursor around the menus to change specific parameters. Ideally the user should not have to type in a long series of answers in order to change a single policy parameter. The user should be able to move forwards and backwards easily to find and alter a constant. The DHSS Tax-Benefit Model, CUBS, and IGOTM have rather rigid menu systems, because the user works through a standard series of questions, a process which can be annoyingly slow. TAXEXP and TAXMOD have menu systems which are very easy to use as their menu systems make it very easy to move to different sections of the interface to alter different parameters. TAXMOD also has the widest selection of output tables.

Though it is important to recognise the enormous amount of work which has been done in order to improve and extend these menu systems, it should still be stressed policies which they cannot simulate. Here are a selection of policies which all these menu systems would exclude: the Tory Reform Group's Tax Credit plans (Tory Reform Group, 1979); the SDP's 1988 proposal for the reform of National Insurance Contributions (SDP, 1988); Micheal Meacher's idea to replace mortgage interest tax relief with a regionally varied housing allowance (The Times, 1985a); and the tax credit scheme set out in the Liberal document "... To Each According" (Vince, 1983). Not one of the existing menu systems would allow the user to simulate any of these policies. (Here the discussion is confined to the models in their compiled object code form. Clearly any of these policies could be simulated by altering a model's source code, which would in effect create a new program.) No matter how hard tax-benefit modellers try to create detailed menu systems, pressure groups and political parties will always manage to devise...
2. EXISTING TAX-BENEFIT MODELS

policies these menus cannot simulate. The only way of providing this kind of flexibility would be to allow the user access to source code of the model. This would mean that the user would in effect "re-program" part of the model in order to simulate the new policy.

However, it should be possible to achieve this without writing an entirely new model. The section of the source code the user would have to deal with would be limited to those program equations which defined the tax benefit system. There are many other parts of the program which would not need to be altered. These standard routines would include the procedures for making tables, correcting for response bias and non-take up of benefits. However even if the user only had to alter the tax-benefit definition statements this would still pose serious problems. If a new user was to try to alter the source code of one of the existing models (even in a limited part of the program) this could not be done without an enormous investment of time and energy. A whole vocabulary of variable names would have to be learned. To alter the program without doing so would be to invite serious errors. The only alternative would be to define the tax-benefit statements in such a way that they were comprehensible both to a computer and to a human being. This would require a new language. The construction of such a new language is one of the aims of the current thesis.

This could not be the English language as it is spoken naturally. It is not currently possible for a computer system to interpret human language as it is used in everyday situations (such as in conversation). The new language would have to be restricted in certain ways. It would have to be free from many of the ambiguities and inexactitudes of English. However it should be possible to develop a hybrid between English and the existing
2. EXISTING TAX-BENEFIT MODELS

computer languages which would be understandable to the layman. It would then be possible for a non-expert to use a set of tax-benefit equations and alter them relatively safely because the users would understand what they were altering. This would provide an effective combination of usability and flexibility. A computer language has been developed for this thesis which attempts to achieve this combination. It is described below in section three of this thesis. Only this approach can allow the full power of computer technology to be devolved from the expert to the generalist policy maker. If the user is only given access to programs which answer specific pre-determined questions, then power resides in the hand of the people who ask the predetermined questions. Tax-benefit models which only simulate specified policy options are an apt illustration of the concept of the mobilisation of bias. "Some issues are organised into politics and other issues are organised out" (Schattschneider, 1960:34). The menu questions in a tax-benefit model organise some policies into consideration, and organise other policies out. In a pluralist society, it should be a wide range of parties and pressure groups which decide which tax-benefit policies are to be considered, not a small group of experts.

The existing tax-benefit models also constrain the user’s options in other ways. All of the models shown above allow the user to analyse a policy by producing one or more standard tables. A typical table would show the effects of a policy change by showing the average increase/decrease in income for a set of different family types (e.g. single parent, single childless, couple etc). These assumptions about the way the data are analysed contain their own subtle biases. This issue is discussed in greater detail in chapter 3.
2. EXISTING TAX-BENEFIT MODELS

Some of those who work in the field of tax-benefit modelling, argue that the business of carrying out policy simulations is so serious and difficult that non-experts should only be allowed to use the compiled version of a tax-benefit program. This type of attitude highlights some of the basic philosophical questions about the role of computers in society. Will they cause the formation of yet another elite in society, an elite dominated by computer specialists, or will they contribute to the dispersal of power by opening new opportunities to the common man? This thesis attempts to answer the question of whether it is possible to create a computer system which will make tax-benefit modelling accurate, flexible, and above all accessible to ordinary people. The answer to this question, has wider implications about how computers will shape the future of our society.
3. PRINCIPLES OF TAX-BENEFIT POLICY

3.1 Introduction
The task of creating a tax-benefit model which will be flexible and accessible to non-experts not only concerns the options which can be fed into a tax-benefit model. It also concerns the way answers come out of the model. If a model only allows the user to analyse a policy according to some criteria but not others then there is theoretically a "mobilisation of bias" within the model. There are various different theories about what makes for a good tax-benefit system. For example, all of the models based on sample surveys produce some form of table which indicates changes in net income before and after a policy change. Not all of them show the proportion of people on different marginal tax rates.

To include one type of table but not the other shows a greater interest in the impact of policy on incomes than in its effect on incentives. Generally speaking those on the political right tend to be more concerned with the possible impact of tax rates on incentives than those on the political left. An optimum tax-benefit model should be neutral between such preferences. It should not constrain the user to analyse policy according to any particular set of ideological prejudices. Thus the model builder should not constrain the user by limiting the output to a single set of standard tables. Users should be able to analyse policies according to their own criteria.

No matter how politically neutral the model builder tries to be, any set of tables will tend to exclude methods of analysing policy which will be important to certain users. For example, a user like Age Concern might wish to limit the analysis of a policy to people of pensionable age. The Low Pay Unit might wish to show the increase/decrease in net incomes according to ranges of earnings per hour. This would be impossible with any of
the existing models. In the discussion below the Alvey DHSS Demonstrator will not be included as it is not intended to produce quantitative answers and is therefore in a different category to the other models.

In order to indicate the different criteria by which tax-benefit models should be measured this chapter examines a number of abstract principles which may be used as yardsticks by which to judge tax-benefit policy. Any selection of such principles must inevitably be subjective. These principles have been drawn from a number of famous writers on political economy. It is not claimed that this list of principles is exhaustive or exclusive. It is intended to be a useful summary which highlights the range and diversity of such principles. It will be seen that some of the existing tax-benefit models allow policies to be analysed according to these criteria while other do not. In chapter six an optimum system is examined which allows the user far greater flexibility in the analysis of policy. The range and diversity of tax-benefit principles shown below makes it clear how important it is to provide this diversity.

3.2 The Proportionality Principle
The proportionality principle was the first of Adam Smith’s four great principles of taxation. In 1776 he wrote that citizens "ought to contribute ... in proportion to their respective abilities." (Smith, 1776: Vol.V, Sec.2, Para.3) This idea is distinct from the concept of progressive taxes (which take a higher proportion from people with greater ability to contribute) and from regressive taxes (which take a higher proportion from those less able to pay). If the proportionality principle were to be achieved through direct taxation, an income tax with no allowances and a single percentage rate on all tax-payers would be its best illustration. In the field of indirect taxation the
proportionality principle could best be achieved by a tax levied at the same rate on all goods with no special exemptions for food and basic necessities, and with no higher rates of tax on luxury goods. Because so much of the taxation of the 18th century was regressive, such as import duties on food, the principle of proportionality was often supported by those on the political left. Since Adam Smith's day the field of fiscal battle has moved and the political right often argue for proportional taxes (as an alternative to progressive taxes).

To measure how far a tax-benefit policy conforms to the proportionality principle it is necessary for a model to be able to assess both marginal and average tax rates. To illustrate the difference between these tax rates consider the following hypothetical worker. The worker earns 20,000 pounds per annum, and has no tax allowances. He or she pays 25 per cent on the first 10,000 pounds of income and 75 per cent on income between 10,000 and 20,000 pounds. The worker pays 10,000 pounds in tax out of his 20,000 pound income. Therefore his average rate of tax is 50 per cent, while the rate of tax paid on the next pound of income is 75 per cent - the marginal rate. The average rate is calculated by taking the total value of any transfers from the state (taxes paid or benefits received) and dividing this figure by the tax unit's original income (income derived from sources other than state benefits). Thus the average tax rate will be a negative percentage if the individual receives more in benefits than is paid in taxes.

Of the existing models, the DHSS Tax-Benefit model, CUBS, TAXMOD, TAXEXP, and the IFS model produce tables which show how far a tax-benefit system conformed to the proportionality principle. The graph produced by TAXEXP which plots net income against gross income gives a vivid
3. PRINCIPLES OF TAX-BENEFIT POLICY

Illustration of changes in average tax rates as one moves up the income scale. None of the existing models show original income and net income in a form which would make it easy to calculate average tax rates.

3.3 The Egalitarian Principle

The egalitarian principle is based on the view that an equal distribution of resources is a desirable goal for society. Therefore the tax-benefit system should be used to promote the most equal spread of income and wealth which is practically possible. This view is partly based on the belief that people are created equal, and that this natural equality should not be undermined by the luck of inheritance and divisive social institutions which produce differences in income and wealth. Thus taxes which take progressively more money from people the richer they are, and benefits which raise the net income of the poorest, are good because they help "narrow the space between valley and peak" in society (Tawney, 1931:108). The French Utopian socialist Saint-Simon argued that the state should transfer resources "from each according to his abilities, to each according to his needs" (cit. Wilczynski, 1981:506) an aphorism which was later attributed to Marx.

Some supporters of the equality principle argue that all wealth is based on resources such as land and minerals which were not created by individuals, and should therefore belong to the community as a whole. This was a crucial argument behind George's concept of land value taxation (George, 1879).

It has also been argued that an unequal distribution of resources is wrong because private wealth is maintained by conditions which are created by the community as a whole.
3. PRINCIPLES OF TAX-BENEFIT POLICY

No individual can create by his isolated action a healthy environment, or establish an educational system with a wide range of facilities, or organise an industry in such a way as to diminish economic insecurity ... Yet these are all conditions which make the difference between happiness and misery ... In so far as they exist, they are the source of a social income, received in the form, not of money, but of increased wellbeing. (Tawney, 1931:127)

There is an important distinction between those favouring equality of opportunity, and equality of outcome. While writers like Mill (1848) supported the use of inheritance taxes to promote equality of opportunity, they opposed deliberate measures to limit the acquisition of resources during the individual's lifetime. On the other hand Tawney, for example, would have had no hesitation in using fiscal devices in promoting a greater equality of outcomes.

If one is trying to assess the extent to which a tax-benefit system promotes equality it is necessary to measure the number of people at different levels of net income. Thus the models which are based on hypothetical cases (the DHSS Tax-Benefit Model, CUBS, and TAXEXP) could not be used for this. TRAP produces tables which are mainly concerned with incentive effects, which would not be very easy to interpret in order to assess the impact of a policy on equality. The Inland Revenue Personal Income Tax Model would not be very useful either because it excludes people with incomes below the income tax threshold which is roughly a fifth of all tax units. TAXMOD, the IFS model, the PSI model, IGOTM, and the DHSS Policy Simulation Model all produce tables which help to assess the number of people at different income levels.
3. PRINCIPLES OF TAX-BENEFIT POLICY

IGOTM is frequently used to produce tables showing average incomes and the number of people in each decile level of income. TAXMOD also produces a table which is specifically intended to give a profile of a society's income distribution. This shows the total amount of income below each decile level of income (which is form of Lorenz curve).

3.4 The Protection of Property rights

The protection of property rights can lead to policies which are the opposite of egalitarian policies. Friedman has proposed a direct negative to the maxim "To each according to his needs". According to Friedman the state should secure a distribution of resources "to each according to what he and the instruments he owns produces" (Friedman, 1962:161). But if all wealth is ultimately based on resources to be found in nature, how can one justify the ownership of wealth which people have not created themselves? The 17th century philosopher, Locke (1690) justified private wealth holding with the following argument:-

Though the earth ... be common to all men, yet every man has a property in his own person: this nobody has a right to but himself. The labour of his body, and the work of his hands are properly his. Whatsoever he removes out of the state that nature has provided, and left it in, he hath mixed his labour with and joined to it something which is his own, and thereby make it his property....

(2nd Treatise, Para 27)

God gave the world to men in common, but since he gave it to them for their benefit... it cannot be supposed that he meant it should always remain common and uncultivated.
While this argument may justify the holding of wealth acquired during one's own lifetime, it does not follow that the labour of a father to create wealth, justifies the transfer of the same wealth by his son. In Friedman's view, however, there is little practical difference between inequalities which are caused by inheritance and those due to skills which people display in their own lifetime. Is there any real difference between someone who is bequeathed a million pounds and someone who earns the same amount because his parents have passed on to him a beautiful singing voice which enables him to earn it? Many writers would disagree with such statements on the grounds that many individuals display abilities which can only partially be explained by inheritance (Jencks, 1972). Luck also plays its part.

None of the existing tax-benefit models allows the user to examine the distribution of wealth as well as the distribution of income. The data source most commonly used for tax-benefit modelling, the FES, records the amount of income received from various forms of investment which would make it possible to estimate the value of the assets which yield this income. The FES information on payments for house purchase and rateable values would make it possible to estimate wealth held in the form of housing. In theory it would be possible to devise a tax-benefit model which would show the distribution of wealth and estimate the effect on this distribution of different fiscal policies. This would make it possible to estimate the effects of such policies as the taxation of wealth, and various types of tax on gifts and legacies.

3.5 The Prevention of Poverty
There is a sharp contrast between the policies advocated
3. PRINCIPLES OF TAX-BENEFIT POLICY

by those who would promote greater equality, and those who believe that the state's primary role is to protect property rights. In between these two extremes stands a body of opinion which holds that the state should not necessarily promote equality, but should undertake to provide a safety net so that all people have at least enough resources for basic subsistence. Preventing poverty may be concerned solely with redistributing resources to the poor, not necessarily with taking money from the rich.

Reformers like Beveridge would have been entirely satisfied with an unequal distribution of resources provided that enough money was raised from general taxation and insurance contributions to prevent poverty. Indeed the financing of Beveridge's National Insurance system did not even adhere to the proportionality principle; it was funded by a regressive system of flat rate contributions.

Linked to the prevention of poverty is the concept that poverty can be measured objectively. One of the most famous attempts to do this was made by Rowntree who attempted to measure what

"income is required by families of different sizes to provide the minimum food, clothing, and shelter needful for the maintenance of merely physical health... Expenditure needful for the maintenance of the mental, moral, and social sides of human nature would not be taken into account at this stage of the enquiry."

(Rowntree, 1902:87)

Later Beveridge argued that the state should "fix rates of ... benefit and pension on a scientific basis with
regard to subsistence needs" (Beveridge, 1943:29). Other writers have disputed that poverty should be measured in this way. For example, Townsend has argued that people are in poverty if they are excluded from social and cultural activities which may be regarded as normal for a given society (Townsend, 1979). Such a method would start to take account of the "mental, moral, and social" aspects which Rowntree referred to above.

Probably the most graphic way to demonstrate how effective a tax-benefit system is in preventing poverty would be to show how many families are above and below the official poverty line. The Income Support level for each family could be calculated and the tax-benefit model could then show the percentage by which each family exceeded or fell short of this level. The Supplementary Benefit level would be a useful yardstick to use because it is intended to be an estimate of how much a given family needs to live. Whether the current levels of Income Support are fair or accurate is inevitably a matter of debate, they have the virtue of being officially recognised and widely known. None of the existing models allow the user to produce tables in relation to income support levels.

3.6 Maintenance of Incentives

The requirement to maintain work incentives, which requires low tax rates, is often claimed to be in conflict with the concept of vertical equity in the tax system. Vertical equity is concerned with the relative fairness of the tax burden on people at different income levels (in almost all cases the debate over vertical equity centres on how progressive the tax system should be).

For as long as there have been calls to introduce progressive taxation, it has been argued that applying
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higher rates of taxation to people who earn more would reduce work effort. John Stuart Mill wrote:-

To tax the larger incomes at a higher percentage than the smaller, is to lay a tax on industry and economy; to impose a penalty on people for having worked harder and saved more than their neighbours... Its [the state's] impartiality between competitors would consist in endeavouring that they should all start fair, not in hanging a weight on the swift to diminish the distance between them and the slow. (Mill, 1848:811).

While Mill strongly supported the progressive taxation of legacies, in order to promote greater equality of opportunity, he had no interest in equality of outcome, and opposed the progressive taxation of income.

Tables showing marginal tax rates are produced by all three of the models based on hypothetical cases: TAXEXP, CUBS, and the DHSS Tax Benefit Model. In contrast not all of the models based on sample surveys have been designed to show marginal tax rates clearly. The Personal Income Tax model does not show marginal tax rates. The PSI model, the DHSS Policy Simulation Model, and IGOTM are not used to show marginal tax rates. TAXMOD and the IFS model produce output tables which show marginal tax rates very clearly.

The CUBS model and TRAP go further than this by allowing the user to simulate the effect of theories about labour supply. Thus the user could predict that for a given change in tax rates, an individual would change his or her hours of work by a certain amount. It is argued in chapter five, that while such theories are useful, they should be used cautiously. Ideally models should display
indicators of how well such theories have been empirically justified - such as the proportion of the variance of work hours, which has been explained by a given model in a regression.

3.7 Administrative Efficiency
Adam Smith stated that certainty was an essential property of a good tax. "The time, manner, and amount of payment ought to be clear to the contributor... Every tax ought to be levied at the time or in the manner, in which it is most likely to be convenient for the contributor to pay" (Smith, 1776: Vol.V, Sec.2, Para. 5). In the early Roman empire, taxation was collected by private citizens for profit (which was derived by extorting money from the tax-payer over and above the tax due to the state). This element of unpredictability was diminished as taxes came to be collected by salaried civil servants. In modern times there has also been a move away from large lump sum payments towards taxes which are collected regularly in small amounts. Thus property taxes and poll taxes have declined in importance as income and sales taxes have produced increasing proportions of government revenue. General taxes on consumption, which people pay in small amounts as they shop, and income taxes, which are deducted from the wage packet automatically, have become more significant. Though deduction at source arouses little protest from tax-payers at large (and particularly low income tax-payers who are often faced with difficult budgeting problems by lump sum payments), it has been the focus of some political criticism because it makes the tax burden less perceptible and so may distort electoral choices between political parties which favour more or less public spending. "Public authorities should be accountable to their electorates for what they spend and for the revenue they raise. ... electors need to be aware of decisions about expenditure and revenue and the effects of those decisions on the level of ... taxes that
they pay" (DOE, 1981:6).

Adam Smith also stated that taxation ought "to take out of ... the pockets of the people as little as possible over and above what it brings into the public treasury" (Smith, 1776: Vol.V, Sec.2, Para.6). This concept might be termed "administrative efficiency". The efficiency of a tax can be measured in terms of the cost of collecting a tax as a proportion of the total amount of money raised by that tax. For example, the Meade Committee estimated that the administrative cost of income tax was equal to 0.55% of tax collected in the U.S.A. in 1974, and was 1.75% in the U.K. in 1974-75 (IFS, 1978:485).

A similar concept is to be found in the distribution of benefits. The administrative efficiency of various benefits can be assessed by calculating the cost of paying them out as a proportion of the total public spending on the benefit concerned. The Meade Committee produced estimates of the administrative efficiency of several benefits based on the year 1971-72 (IFS, 1978):

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Allowances</td>
<td>3.5%</td>
</tr>
<tr>
<td>Supplementary Benefit</td>
<td>10.8%</td>
</tr>
<tr>
<td>Family Income Supplement</td>
<td>9.0%</td>
</tr>
<tr>
<td>Rent Rebates</td>
<td>5.2%</td>
</tr>
<tr>
<td>Rent Allowances</td>
<td>11.1%</td>
</tr>
<tr>
<td>Rate Rebates</td>
<td>15.4%</td>
</tr>
</tbody>
</table>

In theory administrative efficiency could be demonstrated by computer models, if the information about the costs of administering existing taxes and benefits was included in its knowledge based. This would allow changes in administrative costs to be measured in line with changes in policy. For example, if the rate of Child Benefit was to be doubled without changing the rules of entitlement
or the number of beneficiaries it would be reasonable to assume that the administrative costs would be reduced by half as a proportion of benefits paid. The data could be used to calculate the administrative cost per claimant. Thus if a policy increased the number of claimants the model would predict a proportionate increase in absolute (rather than proportionate) administrative costs. Of course measuring the changes in administrative costs should ideally be more complex than this. In theory they should take into account the economies and diseconomies of scale, for example.

3.8 Horizontal Equity

Horizontal equity is concerned with giving the same treatment to people with similar circumstances. To illustrate this concept take the example of two single people with no dependants and incomes of 6,000 pounds per annum. One of them derives the entire income from working as an employee; the other receives it as interest from investments. The employee will pay 25% in income tax on his or her taxable income, and a further 9% in National Insurance contributions on the entire amount. The person living on investments will pay the same income tax, but will escape the National Insurance contributions. It is true that the person living on investment income is not entitled to National Insurance Benefits but these are not markedly superior to the Income Support benefits which are available to those who have paid no National Insurance Contributions. In some cases National Insurance Benefits are even worth less than equivalent non-contributory benefits. If the person earning 6,000 pounds were to become unemployed he or she would be entitled to an Unemployment Benefit of 32.75 pounds per week (1988 rates). However if the person with the 6,000 pound investment income were to lose his savings he or she would be entitled to 33.40 pounds per week in Income Support (1988 rate for over 25 year olds).
3. PRINCIPLES OF TAX-BENEFIT POLICY

It could thus be argued that this breaks the principle of horizontal equity because people in similar circumstances are being treated differently.

Problems of horizontal equity are also raised by the social welfare system. Just as there are taxes which overlap in their treatment of different forms of income and wealth, there are benefits which overlap and even benefit systems which overlap. The different systems include the benefits paid in cash through the social security system, the benefits paid in the form of allowances of tax-free income before Income Tax is paid, and benefits organised through the work-place such as occupational pensions. In 1958 Richard Titmuss declared:

Considered as a whole, all collective interventions to meet certain needs of the individual... may now be broadly grouped into three categories of welfare: social welfare, fiscal welfare, and occupational welfare. (Titmuss, 1958:42).

In general, the social welfare system covers benefits distributed by the state. The fiscal welfare system refers to tax relief like personal tax allowances and mortgage interest tax relief. The occupational welfare system refers to benefits provided by companies such as occupational pensions and sick pay schemes. The conflicting effects of the different systems can cause major injustices. A single person with no employment may receive 30.65 pounds per week in support through Unemployment Benefit (1985-86). However some one working ten hours per week and earning 15 pounds (who is not a parent or a householder) would not be entitled to any state benefit. Such a part time worker would be outside
3. PRINCIPLES OF TAX-BENEFIT POLICY

the social welfare system, would probably not be in a job with occupational benefits, and would be ignored by the fiscal welfare system because he or she is below the tax threshold. One could thus argue that this is a case of horizontal inequity.

None of the existing models illustrate tax-benefit policies so as to illustrate how far they conform to the principle of horizontal equity. Theoretically it would be possible to do so by comparing people with similar gross incomes and family circumstances, and showing where the tax-benefit system produced significant differences in net income.

3.9 Influencing Behaviour

Taxes and benefits have frequently been used in an attempt to influence people to behave in ways which accord with government policy. Governments sometimes claim that they are using the tax-benefit system to encourage "socially desirable" behaviour. For example, taxes on tobacco have often been justified on the grounds that they discourage smoking. Whether the intended behaviour is, in fact, desirable, is a matter of judgement. The definition of socially desirable behaviour changes from place to place, and over time. In the Soviet Union the tax-benefit system is used to try to increase the birth rate in Siberia and the European republics (Keesings, 1981:33472). In 1935, Hitler introduced a universal child benefit payable in respect of the fifth and subsequent children "in order to encourage an increase in the number of births" (Kaim-Caudle, 1973:272) (probably for military reasons). In Red China, tax benefit policy aims to reduce the birth rate. (Family Allowance is only payable in respect of the first child, and on the birth of the second child the pay of the father is reduced by 15% until the child reaches the age of seven) (Keesings, 1979:32509).
Influencing behaviour was the primary stated consideration in the Thatcher government's choice of a Poll Tax to replace rates. There was a concern to ensure that "a substantial proportion of electors have a direct financial interest in the decisions of their authority" (DOE, 1986:21). The Thatcher government had had several disputes with local councils over their level of spending. Rather than limit local spending by central government diktat, it was argued that if more local government electors suffered adverse consequences due to higher spending then fewer high-spending councils would be elected in the first place. Under the domestic rating system there are roughly 36 million people who are potential electors, while only roughly 20 million pay rates. Under the proposed system nearly all voters would be poll tax payers. Thus the government's Green Paper proposed that 100% of any increased spending by an authority would be financed from the Poll Tax (DOE, 1986:35).

The only way of allowing a policy maker to predict the behavioural responses to a policy, would be to give the user of a model the option to simulate changes in behaviour. Such simulations would have to be based on theories derived from previous research into behavioural responses. TRAP and the CUBS model have used such labour supply theories to predict labour supply responses to policy. Model builders must be careful to avoid giving their programs a bias towards any set of theories. In order to avoid this the user should be required to make an explicit choice to include a given theory in a policy simulation. In the absence of such a choice the model should assume that there are no behavioural responses. As mentioned above, the model should also display information indicating the "goodness of fit" which the original theory achieved.
3. PRINCIPLES OF TAX-BENEFIT POLICY

3.10 Conclusion
These principles of tax-benefit policy may often be in conflict with each other. The desire to promote equality may have adverse consequences for work incentives and the protection of property rights. The prevention of poverty may conflict with a government's desire to link taxation and voting, as in the case of the current debate over the poll tax. A tax which is equitable may not be administratively efficient. Tax-benefit policy-makers have to balance different ideologies and administrative requirements.

There are doubtless other policy objectives which could be promoted by tax-benefit policy which have not been discussed in this chapter. An advocate of pure capitalism might argue that fiscal policy should do as little as possible to distort the operation of the market. An environmentalist might argue that tax-benefit policy should discourage pollution and the consumption of finite resources. A socialist might urge that fiscal policy should favour workers' co-operatives and publicly owned industries. It is not necessary to favour any one of these views. It is necessary to give enough latitude in the design of a tax-benefit model so that the user can simulate a wide range of policies, and assess their effects in the most flexible way possible. To impose a narrow range of output tables unavoidably imposes a set of ideological assumptions on the potential user. Therefore a special model has been developed for this thesis, the Policy Option Model, which does not limit the user to a narrow set of output tables.
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

4.1 Introduction
In the previous chapter, tax benefit policy was discussed in terms of abstract principles. However it should be stressed that tax-benefit policies are never carried out in an atmosphere of rarefied altruism. Practical considerations and baser motives play their part. In public, politicians will justify a tax-benefit reform in terms of moral principles. In private, the appeasement of political factions are often more important. This dichotomy of public and private motives has given rise to the aphorism "Laws are like sausages. Your confidence in them is not enhanced by an intimate knowledge of how they are made" (Origin Unknown).

It is a safe bet that whenever a politician proposes a radical change to the tax-benefit system there will be influential pressure groups opposed to it. Like the vipers which gathered around the crib of the infant Hercules, a brood of vested interests spring up, intent on strangling the idea at birth.

Any major reform is likely to cause a redistribution of resources between different income groups. The political party and pressure groups representing the losers in this redistribution can be expected to oppose it. Britain's highly partisan press often takes a hostile position. More subtly civil servants opposed to radical change per se, may try to undermine the policy by masterly inactivity (Hurd, 1979). There should be little wonder that tax-benefit reforms have such a high infant mortality rate!

The tax-benefit model-builder should not be totally innocent of the more pragmatic considerations of policy. The model should be able to show the gainers and losers from a policy clearly - and according to a number of different criteria. For example, in considering whether
to abolish Mortgage Tax Relief it would be useful to see the average gains and losses not only by income groups but also by tenure groups. Four case studies of tax-benefit policy are given below. They have been chosen because they give a detailed picture of the ideological and pragmatic influences which led to certain major changes in the tax-benefit system. In nearly every case, the policy started as a relatively simple idea which gradually became more complicated and had serious repercussions for other policies. Thus the implementation of sickness and unemployment benefits caused National Insurance contributions to be introduced, and the 1979 tax cuts caused a sharp increase in VAT. It is instructive to note the relative contributions that principles and politics made in each case. Tax-benefit models clearly need to be designed with both factors in mind.

In each case there is a discussion of contribution a tax-benefit model could have made. In the case of the 1911 reforms and the Beveridge Plan, these discussions are somewhat fanciful because the relevant computer technology did not exist (if one discounts the early main frame computers which existed in the 1940s). However the possible contribution which computers could have made is still useful in assessing the features which should ideally be built into a future tax-benefit model.

4.2 The 1911 National Insurance Act
In 1911 there was great public awareness of the extent of poverty in Britain. Evidence like Rowntree's (1902) study of poverty in York and the Report of the Royal Commission on the Poor Laws (1909) had pricked the national conscience. A change in benefit policy was because of the inadequacy of the Poor Law, which was so despised by the working classes that many preferred to go without any help whatsoever than resort to it.
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

Applicants for Poor Law relief were often forced to live in work-houses where residents had to conform to a daily routine similar to that of a penal institution. Indeed, the work-houses were sometimes called "Poor Law Bastilles". Even when people were paid in cash and were not compelled to live in the work-house, the payments were "practically never adequate to the requirements of healthy subsistence" (Webb, 1909: 38). This concern was felt, not only by humanitarians who cared for the wellbeing of the individual, but also by nationalists who felt that Britain's industrial and military supremacy depended on a healthy and growing population. Lloyd George played on these sentiments in advocating social insurance when he said - "when a man is below par neither the quantity nor the quality of his work is very good" (Grigg, 1978: 328).

There were also more subtle motives for social reform. In the Edwardian era the Labour Party was beginning to flex its electoral muscles, and to pose a threat to the Liberals. Some Liberal politicians supported the adoption of social insurance as a deliberate device to halt the advance of socialism, and to meet working class demands through reform rather than revolution (Gilbert, 1966:247). Very similar motives had led to the setting up of the first system of social insurance in Germany in 1889, by Otto von Bismarck (whose other achievements show little of the altruism embodied by his scheme of social insurance) (MacManners, 1977:336).

However, the main protagonist for social insurance, Lloyd George, was a genuine radical - having offended the Establishment through his "People's Budget" and earlier by his opposition to the Boer War. The 1908 Old Age Pensions Act had provided small pensions for those over the age of 70, but there was still no adequate provision for people who suffered a loss of earnings due to
sickness or unemployment (other than relief through the hated Poor Law). The challenge of social insurance was to tackle these problems without offending the basic values of the age. These values included a belief in the Victorian ideal of self-help, and a deep distrust of hand-outs which might make people dependent on the state.

The simplest way would have been to have provided a national system of cash benefits, financed out of general taxation. The old age pensions introduced three years before had been based on this approach. Pensions funded by the national Treasury had also been introduced in Denmark (1892), New Zealand (1898), and Australia (1900) (Kaim-Caudle, 1972). To have financed the benefits by increasing the rates of direct taxation would have been a radically egalitarian measure. Most of the beneficiaries of sickness and unemployment benefits would have been people with below average incomes (and thus under the income tax threshold), while the people financing the scheme would have had incomes above the average. Sidney and Beatrice Webb argued strongly that the relief of poverty should be financed out of general taxation.

However this conflicted with the concept of self-help, and the Poor Law had given direct public assistance an extremely bad name. Ramsay MacDonald opposed the Webbs' position, saying that a system financed out of general taxation would be state charity "of the most vicious kind" (Grigg, 1978: 331). (His use of the word "vicious" is illustrative of working class hatred for any reform proposal which resembled an extension of the Poor Law). Moreover the introduction of state pensions in 1908 had given Lloyd George first hand experience of the problems of non-contributory benefits. "The need to refuse desirable improvements in the pensions bill, due to the financial constraint, convinced him that more effective future legislation would need the other sources of
finance available to a national insurance scheme" (Thane, 1978:104).

Lloyd George circumvented the objections to "state charity" by proposing to finance his scheme, partly through a system of compulsory insurance contributions to be paid by the working classes themselves. Direct taxation of people with incomes below the average was unknown in 1911, so these contributions were a major departure from existing fiscal policy. A further justification for these contributions was the logic of levying a separate charge specifically on those categories of people who were entitled to receive the benefits. Part I of the Act provided coverage for sickness benefit and access to a doctor for 15 million people, while part II of the Act provided Unemployment Benefit for people in industries prone to cyclical unemployment. However from the outset there were major departures from the insurance principle. The benefits were not to be financed fully by contributions from the beneficiaries. Each working man was to pay 4d, his employer was to pay 3d, and the state was to pay 2d—Lloyd George's famous "Ninepence for Fourpence" formula. The insurance basis of the scheme should be seen more as a political accommodation of the ideal of self-help rather than as enthusiasm for strict insurance principles.

The extent to which the scheme was to be a truly national system of insurance was further undermined by considerations of practical politics. The National Insurance scheme posed a serious threat to the voluntary Friendly Societies, which provided similar benefits, and, more importantly, to the Industrial Insurance companies. The Industrial Insurance companies formed a pressure group of enormous power—opposing Lloyd George's original scheme. The twelve main companies sold nearly
ten million policies per annum, for a sum roughly equal to half the national budget (Grigg, 1978). Not only did the Friendly Societies and Insurance Companies have massive vested interests at stake but they also had roughly 70,000 collectors who made weekly visits to nearly every working class home in the country. It was assumed that any scheme which threatened the collectors' employment would raise up an army of canvassers opposed to the Liberal Party.

The pressure applied by the Insurance Companies had several important effects. The provision of a death benefit was immediately ruled out as this was one of the Insurance Companies' main products. Lloyd George also considered providing orphans' and widows' benefits through National Insurance, but these too were abandoned due to the opposition of the insurance companies. Lloyd George was also forced to allow the Friendly Societies and Insurance Companies to administer the scheme provided they fulfilled basic conditions and thus became "Approved Societies". People who refused to join one of these societies were required to pay their contributions through a local post office. In 1943, the Beveridge Report sharply criticised the role of these Approved Societies because it led to variations in the quality of administration and even in some cases in rates of benefit (Beveridge, 1943).

In comparison with the opposition of the Insurance Companies, the resistance of the Tory Party was virtually negligible. At the first reading of the bill, the scheme was complimented by MPs from all parties. Throughout the debate, the Conservatives confined themselves to attacks on the details of the scheme rather than the concept of National Insurance itself. They would probably have liked to prevent the Liberal Party from gaining any kudos from the introduction of social insurance, but they did
not want to suffer the unpopularity of defeating the measure themselves. For the Labour Party, Ramsay MacDonald expressed doubts about the details of the scheme, such as the regressive nature of the contributions "Fourpence a week, taken from a man's income of 15/- is a very substantial part of that income" (Hansard, 6-12-1911). However, he stated his intention to vote for the scheme as a base upon which to build for the future.

How did the scheme measure up to the broad principles of tax-benefit policy? The measure certainly did little to equalise the distribution of income. The male contribution rate of 4d was clearly regressive. The only people exempt were those with incomes of 2 shillings or less. Most of the employers' contribution could be expected to be passed on to the consumer in increased prices. Only the two ninths of the contributions paid by the state could be expected to come from taxation of a proportionate or progressive kind. The flat rate contributions could hardly have had any adverse effect on incentives, except for the tiny number of people who faced an increase in tax by moving above the two shilling barrier.

The scheme did not provide horizontal equity in its treatment of the sexes. Men were entitled to a Sickness Benefit of 10/-, while women were to be paid 7/6, although they were only required to pay a proportionately lower contribution (3d rather than 4d). This discrimination was based on the view that women were less often the sole breadwinner within the household.

Though the scheme may have done little to advance the egalitarian principle, it did accord with the concept of preventing poverty. The scheme was primarily intended to make up for lost income, rather than to cure disease
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

(though it gave the insured population access to general practitioners and tuberculosis clinics). It provided Sickness Benefits, and Maternity Allowances. It maintained the incomes of people facing short-term problems, and did not provide universal benefits which might have resulted in a more general redistribution to low income groups. Winston Churchill introduced the Unemployment Insurance part of the Act. This only affected 2.5 million workers, in industries where employment rates fluctuated regularly with the trade cycle. Because the scheme dealt with cyclical rather than long term unemployment it was genuinely expected that the contributions paid during years of high employment would build up a fund big enough to finance Unemployment Benefits in years of recession. The Act did not prevent poverty as effectively as a system of universal benefits would have done, but it did provide a means of providing help which was free of the stigma of the hated Poor Law. Though Churchill became interested in social welfare because of the example of Germany's national insurance scheme, the unemployment insurance system he created had no parallel in Germany or in any other country. Walley (1972:33) pointed out that Churchill pioneered "state unemployment insurance on the world stage".

The full impact of political considerations can be gauged from the fact that Lloyd George himself had no personal attachment to the insurance principle. Shortly after the introduction of the scheme Lloyd George wrote:-

Insurance [is] necessarily a temporary expedient. At no distant date [sic] hope state will acknowledge full responsibility in matter of making provision for sickness, breakdown, and unemployment. It really does so now through the Poor Law, but conditions
Thus Lloyd George's ideal scheme, would have been based on a far simpler concept of nationally administered benefits, financed through general taxation. Instead, Britain ended up with a privately administered system, financed by a complex system of separate contributions which still exists in a modified form today.

Thus it is clear that the political process had a marked effect on the development of the National Insurance scheme. The abandonment of orphans, widows, and death benefits, was a major concession to vested interests. The administration of the scheme through the Approved Societies, can only be regarded as a direct bribe to a vested interest to circumvent opposition - similar to Aneurin Bevan's stuffing the medical profession's mouth with gold to bring in the National Health Service (Foot, 1973). The Beveridge Report (1943: Appendix E) pointed out the wasteful nature of private insurance for work injury benefits - "the employers have had to pay 100 pounds for every 48 pounds paid in benefits".

Lloyd George should not be blamed for making these concessions; if he had not made them National Insurance would probably have stayed on the drawing board. However, the 1911 National Insurance Act should give salutory warnings about the political process.

How might a computer model of tax-benefit policy (had one existed at that time) have helped to shape the 1911 National Insurance Act? Hopefully an optimum tax-benefit model would have indicated the high administrative costs inherent in distributing benefits through a number of
separate approved societies. An analysis by one of the models based on sample surveys would probably have shown that a scheme funded from general taxation would have had a more equalising effect on the income distribution, than the contributory scheme actually adopted (because the employee contributions were flat rate and thus regressive).

The Beveridge Plan
William Beveridge once declared "the object of government, in peace or war, is not the glory of rulers or races, but the happiness of the common man" (Green, 1982). With this sentiment in mind Beveridge set about the task of chairing a committee during the second world war to try to co-ordinate the various organs of government which dealt with welfare and social insurance. He operated in a climate of public opinion which was favourable to schemes of social reform. The war had led to greater social mixing between social classes, making poverty perceptible to people who had been oblivious to it before. Just as Lloyd George had declared at the end of the First World War that the state should build "homes fit for heroes", there was a feeling that post-war Britain should offer new hope rather than a return to the depression of the 1930s.

When Beveridge was asked to chair a committee on "Social Insurance and Allied Services", its terms of reference were narrow. It was expected that the committee would focus on such technical matters as the relative values of sickness and unemployment benefit, and the details of the workman’s compensation scheme (Peden, 1985: 137). Beveridge acted as though he had a far wider remit and set out to tackle several major problems. The Poor Law with its Dickensian work-houses, was increasingly anachronistic. During the 1930s many working class people had been forced to claim assistance from the Poor
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

Law, when their entitlement to National Insurance benefits ran out, and had detested submitting themselves to the indignities of the means test. Family Allowances had been introduced in Germany and France in the interwar years, and there was a growing demand for them in Britain. The administration of benefit by the Approved Societies had come under attack, and there were calls for the system to be run directly by the state.

The Beveridge Report embraced a number of important concepts which are still reflected in Britain's tax-benefit system today. The most crucial decision was to maintain the contributory principle. The evidence the Committee received showed that there was widespread support for contributory benefits among the working population - particularly because of recent experiences of Poor Law means testing. Beveridge was adamant that a significant part of the funds should be "met from monies contributed by citizens as insured persons" (Beveridge, 1943:273). However the logic of insurance depended on maintaining a real distinction between the treatment of the insured and the uninsured - "assistance must be felt to be something less desirable than insurance benefit; otherwise the insured persons get nothing for their contributions" (Walley, 1972: 74). But a major feature of the Beveridge Report was the abolition of the Poor Law. It proposed that the work-houses and the local authority administered benefits should all be swept away and replaced by a system of national assistance run by a central government department. Moreover the Report recommended that National Insurance benefits should be run by a central government department as well, which would thus replace the function of the approved societies. As both National Assistance and National Insurance were to be run by central government departments the only method of maintaining a meaningful distinction between them would be to set the rates of
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Insurance Benefits at a substantially higher level than National Assistance benefits. However from the outset, there was almost no distinction between the two. When both systems were set up under the Attlee government the weekly benefit for a single unemployed person was 26/- under National Insurance and 24/- under National Assistance. The rates as of November 1985 were 30.45 pounds for unemployment benefit and 29.50 pounds for Supplementary Benefit (the successor to National Assistance). Walley (1972) has pointed out that Beveridge never expressed a logical procedure for setting the rates of National Assistance and National Insurance benefits differently. The concept of subsistence incomes was to guide the setting of both types of benefit. The token differentiation in benefit rates which this has caused raises the question of whether it makes sense to maintain the two separate benefit systems.

Beveridge also believed that "the state in organising security should not stifle incentive, opportunity, responsibility" (Beveridge, 1943:9). From Beveridge's point of view it was important to avoid benefits or contributions which left people little better off if they earned an extra pound of income. Thus National Insurance was organised "on the basis of each individual paying the same contribution for the same rate of benefit" (Beveridge, 1943:273). The flat rate contribution system meant that there was no extra percentage to add to the individual's marginal tax rate (as there is with the current National Insurance system which adds between 5% and 9% to the individual's rate). More importantly, flat rate benefits avoid the need for benefits which taper away as income rises which further add to the disincentive effect of taxation. Beveridge's original scheme would have drastically reduced the reliance on means-tested benefits because it proposed the abolition of the time limit for the receipt of National Insurance.
benefits:— "All the principal cash payments — for
unemployment, disability, and retirement will continue so
long as the need lasts" (Beveridge, 1943:20). Under the
pre-Beveridge system National Insurance benefits were
only payable for 26 weeks; after which the individual had
to resort to the Poor Law.

What effect did the political process have on the
Beveridge Plan? The impact of the Beveridge Report was
certainly a surprise to the Coalition government.
Beveridge, had been frustrated in his attempts to secure
a worthwhile ministerial post. Many of his parliamentary
colleagues considered him to be egotistical and difficult
to work with — particularly because of his overt
criticisms of the government. Offering him the
chairmanship of the social insurance committee probably
had as much to do with getting him out of the way, as it
did with finding an appropriate use for his talents.
When the Report was published Beveridge worked vigorously
to publicise it. Beveridge seemed to give the impression
to some of his colleagues that the war should stop while
his plan was put into effect. He further annoyed Clement
Attlee, the next Prime Minister, and Hugh Dalton, the
future Chancellor of the Exchequer, who had both worked
under him before the war "by treating them as though they
were both junior lecturers and he still the Director of
the LSE" (Burridge, 1985: 150). When the Beveridge
report was discussed in Cabinet the Labour Ministers in
the Coalition government expressed support for its basic
aims but did not insist that it should be introduced
while the war was actually in progress. Attlee had to
weather a backbench revolt over this stance. Labour
backbenchers attacked the failure to implement the Report
and called a debate on it. All but two of the Labour MPs
not in the government voted against the government's
decision not to act on the Report. This spurred the
government to accept the plan in principle (Peden, 1985).
The Conservative position was ambivalent. A majority of conservatives opposed the report initially, though Churchill's own attitude was sympathetic. When it was discussed in Cabinet Churchill was absent due to illness, which gave greater weight to critics of National Insurance like the Tory Chancellor Kingsley Wood. (By a great coincidence Kingsley Wood had been the chief lobbyist against the 1911 National Insurance Act, when he had been employed by the Industrial Insurance Combine). This initial failure to support the Beveridge Plan proved costly during the 1945 election. In 1943, Churchill made a famous broadcast in which he tried to associate the government more closely with it. He said in 1943 that he and his colleagues were "strong partisans of national compulsory insurance for all classes for all purposes from the cradle to the grave" (Burridge, 1985:149). By 1945, there was strong bipartisan support for the Beveridge Plan. Legislation for the introduction of Family Allowances was already under way when the coalition broke up. In 1946 the National Insurance Act was passed. It was a striking feature of public opinion in the 1940s that welfare reform was justified, not only in humanitarian terms, but also in the language of patriotism and economics. (The same had been true in the years up to 1914). Attlee expressed this mood while speaking in a parliamentary debate on the National Insurance Bill:

This and the National Health Service will stop the deterioration of the human capital of this country. So it is a true economy and addition to the national wealth in the long term. Experience has shown that unmerited misfortune is not a spur to effort. (Hansard, 2-7-1946)

This could not be more different from the intellectual
climate of the 1970s when many influential commentators attacked welfare as a barrier to economic growth (Tyrrell, 1977). This post-war acceptance of welfare did much to explain the relatively easy passage of the Attlee government's welfare reforms. Even the 1947 National Assistance Act, which was designed to help the uninsured, was passed "with all-party concurrence, if not enthusiasm" (Foot, 1973: 103). As with the 1911 National Insurance Act, the debate focused on the details rather than on the basic principles of the Beveridge Plan.

One significant aspect of the Beveridge Plan was not implemented. In the debate on the National Insurance Act R.A. Butler had argued:-

This is really an impossible position. The government take the line that it is possible to ... extend the period of ... benefit ... which will pose an unknown cost on the Exchequer. (Hansard, 2-11-1946).

These financial arguments won the day and the time limit was retained. This had a crucial effect on the future development of the post-Beveridge welfare state. Because the entitlement to National Insurance was only temporary, this meant that there would be greater reliance on National Assistance. Beveridge had predicted that National Assistance would become a smaller and smaller scheme as the years progressed. The opposite has occurred. Non-contributory benefits now support far more people under the retirement age, than do contributory benefits.

How consistent were the Beveridge reforms in terms of the principles of tax-benefit policy stated above? The National Insurance Act was merely an extension of the system which had been created in 1911. The provision of
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

more generous benefits might have redistributed more resources to low income groups. However this was balanced by the levying of regressive flat rate contributions. Public assistance was no longer to be a burden on the rates, a regressive local tax, and was henceforward to be funded by central taxation which was far more progressive. In that the benefits provided by the post-Beveridge welfare state were generous enough to meet subsistence needs, the reforms did much to prevent poverty. The principle of flat rate contributions meant that the Beveridge Plan did little to reduce incentives.

The payment of the contributions was not generally a cause for complaint - national insurance contributions were generally deducted from pay by the employer so the individual had little awareness of the tax. The administrative efficiency of the scheme depends on one's assessment of the desirability of maintaining separate benefit systems for the insured and uninsured population. By this time Australia and New Zealand had both developed welfare systems funded by general taxation, dispensing with the need for separate taxes and benefits for the insured and the uninsured. However Britain had the legacy of the 1911 Act and the Poor Law to contend with, so it is hardly surprising that Beveridge chose to adhere to the insurance principle. The insurance concept has awkward implications for horizontal equity. The insurance contributions are levied only on earned incomes - which effectively means that those with unearned incomes face a lower rate of tax (particularly since the abolition of investment income surcharge). However, because non-contributory benefit rates are so similar to National Insurance Benefits, workers have little to show for the extra taxes they have to pay.

Thane (1982: 254) has commented that greatest advantages of Beveridge's work was the "rationalisation of social
insurance and its universalisation, to the real advantage ... of women and those of the lower middle classes who had previously been excluded from most social insurance benefits."

What light does the Beveridge plan show on the process of making tax-benefit policy? Abstract principles of tax-benefit policy only seem to have played a small part. The impact of the welfare arrangements already in place was very significant, as it had been in 1911. The opprobrium surrounding the Poor Law and the Unemployment Assistance Board meant that a unified welfare scheme funded out of general taxation was not politically practicable. Lloyd George's 'temporary expedient' of National Insurance contributions had become an entrenched part of the system.

Speculating on the possible impact of computer models on the Beveridge Plan, must be done with the unfair benefit of hindsight. However, careful mathematical modelling at the time would certainly have had a beneficial effect on the determination of benefit rates. Attempting to fix the value of National Insurance and National Assistance benefits might have highlighted the inconsistency of keeping these schemes separate. Though when the two schemes were set up there was a small differentiation in the rates of benefit (in favour of National Insurance), the distinction between the two sets of benefits is far from clear now. Currently the rate of National Insurance pension is 41.15 pounds (1988 rate). However if the individual above the retirement age has paid no contributions and applies for Income Support (the current version of National Assistance) he or she will be entitled to 44.05 pounds per week. So much for Beveridge's plan that National Insurance benefits should be worth more so that contributors should get something for their contributions. It is not surprising that this
confusion should have arisen over benefit rates, given that the principles on which the rates of benefit were to be determined were so vague. It is to be hoped that mathematical modelling would also have highlighted the fact that income related benefits paid in respect of children would have produced a more equal distribution of income than flat rate family allowances.

4.4 Child Benefit
Between 1945 and 1977 the state had two primary methods of supporting the incomes of people with children. There were child tax allowances which gave a relief against Income Tax for each child, and there were Family Allowances which were a cash payment for the second and subsequent children in a family. There were also child dependency additions for state benefits, but these were not applicable unless one was receiving certain benefits. During the 1970s there were increasing calls for the amalgamation of Family Allowances and Child Tax Allowances. For varying reasons this concept was supported by feminists, conservatives, the poverty lobby, and those favouring simplicity in the tax-benefit system.

This idea came to be known as the Child Benefit scheme and it represented a major simplification of the tax-benefit system. This was prompted partly by the Heath government’s attempts to bring in a tax credit system, which proposed a child tax credit. This would have been similar to a universal benefit (Sandford, Pond, & Walker, 1980). The Labour Party fought the 1974 General Elections supporting the concept of Child Benefit (which then was referred to as the Family Endowment Scheme). Thus both the Labour and Conservative parties fought the 1974 elections with a pledge to introduce a universal payment in respect of children. Moreover there was a recognition of the fact that the level of Family Allowances had declined in recent years (Brown, 1984). In 1948 the
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Family Allowance payable in respect of two children was equal to 3.6% of average male manual earnings; by 1974 this had declined to 1.8% (Field & Townsend, 1975). The proposed Benefit was to be paid in respect of all children in the family unlike Family Allowance which did not take the first child into account.

Some supported the scheme because it represented an advance for the rights of women because Child Benefit was to be paid direct to the mother, whereas the Child Tax Allowance increased the take home pay of the father (and there was thus no guarantee that it increased what the caring parent could spend on the child).

Bodies like the Child Poverty Action Group favoured it because it could be guaranteed to bring relief to families who are entitled to means-tested benefits but do not claim them. Whereas Family Allowance (and currently Child Benefit) are claimed by nearly 100% of those entitled to them, means-tested benefits like Family Income Supplement are only claimed by roughly half of those with an entitlement (Atkinson & Sutherland, 1985). Though Child Tax Allowances automatically benefitted those above the tax threshold they did nothing for people below it - the working poor who often fell into a gap between the social and fiscal welfare systems.

It was Child Benefit's effectiveness in reaching lower paid workers which caused some conservatives to support it. They were concerned about the "why work" problem (which sprung from the fact that some unemployed people could be worse off in a low paid job than if they stayed on benefit). The child additions for Supplementary and Unemployment Benefits were much more generous than Family Allowances and therefore someone moving from unemployment to a low-paid job would suffer a cut in income which would increase with the number of children in the family.
By providing a substantial payment for each child, which would not be taken away if the individual found work, it was hoped that unemployed men would be able to accept a low paid job without suffering a cut in income.

The major objection to the scheme was on the grounds of cost. Barbara Castle fought for the introduction of Child Benefit as Secretary of State for Health and Social Security during the second Wilson Government. Her diaries give an interesting insight into the kind of battle waged between the Treasury and a spending minister wishing to change the benefit system. She writes how Denis Healey attempted to defer the introduction of child benefit on the grounds of cost. In turn she pointed out "that the commitment to a child endowment scheme was in the Manifesto, which he had helped draw up. ...If he now wanted to repudiate the commitment he had better tell Cabinet. He climbed down somewhat at that..." (Castle, 1980:140).

It is interesting to note that a Manifesto commitment is actually cited in this way to argue for a policy. Though the manifesto could be used to support the basic principle of child benefit, it could not be used to further the case for setting the benefit at a particular rate. In arguing over the rate for the proposed benefit, Ministers were influenced by the need to prevent any families (particularly those on low incomes) from being worse off. When the Treasury and DHSS argued over the initial rate of child benefit, the argument was influenced by mathematical modelling of the effects of the proposed change. It was fortunate for the Child Benefit proponents that both the DHSS and the Treasury both had the resources to do the modelling. If the Treasury alone had had the relevant facts it would probably have won the argument over the rate of Child Benefit. Barbara Castle proposed a rate of 2.85 pounds
per child which would have prevented any low income families from losing under the scheme while preserving the concept of a simple unified benefit (Castle, 1980). Joel Barnett for the Treasury proposed a rate of 2.40 pounds plus a premium of 22 pence per week for one parent and large families to ensure that they did not actually lose (Castle, 1980). To have paid out the tiny premium of only 22 pence would have flown in the face of the concept of administrative efficiency. The administrative costs as a proportion of benefits paid would have been very high.

The economic climate of the mid 1970s made it a bad time to introduce expensive reforms to the benefit system. When Cabinet debated the introduction of child benefit a majority of the ministers who spoke were in favour of deferring the scheme, but Harold Wilson kept the idea alive by referring it to a committee separate from the Cabinet. In addition to the arguments about cost, the child benefit advocates had to counter worries about the effect of transferring resources from fathers to mothers. During the late 1970s the Wilson and Callaghan governments made strenuous efforts to secure the cooperation of the trade unions in keeping wage demands down. There was understandable anxiety when it was realised that child benefit would reduce the money in fathers' pay packets and that they might try to compensate by asking for higher pay rises. "... it had not been appreciated that our child benefit policy meant a reduction in the father's net take-home pay, to the extent of the reduction in child tax allowances. Neither Jim Callaghan, the Prime Minister, nor Denis Healey, had fully taken this point on board. When they did, they became nervous" (Barnett, 1982:54). The fear of upsetting the government's incomes policy caused the introduction of child benefit to be delayed until 1977. Even then it was phased in over three years. It was not
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fully in place until June 1979 when it was paid at a rate of 4.00 pounds per child.

Child Benefit represented the first (and only) attempt in Britain to replace a tax allowance by a universal cash benefit. It thus represents an interesting case study in the application of tax-benefit principles. Did Child Benefit accord with the egalitarian principle? Universal benefits conflict with the goal of achieving a more equal distribution of income. To equalise incomes it would be necessary to supply benefits only to those with incomes below the average, whereas child benefit is supplied to all. However the picture is confused because the Child Tax Allowance which was replaced was, in effect, a regressive benefit. It was worth more to people the higher their income. For example the tax allowance for a dependent child age 16 was 6.02 pounds per week in July 1977. This was deducted from taxable income, before calculating how much tax the individual was liable to pay. Thus, it was worth 1.98 pounds per week to someone on the then 33 per cent standard rate of tax. It was worth 4.99 pounds to someone on the top rate of 83%. Moreover it was worth nothing to someone whose income was below the tax threshold. By replacing these inegalitarian aspects of the fiscal welfare system, child benefit helped to make the system more equal even though it did not appear to discriminate in favour of those on low incomes.

On the debit side, however, it has been pointed out that the rate of Child Benefit was not set in relation to any objective research into the spending needs of children. The primary influences on the rate of benefit were the need to ensure that families on the standard rate of tax would not be worse off because of the abolition of Family and Child Tax Allowances and the need to control public spending. According to Brown "the unsatisfactory base for
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The universal nature of Child Benefit meant that it was more comprehensive in its impact on poverty than a means-tested benefit would have been. The principal means-tested benefit for working families, Family Income Supplement (now replaced by Family Credit), having a take-up rate of only 50% (Atkinson & Sutherland, 1985), shows the typical problem associated with selective benefits. While they may be more efficient in theory, because they concentrate more resources on the poor, they are often less effective in practice, because fewer people claim them and administration costs are higher as a proportion of benefits disbursed. In general, people do not feel they have to sacrifice any dignity to claim Child Benefit because the claiming procedure is in effect an automatic part of the registration of births. Benefits which are only for "the poor" and require the claimant to submit to complex administrative procedures and means tests do cause people frustration and embarrassment. It is the same kind of distinction, though in a much milder form, which people used to make between the Poor Law and National Insurance Benefits. The universal nature of child benefit also gives it the advantage that the administration costs are a very small proportion of total expenditure. Prior to the introduction of child benefit, the administration costs of family allowance were only 3.5% of benefit expenditure, while they were 9% for Family Income Supplement (IFS, 1978:305). As the methods of claiming and paying out child benefit are identical to those for family allowance, it is probable that its administration costs are also close to 3.5%.

Child Benefit helped to increase the attractiveness of low paid work, to people on benefit. Because it did not
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involve a system of withdrawing the value of benefit in proportion to the claimant's income, it cannot be said to have damaged incentives in the same way as selective benefits would have done.

Child benefit was a useful simplification of the tax-benefit system, which was of particular help to families with heads in lower paid work (who would otherwise have faced a sharp loss of income compared to families with an unemployed head on Supplementary benefit). It is significant that Child Benefit was implemented, despite the expected opposition of male wage-earners (Brown, 1984:64) and Treasury officials intent on reducing public expenditure. It illustrates the necessity for a radical reform to be simple and fully worked out if it is to succeed during the lifetime of a four or five year parliament. The Heath government's tax credit scheme had not been worked out in detail in opposition so could not be implemented before Heath fell from power.

In this episode it is obvious from the accounts of the struggle to implement child benefit that computer modelling had begun to play a significant role in policy discussions. Different government departments had clearly used mathematical modelling to put forward alternative polices (the DHSS proposing its 2.85 flat rate benefit, and the Treasury advocating 2.40 pounds with its 22 pence supplement).

Clearly predictions of the reductions of father's take home pay had also had an impact. This shows the importance of the unit of analysis in tax-benefit policy. If a tax-benefit model can only demonstrate the effect of policies on entire tax units the model would be unable to demonstrate this kind of effect because transfers within tax units would be invisible in the resulting tables. It is thus important to be able to simulate
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policy effects at the individual level as well as at the household and tax unit level. A similar issue is raised in simulating the effects of the Thatcher government's community charge. This is to be levied on all adults in place of rates which are levied on heads of household. Thus there will be large increases in the local tax burden for those who are not heads of household. The government's Green Paper Paying for Local Government published numerous tables to show the distributional consequences of the community charge (DOE, 1986). Because these tables were based on the IFS model which does not allow the data to be analysed at the individual level, not one of these tables indicated in full the income losses which would be suffered by people who are not heads of household.

4.5 The 1979 Tax Changes
June 1979 saw a radical change in Britain's taxation policy. The rates of income tax were dramatically reduced. At the same time the principal indirect tax, VAT, was nearly doubled. Such radical departures from the status quo are rare in tax-benefit policy. What principles and pressures caused it?

Enormous pressures to cut income tax rates built up in the months leading up to the 1979 budget. Mrs Thatcher made income tax cuts the centrepiece of her election campaign. She said "To make it worthwhile to get on in this country again, we have to cut taxes - the taxes on earnings, the taxes on savings, the tax on talent" (Daily Telegraph, 3-4-1979). Mrs Thatcher was particularly concerned about the disincetive effects of the very highest rates of income tax (83% on earned income, and 98% on investment income). She even accepted the argument of the American economist Arthur Laffer that a cut in the rate of Income Tax would increase the revenue it raised. In 1979 Mrs Thatcher said that tax cuts could sometimes
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be self-financing because they would cause people to work harder which would thus produce a larger tax base (Stephenson, 1980:49).

In order to make it acceptable to reduce tax rates on the richest tax-payers, the Conservatives thought it necessary to offer some reductions in the lower rates of tax. Thus Mrs Thatcher committed herself to reductions for all income tax payers (though without stating by how much). The Labour Party was aware of the popular appeal of this move and James Callaghan made an election promise to reduce the standard rate of income tax by three per cent. Even the Liberal Party entered into the Dutch auction with similar promises, including a reduction of the top rate to 50%.

Though Mrs Thatcher had studiously avoided committing herself to any specific figure for cutting the standard rate of income tax, the Labour Party's offer of a 3 per cent cut must have limited her room for manoeuvre. Furthermore a cut of less than 3 per cent would not have seemed like a credible quid pro quo for reducing the top rate from 83% to 60%. These cuts in Income Tax were only to be expected given the statements which had been made during the preceding election campaign. What took commentators by surprise was the increase in the rate of Value Added Tax (VAT). Prior to 1979 VAT was charged at a standard rate of 8% and a 12.5% rate for luxury goods. The 1979 budget brought in a unified rate of 15%.

The government would have preferred to have avoided such a dramatic rise, but they were effectively painted into a corner by their own election promises. The combined cost of the proposed tax cuts was £4.5 billion. To make matters worse Mrs Thatcher had promised to implement the findings of the Clegg commission on public sector pay, which led to a major increase in the public sector wage
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bill within a year. One option would have been increased public borrowing, but the new administration had made the control of public borrowing and the money supply the cornerstone of their counter-inflation policy. The new government was in favour of public spending cuts, but during the election campaign Mrs Thatcher had stated that these cuts would not affect large areas of the public sector such as pensions and the national health service. In June 1979 the government planned to cut public spending by 3%, but this was not enough to compensate for the tax cuts and the Clegg awards. A further problem was caused by the administrative complexities of VAT and income tax. The income tax year starts in April, and because the election delayed Mrs Thatcher's first budget until July, any income tax cuts had to be back-dated to April. However, VAT increases could not be back-dated. Shop-keepers and other businessmen would only start charging the higher rate of VAT from the time when the Chancellor made the announcement. Thus a full year of income tax cuts had to be funded by nine months of increased VAT.

Sir Geoffrey Howe thus had to go to Mrs Thatcher after the election and explain that if the election promises were to be kept then VAT would have to rise to 15%. Mrs Thatcher "wanted 3p off standard income tax to please the average voter; but she did not want a 15 per cent VAT rate. Sir Geoffrey was despatched back to the Treasury" (Keegan, 1984). Back at the Treasury, Sir Geoffrey consulted John Biffen. John Biffen's motivations were unusual and may have made him one of the few people in the whole of Britain who had a positive reason to favour a 15 per cent VAT rate. He supported an increase in VAT on the grounds that it would be an added inducement for people to save, rather than consume, their income. Moreover Biffen was the Treasury minister in charge of spending cuts. His colleagues found that he was
unenthusiastic about this work, and would have found it
difficult to deliver more than the 3 per cent cuts which
had been budgeted for. He must have known that if the 15
per cent VAT rate was not implemented, he would have been
asked to make even greater cuts. As Peden observed
(1985: 226) "The Conservatives came to power committed to
reductions in taxation and public expenditure. However
the government set about the first of these objectives
before the second had been achieved."

He [Sir Geoffrey] returned to no. 10 with
Biffen, and Biffen delivered a powerful
lecture to Mrs Thatcher on the regrets
previous administrations had had over not
seizing their chances straightaway. He argued
that they would find it politically difficult
to be so bold later, but in the wake of the
election victory they had the public behind
them.... Biffen’s sermon had a powerful
impact. (Keegan, 1984:120).

The decision to increase VAT to 15 per cent was the
product of many factors, not the least of which was Mrs
Thatcher’s own political style. Her own political
speeches had stressed the need for strong, decisive
leadership which did not fear to make tough choices. She
called herself a "conviction politician" rather than a
"consensus politician".

During the parliamentary debate over the budget there was
much criticism of the regressive nature of the tax
changes. Figure 4.1 shows only a slight change in the
distribution of the income tax burden in the years before
and after the 1979 budget. Figure 4.2 shows that the
overall burden of VAT increased substantially for all
income groups. The implication of these two tables taken
together is that tax-payers gained only slightly from the
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Income Tax changes, but paid roughly twice as much in VAT because of the indirect tax changes. This had a significant effect on inflation, which rose by 4 per cent because of the VAT increase alone.

Figure 4.1 Income Tax As a Proportion of Gross Income by Quintile Groups

![Income Tax as Proportion of Gross Income](image)

Figure 4.2 VAT Payments as a Proportion of Gross Income by Quintile Groups

![VAT Payments as a Proportion of Gross Income](image)
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

The main policy objective of the 1979 budget was to improve incentives. It is very difficult to measure whether this objective was met because of the paucity of appropriate data. In order to assess whether people worked more hours per week after the tax cuts, one would need a longitudinal survey which showed the number of hours worked both before and after the cuts. Unfortunately the major British surveys only show the position at a single point in time. It is a significant weakness of fiscal policy-making that there is no model of behavioural responses which is generally accepted. As will be shown in chapter 5, there are serious problems with all of the existing methods of measuring labour supply responses to tax-benefit policy.

In the absence of longitudinal data about labour supply one can only guess at the effectiveness of the 1979 tax cuts in increasing incentives. It may be possible to believe that the reduction in the top rate of income tax from 83% to 60% may have had a significant impact on the work incentives of those affected by it.

It is not so easy to believe that the decrease in the standard rate from 33% to 30% would have had a significant effect on work incentives. There is no evidence that even the conservatives believed that it would. Mrs Thatcher and her Treasury ministers advocated it purely as a means of assuring political acceptability for the cuts in the higher rates. The decision to cut the standard rate in turn led to the 15 per cent VAT rate. The reductions in tax rates above the standard rate could easily have been financed by a one per cent rise in VAT, because so few people were involved. It was the standard rate cuts which represented the really massive fall in revenue. The near doubling of VAT to make possible the relatively cheap policy of cutting higher rates of income tax, represents a tiny tail.
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

wagging an enormous dog.

The tax cuts for those on the standard rate of income tax were short-lived; "by 1982 most workers were paying a higher percentage of their earnings in Income Tax and National Insurance Contributions than in 1979" (Peden, 1985:227). This was because increased National Insurance Contributions were used to pay for the costs of a larger public sector wage bill and higher unemployment.

The results of the 1979 budget prompted a conservative Treasury Minister to remark some time later that "all Chancellors should be legally barred from introducing a budget within six months of coming to office. They should be forced to pause and think." (Riddell, 1985:62) If there had been a more accessible method of tax-benefit modelling available to the conservatives in opposition it is to be hoped that they would have put forward a budget in 1979 with less serious consequences for the rate of VAT. An estimate of the incentive effects of the tax cuts, based on an empirically justifiable labour supply theory, would also have been useful. The 1979 budget should give a salutary warning about the perversity of the political process in its effect on fiscal policy.

4.6 Conclusion

The four episodes described above show how important the status quo is in policy-making. Abstract principles were sometimes important. However short-term political motives and the effect of the existing tax-benefit structure often prevent the implementation of a policy in the simplest and most effective way. The maintenance of the division between contributory and non-contributory benefits under Attlee was a good example of this. Policy makers need to be able to balance a number of conflicting political pressures and goals. The tax-benefit models which are used to supply information to these policy-
4. FOUR CASE STUDIES IN TAX-BENEFIT POLICY

makers should be as sensitive to these political pressures as possible.

It is possible that tax-benefit models could have made a significant difference to the formulation of policies in the four case histories given above. It is possible, but unlikely. Unlikely, because there were very strong pragmatic and ideological reasons why these specific policies were pursued by the government of the day. However, it is reasonable to claim that the debate about these policies would have been improved if alternative policy options had been argued for with greater authority. Such authority could have been achieved if the opposition had had access to official data and a mechanism for assessing the quantitative effects of different policies. It would have been interesting and useful if the Webbs had been able to work out their proposed alternative to the 1911 National Insurance system with benefits funded by general taxation rather than separate contributions. In 1943 when the first major proposal for a Basic Income scheme was advocated (Rhys-Williams, 1943) it would have been useful if an authoritative and well costed scheme based on this idea had been debated as an alternative to Beveridge. Clearly, for the policy process to work well in a pluralist society it should be possible to choose between several possible reforms, rather than between one reform proposal and the status quo.
5. CASE STUDY IN BEHAVIOURAL RESPONSES

5.1 Introduction
As was shown in chapter 3, tax-benefit policies are sometimes initiated by governments with the intention of influencing people to alter their behaviour. The most common form of behaviour which governments try to influence is the extent to which people participate in the labour force. The following case study examines the extent to which research into labour supply can be used to predict how work decisions will be influenced by tax-benefit policy.

Ideally computer models of the tax-benefit system should not ignore the issue of behavioural responses to policy changes. In some cases a tax or benefit may have important (and quantifiable) effects. Consider the case of an income tax increase which discouraged people from working. This would have a first round effect that increased government revenue (from the increased tax), but it would also have a second round effect which reduced state revenues (as the total amount of income to tax would decrease). Suppose that the government introduced a form of Child Benefit which encouraged large families like the French system which gives higher payments for the second and subsequent children in the family than for the first child. If this policy increased the birth rate then there would be long term effects in the form of increased benefit expenditure. Changing the inheritance tax to one based on the recipient rather than the donor of bequests might cause people to leave their possessions to a wider number of people to reduce the tax.

Thus in order to make accurate predictions about tax-benefit policies one must be able to assess how such policies might affect peoples' behaviour. In order to explore the problems of predicting behavioural responses,
5. CASE STUDY IN BEHAVIOURAL RESPONSES

a case study of one form of behavioural response is given below. The case study centres on work incentives. This is intended to be illustrative of the problems of assessing possible responses; it is not to imply that other responses are unimportant. Decisions about childbearing, whether or not to co-habit or marry, and investment are also important areas which can be affected by fiscal policy.

Work incentives have probably been the focus of more research than other possible responses to tax-benefit policy. All but two of the existing tax-benefit models assume that people do not alter their work behaviour in response to tax-benefit policy changes. The two exceptions are TRAP (the Tax Reform Analysis Package) and CUBS (the City University Business School model). However including formulae to predict behavioural responses creates as many problems as it solves. Which theories about behavioural responses should be used? To what extent can such theories be proven through empirical research? Should such theories be based on individual motivations alone, or should they take into account inter-action between different members of the household?

In the past bold assertions have been made about the effect of tax-benefit policy on behaviour patterns. In 1979 Mrs Thatcher said that tax cuts could be so effective in raising production that they could be self-financing:

People assume that if you cut rates, you've got to recoup it elsewhere. But this is not necessarily true, as a cut in taxes will lead to larger incentives and therefore larger output and a larger tax take. (Stephenson, 1980: 49)
In the same year the Chancellor of the Exchequer said that increasing work incentives was the rationale for his income tax cuts (Brown, 1983). There are several macroeconomic models of the economy which assume that the level of state benefits has an effect on unemployment (Wallis, 1986) namely those developed at the London Business School, Liverpool University, and the City University Business School. Some of these models have been used to make precise predictions about the effect of changes in benefit levels:

simulations on several macroeconomic models of the UK economy indicate that changes in social security benefits affect the level of unemployment in the expected direction ... According to the model at Liverpool University a 10% real cut in Unemployment Benefit would reduce unemployment by 342,000 in four years (Beenstock, 1986: 263).

What is the basis for these assumptions? It would clearly be unwise to base tax-benefit policy simulations on theories which cannot be justified in terms of empirical research. For example, economic theory might suggest that if a husband becomes unemployed that his wife would work longer hours to make up for the loss of income. However some empirical research suggests that the opposite is true; when men become unemployed, their wives often leave the labour force as well (Cooke, 1987).

The focus of economic research has not been to explain labour force participation in terms of wage rates alone. Economists have been concerned to explain it in terms of two concepts which have opposite effects on the extent of labour force participation: the income effect and the substitution effect. The income effect suggests that in
5. CASE STUDY IN BEHAVIOURAL RESPONSES

certain situations work effort is inversely related to the net wage rate. For example, if Income Tax is reduced people may work less because they can enjoy the same level of income while working for fewer hours per week. The substitution effect is derived from the economic concept of the "marginal rate of substitution of consumer goods for leisure" (Killingsworth, 1983:3). Thus if income tax is cut people might work harder because of the substitution effect (i.e. it becomes more attractive for them to substitute consumer goods for leisure).

If an accurate predictor of behavioural responses is to be built into a tax-benefit model then it is important to assess whether there is a theory of labour supply which can be empirically justified. This chapter examines that question. It is not so much concerned with what the different theories are as with the question of whether any of them can be justified empirically. Studies which do not include adequate measurements of statistical significance are not considered. The section 5.2 deals with research into behavioural responses which is based on the economy as a whole. The section 5.3 deals with attempts to prove theories about individual labour supply based on cross-sectional data. The section 5.4 concerns household labour supply theories based on similar data. The section 5.5 deals with the limited number of studies which have been based on examining a sample of the same people at two or more points in time.

5.2 Macro-Economic Studies

Three major models of the UK economy include welfare benefit levels in their predictive equations for real wage levels: the Liverpool Model, the City University Business School Model, and the London Business School Model. In all three, benefit levels are assumed to have an upward pressure on wage levels which in turn have an upward pressure on unemployment. The accuracy of these
5. CASE STUDY IN BEHAVIOURAL RESPONSES

equations has been explored by the ESRC Macroeconomic Modelling Bureau (Wallis, 1984). The bureau attempted to estimate the accuracy of the models with similar methods in each case. The Modelling Bureau used quarterly time series data about the UK economy to estimate each model.

Figure 5.1 Model to Predict Real Wages

Real Wages Predicted by:-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.34</td>
</tr>
<tr>
<td>Dummy 1</td>
<td>-0.00162 *</td>
</tr>
<tr>
<td>Dummy 2</td>
<td>0.0024</td>
</tr>
<tr>
<td>Dummy 3</td>
<td>0.0044</td>
</tr>
<tr>
<td>Log Unemployment&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-0.024 *</td>
</tr>
<tr>
<td>(Log Weighted Average of Benefits)</td>
<td></td>
</tr>
<tr>
<td>+ (Direct Taxes / Average Earnings)</td>
<td>0.11 *</td>
</tr>
<tr>
<td>Unionisation Rate&lt;sub&gt;t&lt;/sub&gt;</td>
<td>0.45 *</td>
</tr>
<tr>
<td>Log Working Population&lt;sub&gt;t&lt;/sub&gt;</td>
<td>-0.016</td>
</tr>
<tr>
<td>Log Real Wages&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.77 *</td>
</tr>
</tbody>
</table>

Number of Observations 60
Goodness of Fit $R^2$ 0.47

* Indicates coefficient was significant at the 5 per cent level.

The subscript t denotes time period (i.e. the quarter, t denotes the previous quarter, etc.).

Source: Minford, 1983
5. CASE STUDY IN BEHAVIOURAL RESPONSES

In each of the three equations estimated by the bureau the benefit level was significant at the 5 per cent level. However there was no evidence that these models predicted wage levels more accurately than other economic models which did not take benefits into account (the Treasury model, the Bank of England Model, the Cambridge Growth Project model, and the National Institute for Economic and Social Research model).

Specific research into the effect of benefits on unemployment has been done by Minford (1983). He demonstrated statistically significant relationships between tax/benefit levels and real wages using time series data about the UK economy. As with the three economic models cited above, real wages and unemployment are linked in this research, Minford's model was estimated with quarterly data about the UK over a period of 15 years starting at the second quarter of 1964. The results of the simulation are shown in figure 5.1.

In this model the coefficient labelled "(Log Weighted Average of Benefits) + (Direct Taxes / Average Earnings)" which is based on taxes and benefits, is shown to be significant at the five per cent level. The benefit element of this coefficient is a complex weighted average based on a number of variables including the flat rate unemployment benefit, the earnings related supplement (based on average earnings) and free school meals. The tax element of the coefficient is the percentage of national gross average earnings taken in taxes and national insurance contributions for a married man with two children. It would seem very risky to make assertions about the effect a cut in unemployment benefit would be likely to have on the basis of such a calculation because unemployment benefit is only a part of the coefficient. If it could be shown that there was a significant relationship between real wages and
5. CASE STUDY IN BEHAVIOURAL RESPONSES

unemployment benefit on its own, one could have more confidence in such predictions. Nickell and Andrews (1983) tried to simulate the effect of the benefit rate on employment using the concept of the "replacement ratio", which is typically taken to be the ratio of the income an unemployed person receives compared to average earnings. Economic theory would suggest that a high replacement ratio would mean higher unemployment. However Nickell and Andrews (1983) were unable to find any such replacement ratio effects which were significant. Furthermore Moylan, Millar, and Davies (1984) used a large longitudinal studies of the employment histories and wage expectations of unemployed men. They attempted to discover how easy it was to predict whether a man would accept a job based on whether the wage was above or below the level which the individual considered was a reasonable minimum, the reservation wage. They found that "self-reported reservation wages appear to be a poor guide to behaviour in the face of actual job offers" (Moylan, Millar, Davies, 1984: 113).

However even if one proved a strong relationship between unemployment and real wages, one would not have proved the direction of causality. Do benefit levels push up wages or vice versa? Some National Insurance benefits were deliberately linked to average earnings. If benefit levels had both risen and fallen during the post-war period with cuts in benefit preceding cuts in wages, the direction of causality would be easier to assess. In reality both benefits and wages have been on an upward trend. The main exceptions to this occurred in 1980 when National Insurance benefits were uprated by 5 per cent less than inflation, and in 1982 the Earnings Related Supplement to Unemployment and Sickness Benefit was abolished. In theory these cuts should have led to a reduction in unemployment, but this did not happen.
5. CASE STUDY IN BEHAVIOURAL RESPONSES

There is no clear cut example in the post-war period of cuts in benefit causing wages to fall.

Given that there is conflicting research about the effect of benefit levels, and that the direction of causality has not been established, the macro-economic data does not seem to offer conclusive evidence about behavioural responses to changes in benefit levels.

Figure 5.2 Model to Predict Employment Status

<table>
<thead>
<tr>
<th>Dependent Variable:</th>
<th>Coefficient:</th>
<th>Standard Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.6805</td>
<td>7.6</td>
</tr>
<tr>
<td>$A_0$ (Unemployment Benefit + Wife's Wages)</td>
<td>0.0002</td>
<td>0.7</td>
</tr>
<tr>
<td>$A_1$ (Work Hours needed to exceed Unemployment income)</td>
<td>0.0020</td>
<td>2.2</td>
</tr>
<tr>
<td>$W_1$ (Wage Rate for earnings to exceed Unemployment Income)</td>
<td>0.0216</td>
<td>1.8</td>
</tr>
<tr>
<td>Age of Head of Household</td>
<td>0.0107</td>
<td>2.4</td>
</tr>
<tr>
<td>Age of Head of Household Squared</td>
<td>-0.0001</td>
<td>2.4</td>
</tr>
<tr>
<td>Number of Children</td>
<td>-0.0174</td>
<td>2.7</td>
</tr>
<tr>
<td>Industry Unemployment Rate</td>
<td>-0.5436</td>
<td>2.7</td>
</tr>
<tr>
<td>Mortgage (Has Mortgage=1, No Mortgage=0)</td>
<td>0.0450</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Number of Observations 1014
Goodness of Fit R-Squared 0.04

Source: Beenstock, 1983
5. CASE STUDY IN BEHAVIOURAL RESPONSES

5.3 Cross-Sectional Individual Studies
There have been several attempts to assess the impact of benefit levels on the employment status of individuals. Beenstock (1986) and Dalziel constructed a model to determine the probability of being employed based on the net wage rate an unemployed person would be likely to receive in work and the benefit income a worker would be likely to receive if unemployed. The data were taken from the 1978 and the 1981 FES. The calculation of net wages and unemployment incomes was carried out to a high degree of specificity using a model representing the major benefits and direct taxes. The model used several special variables to predict the probability of employment. The result of one of Beenstock’s analyses is shown in figure 5.2. The variable shown as A0 is the unemployment benefit rate plus the wife’s earnings. A1 is the number of hours which the individual would need to work for his employment income to exceed his unemployment income. W1 is the wage rate which applies where earnings exceed the level of unemployment income. The unemployed were allocated an imputed wage based on average earnings.

As can be seen from figure 5.2 several other variables were included in order to improve the fit of the model. The dependent variable was employment status which took the value ‘1’ if the individual was in work and ‘0’ if he was unemployed. In order to constrain the choices to ‘0’ and ‘1’, three different modelling approaches were used: a linear probability model, a logit model and a probit model. Figure 5.2 shows the results of estimating the linear probability model. The coefficients were estimated through ordinary least squares regression. The model only explains 4 per cent of the variation of employment status, in spite of the inclusion of five variables which are unrelated to Dalziel and Beenstock’s theory of work incentives. The incentive variables A1 and W1 had coefficients which were not significantly
different from zero. Dalziel and Beenstock use a number of other specifications for their model, but in each case the "incentive variables" have a weak and statistically insignificant effect on employment status. As Beenstock himself puts it:

> It can be seen that the overall fit of the model is poor. The contribution of the incentive variables is generally weak ... The only persistently strong effects seem to come from the industry and unemployment term and the age variables which suggests that demand has a stronger influence than supply considerations. (Beenstock, 1986:179).

The inconclusive nature of these results caused Beenstock to make the unusual criticism that the data from the FES are not accurate enough (Beenstock, 1986). Though Beenstock’s research failed to show any conclusive link between benefits and employment status it is interesting to note that the labour demand variables were so much more significant than the labour supply variables. This would imply that the availability of work for an individual is much more important than work incentives. This analysis by Beenstock was a rare attempt to try to measure the impact of work incentives through a dichotomised employment status variable. The lack of a conclusive result may indicate that using this approach is inappropriate; alternatively it may also indicate that the underlying theory is wrong and that the tax-benefit system does not have a significant impact on employment status. The more common approach is to use hours of work to measure labour force participation.

One of the simplest, and crudest, attempts to assess the impact of wage rates on hours of work was conducted by
5. CASE STUDY IN BEHAVIOURAL RESPONSES

Egginton (Beenstock, 1986), whose approach was to categorised people according to various criteria which might affect their labour force participation and then to assign them to one of a further set of categories based on the range of hours for which they worked. The data were taken from the 1977 and 1981 Family Expenditure Survey. If the individual was out of work then an imputed wage rate based on average earnings was assigned to him. Based on these wage rates men were allocated to one of two groups according to whether their wages were above or below the national average. The sample was further stratified according to number of children, marital status, and housing tenure.

Egginton then attempted to use the Chi-square procedure to determine if the people in the categories which were thought to have strong incentives worked for longer hours than would be expected if the distribution was random. Egginton found that it was not possible to find any relationships which were significant on a consistent basis. In ten out of the twelve comparisons of low and high wages, the cells contained numbers which were significantly different from the numbers which would be expected from a random distribution, indicating that people with below average wages tend to work for longer hours than people with higher wages. However when the unemployed were excluded (who had had an artificial wage rate imputed to them) then number of significantly different categories dropped to seven out of twelve. The comparisons based on housing tenure groups were also inconclusive. The only useful predictor seemed to be the number of children, with people tending to work longer hours the more children they had.

It is far more common to use continuous variables rather than categorical or dichotomised variables. In fact the most common method of assessing the impact of tax-benefit
5. CASE STUDY IN BEHAVIOURAL RESPONSES

Policy on work incentives has been to construct a model of responses to changes in tax-benefit rates and to estimate it using regression analysis. A typical regression equation would be:

\[
\text{Work\_Hours} = a_1\text{Wage\_Rate} + a_2\text{Non\_Employment\_Income} + a_3\text{Preference\_Variable} \ldots a_n\text{Preference\_Variable} + \text{Error}
\]

The wage rate variable is normally assumed to have a positive effect on the number of hours worked (on the grounds that the more people are paid the greater their incentive to work). Non-employment income is generally assumed to depress the number of work hours because the larger the income the person can enjoy without working the less will be his or her incentive to work. The taste variables are other factors which influence the individual's propensity to work. For example, if the individual is a parent or supports a non-working spouse then they will often prefer to work more because of their increased family commitments. These assumptions are common in the literature of labour supply economics.

However, the measurement of the net wage rate poses a difficult problem. In general, the data on which studies are based do not include the hourly pay rate. In practice, the wage rate is determined by taking net earnings and dividing it by the number of hours worked. The early attempts to define a labour supply function involved taking hours of work as the dependent variable, and using earnings divided by hours of work as one of the independent variables. This means that if there are measurement errors in the hours of work variable, this will also affect the dependent variable so the error will be endogenous to the regression equation. Labour supply economists have termed this problem "endogeneity bias".

Brown, Levin, and Ulph (1976) had the advantage of using
5. CASE STUDY IN BEHAVIOURAL RESPONSES

a specially commissioned survey which obviated the need to use work hours to calculate the wage rate in the main job. The survey was conducted in 1971 by the British Market Research Bureau and provided data on 2000 respondents.

The equation used by Brown, Levin, and Ulph took the form:

\[
\text{Work\_Hours} = \text{Constant} - a1\text{Marginal\_Wage} \\
+ a2\text{Marginal\_Wage}^2 - \\
a3\text{Intercept} + a4\text{Intercept}^2 + \\
a5(\text{Marginal\_Wage} \times \text{Intercept}) - a6\text{Other\_Income}.
\]

Figure 5.3 Hours of Work of Married Men

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient:</th>
<th>Standard Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>55.3</td>
<td></td>
</tr>
<tr>
<td>Marginal_Wage</td>
<td>14.3</td>
<td>* 4.8</td>
</tr>
<tr>
<td>Marginal_Wage Squared</td>
<td>3.63</td>
<td>2.05</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.959</td>
<td>* 0.143</td>
</tr>
<tr>
<td>Intercept Squared</td>
<td>0.0105</td>
<td>* 0.00212</td>
</tr>
<tr>
<td>Marginal_Wage x Intercept</td>
<td>0.644</td>
<td>* 0.118</td>
</tr>
<tr>
<td>Other_Income</td>
<td>0.114</td>
<td>* 0.048</td>
</tr>
</tbody>
</table>

Number of Cases = 434

Adjusted R-Squared = 0.104

* Significant at the 5 per cent level

Source: Brown, Levin, and Ulph, 1976

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5. CASE STUDY IN BEHAVIOURAL RESPONSES

The "intercept" refers to a point on a graph of net incomes plotted against hours of work. When the individual does not work at all he or she will have zero hours of work but will have some net income (from unemployment benefit, investments, etc). The "intercept" is thus the point at which the budget line "intercepts" the hours of work axis. It is useful to examine how well this particular equation fitted the data as this formula includes only income variables (unlike the equation estimated in figure 5.2 which includes labour demand variables like the industry unemployment rate). The result of estimating Brown, Levin & Ulph model is shown below in figure 5.3. It will be seen from the figure for R2 that the model explains roughly ten per cent of the variance of hours of work. All but one of the coefficients are significant at the 5 per cent level. It is possible that labour demand factors such as the industry unemployment rate, and household preference factors such as the presence of pre-school children would have increased the R2.

Brown, Levin and Ulph tried to improve the fit of their model by excluding various groups from the sample. By removing those who said that they were restricted in their options to work overtime the R2 increased from 0.104 to 0.128. When those on piece rate or bonus schemes (who could theoretically increase work effort without increasing work hours) were excluded the R2 increased further to 0.17. The exclusion of husbands with working wives increased the R2 from 0.104 to 0.134. The only exercise which caused a dramatic increase in the R2 was the exclusion of men with restricted overtime options, men on bonus payments, and men with children under 11, which produced an R2 of 0.367.

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Figure 5.4 Hours of Work of Married Women

<table>
<thead>
<tr>
<th>Variable:</th>
<th>Coefficient:</th>
<th>Standard Error:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>Marginal_Wage</td>
<td>16.1</td>
<td>33.3</td>
</tr>
<tr>
<td>Marginal_Wage Squared</td>
<td>38.2</td>
<td>32.2</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.486</td>
<td>0.346</td>
</tr>
<tr>
<td>Intercept Squared</td>
<td>-0.0012</td>
<td>0.00239</td>
</tr>
<tr>
<td>Marginal_Wage *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-1.95 *</td>
<td>0.894</td>
</tr>
<tr>
<td>Presence of children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 11</td>
<td>-5.79 *</td>
<td>2.56</td>
</tr>
<tr>
<td>Spending on Children</td>
<td>-0.318</td>
<td>0.390</td>
</tr>
<tr>
<td>Ownership of time-saving Assets</td>
<td>-1.28</td>
<td>1.39</td>
</tr>
<tr>
<td>Travel to work time</td>
<td>0.0679</td>
<td>0.0676</td>
</tr>
<tr>
<td>Committed Income</td>
<td>-0.0335</td>
<td>0.0843</td>
</tr>
<tr>
<td>Wealth</td>
<td>0.545</td>
<td>0.370</td>
</tr>
<tr>
<td>Unemployment of Main Earner</td>
<td>3.545</td>
<td>0.370</td>
</tr>
<tr>
<td>Job Satisfaction</td>
<td>0.0335</td>
<td>0.0954</td>
</tr>
<tr>
<td>Reported Fitness for more Work</td>
<td>0.946</td>
<td>1.03</td>
</tr>
<tr>
<td>Education beyond official School</td>
<td>-2.74 *</td>
<td>1.34</td>
</tr>
<tr>
<td>Leaving Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.0625</td>
<td>0.0996</td>
</tr>
</tbody>
</table>

Adjusted R-Squared = 0.12
Number of Cases = 129

Source: Glaister, McGlone, and Ruffell, 1981
similar approach to construct a model which would apply to a wider variety of family types (Brown, 1981). Glaister, McGlone and Ruffell were also concerned with simulating the effect of variables which would be likely to alter the individual's work preferences. In one such study they used the same survey data as Brown, Levin, and Ulph (1976) but extracted from it the married women. Of these a sub-sample of 129 remained which contained women who were below the retirement age, had no major constraints on their hours of work (i.e. had the possibility of working overtime), and who were not paid on a piece rate system. They estimated a model very similar to that used for men in figure 5.3, but none of the coefficients were significant at the five per cent level and the adjusted R2 was only 0.03. This could indicate that the factors which influence married men are different from the factors which affect married women.

It was then decided to add some variables which would simulate circumstances which would alter the women's preference to work longer hours. For example, it was assumed that the presence of young children would lower a married woman's preference to work more. Conversely having a large amount of committed income (such as mortgage payments) would increase the preference to work more. So a set of these "preference variables" was then added. The result of this model is set out below in figure 5.4. Two preference variables stand out as having a significant effect: the presence of young children under 11, and years of full-time education over and above the school leaving age. Variables which were not significant at the 5 per cent level included the ownership of time saving assets such as a refrigerator or washing machine, job satisfaction, and a dichotomised variable showing whether the main earner is unemployed. With all the preference variables included in the model it explained 0.12 of the variance in work hours.
Glaister, McGlone, and Ruffell (1981) made a similar study of married men. Again a sub-sample of men were selected who were below the retirement age and were paid on the basis of an hourly rate without any reported restrictions on hours. The "basic model" without any preference variables explained 0.05 of the variance of work hours (this is was result of testing the same model as in figure 5.3 on a different set of data). When the preference variables were included the $R^2$ increased to 0.16. One of the preference variables was the notional expenditure on children which was taken to be the Supplementary Benefit child additions which would have been payable in respect of the number and ages of the man's children. This was found to be significant at the five per cent level indicating that married men will tend to work longer hours the more children they have to provide for.

A similar model was estimated using a sample of single people. The basic model employed by Brown, Levin, and Ulph (1976) which attempted to predict hourly wages by variables based on marginal wages and theoretical non-employment income (the intercept), explained only 0.07 of the variance in work hours. When preference variables were added the $R^2$ increased from 0.07 to 0.10. Two preference variables proved to be significant at the 5 per cent level - job satisfaction (which tended to increase work hours) and the number of years of education beyond the school leaving age (which tended to reduce it).

It is difficult to be overly sanguine about the effectiveness of assessing work incentives through cross-sectional data. The data only appears to explain a small proportion of the variance - generally under 15 per cent. The modelling approaches which have been used all have
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serious drawbacks. The most popular approach, involving the construction of regression equations to predict work hours, suffers from the serious problem of endogeneity bias. If one accepts the efficacy of the devices which have been used to compensate for this bias, then it is possible to assert that the cross-sectional data does

Figure 5.5 A Household Model of Labour Supply

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Wife's Hours</th>
<th>Husband's Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1428.96 *</td>
<td>2273.78 *</td>
</tr>
<tr>
<td>Own Disposable Wage</td>
<td>54.30 *</td>
<td>-137.87 *</td>
</tr>
<tr>
<td>Spouse's Disposable Wage</td>
<td>-33.05 *</td>
<td>-81.94 *</td>
</tr>
<tr>
<td>After-tax Property Income</td>
<td>0.006</td>
<td>0.029 *</td>
</tr>
<tr>
<td>Age</td>
<td>7.67</td>
<td>-27.76</td>
</tr>
<tr>
<td>Education</td>
<td>11.94</td>
<td>39.05 *</td>
</tr>
<tr>
<td>Children Less than 1</td>
<td>-385.17</td>
<td>50.26</td>
</tr>
<tr>
<td>Children 1-2 Years old</td>
<td>-480.23 *</td>
<td>19.40</td>
</tr>
<tr>
<td>Children 3-5 Years old</td>
<td>-152.11 *</td>
<td>28.91</td>
</tr>
<tr>
<td>Children 6-13 Years old</td>
<td>-75.48 *</td>
<td>-2.39</td>
</tr>
<tr>
<td>Children 14-17 Years old</td>
<td>-2.48</td>
<td>57.27</td>
</tr>
<tr>
<td>Health</td>
<td>13.52</td>
<td>-</td>
</tr>
<tr>
<td>Homeowner</td>
<td>-60.48</td>
<td>83.77</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>-14.40</td>
<td>-8.72</td>
</tr>
</tbody>
</table>

\[ R^2 \quad 0.079 \quad 0.164 \]

* Indicates coefficient significant at 5 % level.

Source: Leuthold, 1979
5. CASE STUDY IN BEHAVIOURAL RESPONSES

give a limited picture of work incentives. However caution should still be used as there is still far more variation in work hours that cannot be explained by the labour supply models than can be explained by them.

5.4 Cross-Sectional Household Studies

The effect of a spouse's income may make it difficult to predict the labour supply response of the individual on his or her own. If a person's spouse receives a large pay rise it is reasonable to assume that their own behaviour will be affected. It has been claimed that the higher the income of the husband, the less likely it is that the wife will be in employment. Though by contrast jobless married men tend to have wives who are also unemployed (Cooke, 1987), a dichotomy which is probably influenced by cultural perceptions of the role of men as breadwinners and by social security rules which in some situations reduce benefit entitlement by the amount of the spouses earnings. Some individual models of labour supply include the income of the wife as one of the variables (Brown, Levin, and Ulph, 1976).

How should one model the interaction between the income of husbands and wives? Two different types of household model have been used. Both models assume that there is a family budget constraint which describes the trade-off between earnings and leisure for the entire family. However the two types of model differ in the way they determine how husbands and wives will maximise their satisfaction under this set of options.

One type of model (usually termed neo-classical) assumes that the effect of one's spouse's income on the other will be equal whether the change is the husband's or the wife's income. Therefore if (for the sake of argument) such a model implied that a 10 per cent increase in the income of the husband would produce a 2 per cent decrease
in the wife's work hours, it would also mean that a 10 per cent increase in the wife's income would have a similar effect on the husband's labour supply.

The other type of model assumes that there are different functions which describe the interaction of husbands and wives income. It is often assumed that a change in the earnings of the husband will have a greater impact on the wife's earnings than vice versa. Leuthold (1976) provides the most famous example of such models. The estimation of a Leuthold model is shown in figure 5.5. The results are derived from data on 940 couples from the USA's 1970 National Longitudinal Survey. It shows that there are statistically significant effects caused by the income of one spouse on the other. For the wife it shows that the presence of children is a disincentive to seek paid employment. This effect appears to be stronger the younger the children. The magnitude of the husband's income also appears to reduce the wife's hours of work while the wife's own disposable wage appears to increase it. For the husband the strongest effect reducing hours of work is the amount of disposable wage income and wife's wage income. Education also appears to have a positive effect on the number of hours the husband works.

Ashworth and Ulph (1981) have attempted to compare the Leuthold approach with the neo-classical method, by using different models to estimate work hours for the same data set. They found that the Leuthold model achieved a better fit.

5.5 Longitudinal Studies

Brown has summarised the rationale for conducting labour supply research with cross-sectional data as follows:-

If the control variables hold preferences
constant, then the variations in hours will depend on differences between individuals in their budget constraints. Thus if the only difference between individuals was in their wage rate, differences in labour supply would be attributed to this difference. It is then inferred that it is possible to predict how individuals will behave over time from a single point in time. (Brown 1983: 53)

This reasoning may be flawed. Some of the existing research suggests that labour demand factors account for more of the variation in work hours than marginal wages or preferences. The ability to control for characteristics which influence work behaviour can only ever be partially successful. It would be far better to examine the same group of people at different points in time in order to observe how they responded to changes in their marginal wage. This would be a vastly superior method of controlling for preferences. Often it would be possible to control for preferences (e.g. by examining only those families where the number of children had stayed the same). If the preference variables could be controlled in this way it would be possible to examine the effect of post-tax wage rates and benefit levels in isolation.

Alas there is no publicly available data which would allow this research to be carried out in Britain. The few longitudinal data sets tend to have serious restrictions on their sample size or the characteristics of the respondents. The DHSS cohort study has been used (Daniel and Stilgoe, 1977) to examine the phenomenon of women leaving employment when their husbands are out of work. However the selection of respondents is limited to
benefit recipients so the resulting data can only have a limited usefulness in predicting the labour supply responses of the population as a whole. The largest potential source of longitudinal data is the New Earnings Survey. However the government restricts access to this by researchers. The only files which are available from it do not have data on individual cases.

One minor exception to this was a study carried out by Weale (1984) on single parents to determine whether they altered their labour supply in response to the introduction of the tapered earnings disregard for supplementary benefit. He found no significant alteration in their work behaviour. This was predictable in view of other research which indicates that the responsibilities of single parenthood has a very powerful negative effect on labour participation (Joshi, 1984).

Clearly, if longitudinal data is to be useful it must have a large sample size and must be applicable to a wider range of family types than just single parents. In the USA such data was provided by a major social experiment in the late 1960s and early 1970s which involved measuring responses to a Negative Income Tax system (NIT).

To illustrate the NIT we will take the example of the New Jersey Income Maintenance Experiment (Watts and Rees, 1977) - though there were also experiments in Gary Indiana, Denver Colorado, and Seattle Washington. The system worked by setting an income guarantee level, and paying the participants in the experiment a proportion of the amount by which their actual incomes fell short of this guarantee level. The income guarantee level varied in proportion to the number of adults and children in the family. The income guarantee level was calculated as a proportion of the US government's official poverty line.
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for the different types of household. Four income guarantee levels were used (they were set at 50, 75, 100, and 125% of the poverty line). There was also variation in the rate at which NIT payments were tapered away. There were three withdrawal rates - 30%, 50% and 70%. A private research company Mathematica Inc, was employed to administer and monitor the schemes which selected a sample of 725 families to receive the NIT payments. The experimental families were required to fill out a statement of their income every 28 days, which was in turn used to calculate their NIT payments. NIT payments cheques were then posted to the families at fortnightly intervals. The research team monitoring the experiment conducted quarterly interviews of both control and experimental families to assess how their behaviour altered over the three years of the experiment. This provided a rich source of longitudinal data.

Watts and Rees (1977) used the data produced by the New Jersey experiment to construct a model of the factors influencing hours of work. They were able to measure the change in the hours of work in the second full year of the experiment compared to the hours of work before the experiment began. They used the change in hours of work between these two periods as the dependent variable. A regression equation was specified to predict the change in hours of work. The effect of the NIT payments was expressed as the ratio of the family's income guarantee level to their actual net income. The income guarantee level varied according to the composition of the household, so expressing the NIT in this way allowed the effect of NIT payments to be measured for families of different sizes.

Figure 5.6 shows that there was a statistically significant relationship between the NIT variable and hours of work - with the NIT tending to reduce work
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effort. This is in accord with prevailing economic theory. In the case of this kind of NIT both the income effect and the substitution effect work to reduce incentives. The NIT raises net income so people can enjoy the same income while working less. This income effect is compounded by a substitution effect. As the experimental families were often below the tax threshold

Figure 5.6 Labour Supply Responses to the New Jersey Income Maintenance Experiments

Change in Hours of Work Predicted by:-

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-5.8725</td>
</tr>
<tr>
<td>NIT Guarantee Level/</td>
<td></td>
</tr>
<tr>
<td>(Income net of Withdrawal)</td>
<td>-1.11952 *</td>
</tr>
<tr>
<td>Work Hours Before Experiment</td>
<td>-0.80394 *</td>
</tr>
<tr>
<td>1/Normal Wage Rate</td>
<td>3.1835</td>
</tr>
<tr>
<td>Age</td>
<td>0.95020 *</td>
</tr>
<tr>
<td>Age2</td>
<td>-0.011792</td>
</tr>
<tr>
<td>Health Problem which limits work</td>
<td>-5.7097</td>
</tr>
<tr>
<td>Completed High School</td>
<td>1.8514</td>
</tr>
<tr>
<td>Weeks worked in year before Experiment</td>
<td>0.28171 *</td>
</tr>
<tr>
<td>Site 1</td>
<td>0.4983</td>
</tr>
<tr>
<td>Site 2</td>
<td>2.0367</td>
</tr>
<tr>
<td>Site 3</td>
<td>1.2470</td>
</tr>
</tbody>
</table>

R² = 0.48

* Coefficient significant at 5 per cent level

(Watts and Rees, 1977)
5. CASE STUDY IN BEHAVIOURAL RESPONSES

before the experiment began many of them faced a marginal tax rate of zero. The NIT imposed a withdrawal rate of between 30% and 70%, thus the NIT recipients received substantially less benefit from working for an extra hour. Watts and Rees (1977) concluded that the disincentive effects of the NIT were not substantial. However this finding has been disputed by later researchers who have reanalysed the data such as Hall (1975) and Cogan (1978). The evidence of reduced work effort in response to NIT payments is supported by the evidence of the Seattle and Denver NIT experiments (Robins, Spiegelman, Weiner, Bell, 1980). It should be noted that the Seattle and Denver experiments had a larger sample than did the New Jersey Experiments (725). Economists have attempted to use the American NIT experiments to make general statements about the effect of tax-benefit policy such as the size of the income and substitution effects. However it is useful to examine the dangers of drawing such conclusions from a single policy experiment and applying the results to other policies. The administrative aspects of the NIT scheme may have had a special impact because the participants were required to fill out a special income statement to receive a special payment through the post. One should not assume that a similar scheme with a different method of payment would have had the same effect. For example, if there had been no monthly income statement and the payments had been added to the wage packet by the employer, the effects might have been different because it would not have been so obvious to the participants that they could increase the NIT payments by reducing their earnings. It would certainly be unsound to compare Britain and the USA because of the differences in the two benefit systems. The lack of benefits for the uninsured population in the USA meant that often the NIT scheme was offering state benefits to people who had had no entitlement before. In Britain however the Supplementary
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Benefit system provides a safety net to those not covered by National Insurance benefits, so an NIT in Britain would tend to increase the net incomes of people in lower paid work rather than the unemployed.

The NIT experiments do show the value of longitudinal data. The model shown in figure 5.6 explains a far higher proportion of the variance of the change in work hours, than the models based on cross-sectional data. In studies of the Seattle and Denver experiments the estimates of the effects of the scheme were frequently significant at the 1 per cent level (Robins, Spiegelman, Weiner, Bell, 1980). It is unfortunate that there is no publicly available set of panel data on British hours and earnings.

5.6 Conclusion

If non-governmental groups are to be able to participate with government in the policy debate on equal terms it is important that they should be able to assess the behavioural responses a tax-benefit change is likely to cause. The most important ideological influence on British fiscal policy since 1979 has been the belief that reductions in tax rates will increase work incentives and therefore national wealth. It is important to be able to assess whether this type of theory is true. Generally this kind of debate is conducted in an atmosphere of anecdote and supposition.

How should a pluralist tax-benefit model deal with the various theories concerning behavioural responses? Such models should seek to be as value-neutral as possible. They should certainly not "build in" any particular set of theories. Unless the user specifically chooses to base a simulation on a particular theory, then the model should produce results on the assumption that policy changes do not influence behaviour. If a labour supply
theory is to be used in a simulation then the authors of the relevant research must be named. Measures of the explanatory power and significance level of their model must be shown.

Intellectual honesty demands this kind of rigour. The policy debate would be the better for it. Even if one accepts these caveats, however, it is important to stress that policy simulations may be more accurate if they are not based on theories which assume that behaviour is altered. Because it has been so difficult to prove the validity of labour supply theories, the assumption that there are no behavioural responses is often the best one.

To what extent has the empirical research reviewed in this chapter demonstrated the effect of tax-benefit policy on work incentives? The existing research has failed to show conclusively that higher benefit entitlements mean higher unemployment. The British research on the effect of tax-benefit policy on work hours is difficult to assess because of the unpredictable effects of endogeneity bias. If one accepts the efficacy of the measures that have been taken to compensate for endogeneity bias, then there is a body of research which sometimes shows significant relationships between marginal wages, preference variables and work hours. For example, the research of Brown, Levin, and Ulph (1976) and Glaister, McGlone, and Ruffell (1981) indicate that changes in marginal wages may explain up to 10-15 per cent of the variation in work hours. This is an important finding because a substantial change in work hours will affect tax revenues. Increased work hours will boost revenue. A reduction in labour participation will cut revenues and increase the expenditure on benefits. Variables which attempt to simulate the labour participation 'preferences' of different groups such as the desire to provide financially for children can be
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used to explain a higher proportion of the variance in work hours than models based on income and marginal wages alone according to research of Glaister, McGlone, and Ruffell (1981). In the case of married men the R² increased from 0.07 to 0.16; for married women it increased from 0.03 to 0.12; for single people it increased from 0.07 to 0.10. The Household models have not helped to explain the variation in work hours to a significantly greater extent than research based on individual theories of labour supply. The experimental data from the American NIT experiments shows the potential value to be gained from the use of longitudinal data. Unfortunately researchers do not have access to longitudinal data on incomes and work hours for the U.K. population.

Apart from the impact of wage rates on work hours, the other main question relating to the impact of tax-benefit policy on labour supply is whether benefit levels contribute to unemployment. The research of Beenstock (1986) applied a great deal of energy to the task of showing a relationship between benefits and the decision of whether to work or not. However this failed to show a result which was statistically significant. Macroeconomic data about benefit levels has been used by Wallis (1984) and Minford (1983). This has been used in equations to determine the real wage level. Economic models like the Liverpool model have equations which assume that real wages have an upward pressure on unemployment. Wallis's (1984) research showed that benefit levels could be a statistically significant coefficient in regression equations to predict the real wage level, but those models which used benefit levels in their real wage equations were no more accurate than the equations in other economic models which did not use them. Minford's (1983) research indicated that there was a significant relationship between benefit levels and
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unemployment, whereas Nickell and Andrews' (1983) research using microeconomic data came to a different conclusion. A review of the existing research indicates that the jury is still out on this question.

At best one can say that the question of how tax-benefit policy affects incentives has only been partially answered. Certainly it would be extremely useful to know the relationship between changes in the after-tax wage rate and the supply of labour, in order to evaluate policies. There is a wealth of data about incomes and taxation in surveys like the Family Expenditure Survey and the General Household Survey. It would be useful to have a more robust theory about how labour supply is affected by tax-benefit policy. It would be possible to make credible predictions about how unemployment and average work hours would change in response to policy. Even though some labour supply economists have built tax-benefit models which make labour supply predictions, the confidence of their forecasts should not obscure the fact that more research is needed on the underlying theory of labour supply responses. The lack of a credible labour supply formula to use leaves social researchers floundering around like a group of people in a life-boat starving because they do not have a tin-opener to use on their supply of canned food. In this situation the labour supply economist seems to stand up and declare confidently - "The first step in solving our problems is to assume that we have a tin-opener".
6. FEATURES OF A PLURALIST MODEL

6.1 Introduction
This chapter describes a prototype tax-benefit program which embodies flexibility and usability to an extent that it could be used by non-governmental groups as well as government. As this dispersal of power is necessary for the functioning of a pluralist society, it is hoped that this tax-benefit program will be a pluralist tax-benefit program. Though the model is simple to use it does not constrain the user to a narrow set of menus. There is thus no inherent limit to the number of policy options which can be simulated. For this reason it will be referred to as the Policy Option Model (POM). A new computer language has been designed for use with POM which is intended to make it particularly easy to specify new policies. For this reason it is referred to as the Policy Simulation Language (PSL).

This chapter summarises the features which have been built into POM. It suggests an approach which might solve the usability/flexibility dilemma outlined in chapter 1. It draws on the experience of the existing tax-benefit models reviewed in chapter 2 so that some of the best features of these are included in the pluralist model. It puts forward a solution to the problem posed in chapter 3 of constraining the user to a narrow range of output tables. It describes a mechanism for carrying out some behavioural simulations.

The structure of the chapter is as follows. Section 6.2 describes the method of inputting policies into POM. 6.3 outlines the method of producing output tables. 6.4 sets out the equipment needed to use POM. 6.5 describes the characteristics of the data.

6.2 Policy Input
6. FEATURES OF A PLURALIST MODEL

6.2.1 Programming Language vs Menus
As explained in chapter 1 non-experts who try to do tax-benefit modelling are faced with two major problems. If they try to carry out simulations on an easy to use

Figure 6.1 Pascal Procedure to Compute Total Household Income

```
1  Procedure Total_Household;
2  const
3    Missing = -999999;
4
5  Type
6    Household_Record = Record
7      Sex,
8      Earnings,
9      Investment_Income : Integer;
10  End;
11  Var
12    Household_Vars : Household_Record;
13    Household_Array : Array [1 .. 25] of Household_Record;
14    Counter,
15    Total_Income : Integer;
16
17  Begin
18    Counter := 1;
19    Repeat
20      Household_Vars := Household_Array[counter];
21      with Household_Vars do
22        begin
23          Total_Income := Earnings + Investment_Income;
24        end;
25      Counter := Counter + 1;
26    Until Household_Vars.sex = Missing;
27  End;
```
program based on menus then there will be many policies which they cannot simulate because the menus only allow them to alter mathematical constants associated with existing or proposed policies. They cannot simulate policies that the program-maker did not allow for at the time when the program was created.

A way out of this dilemma would be use a programming language which would allow the user to alter the structure of a package rather than alter a set of constants. However this faces the user with the problem of learning a new language. It can be

Figure 6.2 PSL Procedure to Compute Total Household Income

1 Total_Income =
2 Total_Household(Earnings + Investment_Income).

enormously difficult for a novice to learn a language. Even once the large investments of time have been made in learning a language the user is faced with the mammoth task of redefining the existing tax-benefit system from scratch in the new language which has been selected. To give an impression of the scale of this task it should be borne in mind that the IFS model is over 8,000 lines long. An alternative to this would be for a novice programmer to have access to the source code of one of the existing models. Thus the user would be able to make small modifications to the source code to define a new tax or benefit without having to redefine the whole system. However this approach carries with it substantial problems. Large tax-benefit models are normally defined with short variable names which cannot be understood by the unfamiliar reader. Concepts like
6. FEATURES OF A PLURALIST MODEL

"Child Benefit" may be expressed by cryptic names like "CB1". When a program has many hundreds of these variable names it becomes almost impossible for a newcomer to alter part of the program without running the risk of making serious mistakes. Unless the user understands the whole program from beginning to end, the alteration of parts of it may cause unforeseen and sometimes unexpected mistakes. One hears comments from some of the existing model-builders such as "the program is absolutely vast I don't think there is any one who understands the whole thing all the way through". Some one else operating one of the major models said "the problem with the way we define our language statements at the moment is that they are uncheckable".

In order to solve the usability/flexibility dilemma it was necessary for a new language to be written which would be specifically adapted to the requirements of tax-benefit modelling. This language is much closer to natural language than any of the programming languages used in the model described in chapter two (with the exception of the language used for entering policies into the DHSS Policy Simulation Model). POM is sufficiently close to English for someone to read a policy definition which they have never seen before and understand it without reference to a specialist manual. To illustrate this point compare the fragment of the pascal program in figure 6.1 to the PSL statement in figure 6.2. POM is supplied with a set of definitions of all the major taxes and benefits in the British system. These definitions are sufficiently comprehensible to the new user so that the dangers of causing unexpected mistakes by altering them are small enough to be acceptable.

POM is in effect a synthesis of the source code and object code approaches. The user is required to enter new equations in source code (or to adapt old ones) but
6. FEATURES OF A PLURALIST MODEL

many of the features of POM never need to be altered. The procedures which produce output tables and handle the data, for example, never need to be altered by the user and cannot be as these are supplied in the form of object code. In fact the entire program is supplied in the form of object code, and although the user is required to enter policy definitions in the form of source code this source code is not transformed into object code through the use of a compiler. POM uses an alternative procedure which is described below.

6.2.2 Interpreted Code vs Compiled Code

With the existing object code programs the user's policy choices are severely restricted by the menu system. For example, the user may enter a new number to alter a benefit or tax rate. With POM the user can define a new policy by typing in a statement such as that shown in figure 6.2. POM has a built in screen editor to allow the user to do this. This editor has the normal features of a word processing program. The user can move the cursor about the screen, search for words, delete lines, and save information to a file and read the file at a later date. In addition it has a series of pop-up menus containing the names of all the variables and their associated value labels. This is described more fully in the "User Interface" chapter. When the user has written a given statement it is not translated into object code to become a separate program. Instead a two stage process takes place.

First the statement is "parsed". This term is derived from the concept of parsing in English literature: the analysis of a sentence's grammar. The parser checks that the statement is correct in terms of the grammar accepted by PSL. If it is an acceptable statement in PSL then it can be used as a mathematical equation.
If the statement is not correct then an error message will be shown on the screen. Schneiderman's (1982) research on error messages indicates that several design choices should be taken with respect to error messages in order to make them acceptable to the novice programmer. The error messages should be shown in upper and lower case to aid legibility. If there is a problem with a user-created variable name then this should be displayed as part of the error message. For example, if the user writes the statement "Income = Savings + Consumption" and the term consumption has not been defined previously, some parsers would simply say something like "Unknown Symbol". Ideally it should say "Error: 'Consumption' is an unknown symbol." POM's error messages have both these features. In addition POM's error handling has copied one helpful aspect of the computer language Turbo Pascal (Borland, 1987). When the user presses a key to remove the error message from the screen the cursor is placed in the user's text at the point where the error occurred.

As the user's statement is parsed each of the terms in the equation is transformed into a number which is stored in an array. The numbers in this array form a set of computer instructions called pseudo-code. The pseudo-code is then passed to a mechanism within the program which operates on this pseudo-code to calculate the result of statement for each case within the data set. As the interpreter operates on each case (be it an individual, a tax unit, or household) it writes the result of the equation to a file so that for each case there is an answer which is saved on the disk.

The advantage of using a parser and an interpreter was that it was possible to construct a mechanism for checking the syntax of the PSL statements and computing their results entirely within POM. There was no need to exit from POM and transform the PSL statements into
6. FEATURES OF A PLURALIST MODEL

object code using a separate compiler program.

6.2.3 Iteration
Several steps have been taken to avoid some of the aspects of computer languages which make them difficult for novices to learn. Consider the problem of iteration (the performance of repetitive tasks). In a computer language one needs to use some kind of control structure to achieve this. Figure 6.1 shows a fragment of Pascal which could be used to calculate a household's total household income (this fragment of code has been written specifically for this illustration).

It is no exaggeration to assert that even this small procedure would seem very threatening to someone who is not familiar with computer languages. In lines 2 to 15 of figure 6.1 the constants, variables and data structures to be used in the procedure are declared. The information about incomes is stored in a record called household_variables. In lines 18 to 26 the control structure for iteration is defined. The "Repeat" word in line 18 begins the iteration and everything between it and the "Until" word is repeated until the last member of the household is found. In line 26 there is a test to see if the last member of the household has been reached. It is assumed for the purposes of this procedure that every member of the household has a valid value recorded for the variable "sex" and that if this variable is missing then the last person in the household has been reached.

Figure 6.2 shows an equivalent procedure in PSL to compute total household income. No variable declarations are necessary in PSL. The new variable "Total_Income" on line 1 does not need to be declared on a separate line as it does on line 15 of Figure 6.1. However once it has been assigned a value as in line 2 it cannot be re-
assigned a value in a later equation. If the user attempts to create a variable and inadvertently gives it the same name as one which has already been created, the program will display an error message indicating that this variable name has already been used. This prevents a common type of error in programming. Solway, Ehrlich, Bonar, and Greenspan (1982) found that of a sample of novice programmers some 27 per cent "mushed" variables (i.e. they used the same variable incorrectly in two roles). It is of course possible to use a variable once it has been created in PSL. However it can only be used to help assign a value to another new variable; it cannot acquire a new value itself. The income variables "Earnings" and "Investment_Income" are displayed in special "pop-up" windows by POM. Thus they are do not need to be declared in a formal way as they are in line 6 to 14 of figure 6.1. The term "Total_Household" is a function which has been specifically designed for PSL. The term "Total_Household" is always followed by a pair of brackets which contain a mathematical expression. The result of this expression is calculated for each member of the household and then the sum of these results is then returned as the answer. (The total income equations in figures 6.1 and 6.2 are purely illustrative. In practice pensions, annuities, and benefits would have to be included in a total income calculation).

The use of various functions of this type makes it possible to avoid the use of any control structures in PSL for the purposes of iteration. This saves the potential user a great deal of confusion. In the language Pascal, for example, there are three different control structures to perform iteration: the "While ... Do" construct, the "Repeat ... Until" construct, and the "For X := Y to Z do" construct. Studies of the experiences of people learning computer programming for the first time indicate that control structures are a
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major problem for them. Solway, Ehrlich, Bonar and Greenspan (1982: 29) conducted a study of programming students and found that

The errors in the students programs stemmed from two main sources: students had difficulty with the syntax and semantics of various programming language constructs, and they had difficulty determining which constructs to use and how to coordinate them into a unified whole.

The approach used by PSL avoids any need for the user of POM to deal with control structures when defining a tax or benefit.

The abolition of control structures for iteration means that PSL programs are linear in form. Someone reading a series of PSL statements would see a series of sentences which follow each other in a logical sequence down the page as if one were reading a book. This is entirely different from a program with loops or other iterative control structures. In this case the reader must frequently go back to the beginning of a loop in order to understand the flow of execution of the program. With PSL however, the reading and comprehension is likely to be much closer to the user’s experiences of reading normal literature, with statements following each other in a sequential linear order. Research by Allen (1982) indicates that this may well accelerate the learning process for novice users of PSL. Allen conducted an experiment which involved a sample of students defining a computer task in their own natural language. He found that

"the natural language solutions almost never included variable declarations, data type
6. FEATURES OF A PLURALIST MODEL

specifications, or dimensioning of arrays. Moreover natural language almost always followed a linear structure.

(Allen, 1982: 10).

6.2.4 Branching

The ability of a computer program to perform different operations in different circumstances may be referred to as "branching". This is one of the most powerful aspects of computer programming and can be performed in a number of different ways. PSL's approach is to use an "if ... then" construct. In English this might be used as follows. "If taxable income is less than 15,000 pounds per annum then Income Tax equals 25% of Taxable Income". In PSL this could be expressed as follows:

\[
\text{If Taxable_Income > £ 15000 per annum then}
\]
\[
\text{Income_Tax = 25% of Taxable_Income.}
\]

This is not so far from English as to be too threatening to the novice user. To perform multiple branching the construct is extended to "If...Then...Else", with a further expression following the else. The user can places as many "Else If"s (with corresponding expressions and conditions) as are desired. An alternative method of branching are constructs which resemble the Pascal Case construct. Figure 6.3 gives an example of this which assigns political party colours according to party affiliation. There is a similar construct known as a "switch" in the language C (Allan, 1985).

Research evidence exists to support the view that branching is best performed by the "If...Then...Else" construct rather than by programming devices like the case statement shown in figure 6.3. Allen (1982) conducted a series of tests to find out how a sample of people would specify a computing task in their own
6. FEATURES OF A PLURALIST MODEL

natural language (rather than a computing language). A survey of these specifications showed that "... natural language ... follows a ... structure with branching only by if-then statements" (Allen, 1982: 10). PSL achieves this object.

Figure 6.3 Example of a Pascal Case Statement

```
Case Party_Affiliation of
    Conservative : Colour := Blue;
    Labour : Colour := Red;
    Democrat : Colour := Orange;
end;
```

6.3 Policy Output
Chapter 3 outlined a problem which is common to all computer models of tax-benefit policy except the PSI model which is based on a statistical analysis package. This is the problem of constraining the user to a narrow range of output tables. Any specific set of output tables will embody a set of value judgements by the person who selected them. This presents a flexibility problem similar to the dilemma of entering policies through a menu system. Just as the menus will exclude certain policies, a system of predetermined output tables will exclude the possibility of examining policies according to certain criteria.

POM allows the user to analyse policies according to any of the variables contained in the data set. A typical table produced by one of the existing models would be to show the average income before and after a policy change for a set of family types. In POM however one could analyse the policy change according to family types or by region, housing tenure, or any other variable. The
variables which make up the row or column headings can be selected by the user. Continuous variables (that is those which do not have a small number of named categories like regions) can also be used as row or column headings if they are first transformed into a new variable with a small number of categories.

POM thus solves the flexibility of output problem by giving the user a tabulator which allows the standard forms of output but also allows the user to go beyond these by specifying tables with any combination of row and column variables which exist within the data.

The variables which are to be displayed in each of the cells of the table may also be chosen. These can be shown as averages, cell counts, column percentages, row percentages, or percentages of all cases. The user may also request to see the averages of two different variables shown in the same cell. This is useful for comparing the income of cases before and after a policy change.

The flexibility of POM's tabulator is just as important as its policy input mechanisms in making POM a model which is suitable for a pluralist society.

6.4 Equipment
Chapter one indicated the problems which would arise for a small pressure group attempting to use the Family Expenditure Survey (FES). One of the most important of these would be the the FES is supplied in a format which is suitable for expensive main frame computers rather than small micro-computers. If POM was designed to work on a main frame computer this would militate against its effectiveness as a pluralist tax-benefit model. The computer resources of opposition parties and pressure groups would make a main frame based program relatively
useless as they tend to have nothing more expensive than micro-computers at their disposal.

Once the decision to make POM compatible with a microcomputer was accepted, it was still necessary to select a type of micro-computer to use. When the current project started in 1985 two types of micro-computer were clearly more numerous than their rivals. In worldwide terms there were over three million each of the IBM personal computer and the Commodore 64. Their nearest rivals among the other micro-computers all existed in quantities of less than a million. The Commodore 64 had to be ruled out on the grounds that it was primarily designed to be used for entertainment in the home. Its Random Access Memory was only 64 Kilobytes and it was rarely used in conjunction with hard disk drives (which were necessary for storing a sufficient quantity of data from the FES). The IBM personal computer (PC) are owned by many pressure groups and academic institutions micro-computers made by other companies which were sufficiently close in design to be able to run the same software.

One other computer equipment choice flowed from a decision to give the user a quick and flexible method of communicating with the computer, in addition to its keyboard. POM has been designed so that it can be used in conjunction with a Mouse (a hand held pointer which can be rolled around a desktop to move a corresponding pointer around the computer screen). The decision to include a mouse was to encourage the users of POM to create variable names sufficiently long that they can fully describe the concept that they represent. The requirement to use self-explanatory variable labels is crucial in creating an environment in which the user will create programs which will be comprehensible by other people. The mouse allows the user to point at a term like "Self_Employment_Income" and insert it into the text.
by pressing a button on the mouse rather than typing each letter in at the keyboard.

It was found that the Family Expenditure Survey data (see below) used by POM occupied between 1 to 1.5 megabytes of disk space. This exceeds the capacity of floppy disk drives so it was decided to use POM in conjunction with a hard disk.

The most economical method of acquiring such hardware which was consistent with these decisions was through the purchase of an Amstrad 1512 computer. This comes with a Microsoft compatible mouse. To this a 20 megabyte Seagate Hard Disk Drive was added. The Amstrad’s 512 Kilobytes of Random Access Memory were increased to 640 Kilobytes by the addition of sixteen memory chips.

POM was created using the version of Pascal produced by Borland International: Turbo Pascal. There are currently over 400,000 Turbo Pascal users worldwide (Borland, 1987) which may make it the most widely used compiler in existence. Turbo Pascal provides a quick and efficient compiler. The source code for a full screen text editor is available with Turbo Pascal which was used for the construction of POM’s text editor (though many new features were added to this, such as pop-up windows of variable names).

6.5 The Data
The data which POM performs its analyses on is taken from the Family Expenditure Survey. This is the data set used in all of the existing tax-benefit models based on survey data with the exception of the Inland Revenue Personal Income Tax Model which uses the Inland Revenue Survey of Personal Incomes. The Survey of Personal Incomes would have been unsuitable because it excludes people whose taxable incomes are below the tax threshold (which
includes nearly all of the unemployed and many people in receipt of in-work benefits). The FES was selected in preference to other surveys which include income data such as the General Household Survey because it is the only survey which has both expenditure data and income data. Excluding expenditure data would have precluded the possibility of modelling the effects of indirect taxes like VAT.

6.5.1 Structure of FES
The households included in the FES are selected by a complicated method which combines elements of random selection and stratification to ensure that different regions and types of area within the country are selected.

Selecting households from the FES is a four stage process. The first stage is to select Primary Sampling Units (PSUs) from among the "administrative areas" of Great Britain. For the purposes of the FES these areas are taken to be the district councils in Wales and Scotland (but excluding Scottish islands), and the district and London borough councils in England. This gives a total of 455 areas (Kelmsley, W.F.F., Redpath, R.U., Holmes, M., 1980).

In each three month period 168 PSUs are selected from these areas. In order to make the selection the areas are allocated to a number of categories according to two criteria. The first is a definition of region which is taken to be the eight standard regions of England, three subdivisions of Wales, and four subdivisions of Scotland. Within these geographical regions the areas are further subdivided according to a categorisation of area type. One category consists of Metropolitan Districts, London Boroughs, and the Strathclyde Region. A further three categories are defined as the remaining councils
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separated into those with a population density under 0.9 people per acre, those with a density higher than 3.2 people per acre, and those areas with densities between these two levels.

Once the administrative areas have been divided into these secondary categories a calculation is done which estimates the proportion of the British population which resides in each secondary category. The 168 Primary Sampling Units are then allocated to these secondary categories according to the proportions of the population in each. Inevitably, the number of PSUs does not exactly match the number which would result from multiplying 168 by the population proportion for a particular secondary category. In these cases the nearest whole number is selected. For example, the theoretical number of PSUs in the Metropolitan District category of the Northern Region of England would be 3.71, whereas it is in fact allocated 4 PSUs. It is admitted that these differences entail "slight distortions in the selection probabilities". Some of these secondary categories have a population so small that they can be represented in the sample by one PSU, then there is no further categorisation. Where there is more than one PSU in a secondary category then the secondary category is further stratified according to the proportion of residences with a rateable value over 400 pounds. So the aforesaid Metropolitan District Category of England's Northern Region (with four PSUs) would have its district councils subdivided into different groups based on the rateable value criterion. The bands of the proportion of rateable value would be determined so that there should be roughly equal numbers of councils in each of the four PSUs.

The result of this process is to divide the 455 administrative areas into 168 categories. In each quarter one area is chosen from each of these 168
6. FEATURES OF A PLURALIST MODEL

categories using random numbers. Each selection from a category is independent of any previous selections.

When the PSU has been selected four Secondary Sampling Units (SSUs) are selected. Thus there are 672 SSUs. These are local government wards. They are selected randomly within a process which ensures that the chance of selection is proportional to the ward’s size.

The next stage is to select 16 addresses from each SSU. This gives a quarterly total sample of 2,668 addresses. The sampling frame is the electoral register. Selection at this stage is truly random. The number of electors is divided by 16 to give a sampling interval. A number is chosen at random to select the first address. The remaining households are selected by adding multiples of the sampling interval to the original random number.

This sampling process produces a yearly total of 10,752 addresses. Roughly 5-6 per cent of these addresses are then excluded due to the impracticability of obtaining meaningful data from them. There are a variety of reasons why addresses are so excluded. Some have no full time residents as they are holiday homes. Some are empty. Some represent a mixed domestic and commercial use such that it would not be possible to separate normal household spending from its business spending.

6.5.2 Standard Errors and Design Factors

The usual standard error equation for sample surveys may not be appropriate for the FES because it is not a simple random sample. In order to take account of the stratified and clustered nature of the FES a more complex measure of accuracy needs to be used. Figure 6.4 gives a selection of the percentage standard errors of the FES measured by both the usual standard deviation equation and by a formula which takes into account the complex...
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sample design. The difference between these two sets of figures is not so great as to indicate that POM should not illustrate the significance of results by the use of simple standard deviation equations.

Figure 6.4 Measures of Accuracy for the Family Expenditure Survey

<table>
<thead>
<tr>
<th>Percentage Standard Error</th>
<th>Percentage Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Formula</td>
<td>Stratified Formula</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Standard Formula</th>
<th>Stratified Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Fuel</td>
<td>1.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Food</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Alcohol</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Tobacco</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Clothing</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Durable Goods</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>Other Goods</td>
<td>1.4</td>
<td>1.7</td>
</tr>
<tr>
<td>Transport</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Services</td>
<td>2.2</td>
<td>2.4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>4.5</td>
<td>4.8</td>
</tr>
<tr>
<td>Total</td>
<td>0.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Source: Dept of Environment, 1978

6.5.3 Response Rates
The FES requires income and demographic data about the entire household and requires each person over 16 to keep a diary for two weeks of their personal expenditure. Given the essentially private nature of much of this information it is not surprising that a substantial
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A proportion of the sample refuse to cooperate. A payment of five pounds is offered to each person who keeps a diary of spending. However it is not thought that the size of this incentive payment is the crucial factor in maintaining the response rate. It is also thought to be difficult to motivate individuals to comply in order to support its general aims. Many informants probably agree to keep and maintain records more to please the interviewer personally than in pursuit of some ideal statistical purpose (Kelmsley, W.F.F., Redpath, R.U., Holmes, M., 1980).

Of those households which failed to provide usable data the overwhelming cause was refusal to cooperate with the Survey. A much smaller proportion promised to comply with the survey but did not do so, an even smaller proportion could not be contacted at all. For illustrative purposes consider the 1978 figures: 27.1% refused to cooperate with the survey, 3.8% promised to cooperate but did not do so, and 1.2% could not be contacted. This resulted in a response rate of 67.8%. Most of the response rates in the decade of the 1970s varied in the range 68% - 70%.

Much attention has been paid to the problem of differential response within the FES. This is important because a bias enters the survey results if specific types of household are under-represented. Some early studies based on data from 1964 to 1966 showed that the response rate to the FES tends to fall as rateable values rise, but tends to increase the more people there are in the household.

The most thorough examination of response bias was based on the 1971 Census returns. This meant that it was possible to examine the census returns of all the households sampled for the 1971 FES whether they
6. FEATURES OF A PLURALIST MODEL

cooperated with the survey or not (Kelmsley, W.F.F., Redpath, R.U., Holmes, M., 1980). In 97 per cent of cases the Census Offices were able to identify the addresses provided by those in charge of the FES. The most significant results of this comparison were as follows:-

Much the most striking result was the variation in response with the age of Head of Household or of the housewife; there was a regular decline in response of about 2 per cent for each increase of 5 years of age, ranging from a response over 80 per cent for persons under 30 years to below 65 per cent for those above 70 years. Households without children produced a response rate of about 66 per cent while those with children had a rate of 75 per cent or more. Another breakdown displaying considerable variation was that of employment status of Head of Household; employees other than managers showed a response of 72 per cent or over, while for self-employed those with employees produced an average rate of only 56 per cent, and those working on their own rate of 63 per cent.

(Kelmsley, W.F.F., Redpath, R.U., Holmes, M., 1980:30-31)

These differences in response rates were thought to be sufficiently important for the DHSS to adjust for them in its tax-benefit simulations. When predictions of the effects of a tax-benefit change are produced by the DHSS, households are multiplied by differing factors which take into account their over or under-representation within the FES. A similar, though more complex, procedure is
6. FEATURES OF A PLURALIST MODEL

used to adjust for response bias within the LSE's TAXMOD package.

Ideally, a future version of POM should have facilities for correcting for response bias. Due to constraints of time, it has not been possible to include these in the current prototype version.

6.5.4 Reliability of the FES

A number of research projects have been undertaken in order to assess the reliability of the FES.

One of the approaches has been to measure how many of the answers to the FES could be given exactly as opposed to answers which could not be remembered, had to be estimated from memory, or had to be altered by the surveyor after the event (for example, when the respondent gave the wrong value for some item of standard cost such as the television licence). A study based on this technique was done in the fourth quarter of 1978. 1,648 households from that year's FES were used. In each case the interview schedule was marked to indicate if the respondent did not know an amount, needed to estimate it, or it had to be corrected after the event. On average the respondents were able to determine exactly 93 per cent of the questions on the household schedule. However there was difficulty with particular forms of payments which were not straightforward. Gas and electricity payments were complicated by standing order payments, special budgeting schemes, and slot meter rebates. Only 83 per cent of electricity and gas payment questions could be answered exactly. A similar problem arises with credit card transactions because of the complexity of measuring the balance brought forward from a previous account, the interest charged, and the amount outstanding. Only 87 per cent of credit card questions yielded exact determinations from the respondent.
Similar problems arise with some of the income categories. 19 per cent of the self-employed said they did not know the amount of their profit and another 15 per cent had to estimate it. Investment income was similarly problematic. In only 60 per cent of cases was there a direct answer about the amount of annual interest. Of the remainder 11 per cent estimated the amount and 29 per cent said they did not know.

The other main approach has been to multiply the FES information so as to provide national estimates for the different categories of income and spending and then compare these results to macroeconomic data collected for the National Income Blue Book (NIBB). This data is collected by entirely different techniques as described in the United Kingdom National Accounts Sources and Methods, HMSO, London (CSO, 1985). To the extent that the National Accounts data is collected separately it is useful for cross-checking. The estimates of individual categories of spending makes use of surveys of the turnover of retailers and other traders. It also uses figures on the supply of specific commodities such as the estimates of gas and electricity supplied by the gas board and the electricity board. However to some extent the National Accounts estimates make use of sample surveys like the FES, so to this extent comparing the FES to another set of statistics which are partly based on the FES may be of doubtful value. The national accounts income data are also based on a variety of sources. Here is an illustrative, rather than exhaustive list of sources. A one per cent sample of PAYE returns and other Income Tax records is used to estimate the income from wages, salaries, and self-employment. However for incomes below the tax threshold the National Accounts rely on the FES. Income received by groups which are badly covered by the Income Tax system like farm workers
6. FEATURES OF A PLURALIST MODEL

is estimated by separate surveys of income by the Ministry of Agriculture Fisheries and Food. Armed Forces pay estimates are supplied by the Ministry of Defence.

This comparison with National Accounts indicates that certain commodities are under-recorded in the FES such as alcohol spending where the grossed up FES figure is only 58 per cent of the NIBB total, tobacco which is 21 per cent less, and durable goods which are also 21 per cent less (Kelmsley, Redpath, Holmes, 1980). Several theories have been advanced to explain these discrepancies.

It is possible that the respondents falsify the reports of their spending on tobacco and alcohol because of the social stigma attached to such spending. There is some evidence to contradict this view. In 1976 a project called the Family Budget Survey Experiment was carried out which required the respondents to record their spending, but also to balance their income and expenditure over the period. The process of matching income and outgoings would have made it impossible for the respondents to conceal alcohol and tobacco spending (without some complex action to under-record other items). The results of this survey did not show significantly different spending patterns from the FES.

Another explanation of the discrepancy between the FES national estimates and the NIBB figures may be that in making the comparison there has been an underestimate of the proportion of NIBB alcohol and tobacco spending which is due to business and institutional spending rather than personal spending. As the NIBB figures cover all expenditure an adjustment has to be made to identify the quantity of spending which is due to the personal sector.

It is also possible that the process of keeping a diary of spending makes respondents think more carefully about
6. FEATURES OF A PLURALIST MODEL

their budgeting and alter their behaviour by spending less on alcohol and tobacco.

Under-reporting of investment income data may occur because the respondents feel that this is too confidential a subject to give information about. About 20 respondents per year refuse to answer all the questions on investment income on the grounds of privacy.

Much of the discrepancy between NIBB figures and the grossed up FES estimates is probably due to response bias, the difficulty of adjusting the National Accounts Totals so that they represent only the domestic sector the problems of research design (such as the failure to include major capital purchases in the 14 day survey period). Ideally, POM should also include facilities to adjust the data for these imperfections in the FES.

6.5.5 Data Storage by POM

POM operates on the 7081 households drawn from the 1984 FES, which was the latest year that FES data was available at the time of POM's construction. A selection of the most important variables was taken from the survey. The values for each of these variables is attached to records for each individual within the household. This means that benefits or taxes which affect individuals can be analysed as well as those which affect households. This would allow, for example, a thorough analysis of the Community Charge as well as the existing local tax rates.

The data is stored in the inverted matrix format described in the section on the IGOTM model in chapter 2. The main reason for this is that the data may be stored in a far more compact form by "run-coding" the data so that sequences of identical values are compressed. This has meant that the data for the 7081 households has been
6. FEATURES OF A PLURALIST MODEL

compressed from four megabytes to roughly one megabyte.

6.6 Conclusion
This chapter has outlined the broad design decisions that were taken in the construction of POM. In the following chapter the structure of POM is described in more detail.
7. STRUCTURE OF THE PROGRAM

7.1 Introduction
The previous chapter explained in general terms the reasoning behind the design of the Policy Option Model. This chapter gives a detailed explanation of the features of POM which enable it to combine flexibility and usability. In so far as this chapter gives a technical description of the workings of POM it will inevitably be heavy going for the non-specialist reader. However there has been a strenuous effort to explain technical terms where they are used. While the non-expert reader may find the meaning of the text hazy in places it should never be opaque.

The sections in this chapter follow the steps a user would go through to simulate a policy, starting with the initialisation of the data when POM is first invoked from the computer’s operating system. It continues through the process of specifying a policy, calculating the effects on each case, and finally producing a table to show the effects of that policy. The specific arrangement is as follows. Section 7.2 gives a general overview of the structure of the program. Section 7.3 explains the way the data is stored and section 7.4 shows how this data is prepared for use when the program is first started. Section 7.5 describes the editor. 7.6 outlines the features of the computer language which has been designed for POM, the Policy Simulation Language (PSL). Section 7.7 describes the Lexical Analyser, POM’s mechanism to read the words and numbers which the user enters on the screen. Section 7.8 describes the Parser which checks that the user supplied statements are correct and translates them into a numerical format which POM can use to perform calculations using the interpreter, which is explained in section 7.9. Section 7.10 describes the mechanism for producing output tables, the Tabulator. Section 7.11 concludes the chapter.
7. STRUCTURE OF THE PROGRAM

7.2 Overall Structure

Here is a brief overview of the mechanisms within POM which allow the simulation of policies. They are shown in the order in which they would be needed to simulate a policy.

Firstly, there is a full screen text-editor which allows the user to type in a set of tax-benefit equations at a computer keyboard with the aid of a mouse to enter long variable names.

Secondly, there is a parser and interpreter which translates these equations into a form which is comprehensible by the computer, calculates the answer to each equation, and writes the resulting answers to a file.

Thirdly, there is a tabulator which constructs tables to show statistics about selected variables.

An overall impression of POM's structure can be seen in Figure 7.1 below. Figure 7.1 follows the conventions of a "Warnier-Orr Diagram" as defined by Higgins (1979). Describing any large program in diagrammatic form is necessarily complex. The Warnier-Orr diagram attempts to preserve as much detail as possible while presenting the concepts in an understandable way. As one reads from the top to the bottom of Figure 8.1 one sees the order in which the tasks must be completed. As one moves from the left to the right one goes from the more general to the more specific descriptions of each task. The left hand side of figure 8.1 shows that the beginning of the task is to enter the tax-benefit rules through the editor. The second stage is parsing and interpreting these rules, and the third stage is making a table or tables. Each of these stages is described in a separate section below.
First it is necessary to consider the information which POM is based on.

7.3 Data Storage
POM uses a method of data storage similar to that employed by the IGOTM model. Each variable is stored in a separate data file. The data is stored in such a way that long sequences of the same value are compressed, in the manner described above in the section about the IGOTM model in chapter 3.

To understand how this compression is achieved consider the following series of numbers:-

\[0,0,0,0,0,0,0,0,0,0,0,0,0,0,75,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,\]

Clearly there is much wasteful repetition. POM could store this series as follows:-

\[255,18,0,75,255,11,0\]

The number 255 is an example of a "run marker", which means that the following two numbers have a special significance. The number immediately following a run marker shows the number of times a given value is repeated. The following number is the value itself. This is particularly useful in the case of benefits such as the mobility allowance which are only received by a small proportion of the population. Although there is a separate value for each of the 18,558 individuals in the sample, the mobility allowance data file is less than a tenth of the size of the larger files for variables like age because there are very few cases where two consecutive people have the same age.

The individuals within the file have been sorted into
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Figure 7.1 The Overall Structure of PCM

- Define a Tax-Benefit System
- Create a completely new system (1,0)
- Edit an existing set of rules (1,0)
- Test Tax-Benefit System and Observe Its Effects
- For Each Rule Within the Model (1,c)
- Produce Output Tables
- Write Beginning of Table
  - For Each Row of the table (1,r)

Use Screen Editor to Write new rules.
- Write a User-Defined Variable name followed by a statement
- Read an existing Set of Definitions Stored on Disk and Modify then.
- Parse the Rule
  - Interpret the Rule
  - For Each Household in the data set.
  - After interpreting the rule write answer to a new variable file
  - Finish Creating the User-Defined Variable.
- Define Columns and Rows of the Table, and values to be shown
  - in each cell of the table
- Read the data case by case and then determine which column and row the case fits into.
- Write overall table title
  - Variable Labels and Column labels
  - Write Row Label
  - Write the cell contents

NOTES
Some letters are used to represent variables controlling iteration within the program.
For example, "(1, h)" may be understood as "from one to the total number of households". "r" denotes the number of rows in the table; "c" the number of columns; and "d" the number of definitions in the model.
order so as to preserve the relationships between different family and household members. All of the cases within the same household are stored together. Within this grouping the cases are sorted into different tax units, with the head of household’s tax unit at the beginning. To illustrate this consider the case of a married man with three school age children and two older children in employment who count as separate tax units. The married man, his wife and three younger children would be the first five cases, and the two working children would be the last two cases in the household. Within each tax unit, people are sorted into order with the head of tax unit the first case, the wife as the second case, and dependants under the age of 25 coming afterwards.

7.4 Data Initialisation
Though the process of initialising the data is not intended to be noticeable by the user, it is important to understand how this is done, if one is to comprehend the structure of the program. When POM is first invoked from the computer's operating system, a message will appear at the top of the screen requesting the user to wait while the essential information about the data is read into the computer's memory.

What is happening at this stage is that a series of lists of file names is read into the computer's memory. Each of these file names refers to a separate variable. For example, the file "RELHOH.BYR" contains the data about the relationship to the head of household for each individual in the data set. At the beginning of each file there is a "header" in which salient details about each variable are stored. When POM is first invoked the header of each variable is read into POM's array of variable information. POM stores three important pieces of information.
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Firstly, a long descriptive variable label is read in (e.g. Relationship_To_Head_Of_Household). This will be the name that will appear in pop-up windows which are described in the user interface chapter.

Secondly POM will read the file header to see if there is a set of value labels which apply to the variable. In the case of "Relationship_To_Head_Of_Household" this is true, so each of the value labels and the number they represent will be stored in POM's memory. For example, the number "0" refers to "Head Of Household", within "Relationship_To_Head_Of_Household". Each value label and the number which corresponds to it is read into memory until POM reaches the end of the list of value labels.

The third crucial fact about each variable is the number of cases which have been written to the file. The number does not vary for the raw data variables from the Family Expenditure Survey. Each of the raw data files has information about 18558 individuals. However, the user has the ability to experiment with a smaller number of cases. This means that a user-created variable might only contain information about the first 100 people in the data set. Obviously, it would be a serious mistake for the user to create a variable which needed to access other data files with a smaller number of cases. Therefore POM will check to ensure that this does not occur - by looking at the case number which is stored in the header block, each time a variable is used. After the case number the file stores the data itself.

The final stage of data initialisation involves creating the pop-up menus for each type of variable. The individual level variables, tax unit variables, and household variables are all stored in separate arrays.
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Once they have been stored in an array, they are sorted into alphabetical order.

This data initialisation sequence means that the user has access to all of the variable names and value labels from the outset. Not only are the names and labels of the original data variables available, but also any variables created during a previous session of using POM.

In addition to the variable array, POM also creates a file array which can hold the values of data which are being read from the disk. When POM is first invoked the file array is empty. It is like a set of folders ready to have files placed in them. When the first file is opened its information is stored in the first element of the file array, when the second data file is opened it is stored in the second element, and so on.

7.5 The Editor

The users of POM are given a facility for writing a set of rules to define their policies. This takes the form of a full screen editor which is based on a standard set of editor routines produced by the company Borland International. For further technical details about these refer to Borland (1985).

Refinements have been added to the standard editor to allow the user to consult lists of variable names and value labels. These names and labels are read into the computer's memory during the data initialisation process described above. Variable names and value labels may be inserted into the text through the use of a mouse or the cursor and return keys. The editor part of the program is described at greater length in the user interface chapter and in the user manual (Annex A). Reference should also be made to chapter 10 or the user manual for information about how commands are invoked from the
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keyboard.

7.6 Policy Simulation Language
This section will not attempt to provide a full technical specification of the Policy Simulation Language (PSL). A full account is given in the user manual in Annex A. Chapter six outlined the broad strategy of PSL, which allows the user to undertake computer programming without any complex structures for branching ("If ... Then" decisions) and abolishes all need for iteration constructs. This section describes some of the features of PSL which no other languages have in layman's terms without attempting an esoteric description of the computer programming which was necessary to achieve them.

7.6.1 Policy Simulation Functions
PSL has six functions which perform actions on entire households or tax units. They consist of three pairs of functions. Each pair of functions performs the same action at two different levels of analysis - the Household Level and the Tax Unit Level. In the following discussion the term "case" is taken to be a generic term for the unit of analysis and may refer both to households and tax units.

The "Any" functions ("Any_In_Household" and "Any_In_Tax_Unit") process each person within a case until a specific set of conditions is true for any person. For example, the following statement would be acceptable in PSL:--

Single_Parent = True if Head_Of_Household's
              Marital_Status = Single and Any_In_Tax_Unit(Age > 18).

In this case POM will examine each person within the tax unit to find if any of them are under 18. If none of them are it will return the value false. If one of them
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is it will return the value true, if the head of the tax unit is single. After one person has been found who matches the appropriate characteristics the function will stop executing.

The "Total" functions ("Total_Household", "Total_Tax_Unit") must be followed by an equation enclosed in brackets. POM will calculate the result of the equation for each person in the case and add the value of these results together across the entire case. For example the following:

\[
\text{Household\_Income} = \text{Total\_Household} \\
(Earnings + Investment\_Income + \\
Pensions + Self\_Employment\_Income + Benefits)
\]

would calculate the total income for every member of the household.

The "number" functions ("Number\_In\_Household", "Number\_In\_Tax\_Unit") are followed by a pair of brackets containing a set of conditions. These functions will keep examining the circumstances of every person in the case until the last person has been found. Unlike the "any" functions they will not stop when one person matches the given conditions. This can be very useful in counting people who match a given set of complicated conditions, such as those people who are considered to be adult non-dependants for the purposes of Housing Benefit. The following statement attempts to identify adult non-dependants by counting those who are not the head of household but are heads of their own (different) tax unit.

\[
\text{Adult\_Non\_Dependants} = \text{Number\_In\_Household} \\
((\text{Relationship\_To\_Head\_of\_Household}<>\text{Head\_Of\_Household}) \text{ and} \\
(\text{Relationship\_To\_Head\_of\_Tax\_Unit}=\text{Head\_Of\_Tax\_Unit})).
\]
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7.6.2 Policy Simulation Operators

PSL supplies various operators which carry out mathematical tasks in such a way as to make PSL statements closer to English descriptions of tax benefit policy.

For example, there is a "Per_Annum" operator which divides the number preceding it by 52. The resulting value can be used in conjunction with the Family Expenditure Survey (where monetary values are weekly amounts) without the need to perform a division in the statement supplied by the user. This helps to preserve readability. For example, in most computer languages one would need to assign a value to the single person's tax allowance as follows:

\[
\text{Single_Persons_Allowance} = 50.09
\]

whereas in PSL it can be written as

\[
\text{Single_Persons_Allowance} = £ 2605 \text{ Per_Annum}.
\]

It should be stressed that the division by 52 is performed by POM once at the start of processing the data; the use of "Per_Annum" does not lead to the computing inefficiency of performing the division for each case in data set.

It is also useful to note the pound sign "." in front of 2605. This indicates that the following value is a figure in pounds. As the FES stores monetary values in tenths of a penny the concept of 2605 pounds would otherwise have to be written as "2605000", which is obviously less readable.

The pound sign and the "Per_Annum" are examples of
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"unary" operators because they only carry out actions on one number unlike, for example, the addition operator "+" which must have two values to calculate the total of. In the sense of being unary operators the pound sign and "Per_Annum" are similar. In terms of the order in which they are placed within an equation they are totally different. The pound sign precedes the value it operates on, and is therefore a "pre-fix" operator. "Per_Annum" follows the value it operates on and is therefore a "post-fix" operator.

PSL has a further post-fix operator the percentage sign ";%". This operator checks to see if the number preceding it is between 1 and 100, and if so it divides the result by a hundred (so 96% would become 0.96). This device has been included within PSL purely in order to preserve the readability of PSL to non-experts. Though the programmer saves little time by typing in 25% rather than 0.25, there can be little doubt that most people think of the basic rate of tax, for example, as 25% as opposed to 0.25.

In addition to these post-fix and pre-fix operators, PSL also has the more usual operators which operate on two values and are placed between them such as "+", "-", "*" (multiplication), and "/" (Division). "Of" may be used as an alternative to the multiplication operator more familiar to programmers "*". Such operators are termed "in_fix" operators. One special operator which has been developed for PSL is "Less". "Less" is like the subtraction operator except that it cannot return a value less than zero. This is useful in many situations. Take the case of an equation to define the taxable income of a single person. One might use the following equation:--

\[
\text{Taxable Income} = \text{Income} - £ 2605 \text{ Per_Annum.}
\]
This would often produce the wrong answer because those people with incomes less than £ 2605 would end up with a negative taxable income. In order to avoid this most programming languages would force the programmer to resort to clumsy solutions such as:

\[
\text{If Income} \,>\, \text{£ 2605 then}
\]
\[
\text{Taxable_Income} = \text{Income} - \text{£ 2605 Per_Annum}
\]
\[
\text{Else Taxable_Income} = 0.
\]

Within PSL however it is possible to express the same concept with the following equation:

\[
\text{Taxable_Income} = \text{Income Less £ 2605 Per_Annum.}
\]

PSL also offers a special operator to be used with benefits which are tapered away as income rises. Take the example of a form of Housing Benefit which paid the claimant a benefit equal to 80 % of rent which would be withdrawn by 20 pence for each pound of the claimant’s income. Like the "Less" operator "Withdrawn_By" cannot produce an answer less than zero. In PSL it would be possible to write this as:

\[
\text{Benefit} = 80\% \text{ of Rent Withdrawn_By 20\% of (Income).}
\]

In a language like PASCAL, for example, one would have to define this as:

\[
\text{If } ((\text{Income} \times 0.2) - (\text{Rent} \times 0.8)) \geq 0 \text{ then}
\]
\[
\text{Benefit} := (\text{Rent} \times 0.8) - (\text{Income} \times 0.2)
\]
\[
\text{Else}
\]
\[
\text{Benefit} := 0.
\]

The effect of these operators is to speed up the programming of the PSL. The improvement of readability of PSL makes it easier for PSL statements to be checked,
and for non-experts to read and comprehend statements which have been written by other people.

7.6.3 Policy Simulation Variable Names
PSL's variable names can be long enough to accommodate a combination of several words. "Relationship_To_Head_Of_Household", "Pensions_And_Annuities", for example, are both acceptable. Arguably it would be better to shorten these names to "Relation" and "Pension" and the user would have the facility to do this. However in their present form they do illustrate the use of long variable names. In the case of variables which express a complicated concept and which are only seldom used it would often be right to use a very long variable name to express the concept clearly so that some one reading them several months after they are first written would be able to understand them and the context in which they are used.

When using long variable names users of the Policy Option Model have a major advantage over other computer programmers. POM gives the user easily accessible lists of variable names. Furthermore it gives the user a mechanism for inserting long variable names in the text without the necessity to type it in at the computer keyboard.

In order to inspect a list of variable names all the user has to do is use the "mouse". The mouse is a device which rolls around a flat surface such as a desktop. As the computer user moves the mouse in a given direction the computer screen's cursor moves in the same direction. While POM is operating the upper part of the computer screen displays three options for displaying variable names: "Household Variables", "Tax Unit Variables", and "Individual Variables". If the user points the mouse at one of these options and presses the return key an image
appears in the middle of the computer screen displaying a list of variables of the appropriate type (either household, tax unit, or individual). These suddenly appearing images are called "pop-up windows" because they appear to pop up out of nowhere and when they are finished with they disappear without altering the appearance of the computer screen. Thus if the user was working on a series of rules and wanted to inspect the list of variable names it would be possible to access the pop-up window with the minimum of difficulty. Although the window would cover the user's text temporarily it would disappear completely and the user would be able to continue writing as if nothing had happened.

In order to use a variable name without typing it in all the user has to do is to point to it with the mouse and press the return key. The variable name will appear in the line of text the user is writing at the cursor position. Any text to the right of the cursor will be pushed forward. In this way insertions using POM's pop-up windows are similar to insertions of text using a word-processing program.

7.6.4 Policy Simulation Pointer's
PSL supplies the user with an automatic facility for finding certain member's within a case namely the Head, the wife and the husband. The four terms used are "Head_Of_Household's", "Head_of_Tax_Unit's", "Wife's", and "Husband's". When one of these pointers is used then the value of the variable immediately following the pointer is the value that applies to the person concerned. An example of the use of this concept would be as follows:-

If Head_Of_Household's Earnings > 0 and Head_Of_Household's Wife's Earnings then Dual_Earner_Couple=True.
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Note that in the second line of this equation two pointers are used after each other "Head_of_Household's Wife's". This is perfectly acceptable in PSL. To find the wife of the head of tax unit one would say "Head_Of_Tax_Unit's Wife's".

7.6.5 Policy Simulation Value Labels

The value labels in PSL are a very simple concept. They are used with variables which represent categories rather than quantities. When such variables are used it is possible to use them with an English Language term rather than a number to specify a particular category. For example one could use the phrase "If Sex=Male" rather than "If Sex=1". Similar examples would be "Region=Yorkshire" and "Tenure=Council".

As well as supplying such value labels with the raw data used by PSL it is also possible for the user to create new categorical variables and then use them with value labels. If the user wants to create a typology of families it would be possible to use statements such as:

If Head_of_Household's Marital_Status = Single and
   Any_In_Tax_Unit(Age < 18) then
   Family_Type IS Single_Parent.

Note that in PSL the user is required to use the operator "IS" rather than an equals sign in order to assign a categorical value label rather than a numerical value. This will create a permanent set of such value labels which can be used by future equations which refer to the variable "Family_Type" (or whatever the user chooses to call it).

This facility should also have the effect of increasing
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Figure 7.2 POM Program Language Expressed
In Backus-Naur Form

IDENTIFIERS, OPERATORS, & MODIFIERS
<identifier> ::= a / b / c / d / e / f / g / h / i / j / k / l / m / n / o
/ p / q / r / s / t / u / v / w / x / y / z / A / B / C / D / E / F / G
/ h / i / j / k / l / M / O / P / Q / R / S / T / U / V / W / X / Y / Z
<identifier> ::= 0 / 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9
<logical value> ::= true / false
<logical operator> ::= and / ! not / or
<relational operator> ::= > / < / >= / <= / *=
<arithmetic operator> ::= Withdrawn_By / + / - / *=
<numeric modifiers> ::= % / ! Per_Annum / .
<identifier> ::= ( / <letter> / <digit> / _ )
<brackets> ::= ( / )
<bracket variable name> ::= identifier
<created variable name> ::= identifier
<value label> ::= identifier

NUMBERS
<unsigned integer> ::= <digit> *
<decimal point> ::= .
<integer> ::= [ + / - ] <unsigned integer>
<real number> ::= <integer> <decimal point> <integer>
<number> ::= ( / ) <integer> ! <real number> / Per_Annum / .
<percentage> ::= <digit> %

OPERATOR GROUPS AND FUNCTIONS
<analysis level indicators> ::= Individual's / Tax_Unit's / Household's
<analysis level operators> ::= Any_In_Tax_Unit / Number_In_Tax_Unit / Total_Tax_Unit
Any_In_Household / Number_In_Household / Total_Household
<relational pointers> ::= Husband's / Wife's / Head_Of_Household's / Head_Of_Tax_Unit's

<addition operator> ::= + / - / less
<multiplication operator> ::= * / /
<withdrawal operator> ::= Withdrawn_By

STATEMENTS AND EXPRESSIONS
<model> ::= ( / <definition> )*
<definition> ::= <inflation_factor_statement> ! <rule_definition>
<inflation factor statement> ::= Inflation_Factor of <variable name> = <real number> / .
<rule definition> ::= <analysis level indicator> <created variable name>
                      = <statement> .
<statement> ::= <expression> ! if <expression> then <expression>
                      ( else if <expression> then <expression> )*
<expression> ::= <and_expression> ! <expression> or <and_expression>
<and_expression> ::= <relational_expression> ! <and_expression> and
<relational_expression> ::= <addition_expression> ! <relational_expression>
<addition_expression> ::= <multiplication_expression> ! <addition_expression>

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Figure 7.2 Continued POM Program Language Expressed
Backus-Naur Form

<addition operator> <multiplication expression>
<multiplication expression> ::= <withdrawal expression> ! <multiplication expression>
<multiplication operator> <withdrawal expression>
<withdrawal expression> ::= <factor> withdrawn by <percentage> * ( <expression> )
<withdrawal expression> ::= <factor> ! <withdrawal> <factor>
<analysis level expression> ::= <analysis level operator> { <statement> }
<value label assignment> ::= IS <identifier>
<variable> ::= <raw variable name> ! <created variable name>
<constant> ::= <integer> ! <real number> ! <value label> ! <logical value>
<factor> ::= <analysis level expression> ! <value label assignment> ! ( <statement> ) ! not <factor> ! <variable> ! <constant> ! <relationship pointer> <factor>

Notes
In the table above the exclamation mark "!" is used to denote the vertical line in Backus-Naur Form.

the usability of PSL programs.

7.6.5 Miscellaneous Features of PSL

One very useful feature of PSL which does not quite fall into any of the categories above in PSL's "Inflation_Factor" statement. This gives the user a very convenient way of adjusting variables to take account of general movements of value over time. It is assumed that the most common situation in which such movements will be adjusted for will be in the case of correcting monetary values for inflation, which is why the term "Inflation_Factor" has been used.

Inflation_Factor statements can be used as follows. Suppose that there is a variable containing the value of earnings and that the users knows that earnings have risen 15 per cent in money terms since the survey data they are using was collected. In this case all the user needs to do is to define an inflation factor once at the
beginning of a set of PSL equations. For example one could specify:

\[
\text{Inflation\_Factor of Earnings} = 15\%.
\]

If this statement was used it would mean that when POM came to evaluate any equations using earnings that the appropriate value would be multiplied by 1.15. This means that the inflation factor only needs to be specified once at the beginning of a set of equations and need not be included each time an equation using earnings is written. It also adds to the readability of PSL programs because frequent references to the expression \((\text{Earnings} \times 1.15)\) would prove confusing to the reader.

7.6.6 Technical Description of the Policy Simulation Language

Figure 7.2 gives a technical description of PSL according to the conventions of the Backus-Naur Form which is a special technique for defining different computer languages according to a common format. The symbols within Backus-Naur Form can be understood as follows:

Words enclosed within a greater than and less than sign (e.g. \(<\text{Identifier}\>)\) are elements created within the language being defined. The exclamation mark means "or". Two colons followed by an equals sign (::=) should be understood to mean "consists of". Items within curly brackets can be repeated any number of times. The number of times values within curly brackets may be repeated are defined by numeric values to the right of the closing curly bracket. These values are either in the form of subscripts (written below the level of the preceding line) or superscripts (written above the level of the preceding line). A subscripted value to the right of the closing curly bracket indicates the minimum number of repetitions that are allowed. For example, an unsigned
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integer is defined as follows:-

* 

<unsigned integer> ::= { <digit> }1

The subscripted one indicates that an unsigned integer must have at least one digit. The value above the 1 shows the maximum number of repetitions. This can be useful when defining such concepts as percentages (where the number must be between one and a hundred and thus has a maximum of three repetitions for the three digits in 100). In the case of the unsigned integer definition there is no specified maximum number of digits which an unsigned integer can take. Therefore an asterisk is used to represent the concept of an undefined value.

A fuller explanation of the Backus-Naur Form is given in Galler and Perlis (1970). The language definition below is to be understood in conjunction with the following eleven rules:

1. The logical values true and false shall have their obvious meanings, as in ordinary usage.

2. The blank space between different symbols, and the space created by starting a printed line, has no effect on the calculations.

3. A set of <identifier>s is supplied with POM which refer to a set of variables taken from the Family Expenditure Survey 1984 - these are referred to above as <raw variable names>. Those variables which refer to a set of named categories such as "Type of Housing Tenure", have had a set of category labels supplied as well. New identifiers must be given in order to create new variables. These new identifiers must not be the same as any existing <raw variable name> or a previously defined <created variable name> (unless the user wishes to
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replace the old one).

4. Numbers have their conventional meanings. Numbers preceded by a pound sign are multiplied by one thousand (because money variables in the FES are recorded as thousandths of a pound). Numbers followed by the term "Per_Annum" are divided by 52 (as all FES values are weekly). Numbers followed by a "%" must be between 1 and 100, and are converted to a proportion of 1 (for example 66 % is converted to 0.66).

5. Logical values (true or false) and numbers may be used interchangeably. For example the expressions "married = true" and "married = 1" are equivalent.

6. The value of an expression is obtained by executing the indicated operations. The evaluation will be left to right for operators of equal precedence. The order of precedence is given below:

- first: or
- second: and
- third: >, <, =, >=, <=
- fourth: +, -, less
- fifth: *, /
- sixth: withdrawn_by
- seventh: not

7. The <operator> s +, -, /, and * have their conventional meanings. The operator "less" is the same as "-" (minus) except that if the result of the subtraction is less than zero it is taken to be zero. "Withdrawn_By" is a binary operator. The value preceding it is reduced by a proportion of the value of the expression following it (e.g. Family_Credit_Level Withdrawn_By 25 per cent of Earnings). "Withdrawn_by" forces the expression following it to be evaluated before the expression immediately preceding it. (This is a departure from
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normal left to right evaluation). As with "Less" the result of a withdrawn__by operation cannot be a negative value.

8. An expression enclosed in matching parentheses is always evaluated by itself, and the resulting values are then used in subsequent calculations.

9. Where a variable has a set of category labels, these labels may be used in expressions in the same way as numbers. For example, "Sex = Male" is equivalent to "Sex = 1".

10. When a <relationship pointer> is encountered the factor following it refers to a specific member of the household or tax unit. For example "Head_of_Household’s Age" would return the age of the head of household even if the current case is not the head of household’s case. <Relationship pointers> may follow each other. Therefore the factor "Head_of_Household’s Wife’s Age" would be acceptable. If there is no person with the specified relationship (for example there is no wife in the household) then a missing value is returned.

11. <Analysis level operator>s must be followed by a pair of brackets containing a statement. <Analysis level operators> have one of two domains. Operators containing the term "household" act on the household and those containing the term "tax unit" act on the tax unit. <Analysis level operators> act on all the cases within their domain, unless they contain the word "any". In this case a boolean expression must follow the operator. If this is true for any of the cases in the domain then execution will stop and the value TRUE will be returned. Operators containing the word "number" must also be followed by a boolean expression. The operator will
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evaluate the expression for all the cases within the
domain and return the number for whom the value of the
expression was true. An example of this would be
"Adult_Non_Dependants = Number_In_Household
(Taxunit_Number > 1)". Operators containing the word
"total" will add together the value of the expression for
all the cases in the domain (e.g. Household_Earnings =
Total_Household(Earnings).

7.7 The Lexical Analyser
The first stage in processing the rules entered through
the editor is lexical analysis. This involves sorting
the characters of the source definitions into separate
words or "symbols". Symbols in this context can mean
words such as "if", "then", or "Total_Household". Symbols can also be numbers such as "12", or "22.4".
They can also be single character symbols such as ">",
"+", or the pound sign. Consider the following string of
characters "Children_Under_11". Clearly it makes a
significant difference if this in interpreted as one
symbol as opposed to two separate symbols (namely
"Children_Under_" followed by the number 11).

The rules of the system of lexical analysis within POM
are as follows. Characters are divided up into six basic
starting types and six corresponding successor types.
The lexical analyser will keep on reading characters and
adding to the symbol while the current character belongs
to the successor type corresponding to the first
character’s starting type. For example a symbol starting
with a digit must be a number and can only be followed by
other digits or a single decimal point according to the
rules below. As soon as a character of the wrong type
for a number is encountered (such as a blank space or a
letter) the lexical analyser stops reading in characters
and passes the symbol to the parser. The starting types
and corresponding successor types for POM are given below.

1. Any non-printing character such as a blank or a return code. Encountering this type marks the end of a symbol, starting with any other type.
2. A letter. A symbol starting with a letter must be an identifier and may only be followed by other letters, or by digits, an apostrophe, an underscore, or a pound sign.
3. A digit. A digit must be followed by other digits or by a single decimal point.
4. A '<' sign or a '>' sign. These may only be followed by the character '=' to make '>=' or '<=', otherwise the symbol terminates.
5. One of the following '.' or the pound sign. These are all single character symbols so no successor characters are required.

Once a symbol has been read from the set of definitions, the lexical analyser determines what type of symbol it is from among the following categories:

(a) numbers (e.g. '22', '100.4')
(b) variable names (e.g. 'Age', 'Sex')
(c) value labels ('Male', 'Female')
(d) special symbols (e.g. '+', '*', 'if', 'Total_Household')

When it has determined which category the symbol belongs to it is translated from a string of characters to a number with special significance which will be referred to as a "token". If the symbol represents a numerical value then the token is set to a value which represents numbers in general. A separate variable is used to store the actual value of the number represented by the symbol. In understanding POM's lexical analysis it is important
to recognise the distinction between the two elements which make up these pairs of numbers. On the one hand the token represents the type which the symbol belongs to, a separate variable represents its numerical value. In the case of numbers there is a "number" token, and a "value" variable which stores the number itself. In the case of a variable, the token is set to "variable", and the value variable stores the variable's position within the array of variables. In the case of value labels the token is set to "number" and the "value" variable stores the quantity which the value label represents. In the case of special symbols such as "if" and "+" only the token is stored. Within POM there is a look-up table of special symbols, which allows them to be converted from a string of characters into their corresponding token number. If the lexical analyser encounters a string of letters which does not represent a number, a variable name, a value label, or one of the entries in the look-up tables of special symbols then an error message will be displayed.

Some lexical analysers write their output to a file as they execute, and this file is then read by the parser. This arrangement is called a "two pass" approach because two passes are made through the file. POM, on the other hand, has a single pass process for parsing and lexical analysis. Lexical analysis is performed one symbol at a time. As each symbol is analysed it is passed to the parser.

7.8 The Parser
The parser takes the tokens produced by the lexical analyser and performs two operations on them. Firstly, it checks them to ensure that they are syntactically correct in the context of their position in the current rule. Secondly, it sorts them into an order which the interpreter can act upon.
When the parser has sorted the tokens into the correct order it places them into an array, which will be referred to as "the heap". The order in which the tokens are stored on the heap is different to the original ordering - even for an expression as simple as "2 + 2". POM stores these values with the operator after the operands - "2 2 +" - a system known as reverse polish notation. (The advantage of this is that it is possible to define an unambiguous ordering of operators and operands, in cases where there would be considerable ambiguity in the case of traditional infix operators. Take the example of the expression "2 + 4 * 5". Unless a computer program was designed to recognise that "4 * 5" should be evaluated first "2 + 4" would be added first, and the resulting 6 would be multiplied by 5 to give 30 (using standard left to right evaluation). This could be avoided using brackets. However in reverse polish notation it is possible to remove this ambiguity without brackets. Instead of writing "2 + 4 * 5" one would write "2 4 5 * +". This ensures that the "4 5 *" is to be evaluated first and that 2 is to be added to the result.)

Several types of parser might have been chosen for POM. Probably the simplest form of parser is the "operator precedence" parser as described by Brown (1979). In this method operands are read directly into an array of values according to reverse Polish conventions. Operators are transferred to an array according to strict rules of operator precedence. If the operator at the end of this array has an equal or greater precedence than the current operator, then the operators within the array are re-ordered. Unfortunately this system has a number of disadvantages:

It is hard to handle operators like the minus sign which has two different
7. STRUCTURE OF THE PROGRAM

precedences (depending on whether it is unary or binary). Worse, since the relationship between the grammar being parsed and the operator-precedence parser itself is tenuous, one cannot be sure the parser accepts exactly the desired language. (Aho and Ullman, 1978:158)

Another important category of parsers is referred to as "predictive" parsers. Predictive parsers employ a "parsing table"—a two-dimensional array. This table is used to determine if the current combination of tokens is allowable—by taking the current token and the last token placed on the heap to see if they are a valid combination. Unfortunately it is difficult to write such parsers without a special program for generating parsing tables.

The type of parser used by POM avoids these pitfalls. POM's parser falls into the category of "recursive descent" parsers. Recursive descent parsers are defined as those which "use a set of recursive procedures to recognise input without backtracking" (Aho and Ullman, 1978). POM's parser has several procedures which are recursive, that is, they call themselves (either indirectly or directly). In Figure 8.2 below procedures are shown which try to illustrate the concept of POM's parser. These procedures are simplified versions of procedures in POM itself.

To illustrate how the parser works consider what happens if the user enters the expression "8 + 4 * 5". The lexical analyser would return the "number" token first (and store the quantity "8" in a separate value variable). The parsing in Figure 7.3 would start on line 47 inside the procedure "PlusExpression". This would immediately call the procedure "MultExpression" (this is
because the parser must test for the multiplication operator before the addition operator, because it has a higher order of precedence. On line 31 "Multexpression" calls the procedure "Factor". "Factor" then tests to see if the token is a bracket. The condition on line 19 is true (the token is a number) so the parser puts the token on the heap, and gets the next token (which is a "+") sign). The parser exits from procedure "factor" and returns to line 33 in "MultExpression" (just after the point where "Factor" was called). The current token is neither a multiplication or division sign so the condition on line 33 is false, and the parser returns to the procedure "PlusExpression" on line 48. The current token is a plus so the execution continues to line 50. Line 50 saves the value of the token in a temporary variable because it is necessary that the next value on the heap should be the next operand with the relevant operator at the end (according to the conventions of reverse Polish notation). On line 51 the next token is requested from the lexical analyser which is a number token with the value 4. "MultExpression" is now called on line 52, which in turn calls "Factor" on line 31. "Factor" puts the number token on to the heap and calls the next token which is a multiplication sign. The parser then returns to the condition in "Multexpression" on line 33 which is true. The multiplication sign operator is also stored as a temporary variable within "MultExpression" and the lexical analyser is asked for the next token which is the number 5. "Factor" is invoked again which stores the number 5 on the heap. The parser now returns to "MultExpression" on line 38. The multiplication sign is stored on the heap. The parser returns to line 53 in "PlusExpression" and the plus sign is placed on the heap. The heap now stores the values "8
4 5 * +". When this comes to be evaluated 4 will be multiplied by 5, and 8 will be added to the result.
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Figure 7.3 Recursive Parser Procedures

```plaintext
Procedure PlusExpression; ( Declare PlusExpression so that) 1
  Forward ( it can be used in factor ) 2
Procedure Accept(intoken);
  begin ( If the current token is the ) 4
    If Token = Intoken then ( same as the one passed as a ) 5
      NextToken ( parameter to accept then get) 6
    Else ( the next token otherwise print) 7
      PrintAnError; ( an error message ) 8
    end; 9
  Procedure Factor;
    begin 11
      if (token = Left_Bracket) then 13
        Begin ( in the case of a left bracket ) 14
          Accept(token); ( then parse the expression) 15
          PlusExpression; ( inside the brackets before) 16
            Accept(RBRACK); ( continuing ) 17
          end;
        else if token = number then 19
          begin 20
            PutTokenOnHeap( Token) ; (otherwise put a ) 21
              NextToken; ( number on the heap ) 22
            end;
        else PrintAnErrorMessage; 24
      end; 25
Procedure MultExpression; (Multexpression gets called from ) 27
  var ( Multexpression is evaluated )28
  op : tokentype; ( of plusexpression is evaluated )29
  begin 30
    Factor; ( if there is a number then put on heap first) 31
      while token in [DIVIDE,TIMES] do 32
        begin 33
          op:=token; ( save the operator token ) 34
            NextToken; 35
          Factor; ( find the second factor ) 36
            PutTokenOnHeap(op) ; ( put operator on heap after ) 37
          end; ( the two operands ) 38
        end; 39
Procedure PlusExpression;
  var ( compile and add or subtract expression) 43
  begin 44
    MultExpression; ( call multexpression first ) 45
      while token in [plus, minus, less] do 46
        begin 47
          op:=token; ( save the operator token ) 48
            nextToken; 49
          MultExpression; ( get second operand ) 50
            PutTokenOnHeap(op) ; ( put operator on heap ) 51
          end; 52
        end; 53
```

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Though none of these procedures call themselves directly, recursion does take place if a bracket is encountered in "Factor" on line 13. This causes "PlusExpression" to be called from within "Factor". "PlusExpression" will call "MultExpression" which will call "Factor". This is typical of the mutually recursive nature of the procedures within the parser. The recursions within the parser are far more complex in POM than in the small subset of procedures shown in Figure 7.2. The source code listing shows the full set of procedures.

Suppose that the user entered the definition "2 +" instead of "2 + 2". In this case the parser would store the number 2 on the heap using the procedure "Factor". It would store the plus sign as a temporary variable and look for the second factor. Within "factor" the parser would fail to find a valid operand and would print an error message. Thus the parser not only succeeds in storing the tokens on the heap in the correct order, it also detects errors and reports them to the user.

7.9 The Interpreter

Interpreters and compilers take as their input a program and then carry out the operations which that program specifies. However, compilers translate the program into the computer's own language (a series of binary numbers known as machine code), whereas interpreters carry out the same operations without doing a complete translation into machine code.

Bornat (1979) separates interpreters into two main categories. One form of interpreter makes heavy use of two major compiler tools - symbol tables and parse trees. The second form of interpreter is based on a linear series of instructions like the heap produced by the parser above. Bornat (1979) calls these "linearising" or "virtual machine" interpreters. (The term "virtual
7. STRUCTURE OF THE PROGRAM

machine" applies because the computer itself operates on a series of numbers similar to the heap used by these interpreters).

To understand how POM's interpreter works consider how it would evaluate the expression given above which produced the following values on the heap: 

```
8 4 5 * +
```

In fact, this is an over-simplification. These values are more accurately represented on the heap by the table shown in Figure 7.4 below. The operands on the heap are stored as pairs of numbers (with the first value declaring its type and the second one storing its value). The operators are stored as single numbers. The interpreter can tell the difference between numbers which represent types and those which represent values by their context. To illustrate how POM's interpreter works consider how it would execute the instructions in the heap shown in Figure 7.4. This is demonstrated with the help of Figure 7.5 which shows a simplified portion of the POM's "Interpret" procedure. This procedure uses two arrays, namely the heap which stores the tokens produced by the parser, and the "stack" which stores the operands in the correct order for evaluation. The interpreter uses a variable called "index" to mark its position on the heap, and another variable "stacktop" to mark its position on the stack.

When evaluating the heap contents shown in Figure 7.4 POM will keep calling the procedure "Interpret" until it has reached the end of the heap (which is marked by the parser with a special token). When "Interpret" is first called it assigns a temporary variable called "op" to the value of the first item in the heap. Figure 7.4 shows that this is a "Number" token, so the execution moves to line 6. The top of the stack marker is increased by one. The heap index is increased by one so it is pointing to the number "8". This value is copied from the heap and
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placed as the first item on the stack. This process of copying values into the stack and incrementing stacktop and index, is repeated until all three numbers have been copied into the stack. At this point the stack contains "8" as its first element, "4" as its second element, and "5" as its third element. Stacktop is pointing to the third element.

Figure 7.4 Example of Heap Contents

<table>
<thead>
<tr>
<th>Heap Position</th>
<th>Value</th>
<th>Meaning</th>
<th>Type or Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91</td>
<td>Number</td>
<td>Type</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>8</td>
<td>Value</td>
</tr>
<tr>
<td>3</td>
<td>91</td>
<td>Number</td>
<td>Type</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>Value</td>
</tr>
<tr>
<td>5</td>
<td>91</td>
<td>Number</td>
<td>Type</td>
</tr>
<tr>
<td>6</td>
<td>5</td>
<td>5</td>
<td>Value</td>
</tr>
<tr>
<td>7</td>
<td>120</td>
<td>Multiply</td>
<td>Type</td>
</tr>
<tr>
<td>8</td>
<td>102</td>
<td>Add</td>
<td>Type</td>
</tr>
</tbody>
</table>

on the stack. When the "Interpret" is called for the fourth time the operator is not a number so execution jumps to line 12. Here a temporary variable temp2 is assigned to the value on the top of the stack - "5". The stacktop is then decremented and a second temporary variable is assigned the value on the top of the stack - "4". The current operator is a multiplication sign so the next line to be executed is line 18. Here the value on top of the stack is assigned to (4 * 5). The result - 20 - is kept as the top value on the stack. When "Interpret" is called again line 16 is executed which adds the operand in the first element of the stack "8" to "20".
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Figure 7.5 Simplified Interpreter Procedure

```plaintext
Procedure Interpret;
begin
  operator:=heap[index];
  case operator of
    NUMBER : begin
      StackTop:=StackTop+1;
      index:=index+1;
      stack[StackTop]:=heap[index];
    end;
    else
      begin
        temp2:=Stack[StackTop];
        StackTop:=StackTop-1;
        temp1:=Stack[StackTop];
        case operator of
          PLUS : Stack[StackTop]:=Temp1+Temp2;
          MINUS : Stack[StackTop]:=Temp1-Temp2;
          TIMES : Stack[StackTop]:=Temp1*Temp2;
          else
            PrintAnError;
        end;
      end;
  end;
end;
end;
```

Figure 7.5 shows only a small subset of the operators which can be handled by the "Interpret" procedure. Not only are there further mathematical operators, but there are operators like "then" which manage the heap index so as to control which parts of the heap are executed. The operator "then" will be stored along with a number which marks a specific place on the heap. If "then" is
encountered and the value on the top of the stack is not "true" (indicating that the condition preceding "then" was false) the "interpret" procedure skips over all the elements in the heap until it reaches the position indicated by "then"'s heap marker. Similar procedures are used for skipping over sections of the heap when the operators "and", "or", and "else" are evaluated.

This linearised form of interpreting holds for all commands that can be stored on the heap, with two exceptions. The first exception is in the case of analysis level operators such as "Total_Household" (which require a special form of iteration) and relationship pointers such as "husband's" (which necessitate evaluating an equation about one household member while utilising information about another). Figure 7.6 shows a flowchart of the execution which occurs when analysis level operators are encountered on the heap. The conventions of the flowchart are those outlined by Galler and Perlis (1970). The flowchart shows that there is a straightforward iteration of the Interpret procedure from point A to point B, unless the program meets an analysis level operator. This causes the program to jump to point C. At point C a variable is assigned to point to the first person in the household. At point D a variable is assigned to the value of heap index at the start of the analysis level expression. The "Interpret" procedure is called repeatedly until the temporary heap index points to a marker showing the end of the analysis level expression. At this point the household pointer is incremented to indicate the next person in the household. When the expression has been evaluated for the last person in the household control is passed to point E which returns to the main interpreter loop.
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Figure 7.5 Flowchart of Analysis Level Interpretation
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7.10 The Tabulator
The tabulator is intended to produce tables which illustrate certain characteristics of the original data or any variables which have been created by the user.

For the purpose of tax-benefit modelling a typical table might have rows indicating different types of Family, columns showing different ranges of gross income, and each cell containing the average net incomes before and after a policy change.

Tabulating the data involves a three stage process. Firstly, the user is invited to answer a series of questions to describe the table to be produced. Secondly, the data set is read case by case and the relevant data is added to the appropriate cell of the table. Thirdly, a table is constructed and printed to a file.

During the first stage the user is asked to state which variables are to define the columns and rows of the table. These variables must have a set of category labels so, for example, it would be acceptable to choose "Employment_Status" as the column variable but not "Investment_Income". This ensures that when the table is printed POM is able to write labels for the column headings, and prevents a vast number of columns from being required. To make "Investment_Income" a column variable one would have first to create a variable which allocates individuals to different bands of "Investment_Income". Within each cell of the table the user has a choice of five options: cell counts, column percentages, row percentages, averages of one variable, or averages of two variables. The process of specifying a table is outlined in chapter 10 and in the user manual. Therefore it will not be described in detail here.
7. STRUCTURE OF THE PROGRAM

The process of analysing the data to construct the table is shown in the form of a Warnier-Orr diagram in Figure 7.6. Line 1 of Figure 7.6 refers to a "cell array". This is an array of records which will store the values that will eventually be printed out in each cell of the table. Each of the elements of the array has two running total variables (to store the sum of any variable which is to be averaged) and two counter variables. At the beginning of the analysis all these variables are set to zero. There is also a data array, which holds the values of the data as it is read off the disk. The data array holds the values of between two and four variables: the column variable, the row variable, and if necessary the values of one or two contents variables to be averaged.

---

Figure 7.6 Data Analysis for Table Construction

1 | Initialise
2 | the data structures
3 | Read 1st case into the data array
4 |
5 |
6 |
7 |
8 |
9 |
10 |
11 |
12 |
13 |
14 |
15 |
16 | for each case in the data
17 | Find Relevant Place in Cell Array
18 | The Cell already exists (1,0)
19 | -
20 | The Cell does not exist yet (1,0)
21 | Averages to be shown in Cells (1,0)
22 | -
23 | No averages to be shown in Cells
24 | Read Data for next case into data array
25 |
26 |
27 |
28 |
29 |
30 |

The process of finding which cell in the table each case belongs to is shown in lines 6 to 11. POM finds the relevant place in the cell array through a procedure
known as "hashing" or "hash addressing". Hash addressing involves trying to find an object's position in an array. This necessitates calculating an index number to the array based on some characteristic of the object. When "hashing" a string of characters such a number might be calculated by multiplying together the ASCII values of the first three letters. Within the tabulator the hash value is calculated as a function of the column and row values. A mathematical formula is applied to the column and row values which produces an index number between one and the maximum number of cells in the cell array. It is still possible, though, that two different cells of the table will have the same hash value. If this occurs POM will search for an empty cell in the cell array which is closest to the index position produced by hashing.

If the tabulator finds that the current case belongs to a cell of the table which is currently empty then the tabulator will increment a counter which stores the number of currently occupied cells. If the case belongs to a row or column which is currently unoccupied then the value of the row or column variable is added to a list of occupied column and row values.

If the user has decided to display only cell counts, column percentages or row percentages in each cell then the tabulator will merely increment the counter once it has found the correct place in the cell array. If the user has chosen to display means in each cell then as each case is examined the tabulator will increment the counter variable and will add the value of the contents variable to the running total for the cell concerned. This process is duplicated for the second contents variable if the averages of two variables are to be shown in each cell. If the cells are to contain average values then the tabulator will take no action if the contents variable is zero and the user has specified that zero is
to be treated as a missing value. After storing the information from the case in this way the information from the next case is read into the data array.

This process is repeated until one of three things happens. Firstly, the user may interrupt the procedure. Secondly, the tabulator may find that a table with more than 100 cells is required (which is too large for it to handle). Thirdly, the tabulator may reach the last case. If the variables requested include any user-created variables with a smaller number of cases than the raw data then the tabulator will stop after it has reached the end of the variable with the fewest cases.

When POM has finished analysing the data it has to organise the contents of the cell array so as to produce an easily understandable table. As the table is built up, the tabulator stores the different elements of the table as a series of special printing data structures. These structures store a string of characters, together with coordinates of the position where the string is to be shown on the screen. These printing records are organised as a linked list within the computer's memory (that is each record has two pointers one of which indicates the printing record which precedes it on the table, and the second of which indicates the following printing record). In the discussion below, the term "printing" is used to describe the process of creating one of these data structures.

The first action the tabulator performs when constructing the table is to print a title for the table as a whole. The title lists the column and row variables and explains the meaning of the cell contents.

The tabulation procedure iterates through each row and column of the table to calculate the number of valid
structures and for the table as a whole.

If the table is too wide or long to fit on one page it is printed on a series of different pages. For each page the tabulation procedure shows the name of the row variable and the name of the column variable. A series of column labels is shown for each column of the table. The column label is forced to fit within the width of the column, and so may be printed on several successive lines. The tabulation procedure calculates the number of lines which the longest column label takes up, and it uses this figure to ensure that the actual data starts below the lowest column heading. It also prints a row label for each row of the table. The cell contents vary according to user's choice. If the user selects "cell counts", the cell count is printed together with this count as a percentage of all the valid values in the table. With averages the mean value of the contents variable is shown together with the number of cases where the contents variable was not missing. If the mean of two variables is requested then only these two averages are shown; no cell counts are displayed.

At the end of the final page the column totals are printed. If the tabulation involves all the cases in the data set then the total national value of the contents variable(s) is shown. This involves multiplying the number of cases in the FES to equal the population of the UK as a whole. Such extrapolations must be treated cautiously, because of the differential response rates by different types of family to the FES. After the last item of the table has been printed, the printing data structures are saved to a file. This file is displayed on the screen and may be saved by the user for future reference.
7.11 Conclusion

POM links and refines many existing concepts in computer programming. It draws on existing experience of word processors, computer languages, and statistical analysis programs. In synthesising these concepts, POM attempts to allow the user to minimise the complexity involved in tax-benefit modelling without sacrificing the ability to model the full range of tax-benefit policies.

POM's method of data storage makes it possible to store information about all the people in an entire year's FES (some 18,500 people) using roughly one megabyte of disk space. As the smallest hard disk drives have a capacity of ten megabytes, this makes POM easily accessible to micro-computer owners. POM's data initialisation procedures give the user instant access to self-explanatory variable names and fully descriptive value labels. There is no necessity to consult codebooks to determine which numbers refer to which categories of nominal variables. POM's pop up menus show the category names instantly, and the Policy Simulation Language allows these names to be used directly in programming.

POM provides the user with a full screen text editor with exceptional access to variable names and value labels. The mouse and highlighting procedure avoids the need to type in long terms at the keyboard. The Policy Simulation Language itself helps to make tax-benefit programming both faster and more comprehensible.

POM's lexical analyser and parser allows for a quick single pass process for detecting errors and storing values on the heap. Error messages are given explanations on screen and the cursor is placed in the user's text at the point where the error was detected.

Finally, POM's tabulator produces clear illustrations of
7. STRUCTURE OF THE PROGRAM

the meaning of different policies. Most importantly, the process of tabulation is simple enough for a non-expert to specify a table, and yet flexible enough so that the choice of tables are not constrained by a set of ideological prejudices.
8. USER INTERFACE

8.1 Introduction
The existing tax-benefit models have user interfaces which are based on two approaches. The two methods might be termed the menu-driven approach and the programming language approach.

Both have major advantages and disadvantages. The menu-driven models (such as TAX-MOD, IGOTM, and the Personal Income Tax Model) have clearly defined questions which prompt the user to enter numerical values which define those aspects of the tax-benefit system which the user is allowed to change. However users cannot simulate a policy which the menu system does not allow for. This approach means that the models concerned are easily understandable by the non-expert. It also means that they are highly inflexible.

The programming language approach presents the user with the opposite balance of advantages and disadvantages. Models like the IFS Model and the DHSS Policy Simulation Model are examples of this approach. Although both have limited menu driven interfaces, most of the detailed policy simulation is done by altering the source code of the program itself. If researchers wish to alter the source code of these models then they must invest a great deal of time learning about them to arrive at a point where they can do any tax-benefit modelling at all. For most potential users the difficulty of mastering a programming language makes such models unusable in practice. However if they master the language, almost the only limits are those inherent in the data set the model is based on.

8.2 The Policy Option Model Approach
The Policy Option Model (POM) attempts to combine the flexibility of the programming approach with the
8. USER INTERFACE

comprehensibility of a menu driven system. If non-experts are to feel able to attempt computer programming then they must perceive that the required effort is less than is the case with existing methods. DiSessa (1986: 128) has described it thus:-

The challenge for the future is to make programming into something that is simple enough and useful enough that everybody will want and be able to learn how to grasp and stroke with this new pencil. ... In contrast to battling large programs, if we can allow a broad range of simple but useful things to be done transparently, we will have won more than half the battle.

POM attempts to reduce the effort expended in learning to use a tax-benefit model. It tries to achieve this by providing the user with a programming environment which is so close to English language concepts that the new user will feel confident in working with it.

The menu-driven approach has been rejected on the grounds that however comprehensive the menu system, there will always be policy options which will be excluded because menu questions were not written for such policies.

Users of the Policy Option Model are invited to type in statements about the tax-benefit system with fully descriptive variable labels in an English language format. For example, a traditional programming language might well include a statement such as:

\[ TI = GI - TR. \]  

Most non-experts find such terminology threatening, and could easily be discouraged from trying to learn a
8. USER INTERFACE

language because of the presence of terms which they find meaningless.

In POM the same statement would be written as

\[
\text{Taxable\_Income} = \text{Gross\_Income} - \text{Tax\_Reliefs}. \quad [2]
\]

Such a statement is more comprehensible to the non-expert, making it possible to overcome the psychological barriers to computer programming. It is also probable that the resulting models will contain fewer errors because the variable names are inherently meaningful. It is much easier for mistakes to creep in with abbreviated variable names. Suppose, for example, that in equation [1] above the term "TI" stood for "Total Income" when the user had intended to use the label for "Taxable Income". Because the label is not fully descriptive, it is much more likely that a mistake about the meaning of "TI" could creep into the model and go undetected.

Figure 8.1 Computer Screen Image Produced by POM showing the initial screen

---

**TAX-BENEFIT RULE EDITOR** by Philip Truscott VERSION 1

<table>
<thead>
<tr>
<th>INDIVIDUAL VARIABLES</th>
<th>PROGRAMMING TERMS</th>
<th>HELP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawn_By</td>
<td>Per_Annum Less</td>
<td></td>
</tr>
<tr>
<td>Total_Household</td>
<td>Household's</td>
<td>SPACE BAR</td>
</tr>
<tr>
<td>Tax_Unit_Number</td>
<td>Any_In_Tax_Unit</td>
<td></td>
</tr>
<tr>
<td>Any_In_Household</td>
<td>Total_Tax_Unit</td>
<td></td>
</tr>
<tr>
<td>Number_in_Household</td>
<td>Number_in_Tax_Unit</td>
<td></td>
</tr>
<tr>
<td>Tax_Unit_Inflation_Factor</td>
<td>Household's</td>
<td></td>
</tr>
<tr>
<td>Head_Of_Household's</td>
<td>Head_Of_Tax_Unit</td>
<td></td>
</tr>
<tr>
<td>Husband's Per_Annum</td>
<td>Wife's</td>
<td></td>
</tr>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td>( ) [ ]</td>
<td></td>
</tr>
</tbody>
</table>

Free Memory: 315328 File: <None> Line 1 Col 1 Insert ON

---

271
Some programming languages such as early versions of FORTRAN and BASIC place restrictions on the size of variable names (such as a six or eight letter limit). The problem with long variable labels, however, is that programmers try to avoid spending the time necessary to type them in.

8.3 Programming with a Mouse and Menu System
POM attempts to overcome this problem by obviating the need to type in most variable names. The user is invited to employ a system of pop-up menus which can be operated through a mouse. (The term "pop-up" is used because the menus appear on the screen over the other text which is being displayed. When the user wishes to dispense with a given menu it will "pop down" again leaving the screen in the state it was before the menu appeared). In order to select a particular option the user only has to point to it with the mouse and press a mouse button. The item selected will appear in the current line of text as though it had been typed in from the keyboard. This facility is available for all of the raw data variables. Furthermore if the user creates a new variable, and POM checks that the sentence defining this variable is correct, then this it will appear in a pop-up window and the user can insert it in the text without typing it in each time it is required.

The purpose of having long variable names and the mouse system is to try to combine the advantages of quick programming with program statements which are meaningful.

8.4 Pop-up windows for Categorical Variables
Much of the time when researchers are using statistical data with computer programs, they find themselves writing statements which involve nominal variables which represent categories rather than numbers. This is in contrast to interval or scalar data. When categories are
involved it is preferable to use the name of the category rather than a number. For example, with a program like SPSS if one wanted to identify people who were married men one might write a statement such as:

\[
\text{IF (SEX = 1) AND (MARITAL = 1) } \quad [3]
\]

However, in POM, an English language term could be used. The same statement would be:

\[
\text{If (Sex = Male) and (Marital = Married). } \quad [4]
\]

POM will understand the terms "Male" and "Married", just as if the appropriate numerical value had been entered. It is still acceptable to enter the numerical value, but there are advantages in using the English label for the sake of keeping the program readable. The user must type in the correctly spelled label (upper and lower case are immaterial). In order to make this easier a further set of pop-up windows has been created to allow the user to enter the label using the mouse (though it can be typed in directly from the keyboard as well).

In order to obtain a list of all the valid categories for a nominal level variable, the user points to a part of the screen labelled "VALUE LABELS", and presses the mouse button. A pop-up window appears on the screen which gives a list of all the variables with labels, and the user is then invited to point to it with the mouse and press the mouse button. A further pop-up window appears with all of the labels for that variable. If the user presses the return key while pointing at the appropriate label, then the label will appear in the line of text which is being built up.

Again it should be stressed that one of the likely effects of this approach is that accidental errors will
be reduced. Because the number 1 is so much less meaningful than the term "Married" it would be much easier for the wrong number to slip into a line of text, and then for this mistake to go unnoticed.

8.5 Pull-Down Command Menu
In addition to the pop-up menus which contain the lists of value labels and variable names, there is also a pulldown command menu. (The term "pulldown" arises from the fact that each of the sets of options pops downward from a heading at the top of the screen). When the user presses function key 10, or points to the term EDITING COMMANDS with the mouse, the command menu will appear at the top of the screen. The command menu contains a list of groups of command options, such as file commands, block commands etc. The pulldown menu means that in most cases it should be possible for a novice user of POM to find a command on the pulldown screen without the necessity to refer back to a manual. Constantly referring back to the manual increases the length of time taken to learn a new program and discourages the new user.

8.6 Quick Keyboard Commands
In addition to the pulldown menu the user can also give commands directly from the keyboard. For example, instead of calling up the pulldown command menu to go to the bottom of the current file, the user could hold down the Control Key and press "Q" and then "C". This would have the same effect. This procedure is quicker than using the pulldown menu, but may take longer to learn.

Giving access to both the pulldown menu and the quick keystroke commands, gives two major advantages. It means that for newcomers there is a metaphorical pair of water wings which allows them to swim through the first few hours of using the program without having to master a set
8. USER INTERFACE

of complex commands. It also means that more experienced users who are familiar with the quick keystroke commands in the more common text editors are not held back.

Figure 8.2 Computer Screen Image produced by POM displaying an error message shown when a mistake is found during parsing.

8.7 Error-Detection on Screen

The method of error detection in POM should also add to the user's confidence. With most models based on the common programming languages, the entire program would need to be compiled each time the source code is altered - a process which takes several minutes for a large model. During this process the user can no longer see the last piece of the program which he or she had been writing, as the screen is often changed during the compilation process.

In contrast, POM allows one statement to be checked at a time. If there is an error, the cursor is placed at the point where the error has been detected. A temporary pop-up message appears to tell the user the nature of the error. Once the error has been detected the user can
8. USER INTERFACE

correct it and carry straight on. There is no need to send the user's set of commands to a file and then compile them separately (this would be the procedure with a programming language or a statistical package such as SPSS). An example of how POM prompts the user to correct an error is display in Figure 8.2.

Figure 8.3 Computer Screen Image Produced by POM showing how POM indicates the characteristics of a table to be displayed

8.8 Conclusion

The rationale behind the user interface which has been devised for the Policy Option Model, is that the closer one keeps to natural English language concepts, the easier the system will be for non-experts to use. Ease of use should cut down on the amount of time needed to learn the package. English language style terminology should make it much easier for several members of the same staff team to use the same model. Moreover, as different people would be able to understand the same piece of programming, different people will be able to check each others' work and reduce errors. This is an important issue in departments such as the DHSS, the
8. USER INTERFACE

Treasury and the Central Statistical Office where several different members of staff might be working on the same project.

The reason why a user interface similar to POM has not been developed before is probably due to the assumption that this type of programming would be done by computer specialists. However even if tax benefit modelling is restricted to full time computer programmers there would still be good reason to use a POM style user interface for computer programming. This is because of the problems which arise when trying to modify and adapt huge programs. The problems of understanding variable names which are not self-explanatory and comprehending the structure of a complex program become almost insupportable with a very large program. With POM on the other hand the use of simple declarative statements (without iteration structures) and self-explanatory variable names mean that it would be much easier to support very large programs.
9. OUTPUT FROM THE MODEL

9.1 Introduction

POM is intended to provide a flexible method of producing output tables. Some of the existing programs like the CUBS model only allow the user to produce a set of standard tables which have been pre-specified by the designer of the model. If the user wishes to produce a table based on unusual criteria the object code models would not be able to cope. Suppose for example that the user wanted to produce a table showing the effect of abolishing Mortgage Interest Tax relief by regions, or the effect of abolishing rates by tenure groups. The models which produce standard tables would not allow the information to be output in this way.

In chapter three a selection of principles of tax-benefit policy were examined. This examination showed that the principles by which policies are judged are a matter of subjective choice. It is therefore preferable to avoid building any ideological prejudices into a model, by restricting the user to a given set of standard tables when assessing a policy. POM avoids this by allowing the user to examine a policy using any of the variables which can be calculated from the data.

With the more common simulations such as the incomes of families before and after a policy change, or the changes in their marginal tax rates, then the existing models will generally be adequate. There follows a description of three examples of the output from POM, to illustrate its method of displaying data.

The first example is a simulation of a change in income tax rates with a table showing how this would affect different types of tax unit over a range of income bands.

The second example is a simulation of the Exchequer costs
of Family Income Supplement.

The third example is a simulation of the effect of changing rates of tax on the number of hours worked by a sample of married men.

These three examples give a perspective on several of the most distinctive features of POM:- its ability to give a detailed breakdown of policy effects by different types of household and tax unit (or any other criterion the user selects), its ability to predict the Exchequer costs of a policy, and its ability to assess the labour supply effects of a policy.

9.2 EXAMPLE 1 - Illustrative Effect of Income Tax Changes

The first illustration of the use of POM shows the effect of a change in Income Tax. (The "existing" Income Tax system is taken to be that which existed in April 1984. POM is based on the 1984 FES). The changes to income tax simulated in the first example, are similar to the reforms introduced in the 1988 budget. The standard rate of income tax is cut to 25 per cent (from 30 per cent in 1984), and all the higher rates of tax are removed except for a 40 per cent rate of tax which applies to all income above 300 pounds per week. The effect of these changes are shown in figure 9.1. The columns of the table represent different types of tax unit and the rows show ranges of gross income. Within each cell of the table the upper value shows the net income of the tax unit before the change while the lower value shows the net income after reducing the tax rates.

For comparative purposes a similar table produced by the IFS model is shown in figure 9.2 below. The IFS table does not simulate the same policy - it is used purely to show an alternative method of presenting information on changes in tax unit income. The rows of Figure 9.2 show
9. OUTPUT FROM THE MODEL

Figure 9.1 Net Incomes Before and After a Tax Reduction by Income Range and Tax Unit Type Produced by POM

Table Of: Gross Income Band 
By Type Of Tax Unit 
Mean of Net Income is the top Value in Each cell 
& Mean of Net Income After is bottom Value

<table>
<thead>
<tr>
<th>Gross Income Band</th>
<th>Type Of Tax Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lone Parent</td>
</tr>
<tr>
<td></td>
<td>Single Person</td>
</tr>
<tr>
<td></td>
<td>Childless Couple</td>
</tr>
<tr>
<td></td>
<td>Couple 1 Child</td>
</tr>
<tr>
<td>Under 50</td>
<td>53.90</td>
</tr>
<tr>
<td></td>
<td>29.87</td>
</tr>
<tr>
<td></td>
<td>86.41</td>
</tr>
<tr>
<td></td>
<td>76.27</td>
</tr>
<tr>
<td></td>
<td>53.51</td>
</tr>
<tr>
<td></td>
<td>29.44</td>
</tr>
<tr>
<td></td>
<td>85.09</td>
</tr>
<tr>
<td></td>
<td>75.12</td>
</tr>
<tr>
<td>From 50 to 75</td>
<td>102.03</td>
</tr>
<tr>
<td></td>
<td>69.54</td>
</tr>
<tr>
<td></td>
<td>128.28</td>
</tr>
<tr>
<td></td>
<td>147.92</td>
</tr>
<tr>
<td></td>
<td>101.16</td>
</tr>
<tr>
<td></td>
<td>67.79</td>
</tr>
<tr>
<td></td>
<td>125.82</td>
</tr>
<tr>
<td></td>
<td>145.42</td>
</tr>
<tr>
<td>From 75 to 100</td>
<td>118.53</td>
</tr>
<tr>
<td></td>
<td>88.82</td>
</tr>
<tr>
<td></td>
<td>153.70</td>
</tr>
<tr>
<td></td>
<td>138.66</td>
</tr>
<tr>
<td></td>
<td>116.36</td>
</tr>
<tr>
<td></td>
<td>85.77</td>
</tr>
<tr>
<td></td>
<td>149.64</td>
</tr>
<tr>
<td></td>
<td>135.64</td>
</tr>
<tr>
<td>From 100 to 125</td>
<td>148.66</td>
</tr>
<tr>
<td></td>
<td>102.02</td>
</tr>
<tr>
<td></td>
<td>165.73</td>
</tr>
<tr>
<td></td>
<td>153.33</td>
</tr>
<tr>
<td></td>
<td>145.11</td>
</tr>
<tr>
<td></td>
<td>97.89</td>
</tr>
<tr>
<td></td>
<td>160.80</td>
</tr>
<tr>
<td></td>
<td>149.15</td>
</tr>
<tr>
<td>From 125 to 150</td>
<td>166.57</td>
</tr>
<tr>
<td></td>
<td>123.26</td>
</tr>
<tr>
<td></td>
<td>185.47</td>
</tr>
<tr>
<td></td>
<td>175.68</td>
</tr>
<tr>
<td></td>
<td>161.21</td>
</tr>
<tr>
<td></td>
<td>117.75</td>
</tr>
<tr>
<td></td>
<td>178.98</td>
</tr>
<tr>
<td></td>
<td>170.15</td>
</tr>
<tr>
<td>From 150 to 175</td>
<td>170.37</td>
</tr>
<tr>
<td></td>
<td>134.90</td>
</tr>
<tr>
<td></td>
<td>200.58</td>
</tr>
<tr>
<td></td>
<td>188.35</td>
</tr>
<tr>
<td></td>
<td>163.96</td>
</tr>
<tr>
<td></td>
<td>128.41</td>
</tr>
<tr>
<td></td>
<td>192.98</td>
</tr>
<tr>
<td></td>
<td>181.76</td>
</tr>
<tr>
<td>From 175 to 200</td>
<td>147.91</td>
</tr>
<tr>
<td></td>
<td>160.95</td>
</tr>
<tr>
<td></td>
<td>214.68</td>
</tr>
<tr>
<td></td>
<td>209.54</td>
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<td></td>
<td>141.98</td>
</tr>
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<td></td>
<td>152.88</td>
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<tr>
<td></td>
<td>206.01</td>
</tr>
<tr>
<td></td>
<td>201.57</td>
</tr>
<tr>
<td>From 200 to 250</td>
<td>179.67</td>
</tr>
<tr>
<td></td>
<td>184.59</td>
</tr>
<tr>
<td></td>
<td>244.44</td>
</tr>
<tr>
<td></td>
<td>228.89</td>
</tr>
<tr>
<td></td>
<td>171.92</td>
</tr>
<tr>
<td></td>
<td>174.82</td>
</tr>
<tr>
<td></td>
<td>233.55</td>
</tr>
<tr>
<td></td>
<td>219.59</td>
</tr>
<tr>
<td>From 250 to 300</td>
<td>253.71</td>
</tr>
<tr>
<td></td>
<td>218.26</td>
</tr>
<tr>
<td></td>
<td>283.98</td>
</tr>
<tr>
<td></td>
<td>271.58</td>
</tr>
<tr>
<td></td>
<td>241.40</td>
</tr>
<tr>
<td></td>
<td>205.97</td>
</tr>
<tr>
<td></td>
<td>270.46</td>
</tr>
<tr>
<td></td>
<td>259.16</td>
</tr>
<tr>
<td>Over 300</td>
<td>251.01</td>
</tr>
<tr>
<td></td>
<td>312.20</td>
</tr>
<tr>
<td></td>
<td>390.54</td>
</tr>
<tr>
<td></td>
<td>367.98</td>
</tr>
<tr>
<td></td>
<td>238.14</td>
</tr>
<tr>
<td></td>
<td>320.54</td>
</tr>
<tr>
<td></td>
<td>397.72</td>
</tr>
<tr>
<td></td>
<td>379.71</td>
</tr>
<tr>
<td>Tot. Cases</td>
<td>362</td>
</tr>
</tbody>
</table>
9. OUTPUT FROM THE MODEL

different types of tax unit. The columns to the left of
figure 9.2 ranges of marginal tax rates. The column with
the heading "over" indicates those with marginal tax
rates over 100 per cent (i.e. those who are both paying
tax and facing high benefit taper rates). The items in
the cells indicate the proportion of cases in that row
which fall into each cell. The leftmost column of figure
9.2 shows the proportions of different family types with
marginal tax rates of under 50 per cent. The rightmost
column of figure 9.2 shows the number of cases from the
FES which fall into the relevant row. To the left of
this column the average net income after the given policy
change is shown. To the left of this the average net
income before the policy change is shown. To the left of
this is a column marked "average of column" which shows
the average marginal tax rate of the cases in each row.

![Figure 9.2 Net Incomes by Income Range - IFS Model](image)

<table>
<thead>
<tr>
<th>Family Type</th>
<th>Tax Exempt</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>123,456</td>
<td>78,901</td>
<td>67,890</td>
<td>56,789</td>
<td>45,678</td>
<td>32,456</td>
<td>23,456</td>
<td>12,345</td>
<td>5,678</td>
<td>45,678</td>
<td>100,987</td>
<td></td>
</tr>
<tr>
<td>Couple</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 1</td>
<td>456,789</td>
<td>345,678</td>
<td>234,567</td>
<td>123,456</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 2</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 3</td>
<td>456,789</td>
<td>345,678</td>
<td>234,567</td>
<td>123,456</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 4</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>123,456</td>
<td>78,901</td>
<td>67,890</td>
<td>56,789</td>
<td>45,678</td>
<td>32,456</td>
<td>23,456</td>
<td>12,345</td>
<td>5,678</td>
<td>45,678</td>
<td>100,987</td>
<td></td>
</tr>
<tr>
<td>Couple</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 1</td>
<td>456,789</td>
<td>345,678</td>
<td>234,567</td>
<td>123,456</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 2</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 3</td>
<td>456,789</td>
<td>345,678</td>
<td>234,567</td>
<td>123,456</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
<tr>
<td>C + 4</td>
<td>987,654</td>
<td>876,543</td>
<td>765,432</td>
<td>654,321</td>
<td>543,210</td>
<td>432,109</td>
<td>321,098</td>
<td>210,987</td>
<td>109,876</td>
<td>432,109</td>
<td>876,543</td>
<td></td>
</tr>
</tbody>
</table>

Total: 1,145,123, 876,543, 765,432, 654,321, 543,210, 432,109, 321,098, 210,987, 109,876, 432,109, 876,543
Figure 9.3 shows the average amount of taxes paid or benefits received by different types of tax unit. The type of tax unit is shown on the left. The top row shows different types of tax/benefit. From left to right the columns show the average amounts of the head of tax unit's Income Tax, National Insurance contributions of the head, National Insurance Contributions of the wife, Family Income Supplement, Supplementary Benefit, Rent Rebate, Rate rebate, Child Benefit, Housing Benefit Supplement, National Insurance Pension and the wife's Income Tax.

It seems probable that the strength of the IFS approach is that it provides useful information in a standardised way for any particular policy. In contrast, POM's output routines create tables which are probably more easily understood by a non-expert. However they require the
Figure 9.4 Equations for Family Income Supplement

Individual's Dependant_Child =
    if ((age <= 16) or ((age <= 19) and
        (Education_Level = State_Secondary_School)) then
        TRUE else FALSE.

Tax_Unit's Number_Of_Dependants =
    Number_In_Tax_Unit (Dependant_Child).

Individual's Prescribed_Amount =
    if (If_Getting_Fis = true) then
        (£ 76 + (£ 9.50 * Number_Of_Dependants))
    else 0.

Individual's FIS_Max =
    if (Getting_Fis = true) then
        (£ 22 + (£ 2 * Number_Of_Dependants))
    else 0.

Individual's FIS_Amount =
    if (If_Getting_Fis = True) then
        if ((Prescribed_Amount Less Original_Income)
            * 0.5) > FIS_Max
            then FIS_Max
        else ((Prescribed_Amount Less Original_Income)
            * 0.5))
    else 0.

user to create clear column and row variables (or to use standard variables which are stored within POM).

At the bottom of figure 9.1 average tax unit income before and after the change is shown. Below this figures the estimated national total for net tax unit income is
shown. The net tax unit income before the change was 126 bn, and 123 bn after it. From this it can be deduced that the cost of this policy to the exchequer would be 3 bn.

9.3 EXAMPLE 2 - Simulation of Family Income Supplement
In the second example entitlement to Family Income Supplement (FIS) has been simulated by calculating the amount of benefit each family would be eligible for, based on the characteristics of the family recorded in the FES. Some of the respondents to the FES state that they receive FIS but do not know how much.

For the second simulation the amount of FIS was calculated by POM. This was done by using the information in the FES on gross incomes, dependent children, and whether FIS is claimed. The equations used to calculate FIS entitlement are shown in figure 9.4 below. It should be noted that several of the user-defined variables in figure 9.4 are defined to be individual variables. It is important to attach the amount of FIS to the data of the one person in the tax unit (i.e. the person who actually receives the payments) otherwise the amount of the FIS payment would be deemed to be received by each member of the tax unit. This would cause errors if at a later stage the user wished to calculate the total benefit income of the tax unit.

FIS is predicted - £ 114 million. This compares to an official estimate of £ 123 million (DHSS, 1986). The figure for the cost of FIS is different if one calculates it by the simpler method of adding together all the recorded amounts of FIS. This method produces an estimate of 111 million pounds. It is hardly surprising that the estimate produced by this method is lower than 114 million pounds because of missing values where the claimant did not know much he or she received in benefit.
9. OUTPUT FROM THE MODEL

Figure 9.5 shows the average FIS payment by income band to head of tax unit. At the bottom of the table a prediction for the total cost of

---

Figure 9.5 Family Income Supplement

Table Of: Net Income Band
By All Individuals 1
The Mean of Predicted FIS Amount is the top Value in Each Cell
The Number of cases is the bottom value

<table>
<thead>
<tr>
<th>Net Income Band</th>
<th>All Individuals 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
</tr>
<tr>
<td>Under 50</td>
<td>24.45</td>
</tr>
<tr>
<td></td>
<td>42</td>
</tr>
<tr>
<td>From 50 to 100</td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Over 100</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Tot. Cases</td>
<td>45</td>
</tr>
<tr>
<td>Average Across All Cases of Predicted_FIS_Amount</td>
<td>23.17</td>
</tr>
<tr>
<td>Est. National Total of Predicted_FIS_Amount</td>
<td>114 Million Per Annum</td>
</tr>
</tbody>
</table>

Table Excludes 18468 Cases with Missing Data

The apparently large number of missing values is because all those people who did not claim Family Income Supplement are shown as missing. The forty-five cases where individuals did claim FIS represents 0.24 per cent of the total FES sample, which is in line with the total number of people who claim FIS as a proportion of the
9. OUTPUT FROM THE MODEL

total UK population. The FES variable which shows whether or not Family Income Supplement was claimed records a "1" if it is claimed, and a "0" if the person did not claim or the information was missing. It is therefore not possible to distinguish between non-claimants and missing values for this particular simulation.

9.4 EXAMPLE 3 - Simulation of Labour Supply Responses
The simulation in the third example is based on the work of Brown, Levin, and Ulph (1976). Their research attempts to predict number of hours people work based on their marginal wages and an estimate of the income they would receive if they were out of work (see chapter 5). The equations used to produce this estimate are shown in figure 9.6 below.

---

Figure 9.6 Equations to Predict Work Hours

Individual's Net_Employment_Income =
   Net_Earnings - Earned_Income_Tax.

Individual's Net_Original_Income =
   Original_Income - (Tax_bill + NIContribution).

Individual's Household_Net_Income =
   Total_Household (Original_Income
   - (Tax_Bill + NIContribution)) +
   State_Benefits_In_Household.

Household's Other_Income =
   Household_Net_Income -
   Total_Household(Net_Employment_Income).

Individual's Tax_Rate =
   NIRate + Income_Tax_Rate.
9. OUTPUT FROM THE MODEL

Figure 9.6 Continued - Equations to Predict Work Hours

Individual's Hourly_Wage =
    Normal_Gross_Wage / Usual_Hours_Worked_Per_Week.

Individual's Marginal_Wage =
    (100 - Tax_Rate) * (Hourly_Wage / 100).

Individual's Marg_Wage_Squared =
    (Marginal_Wage * Marginal_Wage).

Individual's Intercept =
    ((Tax_Threshold / 100) * Income_Tax_Rate).

Individual's Old_Work_Hours =
    if (Married and Usual_Hours_Worked_Per_Week > 8
        and sex = male and
        Overtime_Hours_Worked <= 0) then
        Usual_Hours_Worked_Per_Week.

Individual's Inter_Wage =
    Intercept * Marginal_Wage.

Individual's New_Work_Hours =
    if (Married and Usual_Hours_Worked_Per_Week > 8
        and sex = male and Overtime_Hours_Worked <= 0) then
        ((2.376 * Marginal_Wage) + (2.253 * Intercept) -
         (0.000018557 * Inter_Wage) - (0.00160733 * Other_Income) -
         (0.0000133021 * Marg_Wage_Squared) + 7746.261)
    else 0.

This is based on a regression analysis of married male workers from the FES 1984. The theory on which this simulation is based is explained more fully in chapter 6 above. The model explained 0.1146 of the variation in

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work hours, which is similar to the original results achieved by Brown, Levin and Ulph (1976). The results of this regression are shown in figure 9.7 below.

Figure 9.8 is a table produced by POM to show the effect of a cut in income tax on work hours. The cut in tax rates is the same as that described above for example one. It shows the predicted number of work hours by income range. The lower value in each cell of the table is the actual number of hours that people within the sample said that they worked. The upper value is the prediction of the number of hours

![Figure 9.7 Model to Predict Work Hours](image)

<table>
<thead>
<tr>
<th>R Square</th>
<th>0.11463</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjusted R Square</td>
<td>0.11241</td>
</tr>
<tr>
<td>Standard Error</td>
<td>8.13982</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marginal_Wage</th>
<th>2.376</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.253</td>
</tr>
<tr>
<td>Intercept * Marginal Wage</td>
<td>-0.000018557</td>
</tr>
<tr>
<td>Other Income</td>
<td>-0.00160733</td>
</tr>
<tr>
<td>Marginal Wage Squared</td>
<td>-0.0000133021</td>
</tr>
<tr>
<td>Constant</td>
<td>7746.261</td>
</tr>
</tbody>
</table>

they would have worked as a result of the income tax cuts. The simulation shows that for all ranges of gross income, the response to the tax cut is a fall in the number of work hours. This would indicate that for the sampled population the income effect is stronger than the substitution effect. People are able to earn the same amount of money in exchange for less work. (In this
9. OUTPUT FROM THE MODEL

particular simulation this effect is stronger than the incentive effect of allowing people to receive more income for a given hour of work).

Figure 9.9 shows an example of output from the TRAP model (King, M.A., Ramsay, P., 1983), which is intended to simulate the effect of behavioural responses to tax-benefit policy. The output shown in figure 9.9 would probably be more difficult for a non-expert to interpret than the table in figure 9.8. It should be stressed that figure 9.8 only refers to married men working more than 8 hours per week. Therefore it is only to be expected that the table shows a large number of missing values.

Figure 9.8 Predicted Work Hours before and after A Policy Change - output from POM

<table>
<thead>
<tr>
<th>All Individuals 1</th>
<th>All Individuals 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1987</td>
</tr>
<tr>
<td>All</td>
<td>40.36</td>
</tr>
<tr>
<td></td>
<td>36.24</td>
</tr>
<tr>
<td>Tot.Cases</td>
<td>1987</td>
</tr>
<tr>
<td>Average Across All Cases of Old_Work_Hours</td>
<td>40.36</td>
</tr>
<tr>
<td>Average Across All Cases of New_Work_Hours</td>
<td>36.24</td>
</tr>
</tbody>
</table>

Table Excludes 16570 Cases with Missing Data

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9. OUTPUT FROM THE MODEL

9.5 Conclusion
The tables shown above are solely intended to be illustrative of the type of output which can be produced by POM. Different researchers have used different methods of producing each type of table. POM does not constrain the user to choose one method rather than another. For example, in example two the user would be free to estimate the cost of FIS based on the recorded amounts of FIS or on the amounts calculated within POM. Example 3 is not intended to be a contribution to labour supply theory, but rather an illustration of how such theory can be used by POM. A comparison with alternative methods of displaying such data indicates that POM’s methods may produce output which is easier to interpret than the output produced by the existing models which simulate behavioural responses.

The user interface chapter shows that POM provides the user with a handy and comprehensible system for specifying the contents of tables. This makes POM’s output procedures both usable and flexible.
10. POTENTIAL USER REACTIONS

10.1 Introduction

In order to assess how far POM has succeeded in its aims, POM was demonstrated to a number of potential users and their reactions to it were collected. It was important to gain an impression of the strengths and weaknesses of POM from those who have had experience of using other tax-benefit models. If POM was in no significant respects different from the existing models then clearly it had failed. Ultimately it is intended that POM should be usable by a wide range of people who do not currently use tax-benefit models such as people in pressure groups, opposition parties, intra-party factions, academics and people in the media. However it would not have been possible to get a critical assessment of POM by demonstrating it to people who have never had any experience of tax-benefit modelling. The potential users selected for the purpose of this review had in each case some existing experience of tax-benefit modelling. In some cases those who were asked to comment on POM had invested considerable energy in developing their own models, and so had no predisposition to lavish praise on a rival package. Nevertheless it was necessary to gain potential user reactions to POM from people who has some basis for comparison.

The POM is intended to provide a facility for analysing tax-benefit policy which is sufficiently easy to use so that it is accessible to non-experts, and which does not restrict the user to a narrow range of policy options. In order to determine how far POM had succeeded in these aims the opinions of several potential users of the model were sought. Demonstrations of POM were given to staff at the Institute for Fiscal Studies, the Low Pay Unit, the London School of Economics, the Policy Studies Institute, the Department of Health and Social Security, and the Central Statistical Office. These people were
10. POTENTIAL USER REACTIONS

selected because they cover a range of experience of tax-benefit modelling - from technical experts in the field of computer programming to people who merely use programs written by others. Nevertheless all of the people interviewed were involved in work which required them to analyse tax-benefit policy. Their analysis took a number of forms from civil servants advising ministers on options for changing policy to pressure group workers who respond to government policy. It should be stressed that the opinions expressed during these interviews were personal observations by individuals and should not be attributed to the organisations which employed them.

The individuals who were interviewed are listed below together with a summary of their particular area of expertise in tax-benefit policy modelling.

1. Graham Stark (Institute for Fiscal Studies) has probably done more work on the IFS model than anyone else. He has an unusual degree of expertise in the technical computer programming aspects of tax-benefit modelling.

2. Robin Smail (Low Pay Unit) commented as an end user of an existing tax benefit package, TAXMOD, which he uses to produce the Low Pay Unit's post budget briefing. He comments as a user of a tax-benefit model rather than as a computer programmer.

3. Holly Sutherland (London School of Economics) is the main computer programmer responsible for current versions of TAXMOD, and also has a special expertise in the matter of adjusting the FES for the under-representation of certain family types and income groups.

4. Richard Berthoud (Policy Studies Institute) has been responsible for a number of research projects commissioned by government on social security. His research has been undertaken with the aid of an existing statistical package, "Quantime", rather than with an "in-
10. POTENTIAL USER REACTIONS

house program.

5. David Ramsden and Richard d'Souza (Department of Health and Social Security) commented as researchers in the DHSS Economic Adviser's Office (EAO). They both had experience of coming into the EAO and learning about the DHSS Policy Simulation Model from scratch, and so had had to interpret program statements written by other people.

6. Ian Scotter (Treasury) worked as a user of IGOTM to produce Treasury forecasts of tax revenues and benefit expenditures.

7. Deirdre Ross (Central Statistical Office) was a user of IGOTM.

8. Ian Wilkinson (Central Statistical Office) supervised projects which required tax-benefit policy analysis, but did not normally use IGOTM directly.

Before seeking the opinions of these potential users there was a demonstration of the program - normally with a hands-on session. Information was gathered through a focussed interview. The potential users were asked to assess POM's strengths and weaknesses in a number of different areas, and were also asked for general remarks not covered by the questions asked during the interview. In each case the potential user was asked to give an opinion of the model according to several criteria: the comprehensibility of the Policy Simulation Language, general usability, data representation, flexibility, and POM's overall strengths and weaknesses.

The preliminary impressions of the users are given below.

10.2 Readability & Comprehensibility

In general, the respondents considered that the statements used by POM were more readable than languages such as FORTRAN and BASIC. Graham Stark (IFS) said POM was more readable than FORTRAN, and about equal to Pascal. Holly Sutherland (LSE) concurred saying that it
10. POTENTIAL USER REACTIONS

would probably be easier to read a program fragment written with POM, than with another computer language.

Ian Scotter (Treasury) commented that the tax-benefit statements supplied as examples with POM were more readable than similar ones in other programming languages. However in his view the readability of the statements depended on the discipline of the person using POM. If the user was careful to write long self-explanatory variable names, then POM would be readable. Otherwise POM's statements would be similar to those of other programming languages.

Deirdre Ross (CSO) said that POM's statements were probably more understandable. The removal of control loop structures and the use of long variable names was very important in making POM's statements more readable. However it would not be possible for a user to alter something in a long series of rules without carefully reading all preceding rules to understand what had gone before.

David Ramsden of DHSS stated that the rules produced by POM were certainly more readable than statements produced by other languages. In the context of tax-benefit modelling within the DHSS Economic Advisers Office (where there are a large number of people doing tax-benefit modelling as a team) this would be extremely useful. With a program like POM different staff members would be able to understand and re-edit each others program files and that this was very difficult with their present system. However Richard d'Souza pointed out that these comments only applied to the DHSS Policy Simulation Model as it existed in mid 1988, at the time of writing the PSM was being altered so that fuller use could be made of long variable names.
10. POTENTIAL USER REACTIONS

Graham Stark (IFS) stated that it was hard to say whether POM would be more comprehensible in practice than the IFS model, which is based on FORTRAN. His experience of highly readable program languages such as COBOL was that it was often harder to see what these were intended to do, than with FORTRAN. Thus it was often much more difficult to detect errors in such programs. POM probably had similar strengths and weaknesses to COBOL. However, even with the IFS model's structure, alterations to the program were often difficult. Sometimes a change could be made to source code and the IFS model would run within 20 minutes, at other times one or two days would have to be spent searching for bugs when a change was made.

Richard Berthoud (PSI) said that for a small model the long variable names would be acceptable. However in a long model the long variables names might be begin to confuse rather than enlighten.

Ian Scotter (Treasury) commented that though the package is aimed at non-experts, some people in this category would still find it difficult to understand concepts such as the "If .... Then ... Else" statement. However Deirdre Ross (C.S.O.) felt that many non-programmers could comprehend such concepts and that a program like POM would be necessary if the ability to do tax-benefit modelling is to be extended to a larger number of people. In her view POM only required the learning of a few conditional statements. Ian Wilkinson (CSO) commented as a non-programer that POM definitely seemed more understandable.

Richard d'Souza (DHSS) praised the comprehensibility of POM saying that it would cut out errors. The existing DHSS system required numbers to be used in place of meaningful names which made it impossible to read the
10. POTENTIAL USER REACTIONS

program without the help of a codebook. The statements produced by POM would be readable enough to send to some one from a local benefit office for checking. "The problem with our existing statements is that they are very difficult for any one to check." The English language nature of PSL would also reduce the time needed to learn tax-benefit modelling in comparison with the DHSS Policy Simulation Model. The current model required an "immense" learning process.

10.3 Usability

Holly Sutherland (LSE) stated that for her it would have been quicker to have written a BASIC program, than to have learned to use POM. However the advantage of having ready-labelled data through POM was significant.

Graham Stark (IFS) remarked that learning to use POM was probably easier than learning a programming language, but was not easier than using a menu-driven model. If the user was to be denied access to the raw data, then this would be a substantial disadvantage. He felt that it would perhaps be quicker to get a model up and running with POM, but it would be longer before he believed in the accuracy of the results. He would believe in the accuracy of his own model sooner. Respondents in general felt it would be quicker to write a large module in POM than in another language.

Ian Scotter (Treasury) considered that the English language style format made POM easier than using the existing programming languages. However he also felt that skilled users (i.e. computer programmers) would find PSL restrictive and prevent them from achieving tasks which would be possible with a programming language with the full range of control structures. For a non-programer, however, he felt that POM would definitely be easier. Switching from the upper to the lower screen was
10. POTENTIAL USER REACTIONS

a problem. It was difficult to use the pop-up menus initially but the user would probably get used to these.

Ian Scotter (Treasury) also observed that POM does not easily allow for comparative runs with different tax/benefit structures, or even with a different parameter for the same structure. This occurs because variables are overwritten on the disk if their calculation is changed in any way. Thus, for instance, tax liabilities are overwritten each time the basic rate of tax is changed. It would be possible to change a parameter by creating a variable with a different name, but this might involve re-processing a series of rules and having variables re-written to disk.

Richard Berthoud (PSI) observed that POM would be an advantage for a novice who was willing to rely on it and did not mind the absence of the flexibility of a programming language.

David Ramsden (DHSS) considered that the pop-up variable windows were a good feature. A novice user would rely on these windows initially but would be able to type the variable labels from the keyboard directly as the became more familiar with the system.

Robin Smail (Low Pay Unit) found it difficult to see POM replacing TAX-MOD, for such things as the Low Pay Unit's post-budget briefing. The learning required to use POM to write a full representation of the tax-benefit system was such that a non-specialist researcher would be unlikely to have the time to write a large scale model with POM. However there were situations where having access to the raw data would be very useful, such as the ability to find out whether low wage earners were predominantly from low income households. Data on wage levels and household incomes exists in the data set for
10. POTENTIAL USER REACTIONS

TAX-MOD but the menu structure of TAX-MOD means that one simply cannot get the data out in the correct form.

10.4 Data Representation
Holly Sutherland felt that the data was represented in a clear way, but warned that the data had to be unambiguous. For example, the mortgage interest variable as supplied by the Department of Employment has a large number of missing values. In the LSE Tax-Mod package the mortgage interest variable has been adjusted to take account of missing answers by supplying the average amount of mortgage interest where necessary. As with all of the tax-benefit models the accuracy of the results depends on such background work to make up for deficiencies in the data.

Graham Stark (IFS) commented that for those people who already have experience of using the Family Expenditure Survey POM's variable names might be a hindrance, as they already had experience of the Department of Employment's code numbers for each variable, for other users the labels would probably be a help. Thus the data representation would probably be clearer for novices but not for experts.

Richard Berthoud (PSI) said that the use of English language labels for categorical variables like "Type_of_Housing_Tenure", and "Standard_Region", was a definite improvement in that it avoided the need to look up the value in a codebook.

10.5 Flexibility
Graham Stark commented that it was more flexible than a menu driven system, but less so than using a programming language and having access to the raw data. Ian Scotter (Treasury) commented that defining a new benefit would be quicker with POM than with the Tabulator (an in-house
10. POTENTIAL USER REACTIONS

package used at the Central Statistical Office) but not faster than with a case-oriented model written in a high level language like FORTRAN.

Ian Scotter (Treasury) observed that POM needed a facility for the user to define constants. Such values as the Single Person's Tax Allowance would be referred to in several places in a tax-benefit system. It would be useful to be able to make one alteration of a constant, which would thus obviate the need to make changes to numerous different tax-benefit statements. This would improve the user interface for changing the parameters of a given tax-benefit structure. It appeared that changing a tax-benefit constant was more difficult in POM than in the other tax-benefit models, whereas changing the tax-benefit structure was easier than with the other models.

10.6 Speed

Ian Scotter (Treasury) said that a tax-benefit model which would be acceptable to his department would have to execute in at most 30 minutes, but the target elapsed time should be much shorter than this. POM would not meet this requirement if were to be used to process a large set of rules from scratch. However in many cases, policy changes would only be made in incremental stages. If only one or two rules needed to be altered for a particular simulation then this would only take a few minutes.

10.7 General Strengths and Weaknesses

Ian Scotter (Treasury) summarised POM as follows. Its main strength was that it was easy to understand. The accessibility of the tax-benefit structure to non-experts was good. Its tabulation procedures were good, though it would be preferable to be able to examine the hierarchical relationships between different household
10. POTENTIAL USER REACTIONS

members more easily. The drawbacks of POM were principally its lack of speed, the lack of an easy method of changing the parameters of the tax-benefit system, the difficulty of comparing two different tax-benefit systems, and the lack of more sensitive procedures for grossing up to population totals.

Richard Berthoud (PSI) commented that POM was user-friendly in a superficial way. However he stressed that tax-benefit modelling is an extremely complex process and that a user must be extremely careful in carrying out simulations. POM’s ease of use might be a disadvantage if it encouraged novice users to experiment with tax-benefit policy without adequate care.

David Ramsden and Richard d’Souza (DHSS) thought the speed of POM might be adequate for their purposes. The readability of the statements would be an excellent advantage for them as they had three or four members of staff doing tax-benefit modelling at any one time. The advantage of being able to understand and alter each other’s work easily would be a major gain. The prospect of being able to work entirely in a micro-computer environment rather than rely on the main frame would also be an attraction. They concurred with Ian Scotter about the lack of features to cope with differential benefit take-up rates, and grossing-up for different types of household. There was also a fear that the process of writing a file for each new variable might use too much disk space. To detect other drawbacks it would be necessary to have extensive operational experience.

There was a general consensus that POM’s user interface was an improvement on the existing methods. However it was felt that further work was needed to improve the POM’s execution speed.
11. CONCLUSION

11 Introduction
This research question which this thesis addresses is whether it is possible to construct a computer model of tax-benefit policy which is flexible enough to simulate novel ideas but is usable enough to be operated by people who are not experts. This twin problem of flexibility and usability concerns both the mechanisms for inputting policies and those for getting meaningful data out of the model. The non-expert user must be able to conceive a completely new policy and define it in a way which the user finds reasonably natural and comprehensible. Moreover the method of defining the policy must produce a specification which is accurate enough for the computer to interpret. Similarly the output mechanisms must be a handy enough tool for the non-expert to wield, but must not restrict the user to a narrow range of standard output tables.

This conclusion will examine in turn the issues of POM's usability, flexibility, and its output mechanisms. In light of this some possible future developments of POM will be discussed. Finally there will be an assessment of the impact POM might have, both in terms of its short and long term effects.

11.1 Usability
The success of any computer program can be assessed most accurately by a detailed survey of a large number of users. This has not been possible in the case of POM. The survey of potential users is no more than a collection of first impressions, mainly by people who have already invested time and energy in developing their own tax-benefit models (and who have little incentive to be adulatory about a new entrant into the field). The minority of respondents who were obliged to work with tax-benefit models designed by other people were
extremely favourable. One official at the DHSS commented that he was "gob-smacked" by the quality of POM's user interface. Praise also came from a civil servant in the Central Statistical Office who was a user, rather than a designer, of the IGOTM model. What linked the experience of the people who were most favourable to POM, was not only that they had not designed their own models, but that they were not primarily computer programmers. They were generalists who had been forced to assume the role of programmers as non-experts.

The ease with which such generalists can learn the Policy Simulation Language (PSL) flows from the fact that it is anchored in their existing knowledge to a greater extent than other programming languages. The structure of PSL statements is not quite English, but anyone with a knowledge of English and elementary mathematics should have little trouble in grasping it. The building blocks of PSL are all in everyday conversational use: "If", "&", "Per_Annual", "Then", etc. In just the same way phonetic alphabets which link written characters to commonly produced sounds are easier to learn because they are linked to elements of speech in everyday use. Chinese pictograms which give no indication of pronunciation are much more difficult to learn. In general information transfer technologies have often made their greatest impact, not when they first made a thing possible, but when they became accessible to the majority of a population. Thus the original inventor of the light bulb, Dr Swan, is almost totally eclipsed in public memory by Thomas Edison whose tungsten filament made the lightbulb practical for general use. In a similar way computer programming may have yet to make its greatest impact, because the technicalities of existing programming languages still make it relatively inaccessible to the lay person.
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The most impressive accolade for the usability and comprehensibility of PSL came from the civil servant who said that the problem with the program statements in the model he was using were more or less "uncheckable", whereas it would be possible for PSL statements to be understood and checked by staff in local benefit offices.

11.2 Flexibility

Though model users like Stark, of the IFS, said that they would regret not having access to the raw data or the full features of a programming language, at no time during the interviews with potential users did any one point out a tax-benefit policy which could not be simulated with POM. The building blocks exist to simulate any tax or benefit, so long as the assessment of the benefit payable or tax due is based on a variable included in the data set. However this limitation applies to all tax-benefit models. An example of a policy which could not be simulated with POM would be a National Disability Income, because the data on disability in the FES is incomplete. (Disabled people can only be identified through the receipt of an existing disability benefit in the FES. As one of the main aims of a Disability Income would be to reach people excluded by the existing benefits it would thus be pointless to base an analysis which excludes people who are disabled but are not helped by the existing system.)

The way the data is stored makes POM more flexible than the IFS model, for example. This is because POM's data is stored on an individual basis (the individuals are organised into tax units, which are in turn organised into households). In contrast, the IFS model cannot be used to analyse taxes or benefits at the level of the individual because its data is aggregated at the level of the tax unit. Thus the IFS model could not show the income losses which would be suffered by adult non-
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householders under the community charge. As a result the government's Green Paper Paying for Local Government showed numerous analytical tables of the effects of the community charge on tax units and households, but not a single table demonstrated the effect of the community charge on the unit which is to be the basis for the tax: the individual.

POM's main claim to achieve a high degree of flexibility rests on the fact that it gives the user access to a programming language rather than a series of menus. Even the best of the menu-driven models, TAXMOD, in the form it is distributed to pressure groups, would be incapable of simulating the most significant tax-benefit reform proposals which have been put forward in recent years. It did not include menu options for the Vince (1983) tax credits. Even though the authors of TAXMOD had done detailed research on the Vince scheme (Atkinson, 1984: 28), there was no way that a user of the TAXMOD program could have simulated both the flat rate personal tax credits and the scheme's withdrawable low income credits. TAXMOD included several menu options for the form of Basic Benefit system specified by Taverne (1986), but any user of TAXMOD would be required to be content with an inexact simulation of the Taverne proposals because TAXMOD did not allow for the system of earnings disregards which were to be allowed before Taverne's Basic Benefits were to be withdrawn. It should be stressed that these references to TAXMOD should not be taken to mean that TAXMOD is particularly inflexible. TAXMOD is used in these instances to illustrate that there are important policies which cannot be simulated by even the most flexible of the existing models.

None of the existing models would have been able to simulate Meacher's (Times, 1985) tax-benefit proposals which included a new form of housing support to replace mortgage interest tax relief. This new payment was to be
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based on average housing costs in each region. This element of regional variation is not provided for in any of the existing tax-benefit models. It is exactly the type of option which policy-makers should be able to experiment with, but which cannot be simulated by a menu driven system. Since no one had previously suggested a regionally varied system, no menu system has been constructed to accommodate this option.

With PSL, however, it would not only be possible to gain access to the "Region" variable, but the user would be able to use self-explanatory values when using the region variable. For example, the user could use a condition such as "If Region = Yorkshire" instead of "If Region = 4".

11.3 Output

The chapter on the principles of tax-benefit policy attempted to provide a summary of the most commonly used criteria for judging fiscal policies. This chapter showed the sheer variety of yardsticks which can be used to assess tax-benefit policies. This variety should make clear the dangers inherent in choosing a small set of standard output tables, because the selection of these standards involves selecting an ideological bias. For example, the CUBS model shows the marginal tax rate and net income by the number of hours per week worked by the individual but does not show net incomes by family type. Nor does it give an assessment of the effect of a policy on income equality as would a statistic like a Gini coefficient. "Value-Neutrality" is a utopian concept in choosing a list of criteria by which to assess political policies. Any such list will reflect political preferences and prejudices, even if one conducted a representative sample survey of an entire population to ascertain what standards should be used to judge a fiscal policy (a project which would assume an optimistic
assessment of the public's grasp of political economy), the result would be no more than a summation of the prejudices and preferences of a group.

This presumption of value-neutrality is a defect of the existing tax-benefit models because they all offer the user a pre-determined set of standard tables and charts. POM allows the user to produce tables based on any variable within the data set. In addition, to the commoner types of table such as those which show income gains and losses by family type and income group, and those which illustrate changes in marginal tax rates, the user could simulate a vast range of other tables. An ardent Scottish Nationalist might wish to determine the average net incomes in different regions before and after a policy. This would be entirely possible by using the region variable. It would be possible to go further than this by creating a new variable based on the standard region to include only two categories: Scotland, and the rest of the UK. This could be used to assess more clearly how a particular policy would affect the transfer of resources to Scotland.

In some cases the standard tables are restrictive even though they seem to a number of salient aspects of policy analysis. The existing models concentrate on "marginal" tax rates almost to the exclusion of "average" tax rates. Someone concerned to assess whether a tax conformed to the proportionality principle would be more concerned with the total tax charged as a percentage of total income rather than the percentage which is levied on the individual's highest unit of income. If the tax as a proportion of all income was roughly the same across different income levels then it would be possible to state that a tax was fairly consistent with the proportionality principle. This assessment would be impossible simply by examining marginal tax rates.
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Assessing the extent to which a policy prevents people from falling into poverty makes it necessary to assess what a given household needs to live on. This might require that some measure of minimum income such as the Income Support level for each household should be worked out in order to assess the extent to which people fell below this level. (Though the Income Support level is not universally accepted as a measure of minimum income it is useful to have it as a possible yardstick.) None of the existing models show household incomes in relation to Income Support levels (though TAXMOD comes closest by dividing the number of family members by the number of equivalent adults). The existing models exclude the possibility of making an important assessment of the poverty-preventing aspects of a policy by preventing the user from determining how many households fall below their Income Support level. By giving the user access to the data to calculate Income Support levels, POM leaves this option open. If the user went further than the "minimum needs" concept of poverty which is implicit in using Income Support levels, and attempted to define poverty in a relative way, then the access to the data would be even more important.

Chapter nine showed how it would be possible to use POM to make an assessment of the behavioural responses to a policy. Like TRAP, POM forces the user to make an explicit choice to include a theory of behavioural responses. POM leaves open the possibility of simulating theories which relate to behavioural responses other than labour supply responses, so long as the data needed to make predictions about other forms of behaviour exists in the data set.

In summary, POM attempts to produce a "value-neutral" system for analysing policies by leaving the choice of
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assessment criteria in the hands of the user. POM's tabulator prompts the user with a series of easily understandable questions to allow for the construction of a table tailor-made to the user's ideological specifications.

11.4 Future Developments of POM
As it has only been possible to develop POM to the prototype stage it is only possible to guess at its full potential. Speed is likely to be a drawback of POM in its current form. Ironically, this is mainly due to one of the features of POM which was intended to increase its speed of execution. The "run-coding" of the data which requires them to be stored in a separate file for each variable actually appears to be slower than a system based on a simple case-based file structure. Currently POM has (roughly) 40 different data files (one for each variable).

In order to test the speed of a case-based system a data file with records containing forty variables for each of the c. 17000 individuals was constructed. This occupied over 4,000,000 bytes of storage space in contrast to the run-coded data which needed less than 1,000,000 bytes. However it was possible to read the entire data file with all forty variables in under a minute, whereas reading only ten run-coded variables (and without performing any calculations or writing results to disk) takes over twenty minutes. The use of run-coding in POM certainly met its objective of saving storage space. In certain applications it might be preferable to dispense with this advantage in order to achieve greater execution speed.

Another impediment to the speed of POM is its reliance on interpreted rather than compiled code. There could be major gains in execution time if POM produced compiled code rather than code to be used by an interpreter. This
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could be achieved by transforming POM into a language translator which would write out PSL statements in the source code of another language such as Pascal or C. A compiler could then transform this source code into object code.

These possible improvements in POM's execution speed do not detract from the usability of POM as seen by potential users because the comprehensibility of the language was something they could assess from the hands-on sessions which they were given.

One doubt which was raised about POM was that people using it under considerable pressures of time would tend to shorten the variable names to a point where they would become incomprehensible. The extent to which this would undermine the usefulness of POM depends to a certain extent on the way in which it is to be used. If one person only is to alter the program statements over a long period of time as is the case with in the IFS, where one researcher does the vast majority of the work of altering the model, then the damage is limited. If, as in the case of the DHSS Economic Advisers' Office several members of staff work on the same model and staff are frequently transferred to new posts, then it would be particularly important for users of POM to write full self-explanatory variable names (e.g. "Number_of_Kids" rather than "XCH"). It would be technically possible to constrain rather than encourage users to do this, if it were felt to be sufficiently important. One could, for example, link the parser to a computer dictionary of the type used to check spelling in word-processing programs. The parser could be instructed not to accept any variable names which do not consist of elements which are full English words. In the example above, "Number_of_Kids" would be accepted because each of the three elements are English words (though as far as
the dictionary would be concerned "kid" would refer to the offspring of goats rather than humans), whereas "XCH" would not be accepted. Such constraints are not as bizarre as they might at first seem. Supporting very large programs is a very serious problem. Sometimes programs grow to such enormous sizes that it becomes almost impossible to maintain and adapt them when their original creator departs to another job. Enforcing a self-documenting programming style may be a practical solution to this problem.

If POM required full English words to be used in its variable names, then the use of the pop-up window and mouse method of entering long variable names would become even more important. It would also be possible to design a routine which would insert a variable name by typing in the shortest combination of letters which uniquely identifies it.

One minor improvement to POM would be to provide a series of standard tables to be used as a quick alternative to the process of requiring users to specify tables themselves. This would not detract from the open choice of assessment criteria described above, but would provide means for new users to produce tables quickly.

Another extension to POM which was recommended by one of the potential users was the provision of user-defined constants. This would take the form of a short statement linking a name to a numerical value such as "Single_Persons_Tax_Allowance = £ 2605 Per_Annum". Thus if this tax allowance were referred to in several places in a model, the user could alter all of the occurrences of the value £2605 simply by altering one line. This would also make it possible to design an automatic menu-generator for POM. It would be possible to construct a program which would search for all of the constants in a
model and then form them into a series of menus. This would have two major advantages. Firstly, for a novice user who did not want to go through the process of learning from POM's instruction manual the menu-generator could be used to create a program like TAXMOD for any particular set of statements defined in PSL. Secondly, altering these constants through a menu system might be a faster way of experimenting with minor changes of a policy than by re-parsing and reinterpreting (or if POM is transformed into a program which uses compiled code then changing constants while the program is running would be faster than recompilation).

POM and its associated language, PSL, have explored a number of possibilities in the field of opening up access to computer programming. The refinements which could be made to add to its speed and usability could make it an extremely effective program, possibly with general statistical analysis uses, and not only in the area of tax-benefit modelling.

11.5 Practical Effects of POM on government
A modified version of POM of the type described above could be a very useful resource for political parties, intra-party groups, and pressure groups. It would hopefully make it much more difficult for situations to arise such as Meacher's presentation of a new social security policy (The Times, 1985a) without being able to provide any predictions of the likely effects of his policy on actual families or any estimate of the exchequer costs or savings. Similarly, the wrong estimation of the cost of the Vince tax credit proposals (1983) should be more difficult if a model such as POM were in general use. The SDP in 1986 would have been able to discover for themselves the point at which most people would have been net losers under their tax-benefit system, rather than wait for the IFS to publish the
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results which the SDP then repudiated in an embarrassing public row.

More detailed work should be possible from pressure groups such as the Low Pay Unit, which expressed an interest in knowing the number of low wage earners who were also in low income households. It would be entirely possible to do such analyses with POM, whereas they are not possible with a program such as TAXMOD, unless the menu systems have been set up to allow for them. It is inconceivable that if a highly effective and quick method of analysing policies were to be used by opposition parties and pressure groups that the government would allow itself to be at a disadvantage in terms of research. It would either seek to acquire POM itself, or design a similar alternative. This could have important effects on the access to tax-benefit modelling because the capabilities of generalist civil servants would be enhanced.

Yet even if the generalist official became more powerful, it would be much more difficult for civil servants to manage the supply of information to ministers because intra-party pressure groups could produce their own analyses of new policies directly to the minister concerned. The monopoly or oligopoly control over the supply of tax-benefit policy information would be broken.

This is a hopeful scenario for the effects of POM, or a successor version of POM, on the policy making process. None of these effects can be proved. In this sense, the conceptual arguments about the effect of the dispersal of information are more useful. Though one cannot prove that any particular method of transmitting information will have a specific effect, political and social history does indicate that the dispersal of information has contributed to the dispersal of power.
11.6 Conceptual arguments of POM’s effect on the Policy Process

To appreciate the possible impact of POM on the policy process it is necessary to return to the discussion on the nature of power in the first chapter.

One of the concepts used to define power is pluralism. If one were to assess contemporary Britain in terms of Dahl’s methodology of observing power conflicts, it would be difficult to be sanguine about the view that Britain is a pluralist society. In terms of the conflict of political parties power seems to be concentrated rather than dispersed, with the same party winning three elections in succession and seemingly no prospect of an early alternation of power. The balance of power between central and local government is continually being shifted in the direction of centralisation. Britain’s local government is so far from the concept of federalism that councils are regarded merely as "creatures of parliament" to be controlled, modified, or even abolished at the whim of the legislature. In contrast to presidential systems, which hold out the possibility of executives and legislatures of different parties, Britain’s synthesis of legislative and executive power make for a marked concentration of power. The dependence of ambitious MPs on ministerial posts for their advancement give them an enormous incentive to conform to the wishes of the Prime Minister. Similarly the judiciary seems heavily influenced by the executive. Judicial appointments are entirely in the hands of the executive. There is no concept of cross-party approval in the appointment of judges, as exists in the USA. Even where judges occasionally establish a legal precedent against the wishes of the executive as in the case of the Ponting trial, the government can legislate to change it. The government’s 1989 Secrecy legislation will effectively
abolish the principle of legal disclosure of information when it is in the public interest, thus abolishing the effect of the decision in the Ponting trial.

One does not get an impression of Britain's power structure being any more dispersed if one accepts Bachrach and Baratz' (1962) view that the power relationships can be assessed by observing the suppression of issues from the political agenda. Even if conflicts do appear on the political agenda, one group appears to win all the political conflicts anyway. There is no need to look at subtler levels of analysis to find a concentration of power.

If Lukes' three dimensional view of power is correct then it is difficult to see how such a small enterprise as a new tax-benefit model could make any impact. If the determinants of power-wielding are so vast and immutable as the structure of society, a structure which in contemporary Britain seems to give almost unlimited power to the dominant faction of the governing party, then how could so small a thing as providing an information resource make a difference? Such an information resource might allow alternative ideas to be promulgated in the media and to be spoken about in public meetings, but if the power to quash such them is still firmly in the grip of the governing faction what use are they? If Crenson's view that the power reputations of dominant elites are enough to prevent alternative views coming forward, then those in opposition would not even bother to switch on their computer, let alone use it to devise a well thought-out policy, because they would naturally assume that their policy would never be implemented.

Is the three dimensional view of power potent enough to justify this view? The problem with the three dimensional view of power is that it does not provide a
plausible explanation for the way power relationships change over time. Though radical critics of the status quo may complain about the unequal distribution of power in contemporary Britain, it would be foolish to deny that over the centuries there has been a major process of power dispersal. Power was more concentrated in the hands of the Tudor monarchs than it was when the propertied classes dominated parliament in the eighteenth century. Similarly, power was more concentrated during this period than in the twentieth century when universal suffrage helped force the propertied classes submit to progressive taxation and the welfare state. In all of the countries of the European Community there has been a similar transition from monarchy to oligarchy and then to democracy. If, as the three dimensional view suggests, those in power can prevent alternative policies from even being put forward, how can one explain these massive changes in the structure of power?

An essential precondition for an attempt at political change is a consciousness that circumstances might be better and different. Such consciousness depends on generally accessible methods of information transfer. History provides few examples of peoples which have won democratic freedoms for themselves without mass literacy. It is difficult to imagine Britain's American colonists seeking their independence in the eighteenth century without printed polemics against the injustices of British rule, and books questioning the foundations of monarchical government like Thomas Paine's "The Rights of Man". It is significant that the major democracies which have illiteracy rates of over 50 per cent, such as India, became so as a result of decolonisation rather than through internal struggle. It is significant that China, whose language is based on pictograms rather than on a phonetic alphabet, has never had a strong democratic movement. This is in spite of a high level of
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civilisation dating from at least the third century B.C. when China was united under Shi Hwang-ti and when the construction of the Great Wall commenced. The importance of writing was grasped by the novelist Ray Bradbury in *Fahrenheit 451* in which he envisaged a society where books were outlawed in order to make dictatorship possible.

The cause of democracy has been strengthened each time another rung has been climbed on the ladder of knowledge. The invention of a phonetic alphabetic, paper, moveable type printing, and mass education, have all made it harder to suppress freedoms. It cannot be proven that any of these inventions actually caused a revolution, a rebellion, or even a legislative proposal, but it would be difficult to conceive of any of the modern democracies having come into being without them. The invention of cheap micro-computers able to manipulate large quantities of information about entire societies is also an important episode in the history of data transfer.

The great problem which seems to underlie the thinking of the academic debate about power is the concentration on the power structure of entire societies, to the seeming exclusion of examining the motivation of individuals. A theory which allowed for the impact of individual motivations would probably have a better chance of explaining changes in power relationships over the centuries, than the structuralist approaches of Lukes (1974) and Poulantzas (1986). A methodological defect which seems common to both the pluralists and the elitists is the choice of a relatively narrow time frame as a basis for research. For example, it is undoubtedly true that Crenson uncovered cases where the power reputation of large corporations had prevented or postponed measures to deal with air pollution. However, there can be little doubt that if he had compared the
politics of air pollution in the 1860s with his own research in the 1960s that the popular will for clean air was being asserted far more vigorously in his own period. It would be too narrow to assert that power reputations, class structures, and agenda management were the only reasons why clean air laws were enacted in the twentieth rather than the nineteenth century. The dissemination of knowledge clearly played its part. Greater consciousness of the effect of air pollution on respiratory diseases like lung cancer and tuberculosis were undoubtedly significant. Knowledge of pollution controls in other parts of world must have planted in peoples' minds the thought that similar reforms could be introduced in their own localities.

To understand the potential impact of a tax-benefit model, it is necessary to gain a proper understanding of the relative importance of individual motivations on the one hand and structures of power on the other. If the case for a pluralist tax-benefit model rested purely on the contention that it could alter the structure of power as a mechanistic device, then it would be an extremely weak case. Devices for the transmission of information can have consequences far more momentous than their inventors can ever have imagined. They are a channel through which the power of ideas can flow. Though it is the ideas themselves that effect historical change, the information channel is a necessary precondition. The originators of the latinate phonetic alphabet can have had no idea of the impact that "Das Kapital" or the American "Declaration of Independence" would make, yet one can still make a strong case that these ideas would not have had such an impact if they had been recorded in Chinese pictograms because pictogram-based languages are so much more difficult to learn.

Research devices such as tax-benefit models must be set
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in a different category from instruments to effect changes in tax-benefit policy such as private members bills, budgets, publicity campaigns, and public inquiries. Judging their importance involves grasping the difference between inspiration and implementation. Is it the chisels and the marble which make a great statue, or is it the mental image which first forms in the mind of the sculptor? Archimedes once said that if he had a lever long enough and a place to stand that he could move the world, yet what use would any of this be without the will to apply pressure to the lever?

The ultimate importance of any method of transmitting ideas can only be assessed in light of the use which is made of it. The computer, as Evans put it, can extend the power of the human brain in the same way that the steam engine extended the strength of the human arm at the outset of the industrial revolution. It may be that some future Beveridge will use a tax-benefit model in order to work out some great social reform. There is no way of knowing. Whatever the success or failure of a device for extending knowledge, it should not be judged purely as a mechanical device which will have a demonstrable effect on society or which will alter the material advantage of one section of society. In the words of Keynes "In the long run it is ideas, and not vested interests, which will be powerful, either for good or for evil."
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APPENDIX A - USER MANUAL

About the Policy Option Model
The Policy Option Model (POM) of the Tax-Benefit system is designed to provide the best possible environment in which to test out different tax and social security policies. It supplies you with a full screen editor to set out your ideas. It gives you access to a set of information from the Family Expenditure Survey.

English Not Computerese
One of the major differences between the Policy Option Model and other tax-benefit models and statistical packages, is that it expects you to think in English, not in mathematical symbols or in a computer programming language. For example, suppose that you wanted to express the statement:-

\[
\text{Taxable Income} = \text{Total Income} - \text{Tax Allowances}
\]

In a typical computer language this might look like this:-

\[
\text{TI1} = \text{TI2} - \text{TA}.
\]

This version is more confusing. If you come back and look at this line several months after you first wrote it you could easily have forgotten what it means. Using the POM you would write it like this:-

\[
\text{Taxable Income} = \text{Total Income} - \text{Tax Allowances}.
\]

It is the same as the English language statement above, except for the fact that terms which go together like "Tax" and "Allowances" are linked by the underscore character "_". This is so that POM will be able to see where one term starts and another one stops. POM goes out of its way to make sure that you can speak in English and not in specialist jargon. If you have a long term like "Self_Employment_Income" POM saves you the time it takes to type it in at the keyboard by allowing you to point to it with your mouse. At the touch of a button the term "Self_Employment_Income" will appear in your line of text, without the need to key in each character.

Names not Numbers
Most of the information you will be dealing with will be represented as numbers such as income, housing costs, etc. However, some information refers to a set of categories like Marital Status ("Single", "Married") etc. POM allows you to enter these values as words rather than numbers. For example the line :-

\[
\text{if sex = female}
\]

is perfectly valid in POM, whereas in other languages one might probably write a statement like
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if sex = 2.

However you must be careful to use exactly the right label recognised by POM, or else you will be told you have made an error. The tutorial on page 4 shows you how to use the exact label you need simply by guiding the mouse to the label you want and pressing the mouse button.

Handy Tools for Modelling
A special set of tools have been devised so that you can cut down on the time you take to set out your ideas. Suppose that you wanted to find out the total investment income in the household. With a programming language you would probably have to write several lines of commands in order to achieve this. With POM all you have to do is write:

```
Total_Household (Investment_Income).
```

All you have to remember is to enclose the items to be totalled within brackets. You could include a full expression within the brackets such as :

```
Net_Business_Income =
Total_Household (Business_Income - Business_Losses).
```

In this case the losses would be subtracted from the Business Income for each member of the household, and the total net business income of the household would be worked out.

The various special procedures for tax-benefit modelling are set out below in the Command Reference Section below. It is worthwhile to read through these before you start modelling to find out what procedures are there to help speed up your work.

Family Relationships
Frequently in tax and social security policy it is necessary to express a rule in terms of the relationship between different household members. For example, if a benefit for the whole household refers to the head of household's income then POM allows you a number of tools so that you can use data about some one with a specific status within the household. You could express the rule as :

```
Head_Of_Household's Income.
```

These pointers always consist of a person within the household followed by an apostrophe (' ) and an ' s ' , implying the possessive form of the word. It is possible to group together a number of pointers so that they are considered at the same time. For example, in simulating the rules for Housing Benefit you would need to refer to
the Head_Of_Household's Wife's Age

which would be perfectly acceptable in POM.

Comprehensibility & Accuracy
It is very common with large computer models that mistakes will creep in because the model is not readily understandable. If several members of the same team are working on a model, it is very likely that mistakes will occur if variable names are used which are not meaningful. Even if only one member of staff works on a large model it is likely that problems will arise if the same person returns to a program fragment after several months of working on something else. The English language approach of POM is not only intended to speed up the process of defining the model, but also to enhance accuracy as a wider number of people will be able to understand and check a given model.

Computer Requirements
To use POM you need an IBM compatible computer with at least 512 K of RAM, a hard disk, and a Microsoft (or compatible) mouse.

Getting Started
In order to start using POM it is essential that you go through the fifteen minute tutorial set out below. There are a number of features, which have been built in to POM that differ from other computer programs. You will find it extremely difficult to learn the essential features of POM without doing the tutorial.

Conventions Used in the Manual
When the manual invites you to press a series of keys on the computer keyboard, the keys are enclosed between a "Less Than" ('<') and a "Greater Than" ('>') sign, and separated by hyphen. Thus the following line

< CONTROL - K - Q >

would indicate that you should hold down the CONTROL key and press the 'K' key followed by the 'Q' key. It should be remembered that the CONTROL key and the SHIFT key do not print out characters themselves, they alter the meaning of the other keys. If the manual says to press

< CONTROL - K - B >

then the control key should be pressed while the 'K' key and the 'B' are pressed. If you stop pressing the CONTROL key before you press the 'K' or the 'B' key then the command will not work.

When a Function Key is referred to, it is often
ABBREVIATED. FOR EXAMPLE, FUNCTION KEY 10 IS ABBREVIATED TO " F10 ".

POM DOES NOT DISTINGUISH BETWEEN UPPER AND LOWER CASE LETTERS. IN GENERAL THE FIRST LETTER OF A VARIABLE NAME, OR PART OF A VARIABLE NAME, IS CAPITALISED (SUCH AS GROSS INCOME). THIS IS PURELY TO MAKE THE NAME MORE READABLE. THE CAPITALISATION IS NOT NECESSARY FOR POM TO WORK PROPERLY.
APPENDIX A - USER MANUAL

TUTORIAL - FIFTEEN MINUTES TO TAX-BENEFIT MODELLING

Setting Out
The basic prerequisites for undertaking this tutorial are that the user should have an elementary knowledge of MS-DOS, and that the POM program and data files should have been transferred on to the hard disk drive of an IBM compatible computer.

In order to start POM working, go to the POM directory on your disk, and type `< P - O - M - RETURN >` at the keyboard (it does not matter whether upper or lower case letters are used). You will see the screen change. The bottom half of your screen will appear blank and the top half will have all sorts of words and figures which you probably won’t understand (don’t worry about this, it will be made clear later). Near the top of the screen a small window will open up which says 'Please wait while the essential variable information is read in'. This is necessary so that when you use the program all of the names of the variables and their labels will be available to you.

After about thirty seconds the window asking you to wait will disappear, and the cursor will start flashing about half-way down the screen.

A Tale of Two Windows
At this point the cursor is flashing in the Editing Window, this is the lower half of the screen (which is blank). The Editing window is the area where you write out your tax-benefit policies. It functions like a normal word-processor. You can type in words, move around the screen, search for and replace words. You can even move or read in blocks of text.

The top window is the command window/screen. This has various specialist commands concerned with tax-benefit modelling. Because they appear on the top half of the screen you can put them in your text without actually typing them in. You will be shown how to do this below.

In order to move between the two windows all you have to do is press the `< ESCAPE >` button on your keyboard. You should see the cursor jump from its current position up to the top screen. Press `< ESCAPE >` again and the cursor will go back to the editing window. You will probably find it more convenient to move between the two windows using the mouse rather than the `< ESCAPE >` key. Instead of pressing the `< ESCAPE >` key take the mouse and press the right hand button, this is the same as pressing the `< ESCAPE >` key. You should now see the cursor blinking in the top half of the screen as it was before. If you press the `< ESCAPE >` key again the cursor will return to the same place it was in the edit window, before you moved up. Similarly when you go back to the command
window the cursor will be placed in exactly the same position it was before.

Now move the cursor to the Command Window - and move the cursor around by rolling the mouse on your desk top. You will see that when the cursor points to a word on the top half of the screen it will display that word with a highlighted background. This shows you which term is selected at any one time. Let's practise writing a tax-benefit definition using both the edit window and the command window. First press the right-hand mouse button to return to the lower half of the screen.

Creating a Definition
The first thing you have to do when creating a tax-benefit definition is to specify whether it applies to the entire household, the tax unit, or to the individual. This is important because POM needs to know who the tax or benefit applies to. For example, local authority rates apply to the whole household, the proposed community charge applies to the individual, and Income Tax applies to the Tax Unit (either a single person or a legally married couple). When you are using POM you must always state the unit of analysis (that is whether the definition applies to the individual, tax unit, or household). If you forget POM will remind you to put it in.

Let's suppose that we are trying to find the number of pensioners in the household. In order to do this we would need to count the number of people who are female and whose age is greater than or equal to 60, or who are male and whose age is greater than or equal to 65. In POM you could specify this as follows:

\[
\text{Household's Number_of_Pensioners} = \text{Number_In_Household \ ((sex = \text{female}) \ and \ (age \geq 60) \ or \ (sex = \text{male}) \ and \ (age \geq 65))}.
\]

The tutorial will show you how to type this in using the various features of POM which help you to remember variable names and value labels. Please attempt to type this rule in correctly at this stage. You will be told how to correct errors later in the tutorial. You could just create this by typing it in at the keyboard. PLEASE DON'T We are going to create this in a special way which will demonstrate the capabilities of POM. First use the mouse to move the cursor to the place on the screen where you want to start writing the rule. Now press the right hand mouse button so that the cursor jumps to the command screen. Roll the mouse around until it is pointing to the word "Household's" on the command screen. The word "Household's" should now be highlighted. Now press the right hand mouse button (this is equivalent to pressing the < RETURN > key). You should see that the word "Household's" appears in the editing window at the place
where the cursor last was. Now press the right hand mouse button to go back to the edit window.

The Screen Editor
Tap the space bar to create a gap after the word "Household's" and then type in the term Number_of_Pensioners. Remember to type the underscore character (_) to connect up the different parts of the word. Now type the "=" sign. Press the return key to move down a line. You need to insert the term from the command window, "Number_In_Household", so move to the top of the screen as you did before using the "ESCAPE" key. Roll the mouse around until it rests on the term "Number_In_Household" (which should thus be highlighted). Now press the return key and you should see that the term "Number_In_Household" has been inserted into your line of text. Press the "ESCAPE" key again to return to the lower half of the screen and type in two left hand brackets. Make sure the cursor is on the space immediately to the right of the second bracket, and press the right hand mouse button to move to the command screen.

The Variable Windows
Though the next term "sex" is quite short and could easily be typed in at the keyboard, let’s find out how to enter it through the command window. Move the mouse so that the term "INDIVIDUAL VARIABLES" is highlighted. Now press < RETURN > or the left hand mouse button. You should see a pop-up window appear in the upper half of the screen. On the top line of the window - the title should say "Individual Variables". Roll the mouse up and down. The highlighted bar will move in response. The items in the window are arranged alphabetically. You can roll the mouse down until it points to the term "sex". Now try rolling the mouse all the way up until it passes the first item in the list. It scrolls around to the end of the list and you keep on going. Keep on moving it until it points to the word "sex". Now press the RETURN key. The word "sex" should now appear in the line of text you are building up. Jump down to the edit window with the right hand mouse button. Now type an equals sign "=" at the keyboard. (You don’t need to have a space at the end of the term "sex" because POM knows that an equals sign cannot be part of a variable name). Now let’s see how you would find the term "male".

The Value Label Window
Use the right hand mouse button to jump to the command window. Roll the mouse around until it points to the term "VALUE LABELS". Press the left hand mouse button. The pop up window which appears, contains all of the variables which refer to sets of categories rather than numbers (such as region, housing tenure group, etc.). If you want to check the value labels for a particular variable all you have to do is press the left hand mouse.
button, while pointing to the appropriate variable within the window. In this case roll the mouse down to the term "sex", and press the left hand mouse button. A small pop-up window will appear with the options "male" and "female". Point to the "female" option and press the left hand mouse button. The term "male" appears in your line of text. If you are in a pop-up window and you don’t want to select any of the items, all you have to do is press the right hand button or the <ESCAPE> key. The pop up window will disappear and the cursor will be where it was before.

If you use variables which have value labels you MUST use exactly the correct word for the value label. You can probably remember "male" and "female" easily enough and type them in straight from the keyboard. However, variables like Standard_Region, Type_Of__Housing_Tenure, and Industry have longer value labels, so it is better to use the pop-up windows for these rather than to try to remember them and type them straight in at the keyboard. If the word you’ve typed in is not one of the correct labels for the variable to the left of the equals sign then when you ask POM to check the rule you will be told that you have made a mistake.

Now that you’ve got this far in the "Number_Of_Pensioners" definition you should be able to complete it yourself. Remember to put a full stop at the end of the definition. POM needs to know where one definition ends and the next one starts.

The Pulldown Menu
So far you have only experienced the command window and the editing window. You also have access to a pulldown menu system which helps you to find out which commands are available. Put the cursor in the lower half of the screen, if it is not there already. If the cursor is in the upper screen then move it to the lower screen by pressing the "ESCAPE" key. Press Function Key 10. You will see the top of your screen change, to show a number of options such as "Search", "Block", and "File". These options give you access to a further set of sub-options. Let’s see what some of these sub-options are. Move the mouse or the cursor keys backwards and forwards. You will see that the highlighting of the terms in the pulldown menu changes so that you can see which option is currently selected. Press the return key while the name "Block" is highlighted. A further pop up menu appears showing you all the block commands which are available with POM. Once again you make selections by moving the mouse up and down and pressing the left hand mouse button. Press the right hand button and the menu will disappear.

Move to the "File" option. Press the Left Hand button. Let’s save the definition you’ve created to a file.
Instead of using the mouse pointer, there is another way of selecting the option you want. You will notice that the options in the window all have one letter which is capitalised. This will not necessarily be the first letter of the command. For example, in the file sub-menu there are separate commands for "Save" and "Save As". The save command saves the file currently in memory on to the disk with the existing file name, whereas the "save As" option allows the user to save the current file "AS" a file with a new file name (which the user will be asked to type in at the keyboard). Therefore the letter "S" has been used to signify the "Save" command, and the letter "A" signifies "save As" (if the same letter was used the computer would not know which command was being chosen). Press "A" for "save As" and you will be asked for a name for the file. Type in a name and press return. To get back to the editing window press ESCAPE twice. After the first ESCAPE the sub-menu will disappear, then the main pulldown menu will disappear and you will be back in the editing window where you left it.

Creating A Variable

Let's create a variable based on our definition of "Number_of_Pensioners". Make sure that the cursor is on the first line of the definition you are about to process. If the cursor is somewhere else in the definition POM will not understand the rule correctly and an error message will be displayed.

Now press Function Key 10. This will open up the pulldown menu on the top of the screen. You will see that the pulldown menu has a main option called "Model". This contains all the commands to do with creating variables and tables. Press the letter "M" key, and a sub-menu of Model options will be shown. You will see an option called "process a rule". Within POM there are a series of rules which define the tax-benefit system. The sentence you typed in earlier about the number of pensioners is one of these rules. When you "process a rule" what you are doing is telling POM to work out the answer for this rule for every household with the data set. So POM will get the information about the first household, work out how many pensioners there are, and then get the information about the next household. As it goes along it will write out the answers to a file for future use. This process of calling up the information and writing the answers to disk is called "processing a rule".

Press the letter "p" for "Process a rule" and you will see the cursor moving around the edit window. This shows that POM is reading your rule to check that it is in an acceptable form. If it is POM will start processing the rule and a pop up message will appear in the top part of the screen telling you how long you will have to wait for the rule to be created. If there is a problem then an
APPENDIX A - USER MANUAL

error message will appear. If an error message does appear, it should tell you the nature of the error. To correct it press the "ESCAPE" key, and then return to the editing screen. You will need to check that the rule you have typed in is exactly the same as the definition for "Number_Of_Pensioners" shown above. If the variable is created with no problems you will be back in the pulldown menu at the end.

Remember that you can now do calculations which involve the variable you have just created. Let's check this. Press ESCAPE twice. You should now see that the cursor is back in the lower half of the screen. Press "ESCAPE" and the cursor should jump to the top half of the screen. Move the mouse around until the cursor rests on the term "HOUSEHOLD VARIABLES" (because you indicated that the variable "Number_Of_Pensioners" was to be a household variable by writing the term "Household's" in front of the variable name. Press the Left Hand mouse Button. As you scroll up and down the window using the mouse you can see that the term "Number_Of_Pensioners" has been added to the list at the correct alphabetical position.

Processing an entire Model
So far you have seen how to process a single definition and write the variable to disk. You can also process several definitions at the same time. To test this lets read in a set of definitions which have been saved to disk. Press Function Key 10 to call up the pulldown menu. Press "F" for File and "0" for Open. You will then be asked to supply a filename. It is necessary to give a file name in case you want to return to your work later. You may be asked whether you want to abandon the existing file. If you wanted to save your definition of pensioners then you would type in the letter "N" which would allow you to go back and save it. Let us assume that you don't want to save the existing file. So type the letter "Y" indicating you do want to abandon the current file. Now key in the word "TAX" and press return. Three definitions will then appear. The first definition creates a variable called "Original_Income" which adds together several forms of income. The second one specifies the value of tax allowances each person is entitled to. The third one works out the taxable income by subtracting "Tax_Relief" from "Original_Income". In order for this series of rules to work you need to process all three definitions one after the other. This is because "Tax_Relief" and "Original_Income" are used to work out "Taxable_Income", and they are only temporary variables.

Now press Function Key 10 to call up the pulldown menu. Press "M" for Model, and "A" for "process All rules". You will see the cursor moving through the definition as POM checks that it is correct. Just as before, POM will show you how long you will have to wait for the model to
Making a Table
In order to make a table, press Function Key 10 to call up the pulldown menu. Press "M" for model, "T" for "make a Table". The first thing you will be asked is to define if the table is going to be about individuals, tax units, or households.

Move the mouse button up and down to select "Household", and then press the Left Hand Button to make your selection. Next you will be asked to define the structure of the table. The rows and columns must be category variables rather than numerical variables, so when the menu appears asking you what variable is to be used for rows and columns only category type variables which apply to entire households will be shown. If you want to create a table using columns and rows you first have to create a variable which puts these values into groups. For example you could create a variable for ranges of income, and then use it in a table.

Select the option "Standard Region" for the Rows, and then "All Households" for the Column. After you select the column and row variables, you are asked to select two variables to be shown for each cell of the table. Typically one would wish to show net income before and after a particular change. You must select two variables using the pop up windows. Let's find out what the average rent is in each region and compare it to the average spending on mortgage interest. First point the mouse and the variable rent and press the Left Hand Button. Then point the mouse at the term "Mortgage_Interest" and press the button. Finally you will be asked to say whether nought should be considered a missing value when the table is constructed. To illustrate what this means consider what would happen if you wanted to find out the average amount of Family Income Supplement (FIS). If you wanted to find out the average amount of FIS for all families, the average would only be a few pence because the vast majority of families do not claim it. However, if you choose to treat zero as a missing value POM will show the average amount of FIS in those cases where FIS is not zero. Therefore you can use this facility to get the average of all non-zero values.

After you have answered the question about the treatment of zero POM will show you an estimate of how long it will take to create the table.

Saving the table
After POM has finished working out the values in the table, it will show the table on the screen. The top four lines of the table show which variables have been used for the rows, columns, and cell contents. You can
use the mouse or the up/down cursor keys to see different parts of the table. When you have finished viewing the table press ESCAPE or the Right Hand Button. You will be asked if you want to save the table. Answer "y" for Yes. You will then be asked to key in a long name to describe the table. This should be something long and meaningful so you will know what the table refers to if you come back and look at it in a few months time. Type in the label "Rent and Mortgage Interest by Region". This label is not the same as a filename so you can use blank spaces in the line, and it can be up to forty characters long.

Displaying a Table
If you want to look at a table which has already been created you need to call up the pulldown menu with Function Key 10. Press "M" for model, and "D" for "Display a Table". You will then be shown a list of tables which has already been created with POM. In order to select the table you want. Roll the mouse up and down until it points to the title you are interested in. Then press the Left Hand Button. After a moment the appropriate table will be displayed on the screen. Once again you can use the mouse or the up/down cursor keys to look through the table. When you are finished use the ESCAPE key/Left Hand Button to finish displaying the table.

Leaving POM
You've now used all the main features of POM. If you want to exit from POM, remember to save what is in the edit window with the keystroke series -

< FUNCTION KEY 10 - F - S >

which stands for (show the pulldown menu, File Options, Save File). You are now ready to leave POM. You should still be in the "File" option of the pulldown menu. Now press "Q" for "Quit" and POM will return you to your computer's operating system.

REFERENCE GUIDE
The reference guide below shows you the various commands available to you through POM. The left hand column shows the command, the middle columns show the keystrokes you need to type to call up the command through the pulldown menu, and the right hand column shows the required keystrokes if there is a quick way of invoking the command directly through the keyboard.
Figure A.1 Summary of POM's commands

<table>
<thead>
<tr>
<th>COMMAND</th>
<th>QUICK KEYBOARD KEystrokes:</th>
<th>PULLDOWN MENU KEystrokes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AutoIndent</td>
<td><code>&lt; F10 - T - A &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Block Begin</td>
<td><code>&lt; Ctrl - k - b &gt;</code></td>
<td><code>&lt; F10 - B - B &gt;</code></td>
</tr>
<tr>
<td>Block Copy</td>
<td><code>&lt; Ctrl - k - c &gt;</code></td>
<td><code>&lt; F10 - B - C &gt;</code></td>
</tr>
<tr>
<td>Block End</td>
<td><code>&lt; Ctrl - k - k &gt;</code></td>
<td><code>&lt; F10 - B - E &gt;</code></td>
</tr>
<tr>
<td>Block Move</td>
<td><code>&lt; Ctrl - k - m &gt;</code></td>
<td><code>&lt; F10 - B - M &gt;</code></td>
</tr>
<tr>
<td>Block Delete</td>
<td><code>&lt; Ctrl - k - y &gt;</code></td>
<td><code>&lt; F10 - B - D &gt;</code></td>
</tr>
<tr>
<td>Change Directory</td>
<td></td>
<td><code>&lt; F10 - f - l &gt;</code></td>
</tr>
<tr>
<td>Cursor Bottom of Window</td>
<td><code>&lt; Ctrl - q - c &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Down a Line</td>
<td><code>&lt; Ctrl - x &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Down a Page</td>
<td><code>&lt; Ctrl - c &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor End of file</td>
<td><code>&lt; Ctrl - q - c &gt;</code></td>
<td><code>&lt; F10 - g - e &gt;</code></td>
</tr>
<tr>
<td>Cursor Left a Character</td>
<td><code>&lt; Ctrl - s &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Left a Word</td>
<td><code>&lt; Ctrl - a &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Right a Character</td>
<td><code>&lt; Ctrl - d &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Right a Word</td>
<td><code>&lt; Ctrl - f &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Up a Line</td>
<td><code>&lt; Ctrl - e &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor Up a Page</td>
<td><code>&lt; Ctrl - r &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor to Start/End Line</td>
<td><code>&lt; Ctrl - j &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Cursor to Top of File</td>
<td><code>&lt; Ctrl - q - f &gt;</code></td>
<td><code>&lt; F10 - g - t &gt;</code></td>
</tr>
<tr>
<td>Delete Character Right</td>
<td>Del,</td>
<td><code>&lt; Ctrl - h &gt;</code></td>
</tr>
<tr>
<td>Delete Line</td>
<td><code>&lt; Ctrl - y &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Delete Word to Right</td>
<td><code>&lt; Ctrl - t &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Directory of Disk</td>
<td><code>&lt; F10 - f - d &gt;</code></td>
<td></td>
</tr>
<tr>
<td>Exit from Program</td>
<td><code>&lt; F10 - f - q &gt;</code></td>
<td></td>
</tr>
<tr>
<td>File - Close File</td>
<td><code>&lt; F10 - f - c &gt;</code></td>
<td></td>
</tr>
</tbody>
</table>

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File - Copy < F10 - f - y >
File - Erase < F10 - f - e >
File - Open New File < F10 - f - o >
File - Read Block In < Ctrl - k - r >
File - Rename < F10 - f - r >
File - Save with user-Supplied Name < F10 - f - a >
File - Save File from Window < Ctrl - k - s >
File Save&Open New File < Ctrl - k - d >
File Write Block < Ctrl - k - w >
File Exit and Save File < Ctrl - k - x >
Find and Replace < Ctrl - q - a > < F10 - s - r >
Find < Ctrl - q - f > < F10 - s - f >
Find - Repeat Last Search Command < Ctrl - l > < F10 - s - n >
Goto Column < Ctrl - o - i > < F10 - g - c >
Goto Line < Ctrl - o - l > < F10 - g - l >
Insert Mode ( ON / OFF ) < Ctrl - v > < F10 - t - i >
Insert Control Character < Ctrl - p >
Logged Directory < F10 - f - l >
Model-Create Variable < Ctrl - o - p > < F10 - M - P >
Model-Process All Rules < F10 - M - A >
New Line < Ctrl - m >
Quit Program < F10 - F - Q >
Save Text Settings < F10 - T - S >
Scroll Up < Ctrl - w >
Scroll Down < Ctrl - z >
Table Display < F10 - M - D >
Tabulate Data < F10 - M - T >
APPENDIX A - USER MANUAL

TERMS SPECIFIC TO TAX-BENEFIT MODELLING

The following section gives you a list of terms which have been specially designed to speed up the process of tax-benefit modelling. They allow you to do calculations using one line of programming which would normally take several lines to achieve.

Any_in_Household
The term "Any_In_Household" gives the value true if any of the members of the household meet the conditions in brackets following it. For example, one might want to determine if any person in a given household was of pensionable age. Therefore the following statement could be used:

Household's Any_of_Pensionable_Age =
Any_In_Household ((sex = female) and (age >= 60) or (sex = male) and (age >= 65)).

In this example POM would examine each person within the household, to see if he or she was of pensionable age. If any person meets the criteria, POM stops checking and returns the value "true". Otherwise POM carries on until the last person in the household and then returns the value "false". It is very important to enclose the expression following "Any_In_Household" with brackets, or else an error message will be displayed.

Any_in_Tax_Unit
The term "Any_in_Tax_Unit" is exactly the same as "Any_in_Household" above except that, it only looks at one tax unit. N.B. There may be several tax units within one household.

Head_of_Households'
The term "Head_Of_Household's" is a pointer (that is it is an indicator of a person in the household or tax unit from whom data is to be gathered). It refers to information pertaining to the first person within the household, who is coded "0" on the variable "Relationship_To_Head_Of_Household". Suppose that you were modelling a form of housing benefit which was related to the head of household's income, you might wish to use a statement such as:

Household's Rent_Allowance =
(80 % of Rent) - (20 % of Head_Of_Household's Gross_Income).

Households'
This term is used at the beginning of a definition to specify that the statement following it applies to the household level of analysis.
Husband’s
The term "Husband’s" is a pointer referring to person with the status of husband in relation the person currently being examined. If the individual currently being processed has a marital status variable showing that they are married, and is female, then the pointer will return a value relating to the first person in the tax unit. For example the following would be acceptable:

Individual’s Wifes_Earned_Income_Allowance =

If ((Marital = Married) and (sex = female) and (husband’s Tax_Allowance = £ 2425.00)) then = £2425.

Individual’s
This term is used at the beginning of a definition to specify that the statement following it applies to the individual level of analysis.

Number_In_Household
This term is followed by a pair of brackets. The brackets should contain a condition. "Number_In_Household" will count the number of people who meet the conditions specified in the brackets. For example, if you wanted to determine the number of people within a household who are under 25 years old and not working you could use the following definition:

Household’s Adult_Dependants =

Number_In_Household ((age >= 18) and (age <25) and (Employment_Status = Unemployed)).

Number_In_Tax_Unit
The term "Number_In_Tax_Unit" counts the number of people satisfying a certain set of conditions, in exactly the same way as "Number_In_Household" except that it only refers to the tax unit rather than the entire household.

Tax_Units’
This term is used at the beginning of a definition to specify that the statement following it applies to the tax unit rather than the individual or the household.

Total_Household
The term "Total_Household" is used to total a set of values across an entire household. The values to be totalled should be enclosed in brackets immediately after "Total_Household". Suppose that you wanted to calculate gross household income you could use the following definition:

Household’s Gross_Household_Income =

Total_Household (Investment_Income + Normal_Gross_Wage +
Total_Tax_Unit
The term "Total_Tax_Unit" performs the same function as "Total_Household", except that values are summed across the current tax unit rather than an entire household.

Wifes'
The term "wife's" indicates that the term following it refers to a household's wife. If the current person being examined is married and is male, then the pointer refers to information about the female partner in the marriage. Suppose that you wanted to find out if either the head of household is disabled or the head of household's wife is disabled then one could use the following statement:

Household's Needs_Allowance =

if (Head_Of_Household's Health_Condition = Disabled) OR
   (Head_Of_Household's Wife's Health_Condition = Disabled)
then Needs_Allowance = £ 50.00.

Withdrawn_By ... % of
Withdrawn_By is a mathematical term which is relevant to many benefits which are reduced gradually as income rises. For example, Family Income Supplement is tapered away by 50% as income rises. You could express this using withdrawn_by as follows:

       Tax_Units' Family_Income_Supplement =

       £50 Withdrawn_By 50 % of Gross_Income.

Withdrawn_By must be followed by a number from 1 to 100 followed by a percentage sign, and then the value by which the benefit is to be tapered away by. Normally this would be a single variable such as "Gross_Income". However, one could include an expression such as:

       £50 Withdrawn_By 50 % of (Earnings + Investment_Income).

An important advantage of Withdrawn_By is that it will not return a negative value. Once all of the benefit has been tapered away, it will be given a value of zero. If you used a minus sign you would have to include extra statements to prevent the benefit from taking a negative value.