1 Introduction

A tax and benefit model is a computer program that calculates the effects of possible changes in the fiscal system on a sample of households. By using a sample which is representative of the population, such models allow users to make accurate inferences about the aggregate revenue implications of specific changes, and to examine the distributional effects of policy on different sub-groups of the population. Correspondingly, tax and benefit models play an important part in the analysis of fiscal policy in the UK and abroad.[1]

The IFS has operated a tax and benefit model of the UK, known as TAXBEN, since 1983. TAXBEN operates on data taken from the Family Expenditure Survey (FES), a yearly representative sample of 7,000 UK households. It was substantially revised in 1990, (see Johnson, Stark and Webb, 1990) and since then a range of extra features have been added which have significantly enhanced TAXBEN's power as a tool for the analysis of policy. These include new routines modelling individual's budget constraints and replacement rates which, together with closer compatibility with the IFS labour supply model, Simulation Package for the Analysis of Incentives (SPAIN, Duncan,1991), have allowed us to use TAXBEN to examine behavioural responses to policy changes. The purpose of this working paper is to document the current TAXBEN model, given the changes that have occurred since 1990.

This introductory section outlines the uses of tax and benefit models and the basic structure of TAXBEN. Section 2 looks at the interface between the user and the model and at the sorts of output that can be produced. Section 3 concentrates on the data-source used, the FES, and outlines the means by which inferences of personal characteristics of individuals in the data are performed. Section 4 describes the main modelling routines, and the final section looks at the labour supply modelling routines implemented in TAXBEN.

1.1 The Purpose of Tax Benefit Models

Virtually everybody in the UK is affected by the tax and benefit system. In 1994/95, income tax alone raised over £60bn, while expenditure by the Department of Social Security exceeded £80bn. However, the way in which revenues are raised and benefits distributed has never been static. Since 1979, we have seen the top rate of income tax fall from 83% to 40%, while the standard rate of VAT has more than doubled. We have moved from a system of joint to independent income taxation. During the same period, many benefits have been introduced or abolished and the structure of means-tested benefits has been completely revised.

For all the changes which have come about, hundreds more have been advanced by a large variety of interested parties. In political debate, the motivations for such changes take many forms, well beyond the basic need to raise revenue or maintain levels of income. For example, in the summer 1995 the tax and benefit system was being advanced as the possible catalyst for housing market recovery and the potential saviour of the nuclear family. Undoubtedly, in coming years numerous other issues will arise.

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1 There are three other major tax and benefit models in operation in the UK, IGOTM at the Treasury, PSM at the Department of Social Security and POLIMOD at the Department of Applied Economics in Cambridge.

Given its importance and the interest that tax and benefit policy attracts, it is necessary to have some reliable means of assessing the effects of various policy options. All too frequently, impacts are discussed in terms "example" or "typical" families. Often, this "typical" family has been a single-earner couple with children receiving "average" earnings. However, single earner families with children comprise only 6% of families in the UK, and few of these will be on average earnings. Additionally, the use of such methods carries with it the temptation choose the household to highlight the point, rather than as a representative of the actual UK population, (see Johnson and Stark, 1993).

The advent of modern computer technology has provided a way around these problems. It enables the effects of a reform to be calculated, not just on a small number of examples, but on many thousands of households. Additionally, if the data source is representative of the population and includes detailed information on peoples incomes and expenditures, an accurate picture of the effects on the whole population will emerge. In the UK, the Family Expenditure Survey (FES), a cross-sectional survey of 7,000 households each year, provides a good source for this information.

Tax and benefit models usually provide static analysis, (i.e. the immediate financial effects of a reform on households) which will be inadequate for some policy reforms designed to change the behaviour of individuals. Recently, IFS have been developing techniques to integrate tax and benefit models with behavioural models, to enhance our understanding of the "second round" effects of policy changes. At a simple level, TAXBEN will calculate the effects of an indirect tax reform on expenditure patterns with a user defined demand elasticity for each category of expenditure. We have also integrated TAXBEN with our labour supply model SPAIN to provide estimates of the effects of direct tax and benefit reforms on incentives to work. This involves calculating individual budget constraints for each person in the sample and simulating the desired level of hours worked under two different tax regimes. Using this method we have been able to analyse the impact of reforms primarily intended to alter individuals' labour supply decisions rather than their incomes (see section 5 below).

1.2 What is TAXBEN?

TAXBEN is a PC based program, written in Modula2. Using a Pentium 90MHz processor and one year of FES data, it runs a simple reform of the tax and benefit system in under two and a half minutes. It is maintained and operated by members of the Personal Sector staff at IFS. Executable versions have been supplied to the Employment Department and the Northern Ireland Economic Council, the latter version being adapted to run on the Northern Ireland FES. TAXBEN has also been used as the basis for the development of tax and benefit models for Poland and the Czech Republic.

For speed and simplicity, the model is split into two entirely separate programs. First, the data creation program, takes the data from the FES and creates a subset of this which is needed by the model. This dataset contains gross incomes and expenditures, and can thus be used to model the effects of any tax or benefit system the user chooses. The data creation program also performs any imputations on the FES which are needed to model the tax and benefit system, such as entitlement to non-means-tested benefits. Once the dataset is created,

the model does not have to repeat these imputation calculations each time a new policy scenario is used. Additionally, the resulting model dataset is much smaller that the original FES, allowing it to be read more quickly and to be stored on a single floppy disk.

The second program, TAXBEN proper, contains the routines which calculate household's tax payments and benefit receipts. The program allows the user to alter most of the parameters of the tax and benefit system interactively at run time. Thus, for example, the income tax routine does not contain information on the rates or bands of income on which tax is charged. Rather, it requires that the user pass it variables which specify these values each time the model is run.

The model outputs data in a series of formats. The most important are the tabulation of results, which show the changes resulting from a reform, broken down by various sub-groups of the population. Additionally, results can presented graphically or individual variables can be written to computer files in a format which can be read by other computer packages, such as spread-sheets or statistical programs.

2 Using TAXBEN

Modelling a reform using any tax and benefit model comprises a number of distinct steps. Firstly, the model run must be set up, which involves choosing alternative tax and benefit systems for comparison, the data to be used, the method of uprating and weighting the data. It may also be necessary to specify the forms of output which are required. The model can then be run, calculating the tax benefit position of each of the households under each tax and benefit system. Finally, the results are produced in a format which can be interpreted by the user.

There are a number of ways in which each of these steps can be approached when programming a tax and benefit model. In this section we describe how TAXBEN sets up runs and outputs results, and the means by which the parts of the model are linked together. Our aim here is to demonstrate the type of results which can be obtained using a tax and benefit model and the methods we have used to attempt to make TAXBEN more easily accessible to the user. Sections 3 to 5 deal with the issues which arise in actually modelling the tax and benefit system.

The underlying philosophy in developing TAXBEN has been to make the model as user-friendly as possible. The aim is to produce a model that can be used to simulate complex changes to the tax and benefit system by those who have little knowledge of the model's programming. In addition, good design greatly enhances the speed and efficiency with which experienced users can exploit the model. This has led to the development of the model "front end", a piece of computer code which allows the user to change the parameters of the tax and benefit system, activate a run, view the output and check the results, all from within an interactive environment of menus, data-screens and output displays.

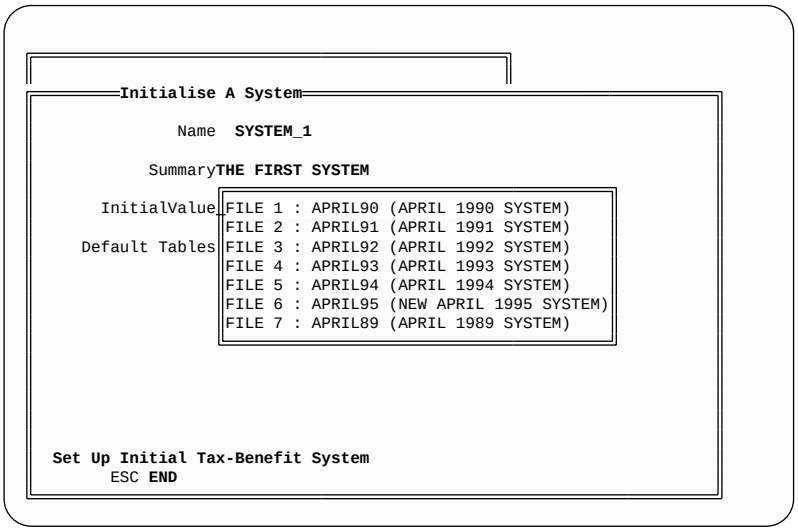
Naturally, this choice of modelling strategy imposes some costs. Most importantly, the computer code which implements the user environment is far more complex than the code necessary simply to model the tax and benefit system. This increases the time and cost of maintaining the model. Additionally, it is inevitable that some large-scale reforms cannot be handled through the user environment and require reprogramming of the underlying model code. While the choice of modelling language, Modula2, allows a high degree of separability between different sections of the program, there are still spill-overs into the procedures which actually do the modelling, making these more difficult to adjust.

2.1 Setting Up a Model Run

The first thing to do when analysing a reform is to specify the parameters of the tax and benefit systems to be used. This can be achieved in a number of ways. Usually, the user will be interested in looking at the effects of a change from the current or a recent tax and benefit system. Therefore the model has access to a number of pre-defined systems. Once loaded, these systems can be altered through a series of interactive screens. For example, over 40 elements of the income tax system can be altered, ranging from the tax rates to the definition of taxable income. Once altered, systems can then be saved for future use. Finally the model must know which dataset to use in the model as well as the take-up and uprating assumptions.

i) Pre-defined systems - these are set-up as ascii text files. These files must follow a standard layout and can be altered with any text editor. The files then need to be converted into a binary format which allows the user to call up the system from inside the TAXBEN environment, using the data-screen shown in Figure 1. In this screen, TAXBEN displays a list of all the pre-defined systems that have been set-up from which the user may select.

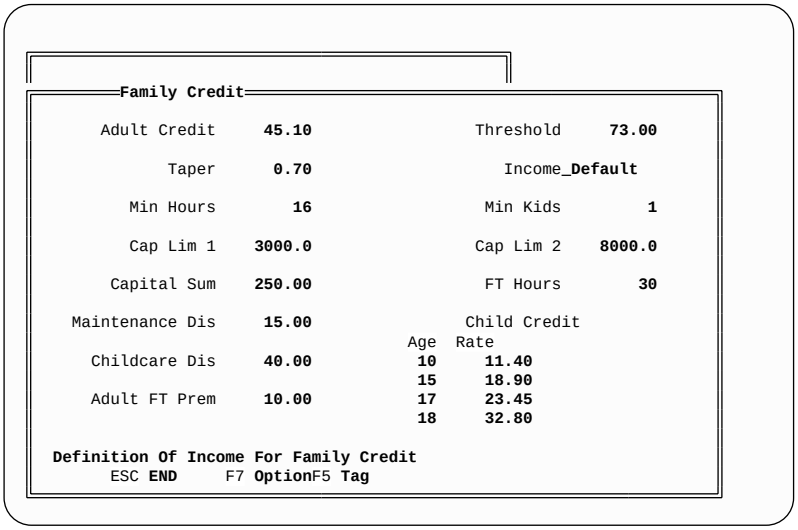
Figure 1: Loading a pre-defined system



In theory, it is possible to set-up any tax and benefit system in this way. However, altering the text files, converting them to binary format and then loading them into the model is rather long-winded, especially where the reform involves an alteration in only one or two parameters. The text files contains all the parameters of the tax and benefit system and runs to over 230 lines. This means that it is difficult, especially for the inexperienced user, to know exactly what each element in the file is referring to. For these reasons, this method of setting up systems is generally only used where the system is likely to be required repeatedly by users, as in the case of systems which have actually been in force in the UK.

ii) Altering systems inside TAXBEN - once a system has been loaded into the TAXBEN environment, the user can alter most of its parameters through a series of interactive menus and screens. Figure 2 shows one of the screens which can be used to alter the Family Credit system. As one would expect, it is possible to alter the level of the benefit credits, the allowance, the taper etc. However, it is also possible to make some more complex reforms. For example, from this screen one can alter the age ranges on the child credits, adding or removing ranges as desired, extend family credit to those with no children or alter the definition of income on which eligibility is assessed. There are over 30 such screens in TAXBEN, which gives the user control over virtually all the benefit and tax rates present in the system.

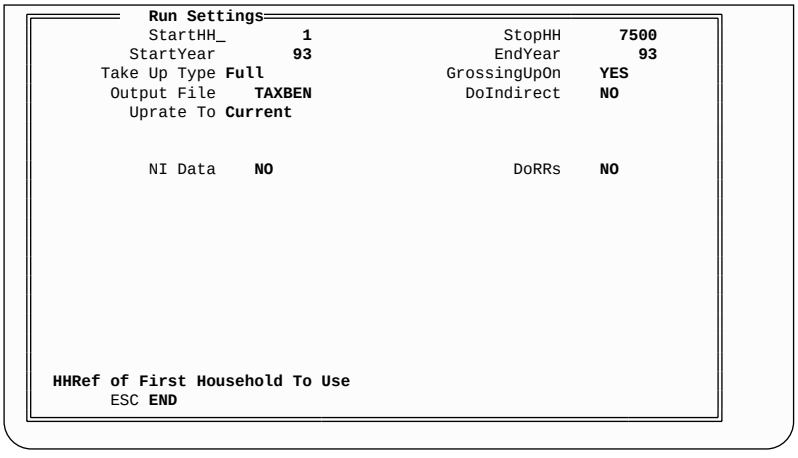
Figure 2: Family Credit data-screen



When users have altered a system from inside TAXBEN, they can then save that system for future use. TAXBEN will write a binary version of the system to a file. When they next come to load a pre-defined system, TAXBEN will add the saved system to the options from which the user can choose.

iii) Selecting Run Settings - Once the two required systems have been loaded, the model can be run and will make comparisons between the two using default run settings. Other run settings can be selected by the user. The "run settings" screen is shown in figure 3. These switches control the data which is to be used, whether indirect taxes and replacement rates are calculated, as well as the grossing up, uprating and take-up assumptions which are to be used.

Figure 3: Run settings screen



Finally, the user may wish to change or set up additional output tables but usually the default options will suffice. Once all the options have been chosen, the user can save the complete model setup (systems, run settings and table settings) to file. These can be loaded back into the model at the start of another TAXBEN session.

2.2 Model Output

TAXBEN is capable of producing a wide variety of results. The most general are the net aggregate costs or gains of a reform. The user may also analyse the distributional results, which show gainers and losers by various socio-economic categories, and individual results for any household in the sample. These results are normally summarised by TAXBEN in simple tables and graphs which can be viewed from inside the user environment.

However, the model can also calculate replacement rates, both at the actual hours level and at hours levels specified by the user, and complete budget constraints at all hours levels. For these calculations, the user may well require more detailed information than that contained in summary tables. In these cases the model outputs selected variables, such as the location of kinks on a budget constraint, for each household to a file. These files can then be loaded into other computer packages for further examination.

In the remainder of this section, we discuss in detail the type of results TAXBEN is capable of generating, and the forms in which these results can be presented to the user.

i) Aggregate results : aggregate results show how much money is raised or spent for different taxes and benefits. Table 1 shows the different categories for which aggregate results are generated. For all of these taxes and benefits, TAXBEN calculates the aggregate revenue or expenditure and the number of payers / claimants for each tax system. These results are also split down into five demographic sub-categories, showing to which sort of households money is being given or from which households it is being taken away. Using TAXBEN it is therefore possible to estimate, for example, the number of additional income tax-payers and the amount of extra income tax collected from a reduction in tax allowances, or the increased number of Housing Benefit recipients from a reduction in the withdrawal rate of Housing Benefit.

While running TAXBEN, it is only possible to view a small part of this information , principally the change produced in total direct taxes, indirect taxes, means-tested benefits and non-means-tested benefits. To view the rest of the aggregate results, the user can get TAXBEN to write these to an ascii file. This can then by viewed by using any text editor.

ii) Distributional tables : These tables are one of the most important analytical tool produced by TAXBEN. They show the effects of the differences between two systems, breaking these down by particular sub-groups of the population. The tables are produced in a way which allows the user a great deal of flexibility in what is shown. For example, the user can easily set up tables to see at a glance the progressivity of tax changes, the regional effects or the types of families principally affected by the reform. These tables can also be graphically summarised using bar charts.

Table 1: Taxes and benefits calculated

Direct Taxes	Income Tax (split into PAYE, other sources and MIRAS)
	National Insurance Contributions
	Council Tax (Rates in Northern Ireland)
Indirect Taxes	Value Added Tax (incorporating Insurance Premium Tax)
	Tobacco Duty
	Alcohol Duties (split by category of alcohol)
	Petrol Duties
	Vehicle Excise Duty
Non-means-tested benefits	Retirement Pension
	Unemployment Benefit
	Incapacity Benefit[1]
	Attendance Allowance
	Severe disablement allowance
	Disability Living Allowance
	Invalid Care Allowance
	Child Benefit
	One Parent Benefit
Means-tested benefits	Income Support
	Housing Benefit
	Family Credit
	Council Tax Benefit

[1]This is amalgamation of Invalidity Benefit and Sickness Benefit. See section 3.3 below.

Figure 4 show the distributional table which was produced from a reform which involved raising the basic rate of income tax and using part of the revenue gain to fund a lowering of the withdrawal rate on Family Credit and Housing Benefit. The table breaks down the effects of the reform by equivalent income deciles. The columns divide benefit units by the size of their monetary gain or loss as a result of the reform. Thus the first column contains those benefit units that lost between £5 and £100 from the reform, the second those that lost between £1 and £5, and so on. The figure given in each cell is the average monetary change in the income for the benefit units that fall into that cell. Thus the average monetary gain of those benefit units in the third decile who gained between £1 and £5 is £2.63.

The power of such distribution tables lies in the fact that virtually all the characteristics can be altered by the user. TAXBEN can redisplay the above table to show the results for average percentage change (eg to look at the progressivity of the change), numbers in each cell (eg how many benefit units gain more that £5) and percentages in each cell (eg what percentage of benefit units lost more than £5). These changes can be made to the table on screen immediately.

Figure 4: Distributional results by equivalent income decile

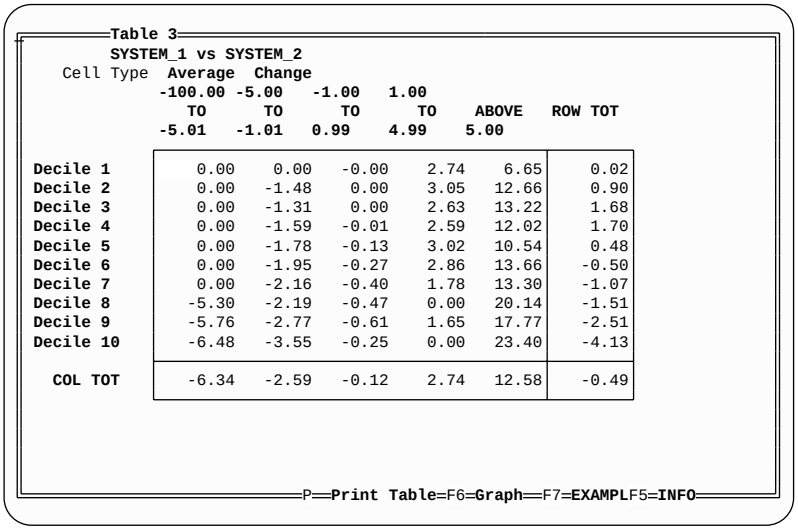


Table 3
SYSTEM_1 vs SYSTEM_2
Cell Type Average Change

	-100.00 TO -5.01	-5.00 TO -1.01	-1.00 TO 0.99	1.00 TO 4.99	ABOVE 5.00	ROW TOT
Decile 1	0.00	0.00	-0.00	2.74	6.65	0.02
Decile 2	0.00	-1.48	0.00	3.05	12.66	0.90
Decile 3	0.00	-1.31	0.00	2.63	13.22	1.68
Decile 4	0.00	-1.59	-0.01	2.59	12.02	1.70
Decile 5	0.00	-1.78	-0.13	3.02	10.54	0.48
Decile 6	0.00	-1.95	-0.27	2.86	13.66	-0.50
Decile 7	0.00	-2.16	-0.40	1.78	13.30	-1.07
Decile 8	-5.30	-2.19	-0.47	0.00	20.14	-1.51
Decile 9	-5.76	-2.77	-0.61	1.65	17.77	-2.51
Decile 10	-6.48	-3.55	-0.25	0.00	23.40	-4.13
COL TOT	-6.34	-2.59	-0.12	2.74	12.58	-0.49

P=Print Table=F6=Graph=F7=EXAMPLF5=INFO

Due to the way in which the tables are constructed by TAXBEN, characteristics that control which cell a household will be placed in must be specified prior to making the tax and benefit calculations. At this point, the user can choose the dimensions of the table. For example, Table 2 shows the socio-economic categories that can act as the row variable on a distribution table. The ranges on the columns can be changed and the number of columns increased up to a limit of 20. As well as these dimensions, the variable to which the column ranges refer can be chosen from gross income net of tax, equivalent income net of tax, point marginal tax rates, tax payments, benefit receipts, or replacement rates at 20, 40 or actual hours. The column ranges can refer to absolute changes (as in Figure 4), percentage changes or levels of this variable.

Table 2: Row variables for distribution tables

Age	Equivalent income decile
Gender	Gross income decile
Family type	Economic position
Number of adults in household	Gross income range
Region	Council tax band
Tenure	

The user may also specify whether the table refers to benefit units (as in Figure 4), individuals or households. Finally, we can exclude people from the table according to their sex, tenure, family type, economic status, or region. All of these options can be altered inside the TAXBEN environment. This allows the user to preform a great deal of analysis using distributional tables. For example, the table in figure 5 shows the percentages of employed single males with actual hours replacement rates within various ranges, broken down by region.

Figure 5: Replacement rates by region

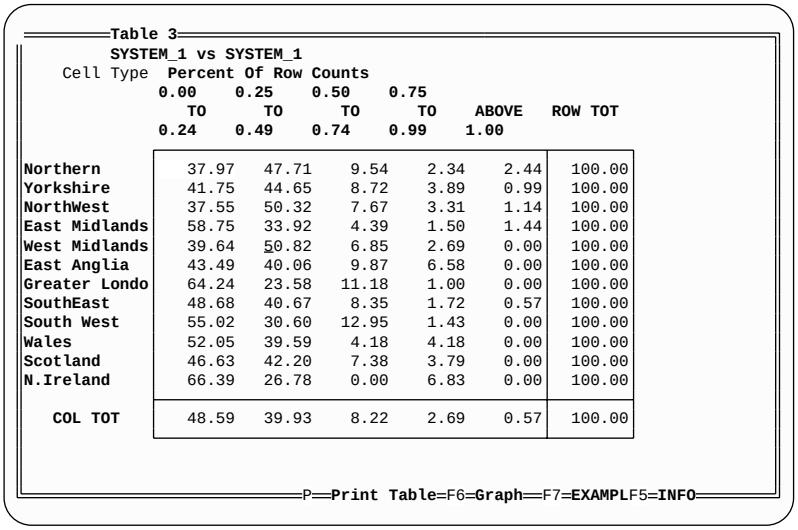


Table 3
SYSTEM_1 vs SYSTEM_1
Cell Type Percent Of Row Counts

	0.00 TO 0.24	0.25 TO 0.49	0.50 TO 0.74	0.75 TO 0.99	ABOVE 1.00	ROW TOT
Northern	37.97	47.71	9.54	2.34	2.44	100.00
Yorkshire	41.75	44.65	8.72	3.89	0.99	100.00
NorthWest	37.55	50.32	7.67	3.31	1.14	100.00
East Midlands	58.75	33.92	4.39	1.50	1.44	100.00
West Midlands	39.64	50.82	6.85	2.69	0.00	100.00
East Anglia	43.49	40.06	9.87	6.58	0.00	100.00
Greater Londo	64.24	23.58	11.18	1.00	0.00	100.00
SouthEast	48.68	40.67	8.35	1.72	0.57	100.00
South West	55.02	30.60	12.95	1.43	0.00	100.00
Wales	52.05	39.59	4.18	4.18	0.00	100.00
Scotland	46.63	42.20	7.38	3.79	0.00	100.00
N.Ireland	66.39	26.78	0.00	6.83	0.00	100.00
COL TOT	48.59	39.93	8.22	2.69	0.57	100.00

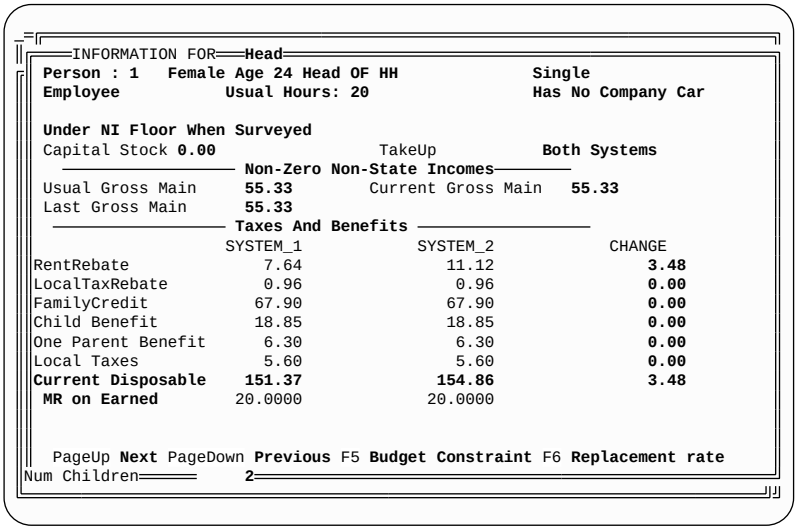
P=Print Table=F6=Graph=F7=EXAMPLF5=INFO

TAXBEN also allows the user to produce a graphical representation of distribution tables, to write the tables to an ascii file for future use, and to examine the results for individual households in each cell. This last feature is extremely useful, both for checking the accuracy of the model and for providing a greater understanding of the processes which are driving the results. All these issues are dealt with below.

iii) Individual Results : Aggregate and distributional results inform the user of the overall consequences of a reform. However, it is often useful to see exactly how the reform will affect individual households. This is especially true where the results for certain households do not correspond with initial expectations. TAXBEN allows inspection of the results for individual households through the distributional tables. The user can choose any cell in the table and call up the results of a number of households which are contained in that cell.

For example, Figure 6 shows the results generated for a benefit unit under the income tax increase / reduction of HB and FC withdrawal rates used in Figure 4 above. This lone parent gained £3.48 because she was working but not earning enough to pay Income Tax and receiving Housing Benefit.

Figure 6: Results for example benefit unit



INFORMATION FOR Head

Person : 1 Female Age 24 Head OF HH Single
Employee Usual Hours: 20 Has No Company Car

Under NI Floor When Surveyed
Capital Stock **0.00** TakeUp **Both Systems**

Non-Zero Non-State Incomes

Usual Gross Main **55.33** Current Gross Main **55.33**
Last Gross Main **55.33**

Taxes And Benefits

	SYSTEM_1	SYSTEM_2	CHANGE
RentRebate	7.64	11.12	**3.48**
LocalTaxRebate	0.96	0.96	**0.00**
FamilyCredit	67.90	67.90	**0.00**
Child Benefit	18.85	18.85	**0.00**
One Parent Benefit	6.30	6.30	**0.00**
Local Taxes	5.60	5.60	**0.00**
Current Disposable	**151.37**	**154.86**	**3.48**
MR on Earned	20.0000	20.0000	

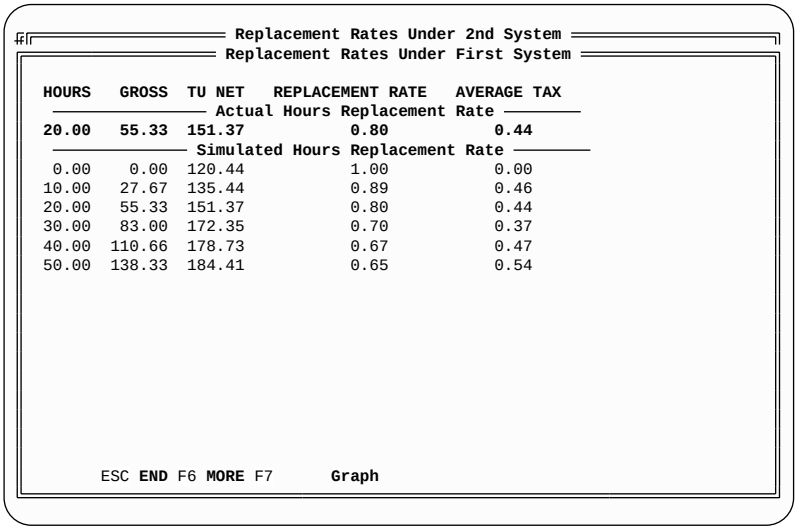
PageUp **Next** PageDown **Previous** F5 **Budget Constraint** F6 **Replacement rate**
Num Children **2**

It is also possible to examine the budget constraints, replacement rates and average tax rates of these benefit units assuming hourly wages are constant. Figure 7 shows the replacement rates faced by same woman at her actual hours and number of other hours levels. The user can further examine these results to see what taxes would be paid and benefits received at any of these hours levels. As is clear, the replacement rate falls as potential hours of work rise, but as this woman has a low wage rate, even at 50 hours a week, her potential replacement rate would be 0.65. In addition, the high rates of benefit withdrawal from Family Credit and Housing Benefit mean that her average rate of tax[2] hovers between 0.4 and 0.5 at most hours levels.

Finally, Figure 8 shows a complete description of the tax and benefit position of our example lone parent at all possible hours levels, i.e. her complete budget constraint. It shows the position of her budget constraint "kinks", which are the points at which the tax and benefit system creates a discontinuity in the linear budget constraint. As the screen shows, these kinks occur when marginal rates of tax change, when benefits are withdrawn or introduced or when income rises to lower tax thresholds. Joined up, these kinks points give a complete description of the budget constraint between 0 and 50 hours a week.

2 The average rate of tax is one minus the ratio of the change in net income to the change in gross income, as compared with a zero hours level. See section 5.2 below.

Figure 7: Replacement rates for example benefit unit



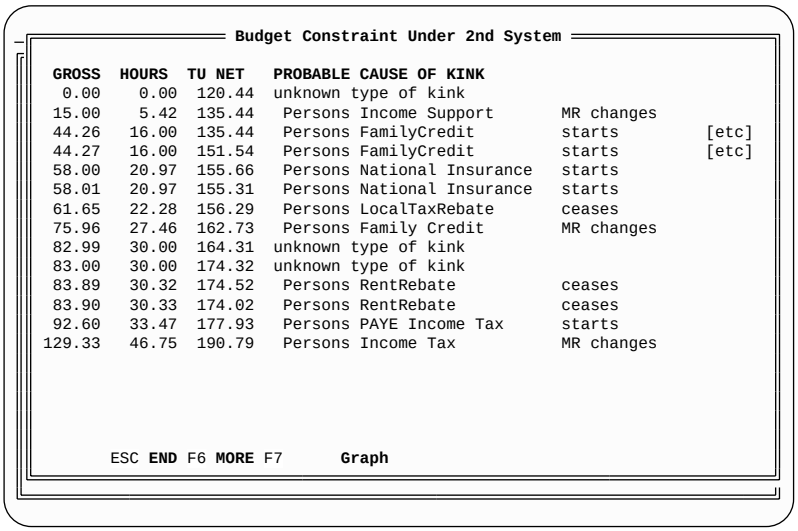
Replacement Rates Under 2nd System

Replacement Rates Under First System

HOURS	GROSS	TU NET	REPLACEMENT RATE	AVERAGE TAX
Actual Hours Replacement Rate				
20.00	**55.33**	**151.37**	**0.80**	**0.44**
Simulated Hours Replacement Rate				
0.00	0.00	120.44	1.00	0.00
10.00	27.67	135.44	0.89	0.46
20.00	55.33	151.37	0.80	0.44
30.00	83.00	172.35	0.70	0.37
40.00	110.66	178.73	0.67	0.47
50.00	138.33	184.41	0.65	0.54

ESC **END** F6 **MORE** F7 **Graph**

Figure 8: Budget constraint kinks for example benefit unit



Budget Constraint Under 2nd System

GROSS	HOURS	TU NET	PROBABLE CAUSE OF KINK		
0.00	0.00	120.44	unknown type of kink		
15.00	5.42	135.44	Persons Income Support	MR changes	
44.26	16.00	135.44	Persons FamilyCredit	starts	[etc]
44.27	16.00	151.54	Persons FamilyCredit	starts	[etc]
58.00	20.97	155.66	Persons National Insurance	starts	
58.01	20.97	155.31	Persons National Insurance	starts	
61.65	22.28	156.29	Persons LocalTaxRebate	ceases	
75.96	27.46	162.73	Persons Family Credit	MR changes	
82.99	30.00	164.31	unknown type of kink		
83.00	30.00	174.32	unknown type of kink		
83.89	30.32	174.52	Persons RentRebate	ceases	
83.90	30.33	174.02	Persons RentRebate	ceases	
92.60	33.47	177.93	Persons PAYE Income Tax	starts	
129.33	46.75	190.79	Persons Income Tax	MR changes	

ESC **END** F6 **MORE** F7 **Graph**

iv) Graphics : Graphical results allow the user to see the effects of a reform at a glance. TAXBEN can display a number of results graphically. Figure 9 shows the graphical representation of the total column of a distributional table. In this case, the results are those shown in Figure 4 above.

TAXBEN can also graph the budget constraints faced by individual tax units under different systems. Figure 10 shows the budget constraint of the same lone parent before and after the reform. The upper line shows her post-reform budget constraint with the lower withdrawal rates in Housing Benefit and Family Credit giving her more money at each hours level and a lower effective rate of tax.

Figure 9: Graphical results for distribution tables

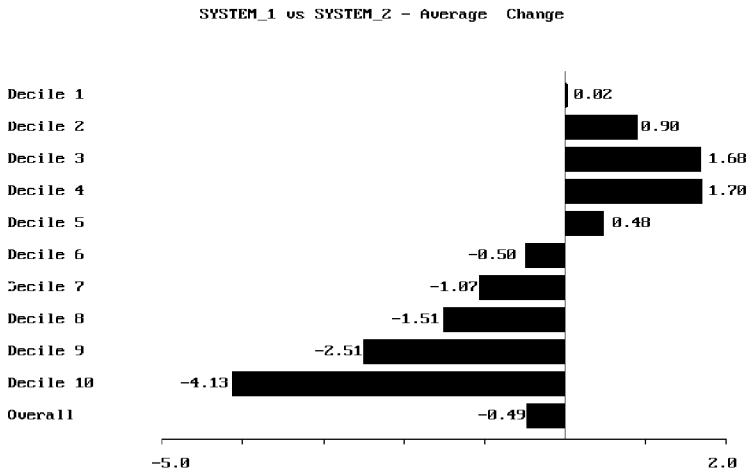
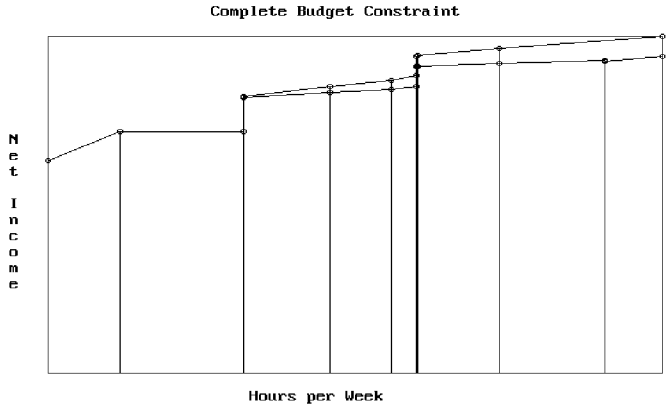
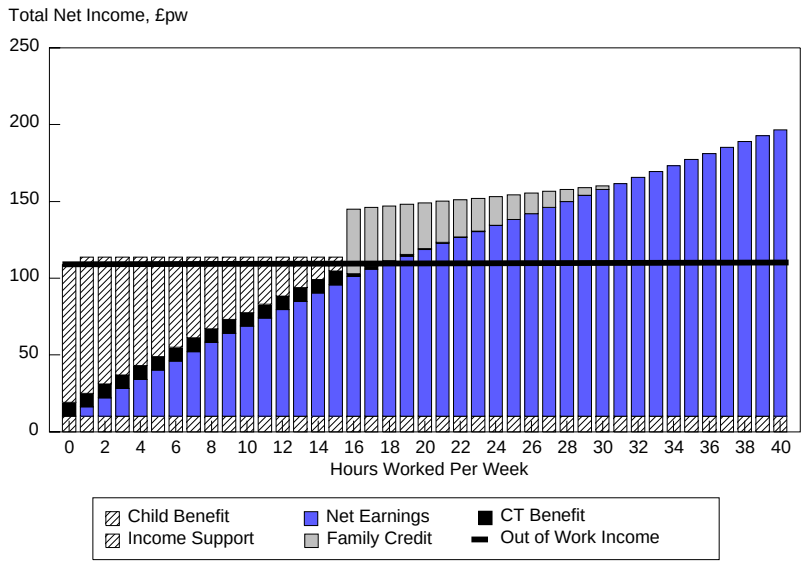


Figure 10: Graphical results for budget constraints



Users often want to check the reasons for the shape of a budget constraint. To aid this, TAXBEN is capable of showing the contribution of different sources of income to total net income at each hours level. Figure 11 below shows the sort of graph produced. It shows very clearly the incentive effects of Family Credit for a lone parent.

Figure 11: Contribution of different sources of income to net income



v) Writing to files : Distributional tables can also be printed to ascii files, where they can be viewed using any text editor. Additionally, the information from the files can be read into spread-sheet or other graphics packages, allowing the user to place the information into documents or slide presentations, either in a table or graphical format.

However, the main use of writing output to files is in the case where the user requires more information than it is feasible to output in tabular or graphical form. This is mainly the case where TAXBEN is used to compute replacement rates or budget constraints for each individual in the survey, or a sub-set of them. For example, the IFS labour supply model, SPAIN, was created to estimate labour supply responses to specific reforms of the tax or benefit system using specific budget constraints that need to be generated by TAXBEN. To do this, SPAIN requires a complete specification of the budget constraint facing each benefit unit under both the base and reform system.

3 Creating the Model Datasets

TAXBEN operates from data collected in the Family Expenditure Survey. Presently, TAXBEN can be run off data from any of the years between 1989 and 1993. However, the model requires only a limited sub-set of the data contained in the survey. It is convenient to create a small model data-set from the FES, both to reduce the run-time of the model and to reduce the size of the data-sets that the model needs to use. Additionally, certain household characteristics, such as entitlement to non-means-tested benefits, need to be inputted from the FES data. These entitlements can be calculated once and for all when creating the model data-set, thus avoiding the duplication of calculations when actually modelling a reform.

In this section, we address a number of issues which arise while converting the FES data into a format which can be used to model the tax and benefit system. We start by outlining the type of data that is available in the FES. We then examine the construction of figures for gross income from employment and self-employment. Next we describe the way in which we model entitlement to non-means-tested benefits from the FES. Then we explain the method used to impute the level of mortgage capital outstanding from the mortgage payment figure recorded in the data. Finally, we address other data related issues which are not specific to the FES, the uprating of prices, grossing-up to population totals and calculating deciles.

3.1 The Family Expenditure Survey

The Family Expenditure Survey (FES) has been collected in every year since 1961. The survey interviews roughly 7,000 households a year from a random sample of 10,000 UK households. The main objective of the survey is to gather detailed information on household expenditure patterns which are used to calculate weights for the retail prices index. However, the survey also collects information on incomes from all sources, as well as household and individual characteristics. This provides tax and benefit modellers a very rich data source from which to calculate tax payments and benefit receipts. It also allows us to disaggregate the results into population sub-groups, which may be of interest to the model user.

However, there are some short-comings to the survey. Firstly, the response rate to the FES is only around 70%. To some extent, we can control for this by "grossing up" the sample to the population totals (see section 3.8). Secondly, certain questions elicit answers which are incompatible with other sources of data such as administrative tax receipt data. For our purposes, the FES is least robust in alcohol and tobacco expenditures, which are seriously under-reported. Finally, in certain cases, it is necessary to impute the information we desire from that contained in the survey. This is necessary for mortgage interest payments and for non-means-tested benefit entitlements. The means by which we make these imputations is dealt with in the rest of this section.

3.2 Income

The FES contains a large amount of information on each household’s income, from major sources of income such as employment earnings, to minor sources such as money made from baby-sitting. For the majority of these receipts, TAXBEN can simply use the monetary amount recorded in the FES.

Complications arise in two areas. With regard to earnings from employment, the FES provides information on both usual and current earnings. It is necessary to decide which of these measures to use, and assess the implications of this choice. Secondly, we discuss the derivation of self-employment income, as the coding in the FES has lead to significant confusion in this area.

3.2.1 Earnings from employment

The FES provides two means by which to measure individuals earnings from employment. Respondents are asked the level of their last payment, and also asked what their usual pay is if the last payment received was not the usual level. Thus we have an option as to whether to use a current or usual measure of pay. The underlying principle we used in determining our choice of income measure was to use the measure most closely related to the definition of income relevant for most taxes and benefits. Of the taxes and benefits related to gross earnings, National Insurance, Income Support, Council Tax Benefit and Housing Benefit are closely aligned to the current earnings definition. Conversely, Family Credit is determined once and then held constant for six months regardless of income changes, so is better suited to usual earnings. Income Tax is calculated on an annual basis, so usual income including bonuses seems preferable.[3]

Earlier versions of TAXBEN used different earnings measures for the different taxes but it became clear that this was difficult to understand and inconsistencies arose when some benefit payments (Housing Benefit in particular) could simultaneously be determined by the two different Income Tax figures (one directly, and one indirectly through the Family Credit entitlement). For simplicity, we have chosen current income as our earnings measure because it related directly to more taxes and benefits.

3.2.2 Self-Employment Income

For tax and benefit purposes, profit from self-employment activities is regarded as a source of income. However, care is needed in interpreting FES codes for self-employment profits, as the relevant FES code can have ambiguous meaning. The FES code does not record net profits (i.e. include negative values when losses are made) which is the relevant measure tax and benefit purposes, but it records profits when the business is making a profit and drawings from the business when no profit or a loss is declared. Any loss incurred is recorded separately.

This is especially important in the UK tax system because drawings from the business are not taxable (they are a capital item in the firms accounts). The inclusion of drawings in the figure for self-employment income will overestimate the tax liability which is actually arises. Additionally losses which are incurred as the result of trading can be offset against Income Tax liability from other sources. Appendix 1 gives details of the problems of FES coding in this respect.

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3 Over the period 1985 to 1992 there is little difference between the aggregate level of current earnings in the FES and the aggregate level of usual earnings including bonuses.

3.3 Non-means Tested Benefits

We attempt to model the entitlement of individuals to non-means-tested benefits rather than simply uprating the level of receipt recorded in the FES. The FES does not provide details of previous National Insurance payments or the exact nature of benefit received (eg whether Attendance Allowance is paid at the higher or lower rates) so these details are inferred using their declared levels of receipt of these benefits in the FES. This is a much easier task for some benefits than for others. There are five principal methods by which we model entitlement to non-means-tested benefits according to their entitlement criteria.

i) We model receipt based on observable characteristics of the household in the FES, regardless of benefit receipt information contained in the FES. Examples of this in the 1995-96 tax and benefit system are Child Benefit and One Parent Benefit, where both entitlement and the level of the payment are determined simply by the composition of the benefit unit.

ii) We model entitlement from FES data, but can model level of receipt from other characteristics of the household. In these cases, entitlement is simply taken to be whether the individual has declared receiving the benefit in the FES. The level at which the benefit is paid will be determined by other characteristics of the benefit unit, typically its composition. The benefits modelled in this way are unemployment benefit, sickness benefit and invalid care allowance.

iii) Certain benefits are paid at a (small) number of rates, depending on criteria which cannot be observed in the FES. In these cases, we compare the level of receipt declared in the FES with these variable rates. We set the entitlement criteria to the value associated with the rate nearest to the actual declared receipt. This is done for Attendance Allowance, Disability Living Allowance and Severe Disability Allowance.

iv) For NI retirement pension, Invalidity Benefit (IVB), and widow's pension, payments tend to fall over a wide range of levels, typically because of incomplete contribution records or the addition of income related components, such as SERPS. For these benefits, we model the level of receipt that we would expect the person to have with a full contribution record, given the composition of the benefit unit and the application of any earnings rules. If this level is within 5p of the declared receipt in the FES, then we model the person as having a complete contribution record.

    In the case of IVB, there are up to four different rates at which the benefit could be received, depending on entitlement to the Invalidity Allowance. We compare the recorded receipt in the FES with all the possible levels of Invalidity Allowance that the person could be receiving, given their age. If the declared receipt falls within 5p of any of these modelled values, the person is assumed to have a full contribution record and the appropriate entitlement to Invalidity Allowance. Where the received amount matches none of the modelled amounts, the person is assigned a random allowance entitlement from those which they could possibly be receiving.

For the NI retirement pension, if the declared amount was not matched with the modelled benefit, it is compared with the Income Support line appropriate to that benefit unit. Again, if the declared amount is within 5p of this level, we assume that the person is receiving Income Support on top of their non-means-tested receipt. Where this is the case, we cannot observe the person's contribution record, which we assume to be complete.

For all unmatched cases of IVB, widow's pension and NI retirement pension, the difference is assumed to be explained by an incomplete contribution record if the declared receipt is below the modelled amount, and by SERPS or graduated pension if it is above. The level of SERPS is simply the difference between the declared receipt and the modelled amount. For incomplete contribution records, we calculate the ratio of the basic rate to the actual payment, allowing for the fact that certain additions are not decreased by incomplete contributions.

v) Finally we do not attempt to model industrial injuries disablement benefit, as there are 18 distinct rates at which it can be received. In this case we simply use the uprated level of declared receipt as the individuals entitlement in TAXBEN.

As the model currently runs on data from the 1993 FES, we have information on entitlement to IVB and Sickness Benefit which were replaced in April 1995 by Incapacity Benefit (ICB). As claimants have been transferred from IVB and Sickness Benefit onto Incapacity Benefit at the same rate, we model entitlement to ICB on the basis of entitlement to IVB and Sickness Benefit. This will prevent TAXBEN from modelling the effects of the more stringent medical tests imposed under ICB until the 1995/96 FES becomes available.

3.4 National Insurance Contributions

There are three rate at which employee Class 1 National Insurance Contributions (NICs) are paid on income between the lower and upper earnings limits. These are the contracted-in, contracted-out and married women's reduced rate. The rate at which a person is paying cannot be determined directly from the FES. Thus, as with certain non-means-tested benefits, we impute the NIC rate by computing the amount of NICs that should have been paid given the person's gross earnings for each possible NIC rate. The assumed rate is the one corresponding to the modelled amount which is closest to the actual amount of NICs paid.

3.5 Mortgage Interest

For modelling Mortgage Interest Tax Relief and mortgage interest payments covered by Income Support, the model needs to obtain a figure for the mortgage interest payment. The main distinction between mortgages is between those which are interest/principal, where the principal of the loan is repaid over the life-time of the mortgage, and those which are interest only, where the entire principal is repaid at the end of the mortgage. For interest only mortgages, the FES provides a value for the interest payment made on the mortgage. Hence the value is straight-forward.

However, for interest-principapal mortgages prior to 1992, the interest figure needs to be imputed from the last payment and the capital outstanding at the time of the last mortgage statement. We calculate the interest payment by assuming a constant payment and find the repayment path necessary to repay the whole mortgage within the time it has left to run. This becomes a complex calculation, especially given the interactions with the Mortgage Interest Tax Relief system. The formulas used are given in Appendix 1.

3.6 Household Expenditures.

TAXBEN calculates indirect tax payments using tax-exclusive expenditures. Therefore the data needs to have the historic indirect tax payments stripped out when the model dataset is created. Family Expenditure diary codes are grouped into 56 different expenditure groups, each of which contains similar goods with identical tax treatment. Examples of these groups include bread and cereals, beer or white goods. For the groups of goods that had VAT charged at a zero rate, the FES expenditures are transferred directly into the model. VAT payments for goods subject to VAT are calculated using the following simple equation, where V is the VAT paid, E_t is the tax inclusive expenditure and R is the VAT rate.

$$V = \frac{E_t}{(1+R)}R$$

For excisable goods, a number of additional assumptions and calculations have to be made. We assume that all excisable goods bought are priced at the standard guide prices given by the UK Customs and Excise, so quantities can be derived from expenditure data. For example, in 1993-94 the standard guide price for a packet of 20 cigarettes was £2.37p per pack. As long as the guide price represents the average price paid, the correct average level of duty will be calculated. The following formula is then applied to extract the historic excise duty (both specific and ad valorem) for each group of good. Finally, the VAT and excise duty payments in the year of survey are subtracted from the tax inclusive expenditures to give a tax exclusive expenditure.

$$Excise = Q(S + (a.P))$$

where Q is the quantity, S is the specific duty, P is the guide price and a the ad valorem duty.

3.7 Uprating Monetary Values

The data used in a model run is usually at least a year out of date. During early 1995, TAXBEN has been running principally on the 1993 FES, with data from 1989 to 1992 also available. This time lag makes it necessary to uprate the monetary values found in the FES to current price levels. Thus, the variables are uprated by the values that most simply and accurately represent the present value of the variable for a particular household in the FES year.

Earnings etc. Self employment earnings are uprated from the date of their accounts in the FES to the present and all other earnings, deductions, private pensions, other income and benefits in kind are uprated from the month of survey in the FES to the present by the increase in average earnings.

Investment income	An estimated capital value is calculated by adding tax back to the FES net interest or dividends number and then dividing it by base rates (average building society rates for building society interest) in the month of the FES interview. This capital value is uprated to the present by nominal GDP and the current gross value of interest or dividends is estimated by multiplying the current capital value by current interest rates. There is no specific allowance made for a change in the stock of capital, other than the rise in nominal GDP.
SERPS	The amount of SERPS that was imputed from the FES state pension variable is uprated by the RPI.
Rents	Uprated by the rents component of the RPI
Consumption goods	Expenditure on a range of goods is uprated by nominal GDP
Other	Variables which are uprated annually by government such as Government Training Scheme income, are uprated by the main RPI series.

3.8 Grossing Up

The aim of TAXBEN is to model the distributional effect of policy changes across the UK economy. However, FES is not perfectly representative of the UK population so weighting the FES (grossing up) is important in tax and benefit models for creating aggregate revenues and expenditures, and for distributional analysis. Certain groups are under or over represented in the survey, either due to sampling error or to more systematic response biases. We attempt to control for this mis-representation at the level of benefit unit composition (eg the number of couple benefit units with children) and age (eg the number of single pensioner benefit units).

To do this, the benefit units in the sample are split into 21 types, based on their composition and the age of the adults. A individual grossing factor for each of these types is attached to each benefit unit. The resulting weighted sample contains the same number of benefit units of the appropriate type as the UK populations in 1994. However, as our grossing procedures reweight the sample in only one dimension, they do not necessarily solve response biases in other dimensions, the most important of which being the proportion of the population that is employed.

If suitable control totals could be found, for example, combining family type subdivided by economic status, grossing could achieve accuracy in more than one dimension. This would mitigate the biases left after our simple grossing procedures but there would be larger confidence intervals around each subgroup because the sample size in each would inevitably be smaller. Another option would be to use an optimising procedure to weight the sample multi-dimensionally without knowing the relevant control totals. Gomulka (1992) devised such a method.

Problems with this method include the lack of a unique grossing factor for each household to solve two or more control totals and the possibility of potential solutions including negative and extremely large grossing factors. To distinguish a unique solution, arbitrary conditions have to be imposed. In addition, distributional analysis becomes problematic and counter intuitive if particular households with outlying grossing factors (as they are being required to do much of the work to arrive at both control totals) are driving the results.

Therefore, for TAXBEN we keep relatively straightforward grossing factors correcting known deficiencies of the FES and we aim to use the most recent data to give as accurate a picture of employment structure as possible.

3.9 Deciles

Deciles are created by dividing the population into tenths according to some income variable. The ideal method of generating deciles is to recalculate them on the base system of a reform each time the model is run. However, this involves storing all the results and sorting the data before distributional tables can be generated. This is quite a lengthy process and usually unnecessary as the equivalent net income rank of households would not change under most base systems used for one year of data. For these reasons, we calculate deciles only once when creating the model data-set, on eight different bases: either benefit unit or household; grossed or not grossed; and equivalent or not equivalent deciles. All the deciles are based on net after-tax income as calculated by TAXBEN using the tax and benefit system which was in force in April of the FES year of data.

4 Tax and Benefit Modelling Routines

In this section, we briefly describe the options for tax and benefit reform programmed into TAXBEN and the techniques used to calculate the relevant tax payments and benefit receipts. A comparison of the aggregate tax receipts and benefit payments generated with administrative figures is given in Appendix 2.

4.1 Direct Taxes

TAXBEN models the personal direct taxes which exist in the UK, but as the modelling is fairly flexible, it is possible to devise many new forms of direct taxation through the user environment.

National Insurance

National Insurance is calculated before Income Tax as the self-employed are entitled to 50% relief in Income Tax on Class 4 National Insurance Contributions. The main options available for users are to change the rates or the bands (and the number of rates and bands) on which NI is charged and the lower and upper earnings limits. It is possible to make the NI rate chargeable on all income below a threshold (as under the pre 1989 system), have the lowest band act as an entry fee levied after the income has risen over the LEL (as under the post 1989 system), or move to a full allowance based system. The definition of income can also be changed, to exclude or include additional sources of income.

As noted in section 3.4, the model dataset creation procedures generate estimates as to whether individuals would pay NI at the contracted in or contracted out rate given their declared NI payments and their income in the original data. Therefore, TAXBEN can model reforms to the incentives to contract out of National Insurance. The self employed are modelled separately, and the relevant rules for Class 2 and Class 4 National Insurance are applied to them. Finally, some married women pay a reduced rate for reduced entitlements. Again the dataset contains flags for these women based on their actual payments in the data and the lower NI rate is applied to them.

Income Tax

The Income Tax routine is called after National Insurance has been calculated. As usual, all the allowances, rates and income definitions in the present tax system can be altered by the user. However, with income tax, many proposed reforms involve an alteration in the structure of the tax system. To cater for this, TAXBEN allows allowances to be restricted to a given tax rate and for the introduction of a child tax allowance. It is also possible to change the unit of taxation the family and impose income tax on the basis of joint rather than independent income.

TAXBEN calculates the effects of tax reliefs, as far as this is possible. Users can change the ceiling and rate of montage interest tax relief, relief on occupational and personal pensions, and Class 4 National Insurance. Finally, we also model the taxation of fringe benefits as far as possible, although finding the value of many fringe benefits form the FES is very difficult.

The most important taxable fringe benefit is company cars. Currently, we model this on the basis of the pre 1994-95 regime, as there is no information on the value of company cars in the FES.

All these options create a very flexible tool for devising different income tax regimes.

Local Taxes

TAXBEN has the facility to model three local tax regimes and any combination of each: Rates; the Community Charge (Poll Tax); and the Council Tax. Rates can only be calculated for households with positive codes for calculated rates (rateable values multiplied by the rate poundages) in the FES. This applies to Northern Ireland households and for all households in the 1990 FES and earlier. For the years of data where the Community Charge was in force (1990 to 1993, 1989 for Scottish households), actual Community charge values were not available in order to keep the survey anonymous. However, the Central Statistical Office provide detailed sample Community Charges which are an average of four similar local authorities to that in which the household lives. For other years, TAXBEN has the facility to impose region specific Community Charges.

Council Tax is modelled in a similar way to that of the Community Charge. For data after the first quarter of 1993 Council Tax band is available in the FES. For data prior to this, TAXBEN uses a hedonic price index (Davies and Rajah,1992) to estimate the value of the house from its characteristics. The rank of the resulting distribution is used to place households into the relevant Council Tax bands given the distribution of houses within bands that is available from the Department of the Environment. Again, the actual Council Tax band D rate of the households local authority is not available due to FES anonymity rules. However, we do have an average band D rate for each household derived an average of similar local authorities. Using this information TAXBEN can estimate the to Council Tax relativities across local authorities.

4.2 Indirect Taxes

TAXBEN uses tax exclusive expenditures from the data to calculate indirect taxes to avoid conflicts between different rates of tax imposed in the year of data to that of the base system. This method implies that the quantity of the good purchased is unaffected by any change in the level of indirect taxation between the year of data and the base system, effectively assuming a zero elasticity of demand. If tax inclusive expenditures were used and differences exist between tax rates in the base and data years, the implicit assumption would be an elasticity of -1 (i.e. constant expenditure). We choose the constant quantity assumption because it is consistent with our default assumption in the model of no behavioural change between two indirect tax systems.

For all goods subject to VAT, TAXBEN calculates the VAT due in the base system simply multiplying the VAT rate by the tax exclusive expenditure. For excisable goods, the calculation is a little more complicated. The base excise duty due is calculated by finding the quantity purchased using the known factor cost (derived from Customs and Excise guide

prices) and the market price using modelled rates of VAT, specific duty and ad valorem duty. From the price and the quantity, the levels of excise duty paid are trivial to calculate. The formulas used are given below.

$$Q = E/F$$

$$P = (F + D + a.P)(1 + R)$$

which implies :

$$P = \frac{(F + D)(1 + R)}{(1 - a(1 + R))}$$

where $Q = quantity$
$P = market\,price$
$E = tax\,exclusive\,expenditure$
$F = factor\,cost$
$D = specific\,duty$
$a = ad\,valorem\,rate$
$R = VAT\,rate$

For the reform, by default TAXBEN uses an elasticity of zero (constant quantities), in which case the calculations are identical. However, the user may also set the elasticity on any good to a level of their choice. The reform tax rates will imply a new price for the good under the equation given above and the new quantity is the following simple elasticity calculation, where e is the chosen elasticity.

$$lnQ_r = lnQ_b + e(lnP_r - lnP_b)$$

Once the reform price and quantity are found, the reform VAT and excise duties follow quickly. The elasticity options given to the user mean that it is possible to run reforms on a number of different assumptions and see the sensitivity of results to the elasticity assumption.

4.3 Non Means-tested Benefits

The modelling of Non means-tested benefits within TAXBEN is relatively straight forward as the eligibility criteria have been determined in the creation of the dataset. Thus the level of payments for the Retirement Pension, Invalidity Benefit, Sickness Benefit (both now Incapacity Benefit), the mobility component of Disability Living Allowance, Invalid Care Allowance, Attendance Allowance, Severe Disablement Allowance and Statutory Sick Pay can all be set directly from the entitlement information to the level of these benefits in the modelled system. In addition, contribution related benefits (the State Pension and Incapacity Benefit) are adjusted to take account of the level of SERPS entitlement or incomplete contribution records estimated when creating the data (see section 3.3). As these sources of income may be taxable, they must be calculated before any direct taxes. Their tax status can be altered by changing the definition of income in the income tax routine.

Child Benefit is apportioned according to the number of children. There are also a number of pre-programmed options available in TAXBEN for the reform of Child Benefit. Users are able to change the rate of benefit for the first child, make the benefit related to the age of the child, paid to the father or means-tested with a withdrawal rate based on gross income.

4.4 Means-tested Benefits

Means-tested benefits are calculated last because they represent a residual, adjusting a family's income up if it falls below certain thresholds. There are five means-tested benefits in the UK and these are all modelled in TAXBEN. Income Support is modelled first, as this provides benefit units with a minimum level of income. The Income Support level for any eligible family is calculated (including additions for mortgage interest and free school meals) and if their income falls below this level, the difference is made up with Income Support. Finally TAXBEN checks whether the level of capital held by the benefit unit reduces or removes the benefit units entitlement. The relevant definition of income for IS purposes is an option in TAXBEN, as are allowable deductions from income such as earnings disregards. Options for reform include all the parameters above, the definition of income, earnings disregards, and options to change the age thresholds within IS, the 100% withdrawal rate, the implied cost of free school meals and the rules on capital.

Family Credit is calculated after Income Support, the two benefits being mutually exclusive in the benefits system[4]. TAXBEN calculates the maximum credit for each eligible family, and then their income (taking account of childcare and maintenance disregards). Any income in excess of the applicable amount is withdrawn from the maximum credit at the withdrawal rate (70% in 1995-96), until all the credit is withdrawn. Options for reform in TAXBEN include all the relevant parameters in the current system and options to change the eligibility criteria to childless families and introduce earnings disregards for second earners.

Finally, TAXBEN calculates the means-tested benefits related to a household bill, i.e. Housing Benefit, Council Tax Benefit and Rate Rebate. Additionally, TAXBEN can calculate a Community Charge benefit and a mortgage benefit. In each case the model calculates the household needs (on the basis of family size and composition). After taking account of factors such as earnings disregards, non dependent deductions and capital rules, it calculates the relevant net income for the purposes of these benefits. Any excess income over the needs element is tapered at the relevant withdrawal rate. In each case users can change any of the needs parameters, the income definition, the proportion of the bill to be rebated (eg only 80% of the bill was eligible in Community Charge Benefit), the minimum payment or introduce a maximum payment.

All UK means-tested benefits suffer from take-up problems associated with small amounts to which individuals are entitled, the stigma of claiming such benefits and the lack of knowledge of these benefits. TAXBEN can simulate the effect of reforms using a partial take-up algorithm which attempts to correct for the problems of non take-up of benefit. Take

4 Income Support is available only to those who work less than 16 hours per week, while Family Credit only to those who work over 16 hours.

up equations estimated in Fry and Stark (1993) are included in TAXBEN and give for each eligible recipient a probability estimate that the benefit is taken-up. One of the most important positive elements in this take-up equation is the cash entitlement of benefit. Hence the probability of take-up can change with a benefit or tax reform. TAXBEN includes all of these elements by applying the calculated take-up probabilities to the grossing factors, so that for each FES individual we calculate how many similar individuals would take up the benefit, how many would not, and how many would change given a particular benefit reform. The probabilities and grossing factors are used to calculate take-up adjusted aggregate benefit costs.

5 TAXBEN and Labour Supply Incentives

All tax or benefit reforms have distributional consequences but they also may induce changes behaviour amongst some members of the population. As a static model, TAXBEN assumes no change in behaviour. This is not an unreasonable assumption for most tax reforms, especially where they are minor, or have most effect on individuals who are constrained to work a certain number of hours, such as many prime aged men. But some tax or benefit reforms are designed specifically to encourage or discourage labour supply, so a tax and benefit model should have a facility to estimate potential labour supply responses. TAXBEN has the facility to generate Budget Constraints, replacement rates and average tax rates to help analyse these issues (often in conjunction with the IFS labour supply model, SPAIN). These facilities are easy to use in TAXBEN and examples of their use in the UK have generally centred around reforms to in work benefits (eg the 1992 and 1995 Family Credit reforms, see Dilnot and Duncan, 1992 or Duncan and Giles, 1995).

5.1 Budget Constraints

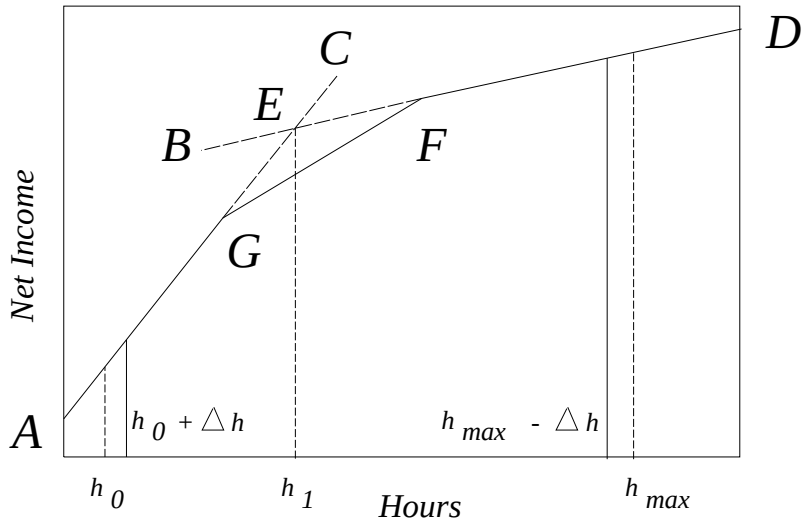
The IFS labour supply program, SPAIN, simulates the desired hours of work for an individual given labour supply estimates from a structural labour supply model and the budget constraint facing an individual. It calculates local optima for each linear segment of the budget constraint and a global optimum hours level by comparing the utility levels for each local optimum. Therefore, it needs an exact representation of the budget constraint with clear linear segments both pre and post reform. TAXBEN produces these budget constraints and the policy reform is analysed by comparing the first round (non behavioural) effects of a reform with the second round (after predicted labour supply response).

In general, tax models have the capability to assess total tax liability and benefit entitlement for any gross income level. However, complete descriptions of individual budget constraints have, up to now, proved computationally time-consuming and also exhibit a degree of inaccuracy. Some tax and benefit models generate approximate budget constraints by incrementing gross income levels through a feasible range of income, and calculating the corresponding net income level for each increment. For example, it would calculate net income at zero gross income, increment gross income by, say, £1.00 and calculate the new net income level. This process continues across a feasible range of gross incomes, and clearly the same number of distinct runs of the tax model are required as the feasible range of income measured. This makes the process unnecessarily time-consuming. Furthermore, the number of calculations carried out is independent of the level of complexity of the budget constraint. Even if only one or two kinks exist, the same number of calculations will be made. Finally, the level of accuracy of the generated budget constraint is limited by the choice of size of the increment. So, some points of discontinuity will not be identified.

The algorithm used in TAXBEN is an improvement in all three respects (see Duncan, Giles and Stark,1995). Our procedure significantly reduces the number of calculations required to describe a budget constraint completely, and is computationally efficient in the sense that simpler budget constraints require fewer calculations. Moreover, the nature of the algorithm allows kink points and discontinuities to be identified exactly.

To describe the algorithm, suppose the true budget constraint facing an individual takes the piecewise linear form, shown in Figure 12 as the solid line AGFD. TAXBEN starts by calculating net incomes corresponding to the two extreme points of the budget constraint, given by h_0 and h_{max} in Figure 12. We proceed by adding a small increment Δh (£0.01) to the lower limit and evaluate the new net income level. By calculating the line which passes through the two adjacent points (h_0 , $h_0 + \Delta h$), we can infer that, in the locality of h_0 , the budget constraint is exactly identified by the line AC in Figure 12. Similarly, by establishing net incomes corresponding to the points (h_{max}, $h_{max} - \Delta h$) the budget constraint in the locality of h_{max} is described by the line BD. The intersection of lines AC and BD is then calculated to give point E and the net income corresponding to the intersection value h_1 is evaluated by TAXBEN. If this net income and the intersection point of lines AC and BD are coincident, then the intersection point E represents a kink point of the budget constraint and the algorithm terminates. If the true net income is not coincident with E, the initial range h_0 to h_{max} is split into the two subsets (h_0 to h_1) and (h_1 to h_{max}). Exactly the same algorithm is applied to the two subsets, with a similar termination condition. The termination condition for each of the two subsets will be satisfied by (exactly) identifying F and G as kink points of the true budget constraint. Thus, for the simple constraint described in Figure 5.2, a complete and accurate budget constraint description can be generated after one iteration and with a minimal number of calculations.

Figure 12: Example of a budget constraint



Finally, in many instances, it is useful to check the reasons for the shape of a particular budget constraints. To aid this, we have developed a graphical display of the budget constraint showing the contribution of different sources of income to total net income at each hours level (see section 2.2).

5.2 Replacement Rates and Average Tax rates

Similarly to the budget constraint procedure, TAXBEN can calculate replacement rates at any hours level or the actual hours of work. The replacement rate is derived in terms of the ratio of out of work and in work net incomes at any given hours level, h. This is shown in the equation below. For workers, we normally assume that their wage rate, w, is their current wage and for non-workers we use a simple selectivity corrected wage equation. However, users also have the option to impose specific wage rates.

$$RR_i = \frac{netY_0}{netY_{(h,w)}}$$

TAXBEN also has generates the average tax rate (ATR) at a given hours level, which shows the proportion of any earnings that is lost in taxes or reduced benefits. The ATR is one minus the ratio of the increase in net income to the increase in gross income, and is shown in the equation below. Similarly to replacement rates, TAXBEN has the flexibility to calculate ATR's for any hours level and for estimated hourly wage levels or user defined wage levels.

$$ATR = 1 - \frac{netY_{(h,w)} - netY_0}{grossY_{(h,w)} - grossY_0}$$

Appendix 1 : Reliability of FES Data

Income from Self-Employment

The FES provides a code (B326), rather unhelpfully labelled "self employment - amount of net profit". There is also a code B307 called "self employment - amount of net loss". It is possible for both these codes to have positive values. This occurs because the value assigned to B326 varies depending on whether the respondent declares a profit or a loss before any drawings for their last full year of self-employment activities. Where a profit is reported, B326 is the weekly equivalent of the value of this profit. In the case of a loss, the interviewee is asked the level of any drawing regularly made from the business. This value is the one recorded at B326, with the amount of the loss being recorded at B307. Where the respondent declares that their self-employment activity broke-even, a notional loss of £1 per year is recorded at B307, and B326 once again contains the value of any regular drawings.

For anyone with a positive B307, the value of their self-employment profits is set to zero. Note that in these cases, any value recorded at B326 is irrelevant for tax purposes. The level of self-employment losses is set equal to B307 and is used as a deduction in the income tax routine. Where a respondent claims to have made a profit (gross of tax and drawings) on their self-employment activities, then self-employment profit is set to be the sum of profits earned in primary and subsidiary self-employment jobs (B326 + B328). This profit will be liable to income tax and Class 2 and 4 National Insurance Contributions.

Employment Earnings

Table 3 shows the codes which are used in the construction of the gross income from both main and subsidiary employment. All of these codes relate to questions asked about the last pay received by the respondent. The person's employment status (A200) is used to determine whether these codes refer to a wage or salary which are still being received.[5] We do not combine the gross earnings received from main and subsidiary employment, as each employment incurs a separate liability for National Insurance, up to an annual maximum liability.

5 Additionally, we assume the last payment is not current for those who are away from work and who receive no pay while away (A209 = 3) or who receive part pay where the last payment was not last week/month (A209 = 2 and A250 = 0).

Table 3: Definitions of gross earnings

	FES Code	Description
Main Employment		
Sum of codes	B303	Net Earnings
	B305	Income Tax
	B306	NI Contributions
	B318	Superannuations
	P180-187	Various Deductions from Pay
Less code	B304	Income Tax Refunds
Subsidiary Employment		
Sum of codes	B309	Net Earnings
	B310	Income Tax
	B311	NI Contributions
	B319	Superannuations

Interest Calculation for Interest / Principal mortgages.

In the FES, code B200 relates to the last payment for an interest / principal mortgage[6]. Prior to 1992, there was also a code for the number of years which the mortgage had to run (A134). Post 1992, there was a code for the mortgage capital outstanding (B134). A combination of B200 and either A134 (pre 1992) or B134 (post 1992) is used to calculate the proportion of the last payment that was interest. For 92% of respondents post 1992 this is trivial because they declare a figure for capital outstanding and the interest component will simply be the product of this figure and the mortgage interest rate. However, for the cases where B134 is missing and prior to 1992, the proportion of the last payment that was interest was calculated using the following formula:

$$P = 1 - \frac{1}{(1+r)^y}$$

where P is the proportion of the payment which is interest, y is the years left to run and r is the effective interest rate. The effective interest rate is given by the formula

$$r = i(1-t)$$

6 We do not use the B150 code (interest paid on interest/principle mortgage) for two reasons. Firstly, this code is missing in a large proportion of cases (277 out of 846 cases in 1993). Secondly, it refers to the last year for which a mortgage statement could be produced, which can be a number of years before the year of survey.

where i is the nominal interest rate and t is the rate of mortgage interest tax relief (MITR). For mortgages where the imputed capital would be below the MITR ceiling or where the last payment is declared to be gross of tax, the above formulae are used to derive the interest payments from the last payment figure (B200). Where years to run (A134) is not recorded, this is imputed using the age of the head of household. This is necessary in only 2.5% of cases in 1991.

However, for mortgages where the implied capital stock is above the MITR ceiling, the effect of the ceiling means that we can not use the above equations. Instead, we calculate the amount of capital that is outstanding on the mortgage, from which it is trivial to obtain the interest payment. To calculate the capital outstanding, we first calculate the final year, m, in which the capital outstanding is above the MITR ceiling, which is given by

$$m = trunc\left(\frac{\log\left(1-\frac{rB}{a}\right)}{\log(1+r)}\right)+y$$

where *a* is the mortgage payment recorded in the FES (B200) and *B* is the MITR ceiling. Given this, we can calculate the value of the capital outstanding in year m+1, K_{m+1}, using our initial formulae, as all further interest payments will receive full MITR. We know that all MITR given in the years up to and including m will receive relief capped by the ceiling. Using this fact, we derive a formula for the current capital outstanding, K_1, in terms of K_{m+1}.

$$K_1 = \frac{K_{m+1}}{(i+1)^m}+\left(\frac{a}{i}+tB\right)\left(1-\frac{1}{(i+1)^m}\right)$$

Appendix 2 : Reliability of Aggregate Results

Table 4 shows the aggregate results from TAXBEN using the April 1994/95 tax and benefit system running on 1993 FES data uprated to October 1994 prices. These are compare against the actual revenue and spending outturns for the 1994/95 fiscal year. Notes below the table explain reasons why TAXBEN gives different results to the administrative figures.

Table 4: Comparison of TAXBEN aggregate results with administrative data

	TAXBEN (£bn)	Administrative data[1] (£bn)
Income Tax[1]	65.0	70.7
NI Contributions	20.1	19.1
Net Local Taxes[2]	9.6	9.1
VAT[3]	26.6	41.8
Tobacco Duty[4]	4.8	7.4
Beer and Cider Duty[4]	1.8	2.6
Wine Duty[4]	1.1	1.1
Spirit Duty[4]	1.3	1.8
Petrol Duty[4]	9.0	15.8
Retirement Pension	28.8	28.8
Unemployment Benefit[5]	1.7	1.3
Invalidity Benefit[6]	6.3	8.1
Sickness Benefit[6]	0.4	0.4
Attendance Allowance[6]	1.1	2.0
Severe Disablement Allowance[6]	0.8	0.8
Invalid Care Allowance[6]	0.6	0.5
Child Benefit	6.4	6.1
One Parent Benefit	0.4	0.3
Income Support		
- Pensioners[7]	1.4	3.9
- Non-pensioners	12.1	12.3
Housing Benefit	8.5	10.3
Family Credit[8]	1.0	1.5

Sources :
- Taxes - *Summer Economic Forecast 1995, HM Treasury*
  Inland Revenue Statistics, 1994
- National Insurance - *Tolloy's National Insurance Contributions, 1994-95*
- Benefits *Social Security Departmental Report, 1994*
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[1] Income tax comparison for 1993-94 using income tax receipt gross income tax data from Inland Revenue Statistics, Table 2.10
[2] Council Tax and domestic rates in Northern Ireland
[3] VAT expenditures are seriously under-estimated because not all VAT is reclaimed by companies and because the FES under-records total consumer expenditure, particularly on goods (such as excisable goods) that are subject to the full VAT rate.

[4] Expenditure on excise goods is under recorded in the FES. Wine duty is accurate because much wine is purchased in restaurants, where the Customs and Excise guide prices used for the calculation of duty will not be accurate. This biases the wine duty upwards despite lower recorded expenditure in the FES.

[5] Unemployment benefit is over-recorded as many fewer people were eligible in 1994-95 than in 1993, the year of the data.

[6] Sickness and disability benefits tend to be under recorded as there is a known non-response bias for sick individuals in the FES.

[7] The FES under samples the poor elderly and excludes the elderly (often in receipt of Income Support) in residential care.

[8] The number of family credit recipients grew by 20% between 1993 and 1994-95.

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