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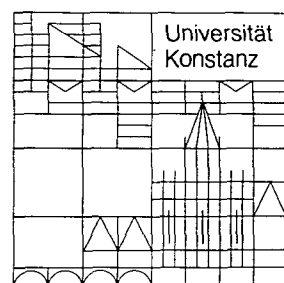
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„Internationalisierung der Wirtschaft“**

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**A Microsimulation Model of
Labour Supply for UK Tax Reform**

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Comments Welcome*

**A MICROSIMULATION MODEL OF LABOUR SUPPLY
FOR UK TAX REFORM**

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Serie II - Nr. 153

Oktober 1991

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ABSTRACT

In this paper, we estimate a theory-consistent model of single parents labour supply behaviour using a variant of the semi-log labour supply function. The underlying preferences are used to simulate the impact of a proposed reform to the Family Credit element of the UK Social Security system using the simulation algorithm **SPAIN** (Simulation Program for the Analysis of **IN**centives). In choosing an appropriate labour supply model to include in the simulation algorithm, the degree to which the model satisfies concavity is an important distributional consideration. In this respect, the semi-log supply function is found to be a most suitable model for simulation, with virtually the entire sample of single parents satisfying the Slutsky condition both at the estimation stage and during simulation.

Using data from the UK Family Expenditure Survey over the years 1981 to 1988, a model of labour force participation is developed. Empirical results indicate that the presence of a young child in the household is the single most important factor discouraging labour market participation. The availability of both formal and informal childcare are seen to raise the probability of participation. Results from our simulation suggest that between 30,000 and 40,000 lone parents will be encouraged to return to work by the changes to Family Credit regulations, emphasising the potential positive labour market role of social security benefits.

1 INTRODUCTION

The use of estimated labour supply models to analyse the work incentive impact of alternative tax regimes can provide valuable insight into the likely behavioural effects of UK tax reform proposals. In this paper, we estimate a theory-consistent model of single parents labour supply - a group who react strongly to changes to the tax-benefit system. The underlying preferences are used to simulate the impact of a proposed reform to the Family Credit element of the UK Social Security system.

Social Security payments are typically thought of as being aimed at those who are not in paid work, whether because of age, ill-health, caring responsibilities or involuntary unemployment. The great bulk of social security expenditure does go to such groups, and most social security recipients fall outside the paid labour market. But there is a potential role for social security in encouraging paid work, by giving benefits to those in work on low incomes which shift the balance between in and out of work income. The principal such benefit in the UK is Family Credit (FC), which replaced Family Income Supplement in 1988. FC entitlement exists for low paid families with children, provided they work 24 hours per week or more. Receipt of FC should guarantee a substantially higher net income than is available while out of work. In 1990 there were 313,000 families receiving FC, of whom 40 per cent were lone parent families.

In April 1992 the UK government will reduce the number of hours which must be worked to qualify for Family Credit from 24 to 16 hours per week. Their stated intention is threefold; to increase the range of jobs which are attractive to lower-earning households; to improve standards of living; to encourage more people into the labour market by lessening the severity of the unemployment trap.

The reform is particularly aimed at potentially lower-earning households for whom part-time work is the most feasible alternative to not working at all. Many single parents fall into this category, and the number of single parents has increased significantly over the last decade; current estimates suggest that there are now more than 1 million one-parent families in the UK (see Haskey (1989)). For many single parents, balancing work commitments with the care of their children makes part-time employment (and potentially relatively low pay) the only viable alternative to non-participation. Any change to the Social Security system as it affects part time work is therefore likely to affect single parents more so than most other demographic groups. The reduction in the hours qualification for FC suggested by the government brings many more jobs within the 16 to 24 hours range into the Family Credit system, and could have a significant positive impact on work incentives for many one-parent families.

It is clear that an empirical assessment of the FC reforms must take into account possible changes in labour supply behaviour, since by its very nature the reform encourages people to alter the number of hours they work. Given the current system, single parents have little reason to work between 16 and 24 hours per week because their Income Support entitlement is reduced £ for £ for any earnings in excess of £15 per week. We would not expect to see many lone parents working in this hours range at present. Any analysis of the proposed reform must therefore take account of possible changes in labour supply behaviour, since the aim of the reform is precisely to encourage people to work within the 16-24 hour range, which is at present unattractive.

For this reason, an analysis based solely on conventional tax-benefit models is inappropriate (the standard tax-benefit model evaluates reforms on the presumption that behaviour does not change post-reform so that non-participants, for example, would remain out of the labour force whatever happened to the tax system). In this paper we apply a *simulation* methodology which can be used to predict the labour supply behaviour of single parents under any tax-benefit regime. The simulation will be carried out using the IFS simulation routine SPAIN¹. Using SPAIN, we can estimate the labour supply responses of single parents to the FC reform, concentrating both on the overall distributional change to labour supply, and on a detailed examination of the impact the change in FC regulations will have for specific households.

The simulation process essentially involves solving a set of (non-linear) constrained optimisation problems for each individual in our sample. The constraints under the base tax system, and budget sets under the tax reform proposal, are generated using the IFS Tax Benefit model TAXBEN2 (Johnson, Stark and Webb (1990)). The distributional consequences of the FC are analysed using a variety of statistical and graphical techniques, and serve to highlight the distortions associated with this element of the UK tax system.

Because the individual is assumed to exhibit utility maximising behaviour, the labour supply model must be capable of satisfying the normal axioms of utility theory (at least over a large range of feasible hours). In the simulation model, this requires that the Slutsky condition is satisfied at the optimal supply of hours both pre- and post-reform for most sample data points. In choosing an appropriate labour supply model to include in the simulation algorithm, the degree to which the model satisfies concavity is an important distributional consideration. For the labour supply model utilised in this paper, virtually the entire sample of data points satisfy concavity both at the estimation stage and during simulation.

¹ Simulation Program for the Analysis of INcentives (see Blundell, Meghir, Symons and Walker (1989); Duncan (1991))

2 TAXATION, SOCIAL SECURITY AND SINGLE PARENTS

Single parents arguably face a more complex collection of tax and social security rules than any other large group in the UK, and consequently pose serious questions for those framing policy. In this section we briefly describe the direct tax and social security structure that faced single parents over the period up to April 1988².

Not Working

For non-participants in the labour market, the principal social security benefit available during this period was Supplementary Benefit (SB), which was replaced by Income Support (IS) in the April 1988 reforms. SB was a severely means-tested benefit, intended to act as a safety net guaranteeing a minimum income to those eligible.

The basic structure of SB was that an amount of benefit related to family structure (married, single, retired) and number of children, called the SB scale rate, would be paid where no other income was available. Any investment income, or payments such as alimony, was deducted in full from SB entitlement. The first £4 per week of any earned income was disregarded, and in the case of single parents the next £16 per week was subject to a 50 per cent withdrawal rate. Thus a single parent earning £20 p.w. would receive £8 p.w. Less in SB than if she had earnings of up to £4 p.w. For earnings in excess of £20 p.w., SB entitlement was reduced by the full amount of the additional earnings. If income tax or National Insurance contributions were due, these were deducted from the income used in the assessment of SB entitlement, ensuring that a marginal withdrawal rate in excess of 100% would not occur.

Prior to 1983, recipients of SB had their housing costs met by SB payments. Housing costs covered included rents, rates and mortgage interest and these could be paid in full by SB. From 1983, SB recipients received benefits to cover rents and rates through the separate Housing Benefit system, while mortgage interest payments continued to be dealt with within SB. The Housing Benefit (HB) received by SB recipients from 1983 was Certificated HB, as opposed to Standard HB received by those outside the SB system.

² See Dilnot, Kay and Morris (1984) Chapter 1 for a discussion of the development of the UK social security system, HMSO (1985) and Dilnot and Webb (1988) for a discussion of the 1988 reforms.

Working

Single parents over this period were entitled to two tax free allowances for income tax; the single allowance (SA) and the Additional Personal Allowance (APA). The APA was roughly 60% of the value of the SA, and set equal to the difference between the SA and the Married Man's Allowance (MMA). The combination of SA and APA thus gave single parents a tax free allowance equal to that of married men.

Taxable income included earnings, investment income, and in general any maintenance or alimony. Once taxable income³ exceeded the combination of SA and APA income tax was due, at a rate which varied over the period from 25% to 30%. Higher rates of income tax affected only the top 5% of the income distribution.

National Insurance contributions (NICs) had possibly a more significant impact on single parent behaviour over this period (see Duncan (1991a) for more detailed discussion). NICs are due from both employees and employers, at a joint rate of almost 20% of earnings; for most of this period they were the second most important source of revenue for the UK government, after income tax. The structure of NICs imposed peculiar incentive problems as a result of its rather odd structure (see Davis and Dilnot (1985), Dilnot and Webb (1989) for further discussion). Throughout the period under discussion there was a significant financial penalty for both employee and employer from increasing an employee's earnings so as to take them above the Lower Earnings Limit (LEL), the point at which NICs become due. The disincentive was severe because as earnings passed the LEL, NICs became due not on the excess of earnings over the LEL, but on *all* earnings. In 1984, the LEL was £34, and the employees and employers' rates of NIC 9% and 10.45% respectively. If an employee's earnings were to have been increased from £33.99 to £34, NICs would have risen from 0 to £3.06 and £3.55 for employee and employer respectively. Hardly surprisingly, bunching occurred a earnings immediately below the LEL. The 1985 Budget reduced the size of the jump in NICs at the LEL, but introduced additional jumps at higher earnings to pay for the change.

The fact that both employees and employers faced an incentive to keep earnings just below the LEL made distortion of the labour market all the more likely, and as Duncan (1991b) showed, such distortion was readily identifiable.

Turning to the social security system, the two main benefits of relevance to working single parents were HB and FIS; we begin with HB. One important point to note is the absence of support available for mortgage interest payments outside the SB system. HB, on the other hand, did provide assistance for rent and rates. This

³ subject to deduction such as mortgage interest and private pension contributions.

asymmetry in the social security system effectively reduced the incentive to work for social security recipients living in mortgaged accommodation relative to those living in rented property.

Housing benefit for those in work splits into two regimes: rent rebates and allowances and rate rebates and allowances. Both rent and rate benefits were means-tested, with withdrawal rates varying from as low as 7% for rate rebates on occasion, to as high as 33% for rent rebates. The benefit calculation centred around a "needs allowance" (NA), which was related to size of family. If income was equal to the needs allowance 60% of rent and rates would be paid in benefit. If income was less than the NA, benefit would exceed 60% of rent and rates by the relevant withdrawal rates multiplied by the deficiency of income below the NA. If income exceeded the NA, the benefits would be reduced by the excess multiplied by the relevant withdrawal rate. If income was sufficiently low, 100% rebates were allowed, subject to certain maxima applied to rents and rates.

The other important in-work benefit for single parents was Family Income Supplement, (FIS), which was replaced by Family Credit (FC) in April 1988. FIS was available only to single parents working for 24 or more hours every week. FIS entitlement was related to income and number of children. If income was below a prescribed level, full entitlement to FIS was conferred. If gross income exceeded the prescribed level, entitlement was reduced by 50% of the excess.

It is important to note here that there were serious problems of non-take-up with means-tested benefits, particularly HB and FIS, and especially FIS, where the proportion of those entitled actually receiving was only around 50%. The take-up problems with HB appeared to be most severe amongst the working population, as described in Blundell, Fry and Walker (1987), while the problems with HB take-up are discussed in Fry and Stark (1987,1991).

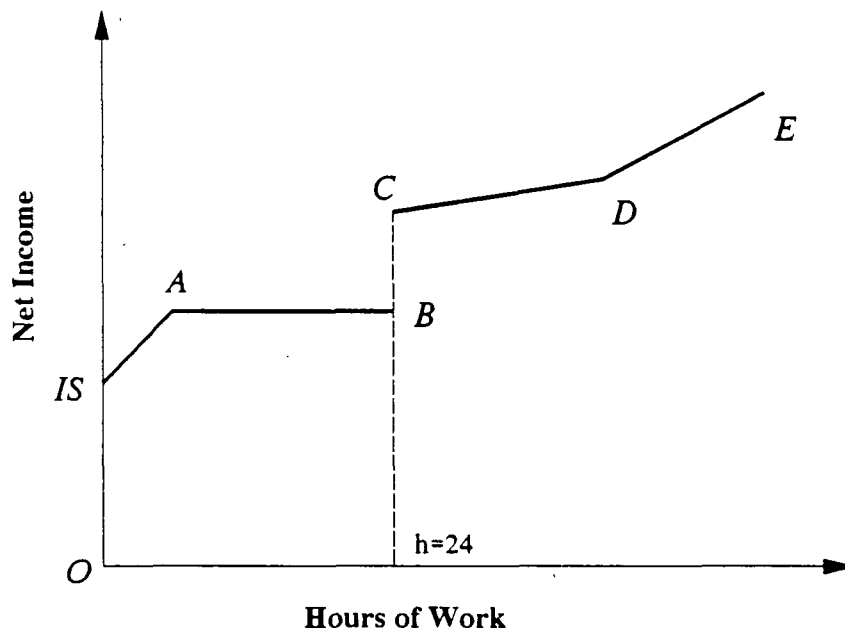
The labour market role of Family Credit

In general, social security benefits are seen as a means of replacing earnings where no earnings exist, or supplementing them where they are low. While FIS did, and FC does, fulfil the latter role, both also have a potentially positive role in encouraging labour market participation. There is a sense in which FC is almost a bribe to encourage people to work. Figure 2.1 presents a simplified view of the Budget constraint facing a single parent in the UK.

At zero hours, the single parent receives OIS of Income Support. From IS to A, there is no withdrawal of benefit, since earnings are below the earnings disregard of the Income Support system. Beyond A, the budget constraint is horizontal until B, reflecting the 100% withdrawal rate under Income Support (as under SB). At B, corresponding to a 24 hour week, there is a sharp jump in net income as the

single parent becomes entitled to FC (or FIS pre-1988). From C to D the overall withdrawal rate remains quite high as a result of the combination of means-tested benefits and direct taxes. The jump in net income at 24 hours should have a positive impact on single parent labour market participation, but two problems exist. The first is simply non-take-up of FC, and lack of awareness of its existence. Even if the true budget constraint is as shown in Figure 2.1, single parents who are unaware of FC will perceive a budget constraint providing far less encouragement to work. The second problem is that a 24 hour week may be unattractive to a single parent with competing non-work obligations.

Figure 2.1: The Impact of Family Credit



Arguments of this kind have persuaded the government to reduce the qualification for FC entitlement from 24 hours per week to 16 hours per week, hoping to increase the range of jobs which are attractive to single parents, improving their standards of living, and helping them back into the labour market. In the remainder of this paper, we analyse how this reform proposal will effect single parent families both from a distributional point of view, and by focussing on the impact the reform might have on specific one-parent households.

3 THE LABOUR SUPPLY MODEL

3.1 Economic Framework

The underlying theoretical framework in this paper is the life-cycle consistent model of within-period labour supply, as described in Blundell and Walker (1986). In that model, desired hours of work h is defined by

$$h = g(w, \mu, z) \quad \dots(1)$$

where w is the marginal after tax wage rate, and μ is a virtual income measure accounting for savings and defined by $\mu = c - wh$, c being a measure of consumption. The variables z are taste shifters, and include the demographic characteristics of the household.

We apply the full selectivity approach of Heckman (1974) to estimate a model of single parent's labour supply (see Blundell, Duncan and Meghir (1991)) over a sample of data from the Family Expenditure Survey (FES) from 1981 to 1988. In specifying the stochastic structure of our model, we assume joint normality of unobservable components. This is clearly an assumption which must be tested, and some indication of its validity in this particular application will be given when we report our estimation results. In terms of equation (1),

$$h = g(w, \mu, z) + v \quad \dots(2)$$

represents the labour supply function, where v is an error term reflecting random preference variation. We may control for the potential endogeneity of the wage rate in (2), using a reduced form log wage equation of the form

$$\ln(w) = q'\gamma + u_w \quad \dots(3)$$

where q represents a vector of individual and demand-side variables. The disturbance term u_w is assumed normal and independent of v . Following Smith and Blundell (1986), we may test and correct for wage rate endogeneity by adding the reduced form wage residual to our structural equation. A similar procedure can be adopted to control for endogeneity of μ from the reduced form virtual income equation

$$\mu = q'\delta + u_\mu \quad \dots(4)$$

Finally, the participation equation required to model the probability of selection into work can be written as

$$I^* = q'\theta + u_i \quad \dots(5)$$

where I^* denotes a binary variable indicating labour force participation. Given the selection criterion described above, a normality assumption on v allows us to specify the conditional distribution of working hours as

$$E(h|w, \mu, z, h > 0) = g(w, \mu|z) + \alpha_w u_w + \alpha_\mu u_\mu + \alpha_h \lambda \quad \dots(6)$$

The selectivity correction term is defined by $\lambda = \phi(q'\theta)/\Phi(q'\theta)$, where $\Phi(q'\theta)$ denotes the probability of participation and $\phi(\cdot)$ defines the corresponding density function (see Heckman (1979)). The inclusion of the residual u_w accounts for the possible endogeneity in the gross wage rate as well as possible measurement error in the marginal tax rate, while u_μ accounts for the endogeneity of the other income measure. Standard errors are corrected for the endogeneity of wages and other income, and for the heteroskedasticity induced by λ .

3.2 Model Specification.

When modelling hours decisions in the presence of a system of taxation which renders the budget constraint non-linear, it is important that labour supply models should satisfy theory consistency and at the same time remain sufficiently flexible to allow for a wide range of behavioural responses. Although the Slutsky condition places certain constraints on the "shape" of labour supply behaviour, provided appropriate functional forms are considered, these restrictions can be fairly weak. In general labour supply functions should have a positive wage effect at zero or low hours. For higher hours the wage effect may become negative, allowing labour supply curves to become backward bending. Provided the income effect is sufficiently negative, labour supply curves which exhibit backward bending behaviour for high hours can be theory consistent at all conceivable points.

The model chosen for estimation is a particular version of the Gorman polar form, such that

$$h = \alpha + \beta \ln w + \gamma \mu/w \quad \dots(7)$$

which is attractive since it can be seen to allow theory-consistent backward bending behaviour provided β is negative. The restrictions of economic theory require that, as h tends to zero, the labour supply curve becomes forward sloping. In fact, the Slutsky condition requires that $\beta - \gamma(\mu/w) - \gamma h$ is positive. Slutsky success at zero hours is therefore guaranteed if and only if the labour supply curve is forward-sloping at $h=0$. The indirect utility associated with (7) is

$$V(w, \mu) = \frac{w^{1+\gamma}}{1+\gamma} \left\{ \frac{\mu}{w} (1+\gamma)^2 + \beta \ln w + \alpha - \frac{\beta}{1+\gamma} \right\} \quad \dots(8)$$

see Duncan (1990). The direct utility function may be recovered by substituting the support wage $w = w(h, \mu)$ from (7) into $V(w, \mu)$. For models which form the basis of a simulation routine, the availability of a tractable, theory-consistent (in)direct utility function is an important requirement since comparisons of utility across different budget segments are generally required to establish the globally optimal supply of hours.

4 EMPIRICAL RESULTS

4.1 The Data

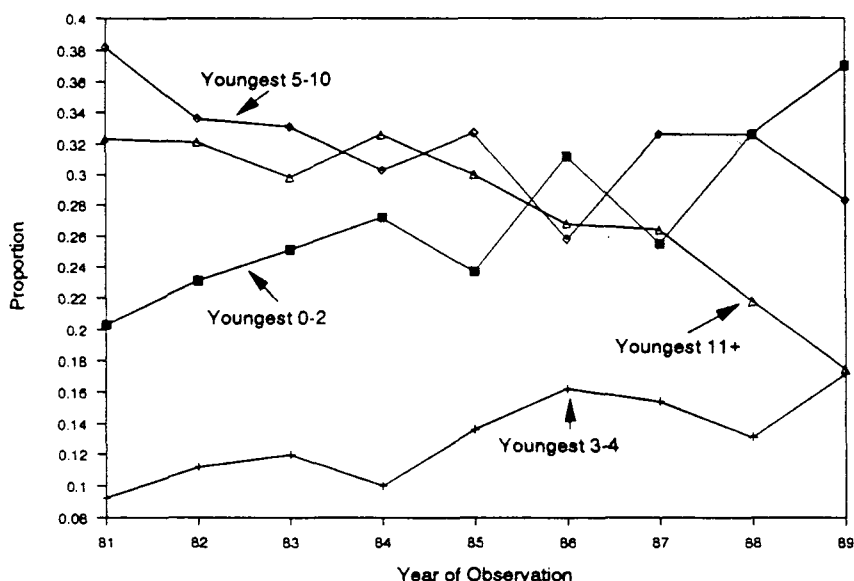
The data used in this study have been drawn from the Family Expenditure Survey (FES) over the years 1981 to 1988. The FES contains details of the incomes, expenditures and demographic composition of around 7000 households each year, and is an ideal data source for micro-econometric research. There are two reasons for our choice of the sample length; firstly, given that the UK tax-benefit system was fundamentally reformed by Norman Fowler in April 1988, choosing a sample up to the point of structural change eases the task of estimating an econometric model of labour supply. Secondly, the child-care data used in our empirical work has only been available in its current format from 1981. Thus, the period from 1981 to 1988 provides the largest sample with reasonable data-consistency.

A number of selection criteria were applied to the data resulting in a sample of 2593 lone parents, of which 1093 are working, with the remainder being either unemployed and seeking work, or non-participant in the labour market. The Data Appendix gives a more complete description of the data used in this study and of the selection rules applied.

4.2 Labour Market Participation

In common with other work⁴ we find that labour force participation rates among one-parent families have fallen over the last decade. However, we note also that the *composition* of single parent households has changed significantly over the same period. As Figure 4.1 shows, there has been a marked increase in the proportion of one-parent families with very young (pre-school) children; a group for whom labour force participation rates are historically relatively low.

Figure 4.1: Proportions of One-Parent Families

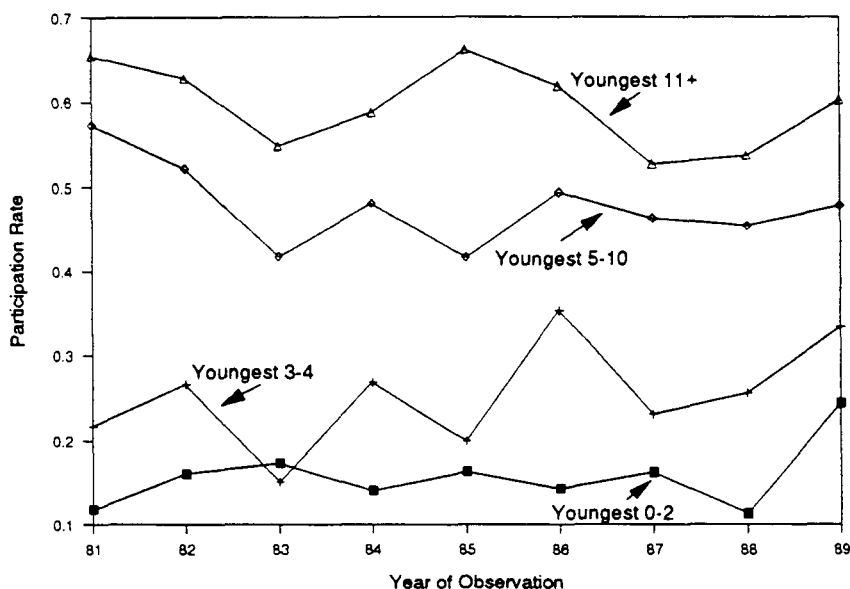


Source: Family Expenditure Survey (1981-1989)

In Figure 4.2, separate participation rates are shown for single parents with a youngest child in each of the age ranges 0-2, 3-4, 5-10, and 11 and over. Participation rates for each age group are relatively stable, with some evidence of an increasing rate of participation across the decade for single parents with young children. The reduced aggregate participation rate among one-parent families therefore seems to be caused more by an increase in the proportion of single parents with very young children than by a general decline in participation rates across all single parents.

⁴ see Bingley, Symons and Walker (1991), Ermisch and Wright (1989), Haskey (1989).

Figure 4.2: Participation Rates Among One-Parent Families

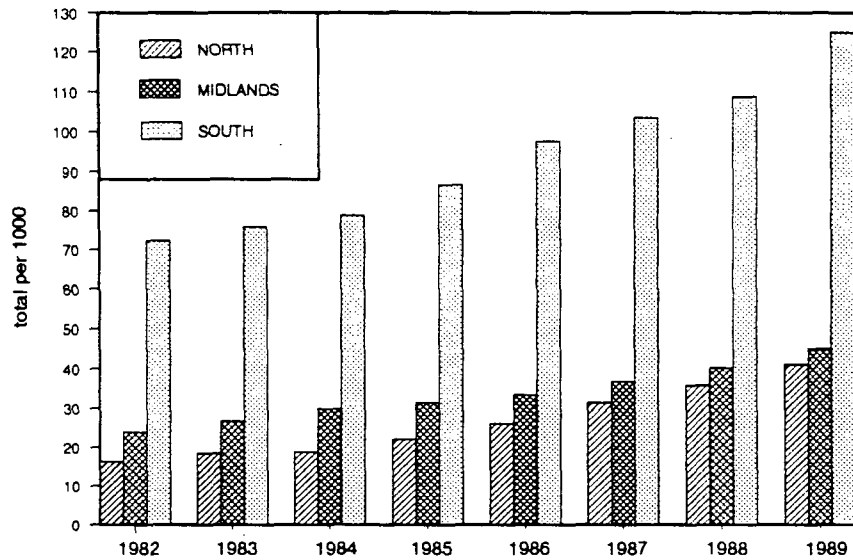


Source: Family Expenditure Survey (1981-1989)

The proportionate increase in numbers of single parents with pre-school children may help to account for the significant rise in full day-care facilities. Figure 4.3 charts the availability of childcare across the period of our sample, where childcare availability is measured by the number of places with registered child-minders per 1000 of the pre-school population. A consistent increase in childcare availability is apparent, with noticeable variation in the numbers of childcare places across different regions. This evidence tends to support the belief that policies designed to assist the development of affordable childcare would encourage more single parents into the labour market.

To analyse within-period labour supply behaviour we need a selection probability to capture sample selection into the group of working single parents. In addition, virtual income and wage equation estimates are required. Taken together, these will allow us to correct for the potential endogeneity of other income, wage and the sample selection as described in equations (3) to (5) above. The Probit estimates of the participation decision of single parents are supplied in Table 4.1. Results conform to *a priori* expectations, and indicate that the presence of a pre-school child in the one-parent household is the single most important factor dissuading labour market participation. Those variables included in an attempt to capture the availability of both formal and informal childcare indicate strong positive effects

Figure 4.3: Childcare Availability



Source: Regional Trends (1982-1989)

on the probability of labour force participation⁵. There is also a greater likelihood of participation among single parents in receipt of maintenance. As noted in Walker (1990), maintenance payments are classed as income in the assessment of Income Support entitlement and were treated in the same way for Supplementary Benefit. The severity of the unemployment trap caused by this element of the benefit system is therefore reduced among maintenance recipients.

In Table 4.2 we present estimated participation probabilities for a range of (hypothetical) households. The reference individual is a 30 year old single woman living in London with one child aged between five and ten. She left school at 16, receives no maintenance, and there are no other adults living in her household. For such an individual, our estimates suggest the probability of labour market participation is 0.425. Table 4.2 computes the effects of changing demographic characteristics, the state of the economy, the number of childcare places available, and introducing maintenance payments.

⁵ In the participation Probit, the presence of the single parent's mother in the household was included in order to capture the availability of informal childcare. Formal childcare provision was proxied by the regional density of full day-care places. The parameters of both variables are strong and positive. Moreover, even with the inclusion of variables to capture both regional differences and time variation, the formal childcare parameter returns a near-significant value.

TABLE 4.1: Participation Index (1981-1988 Data)

Variable	Estimate	Std. Error	T-Statistic
Constant	-1.670	1.448	-1.15
Age	-0.058	0.140	-0.41
Age ²	-0.142	0.071	-2.00
Education	0.262	0.050	5.15
Education ²	-0.014	0.006	-2.17
1920 Cohort	0.218	0.457	0.48
1930 Cohort	-0.352	0.301	-1.17
1940 Cohort	-0.225	0.207	-1.09
1950 Cohort	-0.060	0.131	-0.46
Number of children	0.137	0.186	0.74
(Number of children) ²	-0.094	0.045	-2.05
Youngest child aged < 2	-0.830	0.194	-4.27
Youngest 2-4 not at school	-1.040	0.279	-3.72
Youngest 2-4 at school	-0.630	0.267	-2.35
Youngest child aged 5-10	-0.344	0.088	-3.90
(Youngest child <2)xAge	0.237	0.188	1.26
(Youngest child 2-4,not at school)xAge	-0.169	0.240	-0.71
(Youngest child 2-4,at school)xAge	0.243	0.246	0.99
(Youngest child 5-10)xAge	0.026	0.121	0.22
Child at special school	-0.288	0.133	-2.16
Female unemployment by age	-3.190	1.708	-1.87
Vacancies by region	0.117	0.092	1.27
Redundancies by region	0.021	0.032	0.65
Quarterly unemployment	-6.815	5.742	-1.19
Receiving maintenance	0.505	0.060	8.40
Mother in household	0.491	0.102	4.80
Full childcare	0.949	0.659	1.44
Sessional childcare	-0.225	0.274	-0.82
Sample Size:			2599
Likelihood Ratio Chi-square:			660.49
Percent Correctly Predicted:			71.37
McFadden's pseudo R-square:			0.189
Skewness (DF=1):			0.7439
Kurtosis (DF=1):			0.5433
Normality (DF=2):			2.9181

Notes: Childcare availability is measured by the number of full childcare places per 1,000 of the regional population (source: *Regional Trends* 1981-88). Vacancies and redundancies by region are taken from *Employment Gazette* 1981-88. Education is defined to be (Age left education-15). Regional and year dummies were also included.

Table 4.2: Estimated Participation Probabilities

Household Type	Probability	Change
Reference Household	0.425	
Reference, but with youngest aged 0-2	0.188	-0.237
As above, with childcare up 50%	0.579	0.154
Reference, with additional child 0-2	0.150	-0.275
Reference, with parents mother in H/H	0.621	0.196
Reference, but NORTH	0.420	-0.005
Reference, but age = 20	0.282	-0.143
Reference, but age = 50	0.332	-0.093
Reference, but left school at 18	0.561	0.136
Reference, with unemployment up 50%	0.380	-0.045
Reference, but receiving maintenance	0.624	0.199

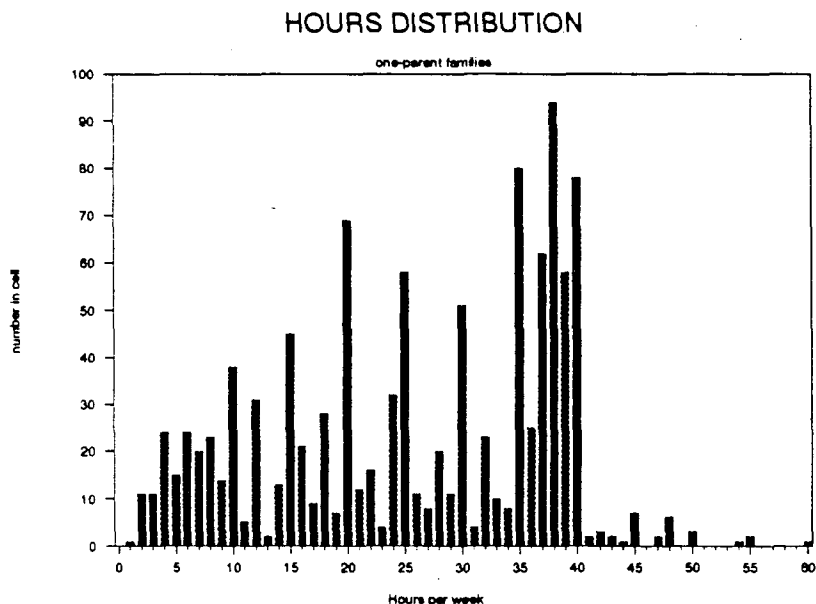
The most dramatic change in the probability of participation is associated with a different age for the youngest child; for an individual with a child aged 0-2 rather than 5-10, but otherwise identical to the reference household the probability of participation falls to 0.188. Increasing by 50% the number of full childcare places available shifts the participation probability back up to 0.579. Adding a further child aged 0-2 to the reference household imposes a reduction in the probability of participation to 0.150. If the lone parent's mother is living in the same household, the participation probability increases to 0.621, presumably reflecting the availability of informal childcare. Age has a significant impact, with younger lone parents less likely to participate, and older lone parents also less likely to participate than the reference individual. Increasing the number of years of education increases the probability of participation, possibly reflecting both different preferences and a higher potential wage. Introducing maintenance payments increases participation probabilities as noted in Walker (1990) by reducing entitlement to Supplementary Benefit/Income Support and thus reducing the level of earnings at which the individual exhausts benefit entitlement and begins to gain financially from increased earnings.

4.3 Labour Supply Estimates

To complete the specification of our simulation model, we require estimates of the labour supply equation presented in the previous section. Such a model can then be used to predict behavioural responses to the proposed FC reform. It is clear that, with institutional constraints on the length of the working week, a significant proportion of single parents are not at liberty to vary their labour supply freely. As Figure 4.4 demonstrates, there are a number of peaks in the hours distribution

for working one-parent families around 20 and 40 hours per week. However, it is equally clear that the range of labour supply is sufficiently wide and varied to use a continuous labour supply function for estimation.

Figure 4.4



As discussed above, the estimation procedure for the labour supply model requires a mechanism to correct for the potential endogeneity of wages and other income. Reduced form estimates of the virtual income equation and the selectivity adjusted wage equation are presented in Table A1 of the Data Appendix, from which log wage and virtual income residuals \hat{u}_w and \hat{u}_μ are generated. The distribution of the error term in the labour supply model can be assessed firstly, dealing with endogeneity, by conditioning on the reduced form residuals and secondly by testing for normality. Since there will very likely be dependence between the distributions of the participation and labour supply equations, this requires an evaluation of the generalised error products (Smith(1985)).

Table 4.2 presents the labour supply estimates for our full selectivity model (6), with demographic variability imposed on each of the parameters. Notice first that the coefficients on both the other income residual and the log wage residual are negative and significant, suggesting a negative bias on the β and γ parameters were we to exclude the residuals from the estimation procedure.

TABLE 4.2: Labour Supply Estimates (1981-1988 Data)

Variable	Estimate	Std. Error	T-Statistic
Constant	27.550	2.795	9.857
Youngest child aged 0-2	-7.682	2.254	-3.407
Youngest child aged 3-4	-4.033	1.683	-2.396
Youngest child aged 5-10	0.294	1.980	0.149
Age-40	-1.377	0.654	-2.104
(Age-40) ²	0.670	0.432	1.553
ln(wage)	5.065	1.688	3.000
ln(wage)x(Youngest child aged 2-4)	3.081	2.376	1.297
ln(wage)x(Number of children aged 5-10)	0.726	1.023	0.710
ln(wage)x(Number of children aged 11+)	0.173	0.988	0.175
μ/w	0.010	0.006	1.666
μ/w x(Youngest child aged 2-4)	0.038	0.024	1.586
μ/w x(Number of children aged 5-10)	0.007	0.006	1.132
μ/w x(Number of children aged 11+)	-0.003	0.007	-0.498
σ	11.977	0.568	21.097
ρ	-0.485	0.106	-4.578
u_w	-4.443	1.433	-3.101
u_μ	-0.070	0.008	-8.664
Sample Size			2593
Log-Likelihood			-5324.97

Notes: The hours equation was estimated using the Heckman two-step selectivity technique. ρ denotes the correlation between the structural model and the participation equation, and u_w and u_μ are reduced form residuals included to control for the potential endogeneity of wages and unearned income in the labour supply equation.

Turning to the structural parameters themselves, we see a significant degree of forward-sloping labour supply behaviour for all demographic groups in the sample, although for families with young children the curvature is more varied. In terms of the theory-consistency of the model, the Slutsky condition was found to be satisfied globally. This accords with other work using alternative labour supply

specifications (see Blundell, Duncan and Meghir (1991)) and suggests that single parents are a group whose labour supply behaviour is strongly consistent with economic theory. This emphasises the suitability of the model for simulation purposes.

For a more intuitive idea of the types of labour supply behaviour characterised by our model, Table 4.3 presents the distribution of estimated wage elasticities for the sample of working single parents, both in aggregate and split by the age of the youngest child. From Table 4.3, we see that the estimated wage elasticities for the sample of working single parents are predominantly positive, with a greater proportion of high wage elasticities for families with young children. Examination of the model indicates that lone parent labour supply behaviour can be quite wage-elastic at low hours, suggesting that the incentive effects of changes to the tax system will be more pronounced for part-time workers.

Table 4.3: Estimated Wage Elasticities

Age of Youngest Child	0-2	3-4	5-10	11+	All
e(minimum)	-0.132	-0.179	-0.802	-0.252	-0.802
e(lower quartile)	0.099	0.105	0.092	0.092	0.094
e(median)	0.138	0.147	0.111	0.107	0.113
e(upper quartile)	0.361	0.293	0.201	0.171	0.203
e(maximum)	3.367	1.795	1.180	3.027	3.367
mean elasticity	0.300	0.285	0.173	0.177	0.199
standard deviation	0.417	0.360	0.180	0.257	0.270
N	117	91	393	422	1023

Notes: e(.) represents the wage elasticity evaluated at a particular point in the distribution. For example, e(median) denotes the median elasticity calculated both in aggregate and for each sample subset.

5 MODEL SIMULATION

The labour supply estimates presented in the previous section provide us with a model which is suitable for simulation in a number of respects. Firstly, the functional form chosen is parsimonious yet sufficiently flexible to allow for backward-bending labour supply behaviour. Moreover, the fact that an explicit algebraic form exists for the indirect utility function allows for a straightforward comparison of utility levels if required. Finally, the preference parameters are shown to be theory-consistent for virtually the entire sample of data points.

The simulation algorithm described here is a modified version of the IFS simulation model SPAIN (Blundell, Meghir, Symons and Walker (1988)) and can potentially operate on any subsample of Family Expenditure Data from 1968 onwards. The general aim of the simulation module is to solve a series of constrained optimisation problems. Each individual in the sample faces a budget set which is rendered non-linear by the interaction of the incumbent tax-benefit system. While the budget constraint can include a complex range of kinks and discontinuities, in general it will be piecewise linear. Thus, the budget constraint can be separated into a series of linear segments, each of which is described by a relationship of the form

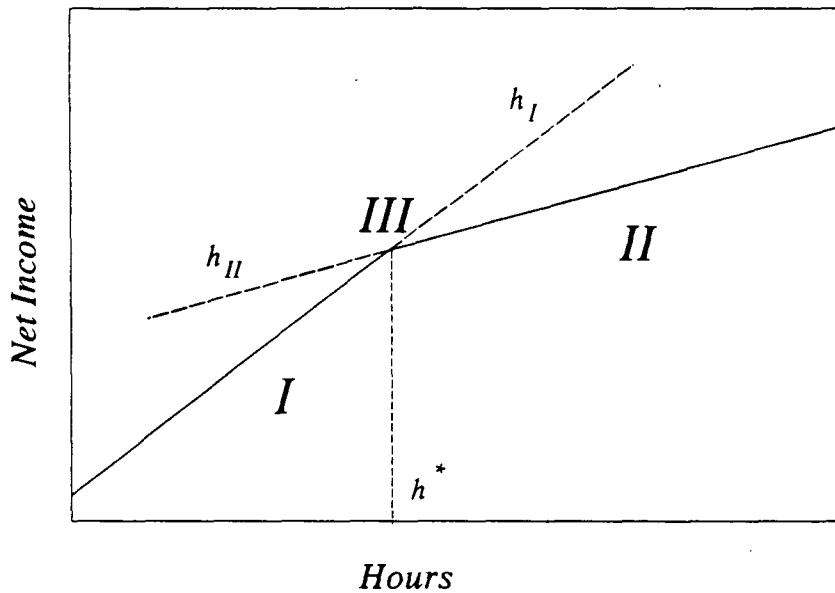
$$Y = (1 - t(h))wh + \mu(h) \quad \dots(8)$$

where Y represents net income, w and h denote gross wage and hours of work, and $t(\cdot)$ and $\mu(\cdot)$ represent functions for the marginal tax rate and virtual income respectively. Given the gross wage rate, the values of functions $t(\cdot)$ and $\mu(\cdot)$ depend on hours of work. Moreover, by observing the change in marginal tax rates and virtual income across adjacent segments, we can distinguish between convex and non-convex kink points and discontinuities in the complete budget constraint.

For the base run in any simulation, the algorithm proceeds by identifying the locally optimal choice of hours for each linear segment of the budget constraint. If the locally optimal solution is calculated to be within the range of hours over which the linear segment is defined, it is said to be "feasible". After all feasible local optima have been identified, the global optimum is established by calculating which of the feasible local optima generates maximum utility. Where the budget constraint is (locally) convex, a situation such as that described in Figure 5.1 may arise.

With reference to Figure 5.1, if the optimal solution h_I for the lower budget segment (I) lies above the feasible range (that is, $h_I > h^*$) and the optimal solution h_{II} for the upper budget segment (II) lies below the feasible range (that is, $h_{II} < h^*$), then the local optimum must exist at the intersection of I and II. In this case, the "feasible" supply of hours is at the kink point (III) of the budget constraint, at h^* . The utility level corresponding to the kink point can then be established by evaluating the direct utility at h^* . For models where the direct utility is only implicitly available, the level of utility at h^* can be recovered by (numerically) evaluating the inverse demand function $w = w(h, \mu)$ to yield the support wage. By duality, the substitution of the support wage into the indirect utility function at h^* is sufficient to evaluate the level of direct utility at the kink point. For discontinuous kinks in the budget constraint, the direct utility at the point of discontinuity must be compared with the indirect utility at any adjacent feasible solution, in order to establish the local optimum. The algorithm compares all local

Figure 5.1: Convex Budget Constraints



optima for the complete budget constraint, and returns the global optimum as the maximum maximum of utilities. Budget constraints are generated using the IFS Tax Benefit Model TAXBEN2 (Johnson, Stark and Webb 1990)). Its coverage of the UK tax system is significantly more detailed than the brief description supplied in Appendix A. As such, it offers a unique opportunity to assess the full impact of alternative proposals for the reform of labour supply.

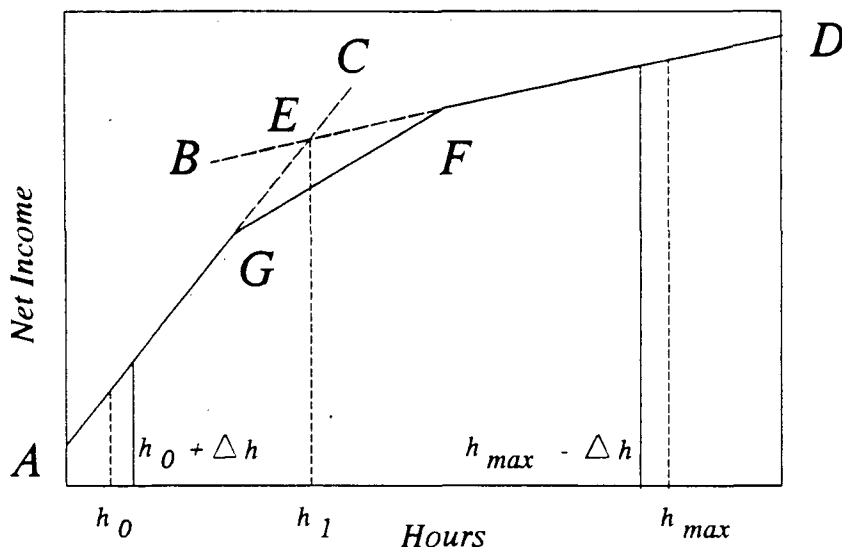
In general, tax models have the capability to assess total tax liability and benefit entitlement for any gross income level. However, complete descriptions of individual budget constraints have, up to now, proved computationally time-consuming and also exhibit a slight degree of inaccuracy. In the LSE/STICERD tax model TAXMOD (see Atkinson and Sutherland (1988)), approximate budget constraints are generated 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 income up to, say, \$300. Clearly, in this example, 300 distinct runs of the tax model are required, making 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. Thus, some points of discontinuity will not be identified.

The algorithm used in TAXBEN2 is an improvement in all three respects. Our new 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 described in Figure 5.2. The algorithm is initiated by invoking TAXBEN to calculate net incomes corresponding to the two extreme points of the budget constraint (as given by h_0 and h_{\max} in Figure 5.2). We proceed by adding a small increment Δh 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 (See Figure 5.2). 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 (at point E) and the true net income corresponding to the intersection value h_1 is evaluated by TAXBEN. If the true 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.

For non-participants in the sample, the budget constraint is modelled using a predicted gross wage from the estimated wage equation presented in Appendix B. This allows us to generate a complete set of budget constraint descriptions under both the base tax system and reform system for all sample data points. The simulation algorithm proceeds by calculating the pre-reform supply of hours for all individuals in the sample. Because the stochastic structure of the labour supply model is consistent with unobserved taste variation, the random preference component for each observation is identified simply by evaluating the estimated pre-reform residual. For non-participants in the sample, an 'estimate' of the random preference component is generated by applying the generalised residual methodology of *Gourieroux et al (1987)*.

Figure 5.2



Turning now to the results of our simulation, we present labour supply responses to the proposed FC reform for the 1989 UK tax system⁶. The labour supply effects of the FC reform are predicted using a subsample of single parents from the 1988 and 1989 Family Expenditure Surveys, with all incomes and expenditures normalised to December 1989 prices. Table 5.1 compares predicted labour supply before and after the FC reform. Each row gives a count of single parents predicted to work within a particular hours range before the reform, each column hours after the reform. For example, 352 single parents in our sample are predicted to work less than 5 hours per week (including not working at all) both under the base tax system and after the reform to Family Credit (see Table 5.1: row 1, column 1), while 40 households work at least 5 but less than 8 hours per week both pre- and post-reform (Table 5.1: row 2, column 2). The leading diagonal (picked out in bold) identifies those households whose labour supply does not change significantly in response to the reform. Those *above* the diagonal work more hours post-reform while those *below* work less.

Two features are immediately apparent from this analysis. A significant number of single parents (20, around 4% of our sample) are predicted to move from non-participation (or near-unemployment) to a post-reform supply of labour of between 16 and 24 hours per week. This is precisely the positive labour market

⁶ 1989 was the first full (calendar) year for which the new system of Family Credit applied.

Table 5.1: Hours Cross-Tabulation

	Post-reform Hours											All
	<5	<8	<12	<16	<20	<24	<28	<32	<36	<40	40+	
<5	352	-	-	-	5	3	-	-	-	-	-	360
<8	-	40	-	-	4	8	-	-	-	-	-	52
<12	-	-	10	-	-	-	-	-	-	-	-	10
<16	-	-	-	4	-	-	-	-	-	-	-	4
<20	-	-	-	-	1	-	-	-	-	-	1	2
<24	-	-	-	1	1	1	-	-	-	-	-	3
<28	-	-	-	-	4	8	17	-	-	-	1	30
<32	-	-	-	-	-	1	1	22	-	-	1	25
<36	-	-	-	-	-	-	-	1	23	-	-	24
<40	-	-	-	-	1	-	-	1	-	17	1	20
40+	-	-	-	-	-	-	-	-	-	1	18	19
All	352	40	10	5	16	21	18	24	23	18	22	549

impact the FC reforms are intended to have. Grossing up from our sample to the population suggests that between 30,000 and 40,000 will be encouraged into the labour market by the FC reform.

A second effect is highlighted by Table 5.1, and concerns those single parents who work exactly 24 hours per week under the pre-reform system (that is, their preference structure is tangential to the budget constraint at the FC kink point). In some sense, these households would like to work fewer hours, but are constrained from doing so by the fact that if they do work less they will lose their FC entitlement and suffer a discrete drop in net income. By extending the range of the FC system to 16 hours per week, these single parents are able to reduce their labour supply without losing entitlement to FC. Here also, around 4% of the sample will be affected by the FC reform, although the reduction in their labour supply is comparatively slight.

Budget constraints for representatives of the two groups of households are illustrated in Figures 5.3 and 5.4. The simulation model predicts that the lone parent in Figure 5.3 would shift from very low earnings equal to the Income Support earnings disregard to a job in the newly attractive 16 to 24 hours range, achieving a substantial increase in net income. By contrast, the lone parent in Figure 5.4 is predicted to reduce hours from the previous kink of 24 hours to just above the new kin at 16 hours per week.

Figure 5.3

HOUSEHOLD A

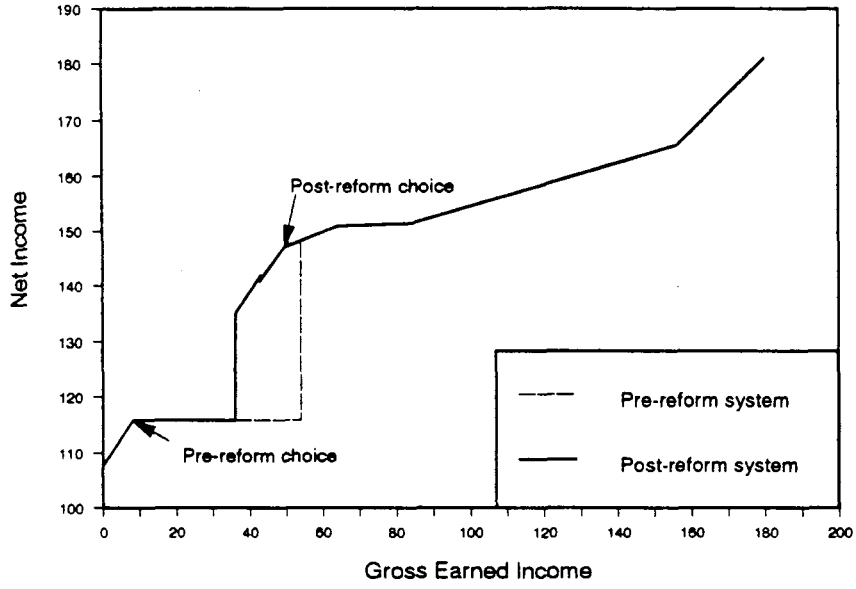
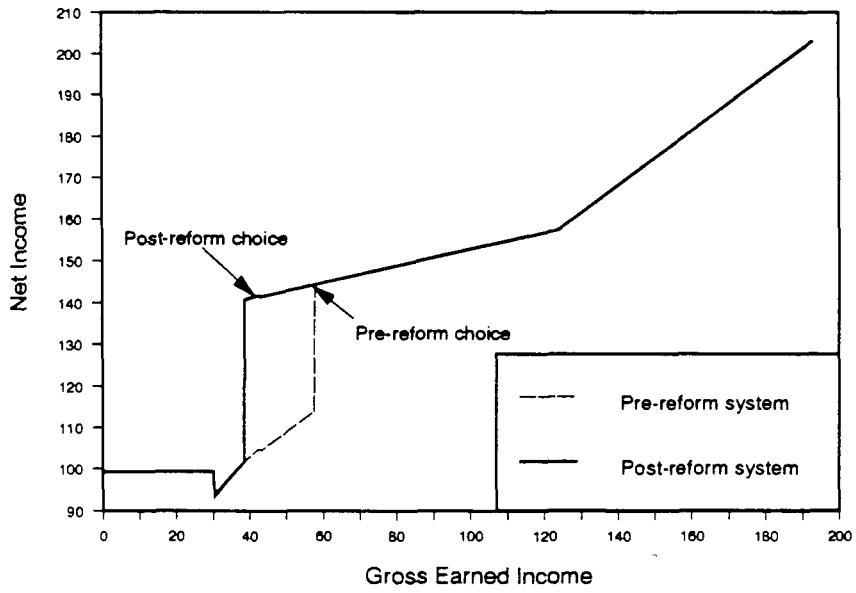


Figure 5.4

HOUSEHOLD B



6 CONCLUSIONS

The work presented in this paper incorporates estimates from a theory consistent model of single parent labour supply into the a simulation procedure for the analysis of tax-benefit reform. The IFS simulation algorithm SPAIN incorporates the tax-benefit model TAXBEN2 to generate accurate budget constraints for tax policy analysis. A proposed reform to the UK Social Security system is examined both from a distributional point of view and with reference to specific one-parent households to highlight the possible incentive effects of the proposed reform.

The simulation model outlined in this paper suggests that between 30,000 and 40,000 lone parents will be encouraged to return to work by the reduction in the hours required to qualify for Family Credit. This result should be welcome to the government, and emphasises the potential positive labour market role of social security benefits.

While the estimated model performed well in simulation, numerous issues remain to be discussed. Our work has assumed full information about FC, immediate 100% take-up of entitlement, and a fully flexible labour market. All this is plainly unreal; take-up of FC may be as low as 50 per cent, and there is not a fully flexible labour market, especially in the short term. However, the fact remains that any attempt to analyse this reform without taking account of behavioural change would have been pointless; and although much further work remains to be done, we hope to have highlighted the most important effects of this welcome reform.

Data Appendix

The data set used in this study is drawn from the Family Expenditure Survey (FES) over years 1981 to 1988, normalised to December 1988 prices. A single parent is a woman under 60 with at least one dependent child, with no other adults in the household other than blood relatives of the mother. The following sample selection criteria were applied:

- (a) Age at which education ceased <25,
- (b) No self-employed, HM Forces or retired,
- (c) Northern Ireland excluded.

DESCRIPTIVE STATISTICS

i) All single parents (sample=2593)

YEAR	81	82	83	84	85	86	87	88
Participation Rate	0.474	0.444	0.364	0.402	0.401	0.395	0.368	0.336
Other Income	62.556	61.869	59.054	68.026	60.514	63.484	53.712	53.743
No. children aged 0-2	0.227	0.254	0.269	0.295	0.245	0.334	0.279	0.342
No. children aged 3-4	0.127	0.164	0.178	0.142	0.179	0.236	0.226	0.215
No. children aged 5-10	0.570	0.601	0.560	0.483	0.580	0.513	0.493	0.547
No. children aged 11+	0.789	0.619	0.575	0.632	0.580	0.506	0.493	0.409
Youngest child aged 0-2	0.203	0.231	0.251	0.272	0.237	0.312	0.255	0.326
Youngest child aged 3-4	0.092	0.112	0.120	0.100	0.136	0.162	0.154	0.131
Youngest child aged 5-10	0.382	0.336	0.331	0.303	0.327	0.258	0.326	0.326
Youngest child aged 11+	0.323	0.321	0.298	0.326	0.300	0.268	0.264	0.218
Full childcare density	1.723	1.716	1.779	1.799	1.898	1.910	1.942	2.009
Sessional childcare	1.610	1.559	1.664	1.575	1.660	1.656	1.641	1.763
Age	34.693	33.728	32.451	33.287	33.482	32.182	31.774	32.195
Education	16.745	16.685	16.665	16.770	16.984	16.981	16.967	16.983
Receiving Maintenance	0.355	0.321	0.280	0.276	0.323	0.290	0.288	0.252
Female Unemployment/Age	0.077	0.077	0.088	0.096	0.099	0.106	0.085	0.064
Vacancies by region	1.797	2.062	2.674	2.827	2.899	3.296	4.149	4.260
Redundancies by region	10.222	7.997	6.281	4.685	4.591	4.758	2.921	2.112

ii) Working single parents (sample=1093)

YEAR	81	82	83	84	85	86	87	88
Marginal wage	1.674	1.242	1.523	1.605	1.662	1.271	1.672	1.943
Gross wage	3.385	3.001	3.347	3.447	3.437	3.201	3.733	3.912
Gross income	100.699	89.003	97.220	96.079	94.849	85.226	101.449	107.151
Other Income	39.850	46.035	42.563	41.533	41.347	47.655	27.954	30.516
Hours of Work	28.277	27.160	26.070	25.524	26.485	24.661	24.605	26.470
No. children aged 0-2	0.059	0.084	0.130	0.105	0.097	0.121	0.129	0.110
No. children aged 3-4	0.042	0.084	0.050	0.076	0.078	0.169	0.121	0.130
No. children aged 5-10	0.546	0.597	0.530	0.400	0.505	0.468	0.500	0.600
No. children aged 11+	0.950	0.773	0.690	0.790	0.796	0.702	0.565	0.580
Youngest child aged 0-2	0.050	0.084	0.120	0.095	0.097	0.113	0.113	0.110
Youngest child aged 3-4	0.042	0.067	0.050	0.067	0.068	0.145	0.097	0.100
Youngest child aged 5-10	0.462	0.395	0.380	0.362	0.340	0.323	0.411	0.440
Youngest child aged 11+	0.445	0.454	0.450	0.476	0.495	0.419	0.379	0.350
Age	37.218	36.370	35.080	36.295	36.728	35.194	33.419	35.320
Education	16.941	16.681	16.670	17.143	17.534	17.137	17.290	17.230

TABLE A1: Reduced Form Estimates (1981-1988 Data)

Variable	Log Wage Equation		Virtual Income	
	Estimate	SE	Estimate	SE
Constant	4.619	0.683	187.573	50.239
Age	0.041	0.054	2.264	5.028
Age ²	-0.078	0.029	5.328	2.450
Education	0.086	0.023	-7.189	1.671
Education ²	0.001	0.002	-0.178	0.218
1920 Cohort	0.244	0.197	-18.079	16.166
1930 Cohort	0.018	0.136	4.456	10.522
1940 Cohort	-0.016	0.098	-2.713	7.089
1950 Cohort	-0.061	0.067	-4.997	4.383
Number of children			5.255	4.654
(Number of children) ²			1.148	1.015
DK1			2.788	6.414
DK2x(not at school)			13.254	9.174
DK2x(at school)			-6.241	9.243
DK3			5.565	3.189
DK1xAge			1.880	6.353
DK2(not at school)xAge			8.330	8.041
DK2(at school)xAge			-3.754	8.421
DK3xAge			5.312	4.351
Child at special school			15.093	4.833
Female unemployment by age	0.884	0.857	-2.492	54.496
Vacancies by region	0.017	0.043	-3.514	3.227
Redundancies by region	0.040	0.014	-0.895	1.127
Quarterly unemployment	-2.095	2.515	-309.289	200.070
Receiving maintenance	-0.024	0.031	-6.466	2.134
Mother in household	0.102	0.050	75.992	3.499
Full childcare	0.490	0.309	-64.487	22.976
Sessional childcare	-0.002	0.128	15.169	9.481
Hazard Rate	-0.087	0.060		
Sample Size:				2599
Likelihood Ratio Chi-square:				660.49
Percent Correctly Predicted:				71.37
McFadden's pseudo R-square:				0.189

Notes: DK_i, i=1,...,4 are dummies for the presence of the youngest child in each of the age groups 0-2, 3-4, 5-10 and 11 and over. Regional and year dummies were also included.

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WORKSHOP ON
ISSUES IN INTERNATIONAL ECONOMICS: QUESTIONS TO AND ANSWERS FROM
COMPUTABLE GENERAL EQUILIBRIUM ANALYSIS

JULY 8-9, 1991
UNIVERSITY OF KONSTANZ

MONDAY, JULY 8, 1991

10.00 Opening Address
Wolfgang Franz (Dean, University of Konstanz)
Bernd Genser (University of Konstanz)

"General Equilibrium Economics: Computation and Application"
John Whalley (University of Western Ontario)

11.00 Session 1: International Taxation

"Value-Added Tax Harmonization in the EC"
Wolfgang Wiegard/Hans Fehr/Christoph Rosenberg (University of Regensburg)

"Commodity Tax Reform under the Restricted Origin Principle"
Andreas Haufler (University of Konstanz)

14.30 Session 2: Factor Supply

"Simulation Models of Labour Supply"
Alan Duncan (Institute for Fiscal Studies, London)

"An Intertemporal General Equilibrium Model for Austria with Application to Foreign Trade"
Christian Keuschnigg (University of Bonn)/Wilhelm Kohler (University of Innsbruck)

17.00 Session 3: Environment

"CGE Modelling of International Public Goods: Air Quality and Global Warming"
John Piggott (University of New South Wales)

TUESDAY, JULY 9, 1991

09.00 Session 4: Imperfect Competition and Growth

"AGE Models in International Economics with Special Reference to Imperfect Competition and Increasing Returns to Scale".

Albert Schweinberger (University of Konstanz)

Growth and International Capital Movement: A Simulation Study

Karl-Josef Koch (University of Konstanz)

(presentation cancelled due to accident)

10.45 Round Table: "The Payoff of Investment in CGE - Modelling"

Chair: Bernd Genser

Introductory Statements:

John Chipman (University of Minnesota)

Friedrich Schneider (University of Linz)

Closing Address: Bernd Genser