TAXES, TRANSFERS AND LABOUR MARKET RESPONSES:

WHAT CAN MICROSIMULATION TELL US?

Tim Callan and Brian Nolan are Research Professors at The Economic and Social Research Institute. Robert Moffitt is a Professor of Economics at Johns Hopkins University. John Creedy is a Professor of Economics at the University of Melbourne, Alan Duncan is a Reader in Economics at Nottingham University. Arthur van Soest is a Professor of Economics at Tilburg University and Marcel Das is Senior Researcher at CentER Applied Research Tilburg University. Aedín Doris is a Lecturer in Economics at the National University of Ireland, Maynooth.

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PREFACE

Tax and transfer policies are an important part of the context in
which individuals and families make decisions about the nature
and extent of their participation in the labour market. Decisions
about whether one or both individuals in a couple will seek paid
employment, hours of work, or the balance of advantage between
acceptance of a job offer and continued search for a better job, can
be significantly affected by taxes and transfers. Changes in labour
market behaviour are sometimes the primary aim of a particular
tax or welfare reform; in other cases, the main aim may be a
different one, but the consequences for labour market behaviour
may be central to an overall evaluation of the impact of a
proposed reform.

Questions about the impact of policy changes on labour market
behaviour have been of concern in many countries, and have
motivated a great deal of highly focused research on the topic. As
a result, methods for analysing the impact of tax and transfer
policy changes on labour market behaviour have continued to
advance rapidly in recent years. In order to learn from these recent
advances, a conference was convened at the Economic and Social
Research Institute in December 1998, at which drafts of the papers
gathered together in this volume were first presented. This
represents the first stage of a project ultimately aimed at producing
the technical tools to undertake such an analysis in an Irish
context.

The paper by Robert Moffitt stresses the key role of
microsimulation models, operating at the level at which actual
decisions are taken rather than some more aggregate level. Moffitt
shows clearly the steps involved in designing and estimating a
model which is capable of analysing the impact of possible
changes to US policies towards lone mothers. One element of the
model is that it simplifies the labour market choices facing lone
mothers into three possibilities: full-time work, part-time work and
remaining outside the paid labour force. One key factor which is
taken into account is that benefits such as Aid for Dependent
Children (AFDC), Food Stamps and subsidized housing are not
always taken up by those who are entitled to them.

The paper by John Creedy and Alan Duncan provides a
technical survey of recent developments in behavioural
microsimulation. They discuss the criteria by which models of
labour supply may be chosen in this context. They conclude that
an approach based on estimation of what is termed a structural
discrete choice model of labour supply offers the greatest
potential. Such models attempt to identify the underlying
preferences guiding individual or family choices in the labour
market, but simplify these choices to a limited set of hours points.
The recent change in the UK to a Working Families Tax Credit,
replacing Family Credit, is examined in order to illustrate the value

of such an approach. The change can be summarised as a more generous version of Family Credit (with increased payments and a reduction in the "benefit withdrawal rate" or taper), coupled with a change in the payment mechanism. The results show that higher participation in employment is likely for one parent families, but finds that a significant number of women married to low earning men would be likely to withdraw from the labour force. The net financial gain from their continued employment would be reduced because of the more generous income support available under WFTC if they were to withdraw from employment.

Arthur van Soest and Marcel Das also adopt a structural discrete choice approach to the modelling of labour supply in their paper, building on earlier work such as Van Soest (1995). Their model takes into account fixed costs of working, and variation in preferences across households. The model is designed to examine the potential impact of proposed tax reforms in the Netherlands on the labour supply of married or cohabiting couples. Simulation of one structural reform revealed that while the macroeconomic objective of stimulating increased labour supply would be met, there could be negative labour supply consequences for a significant sub-group. Women with low earnings working part-time might find the net reward from employment reduced to such an extent that they would withdraw from the paid labour market. This could have undesired consequences for sectors of the labour market (e.g., home care work in the health sector) in which such workers are strongly represented.

Callan, Doris and Nolan set out the context for estimation and simulation of labour supply responses to tax and welfare changes in Ireland. In the not-so-distant past, the predominant concerns were about high levels of unemployment and outward migration. More recently new concerns have emerged about meeting labour shortages through increased labour supply and/or immigration. But an understanding of the nature of labour market responses to tax and welfare policy changes remains a pressing issue. Building a framework in which labour supply responses to tax and welfare changes can be simulated is a complex task, as shown by the papers gathered here. Strategic simplifications are essential to make the task a feasible one: the most central of these is to estimate preferences over a limited set of hours options. Essential building blocks include an ability to model the consequences of alternative labour market choices for the disposable incomes of individuals and families. The experience gained in building SWITCH, the ESRI tax-benefit model, which examines the "cash" or "first-round" effect on incomes of changes in tax and welfare policy, provides a sound basis for the production of this element of a broader model. Given the groundwork that has been done, it is now possible to make further progress towards models which can quantify the labour market impact of changes in Irish tax and transfer policy.

1. SIMULATING TRANSFER PROGRAMMES AND LABOUR SUPPLY[*]

Robert A. Moffitt

1.1 Introduction

Microsimulation is a powerful policy tool which has become indispensable in the calculation of the effects of reforms of the tax and transfer system in the US. The use of such models began in the 1960s, when policy research on social issues became a major activity of social scientists and policy analysts, and has grown steadily since that time. Today, dozens of microsimulation models are in use in the US. Most of the models have a particular area of policy focus – either transfer programmes for the poor, retirement and medical programmes for the aged, or tax systems, for example, although there are one or two that attempt to be completely general. Government agencies routinely call upon research organisations to perform microsimulations of policies they have proposed or are considering, in order to learn their effects on individuals and families as well as their effects on costs (Citro and Hanushek, 1991; Haveman and Hollenbeck, 1980). As stated by Citro and Hanushek (1991) in a recent report on the uses of microsimulation modelling:

> The microsimulation model approach to producing estimates of the effects of proposed changes in government programmes involves obtaining inputs from microlevel databases of individual records, mimicking how current and alternative programme provisions apply to the individuals described in those records, and maintaining the simulated outputs for each programme scenario on each of the individual records (p.8).

Unlike back-of-the-envelope estimation, aggregate forecasting, or spreadsheet modelling, microsimulation modelling operates at the individual, or micro level, where the actual decisions are made. Aside from generating estimates that may be, therefore, more accurate in general, microsimulation modelling has two other advantages over these other types of policy tools: (1) it can show the actual distribution of impacts of policies across different types of individuals, as well as the distribution of costs and benefits across those types, and (2) it can capture the complex interactions between different programmes, and between programme rules and individual characteristics, that naturally arise from the operation of real-world policy programmes.

Many microsimulation models are, in essence, simply glorified accounting models. An accounting model is one which simply counts up the changes in income or costs from a policy change, taking all the other characteristics of the individuals as fixed and unchanged. The phrase "simply" is used guardedly here, for conducting this accounting exercise correctly can be very complex and require great skill and judgement, given the complexity of government programmes combined with the difficulties in operationalising those programme rules in the data sets that are generally available – which usually do not have all the variables needed to implement the rules in their exact detail. Nevertheless, the research community is in general agreement that accounting models have the significant deficiency of ignoring what is generally termed "behavioural response". Behavioural responses occur when individuals respond to changes in programmes by altering their behaviour of one type or another. Perhaps the most common type of response is in work behaviour, or what economists term labour supply. Some programmes for the poor lead some individuals to reduce their labour supply, while other programmes give individuals an incentive to work more. Not only is this inherently something that policy makers should want to know, but the magnitude of such responses will inevitably affect costs as well. Another, perhaps more basic example is the behavioural response in the form of take-up – making programmes more generous will lead to higher rates of take-up, generally, which leads to a higher caseload and higher costs.

This paper offers one example of a model that specifies and estimates the labour supply response of lone mothers to changes in US welfare programmes, and simulates the effect of a number of reforms in those programmes on their labour supply. The model was developed by Keane and Moffitt (1998). Although it is just one example, it illustrates many of the technical issues that are involved in conducting the estimation and simulation necessary to gauge the effects of policy reforms. This paper also comments on the issues that surround this particular model, the decisions that were made in specifying it, and alternative decisions that might have been made. Finally, the paper discusses extensions of the

model to issues concerning "dynamics" of programme participation and labour supply.

1.2
Some General Issues in Micro-simulation

Microsimulation models are constructed from (1) a data base with information on individuals and their characteristics, and (2) a set of equations that apply to those individuals. Each equation describes how a particular behavioural response – labour supply, programme participation, or whatever is assumed to be determined. The determining variables in those equations include: (a) variables that describe the characteristics of each individual (income, age, education, etc.); (b) variables that describe the features of the policy programmes under examination (eligibility and benefit rules, etc.); and (c) a set of "parameters", or regression coefficients, that describe how individuals differ according to their individual characteristics and, more importantly, how they respond to changes in programme features and rules.

There are many issues concerning the first component – the data set – that will not be pursued or discussed in detail here. Most household survey data sets often miss the detailed asset and household structure variables needed to represent programme eligibility and potential benefits completely accurately, for example, and often income is in the wrong time unit (e.g., annual instead of monthly) for programme evaluation purposes. When administrative data from programme participants are used, there is the additional problem of not having information on those who are not in receipt of benefits. Considerable effort and judgement is needed to address and resolve the data difficulties of this type. Indeed, a US National Academy of Sciences report (Citro and Hanushek, 1991) concluded that data deficiencies were one of the major problems with microsimulation models in the US, and recommended major new investments of resources in data collection to help remedy those deficiencies.

Most research attention has instead focused on the second element of microsimulation models – the equations – and, in particular, on the choice of parameters in the equations of the model. Choosing the parameters of the equations is known in the microsimulation literature as "calibrating" the model.[1] There are two generic approaches to the problem of calibrating a model. The first is to specify a single model composed of a set of internally consistent equations describing behaviour, to find a suitable data set upon which those equations can be jointly estimated, to estimate the model on that data set, and then to simulate outcomes from that same data set using the set of equations estimated. This is the approach described below with the Keane-Moffitt model. The second approach is to select parameters which have already

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[1] The term "calibration" has come into more recent use in academic research on macroeconomic models to describe a related exercise of assigning parameter values to fairly stylised models of the entire economy.

been estimated in past research in the literature, usually from a set of different research studies, and simply to insert those values of the estimated parameters from past work into the equations that have been specified for the microsimulation model. Often the data sets used in the studies from which the estimates are drawn differ from the data set used for the microsimulation model as well.

The second approach is more problematic from a statistical point of view because drawing parameter estimates from different studies may result in estimates that are not fully consistent with one another. Another difficulty is that the relationships between the estimated parameters in different studies – namely, the covariances – are not available, by definition, since the parameters were not estimated from a common data set and as part of the same model.[2] Applying a set of parameters estimated from one data set to a different data set also requires some care to ensure that the parameters are consistent with the distribution of the outcome variables in the latter. Despite the drawbacks to this approach, it is often employed nevertheless because frequently the microsimulation models needed to simulate a particular type of policy outcome or programme are extremely difficult to estimate beforehand, either because the number of parameters is exceedingly large or because the equations are sufficiently complex as to make estimation infeasible. In addition, often there is not a single data set which has all the variables needed to estimate a model. In these cases, drawing parameters from multiple studies is needed. The problems just noted must therefore be addressed.[3]

Finally, a major issue in microsimulation models concerns conveying their uncertainty to policy makers. Policy makers in the US tend to prefer single "best" estimates of policy effects and are often not comfortable with estimates that are presented in the form of a range, such as that generated by a confidence interval. Generating confidence intervals on microsimulation output is relatively straightforward if the model is calibrated to a single previously estimated model, as described above.[4] When the model is calibrated to multiple prior estimates, generating standard errors

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[2] Consequently, implicit independence assumptions are usually made. See Sims (1972) for an early statement of this problem.

[3] The process of calibrating a model to multiple prior research studies involves the exercise of "validation" of the model, which means checking its accuracy and reliability (in terms of some metric) after parameter values are assigned. The National Academy of Sciences referred to earlier (Citro and Hanushek, 1991) regarded poor and inadequate validation of microsimulation models – especially as regards their ability to track historical trends – as the second main deficiency of microsimulation models in the US (the first being deficiencies in the underlying data).

[4] Even here, however, most microsimulation models do not add in the sampling error in the underlying data set. The models thus fail to capture the error in estimating aggregates for the true total population that arise because only a sample of that population is used for simulation.

on predictions requires assumptions on the covariances of the parameters. However, these methods of incorporating uncertainty only deal with the uncertainty in the estimated parameters, and not with the specification error in the model itself that is surely also present. Indeed, some microsimulation modellers believe that model specification error is much more of a problem than parameter uncertainty. This explains why modellers typically spend quite a bit of time testing the sensitivity of their simulated outcomes to the specification of the form of the equations; to the assumptions on the error terms; to how variables are defined and which are included; to non-linearities, and to dozens of other assumptions and decisions that are made in setting up the model in the first place. There is no rigorous scientific or statistical formula for this type of sensitivity testing, and it therefore requires considerable expertise and judgement in modelling, estimation, and simulation to be done well.

1.3 Simulating the Static Labour Supply Response to Transfer Programmes

The theory, estimation, and simulation of labour supply subject to taxes and transfers is well developed (see Blundell and MaCurdy, forthcoming, for a recent review). The basic theory upon which static labour supply models are grounded assumes that individual work effort is primarily influenced by two variables – the after-tax, or net, hourly wage rate, and the income available to the individual if he or she does not work. The latter includes transfer-programme payments, income available from other family members, and income from past savings. The (utility-compensated) effect of net wages on labour supply is expected to be positive while that of unearned income is expected to be negative. There are many important issues that have been discussed in this literature concerning the influence of childcare if children are present, how the decisions within families are made by multiple family members, and so on. The most difficult issue from the standpoint of microsimulation, however, is how to deal with constraints from the demand side of the labour market, namely, those which result in restrictions on the types of jobs and the hours worked offered by the labour market, and the problem of involuntary unemployment. How the model addresses these issues has a significant influence on how responsive individuals are assumed to be to changes in the net wages and incomes which are available to them.

In addition, there is one analytic, or technical, difficulty that has received enormous attention in the estimation and simulation of labour supply responses to tax and transfer programmes, and that is the problem of having piecewise-linear, or "kinked," budget constraints (see Hausman, 1985, Moffitt, 1986, and the other papers in this symposium). Most tax and transfer schedules are highly non-linear. Most income tax rates in advanced industrialised countries are reasonably progressive and contain a number of exemptions, deductions, and special provisions that create kinks,

notches, and other non-linearities in the constraint, for example. In addition, all transfer programmes which are income-conditioned create, at minimum, one non-linear non-convex kink and hence one major form of non-linearity at the point of eligibility. Also, most transfer programmes have, like tax programmes, other aspects of the benefit formula which create additional kinks and notches and other non-linearities.[5]

The difficulty that these kinks, notches, and brackets create is that they make the labour supply function itself highly non-linear. Changes in programme parameters may result in changes in net wage rates in some ranges of earnings and not in others, and by very different amounts in different ranges. Some individuals may not respond at all to programme parameter changes in ranges irrelevant to their behaviour while others will respond by a great deal.

This problem was first confronted by Burtless and Hausman (1978) and Hausman (1981) for the case of US transfer programmes and income taxation, using a formal structural labour supply model using continuous hours of work and treating the piecewise-linear budget constraint in a fair amount of detail. The general method was used in a number of other studies (see Hausman, 1985 and Moffitt, 1986 for reviews of this approach). The approach has by now been well worked out in principle, although a variety of computational and practical difficulties with implementing it still remain.

One of those difficulties arises when the number of segments, kinks, and notches is reasonably large in number. Indeed, in most applications this has turned out to be the rule rather than exception, particularly if the tax system is incorporated, for tax systems usually have a fairly large number of segments and brackets and special features. Implementation of the general method of handling piecewise-linear budget constraints in that case is computationally very burdensome because of the complexity of the constraint. The solution to this practical problem that has been developed in the literature is to shift away from treatment of continuous hours of work (say, per week) to the choice to discrete hours of work choice, for example, the choice of full-time versus part-time, and the choice of not working at all. This approach simplifies the problem by requiring that the budget constraint opportunities facing the individual only be computed, and evaluated, at a small number of points (e.g., only three in the full-time/part-time/non-work example) and hence makes the approach much more feasible. The discrete-hours approach was first applied (to this author's knowledge) by Zabalza et al. (1980) (see also Moffitt (1984) for an early application in a non-tax context). It has since been applied many times and has proven to

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[5] Not all countries have highly progressive schedules, and in these countries these problems can be argued to be circumvented. Blundell (1993) argues that the UK is one such country.

be flexible in estimation as well as capable of capturing labour supply responses. The Keane-Moffitt model below takes this approach (see also van Soest (1995)).[6]

The discrete-hours approach is popular among some analysts for the additional reason that it can be argued to more accurately capture the restrictions that the job market offers workers in terms of hours of work. Most male workers work at full-time jobs and would have difficulty finding part-time work at the same wage rate and fringe benefits. Even female workers, who work part-time more often, often work full-time in larger numbers. Some analysts argue, however, that rather than simply assuming only (say) three choices to be available, it is better to model the problem more directly. For example, one could assume that jobs are available at all hours points, but that part-time jobs have lower wage rates and fringe benefits, thereby implying that few workers will choose them. Alternatively, one could assume that there are only a finite number of part-time jobs available, and there is a queue to get them. Unfortunately, directly modelling these features of the labour market is not simple, and the assumption of a discrete hours choice can be viewed as a simplifying assumption to capture some realism without making the model too complex and difficult to estimate.[7]

In addition to the problem of piecewise-linear budget constraints, there is a second modelling problem in the literature on labour supply and transfer programmes related to the problem of take-up, or participation. Participation rates among eligibles for transfer programmes are almost never 100 per cent, although they vary tremendously from country to country and from programme to programme and are, in a few cases, relatively high. There have been many reasons adduced for such non-participation. One is that welfare receipt is stigmatising, and individuals will often prefer to stay off welfare, even at a lower level of income, than become welfare recipients (Moffitt, 1983). Another explanation is that it takes time and money to apply for welfare, and to maintain compliance with the rules of the programme. These may be termed as fixed costs of participating. Another, rather different, explanation is that individuals who do not participate even when eligible are investing in their human capital off the programme – that is, gaining work experience. Even though income may be

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[6] Some authors have argued that the discrete-hours approach circumvents the coherency problems noted by MaCurdy *et al.* (1990). This is not correct to the extent that global concavity solves the coherency problem, for in the absence of global concavity similar problems can arise even in the discrete-hours approach.

[7] The difference in views shows up as well in whether one simulates continuous hours choice or discrete hours choice. If the use of a discrete hours model is made only for computational convenience for estimation (as opposed to simulation) then, after estimating the model, one could simulate a continuous hours choice. But if the discrete hours model is used because it is thought to actually better represent the labour market, then one should simulate a discrete hours outcome as well. See the paper by Creedy and Duncan in this volume for a discussion.

reduced in the short run by not going on welfare, income in the long run is improved, in this argument, from the investment in labour market skills. This explanation does require that there should be some reason that the individual does not work at the same time as being on welfare, however. Yet another explanation for non-participation is that the data are inadequate, and are incapable of correctly measuring eligibility. Most studies show that, while this is a factor, it is not the complete explanation.

The Keane-Moffitt model described below attempts to address this issue by positing that welfare participation is a utility-maximising choice but one for which there may be fixed costs, possibly arising from stigma, that may prevent participation. The potential income gain from being on welfare is still a factor in the participation choice, but not the only one. The model implies that higher benefits or a more generous programme will still increase take-up, because more eligibles will find that the income gain outweighs the negative aspects of welfare participation. But there will still be participation rates less than 100 per cent among eligibles.

1.4 The Keane-Moffitt Model: Specification and Estimation

The Keane-Moffitt (KM) model, as already noted, is a discrete-hours model, treating the choice problem as a multinomial utility-maximising choice from among the discrete points in the choice space. In addition, the KM model addresses the participation decision as a decision related to labour supply choice, but somewhat independent as well. Labour supply choice does not automatically imply a participation choice. Consequently, participation in a transfer programme becomes a choice variable. There is thus an extra equation needed for participation, in addition to that for labour supply.

The KM model goes one step further than this by permitting multiple transfer programmes for which the individual (or family) is potentially eligible. There are in reality many different transfer programmes in most developed countries. The KM model allows each of M programmes to each base its payment to a recipient on a particular "guarantee" amount – the payment to a family with no earnings and no income from any other transfer programme – and on a set of tax rates (or benefit-reduction rates, as they are sometimes called) which denote the amount by which the payment is reduced for each extra dollar of income. That income may arise from earnings, or from non-transfer unearned income, or from benefits from other transfer programmes. The latter implies that there will be programme interaction because a change in the benefit formula in one programme will affect benefit levels for its recipients, but this will also affect benefit levels received by individuals participating in other programmes. Also, an increase in earnings or other forms of income will change the benefits in multiple programmes in complex ways – both directly, through the tax rate in each programme, and indirectly, through changes in the

benefits in other programmes which are counted as income in each programme.

Denote the utility function as $U(H,Y,P_1,P_2,...,P_m)$ where P_m is a dummy variable equal to 1 if the individual participates in programme m and 0 if not. The presence of participation indicators in the preference function can be interpreted as representing either stigma influences or, more generally, as costs of participation (neither money nor time costs are directly measured in most data sets). Assume $\partial U/\partial H < 0$, and $\partial U/\partial Y > 0$, and $\partial U/\partial P < 0$. In the separable case, we have

$$U(H,Y,P_1P_2,...P_m) = \overline{U}(H,Y) - \sum_{m=1}^{M} \Psi_m P_m \qquad (1)$$

where each Ψ_m denotes the marginal disutility of participating in programme m. Thus if Ψ_m is sufficiently large, a particular programme may not be chosen even though participation increases $\overline{U}$.

The KM model considers three hours points, *H=0, H=20*, and *H=40* per week, taken as the choice of non-work, part-time work, and full-time work, respectively. Extensions to greater number of points can and have been made in other articles in this literature. With three H points and M transfer programmes there are $3*2^M$ discrete choices available to the individual. The budget constraint gives disposable income for each m

$$Y(H,P_1,P_2,...,P_m) = wH + N + \sum_{m=1}^{M} P_m B_m(H) - T(H) \qquad (2)$$

where w is the hourly wage rate, N is non-transfer non-labour income, $B_m H$ is the benefit function for programme m, and *T(H)* is the positive tax function. For notational simplicity we have suppressed the dependence of the functions $B_m H$ and *T(H)* on N, wH, and the benefits of other transfer programmes in which the individual might participate (as well as individual and family characteristics that may affect taxes or transfers).

Letting $j = 1,...,3*2^M$ index alternatives from the choice set, the choice problem is

Choose alternative j *iff* $U_j \geq U_k \ \forall \ k = 1,...,3*2^M$ \qquad (3)

where U_j denotes the evaluation of (1) for combination j obtained by inserting (2) evaluated at that combination into (1) and by setting H and the P_m at their appropriate values for combination j. KM considered the choice of single mothers in the US from among three different programmes – Aid to Families with Dependent Children *(AFDC)*, Food Stamps, and subsidised housing, although

set $m=A$ for *AFDC*, $m=F$ for Food Stamps, and $m=R$ for subsidised (rental) housing. With three categories of H the number of alternatives is 24. For the utility function in (1) above, KM assume a conventional flexible-form, quadratic function representing a second-order Taylor series expansion in its arguments

$$
\begin{aligned}
U(H,Y,P_1,P_2,...,P_m) = \alpha H + Y - \beta_{HH}H^2 - \\
\beta_{YY}Y^2 - \sum_{m=1}^{M}\Psi_m P_m + \sum_{m=1}^{M}\sum_{n>m}^{M}\Phi_{mn}P_m P_n + \beta_{HY}HY - \\
\sum_{m=1}^{M}\delta_m HP_m - \sum_{m=1}^{M}\eta_m YP_m
\end{aligned}
\tag{4}
$$

The marginal utility of Y at $Y=0$ is normalised to 1; the remaining parameters are therefore in dollar terms. Interactions between the different participation programmes (Φ_{mn}) were allowed although most were estimated to be insignificant. The multinomial choice model therefore consists of (4) and (2), with solution (3).

The stochastic structure posited by KM permits α and the Ψ_m to vary in the population conditional on a set of observable socio-economic characteristics

$$
\alpha = X'\bar{\alpha} + \varepsilon_\alpha
\tag{5}
$$

$$
\Psi_m = X'\overline{\Psi}_m + \varepsilon_m, \ m = A,F, \text{or } R
\tag{6}
$$

where X is a vector of characteristics and $\bar{\alpha}$ and $\overline{\Psi}_m$ are vectors of coefficients. The parameter α represents the marginal disutility of work at $H=0$, and the parameters Ψ_m represent the marginal disutilities, or costs, of programme participation if there are no higher-order interactions in the preference function.

The full model can be derived by inserting (2), (5), and the three equations in (6) into (4). There are 24 possible combinations of the choice variables, and hence 24 "equations", and there are four error terms. The model is "structural" in the sense that it has a particular factor structure of the errors that arises from the imposition of a particular utility function (albeit one with flexible form) and a presumption that the major source of variation in choices arises from heterogeneity in a selected set of preference parameters. Since wage rates are unobserved for non-workers, KM also specify a log wage equation as

$$
\ln(w) = X'\nu + \varepsilon_w
\tag{7}
$$

The five error terms in the model ($\varepsilon_\alpha, \varepsilon_A, \varepsilon_F, \varepsilon_R$, and ε_w) are assumed to be distributed multivariate normal with an unrestricted

covariance matrix with diagonal elements σ_j^2, $j = \alpha, A, F, R, w$, and with off-diagonal elements $\rho_{jk}\sigma_j\sigma_k$, $j,k = \alpha, A, F, R, w$. The elements of the covariance matrix are all identified by the normalisations in the model and the other parameters of the model are identified by the distributional assumptions and various non-linearities. However, to lessen their dependence on those functional form assumptions, KM also impose exclusion restrictions in Equations (5)–(7) by employing variables that affect programme participation but not labour supply and by excluding some variables that are in (6) from (5). Also, as in more standard wage-labour-supply models, KM exclude some variables in (5) from (7) and some variables in (7) from (5) in order to identify the parameters of each.

KM estimate the model using the Monte Carlo simulation methods of estimation because the dimension of the error space is large, and because deriving the boundaries of the error space within which each choice is optimal is analytically difficult KM apply a variety of simulation methods, including the simulated method of moments developed by McFadden (1989).

A drawback of the KM model, as in many discrete-hours models, is that it does not allow optimisation error or measurement error in the choices. This has shown to be an important issue in the literature not just because it is reasonable to suppose such error exists, but because it is necessary to explain why observations might be seen in cells which have predicted probabilities of zero. KM added an i.i.d. extreme-value error to the utilities in part to circumvent the problem, but a true measurement-error interpretation is inconsistent with that specification (a true measurement-error interpretation requires adding errors to the observed choices, not to the latent utilities). This is an area for further work.

Estimates. The model was estimated on 1984 data from a representative, cross-section of the US population drawn from a survey called the SIPP (Survey of Income and Programme Participation). The sample was composed of all lone mothers aged 18-64 in the US that year, although a few families with high assets were excluded. Otherwise, all such mothers were excluded, whether on welfare or not. Part-time work was defined as 1-35 hours per week, and full-time was defined as over 35 hours. As the data distribution turned out (Keane and Moffitt, 1998, p.565), almost all mothers not on any welfare programme worked, and almost all mothers on any type of welfare programme did not work. Thus the choice for eligible women seemed almost bimodal – women could go on welfare and not work, or stay off welfare and work. The best explanation for this difference is the extremely high tax rates in the programmes, which were often over 100 per cent. Tax rates in the *AFDC* programme are approximately 100 per cent by themselves; those in the Food Stamp programme are about 30 per cent; and in the housing programme, they range from 10

per cent to 30 per cent. Thus the cumulative tax rate for those participating in more than one programme generally exceeded 100 per cent.[8]

The KM estimates of the full model are shown in Table 1.1 The first portion of the table shows the coefficients on the elements of the X vector for tastes for work, stigma costs, and the wage equation (see Equations (5) – (7)). The specification of the vector shown in the table represents the final specification after considerable testing. The parameter estimates are mainly as expected from other work. Children significantly reduce labour supply; they also reduce welfare costs for *AFDC* and Food Stamps (i.e., they increase welfare participation), though the effect is not significant. Women who are older, who have higher levels of education, who are in good health, and who are white have higher levels of labour supply and usually have lower welfare participation propensities, though once again not always significantly. The state unemployment rate has a very weak negative effect on labour supply, workers in SMSAs and in states with high fractions of employment in services (where low-income women are heavily concentrated) have higher wages, and individuals in states with high *AFDC* administrative expenses have lower *AFDC* participation rates but higher Food Stamp participation rates, possibly because these expenses are spent implementing more stringent administrative *AFDC* requirements.

The second panel of the table shows the estimates of the utility function parameters and the covariance matrix of the errors. Initial estimates of the quadratic utility function (4) revealed a lack of significant interactions between H and Y, or between H or Y and programme participation; the model shown in Table 1.2 therefore omits these terms. The remaining parameters are all significant at conventional levels. The utility function parameters β_{HH} and β_{YY} have no direct interpretation but they together determine wage and income elasticities. At the means the uncompensated wage elasticity ξ_w is 1.82 and the total income elasticity (ξ_y) is .21. The wage elasticity is in the high end of prior estimates for women, but most prior estimates have been obtained for married women rather than female heads. The income elasticity is on the low side of past estimates for married women, on the other hand.

The parameter γ_R measures the effect of housing benefits, and is small and has a high standard error, implying that subsidised housing benefits have no significant impact on participation in housing programmes. KM concluded that this estimate reflected extensive rationing in the allocation of subsidised housing units.

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[8] However, as discussed by Keane and Moffitt, the cumulative tax rate is not the simple sum of all three because the benefit formulas interact, i.e., some of the programmes treat each others benefits as income and hence tax them. This tends to lower the cumulative tax rate.

Table 1.1: Keane-Moffitt Estimation Results (with housing)

	Tastes for Work (α)	AFDC Costs (ψ_A)	Food Stamp Costs (ψ_F)	Housing Costs (ψ_R)	Wage Eq (w)
No. children less than 18	-0.26* (0.10)	-0.27 (0.22)	-0.27 (0.25)	0.05 (0.34)	-
No children less than 5	-0.36* (0.14)	-	-	-	-
South	0.56* (0.19)	-0.46 (0.49)	0.68 (0.52)	-0.60 (0.88)	0.0 (0.05)
Education	0.02 (0.05)	0.44* (0.11)	0.55* (0.14)	0.12 (0.12)	0.08* (0.01)
Age	0.13 (0.08)	0.18* (0.03)	0.18* (0.04)	0.22* (0.07)	0.01* (0.02)
Age Squared/100	-0.15 (0.10)	-	-	-	-0.12* (0.02)
Fair or poor health	-0.50* (0.25)	-0.63 (0.67)	-1.25* (0.71)	-2.40* (1.27)	-0.16* (0.06)
Race (1=white)	0.26 (0.17)	1.75* (0.50)	2.20* (0.58)	6.42* (1.89)	0.03 (0.05)
State unemployment rate	-0.08* (0.04)	-	-	-	-
SMSA	-	-	-	-	0.03 (0.04)
State Service Employment Pct.	-	-	-	-	2.17* (0.77)
State AFDC Admin. expenses/100	-	0.57* (0.14)	-0.01 (0.14)	-0.61* (0.28)	-
Constant	1.62 (1.52)	-6.44* (2.03)	-7.51* (2.34)	2.55 (3.25)	-1.88* (0.32)
σ	1.76* (0.24)	4.37* (0.43)	5.51* (0.76)	9.96* (2.69)	0.51* (0.01)
Utility Function Parameters					
β_{HH} [a]	3.86* (0.45)		$\xi_w =$	1.82	
β_{YY} [b]	3.77* (1.38)		$\xi_y =$	-0.21	
λ	0.07* (0.03)				
γ_R	0.10 (0.09)				
γ_{MED}	0.48* (0.23)				
γ_{PHI}	0.62 (0.65)				
Correlation Matrix of Errors					
	$\in_A$	$\in_F$	$\in_R$	$\in_w$	
$\in_\alpha$	-0.13* (0.06)	-0.08 (0.06)	0.07 (0.06)	0.01 (0.09)	
$\in_A$	-	0.69* (0.03)	0.19* (0.04)	0.04 (0.06)	
$\in_F$	-	-	0.30* (0.05)	0.22* (0.05)	
$\in_R$	-	-	-	0.08* (0.05)	

Simulated Log Likelihood = -2249.1
Simulated Log Likelihood = -1822.3 (choices only)
Chi-Squared = 53.83

Notes: Standard errors in parentheses.
* = significant at the 10 per cent level.
Sample size = 968.
Parameters in three cost equations (including sigmas) are divided by 10.
[a] Multiplied by 100.
[b] Multiplied by 10000.

In the US, the stock of housing units and housing vouchers is limited and there is excess demand for slots and the criteria by which slots are awarded have little relation to the potential benefit from such housing. KM dropped housing from the model thereafter.

1.5
The Keane-Moffitt Model: Simulations

Table 1.2 shows simulations of the model obtained by computing mean probabilities for each of the outcome categories over all individuals in the sample for different alterations in the budget constraint. The first row shows the baseline simulation while the second and third rows show the effects of reducing the marginal tax rates facing welfare recipients. Interestingly, a reduction of the *AFDC* tax rate from its current level of 100 per cent to 50 per cent has scarcely any effect on labour supply, and it actually increases the participation rate in both *AFDC* and Food Stamps. This result is a reflection of a phenomenon noted in the welfare literature sometimes referred to as the "breakeven problem". The problem arises because a reduction in a welfare-programme tax rate raises the breakeven level (i.e., the point at which eligibility terminates), which draws some individuals onto the rolls with consequent reductions in labour supply.

That this is occurring in the present example is clear from Table 1.2, for the fraction of recipients working full-time actually falls when the tax rate is reduced; this arises because it is generally full-time workers who are made newly eligible, or nearly eligible, by the increase in the breakeven point, and it is they who reduce their labour supply when going onto the welfare rolls. The table also shows the effect on costs, defined as the increase in benefits of new entrants minus benefit reductions from existing recipients who work more or who leave the rolls, plus the change in the tax payments of both groups, as a percentage of initial benefit payments minus tax payments. KM find that there is little effect on costs from the tax rate reduction to 50 per cent, for the benefit savings from increased numbers of working recipients is cancelled out by increased benefits for new entrants.

A more massive change of reducing both *AFDC* and Food Stamp tax rates to .10 succeeds in increasing labour supply by about 2 hours per week, but at the cost of increasing the *AFDC* caseload by about one-third and the Food Stamp caseload by about one-fourth. The tax-rate reduction in this case induces large numbers of non-working recipients to go to work, either part-time or full-time, outweighing the labour supply reductions of the new recipients. However, costs rise by almost 80 per cent for this reform because of the larger number of recipients.

The effects of these changes in marginal tax rates are in sharp contrast to the effects of increasing wage rates, for the two are not symmetrical for welfare programmes. The remaining rows of Table

Table 1.2: Simulated Responses to Changes in the Budget Constraint

	Programme Participation (%)		Work Hours Distribution (%)			Mean Hours	Cost Change
	P_A	P_F	NW	PT	FT	Worked	(%)
Baseline	25.0	33.5	34.6	10.4	55.0	24.1	-
Decrease in AFDC tax rate from 1.00 to .50[a]	25.7	33.7	33.7	11.5	54.8	24.3	1
Decrease in AFDC and Food Stamp tax rates to .10	32.8	40.0	27.9	14.4	57.7	26.0	79
Wage Increase of $1	20.9	28.9	26.5	9.7	63.8	27.5	162
Subsidised Minimum Wage of $5	19.1	26.8	22.4	10.8	66.8	28.9	128
Wage-Rate Subsidy[b]	20.3	28.3	24.8	10.6	64.6	28.0	89
Increase in EITC[c]	21.9	31.9	27.2	20.0	52.8	25.1	46
Universal Work Subsidy[d]	20.8	28.9	27.7	17.8	54.5	25.4	-3

Notes:

P_A = probability of participating in AFDC.

P_F = probability of participating in Food Stamps.

NW = probability of not working.

PT = probability of working part-time.

FT = probability of working full-time.

Mean Hours Worked = 20*PT + 40*FT.

[a] All income screens simultaneously eliminated.

[b] Subsidy = .50* ($6.00 − wage).

[c] A refundable tax credit equal to 30 per cent of earnings up to a maximum $1500 annual credit, followed by a 20 per cent phase-out rate.

[d] All AFDC and FSP deductions for work expenses are eliminated and replaced by a work subsidy defined by: Subsidy = $23 - .07*Income, and the subsidy is also offered to those off welfare.

1.2 demonstrate this result. An increase in the gross hourly wage rate of $1 significantly reduces participation in both *AFDC* and Food Stamps and also increases expected weekly hours of work by about 3.5 hours. A wage change pivots the budget constraint around the origin and increases income if off welfare both above and below breakeven (the below-breakeven income increase pulls women off *AFDC* as well as the above-breakeven increase), in contrast to the tax-rate reduction. The magnitude of the hours increase is somewhat less than that implied by the wage elasticity (which was 1.94) primarily because about one-third of the sample does not work. The wage-increase increases costs by more than 160 per cent (costs in this case are defined to include the increased wage costs).

A subsidised minimum wage (i.e., a government subsidy of wage rates up to $5, not a requirement that the firm pay that wage), which pulls up only the bottom portion of the wage distribution, has even greater downward effects on programme participation and upward effects on labour supply. However, it costs less than the dollar-increase in the wage because the wages of high-skilled workers are not increased. A wage-rate subsidy − a

policy often proposed to draw women off welfare – with a 50 per cent subsidy rate up to a wage of $6 per hour is simulated to have about the same effects as the wage-increase, but once again at lower cost because the wage increases are concentrated at the lower end of the distribution. An increase in the *EITC* (the earned income tax credit) operates in a similar way, by increasing after-tax wages if off *AFDC*. The effects on programme participation and labour supply are in the same direction as those already discussed, but smaller in magnitude. The smaller magnitude is, in part, a result of the phase-out region of an *EITC*, which tends to reduce labour supply.

The final row of the table shows the effect of offering a small work subsidy to women off the welfare rolls as well as to women on the rolls (for the latter, to replace existing welfare deductions for work-related expenses). This policy both increases labour supply and reduces programme participation, at reduced cost. The policy succeeds in drawing women off the rolls because the small work subsidy substantially reduces the work-discouraging effects of fixed costs of work (which we have in our model), and because many women with high levels of stigma are willing to leave the welfare rolls, even at reduced income, if such work subsidies are available. Costs are reduced because of the substantial numbers of women who exit the rolls.

1.6
Frontiers:
Dynamic
Simulations

The discussion thus far has no doubt demonstrated that there are many issues to work on in the static model, and which could bear improvement. The specification of the demand side of the labour market and incorporating childcare considerations are just two examples. But a more fundamental problem with the model that is often mentioned is its static nature, and lack of dynamics.

There are many types of dynamics that are missed in the KM and other static models. The first is the existence of adjustment costs. Because there are adjustment costs to going on and off the welfare rolls, any policy change will take time to have an effect. Adjustment costs are certain to be present because the costs of learning about a programme and applying for it, in the case of entry, or from learning to become "self-sufficient" off the rolls, in the case of exit, requires time. These costs are quite likely to be large, but they are not illuminated by static models.

Thinking of welfare participation as a process of entry and exit over time, rather than as a one-shot static decision, also helps understand the key issue of the effect of changes in earnings deductions on welfare programmes discussed earlier. The work disincentives that arise from lowering the welfare-programme tax rate have their effects, in practice, in the form of changed entry and exit effects onto, and off, welfare. A lower tax rate on the welfare programme makes the programme more attractive because income is higher on the programme. This implies that any given comparison between an off-welfare activity like a job offer, and

the welfare programme, will tilt slightly more toward the latter than it did before. Thus entry rates will increase. The lower tax rate also reduces the exit rate because recipients are less likely to move off welfare if they will lose their now-greater welfare benefit while working. Any given comparison between a particular job offer from the private sector, to the welfare programme, will again be tilted slightly toward the latter.

Whether such entry and exit effects would occur would depend on several issues. One is the degree of forward lookingness of the welfare population – that is, the discount rate. A key question is whether welfare recipients and welfare eligibles are completely myopic, or whether they are at least partly forward looking. If they are completely myopic and therefore compare only the current gains and losses of being on welfare, and do not anticipate the gains from the lower tax rate, the lower tax rate may have little effect on entry. If welfare recipients and potential applicants are not completely myopic, on the other hand, but are at least partly forward looking, responses could be quite different.

Another type of dynamics ignored by the static model is the development, or stagnation, of work skills, commonly termed human capital. Nothing in a static model permits future wages to depend on past work effort. Yet it seems clear that in the real world they do, and that this has implications for welfare reform. Being on welfare, for example, leads to lower wages in the future, as skills deteriorate through non-work, leading to even higher probabilities of being on welfare in the future. Being off welfare and working leads to human capital accumulation and higher wages, leading to even lower probabilities of being on welfare in the future. This may lead to divergent paths in which some individuals end up with long "stays" on welfare and others end up with almost none. It may also explain the common data feature noted previously, which is that almost all women on welfare do not work and almost all women off welfare do work.

Another source of dynamics that is missed by the static model is job search and unemployment spell dynamics. The static model assumes that jobs are always available at the going wage, and that an individual has a one-shot offer to accept or reject jobs at that wage. But in fact those who are unemployed only get a certain number of offers and, if they reject them, they know that they will get more offers in the future. There is a large literature on models of job search (Devine and Kiefer, 1991) which illustrates behaviour under this type of model. There is no reason in principle that it could not be simulated.

Most of these types of dynamics have not been modelled, but some aspects of the first one – the dynamics of entry and exit, and turnover in welfare programmes – has. The most straightforward way to incorporate these fixed costs of transitions into the model is to specify a dynamic discrete choice model under uncertainty (see Eckstein and Wolpin, 1989 for a survey and Swann, 1995, for an

application to welfare participation). At time t assume that the individual maximises

$$V\left(H_t, Y_t, P_{1t}, ..., P_{mt}\right)$$

$$= E_t \sum_{\tau=t}^{T} \rho^\tau \left[U(H_\tau, T_\tau, P_{1\tau}, ..., P_{m\tau}) - F\left(H_\tau, Y_\tau, P_{1\tau}, ..., P_{m\tau} | S_{\tau-1}\right)\right]$$

$$= U\left[(H_t, Y_t, P_{1t}, ..., P_{mt}) - F\left(H_t, Y_t, P_{1t}, ..., P_{mt} | S_{t-1}\right)\right]$$

$$+ E_t \sum_{\tau=t+1}^{T} \rho^\tau \left[U(H_\tau, Y_\tau, P_{1\tau}, ..., P_{m\tau}) - F\left(H_\tau, Y_\tau, P_{1\tau}, ..., P_{m\tau} | S_{\tau-1}\right)\right] \quad (8)$$

where ρ is the time rate of discount, T is the length of the horizon, U is the same function as shown in Equation (1), F is a fixed cost function, and S_{t-1} is a vector of the H and P variables for time periods *t-1, t-2,* and further periods back. The simplest specification is one in which only last period's state *(t-1)* matters for the transition costs, but a more realistic specification would allow the duration in different states to affect fixed costs. A complete specification of the fixed cost function would allow those costs to be unique for each transition. In the case of the Markov model in which only time t-1 matters, one would have

$$F_{ij} = c_{ij}(Z) + u_{ij} \quad (9)$$

where i and j are indicators of the state at periods t and *t=1,* respectively, and where Z is a vector of individual co-variates and policy parameters that affect fixed costs.

If Equations (4) – (7) are also assumed, this model embeds the KM model. At each t, after the transitions have been made, choice can still be described by the same static structure of the KM model, but with the new fixed costs subtracted off. When the fixed cost functions are added in, they can be combined with the cost parameters shown in Equation (4), with the only alteration in the interpretation to be that costs depend on the individual's work and programme participation history, not just the current values of labour supply and programme participation. Thus a period-by-period estimation and simulation could still be performed. But this model also generates a series of transition-rate equations, composed of entry and exit equations, as well, so the individual moves over time to an equilibrium. Policy changes induce additional movements to a new equilibrium.

Estimation of models of this type require considerable computational burden but that burden has been greatly reduced by modern computational technologies. Policy simulation still requires more computational burden as usual as well because the optimal plan for each individual has to be worked out. However, this is much simpler than estimation itself. Policy simulation can also be conducted by randomly drawing un-observables from a known or

estimated distribution, and this provides another avenue toward reduction of effort.

An alternative strategy which reduces burden further is to specify the future value functions in an *ad hoc* way rather than in a structural way. In the model in (8) above, the future expectations (i.e., the value functions) are a function of the whole dynamic model. One could, alternatively, specify reduced-forms for these functions and thereby simplify the model.

The major estimation and simulation issue in this model is the requirement that the distributions of the un-observables be properly accounted for. Each period's distribution of families over the different work-participation cells is conditional on last period's distribution and hence is a truncated distribution. If the un-observables are correlated over time, as they no doubt are, then the distinction between heterogeneity and state dependence must be implicitly or explicitly made. This is more of a problem for estimation than for simulation, for when simulating one can simply start off a population at a particular point in time with an untruncated distribution of un-observables, and then, by means of Monte Carlo simulation, simulate the time path of choices and let the distribution of un-observables take the path implied by the model. A complication that would arise even in simulation, however, is the need to calibrate the model parameters to an on-going set of observed work and participation choices.

An approach generally similar to this has been taken in a recent US dynamic simulation model called the STEWARD model (Beebout *et al.*, 1994). The STEWARD model was developed to simulate the initial welfare proposals put forth in the US by President Clinton in his first term, whose major features were increased work requirements, time limits followed by guaranteed public service jobs, increased health insurance coverage, and an increase in the Earned Income Tax Credit (an earnings subsidy for private-sector work). These provisions required dynamic simulation.

The STEWARD model uses the KM model in Equations (4) – (7) above, but with lagged duration dependence on welfare added to the vector of variables affecting stigma. Thus a time dependence is set up. The expected value functions in the dynamic programme are ignored completely, consistent with a completely myopic individual choice. This is therefore a drawback. The STEWARD model calibrates choices to a panel of NLSY and PSID single mothers by drawing from distributions of individual-specific random effects, and i.i.d. shocks on top of those random effects, to be consistent with observed histories.

Table 1.3 shows some sample output from the STEWARD simulation of President Clinton's welfare reform plan on *AFDC* caseloads and distributions. The initial reduction in the *AFDC* case-load – coming from the increased earnings subsidy off the rolls, primarily – is rather small. However, the effect cumulates over time because the fixed costs both slow down movement of

welfare, and also tend to keep individuals off welfare once they have gone off. Individuals and families are moving toward a new equilibrium and hence are less likely to come back onto the rolls (although some do because of random shocks).[9]

Table 1.3: Effects of President Clinton's Welfare Reform Package on Welfare Caseload and Dependency

	Per cent Reduction
AFDC Caseload, by 6-month period	
First period	-2.5
Second period	-7.8
Third period	-7.1
Fourth period	-8.8
Fifth period	-12.3
Sixth period	-17.8
Seventh period	-21.5
Eighth period (four years out)	-23.7
Per cent Distribution of Cumulative Time on AFDC over the 4 years	
Never On	0.2
0-12 months	10.8
13-24 months	21.3
25-36 months	-2.3
37-48 months	-28.6

Source: Beebout *et al.* (1995, p.52)

The model is also capable of simulating changes in the distribution on the rolls of short-termers versus long-termers. The percentage of the eligible population never on welfare does not change very much over the first four years of the reform (though it would change more later) but there is a large reduction of those who are on more than half of the period (25 or more months) as compared to the number on less than two years.

1.7 Summary and Conclusions

Microsimulation of the labour supply effects of tax and transfer programmes has made great progress over the past twenty years. Theoretical models as well as computational methods have been developed which can address the labour supply effects of virtually any standard programme. Moreover, the empirical results to date, at least in US simulations, demonstrate that behavioural responses to welfare programmes do matter, and that they significantly affect costs and caseloads. Thus constructing good microsimulation models would appear to have considerable payoffs.

At the same time, more progress needs to be made and the models that have been developed need to be made more realistic and therefore more accurate. Perhaps the most fundamental weakness of the models at the present time is their static nature,

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[9] The time limit in this plan is four years, so none of the exits are a result of that. In addition, because of the myopia assumption, there are no anticipatory departures from the rolls.

and their relative failure to address the lags over which policy effects occur and hence to give policy makers some information on the time frame of effects. Nevertheless, estimates from existing models still provide good first-round estimates of the medium-term responses to alterations in programme features.

REFERENCES

BEEBOUT, H., *et al.,* 1994. *Simulation of Trends in Employment, Welfare, and Related Dynamics* (STEWARD). Washington: Mathematica Policy Research.

BLUNDELL, R., 1993. "Taxation and Labour-Supply Incentives in the UK" in A. B. Atkinson and G.V. Mogensen (eds.), *Welfare and Work Incentives,* Oxford: Clarendon.

BLUNDELL, R., and T. MaCurdy (forthcoming). "Labour Supply" in O. Ashenfelter and D. Card (eds.), *Handbook of Labor Economics.*

BURTLESS, G., and J. HAUSMAN, 1978. "The Effect of Taxation on Labour Supply: The Gary Income Maintenance Experiment", *Journal of Political Economy,* Vol. 86, pp. 1103-1130.

CITRO, C., and E. HANUSHEK, 1991. *Improving Information for Social Policy Decisions: The Uses of Microsimulation Modelling,* Vols. I and II. Washington: National Research Council, National Academy of Sciences, National Academy Press.

DEVINE, T., and N. KIEFER, 1991. *Empirical Labour Economics: The Search Approach.* NY: Oxford.

ECKSTEIN, Z., and K. WOLPIN, 1989. "The Specification and Estimation of Dynamic Discrete Choice Models", *Journal of Human Resources,* Vol. 24, pp. 562-598.

HAUSMAN, J., 1981. "Labour Supply". in H. Aaron and J. Pechman (eds.), *How Taxes Affect Economic Behavior,* Washington: Brookings Institution.

HAUSMAN, J., 1985. "The Econometrics of Non-linear Budget Sets". *Econometrica,* Vol. 53, pp. 1255-1282.

HAVEMAN, R., and K. HOLLENBECK (eds.), 1980. *Microeconomic Simulation Models for Public Policy Analysis.* New York: Academic Press.

KEANE, M., and R. MOFFITT, 1998. "A Structural Model of Multiple Welfare Program Participation and Labour Supply", *International Economic Review,* Vol. 39, pp. 553-590.

MaCURDY, T., D. GREEN, and H. PAARSCH, 1990. "Assessing Empirical Approaches for Analyzing Taxes and Labor Supply", *Journal of Human Resources,* Vol. 25, pp. 415-490.

McFADDEN, D., 1989. "A Method of Simulated Moments for Estimation of Discrete Response Models without Numerical Integration", *Econometrica,* Vol. 57, pp. 995-1026.

MOFFITT, R., 1983. "An Economic Model of Welfare Stigma", *American Economic Review,* Vol. 73, pp. 1023-1035.

MOFFITT, R., 1984. "Estimation of a Joint Wage-Hours Labor Supply Model", *Journal of Labour Economics,* Vol. 2, pp. 550-566.

MOFFITT, R., 1986. "The Econometrics of Piecewise-Linear Budget Constraints", *Journal of Business and Economic Statistics,* Vol. 4, pp.317-328.

SIMS, C., 1972. "Comment". *Annals of Economic and Social Measurement,* Vol.1,pp. 343-45.

SWANN, C., 1995. *A Dynamic Analysis of Marriage, Labour Force Participation, and Participation in the AFDC Program.* Mimeo, University of Virginia,.

van SOEST, A., Winter 1995. "Discrete Choice Models of Family Labour Supply". *Journal of Human Resources,* Vol. 30, pp. 63-88.

ZABALZA, A., C. PISSARIDES, and M. BARTON. 1980. "Social Security and the Choice Between Full-Time Work, Part-Time Work, and Retirement", *Journal of Public Economics* Vol. 14, pp. 245-276.

2. BEHAVIOURAL MICROSIMULATION METHODS FOR POLICY ANALYSIS[*]

John Creedy, Alan Duncan

2.1 Introduction

Microsimulation modelling has now become widely used for policy analysis, both as a means to assess the distributional consequences of a tax or benefit change among heterogeneous groups of families in the population, and as a means with which to assess the likely cost to the Government of a proposed or hypothetical policy reform. The most common type of model is "static", in the sense that behaviour is assumed to be exogenous to the tax and benefit system. Based on a large scale cross-sectional data,[1] such models enable the researcher to examine "impact" or "morning after" effects of specified changes in taxes and benefits, and can identify gainers and losers from a particular reform. The advantage of using such a data set, compared with the more anecdotal use of so-called "typical" households, is that it is possible to capture the kind of heterogeneity at the individual and household level that is found in practice. This leads to a more authentic assessment of the overall effects of tax or benefit reform, and "grossing up" factors can usually be used in order to obtain appropriate aggregate tax and benefit expenditure levels. However, many tax and transfer policies are designed specifically to have labour supply effects, particularly those, which try to

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[1] These include, for example, the Household Expenditure Survey (HES) or Income Distribution Survey (IDS) in Australia, the Family Expenditure Survey (FES) or Family Resources Survey (FRS) in the United Kingdom.

encourage more labour force participation.[2] Tax revenue and expenditure calculations may be seriously misleading if potential labour supply responses are not taken into consideration. Furthermore, without behavioural responses it is not possible to examine the welfare effects of changes; attention is necessarily restricted to measures of changes in net income of individuals or households. Very small changes in labour supply may nevertheless be associated with large welfare losses.

The aim of this paper is to provide an introduction to microsimulation modelling where labour supply responses to changes in direct taxes and benefits are explicitly modelled. This type of modelling presents many computational as well as analytical problems. The need to handle extremely complex budget constraints, allowing for the fact that each individual's constraint is unique, along with a desire to model considerable preference heterogeneity, imposes strong modelling and computer programming demands. All components of tax and benefit models must be closely integrated and, given the large number of individuals involved; a premium is placed on the production of efficient computer routines. However, this paper concentrates on the analytical rather than the programming and econometric aspects of modelling. Furthermore, it is not intended to present a guide for constructing microsimulation models: attention is restricted to the labour supply aspects.

Section 2.2 begins with a brief introduction to the basic theory of labour supply, and the problem of integration from a labour supply function to the utility function. Section 2.3 turns to a discussion of the various elements, which combine to form a practical computational tool for behavioural microsimulation. These elements briefly comprise: an appropriately modified static microsimulation model; an algorithm by which complete and accurate budget constraints may be generated for each member of the simulation sample; and a flexible model of labour supply which allocates individuals to points on any relevant budget constraint.[3]

Section 2.4 discusses alternative methods by which such models may be estimated. The major debate in this regard is the choice of a continuous or discrete mode of estimation. The merits of both are discussed and the appropriateness of continuous and discrete models for behavioural microsimulation are examined.

Section 2.5 turns to the method of finding the optimal labour supply for each individual. The economic principle involved, that of jointly choosing the number of hours of work and consumption in order to reach the highest indifference curve subject to a budget

[2] See *inter alia* the Europe-wide debate on an appropriate structure for in-work benefits; the series of reforms in the UK to the Family Credit (FC) system and the introduction of a successor, the Working Families Tax Credit (WFTC); the close scrutiny in the US of the efficacy of the Earned Income Tax Credit (EITC).

[3] This allocation can either be probabilistic or definitive.

constraint, is elementary. However, the efficient evaluation of such choices, given the labour supply function and indirect utility function, is not so straightforward. Moreover, the estimation methods employed (principally, whether the method is continuous or discrete) can determine to a degree the mechanism by which optimal labour supply is evaluated. Section 2.6 considers the evaluation of the welfare effects of tax and benefit changes. Section 2.7 briefly concludes.

2.2 Some Basic Theory

The simplest approach to the analysis of labour supply involves maximisation of a specified direct utility function, $U(h, c)$, where h and c represent hours worked and consumption (or net income, where the price index of c is normalised to unity) respectively, subject to a budget constraint. Unlike the standard commodity demand model in which prices are constant irrespective of the amount of each good consumed, the individual faces a variety of net wage rates. The actual wage depends on the chosen position on the budget constraint, and is therefore, like the number of hours worked, endogenous. However, an interior solution (a tangency position) can be regarded as if it were generated by a simple linear constraint of the form

$$wh + \mu = c, \tag{1}$$

where w and μ represent the appropriate net wage rate and virtual income respectively. Care must be taken in the choice of direct utility to be used when deriving labour supply functions, and often the more tractable direct utility functions lead to labour supply functions which are in most cases insufficiently flexible for practical labour supply modelling.[4] The difficulty of solving the first-order conditions for utility maximisation, starting from a direct utility function, are familiar from the standard commodity demand models. Further progress often involves making use of duality results, starting with either the indirect utility function or the labour demand function itself. This section discusses the latter approach.

2.2.1 THE PROBLEM OF INTEGRATION

Consider a flexible supply function where, for example, h is considered to vary continuously with w and μ. In other words,

$$h = h(w, \mu) \tag{2}$$

[4] See Stern (1986, pp.181-184) for a discussion of the properties of a wide range of candidate labour supply functions, either specified directly (for example, the semi-log supply function) or derived from direct utility (the linear expenditure system, the CES, quadratic direct utility and direct translog) and indirect utility functions (the indirect quadratic, or indirect translog).

It is required that this type of function is consistent with utility maximisation, certainly for the purposes of behavioural microsimulation where individuals may be simulated to change the number of hours they work quite considerably in response to some policy reform.[5] A first requirement for consistency is therefore that (2) satisfies the integrability conditions. Application of the general conditions derived by Hurwicz and Uzawa (1971) to the context of labour supply gives the result that the wage response of the compensated labour supply is non-negative; that is,[6]

$$\frac{\partial h}{\partial w} - h \frac{\partial h}{\partial \mu} \geq 0 \tag{3}$$

This condition is referred to as the Slutsky condition and can easily be checked from the form of (2) specified.

In order to examine the welfare effects of tax changes it is necessary to be able to derive the indirect utility function, $V(w, \mu)$ from the form of (2) used. It is not sufficient just to know that the integrability conditions are satisfied. The need to be able to obtain an explicit form for the indirect utility function places a strong constraint on the range of functional forms for (2) that can be used. Numerical methods of integration are available, but would be too cumbersome in microsimulation models given the very large number of times this would be required.

The indirect utility function can be derived as follows.[7] Consider first the standard consumer problem involving the choice of consumption of each of n goods, $x_i, i = 1, ..., n$ subject to a budget constraint, $\sum_i p_i x_i = m$. For a single price change, say of good i combinations of m and p_i for which utility is constant must satisfy

$$\frac{\partial V}{\partial p_i} dp_i + \frac{\partial V}{\partial m} dm = 0, \tag{4}$$

which can be re-arranged to give

$$\frac{dm}{dp_i} = \frac{\partial V / \partial p_i}{\partial V / \partial m}. \tag{5}$$

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[5] In estimation one ought to test rather than impose concavity. Indeed, this was one of the problems with the methods Hausman (1985) originally employed to account for non-linear taxes in estimation. His probabilistic method of factoring taxes into the likelihood used for estimation essentially required the satisfaction of the Slutsky condition at each kink point on the budget constraint. In conjunction with a linear labour supply model, this forced positive wage elasticities and the global satisfaction of Slutsky concavity.

[6] These require (for necessity and sufficiency) the Slutsky matrix to be symmetric and negative semi-definite. For further discussion in the present context, see Deaton and Muellbauer (1980, pp.89-93) and Stern (1986, pp.145-146).

[7] Early use of the approach was made by Mohring (1971), followed by Hause (1975). It was explored further by Deaton and Muellbaure (1980) and Hausman (1981); for further references and discussion, see Creedy (1997).

From Roy's Identity, the Marshallian demand, $x(p,m)$, is related to the indirect utility function by

$$x_i(p,m) = -\frac{\partial V/\partial p_i}{\partial V/\partial m}. \tag{6}$$

Combining (5) and (6), $\partial m/\partial p_i = x_i(p,m)$, so that the solution to the first-order differential equation, $-\partial m/\partial p_i = x_i(p,m) = 0$, along with an appropriate initial condition (for the constant of integration), gives the required minimum expenditure associated with any given utility level and set of prices. It therefore gives the expenditure function. In the labour supply context, a choice can be made concerning the way in which the expenditure function is expressed. One approach involves writing it in terms of the individual's "full income" defined as $M = \mu + wT$, where T is the total number of hours available (the individual's endowment of time). Alternatively, it can be written simply in terms of virtual income, μ. The two approaches give equivalent results, but of course the use of just μ avoids the need to specify T. It is most convenient here to avoid the use of full income.[8] Hence, recognising also that work is a "bad", it is required to solve the differential equation

$$\frac{\partial \mu}{\partial w} + h(w,\mu) = 0 \tag{7}$$

for μ. The constant of integration may be equated to the initial utility level, $\bar{U}$ so that the solution gives the expenditure function as μ $(w, \bar{U})$. This is then (where possible) inverted to obtain the required indirect utility function, V (w, μ). Given the indirect utility function, it is in principle possible to obtain the direct utility function, U (c,h). This is achieved by using the labour supply function to solve for w in terms of h and μ, combining this with the budget constraint, $\mu = c-wh$, and substituting in V (w, μ) to get U (c,h). However, it is not always possible to solve for w explicitly from the specified labour supply function, so this process may need to be carried out numerically.

2.3 Behavioural Micro-simulation: Some Prerequisites

There are essentially three components, which combine to form a practical and serviceable behavioural microsimulation model. The first is a detailed so-called "static" microsimulation model (sometimes termed a tax-benefit model) with which to impute net household incomes at a micro level for a representative sample of households, and for both incumbent and counterfactual tax-benefit

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[8] See also Stern (1986, p. 148). However, the use of virtual income can create problems if μ is zero or negative.

regimes. Such models have existed for some time.[9] The second component is a quantifiable behavioural model of individual tastes for net income and labour supply (or equivalently, non-work time), with which preferred labour supply for a given set of economic circumstances may be simulated. For the purposes of behavioural microsimulation this essentially relates to the budget constraint faced by the individual under a given tax and benefit regime. The third component is a mechanism to allocate to each individual a preferred supply of hours in the face of any tax-benefit system. Analysing simulated changes in this allocation between some base tax system and a counterfactual regime forms the essence of behavioural microsimulation.

2.3.1 THE STATIC MICROSIMULATION MODEL

A primary requirement of any behavioural model (other than the obvious need for an appropriate data base) is a component that is able to apply a specified tax and transfer system, involving as many as possible of the complexities of means-tested social welfare programmes, to each individual.[10] Such a component in fact forms a "static" or non-behavioural model. In the present paper, the existence of such a component, capable of evaluating a given individual's net income for a specified number of hours worked, is simply taken for granted. That said, it is important to establish the minimal specification requirements required of a static microsimulation model that is to form part of a behavioural microsimulation facility. These should ideally include the following three features. The static model must have the ability to simulate household net incomes at hours' points other than those observed for each individual in the simulation sample. For this to be possible, information about the individual's hourly wage rate must be provided, along with other characteristics. The wage rate is typically evaluated by dividing total earned income by the reported number of hours worked. For non-working individuals, an appropriate wage rate must be imputed, usually based on an estimated wage function. Such a function would normally be estimated using the same data set that forms the basis of the simulation model (allowing for many individual characteristics), with allowance for the sample selection involved in observing only the wage rates of individuals who work in the sample period.

For the application of continuous as opposed to discrete behavioural microsimulation methods, the static tax benefit model

[9] Examples include *SWITCH* from The Economic and Social Research Institute, Dublin, TAKBEN from the IFS, POLIMOD from the Microsimulation Unit in Cambridge, and STINMOD from NATSEM in Australia.

[10] The extent to which the complete tax and transfer system can be modelled depends on the details provided in the data base; in view of the complexity of tax systems, it is unlikely that any model would be able to deal with every single feature. In some cases it may be possible to impute values of missing variables, such as assets.

ought ideally to have the facility to generate complete and accurate budget constraints for all individuals, and not simply a collection of household net incomes at a discrete collection of hour's points. Increasingly, econometric techniques require resampling methods to build up distributions for important but potentially stochastic or endogenous economic variables. An example might be the control of wage endogeneity in discrete choice models of labour supply, following Keane and Moffitt (1998) or van Soest (1995).

2.3.2 BUDGET CONSTRAINTS

The determination of preferred labour supply in continuous behavioural microsimulation requires complete knowledge about the budget constraint facing each individual over the whole of the relevant range of hours.[11] As mentioned above, one component of a behavioural model is a routine which uses the detailed information about the tax and transfer system and calculates the net income, for any type of individual with a specified wage rate and working a particular number of hours.

One approach to calculating budget constraints, which is often used when they are produced for illustrative purposes, involves using a static model to evaluate net income for a large number of labour supply (time) intervals. In order to identify the corners and discontinuities reasonably accurately, small time intervals are needed; for five-minute intervals spread over 50 hours of work, 600 evaluations of net income would be required. However, in the context of behavioural models involving a large number of different individuals, this would be computationally very cumbersome and inefficient. In particular, it requires the same number of evaluations of net income irrespective of the complexity of an individual's budget constraint, and may not precisely identify the position of each kink. Budget constraints can be obtained more efficiently and accurately using the procedure devised by Duncan and Stark (1995) in which trigonometric rules are used to identify kinks and discontinuities. Their algorithm is initiated at a user-defined start and end point to the budget constraint (expressed either in terms of hours or gross income). The budget constraint is then extrapolated forward and back from the start and end points respectively. If the intersection of these extrapolated segments coincides with a point on the true budget constraint, the algorithm
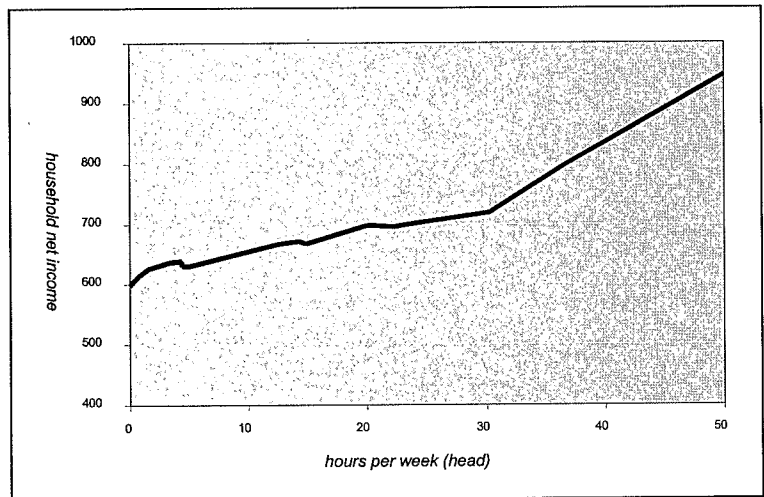
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[11] This contrasts with discrete microsimulation where net incomes before and after a policy reform are required only for a finite set of hours' points. Whilst computationally much simpler, discrete microsimulation suffers from a number of drawbacks. First, simulated hours do not cover the full range of feasible hours' choices open to the individual. Second, the precise detail of the budget constraint is lost in simulation. Third, it is computationally non-trivial to calibrate the econometric model to replicate observed behaviour. See Duncan and Weeks (1998) for a discussion of this last point.

terminates. Otherwise, the budget constraint is subdivided at the intersection and the algorithm proceeds separately on each subsegment.

A full technical description of the budget constraint algorithm, together with source code, is provided in Duncan and Stark (1995). Here we concentrate on a practical implementation by presenting budget constraints, marginal effective tax rate (METR) schedules and METR diagnostics, all of which derive directly from the Duncan-Stark algorithm. This implementation is based on input from the Melbourne Institute Tax and Transfer Simulator (MITTS), a new microsimulation model of the Australian tax and transfer system under development at the Melbourne Institute of Applied Economic and Social Research.[12]

For our particular example we focus on the budget constraint facing the primary earner in a two-person household under the March 1998 Australian tax and transfer system. Figures 2.1 and 2.2 present graphical representations of the budget constraint and METR schedules facing the primary earner in an example two-person household. The complexity of the tax schedule, and the success and accuracy with which the algorithm pinpoints kinks and discontinuities, is evident particularly from the second METR schedule. Once kinks have been accurately identified, one can proceed to diagnose the reason (or reasons) for the presence of the turning point by perturbing hours around the kink and examining the changes in the constituent parts of full net income. In Table 2.1 the turning points are rationalised for the March 1998 Australian tax and transfer system.

Figure 2.1

Figure 2.2

Table 2.1: METR Diagnostics: Primary Earner

Hours	Gross	TU Net	METR	Probable Reason for Kink
0.00	0.00	598.60	0.000	Constraint Starts
0.72	14.42	613.03	0.200	Income Tax Starts
1.50	30.00	625.49	0.700	MR Changes for New Start Payment
				MR Changes for Beneficiary Tax Rebate
3.50	70.00	637.49	0.900	MR Changes for New Start Payment
				MR Changes for Beneficiary Tax Rebate
4.40	87.94	639.28		Discontinuity
4.40	87.96	629.67	0.900	Family Tax Payment Pt B Stops
5.01	100.29	630.90	0.760	Beneficiary Tax Rebate Stops
12.54	250.81	667.02	0.900	Partner's MR Changes for Income Tax
14.30	286.02	670.53	1.400	Partner's MR Changes for Family Payment
14.86	297.29	666.03	0.700	Parenting Payment Stops for Partner
19.90	398.08	696.27	0.880	MR Changes for Low Income Rebate
20.55	411.04	697.82	1.080	Medicare Levy Starts
2.22	444.37	695.15	0.895	MR Changes for Medicare Levy
23.51	470.19	697.87	0.855	Low Income Rebate Stops
30.33	606.60	717.65	0.355	Partner's MR Changes for Family Payment
				Family Tax Payment Pt A Stops for Partner
				Family Tax Assistance Starts
36.54	730.77	797.73	0.445	MR Changes for Income Tax
48.08	961.54	925.81	0.485	MR Changes for Income Tax
50.00	1000.00	945.62		Constraint Ends

Notes: Budget constraints and METR diagnostics generated using the Melbourne Institute Tax and Transfer Simulator (MITTS), and are based on the March 1998 Australian tax and transfer system. Budget sets and marginal effective tax rates details relate to the principle earner in a two-earner couple with three young children and one school aged child. The secondary earner works for ten hours per week, and both adults in the couple receive a gross hourly wage of Aus$20. See Creedy and Duncan (1999) for further details.

In applying the algorithm in the context of behavioural microsimulation, the position (number of hours) of all kinks and slopes of all linear sections of the budget constraint of each individual in a large and representative sample are automatically computed. In addition, it is necessary to compute, for each linear segment, the intersection of that linear section when extended to the horizontal axis (that is, net income corresponding to zero hours). For each linear section, the slope is identified as the net wage rate and the intercept is referred to as the "virtual income" corresponding to that section. The set of net wages, virtual incomes and hours at which the net wage changes (that is, the kink points) for the full microsimulation sample are retained for use in the solution algorithm, described below in Section 2.5, for determining optimal labour supply.

2.3.3 MODELS FOR LABOUR SUPPLY AND INDIRECT UTILITY

In specifying a form of labour supply function to be used in behavioural microsimulation, care must be taken to choose a model which is sufficiently flexible to account for a wide range of behavioural responses in estimation, yet consistent in simulation with utility maximising behaviour for a high proportion of the sample over a wide range of hours' choices.

If the empirical model used in simulation is not broadly consistent with the normal axioms of utility theory, then it is unclear how one rationalises simulated behavioural responses to some policy reform. Two alternatives are available. One option is to specify directly the form of the labour supply function. This option tends to be favoured in continuous studies, which place emphasis on the flexibility of the relationship between hours and wage rates. However, in order to compute an individual's utility at any point on the budget constraint, it is necessary to derive the form of the indirect utility function from whichever hours' function is preferred.

The second is to specify the model directly in terms of the direct utility function. This is typically the most appropriate option when estimating discrete models of labour market status, although it is again necessary to derive the desired hours function if the estimated model is to be applied to continuous behavioural microsimulation. The link between the labour supply function, specified in terms of continuous variations in hours worked, and the indirect utility function has been outlined in Section 2.3, but this subsection reports two examples in more detail.

Example 1: Specifying Labour Supply Directly

While several labour supply functions can be integrated to obtain an explicit indirect utility function, it is important to use a flexible form that allows them to be "backward bending" over a range of

higher wage rates, while having a positive slope at lower wages.[13] This is particularly important when modelling female labour supply. This need for flexibility rules out the use of a simple linear function. The following discussion takes as an example the specification introduced by Duncan (1993), whereby[14]

$$h = \alpha + \beta \log w + \gamma \left(\frac{\mu}{w} \right) \qquad (8)$$

and the parameters α, β and γ are allowed to depend on the characteristics of the individual. From (8), $\partial h / \partial \mu = \gamma / w$, so for this to be negative (for an increase in virtual income to increase the consumption of leisure), it is required to have $\gamma < 0$. Differentiation with respect to w gives

$$\frac{\partial h}{\partial w} = \frac{1}{w} \left(\beta - \gamma \frac{\mu}{w} \right) \qquad (9)$$

Hence for $\mu > 0$ and $\beta > 0$, the supply function is forward-sloping for $w = <\gamma\mu/\beta$. Substitution of (8) into the budget constraint $c = wh + \mu$ and differentiation gives

$$\frac{\partial c}{\partial w} = \alpha + \beta(1 + \log w), \qquad (10)$$

so that if α and β are positive, a higher wage is associated with higher net income.

The derivation of the indirect utility function involves solving the differential equation obtained by substituting (8) into (7), that is

$$\frac{\partial \mu}{\partial w} + \alpha + \beta \log w + \gamma \left(\frac{\mu}{w} \right) = 0 \qquad (11)$$

The solution gives the expenditure function, expressed in terms of virtual income, as[15]

$$\mu(w, \overline{U}) = \overline{U} w^{-\gamma} - \frac{w}{1 + \gamma} \left[\beta \log w + \alpha - \frac{\beta}{1 + \gamma} \right]. \qquad (12)$$

This can easily be inverted to give the indirect utility function

$$V(w, \mu) = \frac{w^{1+\gamma}}{1 + \gamma} \left[\frac{\mu}{w}(1 + \gamma)^2 + \beta \log w + \alpha - \frac{\beta}{1 + \gamma} \right]. \qquad (13)$$

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[13] For detailed treatment of some special cases, see Stern (1986).
[14] The use of a term in log w^s was investigated in Duncan (1993), but in most cases it is not signififcant and is therefore omitted here.
[15] For the complementary function, $\frac{\partial \mu}{\partial w} + \frac{\gamma \mu}{w} = 0$ or $\frac{\partial \mu}{\mu} = -\frac{\gamma \partial w}{w}$.

Hence, h as expressed in (8), arises from the maximisation of (13) subject to the linear budget constraint (1). However, it can be seen that no analytical expression can be found for the direct utility function in this case.

Example 2: Specifying Preferences Directly

The alternative approach is to specify directly the form for preferences, which underpin the economic model of labour supply. For example, Keane and Moffitt (1998) favour a quadratic direct utility function of the form

$$U(h,c) = \alpha c^2 + \beta h^2 + \gamma ch + \delta c + \varepsilon h ,\qquad (14)$$

where parameters δ and ε are allowed to depend on the characteristics of the individual. This specification corresponds to a labour supply function of the form

$$h = \frac{2\alpha\mu w + \gamma\mu + \delta w + \varepsilon}{-2\left(\alpha w^2 + \gamma w + \beta\right)}\qquad (15)$$

which can admit backward-bending labour supply at higher hours for certain combinations of parameters. Substituting (15) and $c = wh + \mu$ in (14) yields the indirect utility function.[16]

2.4
Estimating Models of Labour Supply

The basic theory of labour supply behaviour is reasonably well established. That is not to say that the preceding discussion is by any means exhaustive; it does not examine life-cycle issues in labour supply analysis, nor the complexities of the household decision-making process and how that affects labour supply within the family. Nevertheless the previous section provides a framework within which the simulation of behavioural responses might be investigated.

However, this does not solve the practical problem of estimating empirical models of labour supply. Despite a well-established theory, there exist many practical difficulties in estimation. These include:
1. The incorporation of taxes;
2. Dealing with endogeneity and random preference heterogeneity;
3. Eliminating the reservation wage condition in a manner consistent both with estimation and behavioural microsimulation;
4. Accommodating stochastic elements in microsimulation;
5. Dealing with incomplete welfare programme participation.

There are essentially two routes available when seeking to resolve at least some of these difficulties. These are either a

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[16] It is not clear why Stern (1986) considers the resulting expression to be "inelegant".

continuous mode of estimation, or a more discrete estimation procedure. There are advantages and disadvantages with both, although it is perhaps true to say that in recent years there has been a move towards the use of more discrete modes of estimation. The arguments for each are rehearsed below.

2.4.1 DISCRETE VERSUS CONTINUOUS LABOUR SUPPLY

The traditional approach to the modelling of labour supply maintains that the decision variable, hours of work, is continuous and unconstrained. Individuals are assumed to derive utility from net household income C (shared between current and future consumption) and leisure $L = T - h$. Let these preferences be represented by

$$U = U(h, c; X),$$ (16)

where X represents individual characteristics. Behavioural decisions are constrained to lie within a budget set defined in terms of gross wage rates w total household income μ from assets and other unearned sources, and the tax system $T(h, w, \mu; X)$, where $h = T - L$ for some time endowment T. The budget set takes the following general form

$$C = wh + \mu - T(h, w\mu X) - FC(Z_c),$$ (17)

where $T(h, w, \mu; X)$ represents tax payments minus benefit receipts, assumed to depend on hours, wages, unearned income and household characteristics, and $FC(Z_c)$ represents the fixed cost of employment for someone with characteristics Z_c. One may assume that households choose a point on the edge of their budget set, which ignores the potential to save for future consumption. Alternatively, one may replace income by current consumption expenditure (if data are available) to make the model consistent with a life-cycle behavioural pattern; see Blundell and Walker (1986). In the standard continuous model households are assumed to maximise (16) subject to (17) over a continuum of hours. That is, desired hours h^* for each household member stem from the solution to the following problem

$$\frac{\max}{H} U(c, T - h) \ s.t. \ c \leq wh + \mu - T(h, w, \mu; X) - FC(Z_c).$$ (18)

The maximisation problem is not straightforward, however, because of the fundamentally non-linear character of the tax function $T(.)$. What tends instead to happen is that (18) is solved for a *constant* marginal tax rate to recover parametric forms for the Marshallian labour supply functions $h^* = h, \mu; X$. The complexities of the tax schedule are then dealt with in estimation (see, for

example, Hausman and Ruud (1984); Hausman (1985); Moffitt (1986) or Blundell, Duncan, and Meghir (1998)).

However, in a number of recent studies analysts have begun to examine policy issues using labour supply models which are characterised by a more realistic discretised budget set.[17] There are a number of reasons for this. First, analysts increasingly question whether a model which allows continuous substitution of hours for leisure constitutes a realistic representation of the supply choices open to the individual. For many socio-demographic groups labour market participation takes the form of fixed wage-hours contracts, with individuals choosing from among a discrete set of hours combinations (most often at part-time levels of around 20 hours, and at full-time levels of between 38 and 40 hours per week). Second, there are statistical and practical reasons to favour a discrete approach to the modelling of labour supply in preference to more classical continuous models. These largely stem from the difficulties associated with the treatment of non-linear budget constraints in continuous estimation (see Gourieroux, Laffont, and Montfort (1980) and Blundell, Duncan, and Meghir (1992)).

The strategy adopted in the discrete approach is to replace the entire budget set with a finite number of points thereon, and optimise only over those discrete points. The procedure supposes that hours' choices can be approximated by the discretised hours level $h(.) \in \{h^1, h^2, ..., h^r\}$ according to the grouping rule

$$= h^1 \; if \; h_1^B < h \leq h_2^B \qquad ,$$

$$= h^{P-1} \; if \; h_{P-2}^B < h \leq h_{P-1}^B$$

$$= h^P \; if \; h > h_{P-1}^B,$$

giving P alternative values for $h(.)$.[18] Household net incomes may then be calculated for the set of discrete hours combinations $h(.)$ as

$$c[h_{(.)}] = wh_{(.)} + \mu - T(h_{(.)}, w, \mu; X) \; for \; h_{(.)} \in \{h, h^2, ..., h^P\}.$$

The household is assumed to maximise the following

$$h_{(.)} \in \begin{array}{c} \max \\ \{h^1, h^2, ..., h^P\} \end{array} U(c[h_{(.)}] \; T - h_{(.)}) \; for \; h_{(.)} \in \{h^1, h^2, ..., h^P\}. \qquad (19)$$

This approach removes from the optimisation problem many of the complexities of a non-linear tax schedule, but at the cost of introducing rounding errors in the hours levels used for estimation. The degree of aggregation may therefore have a potentially detrimental effect on the authenticity of the parameters estimated under a discrete regime, and ought at the very least to be subjected to sensitivity analysis.

2.4.2 ESTIMATING A DISCRETE MODEL OF LABOUR SUPPLY IN REDUCED FORM

To operationalise the discrete choice model requires a specification both of the preference function and of the stochastic structure. A popular approach specifies directly a series of state-specific utilities to be enjoyed in each discrete hours regime $h_{(.)} \in \{h^1, h^2, ..., h^P\}$. Let state specific utilities be represented by

$$U_{h(.)} = U_h\left(c_{h(.)}; Z, X\right),\qquad(20)$$

where $c_{h(.)}$ represents the net household income that would be enjoyed at $h_{(.)}$. Often, (20) is specified as a linear combination of state-specific incomes and household characteristics, such that $U_{h(.)} = X'\beta_{h(.)} + \gamma.c_{h(.)}$. Random disturbances are added to utilities in each state of the world, leading to a stochastic utility specification of the form

$$U*_{h(.)} = X'\beta_{h(.)} + \gamma.c_{h(.)} + \varepsilon_{h(.)}, for\, h(.) = h^1, h^2, ..., h^P.\qquad(21)$$

By introducing stochastic structure, we are in a position to derive probabilistic expressions for the likelihood of choosing any labour market regime by application of the maximum utility criterion (19). That is to say, the probability that the individual works $h^j \in \{h^1, h^2, ..., h^r\}$ hours is

$$\Pr\left(h_{(.)} = h^j\right) = \Pr\left[U_{h^j}{}^* > U_{h^P}{}^* for\, all\, j \neq p, p \in \{1, ..., P\}\right]$$

$$= \Pr\left[X'\beta_{h^j} + \gamma_{h^j} + \varepsilon_{h^j} > X'\beta_{h^P} + \gamma.c_{h^P} + \varepsilon_{h^P} for\, all\, j \neq p\right]\qquad(22)$$

$$= \Pr\left[\varepsilon_{h^P} - \varepsilon_{h^j} < X'_i\left(\beta_{h^j} - \beta_{h^P}\right) - \gamma.\left(c_{h^P} + c_{h^j}\right) for\, all\, j \neq p\right]$$

We may estimate the parameters of (21) via a likelihood formed from probabilities (22) for a sample of data once assumptions are made about the distribution of random components $\varepsilon_{h(.)}$.[19] For example, if one assumes that each ε_{h^j} in

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[19] In fact, one can only identify $P\text{-}1$ sets of parameters $\beta_H()$. Typically, a reference of the world is chosen for which $\beta_0 = 0$.

(21) is distributed as a Type I Extreme Value error, then parameters may be estimated using standard Multinomial Logit methods. Note that the probability (22) depends both on state-invariant individual characteristics and state-varying characteristics (specifically, net income at different hours levels).

One problem with this approach is the difficulty with which the statistical model may be tested against economic theory. Since the parameters of the utilities in each state are estimated independently, one cannot easily confirm that the preference function itself is consistent with theory. Moreover, the number of parameters multiplies in direct proportion to the number of distinct labour market states, and in practice such models can yield imprecisely determined parameters. This can make simulated responses volatile. For this reason we see greater potential with a more structural approach.

2.4.3 A BASIC STRUCTURAL MODEL OF LABOUR SUPPLY

A more structural approach to the modelling of household labour supply behaviour derives from van Soest (1995) and Keane and Moffitt (1998), both of whom model hours' behaviour as the outcome of a discrete choice among a finite set of hours' alternatives. The approach allows both for random preference heterogeneity and state-specific errors in perception, and can also incorporate either directly estimated or indirectly imputed fixed costs in estimation. To see the essence of their approach, let

$$U_{h()} = U\left(T - h(), c_{h()}; X\right), \text{ for } h() \in \left\{h^1, h^2, ..., h^P\right\}, \tag{23}$$

where the unified preference function now depends both on (discrete) hours $h()$ and income $c_{h()}$. Compared with the discrete approach, this method is parsimonious in its parameterisation and preserves the same preference structure over the whole range of hours. Random disturbances specific are added to utilities in each state $h() \in \left\{h^1, h^2, ..., h^P\right\}$ as with the discrete approach to give random utilities

$$U_{h()}{}^* = U\left(T - h(), c_{h()}; X\right) + \varepsilon_{h()}, \tag{24}$$

where each $\varepsilon_{h()}, h() \in \left\{h^1, h^2, ..., h^P\right\}$ is assumed to be independently distributed as a Type I Extreme Value. The probability of choosing state $h() = h^j$ is therefore

$$\Pr\left[h_{(.)} = h^j\right] \quad = \Pr\left[U_{h^j}^{*} > U_{h^p}^{*} \ for \ all \ j \neq p. p \in \{1,...,P\}\right]$$

$$= \frac{\exp\left[U\left(T - h^{j}, c_{h^j}; X\right)\right]}{\Sigma_{k=1}^{P} \exp\left[U\left(T - h^{k}, c_{h^k}; X\right)\right]}. \tag{25}$$

2.4.4 REFINEMENTS

Unobserved Wage Rates

In a typical sample of microdata, it is not possible to observe wage rates for non-working individuals. This poses a problem when simulating behavioural responses, since the budget constraint over which the non-working individual is supposed to optimise requires a value for the gross hourly wage rate. For practical microsimulation it is necessary to estimate the expected market wage rate commanded by individuals with a given set of observed characteristics. This conditional wage expectation is used in place of missing data for non-workers in the continuous method of microsimulation.[20] Econometric methods also make it possible to factor unobserved characteristics into this expectation, particularly those unobserved characteristics thought specifically to influence the level of the market wage available to non-working individuals in the sample.[21] The method of estimating wage rates also offers the possibility of repeatedly sampling from conditional wage distributions in simulation, given pre-estimated expressions for expected wage rates conditional on observed characteristics.

Modelling Non-participation

The participation decision is probably the hardest aspect of the labour supply decision to get right. Yet the work incentive impact at the point of participation is often the most important consideration when assessing the incentive and welfare impact of tax or benefit reform proposals.[22] For example, in the UK, the Family Credit system of in-work support has seen three relatively recent structural reforms, each of which has been designed with the objective of encouraging participation.[23] Empirical evidence suggests that the participation elasticity is large relative to

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[20] It is not appropriate to estimate earnings functions for use in behavioural microsimulation, since such a function combines both hours choices and wage rates, both of which are endogenous.

[21] In particular, methods of estimating conditional expectations which control for sample selection are used; see Heckman (1979).

[22] See Heckman (1993).

[23] See Duncan and Giles (1996) for more detail on the history of reform to Family Credits.

conditional hours elasticities, suggesting a low reservation wage for many groups.

Most microsimulation studies of the impact of tax reform on labour supply deal with participation simply by assuming that reservation wages exceed the market wage available. However, there is empirical evidence suggesting that this corner "solution" characterisation of non-participation is statistically unsustainable.[24] Other reasons for observing individuals out of the labour market include involuntary unemployment, and potential participants being discouraged from seeking work as a result of fixed costs or search costs of employment. These affect the likelihood that a potential worker will move into paid employment, and can be controlled for in estimation. Hence, ideally they should also be accommodated in microsimulation applications. Blundell, Ham, and Meghir (1987) discuss a likelihood-based approach which exploits sample information to differentiate those who are unemployed but seeking work and those who are self-reported non-participants, and Cogan (1981) describes a method to control directly for fixed costs in estimation.

Perhaps the main reason why many microsimulation studies adhered to the corner solution notion of non-participation is the expectation that the tax and benefit reform should have some impact on the likelihood of voluntary labour market participation. The implementation of selection-type models to separate the participation decision from the choice of hours, conditional on participation, are consistent with fixed costs in estimation. However, the participation decision is typically modelled in reduced form, to the extent that the choice does not explicitly depend on the full detail of the tax and benefit system.[25] In consequence, such models make an uneasy transition into microsimulation, where tax and benefit changes ought explicitly to affect participation decisions.

Some sources of microdata separately identify various types of individuals not in paid employment. Some people report that they are looking for work, some report that they want to work but are not looking (including those who cite the need to care for children as a reason for not looking), and some report that they do not want to work. This information can be used to differentiate individuals in estimation and simulation. Keane (1995) factors exogenous child-related and fixed costs of work into his estimation procedure, by netting from the household net income of working families a state-specific average fixed cost. Callan and van Soest (1996) introduce a method by which fixed costs may directly be imputed in estimation. Specifically, by attributing to those who

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[24] For example, see Mroz (1987).

[25] There have been developments in the recent literature to factor some detail of the tax and benefit system into a separate participation decision, but the level of this detail is typically limited; see Bingley and Walker (1997), Blundell, Reed and Stroker (1997) and Duncan and Giles (1998a).

want to work but do not look for work an unobserved (shadow) fixed cost, and parameterising this cost in terms of observable characteristics and a random element, they were able to estimate a "shadow fixed cost" equation. This equation was used in microsimulation to eliminate the reservation wage condition most commonly applied as an explanation of non-participation.[26]

Duncan and Giles (1998b) implement the Callan-van Soest method in an application to UK data. They analyse the potential labour market impact of the Working Families Tax Credit (WFTC) as a replacement for the UK Family Credit system of in-work benefit, concentrating on the likely effect on single parent families. They found that the imputation of fixed costs reduced significantly the inertia in discrete microsimulation that is typically found at the point of non-participation.

2.4.5 CHOICE OF MODE OF ESTIMATION

Whether using a continuous or a structural discrete mode of estimation for an empirical model of labour supply, the successful application of continuous behavioural microsimulation methods requires a quantifiable model both for preferences over any combination of net income and hours of work, and a model which predicts the most preferred supply of hours for any combination of marginal net wage rate and virtual income. Ideally, the empirical model should also have the potential to factor fixed or child-related work costs into the behavioural model. This serves to eliminate the reservation wage condition in estimation, and also offers an opportunity to simulate the behavioural impact of policy reforms designed to compensate for expenditures on childcare.

Among the alternative estimation methods available, it is suggested that the Keane-Moffitt approach is best suited to address these various concerns. The reasons for this judgement are as follows:

- The estimation strategy is consistent with the presence of taxes.
- Observed and unobserved heterogeneity is easily incorporated in estimation.
- The behavioural model may be applied equally well to continuous or discrete microsimulation.
- Fixed and child-related costs may be imputed in estimation and altered in simulation. Stochastic elements of the behavioural model may feasibly be factored into behavioural microsimulation.
- Incomplete programme participation may be controlled for in estimation and imputed in simulation.

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[26] The advantage of the Callan-van Soest approach is that the fixed cost imputation can be factored directly into either continuous or discrete behavioural microsimulation.

2.4.6 CHOICE OF FUNCTIONAL FORM

For continuous estimation a prime concern when choosing an appropriate functional form for hours of work is the flexibility of the potential behavioural responses, coupled with the availability of manageable utility functions, either direct or indirect. It is rare to find specifications which are flexible and which yield explicit forms for both versions of utility; see Stern (1986). Most of the more recent contributions to the continuous labour supply literature have chosen functional forms which are either quadratic or log-linear in the marginal wage, and are linear in non-labour income. Duncan (1993) introduced the variant of the semi-log supply function described in Equation (8), which combines the advantage of an explicit form for indirect utility with a degree of flexibility in the income elasticity of labour supply.

For the implementation of the structural discrete approach, van Soest and Callan and van Soest (1996) used a direct translog utility function for (24) whereby

$$U(h,c) = \alpha_{cc} \ln c^2 + \alpha_{hh} \ln(T-h)^2 + \alpha_{ch} \ln c \ln(T-h) + \\ \beta_c \ln c + \beta_h \ln(T-h) \tag{26}$$

for some pre-specified value for the time endowment, T. Equation (26) requires net household incomes, $c_{h()}$ to be positive for all hours alternatives. This may cause a problem if one chooses to net fixed costs from household income in the estimation procedure, in which case the difference can become negative for low-earning households with high fixed costs. The quadratic direct utility function is favoured by Keane and Moffitt (1998), where

$$U(h,c) = \alpha_{cc} c^2 + \alpha_{hh} h^2 + \alpha_{ch} ch + \beta_c c + \beta_h h \tag{27}$$

for parameters $\phi = \{\alpha_{cc}, \alpha_{hh}, \alpha_{ch}, \beta_c \beta_h\}$. This function is tractable, yet permits a wide range of possible behavioural responses; see Stern (1986) for a discussion of the properties of this and other functions.

Whether (26) or (27) is chosen, observed heterogeneity can be introduced linearly through parameters β_c and β_h.

Specifically,

$$\beta_c \quad = \quad \beta_{c0} + \beta'_c X \tag{28}$$

$$\beta_h \quad = \quad \beta_{h0} + \beta'_h X \tag{29}$$

In order to incorporate random preference heterogeneity, a subset of the parameters in (27) may be randomised. For example, the linear utility parameters, β_c and β_h, can be randomised, giving

$$\beta_c^* \quad = \quad \beta_{c0} + \beta'_c X + v_c \tag{30}$$

$$\beta_h^* \quad = \quad \beta_{h0} + \beta'_h X + v_h , \tag{31}$$

where $\{v_c, v_h\}$ are assumed to be jointly normal with variances $\{\sigma_c, \sigma_h\}$. The estimation of this model with random preference heterogeneity requires simulation methods, either using a simple method of Simulated Maximum Likelihood or the more complex Method of Simulated Moments. Both methods were examined in detail by Keane and Moffitt (1998), although they noted that the simpler method is not unbiased for a finite number of Monte Carlo draws.

When choosing a functional specification for direct utility, it is necessary to have some regard to the application in hand. If the principal concern is with continuous behavioural microsimulation, then the main requirement is the flexibility and consistency of the behavioural model, and the availability of tractable forms for the various functions (direct and indirect utility and labour supply). Given these criteria, the direct quadratic utility specification is favoured.

2.5 Solving for Optimal Labour Supply

2.5.1 A SOLUTION ALGORITHM FOR CONTINUOUS HOURS
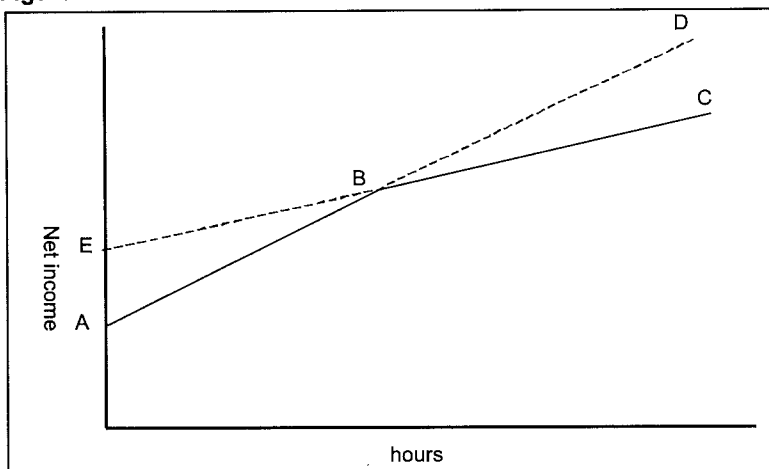
The budget constraint, while typically highly non-linear, consists of a number of piecewise linear sections, as identified using the algorithm described in Section 2.2. Each section is associated with a particular slope, the corresponding net wage, w, and virtual income, μ. The algorithm for determining the individual's labour supply involves investigating the local optima on linear sections and corners of the budget constraint. The utility associated with each local optimum is evaluated and the position giving the global optimum is identified as the labour supply. The procedure is described in the context of the labour supply function (8), but of course applies to any legitimate form of function.

Consider Figure 2.3, which shows the first two linear sections, AB and BC, of a budget constraint. The first section, AB, is associated with a net wage of w_1 and virtual income of μ_1 while the second section, BC, is associated with w_2 and μ_2 respectively. The first step of the algorithm involves substituting the values w_1 and μ_1 into the individual's labour supply function (8). If the resulting value of h is less than zero, then the corner solution at point A is identified as a local optimum involving no work.

The evaluation of the utility associated with this point must be obtained by first obtaining the virtual wage and virtual income associated with the corner solution. The virtual income has already been discussed above and in this case is simply given by $\mu = \mu_1$. The virtual wage is that which would generate the optimal position as a tangency position. The approach at this non-working corner involves setting $h=0$ and, from (8), solving numerically

Figure 2.3

for the virtual wage is the value of w for which $\alpha + \beta \log w + \gamma \mu_1 / w = 0$.[27] The concept of the virtual wage is thesame as that of the virtual price used in the theory of rationing, and stems from Hicks (1940). If it is known that the budget set is convex, there is no need to look for other positions on the budget constraint.

Alternatively, if the resulting value of h lies between points A and B, then it is identified as a local maximum associated with a tangency position of an indifference curve with that section of the budget constraint; the level of utility can in this case be obtained by direct substitution into the indirect utility function (13). Again, if it is known that the budget set is convex, there is no need to look for other positions on the budget constraint.

A third possibility is that the value of h obtained from the use of w_1 and μ_1 lies to the right of B along the extension BD, in which case no clear decision can be made until the next linear section is investigated. The next stage therefore involves substituting w_2 and μ_2 into the labour supply function (8). If the resulting value of h lies to the left of B along the extension EB, it can be concluded that the corner, B, is indeed a local optimum. Evaluation of the associated utility level requires the use of the corresponding values of h and c at point B. But since only the indirect form of the utility function is available, and values of w and μ are not defined for corner solutions, it is necessary to obtain the virtual values; these are the values of w and μ that, if associated with a tangency position, would place the individual at the kink.

The two equations used to solve for the two unknowns, the virtual wage and income, are the budget constraint and the labour

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[27] It is clear form the form of (8) that there is a unique value of w corresponding to any given h.

supply function. Substituting $\mu = c\text{-}wh$ into (8), it is necessary to solve numerically for the value of the virtual wage, the value of w for which
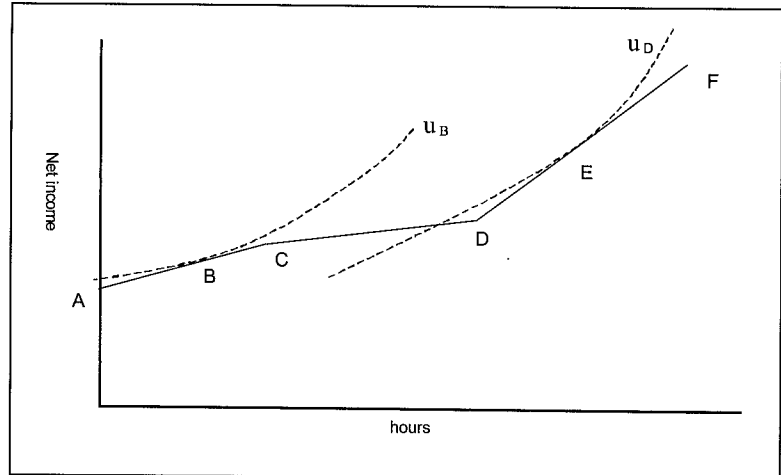
$$(1+\gamma)h = \alpha + \beta \log w + \frac{\gamma c}{w} \qquad (32)$$

Given the value of w the corresponding value of μ is obtained by substitution into the budget constraint. These two values can then be substituted into the indirect utility function.

Alternatively, the value of h obtained from the use of w_1 and μ_1 may be between B and C, in which case it provides a local optimum as a tangency solution. The associated utility level can be calculated by the substitution of w_1 and μ_1 into the indirect utility function (13). If the budget set is known to be convex, there is no need to look for other positions. But if the budget set is non-convex, the procedure continues in this way by moving across the complete budget constraint and identifying all local optima.

In general, the utility levels corresponding to tangency or interior solutions are easily evaluated using the indirect utility function, (13). Utility levels corresponding to corner solutions are obtained by first calculating the virtual wage and virtual income for the required values of c and h involving the numerical solution to (32), and then substituting into the indirect utility function. The global optimum is chosen as the local optimum giving the greatest utility.[28]
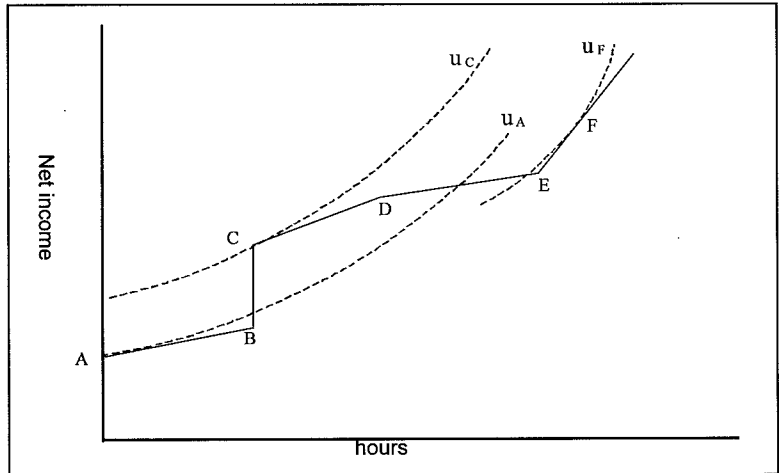
Figure 2.4

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[28] Cases where two positions give the same utility can arise in principle with non-convex budget sets, but in practice the probability is negligible.

Further examples showing more than one local optimum are given in Figures 2.4 and 2.5. These figures show the associated indifference curves, but it is important to recognise that such indifference curves are in practice not used and would be very cumbersome to trace out, in view of the fact that the direct utility function cannot be derived explicitly.

Figure 2.5

2.5.2 A SOLUTION ALGORITHM FOR DISCRETE HOURS

For a discrete choice model of labour market status of the form described in (25) there is inevitably less accuracy both in the budget constraint information brought to bear in estimation and in the microsimulated hours responses to a tax policy reform. Specifically, hours' responses are limited in accuracy to the number of discrete hours bands into which the simulation sample is divided, and the nominal value for hours of work allocated to observations falling within each band. This may be appropriate for certain demographic groups, such as married male workers, and certain tax reforms, but it is by no means a universally acceptable feature. It is known, for example, that the labour market decisions of one-parent households are relatively marginal or flexible, reflecting the high value such households place on non-work time. It is therefore desirable to extend both estimation and simulation methods for such groups to embrace a wider set of hours alternatives and a variety of reasons for non-participation. However, such households tend to have more complex budget constraints than most, so the estimation of continuous hours models is particularly problematic and prone to bias. This leaves one alternative, which is to estimate a discrete choice model based upon a large number of labour market states, of the form described in, say, Callan and van Soest (1996).

The methods by which discrete models of labour market status are applied to discrete microsimulation are to some extent under-

developed. One approach is to restrict attention to aggregated groups in the simulation sample and to summarise probabilities of occupation of each discrete state before and after some policy reform. This tends to conceal the impact of reform at the individual level, making it difficult to assess how the behaviourally-adjusted cost of the reform might be judged, and the impact of a reform targeted either at a specific demographic group or over a specific range of hours.[29]

If, on the other hand, simulated responses at the level of the individual are required, it is not obvious which is the most appropriate strategy to adopt. In continuous microsimulation, the optimal hours before and after a policy reform are solved and fed back into a static microsimulation model to generate behaviourally adjusted costings and distributional results. This raises the question of what parallel approach might be adopted using discrete models.

It is common to see discrete microsimulated responses based on a maximum probability rule as a "one-shot" or "all-or-nothing" mode of individual allocation, disregarding the probabilistic nature of the model specification. This approach is wasteful of information, and it can be demonstrated that the maximum probability rule method of simulating labour market transitions is biased, particularly in discrete models where some states are either sparsely or densely represented in the sample.[30] A second strategy is to respect the probabilistic form of the discrete model by basing the behavioural simulation directly on predicted state probabilities. For a simple two-state model this strategy is relatively straightforward. Suppose $\hat{p}_{i0}^B$ and $\hat{p}_{i1}^B$ represent predicted probabilities for two labour market states (of work or non-work, say) for the ith individual under some base system, B. Further, let $\hat{p}_{i0}^B$ and $\hat{p}_{i1}^B$ represent equivalent probabilities under a reformed tax system, R. The correct transitions probabilities are

$$P_{i(0 \to 0)} = \min\left\{ \hat{p}_{i0}^B, \hat{p}_{i0}^R \right\} \tag{33}$$

$$P_{i(0 \to 1)} = 1\left[\hat{p}_{i0}^B > \hat{p}_{i0}^R\right]\left(\hat{p}_{i0}^B - \hat{p}_{i0}^R\right) \tag{34}$$

$$P_{i(1 \to 0)} = 1\left[\hat{p}_{i0}^B < \hat{p}_{i0}^R\right]\left(\hat{p}_{i0}^R - \hat{p}_{i0}^B\right) \tag{35}$$

$$P_{i(1 \to 1)} = \min\left\{ \hat{p}_{i1}^B, \hat{p}_{i1}^R \right\} \tag{36}$$

In other words, it is necessary only to difference the two state probabilities in order to obtain a correct measure of the probability of transition. Only one of the off-diagonal transitions probabilities can be non-zero. However, it is difficult to extend these formulae to higher dimensional problems. Suppose, for example, that a

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[29] One might think, for example, of a reform to in-work support along the lines of the US EITC (see Sholz 1996) or the new WFTC in the UK (see HM Treasury (1998)).

[30] see Duncan and Weeks (1998).

matrix of transitions probabilities for a five-state labour supply model is required. The conditional integrals which underpin the formulations (33) to (36) become practically insoluble in multiple dimensions. It is tempting to form a matrix of transition probabilities simply using the arithmetic product of predicted state probabilities pre-and post-reform. Hence, for example, $\hat{p}_{i0}^{B}\hat{p}_{i0}^{R}$ would become the joint probability that state 0 is chosen both before and after the reform. However, this formulation is incorrect because it assumes inappropriately that the probabilities are independent. A way of extending (33) to (36) to higher dimensions is by the following computationally time-consuming method.

Apply resampling methods to draw repeated realisations of the stochastic elements of the discrete choice model (which, in the case of Duncan and Giles (1998) or Keane and Moffitt (1998) would involve draws from Type I Extreme Value and Multivariate Normal distributions for, respectively, state specific errors and random taste parameters).

Apply the so-called "maximum probability" rule to allocate each individual to the most probable state following each random draw. Averaging these resampled transitions frequencies to arrive at a simulated version of (33) to (36) in higher dimensions.

2.5.3 AN EXAMPLE: MODELLING THE IMPACT OF TAX CREDITS IN THE UK

The system of in-work support currently in place in the UK is known as Family Credit (FC), and is designed to provide support for low wage families with children who are working. Once someone in a family with children works more than 16 hours a week, they become eligible for FC. Each family is potentially eligible to a maximum amount, depending on the number of children in the household and a small addition if they work full time. Currently, the maximum level of FC comprises a weekly adult credit of £48.80 and child credits starting at £12.35 per child for children under 11. This maximum amount is payable if the family's net income (after income tax and National Insurance Contributions) is lower than a threshold (£79.00 per week in 1998-1999). Net income in excess of this threshold reduces entitlement to FC from the maximum by 70p for every £1 of excess income.

As a topical illustration of the method of discrete behavioural microsimulation, we summarise the results of a recent study into the incentive impact of a proposal to replace Family Credit with a new Working Families Tax Credit (WFTC).[31] The WFTC will
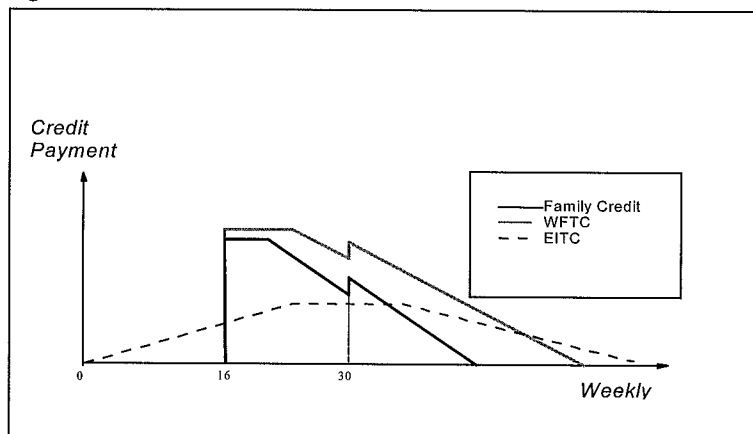
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[31] The UK government announced in the March 1998 Budget that Family Credit was to be replaced by a new income tax credit to be known as the Working Families Tax Credit (WFTC). The WFTC can be summarised as a more generous version of FC with an altered method of payment. A full discussion of the work incentive impact of WFTC can be found in Duncan and Giles (1998b).

increase the generosity of in-work support relative to the FC system in three ways,[32] through
1. an increase in the credit for children under 11 from £12.35 to £14.85 per child;
2. an increase in the threshold from £79 to £90 per week;
3. a reduction in the taper from 70 to 55 per cent.

A stylised comparison of the structure of WFTC with FC is shown in Figure 2.6.

Figure 2.6

Simulated Responses to the WFTC

Tables 2.2 to 2.4 report simulations for single parent households, women with employed partners and women with unemployed partners. These results are presented in the form of a matrix of simulated transitions between non-participation (NP), discouraged workers (DW), and hours' ranges 1-10, 11-20, 21-30 and 31-40 using the resampling method of discrete behavioural microsimulation described in the previous section. We see no offsetting movements out of the labour market. To take account of sampling variability, a standard error of 0.42 per cent simulated around this figure, which would admit the possibility that the actual increase could be as much as 3 per cent.

Among one-parent households (see Table 2.2), the most common simulated transition takes around 2.2 per cent of the sample from no work to either part-time or full-time work to take advantage of the increased generosity of WFTC at part-time hours. We see no offsetting movements out of the labour market. To take account of sampling variability, a standard error of 0.42 per cent simulated around this figure, which would admit the possibility - that the actual increase could be as much as 3 per cent.

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[32] Although there will be an additional childcare tax credit of up to £105 per week for those who pay for some form of formal childcare.

For married women the simulated incentive effect is quite different. Table 2.3 presents results which suggest a significant overall reduction in the number of women in work of around 0.57 per cent, equating to a grossed-up figure of around 20,000 in the population. This overall reduction comprises around 0.2 per cent who move into the labour market following the reform, and 0.8 per cent who move from work to non-participation. The predominant negative response is clearly not one that is intended, and stems from a proportion of non-working women whose low earning partners will be eligible for the WFTC. The greater generosity of the tax credit relative to the current system of Family Credit increases household income. This increase in income would be lost if the woman in the household were to work. And for those women currently in the labour market, the WFTC increases the income available to the household if she were to stop working.

Table 2.4 reports a predominantly positive work incentive response to the WFTC among women whose partners do not work. The rationalisation of this result is the same as for the single parent group.

Table 2.2: Simulated Response to WFTC Reform: One-parent Households

Pre-Reform	NP*	DW**	Post-Reform				Row Percentage
			1-10	11-20	21-30	31-40	
NP*	29.66	1.81					31.47
DW**		26.53		0.68	0.81	0.71	28.73
1-10			8.56	0.11	0.15	0.14	8.96
11-20				9.93	0.10	0.11	10.14
21-30				0.05	9.62	0.03	9.70
31-40				0.11	0.06	10.84	11.01
Col. Perc.				10.87	10.73	11.84	100

Notes:: cell entries represent percentages. Transitions tables are built by drawing 100 times from the distribution of unobserved heterogeneity and allocating each observation to the cell which yields maximum utility for each draw. Standard deviations for each transitions cell and summary measure are simulated by drawing 100 times from the estimated asymptotic distribution of the parameter estimates, and for each of those 100 parameter draws, applying the method described above to build transitions matrices.
* Non-participation.
** Discouraged Worker.

Table 2.3: Simulated Response to WFTC: Women in Couples (partner employed)

Pre-Reform	NP*	DW**	Post-Reform				Row Percentage
			1-10	11-20	21-30	31-40	
NP*	22.24	0.17					22.41
DW**	0.54	9.29	0.04	0.06	0.06	0.04	10.03
1-10		0.14	15.26	0.02	0.01	0.11	15.45
11-20		0.19	0.02	16.32	0.01	0.11	16.55
21-30		0.22	0.03	0.01	17.11	0.03	17.38
31-40		0.22	0.04	0.03	0.01	17.90	18.19
Col.Perc.	22.79	10.23	15.39	16.45	17.20	17.95	100

Notes:: as for Table 2.2.

Table 2.4: Simulated Response to WFTC: Women in Couples (partner unemployed)

Pre-Reform	NP*	DW**	Post-Reform 1-10	11-20	21-30	31-40	Row Percentage
NP*	37.39	1.09					38.49
DW**	0.02	18.27	0.01	0.40	0.50	0.43	19.61
1-10			12.86	0.09	0.14	0.10	13.19
11-20				9.26	0.05	0.06	9.38
21-30				0.01	8.81	0.03	8.86
31-40		0.01		0.12	0.03	10.32	10.47
Col. Perc.	37.41	19.37	12.87	9.88	9.53	10.93	100

Notes: as for Table 2.2.

2.5.4 ACCOUNTING FOR PREFERENCE HETEROGENEITY IN SIMULATION

When examining the labour supply effects of a change in the tax and transfer system, it may sometimes be convenient to ensure that the pre-change optimal choice of each individual, given the estimated labour supply function, correspond to the choice actually made. This is particularly the case when the analysis of a policy reform invites a comparison of static and behavioural costings and distributional results. However, the parameters of the labour supply function are expressed as functions of a wide range of individual and demographic characteristics. The values assigned to a particular type of person are based on the conditional expected values, so there is no guarantee that the optimal choice of any individual of that type corresponds to the actual choice. The required correspondence can be obtained by interpreting any difference between observed and predicted hours under an incumbent tax system as individual random preference heterogeneity, and factoring this term back into the underlying preference structure as an individual-specific parameter. This is obviously a strong assumption, given the range of reasons for a difference between observed and predicted behaviour. However, it provides a useful benchmark against which more sophisticated stochastic structures might be compared. Moreover, the manner by which such correspondence can be brought about depends on whether the method of behavioural simulation is continuous or discrete.[33]

[33] Blundell, Meghir, Symons, and Walker (1986) describe a method to calibrate hours in continuous behavioural microsimulation. For discussion of the problems of calibration in discrete microsimulation, see Duncan and Weeks (1998).

2.6 Simulating Welfare Changes

Since each individual's expenditure function, $\mu(w,U)$, is obtained as part of the process of determining optimal labour supply, "exact" measures of welfare change resulting from a tax change can be calculated in a relatively straightforward way.[34] This is because welfare changes are defined directly in terms of expenditure functions.

A change in the net wage rate, resulting from a tax change, affects both the effective price of leisure and the value of virtual income. Welfare changes are therefore more complicated than in the context of a price change for a standard commodity.

2.6.1 EQUIVALENT VARIATIONS

Consider a change in the tax system such that the net wage and the value of virtual income for an individual change from w^0 and μ^0 to w^1 and μ^1. The equivalent variation, EV is given by

$$EV = \left\{ \mu\left(w^{},U^1\right) - \mu\left(w^0,U^1\right) \right\} + \left\{ \mu^0 - \mu^1 \right\} \tag{37}$$

The absolute value of the first term in curly brackets in the above expression corresponds to an area to the left of a Hicksian (compensated) leisure demand curve between appropriate "prices", and clearly $\mu\left(w^1,U^1\right) = \mu^1$. As mentioned above, the expenditure function and hence the equivalent variation could alternatively be expressed in terms of full income, $M = \mu + wT$, rather than the non-wage income, μ where, as before, T is the individual's total endowment of time. The equivalent variation in (37) is expressed such that it is positive for a welfare loss. The dead-weight loss arising from the tax structure change is thus the sum over all individuals of the equivalent variations, less the increase in aggregate tax revenue.

Consider the use of the labour supply function given by (8). Suppose that the pre-change optimal position for an individual is at a tangency position on a section of the budget constraint having a net wage and virtual income of w^0 and μ^0 respectively. These values can easily be substituted into the indirect utility function, (13) in order to obtain the pre-change utility level, $U^0 = V\left(w^0, \mu^0\right)$. This tangency position is illustrated in Figure 2.7. If a change in the tax and transfer system causes the individual to move to another tangency position, associated with a net wage and virtual income of w^1 and μ^1 respectively, then $U^1 = V\left(w^1, \mu^1\right)$.

The calculation of the equivalent variation involves substituting w^0 and U^1 into the expenditure function given by (12) to get $\mu\left(w^0, U^1\right)$. Hence the equivalent variation can easily be obtained

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[34] Each individual has a unique expenditure function in view of the adjustment of the constant term, described above.
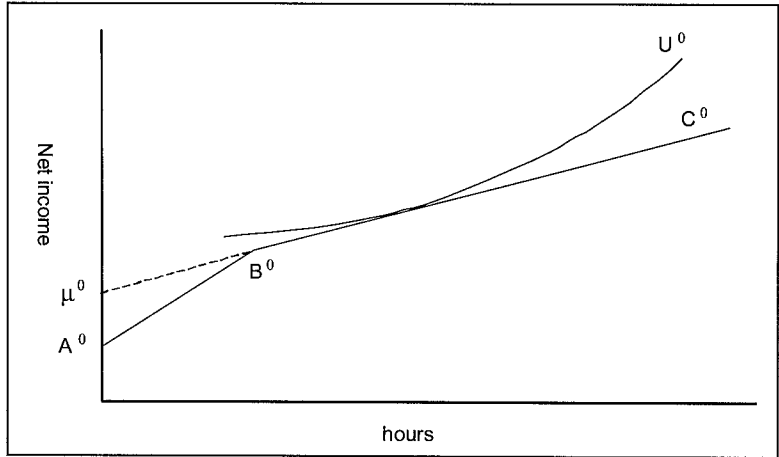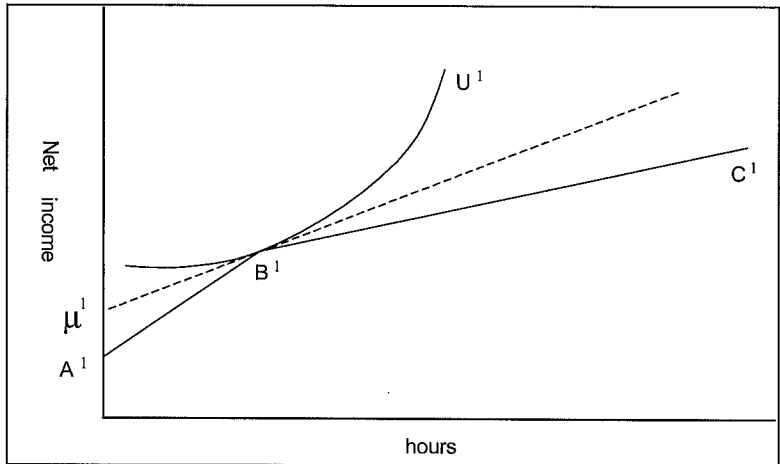
Figure 2.7

Figure 2.8

from (37). Alternatively, suppose that the change in the tax and transfer system causes the individual to move to a corner solution, for example the point B^1 in Figure 2.8. This could occur from an increase in the marginal tax rate over the range.

It is then necessary to compute the virtual wage and income w^1 and μ^1 which define a linear budget constraint that would place the individual at B^1 as a tangency solution. It is then possible to proceed as before, by obtaining $U^1 = V(w^1, \mu^1)$ and substituting w^0 and U^1 into the expenditure function (12), to get $\mu(w^0, U^1)$. Finally, the equivalent variation is obtained from (37).

An important implication of this example is that *any* tax change that places the individual at point B^1 has the same effect on the equivalent variation. For example, further changes in the particular

marginal tax rate that affects just the slope of the section B^1C^1 have no effect, so long as the corner remains fixed and is the optimal position.[35] This is because the virtual wage and income do not change.

However, a change to a marginal tax rate that applies to lower income ranges affects the position of the kink, B^1 which in turn causes the virtual income and virtual wage to change. Such a change may simply cause the point B^1 to shift upwards or downwards, and so may leave labour supply unchanged. The method of computing equivalent variations in cases where the individual is initially at a corner solution follows the same kind of procedure as described above, except that the initial utility level is not actually required.

However, all the values of virtual incomes and wages required for the evaluation of welfare changes will typically already have been computed as part of the process of working out the individual's optimal labour supply. Thus the welfare changes can be obtained at very little extra cost.

2.6.2 SOCIAL EVALUATIONS

Using the procedures described above, a behavioural microsimulation model can be used to evaluate the detailed welfare effects on each different household of a policy change. In some cases, it may be required to provide an overall evaluation of a change in the tax structure. Such an evaluation can be carried out using a specified social welfare function that reflects explicit value judgements. In "static" models, the welfare function is often based on incomes, although in view of the allowance for labour supply behaviour, it may be desired to allow for the utility from leisure. In some cases, social welfare functions are specified in terms of utilities; this is usual in optimal tax studies. It should be recognised that the results may depend on the particular cardinalisation of the utility function that is used.

It has also been suggested that welfare functions can be expressed in terms of money metric utility, defined as the value of income, m_e, which, at some reference set of prices, p_r gives the same utility as the actual income. In terms of the indirect utility function, m_e is therefore defined by the equation

$$V(p_r, m_e) = V(p, m) \qquad (38)$$

Using the expenditure or cost function gives

$$m_e = E(p_r, V(p, m)) \qquad (39)$$

[35] This would not be true of compensating variations, which require the expenditure function to be evaluated for w^1 and U^0.

This may be written as $m_e = F(p_r, p, m)$. The use of such a money metric was explored in detail by King (1983), who called m_e "equivalent income" and F the equivalent income function. An advantage of the equivalent income concept is that comparisons are made using a fixed set of reference prices, and it does not depend on the cardinalisation of utility functions used. In the special case where pre-reform prices are used as reference prices, then $m_e^1 = m^1 - EV$ where the superscript refers to the post-change value.

The effect on a specified social welfare or evaluation function of a change in prices and incomes can be measured in terms of a change in the distribution of equivalent incomes. Values of the social welfare function can be calculated for a population group using a complete distribution of values of m_e^0 and m_e^1 so that, according to the value judgements implicit in the welfare function, a change can be judged in terms of its overall effect.

Instead of starting with an explicit form of the social welfare function, an initial analysis might, for example, first examine the generalised Lorenz curves for the distributions of m_e^0 and m_e^1 to see if standard "dominance" results apply; for a statement of the various dominance conditions available, see Lambert (1993). These give comparisons of social welfare involving a minimum of assumptions about the precise form of welfare function. If these results do not provide a complete ordering of the distributions, then fully specified welfare functions can be evaluated using the distribution of equivalent incomes. Consider, for example, the use of a social welfare function defined in terms of equivalent incomes, such that welfare per person, W is given by

$$W = \frac{1}{N} \sum_{i=1}^{N} \frac{m_{e,i}^{1-e}}{1-e} \qquad (40)$$

where e is the degree of constant relative inequality aversion of the judge. This has the abbreviated form, expressed in terms of the arithmetic mean, $\overline{m}_e$, and Atkinson's inequality measure, I_A of equivalent income, given by

$$W = \overline{m}_e(1 - I_A) \qquad (41)$$

This conveniently reflects the trade-off between mean equivalent income and its equality, or what is often referred to as the trade-off between "equity and efficiency", that the judge finds acceptable. Alternative forms of the welfare function may of course be used. For example, welfare rationales are available for the use of (41) along with the Gini inequality measure or extended Gini

measure substituted for the Atkinson inequality measure.[36] In practice it would be useful to examine the implications of adopting a range of value judgements.

A potential difficulty with this approach arises from the fact that the equivalent income function is not guaranteed to be concave, leading to the problem that its use in a social welfare function could lead the latter to favour disequalising transfers. This was investigated in detail by Blackorby and Donaldson (1988), who showed that concavity requires quasi homotheticity.[37] Blackorby, Laisney and Schmachtenberg (1994) also showed that welfare prescriptions using this approach are not necessarily independent of the reference prices used.

2.7 Conclusion

The aim of this paper was to provide an introduction to behavioural microsimulation modelling. Alternative methods of simulating labour supply responses to changes in direct taxes and benefits were discussed, concentrating on those factors which influence the choice of a continuous or a discrete mode of estimation or simulation. The ease with which fixed costs, child-related costs and incomplete programme participation may be factored into the microsimulation process formed a major criterion.

It was suggested that, for estimation, the structural discrete choice approach developed by Keane and Moffitt (1998) offers the greatest potential for behavioural microsimulation. In particular, the Keane-Moffitt method allows for the direct estimation of preference functions in a manner consistent with the presence of taxes and incomplete welfare programme participation. The model easily extends to household preference structures, as for example in van Soest (1995). Their model may also be augmented along the lines suggested in Callan and van Soest (1996) to impute a fixed costs component in estimation. This is a highly desirable extension to the basic method, since it avoids the corner-solution or reservation wage characterisation of non-participation which represented a major problem with previous microsimulation methods. A second reason for favouring this style of model specification is that, despite estimating the model as a discrete choice, one may equally well apply discrete or continuous microsimulation techniques using the same underlying preference structure.

Stochastic elements in the econometric specification may be factored into the behavioural microsimulation in a number of ways. For continuous microsimulation methods the model may be calibrated to replicate observed behaviour under the assumption that errors may be interpreted as random preference heterogeneity.

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[36] On alternative abbreviated welfare functions, see Lambert (1993).

[37] Homothetic utility functions are positive monotonic transformations of linear homogeneous utility functions for which $U(\theta_x) = \theta U(x)$.

For discrete methods of microsimulation a similar calibration may be achieved with suitable draws from the conditional distribution of stochastic elements in the model specification.

These recent developments have provided fresh impetus to the development of realistic and accurate behavioural microsimulation methods, particularly at the point of non-participation. This opens the way for detailed and authentic analysis of policy reform options at the micro level.

REFERENCES

BINGLEY, P., and I. WALKER, 1997. "Labour Supply, Unemployment and Participation in In-work Transfer Programmes", *Economic Journal*, Vol. 107, pp. 1375-1390.

BLACKORBY, C., and D. DONALDSON, 1988. "Money Metric Utility: a Harmless Normalisation?" *Journal of Economic Theory*, Vol. 46, pp.120-129.

BLACKORBY, C., F. LAISNEY, and R. SCHMACHTENBERG, 1994. "Ethically Consistent Welfare Prescriptions are Reference Price Independent", in R. Blundell, I. Preston and I. Walker (eds.), *The Measurement of Household Welfare,* pp. 247-264, Cambridge: Cambridge University Press.

BLUNDELL R., A. DUNCAN, and C. MEGHIR, 1992. "Taxation in Empirical Labour Supply Models: Lone Mothers in the UK", *Economic Journal*, Vol. 102, pp. 265-78.

BLUNDELL R., A. DUNCAN, and C. MEGHIR, 1998. "Estimating Labour Responses Using Tax Reforms", *Econometrica*, Vol. 66, pp. 872-862.

BLUNDELL, R., J. HAM, and C. MEGHIR, 1987. "Unemployment and Female Labour Supply", *Economic Journal*, Vol. 97, pp. 44-64.

BLUNDELL, R.,W., and I. WALKER, 1986. "A Life Cycle Consistent Empirical Model of Labour Supply Using Cross Section Data", *Review of Economic Studies*, Vol. 53, pp. 539-558.

CALLAN, T., and A. van SOEST, 1996. "Family Labour Supply and Taxes in Ireland", Discussion paper, mimeo, Tilburg University.

COGAN, J., 1981. "Fixed Costs and Labour Supply", *Econometrica*, Vol. 49, pp. 945-964.

CREEDY, J., 1999. "Measuring Welfare Changes and the Excess Burden of Taxation", *Bulletin of Economic Research*, forthcoming.

CREEDY, J., and A. DUNCAN, 1999. "The Melbourne Institute Tax and Transfer Simulator", Discussion paper, University of Melbourne: Melbourne Institute.

DEATON, A. S., and J. MUELLBAUER, 1980. "Economics and Consumer", *Behaviour*, Cambridge: Cambridge University Press.

DUNCAN, A., and C. GILES, 1996. "Labour Supply Incentives and Recent Family Credit Reforms", *Economic Journal*, Vol. 106, pp. 142-155.

DUNCAN, A., and C. GILES, 1998a. "Alternatives to Family Credit: Tax Credits in the UK Context", in K. Pichelmann (ed.) *Taxation, In-Work Benefits and the Labour Market: An Analysis of Crucial Design Features*, Vienna: Institute for Advanced Studies (forthcoming).

DUNCAN, A., and C. GILES, 1998b. "The Labour Market Impact of the Working Families Tax Credit in the UK", paper presented to the 1998 International Institute for Public Finance Conference, Cordoba, Argentina.

DUNCAN, A., and G. STARK, 1995. A Recursive Algorithm to Calculate Piecewise Linear Budget Constraints", mimeograph, Institute for Fiscal Studies.

DUNCAN, A., and M. WEEKS, 1997. "Behavioural Tax Microsimulation with Finite Hours Choices", *European Economic Review*, Vol. 41, pp. 619-626.

DUNCAN, A., and M. WEEKS, 1998. "Simulating Transitions Using Discrete Choice Models", Proceedings of *The American Statistical Association*, Vol. 106, pp. 151-156.

GOURIEROUX, C., J. LAFFONT, and A. MONTFORT, 1980. "Coherency Conditions in Simultaneous Linear Equation Models with Endogenous Switching Regimes", *Econometrica*, Vol. 48, pp. 675-695.

HAUSE, J. C., 1975. "The Theory of Welfare Cost Measurement", *Journal of Political Economy*, Vol. 83, pp. 1145-1182.

HAUSMAN, J. A., 1981. "Exact Consumer's Surplus and Deadweight Loss", *American Economic Review*, Vol. 71, pp. 662-676.

HAUSMAN, J. A., 1985. "The Econometrics of Non-Linear Budget Sets", *Econometrica*, Vol 53, pp. 1255-1282.

HAUSMAN, J. A., and P.A. RUUD, 1984. "Family Labour Supply with Taxes", *American Economic Review*, Vol. 74, pp. 242-248.

HECKMAN, J. J., 1979. "Sample Selection Bias as a Specification Error", *Econometrica*, Vol. 47, pp. 153-161.

HECKMAN, J. J., 1993. "What Has Been Learned About Labour Supply in the Past 20 Years'", *American Economic Review*, Vol. 83, pp. 116-121.

HICKS, J. R., 1940. "The Valuation of the Social Income", *Economica*, Vol. 7, pp. 105-124.

HM TREASURY, 1998. "The Working Families Tax Credit and Work Incentives," *The Modernisation of Britain's Tax and Benefit System*, No. 3. London: HM Treasury.

HURWICZ, L., and H. UZAWA, 1971. "On the Integrability of Demand Functions", in. S. Chipman *et al.* (eds.), *Preferences, Utility and Demand,* pp. 174-214. New York: Harcourt Brace.

KEANE, M., 1995. "A New Idea for Welfare Reform", *Federal Reserve Bank of Minneapolis Quarterly Review*, Spring , pp. 2-28.

KEANE, M., and R. MOFFITT, 1997. "A Structural Model of Multiple Welfare Program Participation and Labour Supply", *International Economic Review* (forthcoming).

LAMBERT, P. J., 1993. *The Distribution and Redistribution of Income: A Mathematical Analysis*. Manchester: Manchester University Press.

MOFFITT, R., 1996. "The Econometrics of Piecewise – Linear Budget Constraints", *Journal of Business and Economic Statistics*, Vol. 4, pp. 317-328.

MOHRING, H., 1971. "Alternative Welfare Gain and Loss Measures", *Western Economic Journal*, Vol. 9, pp. 349-368.

MROZ, T. A., 1987. "The Sensitivity of an Empirical Model of Married Women's Hours of Work to Economic and Statistical Assumptions", *Econometrica*, Vol. 55, pp. 765-799.

SHOLZ, J., 1996. "In-work Benefit in the United States: the Earned Income Tax Credit," *Economic Journal*, Vol. 106, pp. 156-169.

STERN, N. H., 1986. "On the Specification of Labour Supply Functions", in R.W. Blundell and I. Walker (eds.), *Unemployment, Search and Labour Supply*, pp. 143-189. Cambridge: Cambridge University Press.

van SOEST, A., 1995. "Structural Models of Family Labour Supply", *Journal of Human Resources*, Vol. 30, No. 1, pp. 63-83.

3. FAMILY LABOUR SUPPLY AND PROPOSED TAX REFORMS IN THE NETHERLANDS

Arthur van Soest, Marcel Das

3.1 Introduction

This paper aims at analysing the effects of the proposed reform of the income tax rules in the Netherlands on labour supply of married or cohabiting couples. Static neo-classical models of labour supply which can be used to analyse tax reforms have been used by, for example, Hausman (1985), Hausman and Ruud (1984) and Moffitt (1986, 1990a). These models are fully structural, in the sense that they completely identify preferences of leisure versus consumption. They allow, in principle, for an analysis of the effects on labour supply of any permanent change in the tax rules. Moreover, participation and hours worked are jointly treated as the outcome of the same utility maximisation problem. This means that the effects on participation and the effects on hours worked can be jointly analysed. This makes these models a useful tool for policy analysis in spite of apparent drawbacks such as their static nature.[1]

In the traditional Hausman (1985) model for individual labour supply, and in the labour supply model for married couples in Hausman and Ruud (1984), the budget set is piece-wise linear and convex. The utility maximisation problem can be solved from the first order conditions using Lagrange multipliers. Using the dual approach, the empirical models in these articles use an explicit expression for the labour supply function and the indirect utility function. An easy algorithm to find the solution is available, which is guaranteed to converge if preferences are quasi-concave (see Blomquist, 1983). This approach has been applied fruitfully to analyse labour supply in many countries. See, for example, all six studies in Moffitt (1990b). Still, it has some drawbacks. First, solving

[1] See Blundell (1994) and Card (1994) for surveys of labour supply models in a dynamic (life cycle) context, and Heckman (1993) for a critical discussion of the state of this art.

the model becomes substantially more complicated if the budget set is not convex or piece-wise linear. In practice, this is an important limitation, due to, for example, fixed costs, benefits, tax allowances depending on whether the partner works or not, thresholds in social security premiums, etc. To account for non-convexities, either a restrictive functional form has to be used which allows for explicit expressions for both the direct and the indirect utility function, or *ad hoc* features are added to the model, for example explaining the choice between working and not working.

Second, quasi-concavity of preferences has to be imposed a priori. Together with functional form assumptions on the utility function, this implies that prior restrictions are imposed. For restrictive functional forms (such as a linear labour supply curve) this may mean that elasticities are to a large extent driven by these assumptions, instead of being the outcome of the estimations. See the discussion in MaCurdy *et al.* (1990).

These drawbacks can be overcome by approximating the choice set by a finite subset of its points. For example, the assumption that an individual can choose any number of working hours on the interval [0,80] (with corresponding net incomes), can be replaced by the assumption that the individual can only choose from {0,4,8,12,...,80} (with corresponding net incomes). The choice set then consists of 21 points instead of a continuum of points. The utility maximum can be obtained by comparing the 21 values of the (direct) utility function. This simply boils down to finding the maximum of 21 values. It does not require first order conditions, etc., and it does not rely on convexity or piece-wise linearity of the budget set or quasi-concavity of preferences. Models for individual labour supply with discrete choice sets have been used by, for example, Dickens and Lundberg (1993), Tummers and Woittiez (1991), and van Soest *et al.* (1990).

A discrete choice labour supply model for couples, with a stochastic specification similar to that of a multinomial logit model, has been introduced by van Soest (1995). Further refinements of this model, for example allowing for fixed costs of working, and using information on actual as well as desired hours of work, have been introduced in some subsequent papers, see for example Callan and van Soest (1996) and Euwals and van Soest (1999).

This discrete choice framework with multinomial logit type errors is also the basis of the current paper. We assume that the two spouses have a common utility function. We use a direct quadratic translog utility function with arguments, family income, leisure of the husband, and leisure of the wife. We allow for preference variation across households. This is achieved by making several parameters of the utility function dependent on characteristics such as age and family composition. We include separate error terms in the values of the utility function at all points of the choice set, with the same specification as in the multinomial logit model.

To explain why there are relatively few people with a part-time job, we incorporate fixed costs of work. These fixed costs are again allowed to depend upon observed and unobserved characteristics of the family and its members. We allow for different fixed costs functions for husbands and wives. The fixed costs are fully integrated in the structural model: they are subtracted from family income of workers, and thus enter the utility function through income. Increasing fixed costs will lower the income if working, and will thus make not working relatively more attractive compared to working assuming that utility increases with income.

We assume that before tax hourly wage rates do not vary with hours worked. This assumption is maintained in most of the neo-classical labour supply models, though there are exceptions, such as Moffitt (1984), Tummers and Woittiez (1991), and Ilmakunnas and Pudney (1990). Thus each individual has a unique before tax wage rate. Together with hours worked and the tax system, the before tax wage rate determines net earnings. A common problem in labour supply models with non-workers is that wage rates of non-workers are not observed. To account for this, a wage equation is estimated, and wage predictions are constructed for non-workers. Due to the non-linear nature of the labour supply model, however, replacing wage rates by their predictions leads to inconsistent estimates, even if the wage predictions themselves are unbiased. To account for this, wage rate prediction errors are explicitly incorporated in the model, as additional unobserved error terms.

The labour supply model is based upon the assumption that individuals or couples maximise (joint) utility, and thus aims at estimating preferences of those who supply labour. It is therefore estimated using information on desired hours of work, so that deviations between desired and actual hours of work − due to, for example, involuntary unemployment or a lack of part-time jobs − are allowed for.

The model is estimated on data from the 1995 wave of the Netherlands' Socio-Economic Panel, which, at least for our purposes, is representative of the Dutch population. To account for the various unobserved error terms, the model is estimated with smooth simulated maximum likelihood: the likelihood function is replaced by an approximation based upon simulation, and the simulated approximation of the likelihood is maximised. The estimator is asymptotically equivalent to exact maximum likelihood.

The results are used to set up a micro-simulation model for analysing the sensitivity of labour supply for financial incentives. First, participation rates and average hours worked are computed on the basis of the estimates and the actual wages and tax rules. Second, the simulation is repeated for different alternative scenarios. Increasing all wage rates of husbands or wives by the same percentage leads to estimates of own and cross wage elasticities of both spouses. The focus of the simulations is the analysis of labour supply effects of changing the income tax rules.

Proposals for substantial revisions of the tax system, including detailed plans for changing the income tax rules, have recently been published by the Dutch government (Ministry of Finance, 1997). These plans have played a major role in the recent policy debate at the time of the general elections of 1998. Currently, a revised and more specific version of these plans is proposed by the government. The proposals suggest, for example, to change tax free allowances and marginal tax rates in such a way that the income difference between working and not working would increase. This should help to stimulate participation and improve the working of the labour market. Moreover, several measures have been proposed which change the tax treatment of two earner versus one earner families. For women whose husbands work full-time, the current system creates a disincentive to work part-time or full-time, and thus it stimulates non-participation of married females. On the other hand, special treatment of married women who earn less than about one-third of the annual minimum wage for a full-time job, means that the current system does not create a disincentive for married women to work only a few hours per week. This feature is not shared by the proposed reform, which therefore makes small part-time jobs less attractive. Our discrete choice framework is particularly convenient to analyse the effects of this type of change, since it allows us to take account of the complete structure of the tax system. We disentangle the effect on the number of people who want small part-time jobs, large part-time jobs, and full-time jobs, and also look at the consequences for total labour supply.

The structure of this paper is as follows. In Section 3.2, we describe the data. The labour supply model is discussed in Section 3.3. In Section 3.4, we discuss the results and the labour supply elasticities. Section 3.5 briefly compares the actual (1998) tax system with the proposed reform which we want to analyse. In Section 3.6 we discuss the outcomes of our analysis of the labour supply effects of this reform. Section 3.7 concludes.

3.2 Data

The data are drawn from the Dutch Socio-Economic Panel (SEP). This is a panel consisting of about 5,000 households, which is representative for the Dutch population excluding people living in nursing homes, etc. We have used the wave drawn in May 1995. We focus on married or cohabiting couples in the age group 16-64. We classify the individuals into four groups according to their labour market status: not available (NA), voluntarily unemployed, involuntarily unemployed, and employed. The category NA consists of students; persons receiving full-time disability benefits; persons receiving pensions or other retirement benefits; and persons in mandatory military service. Labour supply of people in this category is not explained by our model. Their spouse's labour supply behaviour, however, is analysed. This explains why the

numbers of men and women in the SEP sample used in the analysis are different: 1,948 men, 2,069 women.

The group of employed individuals includes everybody with a paid job who is not in the category NA. It includes those with a part-time job looking for additional work. On the other hand, it excludes, for example, students with a job one day per week, who are in category NA. The distinction between involuntary and voluntary unemployment is based upon sample information on search behaviour. The requirement for involuntary unemployment is that an individual claims to be seriously looking for work, or has applied for a job at least once in the past two months. For people in involuntary unemployment, desired hours of work are positive, for those in voluntary unemployment, they are zero.

Earnings in the SEP are measured as gross earnings in the year 1994, retrieved from the respondents' tax files. These earnings can only be used to compute an hourly wage rate for the job held at the time in the survey in May 1995 for people who have not changed jobs in 1994 or from January 1995 until May 1995. For those who did change jobs in that period, earnings are set to missing.

The sample contains information on actual as well as desired hours worked. Desired hours of workers are based upon the survey question "How many hours per week would you like to work, for your current hourly wage?" In SEP 1995, this is only asked if respondents are considering changing jobs, however. For those who are not looking for another job, it is assumed that desired hours are equal to actual hours. Job searchers are simply asked how many hours they would like to work.

Table 3.1 presents some sample characteristics for the men and women in our sample. Since we have excluded students and disabled people and focus on couples, the employment and unemployment rates cannot be compared to the commonly published figures. The sample participation rate of men is quite large, and involuntary unemployment is very low. Non-participation among married women in the Netherlands is still substantial, but has fallen substantially during the past two decades. The positive differences between means of desired and actual hours are due to involuntary unemployment.

3.3 Model

We present a static neo-classical structural labour supply model. The framework is similar to that of Van Soest (1995). We only consider people with a spouse (married or cohabiting). They are assumed to maximise a joint utility function for the couple, taking account of their own and their spouse's leisure, and of family income.

3.3.1 UTILITY

We specify a direct utility function in which utility depends on one's own working hours (h), on total net income (y), and on working hours of the partner (hp). Net income includes asset income, the partner's income and child allowances, but earnings of other household members are excluded. The model would be consistent with utility maximisation in a life cycle framework with intertemporally additive preference if y could be replaced by total expenditures (see Blundell and Walker, 1986). Due to lack of data on consumption expenditures, however, we could not do this.

Table 3.1: Sample Statistics

		Men	Women
Age	Mean	41.1	40.0
Education Level	Lower	25.4 %	41.1 %
	Intermediate	47.6 %	40.3 %
	Higher	24.6 %	15.9 %
	Unknown	2.4 %	2.7 %
Gross Wage Rate (dfl. per hour)	Mean	31.51	23.64
Actual Number of Hours Worked (per week)	Mean	39.63	14.13
Desired Number of Hours Worked (per week)	Mean	40.05	15.37
Labour Market Status	Employed	93.7 %	59.2 %
	Involuntarily Unemployed	2.6 %	6.4 %
	Voluntarily Unemployed	3.7 %	34.4 %
Nch0-18 (number of children, aged 0-18years)	Mean	1.16	1.08
D ch0-5 (Dummy Children 0 –5 years)		27.3 %	25.5 %
Child Allowance	Mean	49.56 %	46.77 %
Total		1,948	2,069

Note: Married and cohabiting people only (age group 16-64). Those who are not available for the labour market (students, disabled, retired) are excluded.

We take the direct utility function quadratic in logarithms:[2]

$$U(v) = v^1 A v + b^1, \quad v = (\log y, \log(80 - h), \log(80 - hp))^1 \qquad (1)$$

Without any restrictions on the parameters, this utility function is locally second order flexible. In principle there is no reason to prefer this utility function to any other direct utility function with the same (or larger) flexibility. We impose parameter restrictions to guarantee that utility decreases with h and hp and increases with income.[3] We do not impose quasi-concavity of preferences, and thus avoid the critique by MaCurdy *et al.* (1990).

The time endowment is fixed and set equal to 80 hours per week.[4] We follow the bulk of the labour supply literature, in which the difference between the time endowment and hours worked is usually called leisure time, but actually comprises an aggregate of all time use categories except for paid work.

A is a 3x3 matrix of unknown parameters and b is a three-dimensional vector. We assume that b_2 and b_3 depend on individual or household characteristics, i.e., we allow for variation of preferences across the sample through observed characteristics: $b_k = X'\beta_k$, $k=2,3$, where X are observed characteristics (age of husband and wife, number of children, dummy for the presence of children younger than 6). We also included unobserved characteristics (reflecting unobserved heterogeneity of preferences), but the variance of the corresponding error term was estimated to be zero.

Husband and wife are assumed to maximise the same utility function, although, of course, in our notation, hours (h) of one spouse are hours of the partner (hp) for the other. The labour supply decision is thus modelled at the household level, as in, for example, Hausman and Ruud (1984) and van Soest (1995). A more general framework would be a game theoretic model with different utility functions for the two spouses (see Kooreman and Kapteyn, 1990, for example). The intra household decision making process, however, is beyond the purpose of the current paper.

3.3.2 CONSTRAINTS

The answer to the question: "how many hours would you like to work?" is based upon utility maximisation under constraints. An obvious constraint is the budget restriction: to each choice of the number of working hours of husband and wife corresponds a different net income. Moreover, we assume that respondents take the actual working hours of their partner as given.

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[2] For notational convenience, the index for the household is dropped.

[3] Vlasblom (1998) avoids this by using a CES utility function. This function, however, has fewer parameters and is therefore not second order locally flexible without parameter restrictions.

[4] We experimented with different time endowments but this led to smaller values of the likelihood.

To determine net income as a function of working hours, the following is required: net earnings; earnings of the partner; other household income (child benefits, asset income); potential unemployment assistance and other social security benefits. Income of the partner and other household income are usually observed. To determine net own earnings for each number of working hours, we assume that the gross hourly wage rate does not depend on hours worked (see Section 3.1). For workers with observed wage rate, we can then compute net earnings for each possible number of working hours. For non-workers, we need to predict the before tax wage rate. For this purpose, we have estimated wage equations for males and females, accounting for selection bias in the usual way (see Heckman, 1979). The estimates of the wage equation are then used to predict the wages of non-workers. Because the labour supply model is non-linear in wages, it is necessary to take the wage rate prediction errors into account for consistent estimation of the labour supply model.

To determine social security benefits in case of working few or zero hours, we incorporate the basic system of unemployment assistance only. This is relatively easy to model: according to the Dutch social security system, all families are entitled to financial assistance if family income falls below the minimum standard of living, which depends on age, marital status and family composition (we ignore the fact that these unemployment assistance benefits are means tested). We do not model unemployment insurance benefits. This is difficult to model due to lack of data and due to the static nature of our framework — unemployment insurance benefits are of a temporary nature. Following van Soest (1995), the budget constraint under which the individual maximises utility will be approximated by a finite number of points. There is some discussion in the literature in how to choose the number of points. Earlier studies such as Moffitt (1986) and Ilmakunnas and Pudney (1990) have used only three points for each individual (not working, working full-time, and working part-time). This has computational advantages. Moreover, hours' distributions are usually of a peaked nature, and using few points might reduce the potential bias due to rounding errors made by people reporting their hours of work. On the other hand, using few points introduces rounding errors as well, since observed hours are rounded off to one of the few points. More importantly for our purposes, the more points are included, the more detail of the budget set will be captured. This becomes particularly relevant if, due to tax and benefits rules, the budget set is non-convex and irregular. On the other hand, where irregularities in the budget sets occur typically depends on income and not on hours. Due to variation in wage rates, therefore, choosing fixed hours' points may lead to missing the irregularities for some people, but will include them for others with different wages. Thus for the aggregate results, working with very many points does not seem necessary. We,

therefore, will work with more than just a few points, and analyse the sensitivity of the results for the chosen number of points.

In the benchmark model, we take multiples of 6 hours and work with 10 possible numbers of hours worked for each individual: 0,6,...,54. For given hours of the partner, each choice of h corresponds to some net family income y_j (j=0,...,9), where j=0 corresponds to 0 hours, j=1 corresponds to 6 hours, etc. In the sensitivity analysis, we will also discuss results based upon hours intervals of 4 or 8 hours.

The vectors appearing in the utility function are denoted by v_j:

$$v_j = (\log y_j, \log(80 - 6_j), \log(80 - hp))^1 \ (j = 0,...,9) \quad (2)$$

where hp denotes given actual hours worked by the partner. Maximising utility- for given actual hours of the partner-now boils down to choosing the best point out of a set of ten points. First order conditions etc. are not required; the choice is discrete.

3.3.3 ERROR TERMS

The utility function in (1) does not give room for an error term. We introduce error terms as follows

$$u(v_j) = U(v_j) + \varepsilon_j \quad (3)$$

We assume that the ε_j are iid and follow an extreme value distribution. When he or she answers the desired hours' question, the individual is assumed to choose $j \in \{0,...,9\}$ such that $u(v_j)$ is maximised. Due to the ε_j this is not always the same j for which $U(v_j)$ is optimal. The ε_j can be interpreted as alternative specific utilities, or as errors in evaluating each alternative. They play a role similar to the optimisation errors in the Hausman (1985) model. As explained above, the empirical model we present does not allow for random preferences. Incorporating random preferences by adding an error term to the parameters of the utility function did not improve the model significantly.

Due to the assumption on the distribution of the ε_j, the resulting model is very similar to the multinomial logit model. The probability that an individual chooses alternative j, conditional on the wage, potential benefits, exogenous variables, and the partner's number of hours worked, is given by

$$P[j] = \exp\{U(v_j)\} / \sum_{k=0}^{9} \exp\{U(v_k)\} \ (j = 0,...,9) \quad (4)$$

P[j] increases with $U(v_j)$. Since U is increasing in income, the utility of working increases with the (before and after tax) wage rate. On the other hand, the utility of non-participation does not vary with the wage rate. As a consequence, the participation probability increases with the wage. On the other hand, the participation

probability decreases with the benefits level: a higher benefits level increases $U(v_0)$ but does not affect utility values of the alternatives where working hours are so large that benefit income is zero.

3.3.4 FIXED COSTS OF WORKING

The model described so far appears to underpredict the number of non-workers substantially. A possible explanation is that there are fixed costs for working. In other words, there is an extra gain to not working compared to all the other possibilities, which makes not working relatively more attractive than working few hours per week. The level of the fixed costs may depend on individual and household characteristics Z. We model them loglinearly: $\log FC_k = Z'\alpha_k$, $k=2$ (husband) and $k=3$ (wife).[5] In computing the values of the utility function, we now replace $\log y_j$ by $\log y_j - \log FC_2$ if according to this alternative the husband works, by $\log y_j - \log FC_3$ if only the wife works, and by $\log y_j - \log FC_2 - \log FC_3$ if, for alternative j, both $h>0$ and $hp>0$. Since U is increasing with income, positive fixed costs decrease the utility of working but do not affect the utility of not working. They thus make working less attractive, and decrease the probability of participation.

Fixed costs are not incorporated in van Soest (1995), who, instead, uses disutilities of part-time jobs to model the lack of part-time jobs. The fixed costs approach is more in line with economic models of labour supply. It was introduced earlier in this framework by Euwals and van Soest (1999) and Callan and van Soest (1996). Another possibility to explain the lack of part-time jobs is to model the availability of part-time jobs using job offer probabilities. This implies that the choice set varies across households, with a common probability distribution for all households in the sample. This approach is followed by Dickens and Lundberg (1993), Woittiez and Tummers (1991), and van Soest *et al.* (1990).

3.3.5 ESTIMATION

We estimate the model using all observations in the sample except those who are not available for the labour market (NA, see Section 3.2). For those in voluntary unemployment, desired hours are zero; for those who work or are involuntarily unemployed, desired hours are positive.

Due to the multinomial logit nature of the model, estimation by maximum likelihood would be straightforward if all wages were observed. As explained above, unobserved wages are replaced by predictions. Prediction errors will be substantial and should properly be taken into account. This can be achieved by integrating out the disturbance term of the wage equation in the likelihood. This, however, becomes computationally burdensome, particularly

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[5] We also added an unobserved heterogeneity term here, but (like random pr eferences added to b_2 and b_3) this did not significantly improve the model.

if the wage of a working spouse is unobserved and the unknown error term is bivariate. Instead, we approximate the integral by a simulated mean. For each individual whose wage is unknown, we take R draws from the distribution of the error term(s) in the wage equation(s), and compute the average of the R likelihood values, conditional upon the drawn error. This estimator is a special case of smooth simulated maximum likelihood. It is asymptotically equivalent to maximum likelihood, provided that R tends to infinity at a fast enough rate with the number of observations. See, for instance, Hajivassiliou and Ruud (1994). The results we present are based upon $R=10$. In the sensitivity analysis, we also looked at $R=5$.

3.4 Results

The parameter estimates are shown in Table 3.2. The upper panel refers to the terms in the utility function.[6] An index m denotes the husband and f denotes the wife. A positive coefficient on one of the interactions with leisure (i.e. one of the β-s in b_2 and b_3) implies a positive effect on the marginal utility of leisure and thus a negative effect on labour supply. For both spouses, age is significant, and the age pattern of desired hours is decreasing, particularly for older individuals. The presence of children has a strong negative effect on the wife's labour supply. For the husband, however, the presence of older children significantly stimulates labour supply. The presence of young children (aged 0-5) reduces labour supply of both spouses significantly, though the effect is stronger for women than for men.

Fixed costs of working depend on the presence of children and on age and education level of husband and wife. Estimated fixed costs appear to be positive for all individuals in the sample. For women, fixed costs decrease significantly with education level. This may suggest that fixed costs should be interpreted in a broad sense: they may also reflect immaterial or psychological costs or benefits. Women with high education level may find it rewarding to have a (relatively attractive) job, which partly compensates their material fixed costs. Still, also for the high educated women, fixed costs remain significantly positive. For men, the education level pattern is less clear: some educational dummies are significant, but the pattern is not monotonic. While age of the woman does not change her fixed costs significantly, fixed costs of men do increase with age. As expected, fixed costs for females increase significantly if there are young children. Surprisingly, however, the presence of older children has the opposite effect, and is significant for both men and women.

[6] The coefficient of $(\log y)^2$ was insignificant and imprecise, and we therefore set it to zero.

Table 3.2: Estimation Results

Variable	Estimation	T-Value
$\log(80 - h_m)^2$	-2.910	-14.3
$\log(80 - h_f)^2$	-3.174	-7.9
$\log(y) \log(80 - h_m)$	0.845	7.5
$\log(y) \log(80 - h_f)$	-0.297	-2.2
$\log(80 - h_m) \log(80 - h_m)$	0.832	7.6
$\log(y)$	4.457	3.0
$\log(80 - h_m)$	83.658	4.4
$\log(80 - h_m) \log(age_m)$	-43.549	-4.2
$\log(80 - h_m) \log(age_m)^2$	6.114	4.3
$\log(80 - h_m)$ nch0-18	-0.255	-2.7
$\log(80 - h_m)$ d ch0-5	0.663	2.6
$\log(80 - h_f)$	121.933	6.8
$\log(80 - h_f) \log(age_f)$	-58.738	-5.8
$\log(80 - h_f) \log(age_f)^2$	9.020	6.4
$\log(80 - h_f)$ nch 0-18	1.482	11.0
$\log(80 - h_f)$ d ch 0-5	1.999	5.6
Fixed Costs – Men		
Constant	-1.308	-3.8
$\log(age_m)$	0.421	4.8
nch0-18	-0.071	-2.8
d ch0-5	0.082	1.2
d opl2$_m$	-0.148	-3.1
d opl3$_m$	-0.103	-2.4
d opl4$_m$	0.047	0.9
d opl5$_m$	0.077	1.3
d opl6$_m$	0.105	1.5
Fixed Costs - Women		
Constant	0.008	0.05
$\log(age_f)$	0.047	1.2
nch0-18	-0.022	-2.8
d ch0-5	0.068	3.0
d opl2$_f$	0.006	0.4
d opl3$_f$	-0.052	-3.0
d opl4$_f$	-0.099	-4.3
d opl5$_f$	-0.196	-2.9
d opl6$_f$	0.028	0.6

3.4.1 ELASTICITIES

The estimates do not directly reveal the sensitivity of labour supply for the wage rates. For this purpose, simulations are necessary to compute elasticities. The elasticities vary across the sample. Since we want to use the model for policy analysis, we are interested in aggregate elasticities. We define the (own or cross) wage elasticity of labour supply of some given group of people (husbands or wives) as the percentage change in total desired hours of that group if all before tax wage rates (of husbands or wives) in that group rise by 1 per cent. Although this comes close to some definitions used elsewhere, it is not the same. Many studies only consider the elasticities for the average ("representative") family. In a highly non-linear model like ours, these elasticities are not very informative for the consequences of wage changes for a heterogeneous population. Others consider average elasticities

instead of elasticities of the average, thus giving more weight to people with lower desired hours. Moreover, some people look at elasticities of hours worked conditional upon participation. We take full account of the (positive) impact of the wage rate on the participation decision (with desired hours equal to zero for non-participants). Actually, most of the sensitivity of labour supply for wage rates is, according to our results, driven by changes in the decision to participate. Finally, elasticity calculations vary with the way in which the tax system is accounted for. We change all gross wage rates by 1 per cent and leave the tax system unaffected. The way in which net wage rates change is endogenous. On average, they will change by slightly less than 1 per cent due to the progressive nature of the tax rules.

For men, we find a positive own wage elasticity of 0.082. For women, the estimate is 0.705. This is well in line with another recent finding for the Netherlands of Vlasblom (1998), who finds an elasticity of 0.59 for married women, using a similar methodology.

On the other hand, Grift (1998) finds much larger elasticities for married women, with values between 2 and 3. She uses the same data as Vlasblom (1998) but a very different type of model (a censored regression model, with endogenous after tax wage rates instrumented). Theeuwes (1988) already pointed at the vast range of the empirical findings of labour supply elasticities for the Netherlands, which is not out of line with findings in other countries (see Killingsworth and Heckman, 1986).

We find cross wage elasticities of -0.064 for men and -0.358 for women. Thus, if all wage rates of both men and women would rise, we would predict a very small positive change for labour supply of men (0.082-0.064=0.018 per cent) and a positive change of 0.347 per cent for women.

We have also looked at elasticities for several subpopulations. Of particular interest from a policy point of view is labour supply of the low educated women, since their participation rates are lower and their unemployment rates are higher than for other women. In general, we find that the supply of labour for the low educated is more sensitive for wage rate changes than for the high educated. For example, for low educated married women, we find an own wage elasticity of 0.928, compared to 0.705 for the whole population of married women. Their cross-wage elasticity is –0.430, compared to -0.358 for all married women.

3.4.2 SENSITIVITY CHECK

We have checked the precision of our estimates in two different ways. First, we have computed confidence intervals, maintaining the assumption that the model is correctly specified. The methodology is the same as in van Soest (1995): we have drawn parameters from the estimated (normal) asymptotic distribution of the estimator, and have computed the elasticities for a large

number of drawn parameter vectors. This gives the estimated distribution of the estimates of the elasticities.

For the own wage elasticities of all men and women, we find 90 per cent confidence intervals of [0.069;0.101] and [0.671;0.739], respectively. For the cross wage elasticities, the intervals are [-0.070; -0.061] and [-0.396; -0.319]. These results suggest that the estimates are quite precise.

Second, we have re-estimated the model after changing certain features of its specification. Of particular interest, for example, is the robustness of the results for the number of points in the discrete choice set. While the estimates in Table 3.2 are based upon hours intervals of length 6 (h=0,6,...,54), we have also estimated the model for 4 (h=0,...,56) and 8 (h=0,...,56) hours' intervals. This has some effect on the elasticities, but the effect is not dramatic. See Table 3.3.

Table 3.3: Results of the Sensitivity Analysis

Parameters in the Estimation	Parameters in the Simulation	Men		Women	
		Wage man + 10 per cent	Wage woman +10 per cent	Wage man + 10 per cent	Wage woman +10 per cent
IL=6,R=10	IL=6,R=10	0.82	-0.64	-3.58	7.05
	IL=4,R=10	0.69	-0.64	-3.21	6.48
	IL=8,R=10	0.90	-0.70	-3.92	7.56
	IL=6,R=5	1.09	-0.66	-4.26	8.03
IL=6,R=10	IL=6,R=10	0.82	-0.64	3.58	7.05
IL=4,R=10		1.01	-0.67	-3.84	8.47
IL=8,R=10		0.62	-0.62	-3.37	6.60
IL=6,R=5		0.83	-0.63	-3.51	6.99

Note:
IL = interval length.
IL = 4 means h is chosen from {0,4,8,...,56}
IL = 6 means h is chosen from {0,6,12,...,56}
IL = 8 means h is chosen from {0,8,16,...,56}

Instead of changing the number of points in the choice set during estimation, we have also looked at the same changes in the simulations needed to compute the elasticities. Again, Table 3.3 shows that the elasticities do not change much. Moreover, we have changed R, the number of draws per observation used in our simulated maximum likelihood procedure, from 10 to 5. This affects some of the elasticities, but again, not dramatically. It suggests that R=10 is enough to get reasonably reliable estimates. All in all, we can conclude that our results are reasonably robust for the considered details of the specification. Still, the range of the elasticities in Table 3.3 exceeds the confidence intervals for the benchmark model reported above. This suggests that such confidence intervals – which take the model specification as given – tend to underestimate the uncertainty of the policy relevant outcomes.

3.5 Income Tax Reforms

We first describe the main features of the current Dutch income tax system for married couples (with or without children). The exact numbers refer to 1998. Next, we discuss the main changes proposed by the government. We do not discuss deductibles, health insurance premiums, employee's insurances, etc., since these are not incorporated in our empirical model. We also do not discuss rules for elderly people, retirement income, lone parents, singles, etc., since this is irrelevant for the sample at hand.

3.5.1 ACTUAL INCOME TAX RULES

There is individual taxation for the two spouses: each spouse is taxed for his or her own income. Since the revision in 1990, there are four tax brackets, with marginal rates 0 per cent, 36.35 per cent,[7] 50 per cent, and 60 per cent. The second and third bracket are of fixed length (Dfl 47,000 and Dfl 56,000), the length of the tax free bracket, however, depends upon earnings of the spouse. If both spouses work and both earn more than Dfl 8,600, then the tax free allowance for both is Dfl 8,600. If the wife has no own income, the husband's tax free allowance is Dfl 16,800, i.e., the wife's tax free allowance is largely transferred to the husband. If the husband earns more than Dfl 8,600, but the wife earns less than Dfl 8,600, the wife can (and, in general, will) transfer her allowance to the husband, so that her own tax free allowance is Dfl 400 and her husband's allowance will be Dfl 16,800. The same rules apply if husband and wife are interchanged.

These rules for the tax free allowance give the income tax rules some feature of a joint system. The transfer possibility creates a disincentive for the woman to earn more than Dfl 8,600 if the husbands earnings are high. This is revealed by the solid curves in Figures 3.1 and 3.2, which depict net family income as a function of the wife's hours of work. The before tax hourly wage rate of the wife is set equal to 150 per cent of the minimum wage rate. The husband's earnings are equal to the minimum wage for a full-time worker (Figure 3.1) and 300 per cent of the minimum wage of a full-time worker (Figure 3.2). The dip in both solid curves is reached when the wife's earnings attain the maximum transfer threshold. The dip is more serious for the case where the husband's earnings are larger, since in that case the difference between the wife's and the husband's marginal income tax rate is largest.

3.5.2 "TAXES IN THE 21ST CENTURY: AN EXPLORATIVE ANALYSIS"

In the recent report "Taxes in the 21st Century: an Explorative Analysis" (Ministry of Finance, 1997), the main ideas are sketched for a complete reform of many features of the tax system. The main proposals refer to increasing taxes on polluting activities, changing

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[7] This also includes premiums for national insurances.

some of the VAT rates, and reducing taxes on labour. The latter should mainly be achieved through a revision of the income tax rules. The report contains 21 proposals for income tax revisions. Many of these do not have far reaching consequences for marginal tax rates on earnings. Some only involve small changes in marginal rates or bracket lengths, and leave the system of tax free allowances unaffected.[8] In some others, the tax free allowances are replaced by tax cuts. [9] The third type of change in the proposal is the most far reaching: tax free allowances for two earner families are abolished.[10] In all basic proposals, additional tax revenues are used to lower the marginal tax rates, so that the revision as a whole (also accounting for changes in other taxes) would be revenue neutral. Apart from that, proposals are discussed in which tax revenues are lowered, and the government thus reduces the tax burden to stimulate the working of the labour market. In the current paper, we will focus on the basic version of the second type of change: replacing tax free allowances by tax cuts, with adjustment of marginal tax rates. Such a type of revision is currently proposed and will be discussed in parliament.

According to this proposal, the tax cut for the earner in a one earner family would become Dfl 6,282. As soon as there is a second earner, however, this would go down to Dfl 3,211, even if the second earner has very low earnings. (The second earner would also have a tax cut of Dfl. 3,211, at maximum.) Thus the possibility of transfer for incomes below some positive threshold disappears. This would change the disincentive to earn more than Dfl 8,600 into a disincentive to earn anything at all, and might thus discourage women with full-time working husbands from accepting a job with only few hours per week.

Figures 3.1, 3.2 and 3.3 illustrate this.[11] The dotted lines in Figures 3.1 and 3.2 refer to the revised system. Figure 3.3 shows the difference in net income between the revised and the actual system on a more detailed scale, corresponding to both Figure 3.1 and 3.2. For full-time working women (with full-time working husbands), the revision would be an improvement. This is in line with the government's intention that the revision should lower taxes on labour. For women with a small part-time job, however, the effect on household income would be negative.

We have checked in our sample, for how many two earners families the reform would imply a negative incentive for the woman to participate. We have computed the difference between family income given actual hours of husband and wife, and family income if the wife would stop working and the husband's hours

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[8] This holds for the proposals discussed in Option 1 in Ministry of Finance (1997).
[9] This is the basic version of Option 2 in Ministry of Finance (1997).
[10] This is the basic version of Option 3 in Ministry of Finance (1997).
[11] The proposal also implies that the first tax band is extended by Dfl 5,000, while the marginal tax rates for the three taxed income bands will be reduced to 34.1 per cent, 43.9 per cent and 56.2 per cent.

Figure 3.1: After Tax Family Income as a Function of the Hours Worked by the Wife. The Husband Earns the Minimum Wage
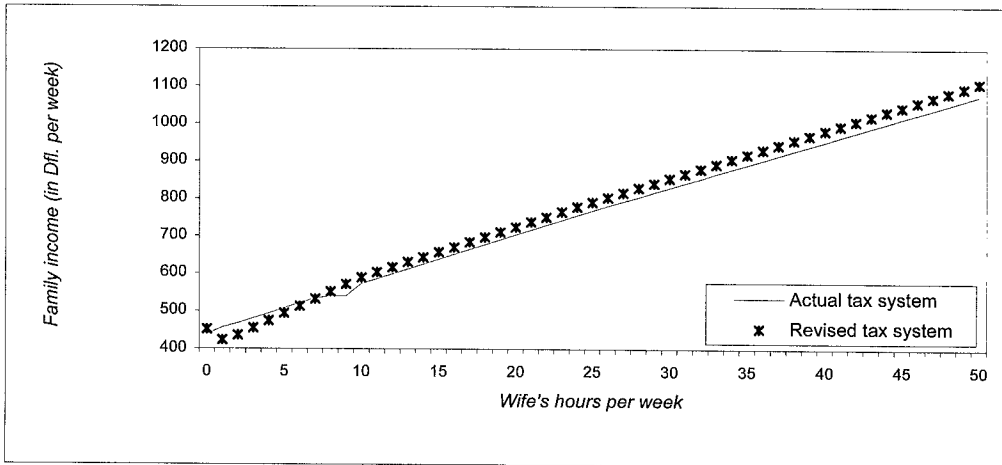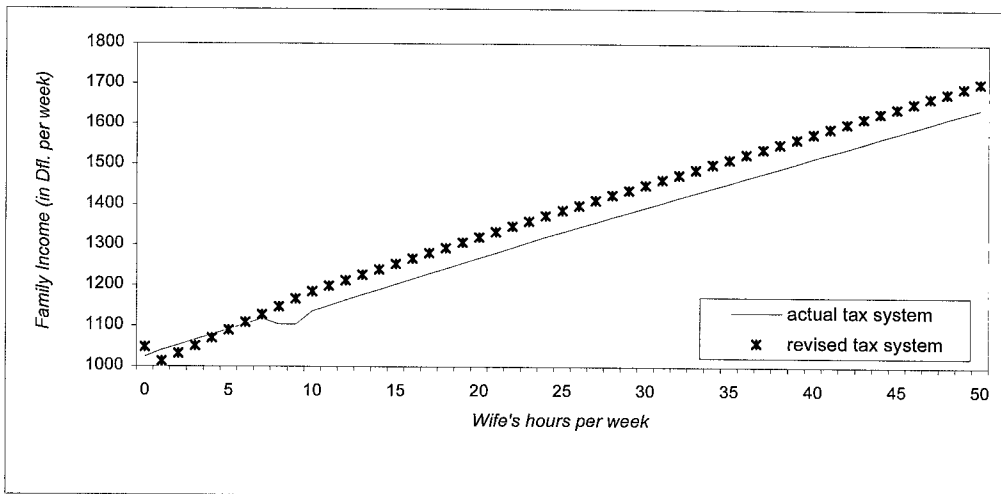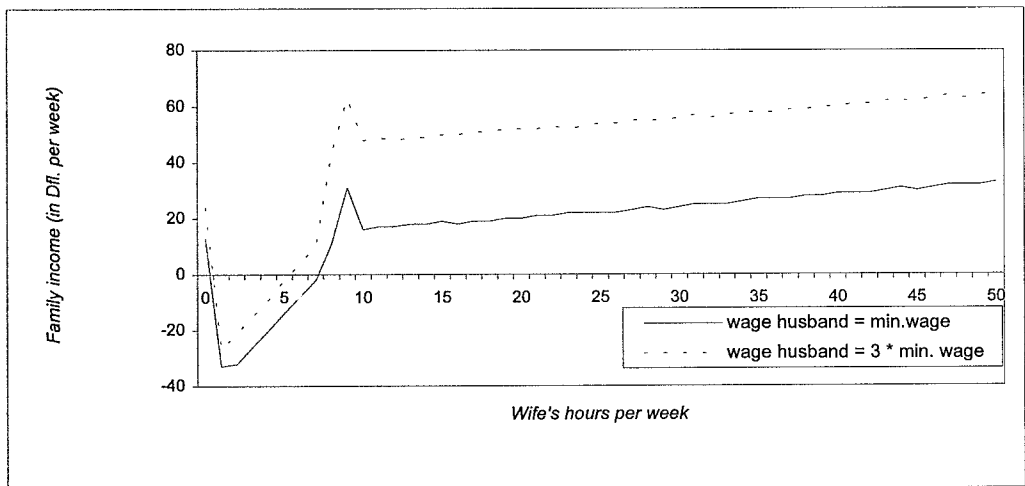

Figure 3.2: After Tax Family Income as a Function of the Hours Worked by the Wife. The Husband Earns Three Times the Minimum Wage

would remain the same. This difference can be seen as the marginal contribution of the wife to family income, reflecting the financial incentive for the wife to participate. We have computed it twice: according to the actual tax rules, and after the proposed reform. For about 11 per cent of all two earners families, the marginal contribution of the wife to family income would decrease. As expected from Figure 3.3, this mainly concerns women with low earnings who work part-time. This group also contains relatively many women with low education levels and low hourly earnings.

Of course the government is aware of this problem, and has announced that it may be necessary to tackle this in some way. Proposals for how to do so have not been worked out yet. One purpose of our analysis is to analyse what the (negative) labour supply effects would be if this problem is not tackled. In particular, women with a small part-time job are overrepresented in the health sector. Many women work about one day per week or less, helping out in private households with elderly, ill, or handicapped people. These women earn so little that they can transfer their tax free allowance to their husband in the current system. The Ministry of Health is concerned that many of these women will withdraw from the labour market if the tax revision proposal is carried out.

Figure 3.3: Difference Between Family Incomes Based on Tax System as a Function of the Hours Worked by the Wife

3.6 The Tax Reform and Labour Supply

In this section we analyse the first order labour supply effects of the tax reform proposal described above. Our structural model is particularly well suited for this, since it accounts for the complete structure of the tax system, including non-convexities like the kinks in the current tax system in Figures 3.1 and 3.2. Moreover, the model predicts the effects on participation as well as the effects on the distribution of hours worked.

The way in which the effects are predicted is very similar to the method of computing the elasticities in Section 3.4. Using the parameter estimates, we first predict labour supply using the actual tax rules. We then repeat the simulation using the tax rules according to the proposed reform. Comparing the two outcomes gives the predicted changes. For the simulation after the reform, we assume that before tax wage rates remain the same. Thus general equilibrium effects are not taken into account: we consider the first order effects only. Our results can in principle serve as input for a

macro-economic general equilibrium type of model based upon micro foundations.[12]

The results are presented in Table 3.4. The results for men are in line with the intentions of the reform. Men usually work full-time, and the reform is favourable for net earnings in full-time jobs. Thus labour supply effects for married men are positive: participation would rise by 0.20 per cent points, average desired hours would rise by 0.58 per cent (from 38.40 to 38.62). Fewer men would prefer a part-time job. However, all the effects for married men are small.

For married women, the effects would be larger, corresponding to women's larger sensitivity for financial incentives (see Section 3.4). The percentage of women with partner preferring a part-time job of less than 20 hours per week would fall from 32.05 per cent to 31.54 per cent. This reflects the negative income effects for small part-time jobs in Figure 3.3. About 1.29 per cent-points more women would prefer a job of at least 20 hours per week. Together, these two changes imply that participation would rise by 0.78 per cent-points. Labour supply of married women measured in hours would increase by about 3 per cent.

Table 3.4: Effects of the Tax Revision

	Men	Women
Participation (in per cent-points)	0.20	0.78
Average Hours (in per cent)	0.58	3.01
Part-time, < 20 hours (in per cent-points)	-0.18	-0.51
Part-time, ≥ 20 hours (in per cent-points)	-0.20	0.72
Full-Time (in per cent-points)	0.59	0.57

Thus we conclude that the macro-economic effect on labour supply will be positive, as is the intention of the government. But the effects are not uniform for all workers, and for some groups, negative effects are found. This implies that the reform may lead to undesirable effects in some sectors of the labour market where these groups are strongly represented, such as the health sector.

3.7 Conclusions

We have constructed a discrete choice structural labour supply model which is able to capture important features of household labour supply behaviour from a policy point of view: the model accounts for the full structure of the tax rules; it simultaneously

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[12] An example of such a model in the Netherlands is MIMIC, which is one of the main models used for policy analysis. See Gelauff and Graafland (1994).

captures the participation decision and the decision on hours worked, by allowing for fixed costs of work; it appropriately accounts for missing information on wage rates; it does not impose quasi-concavity of preferences and thus avoids the MaCurdy critique that elasticities are largely determined a priori. We have estimated the model using Dutch data and have obtained elasticities which are well in line with other recent findings, and are robust for changes in the specification. The usefulness of our approach is illustrated by applying it to analyse the possible first order labour supply effects of a recently proposed tax reform. Although this reform would have a positive effect on total labour supply, it would also imply a negative incentive for married women with a part-time job, and would therefore reduce the number of women who want to work less than 20 hours per week. This could have distortionary effects on segments of the labour market where women with a small part-time job are strongly represented, such as a large part of the health sector.

Although we hope to have shown that our discrete choice framework has clear advantages compared to the traditional neo-classical static labour supply model, we cannot claim that it has no limitations. These limitations are very similar to those of the traditional model. First, the model is static and is not consistent with a life cycle framework. It could be embedded in a life cycle model with reliable data on consumption expenditures on savings, but to make it a useful tool for policy analysis, it should then also be enriched with a model explaining intertemporal substitution and the impact of taxes on the marginal utility of life-time leisure. To our knowledge, no attempt has yet been made to analyse the impact of taxes in a complete life cycle framework. This seems an enormous task requiring much better (panel) data than the data we have used in the current paper.

Another limitation is the way in which we treat hours restrictions and involuntary unemployment. Although considering desired hours instead of actual hours can be seen as a step in the right direction, it is far from the ideal model. A simultaneous structural model for preferences and hours' restrictions could be seen as the ultimate goal. Again, however, we know of no study which attains this goal, although a study like Ilmakunnas and ·Pudney (1990) seems a promising step towards this.

Even within the static framework without demand side or institutional restrictions, a more general framework could be exploited. We have assumed joint utility maximisation of husband and wife. A more general alternative is the bargaining framework with separate utility functions for husband and wife, who then attain some game theoretic equilibrium allocation (see Kooreman and Kapteyn, 1990). Another way of extending the model is to disaggregate what we call "leisure" into a number of different categories of time allocation (see Apps and Rees, 1996). Similarly, what we call consumption could be disaggregated in several categories of commodities. Some work on these types of extensions

has been done, and it has been shown that ignoring them can lead to biased labour supply estimates, but using these models for analysis of tax policies etc. still seems a hardly explored research area. Provided that rich enough data become available, extending the discrete choice framework in these directions could be a promising direction of future research.

REFERENCES

APPS, P.F., and R. REES, 1996. "Labour Supply, Household Production and Intra-family Welfare Distribution," *Journal of Public Economics*, Vol. 90, pp. 199-219.

BLOMQUIST, N., 1983. "The Effect of Income Taxation on The Labour Supply of Married Men in Sweden," *Journal of Public Economics*, Vol. 22, pp. 169-197.

BLUNDELL, R., 1994. "Evaluating Structural Microeconometric Models of Labour Supply", in C. Sims (ed.), *Advances in Econometrics Sixth World Congress*, Vol. II, Cambridge: Cambridge University Press, pp. 3-48.

BLUNDELL, R., and I. WALKER, 1986. "A Life Cycle Consistent Empirical Model of Labour Supply Using Cross-Section Data", *Review of Economic Studies*, Vol. 53, pp. 539-558.

CALLAN, T., and A. van SOEST, 1996. "Family Labour Supply And Taxes in Ireland," mimeo, Tilburg University.

CARD, D., 1994. "Intertemporal Labour Supply: An Assessment", in , C. Sims (ed.), *Advances in Econometrics Sixth World Congress*, Vol. II, Cambridge: Cambridge University Press, pp. 49-80.

DICKENS, W., and S. LUNDBERG, 1993. "Hours Restrictions And Labor Supply," *International Economic Review,* Vol. 34, pp. 169-192.

EUWALS, R., and A. van SOEST, 1999. "Desired and Actual Labour Supply of Unmarried Men and Women in the Netherlands", *Labour Economics*, Vol. 6, pp. 95-118.

GELAUFF., G., and J. GRAAFLAND, 1994. "Modelling Welfare State Reform", Amsterdam: North-Holland.

GRIFT, Y., 1998. "Female Labour Supply: The Influence of Taxes And Social Premiums", PhD thesis, University of Utrecht.

HAJIVASSILIOU, H., and P. RUUD, 1994. "Classical Estimation Methods for LDV Models Using Simulation", in R.F. Engle and D.L. McFadden (eds), *Handbook of Econometrics*, Vol. IV, Amsterdam: North-Holland, pp. 2384-2443.

HAUSMAN, J., 1985. "The Econometrics of Nonlinear Budget Sets", Econometrica, Vol. 5, pp. 1255-1283.

HAUSMAN, J., and P. RUUD, 1984. "Family Labor Supply with Taxes, *American Economic Review,* Vol. 74, pp. 242-248.

HECKMAN, J., 1979. "Sample Selection Bias as a Specification Error, *Econometrica*, Vol. 47, pp. 153-161.

HECKMAN, J., 1993. "What Has Been Learned About Labor Supply in the Past Twenty Years?" *American Economic Review*, Vol. 83, pp. 116-121.

ILMAKUNNAS, S., and S. PUDNEY, 1990. "A Model of Female Labour Supply in the Presence of Hours Restrictions", *Journal of Public Economics*, Vol. 41, pp. 183-210.

KILLINGSWORTH, M., and J. HECKMAN, 1986. "Female Labor Supply: A Survey", in O. Ashenfelter and R. Layard (eds.), *Handbook of Labor Economics,* Vol. 1, Amsterdam: North-Holland.

KOOREMAN, P., and A. KAPTEYN, 1990. "On the Empirical Implementation of Some Game Theoretic Models Of Household Labor Supply, *Journal of Human Resources,* Vol. 25, pp. 584-598.

MaCURDY, T., D. GREEN, and H. PAARSCH, 1990. "Assessing Empirical Approaches for Analyzing Taxes and Labor Supply", *Journal of Human Resources,* Vol. 25, pp. 415-490.

MINISTRY OF FINANCE, 1997. "Belastingen in de 21-ste eeuw: een verkenning", The Hague.

MOFFITT, R., 1984. "Estimation of a Joint Wage-Hours Labor Supply Model", *Journal of Labor Economics,* Vol. 2, pp. 550-556.

MOFFITT, R., 1986. "The Econometrics of Piecewise Linear Budget Constraints: A Survey and Exposition of the Maximum Likelihood Method", *Journal of Business and Economic Statistics,* Vol. 4, pp. 317-327.

MOFFITT, R., 1990a. "The Econometrics of Kinked Budget Constraints", *Journal of Economic Perspectives,* Vol. 4, pp. 119-139.

MOFFITT, R., 1990b. "Special Issue on Taxation and Labor Supply in Industrial Countries", *Journal of Human Resources,* Vol. 25, pp. 313-558.

THEEUWES, J., 1988. "Arbeid en Belastingen, in Belastingheffing en Belastinghervorming, Koninklijke Vereniging voor Staathuishoudkunde", Stenfert Kroese, Leiden, pp. 111-143.

TUMMERS, M., and I. WOITTIEZ, 1991. "A Simultaneous Wage and Labour Supply Model with Hours Restrictions, *Journal of Human Resources,* Vol. 26, pp. 393-423.

van SOEST, A., I. WOITTIEZ and A. KAPTEYN, 1990. "Labour Supply, Income Taxes and Hours Restrictions in the Netherlands", *Journal of Human Resources,* Vol. 25, pp. 517-558.

van SOEST, A., 1995. "Discrete Choice Models of Family Labor Supply", *Journal of Human Resources,* Vol. 30, pp. 63-88.

VLASBLOM, J.D., 1998. Differences in Labour Supply and Income Of Women in the Netherlands and the Federal Republic of Germany", PhD thesis, University of Utrecht.

4. TAXES, TRANSFERS AND LABOUR MARKET RESPONSES IN IRELAND: WHERE DO WE GO FROM HERE?

Tim Callan, Aedín Doris and Brian Nolan

4.1 Introduction

The impact of taxes and transfers on labour market behaviour has long been of concern to policy makers in Ireland as elsewhere. In the 1980s and into the 1990s, this concern was fuelled by very high levels of unemployment and continuing outward migration. The macroeconomic environment is now very different. Total employment has risen rapidly, leading to a combination of substantial falls in unemployment and sizeable inward migration. Reductions in unemployment, and particularly in long-term unemployment, remain a priority, but new concerns about meeting emerging labour shortages have emerged more recently. In this changed environment the size and nature of labour market responses to tax and welfare policy changes continues to be a pressing policy issue in the Irish context. Tax-benefit simulation models incorporating behaviour have an important contribution to make in analysing these responses and framing policy, and the aim of this paper is to outline the current Irish position in this regard and point to directions for development.

By now, a significant body of international experience in the estimation and simulation of labour market responses has been accumulated. The other chapters in this volume deal with different aspects of this experience, and provide a very valuable base from which new Irish work in this area can depart. Among the lessons to be learned from this international experience we would highlight the following:

- It is not possible to simply take a simulation model developed elsewhere from "off the peg", as it were, and apply it in Ireland. Such a model has to be custom-built to a significant extent, to fit with the data available and the policy context in which one is operating.
- It is not sensible either to aim at one catch-all model taking into account all the complexities of tax and welfare systems, consistency across the life-cycle, family labour supply issues, involuntary unemployment, take-up of welfare programmes, and so on.
- As is so often the case, strategic simplifications have to be made if the research strategy is to prove fruitful, reflecting both the key questions on which the research decides to focus and the available data

What we aim to do in this chapter is set out the context in which these choices must be made, as one moves to the estimation and simulation of labour supply responses in Ireland. We describe in Section 4.2 the ESRI's static tax/benefit simulation model *SWITCH*, which provides an essential building-block towards simulation incorporating behavioural responses. Section 4.3 outlines briefly the main findings from research on labour supply behaviour in Ireland. In Section 4.4 we describe the main features of the Irish policy context. Section 4.5 then outlines the way forward and important strategic choices which have to be made, and in conclusion Section 4.6 summarises our main themes.

4.2 The *SWITCH* Tax-Benefit Model

It has long been clear that analysis of tax/welfare changes using selected hypothetical cases has severe limitations. It cannot provide an overall picture of the gains and losses associated with reform packages and may miss some important effects: a small number of selected households cannot adequately deal with the diversity of circumstances relevant to the tax and welfare situation of real households. Static tax-benefit models are thus needed to assess the first-round effects of changes to tax and social welfare policy, before behavioural responses are taken into account. *SWITCH*, the ESRI tax-benefit model (the acronym stands for *S*imulating *W*elfare and *I*ncome *T*ax *Ch*anges) has been developed to allow such analysis to be carried out for Ireland. Being based on a large-scale, nationally representative sample of actual households, it automatically takes account of the wide diversity of circumstances in the real population.

SWITCH is currently based on the Living in Ireland Survey, a large-scale nationally representative survey of households undertaken by the ESRI in 1994. The model database has been adjusted in ways which ensure that it adequately reflects changes in incomes, employment, unemployment and population since then – and draws on projections of such changes as far ahead as

2002 to provide a framework for medium-term analysis of budgetary issues. The model uses detailed information on individual and family circumstances (including information on wages and hours of work for those in paid employment, and on labour force status and receipt of social welfare benefits for those not in paid employment) to assess the social welfare entitlements and tax liabilities of each family in the database. The model can therefore simulate for each family the disposable income they would receive under actual policy, or under alternative policies of interest.

Using these detailed calculations it is possible to summarise the impact of policy changes in many different ways – how the average gain or loss varies depending on the income or composition of the family, for example. The model has been used to assess the static or first-round impact of various policy options and of policy changes actually implemented in recent years.[1] To move beyond first-round effects to simulation of the dynamic impact of policy changes, allowing for behavioural responses, one needs evidence about the scale and nature of these responses. In the next section we therefore briefly review what has been learned from microeconometric analysis of labour supply responses in Ireland.

4.3 Labour Supply Behaviour in Ireland

A central feature of labour supply behaviour in Ireland in comparative context is the relatively low rate of participation in the paid labour force by married women, particularly those with children. This has risen sharply in recent years but is still currently below the levels found in many other European Union countries. The other feature which would until recently have been to the fore was a very high rate of unemployment compared with other EU countries. Since 1994 unemployment has fallen very rapidly, but ILO-based measures of unemployment have fallen more than those based on a count of claimants for unemployment benefit or assistance, and significant numbers remain on State employment-creation schemes. The tax/welfare codes in combination continue to face a significant minority of the unemployed with high replacement rates, and tax rates facing married women can also be particularly high because of the fact that (until Budget 2000) there has been full transferability of personal allowances and rate bands between spouses. The impact of the tax and welfare systems on the labour supply behaviour of both married women and the unemployed, and the effects of potential reforms to those systems, thus remain of enormous interest.

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[1] For example, Kearney (ed.) (1999) examine the impact of tax and welfare policy changes over the 1987 to 1994 period on the income distribution and on work incentives. The analysis in Callan (ed.) (1998) and Kearney (ed.) (1999) points to the need for greater attention to the mechanisms used to uprate welfare payments, if the long-run goals of the National Anti-Poverty Strategy are to be met.

Early studies on this topic include Walsh and Whelan (1976). This study used data gathered in a special survey on women and employment in Ireland, and estimated linear probability models of employment versus non-employment for single and married (non-farm) women. The results suggested that for married women, the presence of children under four years of age, the lack of a third level education, and having a husband in a professional occupation all reduced the probability of employment. The study did not have reliable data on wages and non-employment income, and so could not estimate their impact on participation.

The large-scale household survey carried out by the ESRI in 1987 was one of the first to provide the type of microdata required for the analysis of labour supply for a representative sample of the population as a whole. Analyses using that survey, including Callan and Farrell (1991), Callan and Van Soest (1996), and Doris (1998), have provided useful insights into labour supply decisions, as have Murphy and Walsh (1996) using Labour Force Survey data. Callan and Farrell (1991) analysed the labour supply of married women. Their analysis incorporated models both of female participation[2] and of hours of work, and variables such as industry- and occupation-level unemployment rates were included to account for demand-side constraints in the labour market. The results showed a high wage elasticity of participation for Irish married women, of 2.7. The corresponding figure for men, estimated for the purpose of comparison, was positive but small at only 0.1-0.2. The results for the responsiveness of married women's hours of work, for those who were in paid employment, depended on the model used, but a small negative elasticity was regarded as the most reliable. Participation rates for those with children tended to be lower, even after controlling for other influences, but those women who were in paid employment and had young children tended to have somewhat higher hours of work. The analysis did not attempt to model in detail the impact of tax and welfare structures on the budget constraints facing individuals.

Doris (1998) also used the 1987 ESRI data to look at the labour supply behaviour of Irish married women, focusing on the choice between part-time work and full-time work and estimating two models. One models the choice between full-time and part-time work as a binomial one, where the choice is conditional on participation. (This is equivalent to a double-hurdle model, with independence between the participation and part-time/full-time decisions.) The second is a multinomial logit model of the choice made between four hours of work ranges and non-participation. The results show that own wage, husband's income, the number and ages of children, labour market experience and some

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[2] These participation models were estimated both with and without a wage variable; where a wage variable was included, missing wages were predicted using Heckman's method for correcting for sample selection bias.

occupational variables are the main determinants of the choice of hours range. Children have a stronger negative effect on the probability of working full-time than part-time.

Murphy and Walsh (1996) focus on male labour supply, using micro data from the 1993 Labour Force Survey. The distinction between non-participation and unemployment is emphasised, and non-employment, unemployment and non-participation are each modelled as probit equations. The results suggest that living in urban areas increases the probability of both unemployment and non-participation. Age increases the probability of unemployment, but the probability of non-participation decreases up to the late thirties and increases beyond this age. Married men are less likely to be non-participants and more likely to be unemployed. Men with more than five children are more likely to unemployed, higher levels of education reduce the probability of non-employment, and home ownership and renting in the private sector reduce the probability of non-employment. Since the Labour Force Survey does not include information on income, the direct influence of financial incentives could not be examined.

Callan and van Soest (1996) was the first study to look at labour supply responses for Ireland in the broad estimation and simulation framework on which this volume is focusing. It represented an adaptation of the basic van Soest (1995) model of family labour supply where the endogeneity of partners' labour supply decisions is taken into account. This basic model was extended to deal with involuntary unemployment through a double hurdle model, and to incorporate fixed costs of working. Using the 1987 ESRI data once again, aggregate own wage elasticities for women were found to be about 0.67, with the corresponding elasticity for men being 0.15. The participation elasticity for women is similar to the aggregate own wage elasticity.

This model was used to simulate the effect of a move from the 1987 Irish income tax system of "income-splitting" or fully transferable allowances between spouses to a system of fully independent taxation, in order to assess the maximum impact of a change in the tax treatment of couples. It was found that, on a revenue-neutral basis,[3] this change could lead to a rise in the employment rate of married women of close to 4 percentage points, with a negligible aggregate effect on male labour supply. A more limited change, retaining transferability of unused allowances, but removing transferability of rate bands, was also considered. This was estimated as leading to a rise in the married women's participation rate of about 1 percentage point. These results can be compared with the rise in the participation rate of married women from about 17 per cent in 1980 to around 45 per cent at present.

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[3] More precisely, the change was designed to be revenue neutral in the absence of behavioural changes.

Some initial work exploring labour supply issues has also been undertaken with more recent data. Callan and Doris (1999) use a more recent dataset, from the 1994 Living in Ireland Survey, to analyse participation decisions by Irish men and women via estimation of probit models. (The focus of this work was on the impact of the proposed national minimum wage, but the findings are also of more general interest.) Table 4.1 summarises the key results from the study, in terms of estimated elasticities of participation. These elasticities tell us the proportionate change in the participation rate that could be expected from a 1 percentage point rise in wage rates.

Table 4.1: Estimated Elasticities of Participation with Respect to the Wage Rate

All	Men	Single Women	Married Women	All Women
0.46	0.42	0.36	0.70	0.54

Source: Callan and Doris, 1999, Table 4.4.

Elasticities of participation are similar for men and for single women, but the highest responsiveness is still found among married women. The results suggest that the wage elasticity of participation of married women may have fallen significantly between 1987 and 1994. Further investigation is needed on this issue, but the rise in participation between 1987 to 1994 may itself be a part of the explanation. The results for men show a greater elasticity of participation than is usually found, as a result of allowing the effect to vary with education levels. Men with low levels of education were found to have very high wage elasticities, indicating that many of those classed as "not seeking work" would enter employment if the wage rate were sufficiently high. Men with second-level qualifications or higher, by contrast, are found to be relatively unresponsive to the wage rate, as they were likely to be in employment in any event.

These studies, while limited in number, nonetheless provide a point of departure for the analysis of tax and welfare changes in Ireland through simulation. We return below to the ways in which this evidence needs to be expanded, having first looked at the current policy context in which tax/transfer effects are being addressed in Ireland.

4.4 The Irish Policy Context

The core aim of the social welfare system, and of the tax system insofar as it interacts with it, is to provide a safety-net replacement income support for those without employment, while maintaining a financial incentive for them to become employed rather than remain dependent on welfare. This tension between providing an adequate level of support and maintaining work incentives has of course been recognised for as long as there has been organised income support. One therefore sees what are at root very much

the same issues resurface under different guises in different societies and at different points in time. In the Irish case, concern in the 1980s and into the 1990s focused primarily on unemployment and replacement rates, both in terms of the evolution of welfare levels *vis-à-vis* wages and the taxes levied on those on low earnings. High marginal income tax rates were also seen as contributing to continuing outward migration (and perhaps, with hindsight, to tax evasion). In the very different macroeconomic situation at the end of the 1990s, unemployment has fallen to low levels and substantial return migration has occurred. In this very different environment the nature of the tax and welfare policy reforms being debated has changed a good deal, but the importance of knowing how labour market behaviour is likely to respond to policy changes remains.

The specific areas on which attention has been focused may be briefly outlined. The first, which has also featured prominently in policy debates elsewhere in Europe, is the level and structure of direct taxes on labour through income taxes and social insurance. For about a decade efforts have been made to reduce marginal tax rates, and more recently an emphasis on reducing the taxes levied at low earnings levels has emerged. The proportion of earners paying at the top marginal tax rate remains very high, however, partly because the nettle of indexation of the parameters of the income tax system has not been fully grasped. Attempts to remove low-income families from the tax net via increasing exemption limits resulted in very high marginal rates for those just above the limits and this strategy is now in abeyance. A decision to move towards a system of tax credits, starting from 1999, marks a major structural reform. Reforms of the social insurance system have also attempted to reduce the burden on the low paid, though once again the result has exacerbated poverty traps for those in the region above the specified cut-offs.

The level and structure of unemployment compensation through weekly social welfare payments had been a major focus of attention, though with unemployment declining so rapidly this has receded somewhat. As gross earnings levels have accelerated, the gap between unemployment support and average or lower pay levels has widened without any need for the former to be reduced – indeed, income support levels have been increasing significantly ahead of prices. In addition, the scale of income tax reductions made possible by economic growth has widened the gap between net pay and income support even more. Further, additional payments for children of those depending on unemployment compensation have been frozen as resources have been channelled into universal Child Benefit – to which we return below – so replacement rates for those with families have also been pulled back. For all these reasons, concern about financial incentives facing the unemployed is now focused more on means-tested support other than the standard weekly payment, and on

specific issues relating to housing and childcare, to which we return shortly.

The treatment of couples by the tax and social welfare systems is an issue that has received some attention and is likely to assume increasing prominence. The social welfare system currently makes a payment for the "qualified adult" in a couple which is lower than that for a single adult, and pressures – both internal and at EU level – to move towards individualisation seem likely to grow.[4] As far as income tax is concerned, the system introduced in 1980 is at one extreme of an international spectrum in making available to married couples double the tax allowances and bands applicable to a single person. This contributes to the situation where single people and each earner in a two earner married couple face the top rate of tax at incomes close to the average industrial wage. The Budget for 2000, set out in December 1999, announced a three-year strategy for the individualisation of tax bands, to be phased in over three years, designed in part to deal with this issue.

One by-product of greater independence in the taxation treatment of couples would be that resources intended to benefit children could be channelled more directly through child benefit. The best way to assist families with children, particularly those on low incomes, has become entangled in recent policy debates with the thorny issue of childcare – the latter being an increasingly high-profile issue as more and more married women enter or remain in the paid labour force. Very different strategies have their fervent advocates, ranging from tax breaks, universal or targeted transfers to families, subsidies to childcare providers, and direct State provision, and a coherent approach by the State has yet to emerge.

Childcare issues loom particularly large for lone parents, and as the number of lone parents continues to grow various changes in state income support to this group have been implemented, with the aim of preventing long-term detachment from the labour market. More generally, the Family Income Supplement scheme for low-income employees with dependent children has also been amended and expanded on various occasions over the last decade to improve the incentive for this group to take up employment. Most recently, the basis for assessment of the level of payment to be received under the scheme, if any, has been changed from gross earnings to earnings after tax and social insurance contributions. No steps have been taken as yet to move towards administration of this scheme through the income tax system rather than as direct transfers, as has happened in the UK, but this may become an issue in the future. Concerns about the relatively low level of take-up of this benefit remain.

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[4] Budget 2000 announced that payment rates for qualified adults were to be raised from 60 per cent of the single adult rate to 70 per cent of that rate over a three year period.

In addition to childcare, the major concerns currently being articulated about disincentive effects facing the unemployed or low earners relate to support for the cost of housing and health care. State support for housing costs primarily comes through direct cash payments to those relying on social welfare for their weekly income, and the below-market rents charged by local authorities to low-income households living in public sector housing. As far as medical care is concerned, about the bottom one-third of the population has entitlement to full free medical care on a means-tested basis, with those above this income ceiling having to pay for their general practitioner and prescribed medicines, as well as some charges for hospital care. Both these forms of State support can contribute to actual or perceived disincentives in going from unemployment into a job or increasing earnings levels when employed. As a result, special provision has been made in recent years to ensure that someone going from long-term employment into employment retains full entitlement to free health-care for a period of years. The way in which families receive support for housing costs is however a growing concern as these costs rise rapidly and those in employment are seen to be disadvantaged compared with the unemployed, and this is an area where reforms appear inevitable.[5]

4.5 Where Do We Go From Here?

Against this background, what are the major gaps in knowledge about labour market responses to tax and welfare changes, and what is the best direction in which to develop analysis? The studies described in Section 4.3, together with the static microsimulation model described in Section 4.2, provide a point of departure for the analysis of tax and welfare changes in Ireland through simulation, but so far some important sub-groups have not been studied in depth. As well as investigating the responses of prime-aged males and married women in greater depth, much more needs to be learned about the responsiveness of lone parents to financial incentives, and there is little or no Irish evidence about the sensitivity of the timing of retirement to such incentives. Another serious gap is microeconometric analysis of the responsiveness of migrants to economic conditions (notably unemployment rates and net wages) in Ireland versus elsewhere.

Given such a body of evidence about labour market responses of the various sub-groups of interest, the next priority is to be able to simulate responses to changes of interest in tax and welfare policy. The availability of suitable micro-data is a critical constraint on both estimation and simulation, but the Irish situation in that regard is improving. As mentioned earlier, cross-section data from the 1994 Living in Ireland Survey, with adjustments for more

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[5] Budget 2000 announced that "tapering" arrangements (i.e., a system under which benefit is reduced rather than immediately withdrawn) would apply to those returning to work, as well as to those attending training courses or in part-time work.

recent developments using external information, is currently the basis for the static ESRI microsimulation model *SWITCH*. The Living in Ireland Survey has in fact been gathering panel data annually since 1994, which will open up the possibility of other estimation approaches exploiting the information on individual transitions over time. Data from the Household Budget Surveys carried out by the Central Statistics Office are also now released to researchers in the form of micro-data, with 1987 and 1994 currently available and a new budget survey being carried out in 1999/2000. The micro-data from what was the annual Labour Force Survey, now the Quarterly National Household Survey, is also now made available by the CSO, and in all these ways the available information on which analysts can draw has expanded considerably.

What then are key elements involved in developing the capacity to analyse tax/welfare changes through microsimulation incorporating behavioural responses? The first requirement is a micro-dataset with detailed information on labour market status, incomes from various sources, and demographic composition for a representative sample of Irish households. The second is a static microsimulation model with the capacity to simulate disposable income under alternative choices of hours for the current structure of tax and welfare, so that budget constraints can be modelled in sufficient detail to allow estimation of behavioural responses. Finally, given estimates of behavioural responses, one must then be able to simulate disposable incomes under alternative choices regarding employment and hours of work, for alternative policies.

While significant elements of the foundations for such a development are already in place, some important strategic choices must also be made at this point. The first is whether to model budget constraints as discrete versus continuous: does one seek to model labour supply choices along the entire spectrum of hours, or in discrete ranges? This choice in fact appears fairly straightforward at this stage, as a practical matter. While there is, of course, some loss of accuracy in characterising the budget constraint and hours options in terms of discrete packages, this approach allows much greater flexibility in a number of other key areas and is the one we intend to adopt.

A second choice which has to be made is how best to approach the individual versus familial nature of labour supply decisions. One option is to focus on individual labour supply decisions, with the income and hours worked of the spouse or partner taken as fixed. Another is to treat decisions about the labour supply of both partners as jointly produced by a unitary decision-making entity. Finally, one can explore what bargaining/collective choice approaches have to say about how such decisions are actually reached. Given that some of the key tax and welfare issues concern the treatment of couples, a family labour supply framework may represent the best compromise here. This does not make the restrictive assumption that husbands

make decisions taking their wife's labour supply as fixed and vice versa, but assumes the couple as a unit decide how to adjust their individual supply of labour.

The treatment of unemployment in labour supply models also raises complex choices. Some econometric approaches treat all unemployment as similar to non-participation; others adopt a more nuanced approach, treating those classified under ILO guidelines as "seeking work" as involuntarily unemployed. The best approach may depend in part on the available data. A new development in the Irish context is that the ESRI's 1994 Living in Ireland Survey contains information on desired hours of work for those currently in employment, as well as information on whether individuals who are currently not in employment are seeking work. More detailed work on unemployment duration, and its relationship to the balance between in-work and out-of-work income, would also be of interest.

4.6
Conclusions

Reform of the tax and social welfare systems continues to be a pressing policy issue in the Irish context. The ESRI's tax/benefit model *SWITCH* provides a basis for monitoring the incentives produced by the tax/welfare system for different individuals and families and how that is changing over time. To assess the dynamic impact of policy changes, however, the behavioural responses of different individual and households to such changes must also be taken into account. This requires robust and reliable evidence on key aspects of the different dimensions of labour supply decisions, such as choosing whether to enter the labour force and choices between part-time and full-time work. In particular, it is necessary to derive estimates of labour supply responsiveness which take into account the financial choices which the current tax and welfare system actually offers to a wide range of participants and potential participants in the labour market. This requires an estimation procedure which is linked to the sorts of calculations undertaken by static tax-benefit models.

Although a simulation model developed elsewhere cannot simply be taken and applied in Ireland, experience elsewhere in working towards this type of dynamic simulation is extremely instructive. It suggests, *inter alia*, it is not sensible to aim at one catch-all model taking into account all the complexities of tax and welfare systems, consistency across the life-cycle, family labour supply issues, involuntary unemployment, take-up of welfare programmes, and so on. Strategic simplifications have to be made if the research strategy is to prove fruitful, reflecting both the central questions on which the research is focusing and the available data. In this chapter some of the key choices involved and directions to be explored in future research have been outlined. Given the foundations already in place, further progress

towards simulation incorporating some key behavioural responses can be made.

REFERENCES

CALLAN, T., B. NOLAN, P. O'CONNELL, J.WALSH, R. NESTOR, 1998. "Income Tax and Social Welfare Policies", in. T. Callan (ed.), *Budget Perspectives*, Dublin: The Economic and Social Research Institute.

CALLAN, T., R. NESTOR, B. NOLAN, and J.WALSH, 1999. "Income Tax and Social Welfare Policies", in C. Kearney (ed.), *Budget Perspectives,* Dublin: The Economic and Social Research Institute.

CALLAN, T., and A. DORIS, 1999. "Labour Supply Responses", in *The Impact of the Minimum Wage in Ireland.* Final Report of the Inter Departmental Group of Implementation of National Minimum Wage, pp. 54-144, Dublin: Stationery Office.

CALLAN, T., and B. FARRELL, 1991. *Women's Participation in the Irish Labour Market,* Report No 91, Dublin: National Economic and Social Council.

CALLAN, T., and B. NOLAN, 1999. *Tax and Welfare Changes, Poverty and Work Incentives in Ireland, 1987-1994.* Policy Research Series No. 34, Dublin: The Economic and Social Research Institute.

CALLAN, T., and A. van SOEST, 1996. *Family Labour Supply and Taxes in Ireland.* ESRI Working Paper No. 78, Dublin: The Economic and Social Research Institute.

DORIS, A., 1998. *An Analysis of the Labour Supply Reactions of British Women to their Husband's Unemployment,* Florence: European University Institute.

MURPHY, A. and B. WALSH, 1996. "The Incidence of Male Non-employment in Ireland", *The Economic and Social Review*, Vol. 27, No. 5, pp. 467-490.

van SOEST, A., 1995. "Structural Models of Family Labor Supply: A Discrete Choice Approach", *Journal of Human Resources*, Vol. 30, pp. 63-88.

WALSH, B. M. and B. J. WHELAN, 1976. "A Micro-Economic Study of Earnings in Ireland", *The Economic and Social Review*, Vol. 7, No. 2, pp. 199-207.

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Final Report of the Inter-Departmental Group on Implementation of a National Minimum Wage, published by The Stationery Office (1999, B. Nolan, T. Callan, I. Kearney, J. Fitz Gerald, J. Williams, B. McCormick *et al.*, ISBN No. 0-7076-6787-9), IR£10.00, €12.70).

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