The Melbourne Institute Tax and Transfer Simulator (MITTS): a Behavioural Microsimulation Model

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ABSTRACT: This paper explains the approach of behavioural microsimulation modelling. It describes the Melbourne Institute Tax and Transfer Simulator (MITTS), which is an Australian behavioural microsimulation model that predicts labour supply responses arising from changes in income tax and social security policies. In addition to a few recent developments, some modelling extensions which are currently being developed are discussed.

1. INTRODUCTION

This paper provides a brief description of the Melbourne Institute Tax and Transfer Simulator (MITTS), a behavioural microsimulation model of direct tax and transfers in Australia. Tax policy design can be enhanced by the use of a behavioural tax microsimulation model capable of providing detailed ex ante evaluations of the effects of planned or actual tax reforms. Tax policy questions may relate to specific issues, concerning perhaps the revenue implications of a particular tax, or they may involve an extensive analysis of the cost and redistributive effects of a large number of taxes and transfer payments. The many complexities involved in examining tax issues force economists to produce a framework in which the various inter-relationships become more manageable and transparent. Hence the use of tax models is unavoidable. Small models help to provide useful general lessons and guiding principles for reform. However, specific analyses that can be directly related to practical policy questions and can provide direct inputs into policy debate require the construction of larger tax microsimulation models.

The distinguishing feature of microsimulation models is the use of a large cross-sectional dataset giving information about the characteristics of individuals and households, including their labour supply, earnings and (possibly) expenditure. Microsimulation models are therefore able to replicate closely the considerable degree of heterogeneity observed in the population. What distinguishes behavioural from static or non-behavioural microsimulation models is that the behavioural model estimates an individual’s response to policy changes. In our case, labour supply responses are predicted: that is, entering or exiting the labour market and increasing or decreasing the number of hours to work.

A behavioural microsimulation model estimating labour supply responses to policy changes consists of three components. The first, discussed in section 2, is an accounting or arithmetic microsimulation model, sometimes called a static model. This component imputes net household incomes for a representative sample of households, for both incumbent and counterfactual tax-benefit regimes.

The second component is a quantifiable behavioural model of individual tastes for net income and labour supply (or equivalently, non-work time), with which individuals' preferred labour supply under a given set of economic circumstances may be simulated. 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 of labour supply, between some base tax system and a counterfactual regime, forms the essence of behavioural microsimulation. These two components are described in section 3.

The MITTS model is then described briefly in section 4, where emphasis is placed on giving an informal explanation of the way in which labour supply variations are modelled in the behavioural component of MITTS. Although microsimulation models deal with a wide range of types of individual and household, it is useful to compare some aggregated measures regarding labour supply variations with those available from independent studies. Such comparisons are made in section 5.

Since the first version of MITTS was completed in 2000, it has undergone a range of substantial developments.[1] Indeed, any large-scale model requires constant maintenance (involving, for example, re-estimation of econometric relationships as new data and methods become available, or the introduction of new ways to make simulations more efficient), as well as enhancements such as the extension of "front end" and "back end" facilities. In section 6, this paper therefore also discusses some recent extensions and extensions, which are work in progress, such as the inclusion of welfare measurements or the inclusion of childcare use in the behavioural component of the microsimulation model.

2. NON-BEHAVIOURAL MICROSIMULATION

The majority of large-scale tax simulation models are non-behavioural or arithmetic. That is, no allowance is made for the possible effects of tax changes on individuals' consumption plans or labour supply. It is sometimes said that they provide information about the effects of tax changes on the

[1] A detailed description of this first version can be found in Creedy *et al.* (2002).

“morning after” the change. This section describes a typical arithmetic microsimulation model in subsection 2.1, followed by a discussion of the data required to build this type of model in subsection 2.2. This is followed in subsection 2.3 by discussion of an important component of any tax policy microsimulation model, the tax and transfer system.

2.1 A Typical Arithmetic Model

Advantages of non-behavioural models include the fact that they do not involve the need for estimation of econometric relationships, such as labour supply or commodity demand functions. They are relatively easy to use and quick to run. They can therefore be accessed by a wide range of users. Furthermore, in view of the fact that no econometric estimation is required, they retain the full extent of the heterogeneity contained in the survey data used.

When examining the effects of policy changes, these models generally rely on tabulations and associated graphs, for demographic groups, of the amounts of tax paid (and changes in tax) at various percentile income levels. The more sophisticated models have extensive “back end” facilities allowing computation of a range of distributional analyses and tax progressivity measures, along with social welfare function evaluations in terms of incomes.

Arithmetic models are typically used to generate profiles, again for various household types, of net income at a range of gross income levels. These profiles are useful for highlighting certain discontinuities, and are helpful when trying to redesign tax and transfer systems in order to overcome discontinuities and excessively high marginal tax rates over some income ranges.

2.2 The Data

The two large-scale household surveys in Australia that are potentially useful are the Household Expenditure Survey (HES) and the Survey of Income and Housing Costs (SIHC); both are collected by the Australian Bureau of Statistics (ABS). The former does not contain sufficient information about hours worked by individuals while the latter does not contain information about expenditure patterns. The SIHC is a representative sample of the Australian population, containing detailed information on labour supply and income from different sources, in addition to a variety of background characteristics of individuals and households. The measurement of income in the HES is known to be unreliable, so that in developing models for the analysis of direct taxes and transfer payments, it is not surprising that reliance has been placed on the SIHC. This means that it is not straightforward to include indirect tax in

Australian direct tax models.[2] The extension of models to cover consumption taxes would require some elaborate data merging.

When analysing actual or proposed policy changes, it is preferred to use data which are as close to the relevant time period as possible to avoid having a starting point that is too different from reality. Given the delays in the release of data by the ABS and the occasional changes in surveying frequency of the SIHC, this can be difficult to achieve. For example, when the effect of the tax and social security changes of July 2000 were first simulated in 2001, only 1997/1998 data were available. All financial information had to be updated to the relevant year; that is, the amounts of income in 1997/1998 were increased to reflect the corresponding July 2000 amounts. To update incomes, the Consumer Price Index is used, and to update wage rates, the average male and female wage indices are used. However, if the tax and social security system is substantially different in the year for which the data are obtained from the year for which a change needs to be simulated, the different incentives arising from the different tax and transfer systems in the two years might well have caused labour supply changes. To take this possibility into account, labour supply could be updated in the base dataset using the labour supply model underlying the behavioural microsimulation.

An alternative approach to deal with this issue is to run two behavioural simulations instead of one simulation and compare the pre-reform and post-reform systems via a common third system, which is to be used as the base system in both simulation runs. This third system has to be the system in place at the time the data were obtained. This approach was used for example in Buddelmeyer, Dawkins and Kalb (2004), where data from 2000/2001 were used to evaluate the 2004 system against alternative systems.

2.3 The Tax and Transfer System

Detailed knowledge of the tax and social security system is required to build a microsimulation model. This sometimes involves several government departments and the full details are rarely codified in accessible forms. Actual tax and transfer systems are typically extremely complex and contain a large number of taxes and benefits which, being designed and administered by different government departments, can be difficult to integrate fully. The complexity increases where several means-tested benefits are available, because of the existence of numerous eligibility requirements. It is only when a

[2] Indirect tax models for Australia include the Demand and Welfare Effects Simulator (DAWES) developed in Creedy (1999).

great deal of detailed information about individuals is available that it becomes possible to include the complexities of actual tax and transfer systems in a simulation model.

However, it is unlikely that household surveys contain sufficient information to replicate realistic tax systems fully. In some cases, for example where asset values are required in the administration of means tests, it may be necessary to impute values, which may not always be possible. Furthermore, regulations regarding the administration of taxes and transfers often leave room for some flexibility in interpretation. Changes in the interpretation of (possibly ambiguous) rules, or the degree to which some rules are fully enforced, can take place over time. Furthermore, there may be changes in people's awareness of the benefits available, and the eligibility rules, thereby affecting the degree of take-up.

Due to these limitations, even large-scale models may not be able to replicate actual systems entirely. Thus they may not accurately reproduce aggregate expenditure and tax levels. Similarly, the same problems may give rise to distortions in measuring the extent to which redistribution occurs. Household surveys may contain non-representative numbers of some types of household and benefit recipient, so that it is usually necessary to apply a set of grossing-up factors, or sample weights, to enable aggregation of results to the population level.

3. BEHAVIOURAL MICROSIMULATION

Behavioural models are often needed when assessing proposed policy changes, because many tax policy changes are designed with the aim of altering the behaviour of individuals.[3] For example, some policies are designed to induce more individuals to participate in paid employment or, for those already working, to increase their hours of work. The production of behavioural microsimulation tax models, allowing for labour supply variations, represents a considerable challenge and has involved substantial innovations in labour supply modelling.[4]

Even where labour supply is not the main focus of a policy, there may be unintended consequences which affect other outcomes. Measures of the welfare losses, for example resulting from increases in taxes, are also overstated by non-behavioural models which rely on "morning after" changes in tax paid, rather than allowing for substitution away from activities whose relative prices

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[3] In the context of consumption, environmental taxes such as carbon taxes, or sumptuary taxes, are used to reduce the demand for harmful goods.

[4] On labour supply modelling in the context of tax simulation models, see, for example, Apps and Savage (1989), Banks, Blundell and Lewbel (1996), Blundell *et al.* (1986), Creedy and Duncan (2002), Creedy and Kalb (2005a, 2006) and Moffitt (2000). On behavioural responses in EUROMOD (a European microsimulation model including tax and transfer systems of a number of European countries), see Klevmarken (1997).

increase. In addition, estimates of the distributional implications of tax changes may be misleading unless behavioural adjustments are modelled. Estimates of tax rates required to achieve specified revenue levels are likely to be understated.

3.1 A Typical Behavioural Microsimulation Model

Existing behavioural microsimulation models are restricted in the types of behaviour that are endogenous. At most, individuals' labour supply and consumption are modelled. Variables such as household formation, marriage and births, along with retirement, labour training and higher education decisions, are considered to be exogenous and independent of the tax changes examined. Independence between commodities and leisure is also assumed. Allowing also for consumption demands essentially involves a two-stage procedure in which a decision is made regarding labour supply and hence income, and then the allocation of the resulting net income over commodities is made. Typically, labour supply in just one job is examined, so that the possibility of working additional hours at a different wage rate is ignored. Indeed, the wage rate is typically calculated by dividing total earnings by the total number of reported hours worked.

A component which evaluates the net income corresponding to any given number of hours worked by each individual is a fundamental component of a behavioural model. This produces, for each individual, the precise budget constraint relating net income to hours worked. The behavioural part of the model can then evaluate which part of each individual's constraint is optimal. This component is in effect an associated non-behavioural model. However, it does not mean that any existing non-behavioural model can be augmented by just adding a behavioural component. The complex architecture of microsimulation models requires the kind of integration that can most conveniently be achieved by simultaneously planning and producing all the components. For example, non-behavioural models are not usually concerned with the production of net incomes corresponding to various hours worked by each individual, but only with the relationship between net and gross income at observed labour supply for well-defined demographic types. Therefore, in addition to creating the behavioural component, the non-behavioural component needs to be adjusted as well.

Behavioural microsimulation models have, to some extent, a lower degree of population heterogeneity than non-behavioural models. This is because econometric estimation of the important relationships must involve the use of a limited range of categories. For example, in estimating labour supply behaviour, individuals may be divided into groups such as couples, single males and single females, and single-parent households. Although the number of groups is limited by the sample size, many variables, such as age, location, occupation and education level, are used to estimate the relevant functions. In addition, individual-specific (unobserved) variability may be re-introduced to ensure that the optimum labour supply in the face of current taxes actually corresponds, for each individual, to the level that is observed in the current period.

Some households may be fixed at their observed labour supply in the base sample if, following econometric estimation, individuals in the household do not conform to the assumptions of the underlying economic model. For example, implied indifference curves must display decreasing marginal rates of substitution over the relevant range. Problems with the assumptions of the economic model could be reflected by a difficulty of ensuring for each individual that the predicted labour supply under the base tax and transfer system is equal to observed labour supply.

3.2 Simulating Changes in Labour Force Participation

An important policy issue relates to the nature of tax and transfer changes designed to encourage more people to participate in the labour market. Hence this is likely to provide a focus for behavioural microsimulation studies, but this is also precisely the area that raises the greatest difficulty for modellers. There are several reasons for this. First, there is less information about nonparticipants in survey data. For example, it is necessary to impute a wage rate for non-workers, using estimated wage equations and allowing for selectivity issues. In addition, variables such as industry or occupation, which are often important in wage equations, are not available for non-workers. A second problem is that there are fixed costs associated with working, irrespective of the number of hours worked. These are usually difficult to estimate in view of data limitations. Finally, labour supply models typically treat nonparticipation as a voluntary decision, giving rise to a corner solution. However, demand-side factors may be important and there may also be a discouraged worker effect of unemployment, which is difficult to model.

An important choice must be made between continuous and discrete hours labour supply estimation and simulation. Earlier studies of labour supply used continuous hours models, involving the estimation of labour supply functions. In this case, it is important that the results are such that hours worked can be regarded as the outcome of utility maximisation. In other words, it must be possible to recover the indirect utility function by integration. This contrasts with discrete hours estimation and microsimulation, where net incomes, before and after a policy reform, are required only for a finite set of hours points. The discrete hours approach has substantial advantages from the point of view of estimation, since it allows for the complexity of the tax and transfer system and avoids the problems with endogeneity between the net wage and hours worked which are present when a standard labour supply function is estimated. Furthermore, estimation involves direct utility functions, which can be allowed to depend on many individual characteristics. The determination of optimal labour supply is easier, since utility at each of a limited number of hours levels can readily be obtained and compared. The use of direct utility functions also means that integration from estimated supply functions is avoided in simulation. In addition, modelling the move in and out of the labour market is more straightforward in the discrete than in the continuous model. The discrete hours approach is used in the MITTS model, which is described in the following section.

4. THE MITTS MODEL

The Melbourne Institute Tax and Transfer Simulator (MITTS) is a behavioural microsimulation model of direct taxes and transfers in Australia. MITTS was designed to examine tax policy reforms which capture labour supply responses to changes in budget constraints, and is the first full-scale simulation model of its kind in Australia. The results reflect only the supply side of the labour market, and a discrete hours framework is used in which individuals can move between specified discrete hours levels, rather than being able to vary hours continuously. The non-behavioural component (MITTS-A) and the behavioural component (MITTS-B) are described in sections 4.1 and 4.3 respectively. Section 4.2 describes the way in which MITTS decides on eligibility for benefit payments.

In the present version of MITTS, SIHC data from 1994/1995, 1995/1996, 1996/1997, 1997/1998, 1999/2000, 2000/2001 and 2002/2003 can be used. All results are aggregated to population levels using the household weights provided with the SIHC. The econometric estimates of preferences underlying the behavioural responses are based on data observed between 1994 and 1998. Section 4.4 discusses the combination of different years of data when using the labour supply model. Details of the current wage and labour supply parameters used in MITTS can be found in Kalb and Scutella (2002) and Kalb (2002).

4.1 MITTS-A: The Arithmetic Model

The tax system component of MITTS contains the procedures for applying each type of tax and benefit. Each tax structure has a data file containing the required tax and benefit rates, benefit levels and income thresholds used in means testing. As mentioned before in subsection 2.3, in view of the data limitations of the SIHC, it is not possible to include within MITTS all the complexity of the tax and transfer system. However, all major social security payments and income taxes are included in

MITTS.[5] Pre-reform net incomes at the alternative hours levels are based on the MITTS calculation of entitlements, not the actual receipt. Hence in the calculation of net income it is assumed either that take-up rates are 100 per cent, or a simple rule is used whereby a benefit is not claimed if it is less than a specified amount.

Changes to the tax and benefit structure, including the introduction of additional taxes, can be modelled by editing the programmes in this component. MITTS stores several previous Australian tax and transfer systems, which can be used as base systems for the analysis of policy changes. Alternatively, it is often possible to generate a new tax system by introducing various types of policy change interactively within MITTS by making use of the "front end" menus. This enables a wide range of new tax structures to be generated without the need for additional programming.

The various components of the tax and benefit structure are assembled in the required way in order to work out the transformation between hours worked and net income for each individual under each tax system. For example, some benefits are taxable while others are not, so the order in which taxes and transfers are calculated is important.

MITTS-A contains the facility to examine each household, income unit and individual in the selected base dataset in turn and generate net incomes, at the given hourly wage rates, for variations in the number of hours worked. Thus the changes in effective marginal tax rates (EMTRs) and labour supply incentives faced by households at various levels of the wage distribution can be compared, in addition to calculating the aggregate costs of different reform packages. Furthermore, distributions of effective marginal tax rates, for a variety of demographic groups, can be produced for pre-reform and post-reform tax systems, as well as distributions of gainers and losers, for various demographic characteristics. Hypothetical households can also be constructed and examined.

4.2 Eligibility for Benefits

The information in the SIHC is used to calculate eligibility for the different social security payments. Detailed information on the different sources of income is available, helping to determine this eligibility. However, not all requirements for eligibility can be checked with the available data. For example, information on assets is not available and the amount of assets may also influence eligibility. Fortunately, the group of households who would not be eligible based on their level of assets (which

[5] For details of the different payments, see Payment Guides published by the Commonwealth Department of Family and Community Services (of several years), DVA Facts and the annual report published by the Department of Veterans' Affairs (of several years).

excludes the home), but would be deemed eligible based on their level of income, is relatively small.[6] In particular, because the SIHC records income from investments (such as dividends or interest) and superannuation income, which are incorporated in the calculations, the absence of asset data is unlikely to be a major problem. Other requirements for eligibility, which cannot be checked, are whether someone has been a resident for at least two years and is actively looking for work. One of the requirements for this may be that the unemployment benefit recipient is not working more than a certain number of hours. The number of hours of work may preclude individuals from unemployment-related benefit receipt, if this level of labour supply precludes effective job search. However, there seems no particular hours level available that could be seen as the cut-off point above which no one would receive benefit payments.

The default option in MITTS is not to allow for individuals who decide not to take up the benefits for which they are eligible.[7] This is likely to cause overestimation of expenditure on the different payments. Although the receipt of benefits as recorded in the SIHC could be used to get an amount closer to the actual amount, this cannot help to predict whether after a reform someone will take up a benefit. To simulate changes, one would need to make assumptions or estimate a model that accounts for take-up of benefits. Thus, a 100 per cent take-up is assumed and it is argued that when interest is in the change in expenditure as a result of the reform, this approach is reasonably satisfactory. Both the amounts before and after the reform will be overestimated, and because the changes are not expected to expand eligibility to a large extent, the predicted percentage changes are expected to be informative.

4.3 MITTS-B and Labour Supply

The behavioural component of MITTS examines the effects of a specified tax reform, allowing individuals to adjust their labour supply behaviour where appropriate. The behavioural responses generated by MITTS-B are based on the use of quadratic preference functions whereby the parameters are allowed to vary with individuals' characteristics. These parameters were estimated for five demographic groups, which include married or partnered men and women, single men and women, and sole parents; see Kalb (2002). The joint labour supply of couples is estimated simultaneously, unlike a common approach in which female labour supply is estimated with the spouse's labour supply taken as

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[6] In MITTS it is assumed that if individuals or households are eligible after the income test, they will remain eligible after the assets test. Kalb, Kew and Scutella (2005) checked this assumption empirically using information on wealth collected in wave 2 of the Household, Income and Labour Dynamics Australia (HILDA) data. The assumption was found to be reasonable.

[7] However, MITTS contains an option under which individuals do not apply for income transfers less than a certain amount.

exogenous. The framework is one in which individuals are considered as being constrained to select from a discrete set of hours levels, rather than being able to vary labour supply continuously. Other studies using this approach include Van Soest (1995), Duncan, Giles and MacCrae (1999) and Keane and Moffitt (1998).

Some individuals are observed to be working a number of hours such that they are facing very high effective marginal rates. One explanation for this is that in practice people may not be claiming all the benefits to which they are entitled, especially if the benefits are small, so that their actual EMTR is not as large as it seems from the calculations. An alternative explanation is that people are in practice restricted in their labour supply choice. If people are actually at hours levels that give them marginal rates of 100 per cent or more, this cannot be explained in a continuous hours labour supply framework. Such points could not be the optimal points in the model, since the indifference curves cannot be flat. However, in a discrete hours approach such labour supply points can be optimal, because if people are not free to vary their hours continuously they have to pick the best discrete choice available. In MITTS-B, individuals are constrained to select from a discrete set of hours levels, rather than being able to vary labour supply continuously.

Different sets of discrete hours points may be used for each demographic group. Given that the married male's hours distribution is much less spread over part-time and full-time hours than the other distributions, but is mostly divided between nonparticipation and full-time work, married men's labour supply is represented by just 6 points, whereas everyone else's labour supply is divided into 11 discrete points. For couples, labour supply is estimated simultaneously for the two members; each couple can therefore choose from 66 labour supply combinations.

Given the aim of simulating policy changes with regard to the tax and transfer system and assessing its effect on labour supply, priority is given to incorporating all possible detail on taxes and transfers. Utility is maximised conditional on the restricted total amount of time available to each adult and the restricted amount of total household income. It is expected that utility increases with an increase in leisure, or home production time, and income. Usually more income means less leisure time for one of the adults, except when more income is obtained through social security benefits. It is assumed that everyone who is eligible for benefits takes them up. Maximising a household's utility involves balancing the amount of leisure and income. It is assumed that all nonparticipants are voluntarily not working and that participants are at their preferred labour supply points. Wage rates, non-labour income and household composition are exogenous in this model.

Restricting the number of possible working hours to a limited set of discrete values means that complex tax and transfer details can be incorporated. The economic model, assuming there are two adults in the household, is specified as follows. The utility function, $U(x, l_1, l_2)$, is maximised subject to a time restriction for each adult. Let l_i and h_i denote the weekly aggregate of leisure and home production time, and hours of work of partner i, with $l_1 + h_1 = T$ and $l_2 + h_2 = T$. The hs, the time spent in employment, are chosen from discrete hours sets. Let x indicate total net income per week, which is assumed equal to household consumption. The gross wage rates of male and female partners are denoted w_1 and w_2 respectively and y_i are the non-labour incomes. Let C refer to household composition, and $B(\ )$ is the amount of benefit for which a household is eligible, given household composition and household income. The tax function indicating the amount of tax to be paid is $\tau(\ )$. The budget constraint is given by:

$$x = w_1h_1 + w_2h_2 + y_1 + y_2 + B(C, w_1h_1 + w_2h_2 + y_1 + y_2) - \tau(B, w_1h_1 + w_2h_2 + y_1 + y_2, C) \quad (1)$$

The discrete hours choices are given by the sets $[0,h_{11},h_{12},\ldots,h_{1m}]$ and $[0,h_{21},h_{22},\ldots,h_{2k}]$ for partners 1 and 2 respectively. Using these sets, net income can be calculated for all $(m+1)(k+1)$ combinations of h_1 and h_2.[8] For this limited set of hours, the utility each possible combination of hours would generate, according to the specified utility function, can be computed.

The choice of labour supply is simultaneously determined for both adult members of the household. Depending on the form of the utility function, different interactions between household income and labour supply of both adults can be modelled. For one-adult households, the model is simplified by excluding everything related to the second adult.

Utility is assumed to consist of a deterministic and a random component. Choosing an extreme value specification for the random component results in a multinomial logit model.[9] The utility function used in the MITTS model is a quadratic specification, following Keane and Moffitt (1998), which is simple but flexible in that it allows for the leisure of each person and income to be substitutes or complements. A fixed cost of working parameter, γ, is included in the income variable x to indicate the cost of working versus nonparticipation, following Callan and Van Soest (1996). As a result of the inclusion in x, this cost of working parameter is measured in dollars per week. The deterministic component of utility is specified as follows:

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[8] The arithmetic tax and benefit modelling component provides, using the wage rate of each individual, the information needed for the construction of the budget constraints that are crucial for the analysis of behavioural responses to tax changes.

[9] See Maddala (1983) or Creedy and Kalb (2005a).

$$U(x,h_1,h_2) = \beta_x(x-\gamma_1-\gamma_2)+\beta_1 h_1+\beta_2 h_2+\alpha_{xx}(x-\gamma_1-\gamma_2)^2+\alpha_{11}(h_1)^2+\alpha_{22}(h_2)^2+ \alpha_{x1}(x-\gamma_1-\gamma_2)h_1+\alpha_{x2}(x-\gamma_1-\gamma_2)h_2+\alpha_{12}h_1h_2 \quad (2)$$

where the αs and βs are preference parameters and γ_1 and γ_2 are the fixed cost of working parameters to be estimated, where the indices 1 and 2 denote the husband and wife respectively. The fixed cost is zero when the relevant person is not working. For single adult households, all terms related to h_2 drop out of the utility function and γ_2 is set to zero.

Observed heterogeneity is included by allowing β_1, β_2, β_x, γ_1 and γ_2 to depend on personal and household characteristics. Unobserved heterogeneity may be added to β_1, β_2, β_x, and γ_2, in the form of a normally distributed error term with zero mean and unknown variance. In estimation, the unobserved heterogeneity parameters were found to be insignificant while the other parameter values remained unchanged. Parameter estimates for all four demographic groups are in Kalb (2002).

For those individuals in the dataset who are not working, and who therefore do not report a wage rate, an imputed wage is obtained. This imputed wage is based on estimated wage functions, which allow for possible selectivity bias, by first estimating probit equations for labour market participation, as described in Kalb and Scutella (2002, 2004). However, some individuals are fixed at their observed labour supply if their imputed wage or their observed wage, obtained by dividing total earnings by the number of hours worked, is unrealistic.[10] Furthermore, some individuals such as the self-employed, the disabled, students and those over 65 have their labour supply fixed at their observed hours.

Simulation is essentially probabilistic, as utility at each discrete hours level is specified as the sum of a deterministic component (depending on the hours worked and net income) and a random component (here, an extreme value type I distribution, which is associated with the multinomial logit model). Hence MITTS does not identify a particular level of hours worked for each individual after the policy change, but generates a probability distribution over the discrete hours levels used. Net incomes are calculated at all possible labour supply points. Given a random set of draws from the error term distribution, along with the computed deterministic component of utility at each of the labour supply points, the optimal choice for each draw can be determined conditional on the relevant set of error terms.

A behavioural simulation for each individual begins by setting reported hours equal to the nearest discrete hours level. The deterministic component of utility can be determined using the parameter estimates of the quadratic preference function, which vary according to a range of individual

[10] The current rejection range is less than 4 and more than 100 dollars per hour.

and household characteristics. Then to generate the random component of utility, a random draw is taken from the distribution of the error term for each hours level. In MITTS the error distribution used is the Extreme Value Type I distribution. The utility-maximising hours level is found by adding the random to the deterministic component of utility for each discrete hours level and choosing the hours level with the highest utility. The set of draws from the error terms is rejected if it results in an optimal hours level that differs from the discretised value observed. A user-specified total number of "successful draws" are produced. These are drawings which generate the observed hours as the optimal value under the base system for the individual. This process is described as "calibration". The accepted drawings are used in the determination of the optimal hours level after the policy change.

Given a random set of draws from the error term distribution, once the deterministic component of utility at each of the labour supply points is calculated, the optimal choice for each draw can be determined conditional on the relevant set of error terms. For the post-reform analysis, the new net incomes cause the deterministic component of utility at each hours level to change, so using the set of successful draws from the calibration stage, a new set of optimal hours of work is produced. This gives rise to a probability distribution over the set of discrete hours for each individual under the new tax and transfer structure. For example, in computing the transition matrices showing probabilities of movement between hours levels, the labour supply of each individual before the policy change is fixed at the discretised value, and a number of transitions are produced for each individual, equal to the number of successful draws specified. For the individuals, for whom labour supply changes are simulated, the transition matrices showing probabilities of movement between hours levels are computed using these transitions.

The use of this probabilistic approach means that the run-time of MITTS-B is substantially longer than that of MITTS-A. However, recently a more efficient approach has been implemented to draw values directly from a conditional extreme value type I distribution, so that each draw automatically puts the individual at their observed labour supply. This approach drastically reduces the required run time. See Bourguignon, Fournier and Gurgand (1998) for the conditional distribution function.

When examining post-reform average hours in MITTS-B, the labour supply after the change for each individual is based on the average value over the successful draws, for which the error term leads to the correct predicted hours before the change. This is equivalent to calculating the expected hours of labour supply after the change, conditional on starting from the observed hours before the change. In computing the tax and revenue levels, an expected value is also obtained after the policy change. That is, the tax and revenue for each of the accepted draws are computed for each individual, and the average of these is obtained using the computed probability distribution of hours worked. For the expected tax and revenue levels and for labour supply, confidence intervals can be calculated to indicate the potential prediction error arising from the uncertainty associated with the estimated labour supply model parameter (Creedy, Kalb and Kew, 2007). However, this is relatively time-consuming since the simulation needs to be repeated a large number of times with a different draw from the distribution of parameters for each replication, making use of the estimated parameter values and their covariance matrix.

4.4 Combining Different Years of Data

The simulation procedure often involves data from several years of the Survey of Income and Housing Cost and information on the taxation and social security regimes of several years. A few transformation steps are needed to combine these years in the analysis.

First, the behavioural part of the simulation procedure is based on labour supply models. These models are estimated using the Survey of Income and Housing Cost from 1994/95, 1995/96, 1996/97 and 1997/98 with the corresponding taxation and social security rules. Combining several years of data actually helps to identify the model, since slightly different tax regimes were operational in the four years. This provides more variation in net incomes at different hours of labour supply than would otherwise be the case. To estimate one model combining the four years, the net incomes calculated over a range of different possible hours have to be made comparable over the four years. This can be achieved by expressing the calculated net incomes in each of the years in the dollar value of one year. That is, it is necessary to account for the change in the real value of the dollar. All net incomes are expressed in 1997/1998 dollars and the Consumer Price Index is used to inflate the other years' net incomes to the corresponding 1997/1998 level, before using them in the labour supply model.

Second, when simulating labour supply responses, pre-reform and post-reform values also need to be expressed in 1997/1998 dollars, before they can be used as arguments in the labour supply model. Third, in the simulation all income and wage information is first expressed in dollar values of the pre-reform situation and then in dollar values of the post-reform situation, to calculate net income under the different policies. If required by the user, costings in the tables and differences between pre-reform and post-reform systems can be expressed in dollar values of another period. However, the default is to express costings and differences in pre-reform dollars.

5. LABOUR SUPPLY ELASTICITIES

In constructing any microsimulation model it is important to ensure that, using the base system, it can generate revenue and expenditure totals for various categories that are close to independently produced aggregates, for example from administrative data. For a behavioural model, it is also useful to compare summary information about labour supply behaviour with results from other studies.

It is common in studies of labour supply to provide wage elasticities for various groups, often computed at average values of wages. However, the discrete hours labour supply model used in MITTS simulations of behavioural responses to policy changes does not provide straightforward wage elasticities with regard to labour supply. Indeed, for any individual, there are large variations in the elasticity over the range of hours available. However, elasticities can be calculated by comparing the expected labour supply for an individual after a 1 per cent wage increase with the expected labour supply under the original wage. The resulting percentage change in labour supply can be regarded as an approximation to the wage elasticity. By doing this for each individual in the sample, the average elasticity across the sample, or population when making use of the weights, can be computed. Different concepts are used in the literature. For example, the elasticity is often calculated for a hypothetical person with average values for each of the relevant characteristics. Hence it cannot be expected that the same values will be obtained, but comparisons of orders of magnitude are useful.

Table 1 presents average uncompensated wage elasticities for those in the population who are allowed to change labour supply in MITTS, thus excluding the self-employed, full-time students, disabled individuals and people over 65. In addition to using predicted labour supply alone, calibration can be used to calculate the elasticity starting from the observed labour supply for those already in work. For non-workers, the elasticity cannot be computed because a percentage change starting from zero hours is not defined. The two final columns in Table 1 present the predicted participation rate changes resulting from a 1 per cent wage increase.

The range of elasticities published in the literature is fairly wide, with large differences between studies using different data and approaches.[11] The implicit labour supply elasticities in MITTS are similar to those generally found within the international literature. The results for married and single men and women are well within the range of results usually found.

The elasticity for single parents is often found to be larger than for other groups and this is also found in MITTS. The elasticity implicit in MITTS is at the higher end of this range internationally,

[11] See overviews by Killingsworth (1983), Killingsworth and Heckman (1986), Pencavel (1986) or more recently by Blundell and MaCurdy (1999) or Hotz and Scholz (2003).

although other evidence of a high labour supply responsiveness for single parents in Australia has been found by Murray (1996), Duncan and Harris (2002) and Doiron (2004). Murray (1996) found values between 0.13 and 1.64, depending on the exact specification, for part-time working single mothers. The elasticities for full-time workers and single parents out of the labour force are much smaller, at most 0.30. Murray used 1986 data, where only 13 per cent of all single mothers worked part time and about 23 per cent worked full time. In the 2001 data used here, around 50 per cent of single parents work, and about half of the workers are employed between 1 and 35 hours per week.

Table 1 Average wage elasticities for individuals for whom labour supply is simulated in MITTS

	Elasticity derived from		Percentage point change in participation derived from	
	expected labour supply	calibrated labour supply (hours>0)	expected labour supply	calibrated labour supply
Married men	0.24	0.06	0.15	0.15
Married women	0.56	0.37	0.20	0.15
Single men	0.22	0.04	0.16	0.17
Single women	0.38	0.07	0.19	0.16
Single parents	1.48	0.78	0.41	0.24

Duncan and Harris (2002) analysed the effect of four hypothetical reforms, using a previous version of the labour supply models underlying the behavioural responses in MITTS. Two of these reforms are close to being a 10 per cent increase and 10 per cent decrease in single parents' wage rates. The first is to decrease the withdrawal rate for single parents by 10 per cent, which increases their marginal wage rate while they are on lower levels of income. Duncan and Harris report that this is expected to increase labour force participation by 2.5 percentage points and increase average hours by 0.55 hours. The second reform increases the lowest income tax rate from 20 to 30 per cent. This is expected to decrease participation by 2.8 percentage points and decrease average hours by 1.2 hours. Comparing this with the effect of a 10 per cent wage increase using recent labour supply parameters and data from 2000/2001, effects of a similar magnitude are found. That is, participation is expected to increase by 2.2 percentage points and the average hours are expected to increase by 1.0 hours.

Finally, Doiron (2004) evaluated a policy reform affecting single parents in the late 1980s and found large labour supply effects. Doiron compared the effect obtained through the natural experiment approach with predicted effects of policy changes from the MITTS model, as found in Duncan and Harris (2002) or Creedy, Kalb and Kew (2003). Based on the results from her evaluation, Doiron argued that observed shifts in labour supply of single parents can equal or even surpass the predictions based on behavioural microsimulation.

These results suggest that single parents' labour supply elasticities may be substantial. This is perhaps not surprising, given the low participation rate of single parents and the tendency to work low part-time hours. An increase in labour supply by one hour is a larger percentage increase compared with the same increase for a married man. For the other demographic groups, elasticities of those working few hours are also generally higher than for those in the same group who work greater hours. The single parent group is the smallest demographic group in the population. Thus, a change in their labour supply responsiveness would have a relatively small effect on the overall result.

Another way of validating results is by comparing the predicted effects of a policy change obtained through a simulation with the estimated effects of the policy change after it has been introduced. The problem with this approach is that it is often difficult to find policy changes that can be evaluated accurately. It can be difficult to find a control group with which to compare a treatment group (those affected by the policy change).

Blundell *et al.* (2004) and Brewer *et al.* (2006) evaluated a range of labour market reforms in the UK by a difference-in-difference approach at the same time as simulating the effects of these reforms. They found both similarities and differences in the results. They suggested that this could be due to a number of reasons related to the analyses, such as differences in sample selection rules, not accounting for other changes that occurred at the same time as the reforms or not accounting for general equilibrium effects changing the distribution of wages.

It has been difficult to find policy changes in Australia which could be used to test MITTS in a similar way. Some results comparing, for sole parents, the effect of the Australian New Tax System introduced in July 2000 calculated by MITTS with the effect calculated using a difference-in-difference evaluation approach are available (Cai *et al.*, 2005). The results indicate that, if anything, the simulation results appear to be lower than the effect of the policy change as estimated through an evaluation approach.

6. RECENT DEVELOPMENTS AND DEVELOPMENTS IN PROGRESS

Thinking in terms of models forces analysts, as far as possible, to be explicit about the simplifications used. Hence the inevitable limitations of models can be clearly recognised – all models have their limitations though some are less transparent than others. For example, in using microsimulation models it should be borne in mind that they are supply-side partial equilibrium models. Behavioural components concentrate on examining the effects of changes in the tax structure on variations in the hours of work that individuals wish to supply. No allowance is made for the demand for labour. Hence, depending on what happens to the demand for labour, individuals may in reality not be able to work their desired number of hours. Large changes in the tax structure, designed for example to increase the labour force participation of benefit recipients, may themselves have effects on the demand for labour and as a result affect individuals' wage rates.

New developments can relax some of the required assumptions and/or extend the use of the model. As a result, once a model has been developed it needs continuous maintenance and development to remain relevant to policy analysis. This section discusses recent and current developments regarding additional years of data, childcare use, take up of social security payments, welfare measures and micro-macro model linkages.

Whenever new data become available, they need to be made suitable for inclusion in the MITTS model, so policy simulations can be based on the most recent data available. From time to time, labour supply and wage model parameters need to be updated using the most recent years of data which are available. Furthermore, data from the Household, Income and Labour Dynamics Australia (HILDA) survey were transformed so they could be used as the base data for MITTS. However, in the past, the disadvantage of using the HILDA data was that it was difficult to aggregate results up to the population level, due to missing information on some of the key variables. Continuous improvement of the quality of imputation of missing variables, with every new wave of data that becomes available, means that this data now has become more useful as potential input into the MITTS model.

In addition to updating the model with new years of data as they become available, two years of historical data are currently been added to the model. This will allow in-depth analysis of some of the interesting policy changes in the 1980s and facilitate longer term analysis of labour supply behaviour. The years of data which appear suitable to include in the MITTS model (after some transformations to make them comparable to the later data) are the SIHC surveys from 1986/87 and 1990/91

Although not part of the standard behavioural component of MITTS yet, the labour supply model has been extended to incorporate childcare use decisions and childcare costs (Doiron and Kalb, 2005; Kalb and Lee, 2007). This allows assessment of the effect of an important factor, childcare, in (female) labour supply decisions. Further extensions to achieve a more realistic model of the decision-making process regarding childcare use (together with labour supply decisions) are planned. This area of research is likely to become more important as female labour force participation becomes more important in the light of ageing populations.

Similarly, the labour supply model has been extended with the choice of welfare participation, while at the same time allowing for involuntary unemployment. Again this is not part of the standard behavioural component of MITTS yet. Application of this extended model in microsimulation would allow for less than 100 per cent take-up rate of government payments. That is, individuals can choose whether they take up benefit payments, for which they are eligible, or not. In addition, this approach would distinguish between unemployment and nonparticipation, which could be a first step towards allowing demand side factors to influence microsimulation outcomes.

A very recent addition to MITTS is the computation of social welfare measures based on money metric utility to complement the distributional measures which were based on net incomes only.[12] Few of the studies which estimate utility or labour supply functions actually produce individual measures of the welfare effects of tax reforms. The use of behavioural tax microsimulation modelling provides a strong motivation for developing convenient methods of obtaining accurate welfare measures.[13] The advantage of money metric utility based welfare measures over income-based measures in behavioural microsimulation is that they can take into account the value of leisure and home production time to the household. This is in addition to the financial changes resulting from a policy change which induces labour supply responses. In assessing the effect of a policy change in a behavioural microsimulation context, the value of non-labour market time is important. Different groups may be identified as benefiting the most or suffering the most under proposed policy changes depending on whether an income-based measure or a money metric utility based welfare measure is used.

A final avenue for extension is the establishment of micro-macro linkages. These would allow the combination of advantages of microsimulation models, which provide details on individual and household outcomes and on income distribution and inequality, with those of macro-oriented models which include effects on all sectors of the economy. These linkages could range from relatively simple transfers of information from one model to the other, to iterative transfers of information between the two models, up to a more fully integrated combination of the two types of models. The latter linkage is the most complex type and is not attempted often.[14]

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[12] Distributional measures accounting for the probabilistic nature of the behavioural simulation outcomes were included in MITTS in 2004 (Creedy, Kalb and Scutella, 2004).

[13] Creedy and Kalb (2005b) suggest an approach to calculate welfare measures in a discrete choice labour supply context.

[14] Examples of micro-macro linkage for developing countries are studies by Robilliard, Bourguignon and Robinson (2001), Cororaton and Cockburn (2005) or Hérault (2006).

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