ISSN 0819-2642
ISBN 0 7340 2588 2

THE UNIVERSITY OF MELBOURNE

DEPARTMENT OF ECONOMICS

RESEARCH PAPER NUMBER 932

MARCH 2005

BEHAVIOURAL MICROSIMULATION MODELLING WITH THE MELBOURNE INSTITUTE TAX AND TRANSFER SIMULATOR (MITTS): USES AND EXTENSIONS

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Behavioural Microsimulation Modelling With the Melbourne Institute Tax and Transfer Simulator (MITTS): Uses and Extensions

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Abstract

This paper describes microsimulation modelling in non-technical terms; and it explains what can be achieved with microsimulation modelling in general, and the Melbourne Institute Tax and Transfer Simulator (MITTS) in particular. The focus is on behavioural microsimulation modelling, which takes individuals' labour supply responses into account when analysing tax and transfer reforms. Microsimulation models are built to replicate closely the considerable degree of heterogeneity observed in the population. Several examples of recent uses of MITTS are given and briefly described. In addition, one worked-out example is presented to illustrate some of the features and typical outputs of MITTS. Given the relatively recent development of behavioural microsimulation models, there are several opportunities for further extensions. For example, it would be valuable to allow for the demand side of labour, indicating whether new labour force participants are likely to find work; or to allow for life-cycle dynamics, which are important to deal with population-ageing issues or with female labour force participation.

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1 Introduction

Tax policy questions may relate to specific problems, 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. As soon as tax issues begin to be examined, their many complexities force economists to produce a simplified framework in which the various inter-relationships become more manageable and transparent. Hence tax models are 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 rational policy debate require the construction of larger tax simulation models. The aim of this paper is to explain in non-technical terms what can be achieved with microsimulation modelling in general and what can be achieved with the Melbourne Institute Tax and Transfer Simulator (MITTS) in particular. [1]

The plan of the paper is as follows. 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, and for both incumbent and counterfactual tax-benefit regimes. The distinguishing feature of such models is the use of a large cross-sectional data set 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.

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,

[1] Several publications are available that describe MITTS in more technical detail. For an overview of the complete model, see Creedy *et al*. (2002; 2004).

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.

Section 6 provides an example of a hypothetical policy reform to the Australian tax and transfer system. This is given to illustrate the types of result generated by MITTS. In addition to the three components of a behavioural model mentioned above, MITTS contains extensive 'front end' and 'back end' facilities. The former provides user-friendly menus and allows many tax reforms to be modelled without the need for additional programming. The latter enables a wide range of analyses to be conducted and summary results to be obtained regarding the implications of a tax reform. Section 6 presents a small sample of the many options available in MITTS.

Brief summaries of a further range of tax reform analyses that have been carried out using MITTS are given in Section 7. The production of these analyses often involved significant extensions to MITTS, rather than representing simple applications of the basic model. In addition to the ability to look at hypothetical reforms, a simulation model such as MITTS can be used to provide timely and independent analyses of tax reforms proposed by either governments or other interest groups. Examples of these are also given in Section 7.

Behavioural microsimulation models represent a relatively recent development, made feasible by substantial improvements in computing facilities and innovations in the modelling and estimation of labour supply behaviour. They therefore offer interesting challenges and potential for further extensions. Some recent and planned extensions to MITTS are discussed in Section 8.

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. Section 9 discusses some of these issues and possibilities for potential modelling developments which can be carried out in partnership with MITTS. 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 not in reality 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. As partial equilibrium models, there is an additional assumption that changes in the tax and transfer system have no effect on individuals' wage rates.

Microsimulation models also typically provide a static overview of one point in time and do not allow for life cycle dynamics. A challenging question is how to incorporate dynamic responses to policy changes. Decisions on labour force participation could well be different when only short-term implications are taken into account compared to decisions with a longer-term vision in mind. Some conclusions are provided in Section 10.

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 supplies. It is sometimes said that they provide information about the effects of tax changes on the 'morning after' the change. This section describes a typical arithmetic microsimulation model in Section 2.1, followed by a discussion on the data required to build these types of model in Section 2.2. This is followed in Section 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 the 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 various 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

Reference has already been made to the data requirements of tax models. This raises special problems for modellers in Australia. The two large-scale household surveys that are potentially useful are the Household Expenditure Survey (HES) and the Survey of Income and Housing Costs (SIHC). 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 SIHC. This means that Australian direct tax models cannot also include indirect tax models.[2] The extension of models to cover consumption taxes would require some elaborate data merging.

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

2.3 The Tax and Transfer System

Detailed knowledge of tax and social security systems is required to build a microsimulation model. These sometimes involve several government departments and their 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, are usually 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 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. In particular, the administration of means tests or other benefits may allow a degree of discretion to be exercised by benefit officers who deal directly with claimants. 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.

In view of 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. Another difficulty is that household surveys may contain non-representative numbers of some types of household and benefit recipient. 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 that rely on 'morning after' changes in tax paid, rather than allowing for substitution away from activities whose relative prices 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

The existing behavioural microsimulation models are restricted in the types of behaviour that are endogenous. At most, individuals' labour supplies and household demands 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.[5] 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 that 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

[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 Lewbell (1996), Blundell *et al.* (1986), Creedy and Kalb (2004), Duncan (1993), Duncan and Giles (1996) 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).

[5] Those models allowing also for consumption demands essentially use 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.

worked. The behavioural part of the model can then evaluate which part of each individual's constraint is optimal. It might be suggested that 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 a behavioural component. The complex architecture of microsimulation models requires the kind of integration that can only 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 with the relationship between net and gross income at observed labour supply for well-defined demographic types.

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. The number of groups is limited by the sample size, but many variables, such as age, location, occupation and education level, are used to estimate the relevant functions. In addition, individual-specific 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.

In addition, 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 Simulation of 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 non-participants 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. Also, 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 non-participation as a voluntary decision, giving rise to a corner solution. However, demand-side factors may be important and there may be a discouraged worker effect of unemployment, which is difficult to model.

An important issue concerns the choice 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.[6] 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, and 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.[7] 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 tax and transfers in Australia. Since the first version

[6]On the integrability condition in labour supply models, see, for example, Stern (1986).
[7]The use of direct utility functions also means that integration from estimated supply functions is avoided in simulation.

was completed in 2000, it has undergone a range of substantial developments. Indeed, any large-scale model requires constant maintenance (involving, for example, re-estimation of econometric relationships as new data and methods are 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 the present version of MITTS, SIHC data from 1994/1995, 1995/1996, 1996/1997, 1997/1998, 1999/2000 and 2000/2001 can be used. The econometric estimates of preferences underlying the behavioural responses are based on data observed between 1994 and 1998. [8] All results are aggregated to population levels using the household weights provided with SIHC. Recently, data from the Household, Income and Labour Dynamics Australia (HILDA) Survey have been transformed so they could be used as the base data for MITTS (Kalb, Cai and Vu, 2004). However, the disadvantage of using the HILDA is that it is not straightforward to aggregate results up to the population level.

4.1 MITTS-A

In MITTS, the arithmetic tax and benefit modelling component is called MITTS-A. This component also 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.

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 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. 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 that take-up rates are 100 per cent.

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

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[8] Details of the current wage and labour supply parameters used in MITTS can be found in Kalb and Scutella (2002) and Kalb (2002).

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.

MITTS assembles the various components of the tax and benefit structure 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 evaluated is important.

MITTS-A contains the facility to examine each household, income unit and individual in the selected base data set 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. This allows comparisons to be made with results obtained from other Australian non-behavioural tax-benefit models. In addition, 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 MITTS-B

The behavioural component of MITTS is called MITTS-B. It 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 have been estimated for five demographic groups, which include married or partnered men and women, single men and women, and sole parents (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 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. Different sets of discrete hours points are used for each demographic group.

For those individuals in the data set 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. 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. 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, 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.

Due to the probabilistic nature of simulation, MITTS-B does not generate a single net income for each individual after a policy reform. For this reason, a new approach to the production of distributional analyses of the effects of tax reforms on net incomes is required. Inequality and poverty measures, for example, cannot be computed from the complete set of possibilities available. The present version of MITTS-B uses the method devised by Creedy, Kalb and Scutella (2004).

A behavioural simulation for each individual begins by setting reported hours equal to the nearest discrete hours level. Then, given the parameter estimates of the quadratic preference function, which vary according to a range of characteristics, a set of random draws is taken from the distribution of the ‘error’ term for each hours level. The utility maximising hours level is found by adding the random to the deterministic component of utility for each discrete hours level. This set of draws 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, that is, drawings which generate the observed hours as the optimal value under the base system for the individual. This process is described as ‘calibration’.

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.

When examining 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 taken, using the computed probability distribution of hours worked.

In some cases, the required number of successful random draws producing observed hours as the optimal hours cannot be generated from the model within a reasonable number of total drawings. The number of sets of random variables tried per draw, like the number of successful draws required, is specified by the user. If after the total number of tries from the error term distribution, the model fails to predict the observed labour supply for a draw, the individual is fixed at the observed labour supply for that draw. In a few extreme cases labour supply is fixed for all draws of an individual. The use of such a probabilistic approach means that the run-time of MITTS-B is substantially longer than that of MITTS-A.

5 Labour Supply Elasticities Implicit in MITTS

In constructing any microsimulation model it is clearly 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 see how summary information about labour supply behaviour compares with results from other studies. Such comparisons are examined in this section.

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 one-percent wage increase with the expected labour supply under the original wage. The resulting percentage change in labour supply can be regarded as a form of 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.[9]

Table 1 presents these uncompensated wage elasticities for those in the population that are allowed to change labour supply in MITTS. For self employed, full-time students, disabled individuals and people over 65 this elasticity is assumed to be zero. 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 one-percent wage increase.

The range of elasticities published in the literature is fairly wide, with large differences between studies using different data and approaches.[10] 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.

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[9] As different concepts are used in the literature (for example, the elasticity could have been calculated for a hypothetical person with average values for each of the relevant characteristics), it cannot be expected that the same values will be obtained, but comparisons of orders of magnitude are useful.

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

Table 1 Average Wage Elasticities in Groups for Which Labour Supply is Simulated in MITTS[a]

	Elasticity derived from expected labour supply	Elasticity using calibrated labour supply (for positive hours only)	Change in participation derived from expected labour supply (in percentage points)	Change in participation derived from calibrated labour supply (in percentage points)
Married men	0.25	0.02	0.14	0.30
Married women	0.54	0.68	0.19	0.25
Single men	0.28	0.03	0.18	0.45
Single women	0.34	0.11	0.18	0.48
Lone parents	1.58	1.38	0.42	0.47

Note a) This excludes people over 65, disabled individuals, full-time students and the self employed.

The elasticity for lone parents is often found to be larger than for other groups and this is also found in MITTS. The elasticity implicit in MITTS is on the higher end of this range internationally, although other evidence of a high labour supply responsiveness for lone 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 lone mothers. The elasticities for full-time workers and lone parents out of the labour force are much smaller, at most 0.30. Murray used 1986 data, where only 13 per cent of all lone mothers worked part time and about 23 per cent worked full time. In the 2001 data used here, around 50 per cent of lone parents work, and about half of the workers are employed between 1 and 35 hours per week.

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 lone parents’ wage rates. The first is to decrease the withdrawal rate for lone 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 hour. 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, effects of a similar magnitude are found. That is, participation is expected to increase by 3.0 percentage points and the average hours are expected to increase by 1.3 hours.

Finally, Doiron (2004) evaluated a policy reform affecting lone 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 lone parents can equal or even surpass the predictions based on behavioural microsimulation.

These results suggest that lone parents' labour supply elasticities may be substantial. This is perhaps not surprising, given the low participation rate of lone 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 amongst those working few hours are also generally higher than for those (in the same group) working higher hours.[11]

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) evaluated a range of labour market reforms in the UK by a difference-in-difference approach at the same time as simulation the effects of these reforms. They found similar results for sole parents and married women, but for married men the estimated effects were opposite. 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.

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[11] The lone 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.

It has been difficult to find policy changes in Australia that could be used to test MITTS in a similar way. Some preliminary 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. 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 Illustration of a Policy Analysis Using MITTS

This section illustrates the sort of output that can be obtained using MITTS, by examining a simple hypothetical tax change. The Australian tax and transfer system has a large number of means-tested benefits. The hypothetical policy change analysed here reduces the benefit taper or abatement rates in the 1998 tax structure to 30 per cent. All taper rates of 50 per cent and 70 per cent are reduced to 30 per cent, while leaving all basic benefit levels unchanged.[12] A 30 per cent taper rate means that for every dollar of additional income in the household, the benefit payment is reduced by 30 cents. An important feature of the example is that behavioural modelling makes a difference when examining the effects of policy changes. Given the importance of work incentives in contemporary policy making, these different implications are relevant when analysing the effect of policy changes.

In using MITTS, different sets of discrete hours points are used for men and women. Given that the female hours distribution is much more spread over part-time and full-time hours than the male distribution, which is mostly divided between non-participation and full-time work, women's labour supply is divided into eleven discrete points, whereas men's labour supply is represented by three points in this particular example.[13] A total of 100 accepted draws were produced, giving a probability distribution over the set of discrete hours for each individual under the new tax structure.[14] The results are briefly discussed in three subsections. First, the results

[12] The exception is the withdrawal rate on parental income for people receiving Youth Allowance or AUSTUDY, which remains at 25 per cent.

[13] The current version allows for six labour supply points for married men and 11 points for single men.

[14] In some cases, 100 successful random draws producing observed hours as the optimal hours could not be generated within a reasonable number of total draws. In this earlier version of MITTS, a different approach from the current approach was used to generate draws. That is, if after 5000 draws, the model failed to predict the observed labour supply 100 times, the individual was dropped from the simulation and fixed at the observed hours of work. This occurred 521 times, which in addition to the 121 rejected cases because of unrealistic wages represented 6.5 per cent of all individuals in the database.

using MITTS-A are discussed, then the results on labour supply responses from MITTS-B and finally the corresponding changes in expenditure and revenue. [15]

6.1 Effect of the Policy Change Assuming Fixed Labour Supply

This subsection presents results using MITTS-A. Disaggregation by several different characteristics is allowed and examples are shown in Table 2. For this particular policy change of a reduction in withdrawal rates, there are of course no losers with regard to net income levels. The largest gains are made by income units with children, income units where the head is employed and by income units with a head at prime working age. This is due to the fact that in order to benefit from a taper rate reduction, some non-benefit income must be received.

Table 2 Income Gainers and Losers by Characteristic of Head of Income Unit

Increase in net income ($):	none	1-5	5-10	>10	Average
Number of children					
None	59.4	3.0	3.3	34.3	17.40
One	63.2	1.2	0.6	35.0	27.82
Two	62.8	1.1	1.8	34.3	33.51
Three	60.7	1.4	1.5	36.4	40.65
Four	65.4	2.5	0.6	31.5	32.25
Five	67.8	-	3.0	29.2	36.38
Six	59.8	-	-	40.2	38.97
Age					
15 to 19	84.5	1.0	1.0	13.5	5.76
20 to 24	49.6	2.5	3.5	44.4	20.61
25 to 29	55.9	2.6	2.6	39.0	25.74
30 to 34	58.5	1.8	1.8	38.0	32.75
35 to 39	57.2	1.9	2.3	38.6	36.19
40 to 44	59.3	2.0	1.8	37.0	32.37
45 to 49	56.4	2.4	3.2	38.1	28.01
50 to 54	58.9	1.9	2.0	37.3	24.79
55 to 59	56.2	2.2	2.2	39.4	25.68
60 to 64	55	3.9	3.5	37.6	22.96
65 plus	68.8	3.3	3.5	24.4	9.15
Employment status					
Employed	52.8	2.5	2.8	41.9	28.71
Non-participation	70.7	2.1	2.3	24.9	16.12
Unemployed	81.9	1.5	0.1	16.5	14.23

[15] For further details on the effects and results of this policy reform, see Creedy, Kalb and Kew (2003).

Table 2 (continued)

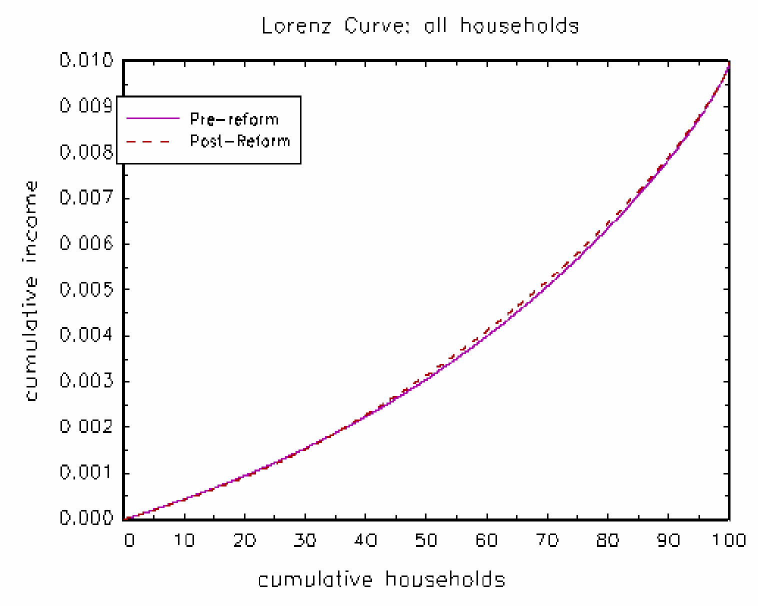
Increase in net income ($):	none	1-5	5-10	>10	Average
Income unit type					
Couple	57.4	2.9	2.8	36.9	22.48
Couple & dep.child	52.9	1.5	1.4	44.3	43.57
Dependent child	99	0.3	0.3	0.5	0.13
Single	61.4	3.1	3.8	31.7	12.17
Sole parent	70.6	1.2	2.5	25.8	10.77
Total	60.69	2.32	2.49	34.5	23.45

MITTS-A can also measure distributional and inequality changes. There is a choice from a variety of poverty and inequality measures, such as the Atkinson measure, the Gini Coefficient, the Lorenz curve, or the Poverty Gap measure. Here two examples are presented. Table 3 shows the Gini Coefficient by age before and after the change, revealing only very small changes in inequality. The Lorenz curve in Figure 1 is found to cross, showing more equality in the middle to higher income groups, but the Gini measure falls very slightly in all but the oldest age group.

Table 3 Gini Coefficients by Age

	Before	After	Change
Age			
15 to 19	0.2134	0.2037	-0.0097
20 to 24	0.2312	0.2193	-0.0119
25 to 29	0.2444	0.2304	-0.0141
30 to 34	0.2682	0.2510	-0.0172
35 to 39	0.2571	0.2395	-0.0176
40 to 44	0.2674	0.2492	-0.0182
45 to 49	0.2593	0.2437	-0.0156
50 to 54	0.2681	0.2529	-0.0152
55 to 59	0.2806	0.2672	-0.0134
60 to 64	0.2828	0.2802	-0.0026
65 plus	0.2352	0.2439	0.0087
All	0.2752	0.2655	-0.0097

Figure 1 Lorenz Curve Before and After Change



6.2 Labour Supply Changes

The effect on labour supply of this reduction in the taper rates is equivocal because it does not automatically mean a reduction in effective marginal tax rates for all individuals. This is an inevitable consequence of flattening the marginal rate structure while keeping basic benefit levels unchanged. A summary of the labour supply effects is given in Table 4 for the five demographic groups. After the reform, more sole parents are expected to participate in the labour market since few women move from work to non-participation, whereas a substantial proportion moves into work from non-participation. The net effect is more than 8 per cent. However, there is a relatively small negative effect for a subgroup caused by the 1.8 per cent of sole parents who decrease their labour supply, which is partly counteracted by the 1.3 per cent of sole parents who increase their working hours after the reform. Nevertheless, the resulting average weekly hours are increased by nearly 3 hours showing that the overall effect is positive.

As actual labour supply points are rounded to the nearest discrete labour supply point, the definition of non-participation depends on the number of discrete labour supply points that are used. For women it is working fewer than 3 hours and for men it is working fewer than 10 hours. Sole parents are predicted to have a larger increase in the probability of working as a result of reduced taper rates than other groups. This sensitivity to work incentives is found in several other studies (Blundell *et al.*, 2000; Blundell and Hoynes, 2001). Families with more children seem also more likely to participate in the labour market after the reform.

Table 4 Simulated Responses of Labour Supply

Behavioural Response	Couples: Men	Couples: Women	Single Men	Single Women	Sole Parents
Wage and salary workers (per cent, base)	56.93	40.63	52.29	43.56	41.28
Wage and salary workers (per cent, reform)	57.49	40.24	52.55	43.44	49.54
non-work-->work (per cent)	1.29	1.72	0.33	0.07	8.3
work-->non-work (per cent)	0.73	2.1	0.06	0.18	0.03
Workers working more	0.08	0.37	1.07	0.42	1.29
Workers working less	2.6	1.43	0.01	0.44	1.81
Average hours change	-0.37	-0.49	0.32	-0.1	2.88

An example of a transition matrix, produced following the method described in the previous section, is shown in Table 5. This is for sole parents, who can be seen to experience both increases and decreases in labour supply as a result of the change. Compared with singles and couples (not shown here), sole parents are more likely to change labour supply, particularly at the lower and upper end of the hours range. Sole parents working fewer than 25 hours seem most likely to increase their hours whereas sole parents working 35 hours or over are more likely to reduce their hours.

Table 5 Labour Supply Transition Table for Sole Parents

	From pre to post reform: rows to columns										
Hours	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
0	85.9	0.0	0.3	0.8	1.0	1.9	1.8	1.7	2.1	2.2	2.5
5	-	89.2	0.3	0.4	1.0	0.7	1.7	1.9	1.6	2.3	0.8
10	-	-	86.3	0.6	0.5	1.4	1.5	2.7	2.1	2.4	2.5
15	-	0.1	0.1	91.7	0.3	0.7	1.4	1.1	1.7	1.4	1.6
20	-	-	-	0.1	95	0.2	1.1	0.9	0.8	1.3	0.7
25	0.0	-	-	-	-	97.8	0.0	0.3	0.4	0.6	0.9
30	-	0.4	0.3	0.3	0.5	1.1	95.2	0.2	0.7	0.8	0.4
35	-	0.2	0.3	0.7	1.0	1.6	0.5	94.7	0.2	0.6	0.3
40	0.2	0.3	0.6	1.6	1.7	2.5	1.7	0.3	90.8	0.2	0.2
45	0.4	0.3	0.4	1.0	1.9	1.8	2.0	1.9	1.1	87.9	1.3
50	0.1	0.3	0.4	0.8	1.1	1.0	1.1	1.3	0.9	0.4	92.5
Total	50.46	2.69	2.22	3.33	4.64	5.21	4.71	5.07	12.67	2.48	6.51

Note: (a) Weighted number of observations on which this table is based is 502,963.

The changes in the probability of working of the head of an income unit, for several categories, are presented in Table 6. Similar categories as are available in MITTS-A can be used to break down the results from MITTS-B as well. Table 6 shows clear differences between the different categories, although it should be kept in mind that some categories, such as families with five or six children, may contain few households in the sample. This means that not too much should be made of these differences.

Table 6 Changes in Probability of Participating in Labour Force

	Decrease in percentage points				Increase in percentage points			
Age	**>50**	**10-50**	**2-10**	**none**	**2-10**	**10-50**	**>50**	**Average**
15 to 19	-	-	2	97	1	1	-	0.11
20 to 24	-	1	12	79	3	6	-	0.65
25 to 29	-	2	15	69	7	8	-	0.89
30 to 34	-	4	13	65	11	7	-	0.67
35 to 39	-	5	16	64	9	7	-	0.43
40 to 44	-	5	20	61	8	7	0	0.26
45 to 49	-	4	22	63	6	4	0	-0.37
50 to 54	-	3	20	66	7	5	-	0.06
55 to 59	-	2	12	75	8	4	0	0.54
60 to 64	-	0	7	77	7	8	0	1.81
65 plus	-	-	-	100	-	-	-	0
Income unit type								
Couple	-	2	18	72	5	3	-	-0.37
Couple & dep.child	-	6	19	55	12	8	-	0.6
Dependent child	-	-	-	100	-	-	-	0
Single	-	0	3	96	1	0	0	0.09
Sole parent	-	0	0	46	12	41	-	8.27
Number of children								
None	-	1	11	84	3	1	0	-0.14
One	-	4	17	59	9	12	-	1.46
Two	-	4	14	64	10	8	-	0.85
Three	-	4	10	67	10	8	-	1.05
Four	-	4	6	65	12	12	-	2.15
Five	-	-	3	64	8	25	-	5.48
Six	-	-	2	79	9	9	-	1.54
Employment status								
Employed	-	4	20	75	0	0	-	-1.47
Non-participation	-	-	-	78	13	9	0	2.44
Unemployed	-	-	-	59	13	28	-	7.28
All	-	2.25	11.9	75.58	5.47	4.74	0.07	0.39
Count	-	300.88	1592.02	10114.93	731.6	634.39	8.83	13382.65

6.3 Effect on Expenditure and Revenue

The labour supply responses presented in the previous section flow through to the expected change in expenditure and revenue after the reform. Table 7 presents the expected changes in expenditure and revenue with and without allowing for labour supply changes. This is done separately for the four demographic groups for which labour supply changes are reported separately. Expenditure and revenue are divided into their components, so the reason for the changes can be found more easily.

Table 7 Tax and Transfer Costs: With and Without Labour Supply Responses

	Pre-Reform	**Change after reform**			
		Labour Supply may change		**Fixed Labour Supply**	
	Abs. Value (in million $)	**Abs. Value (in million $)**	**per cent**	**Abs. Value (in million $)**	**per cent**
Couples					
Government Revenue					
Income Tax	40884.9	-206.0	-0.5	900.3	2.2
Medicare	2516.2	56.9	2.3	114.9	4.6
Total Revenue	43401.1	-149.1	-0.3	1015.2	2.3
Government Expenditure					
Tax Rebates	2340.8	-555.2	-23.7	-567.6	-24.2
Family Payment	3815.8	1923.6	50.4	1531.4	40.1
FTP/FTB	394.0	202.7	51.4	164.4	41.7
Allowances	6484.6	5852.4	90.3	5222.4	80.5
Pensions	11019.7	784.7	7.1	805.0	7.3
Pharm. Allowance	116.6	10.0	8.6	10.0	8.6
Rent Allow	525.8	264.5	50.3	208.6	39.7
Total Expenditure	24697.3	8482.7	34.3	7374.2	29.9
Net Expenditure	-18703.8	8631.8	-46.1	6359.0	-34.0
Single men					
Government Revenue					
Income Tax	10928.0	523.3	4.8	373.0	3.4
Medicare	754.0	48.0	6.4	40.0	5.3
Total Revenue	11682.0	571.3	4.9	413.0	3.5
Government Expenditure					
Tax Rebates	426.2	-16.8	-3.9	-12.2	-2.9
Family Payment	0.0	0.0	0.0	0.0	0.0
FTP/FTB	0.0	0.0	0.0	0.0	0.0
Allowances	3317.7	1227.7	37.0	1357.1	40.9
Pensions	3204.2	145.7	4.5	145.7	4.5
Pharm Allow	54.4	2.4	4.4	2.4	4.4
Rent Allow	297.5	402.3	135.2	410.9	138.1
Total Expenditure	7300.0	1761.3	24.1	1903.9	26.1
Net Expenditure	-4382.0	1190.0	-27.2	1490.9	-34.0

Table 7 (continued)

	Pre-Reform	Change after reform			
		Labour Supply may change		Fixed Labour Supply	
	Abs. value (in million $)	Abs. value (in million $)	per cent	Abs. value (in million $)	per cent
Single women					
Government Revenue					
Income Tax	7398.7	321.0	4.3	334.9	4.5
Medicare	486.2	29.4	6.0	32.4	6.7
Total Revenue	7884.9	350.4	4.4	367.3	4.7
Government Expenditure					
Tax Rebates	793.8	-13.9	-1.8	-19.5	-2.5
Family Payment	0.0	0.0	0.0	0.0	0.0
FTP/FTB	0.0	0.0	0.0	0.0	0.0
Allowances	3297.7	1119.1	33.9	1070.4	32.5
Pensions	7048.2	230.9	3.3	231.6	3.3
Pharm Allow	118.4	3.3	2.8	3.3	2.8
Rent Allow	334.1	309.5	92.6	313.1	93.7
Total Expenditure	11592.2	1648.9	14.2	1598.9	13.8
Net Expenditure	3707.3	1298.5	35.0	1231.6	33.2
sole parents					
Government Revenue					
Income Tax	1643.3	174.5	10.6	74.5	4.5
Medicare	68.9	7.9	11.5	4.9	7.1
Total Revenue	1712.2	182.4	10.7	79.4	4.6
Government Expenditure					
Tax Rebates	533.0	13.7	2.6	-12.0	-2.2
Family Payment	2086.2	116.6	5.6	89.0	4.3
FTP/FTB	224.0	0.0	0.0	0.0	0.0
Allowances	2938.1	77.7	2.6	260.8	8.9
Pensions	155.0	-4.3	-2.7	1.1	0.7
Pharm Allow	48.4	6.9	14.2	5.9	12.2
Rent Allow	398.8	11.8	3.0	5.4	1.3
Total Expenditure	6383.5	222.4	3.5	350.2	5.5
Net Expenditure	4671.3	40.0	0.9	270.8	5.8

Table 7 shows that the net expenditure by the government on couple families and single women are higher if labour supply responses are taken into account, whereas the net expenditure is lower for single men and sole parents. The cost for sole parents resulting from this policy change is expected to be reduced substantially when potential labour supply responses are taken into account.

7 Further Examples of the Use of MITTS

This section describes a variety of examples where MITTS has played a major role in the analysis. Compared with the example in the previous section, less detail is provided. The aim is to provide a broad overview of the types of application in which behavioural microsimulation modelling has been useful. Subsection 7.1 discusses hypothetical policy changes, while Subsection 7.2 examines policy reforms that have actually been carried out or have been proposed in policy debates.

7.1 Hypothetical Policy Changes

Similar to the example in the previous subsection, Duncan and Harris (2002) examined the effect of a hypothetical change of a reduction in taper rates. In addition, they simulated the effect of three other hypothetical changes: a reduction in the taper rate of family payments, an abolition of the Single Parent tax rebate and an increase in the standard rate of income tax from 20 to 30 per cent. They limited themselves to the subgroup of sole parents and found this group to be quite responsive to financial incentives.

Creedy, Kalb and Scutella (2003) studied the extreme example of cutting all payments for sole parents. Naturally, this would have large effects on sole parents' poverty levels. Even allowing for labour supply responses, the expected effect on poverty levels and the decrease in net income available to sole parent families remain severe. Although the results from simulating such an extreme policy change are not thought to be as reliable as the results for more subtle changes, this result indicates that the belief held by some commentators that social security payments stand in the way of families gaining independence from benefit payments is likely to be false.

The use of alternative units of analysis and adult equivalence scales, when examining poverty and inequality changes resulting from policy reforms, can be considered using MITTS.[16] Creedy and Scutella (2004) examined the sensitivity of inequality and social welfare measures to the choice of the unit of analysis and equivalence scales. As part of this exercise, they simulated the effect of flattening the marginal tax rate structure for the whole population. Introducing a basic income (at around the current allowance and pension rates) and a flat tax rate of 54 per cent (which results in a roughly revenue-neutral change if no labour supply changes were to occur), they found that inequality is reduced unequivocally for all choices, but the predicted effect for social welfare depends on the unit of analysis and the aversion to inequality. After accounting for labour supply changes, inequality is reduced by a larger value but social welfare is

[16] The units include individuals, households and 'equivalent adults'.

increased by a smaller amount, and actually decreases for a wider range of parameter values. The lower increase in social welfare is due to the use of a welfare measure that takes only income into account and not the value of leisure or home-production time.

The implications of changes in the age distribution of the population were examined by Cai, Creedy and Kalb (2004), combining MITTS with alternative population projections for 2050 by the Australian Bureau of Statistics (ABS). A ‘pure’ change in the age distribution was examined by keeping the aggregate population size fixed and only changing the relative frequencies in different age-gender groups. Not surprisingly, this example of an ageing population shows that the cost of social security is expected to increase and the revenue from income tax is expected to decrease. The effects of a policy change to benefit taper rates in Australia were compared using 2001 and 2050 population weights respectively. Assuming that labour force participation rates have not changed between 2001 and 2050, this shows that the cost of such a policy is expected to cost slightly less in absolute terms and considerably less in relative terms (as a proportion of the expenditure before the policy change) for the 2050 population. The larger proportion of the population out of the labour force means that fewer people benefit from the taper rate reduction. As a result, a taper rate reduction is expected to be less costly in the older population. It is suggested that the kind of reweighting approach used by Cai, Creedy and Kalb (2004) provides scope for providing insights into the implications of changes to the population composition, indicating likely pressures for policy changes.

MITTS has also been used to examine the effect of a lack of change; that is, the absence of a correction mechanism for inflation to update the income tax thresholds between July 2000 and March 2004. Buddelmeyer *et al.* (2004a) focussed on the extent of bracket creep since the Australian New Tax System (ANTS) package and the distribution of effective marginal tax rates, respectively. It was estimated how much extra tax is paid per year due to bracket creep, that is, the relative increase in tax burden when nominal incomes increase and income tax thresholds remain the same. Thus at the same level of real income the average tax paid increases.

A range of possible tax-cut proposals was then examined, where the costs (before taking into account behavioural changes) are roughly equal to the dollar amount of bracket creep resulting from increases in prices not having been matched by the raising of thresholds. The effects of these different policies were simulated using MITTS.

Components of these reforms include: indexing the current tax thresholds for inflation; increasing the threshold at which the top marginal tax rate applies; lowering the second-highest marginal tax rate from 42 to 40 per cent; introducing an Earned Income Tax Credit; reducing taper rates on benefits; and combinations of these measures.

The labour supply responses are clearly different for the different packages. Two out of eight reform proposals are compared in detail: one that only involves indexation of all tax thresholds with CPI increases and one that introduces an earned income tax credit for low-income households and indexes only the top two thresholds. The expected labour supply effects of the tax credit proposal are nearly twice as large as for the other proposal. The resulting subsequent increase in tax revenues and reduction in benefit payments means that the long-run cost of the tax credit proposal drops considerably compared to the indexation proposal.

7.2 Actual and Proposed Policy Changes

One advantage of microsimulation is that it is straightforward to look at components of policy changes in isolation. Kalb, Kew and Scutella (2003) used MITTS to decompose the effect of the changes in July 2000. First the whole set of changes was studied and then some of its components were analysed separately. The change in income tax rates and thresholds were found to have the largest effect, because it affected a large proportion of the population, whereas the changes to the benefit system were only relevant to smaller groups. This tax change also increased labour supply for all groups, in particular for sole parents, making up part of the loss in tax revenue. Compared with the change in revenue resulting from the complete reform, the increase in expenditure on social security payments is quite small.

Families with children benefited on average most from the changes, firstly through the changes in income taxes and secondly through the changes in Family Payments. However, on the other hand, families with children were more likely to experience a loss indicating a wider range of positive and negative outcomes for this group.

For families with children, the changed structure and rates of family payments were also shown to be important. Other components of the reform provided several positive incentives for sole parents but the family payment reforms seemed to counteract this at least partly, resulting in a small positive overall effect. The simulation results also show that the introduction of the gradual withdrawal of the minimum rate of family payment rather than the previous 'sudden death' cut-out had a negligible effect as the reform only involved a small amount of income at a relatively high level of family income.

The analysis further showed that the reduction in pension taper rates had little effect on expenditure, given that a large proportion of pensioners do not work because of disability or retirement, and are not affected by a change in the taper rate. The reduction in the taper rate had a small positive labour supply effect for sole parents. The effect of an increase in the threshold of the Parenting Payment Partnered is even smaller both in expenditure and in labour supply effects. This is not surprising given that the reform only had a minor effect on net incomes of a small proportion of the population.

Looking at the combined effect of all changes, families with children experienced the largest increase in net government expenditure, mainly caused by increased family payments. However, from a comparison of the proportion of households experiencing a loss, this proportion is also higher for households with children. This indicates a wider variety in both positive and negative effects for these families than for others resulting from the reform. Single person households had the lowest average increase in average income. Given the large effect of the income tax reform, it was also found that families in higher income deciles had larger average income gains.

Although expenditure on benefit payments increased following the reform of July 2000, this increase is lower after taking into account labour supply behaviour. For single men and women, the expectation is that the increase in expenditure may even turn into a saving on expenditure after the behavioural changes are taken into account. Similarly, the decrease in revenue is lower after taking into account the increased labour supply amongst all groups. Thus, the expected changes in labour supply should help to reduce the cost of the reform. Net expenditure (tax revenue and expenditure on benefit payments and rebates taken together) is also increased by less after accounting for behavioural changes.

Some recent examples using MITTS to analyse the effect of proposed policy changes were reported by Buddelmeyer, Dawkins and Kalb (2004), who examined the changes announced by the Coalition in the 2004 Federal Budget. The Melbourne Institute's 2004 Budget Report focused on the effects of the Family Tax Benefit package and the income tax cuts, the two central features of the budget. Labour supply and distributional effects were explored using MITTS. While all families with children benefited from the changes, the benefits tended to go mostly to individuals and families with high incomes.

Examining the labour supply effects of separate components, the effect of the increase in Family Tax Benefit Part A by $600 per child was estimated to reduce labour supply by about 19,000, with the largest reduction being for sole parents, which is a high proportion of sole parents in work. This effect is almost exactly offset by a positive labour supply effect from reducing the withdrawal rate of Family Tax Benefit Part A.

The most surprising finding from the modelling is that changes to Family Tax Benefit Part B are expected to cause around 20,000 people to withdraw from the labour market. Those affected are partnered men and women. This is a result of the additional eligibility of non-working families with full Parenting Payments for Family Tax Benefit Part B. This raises net incomes at zero/low hours of work of the primary earner relative to net incomes at higher levels of labour supply. This seems to be an unintended consequence of this policy change, and its discovery through the analysis provides a further illustration of the advantages of behavioural microsimulation.

Modelling the effect of raising the top two income tax thresholds reveals that it raises labour supply by about the same amount as the Family Tax Benefit changes reduce labour supply. However, different workers are involved in these two effects. Finally, in this report alternative reforms were suggested and simulated, showing that better results with regard to work incentives could have been obtained at the same price as the policy changes in the Budget.

In a report on the Australian Labor Party's Tax and Family Package, Buddelmeyer *et al.* (2004b) predicted the labour supply effects associated with some of the policy changes announced in the package and calculated the effect of these labour supply changes on the budgetary cost of the proposed policy. The package analysed has four components. These are the Consolidation of Family Tax Benefit Part A and Part B into one payment (and some changes to rates and tapers); a Single Income Tax Offset (which provides a tax rebate for single- earner families); the Low and Middle Income Tax Offset, which provides a tax cut of up to $8 per week to tax payers with an income between $7382 and $56,160 per annum (with those below $8453 not paying any tax) and incorporates the existing Low Income Tax Offset; and an increase in the top income tax threshold to

$85,000. Although some of these changes restructured the current system considerably, these changes could be simulated in MITTS after some programming.

A feature of this report was the inclusion of a time path for the predicted employment changes using evidence from previous policy changes. Due to labour market frictions and displacement effects, not all the labour supply effects estimated in MITTS may be converted into an actual increase in employment and thus into the predicted budget savings resulting from these responses. On the other hand when the increase in labour supply is converted into employment, those entering or re-entering employment may experience increases in their wages over time, further increasing income taxes paid by these employees and lowering government benefits received by them, thus increasing the budget savings above that estimated by the MITTS model, which does not account for such wage progression. The report presented evidence that the employment effect can be expected to take about four years to be realised with the biggest incremental effect in the second year. The results are calculated using different scenarios. The central estimate of the time path of the employment effect, taking into account labour market frictions and displacement effects, and the time-lags involved, assumes that 85 per cent of the projected increase in labour supply is converted into increased employment.

8 MITTS Developments

As suggested earlier, a behavioural tax microsimulation is not something that is built and, once available, is simply left for use in policy analyses. In addition to constant maintenance, incorporating new data, the introduction of new front- and back-end menu facilities, microsimulation modelling generates significant analytical challenges. Nevertheless, the idea of producing an ideal or complete tax model that is capable of providing answers to all tax policy questions is a chimera. Such a model would need to be a life-cycle, overlapping generations, dynamic general equilibrium open economy model. It would also allow endogenous choices regarding education, occupational choice, labour supply, household formation, consumption and saving behaviour of all individuals. The mere description of the problem is sufficient to demonstrate its current infeasibility.

This section describes actual and potential enhancements to the basic form of MITTS. Section 8.1 is concerned with recent innovations added to MITTS, while Section 8.2 briefly describes MITTS additions that present challenges for the future.

8.1 Recent MITTS Enhancements

8.1.1 Distributional Measures

The use of a discrete hours framework, which generates a frequency distribution of income for each individual after a tax change conditional on being at the observed hours in the base, immediately presents a problem for distributional analyses. For example, suppose there are n individuals and k discrete hours levels. This results in k^n possible combinations of labour supply, and thus income distributions. Each outcome results in a different value for poverty and inequality measures. In principle, inequality or poverty measures could be calculated as weighted averages of the measures over all possible outcomes, with weights equal to the probabilities of each distribution arising. However, for any realistic sample size, even for few discrete labour supply points, the large number of possible combinations makes this computationally impractical.

To overcome this problem, Creedy, Kalb and Scutella (2004) considered a range of alternative approaches. One involves a sampling approach whereby a large number of possible income distributions are obtained by taking random draws from each individual's hours distribution. With a sufficiently large number of randomly selected samples, the proportion of each combination of individuals' labour supply replicates the precise probabilities, so a simple average of inequality measures over the draws could be used.[17] This approach still requires a large computational effort, depending on the number of draws needed to obtain a good approximation. Another alternative is to use the average value of income for each individual. The final alternative and preferred method, as shown by extensive Monte Carlo experiments, is such that all outcomes for every individual (that is, the combination of hours level and associated income) are used as if they were separate observations. The outcomes are weighted by the individual probabilities of labour supply to produce a pseudo distribution. This approach is computationally efficient and replicates the results of taking extremely large samples in the first approach.

[17] Each choice of discrete hours is drawn with the probability of it occurring for the relevant individual.

8.1.2 The Unit of Analysis and Income Concept

The ability to deal with population heterogeneity, itself an advantage of a tax microsimulation model, immediately raises problems when evaluating a policy change in terms of inequality (or an associated social welfare function), since standard measures are designed for homogeneous populations. In making decisions about the two fundamental concepts of income and the unit of analysis, the difficulty is, as Ebert (1997, p.235) put it, that ‘an (artificial) income distribution for a fictitious population has to be constructed'.

Most studies regard the only relevant non-income difference as household size and its composition. The first stage, involving the artificial income concept, is to convert total household income into a measure of the ‘living standard' of each household member by dividing income by the adult equivalent household size.[18] Then a decision must be made regarding the income unit – involving a choice between individuals or ‘equivalent adults’.[19] A problem with the use of individuals, unlike the use of equivalent adults, is that a transfer from a richer to a poorer household need not necessarily reduce inequality. A problem with the use of equivalent adults is that the weight attached to any individual in the population depends on the household in which the individual lives (each individual does not ‘count for one’).

The choice between individuals and adult equivalents as the basic unit of analysis in inequality and social welfare calculations therefore involves a choice between two fundamentally incompatible value judgements. They can in principle lead to opposite conclusions about the effects of a tax policy change on inequality. Shorrocks (1997) suggested that if concern is with equity, the use of adult equivalents is recommended, whereas if concern is primarily with social welfare, the individual should be the basic income unit. For this reason, it is important that MITTS can report results using both approaches and using a range of equivalence scales to explore the sensitivity of outcomes to these choices. Extensive comparisons of results using different units, and alternative adult equivalence scales, were made by Creedy and Scutella (2004).

[18] A wide range of scales are available in MITTS. The use of income per adult equivalent as a measure of ‘living standard’ is of course subject to much debate, but is widely used.

[19] The choice essentially determines the weight given to the living standard in computing inequality measures.

8.1.3 Adjusting the Base Data

When analysing actual or proposed policy changes, it is preferred to use data that 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 recently introduced 3-yearly frequency of the SIHC instead of surveying annually, this can be difficult to achieve. For example, when simulating the effect of the tax and social security changes of July 2000, only 1997/1998 data were available (Kalb, Kew and Scutella, 2003). MITTS updates all financial information 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 systems in the two years might well have caused labour supply changes. To take this possibility into account, MITTS can also update labour supply in the base data set if required.

An alternative approach to deal with this issue is to run two 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 in Buddelmeyer *et al.* (2004a, 2004b) and in Buddelmeyer, Dawkins and Kalb (2004), where data from 2000/2001 were used to evaluate the 2004 system against alternative systems.

8.1.4 Confidence Intervals

Microsimulation models typically provide no information about the sampling distribution of labour supply or expenditure changes. However, such information would be of interest to those involved in designing policy reforms with specific objectives and a government budget constraint in mind.

Uncertainty regarding a model's projections can arise for a variety of reasons. These include, for example, the fact that estimates of wage rates are used (particularly for non-workers in the dataset where wages are obtained from estimated wage functions), and preference parameters are estimated. In addition, sampling variations arise from the fact that the database is a sample of the population and household weights must be used for aggregation purposes. Kalb and Kew (2004) and Creedy, Kalb and Kew (2004) investigated methods of obtaining confidence intervals where the appropriate distribution of values arises from the sampling distribution of parameter estimates of preference functions.

A direct approach is to take repeated samples from the multivariate distribution of parameter estimates of the utility function, and for each replication carry out a tax reform evaluation (involving re-calibration for each individual). The results can be used to assemble a sampling distribution of aggregate results, such as expenditure totals. Unfortunately, this approach is impractical in many cases because of the extensive computing time required. However, in view of the typical shape of the sampling distributions, Creedy, Kalb and Kew (2004) found that a small number of replications (less than 100 and often only about 50) may be used to estimate the mean and variance. Assuming a normal distribution, percentiles from the resulting distribution can be used to construct confidence intervals.

8.1.5 Reweighting the SIHC

Section 7 discussed the use of MITTS to examine the potential effects of population ageing. This essentially required the reweighting of the SIHC, that is the production of a new set of grossing-up weights such that a specified set of population aggregates (in this case the number of individuals in various age groups) are equal to specified totals that are obtained from extraneous sources (such as ABS population projections). This kind of reweighting is often required in more straightforward situations; for example, it is not obvious that the sample weights provided with the SIHC result in the best match of MITTS totals to a range of expenditure and tax aggregates (obtained, say, from administrative records). One situation where reweighting is valuable is where it is required to carry out a policy analysis using a dataset that is several years old, and for which the sample weights provided may have become outdated.

A facility to produce revised weights using a calibration approach is now available. For each individual in a sample survey, information is available about a selected range of variables; most of these are likely to be either 0 or 1, as they relate to whether or not the individual is in, for example, a particular age or employment group. The sample design weights, provided by the statistical agency responsible for data collection, can be used to produce estimated population totals for these variables based on the sample survey.

The calibration approach can be stated as follows. Suppose that other data sources, for example census or social security administrative data, provide information about 'true' population totals. The problem is to compute new weights, which are as close as possible to the design weights, while ensuring that the population aggregates equal the values from the extraneous data source for each variable. In judging the closeness of the design and revised weights, a 'distance function' must be specified. The problem of computing new weights is thus a constrained optimisation problem, which can be solved using an iterative procedure that rapidly converges on the solution from an arbitrary set of starting values. The reweighting program associated with MITTS allows a choice of several distance functions.

8.2 Further Extensions

8.2.1 Welfare Measurement

Measures of inequality and their associated social welfare functions calculated by MITTS are based on some measure of income (using adult equivalence scales and alternative income units, as discussed above). In a behavioural model, it might be suggested that allowance should be made for changes in individuals' leisure as a result of a tax change. This suggests the use of a 'money metric welfare measure' rather than simply an income measure. Similarly, it would be useful to be able to compute standard measures of welfare change and marginal excess burdens for selected individual and household types (involving equivalent and compensating variations).

However, the computation of such measures in the context of income taxes and transfers is highly complex as a result of the nonlinearity of budget constraints and the role of corner solutions. In a discrete hours model, every position is effectively a corner solution. These problems were examined in detail in Creedy and Kalb (2001), who suggested an algorithm for computing exact welfare changes. The application of the method to MITTS is not straightforward, but the aim is to implement this in future.

8.2.2 Benefit Take-Up

The MITTS model evaluates taxes and benefits for each individual using the detailed information provided by the SIHC, assuming that all benefits to which the individual is eligible are claimed (and no benefits are obtained to which the individual is not entitled). Ideally, it would be useful to model take-up rates for each of the types of benefit at the same time as labour supply behaviour is modelled. This is considerably complicated by the fact that take-up rates may depend on the levels and conditions applying to the benefits for which the individual is eligible, along with the income level and demographic structure of the household. The current version of MITTS allows for a very simple adjustment to take-up rates, whereby benefits below a small specified amount are not claimed. Further work is planned on this aspect of MITTS in future.

8.2.3 Policy Objectives

In practical tax policy design, there are always particular constraints and objectives. For example, an aim may be a desire to stimulate greater labour market participation by a particular demographic group, or to raise the net income levels of certain groups, or reduce overall inequality. Constraints may involve government expenditure, or a desire of governments to retain some features of an income tax schedule, such as top marginal rates or the existence of a tax-free threshold. It would therefore be useful to introduce into behavioural models the facility for users to produce policy changes that are, for example, revenue neutral. This would require iterative search methods in which certain tax parameters (chosen by the user) are automatically adjusted in response to some specified policy change. This represents another challenge for the future.

9 Wider Modelling Developments

Extensive work is needed to deal with general equilibrium adjustment and dynamic aspects of tax reform. This section provides a tentative discussion on the development of new models that could potentially interact with MITTS.

9.1 General Equilibrium Adjustments

The emphasis on population heterogeneity has meant that the large-scale tax microsimulation models are partial equilibrium in nature. They focus on the commodity demands, labour supplies and incomes of individuals and households, along with the associated taxes and transfer payments. Insofar as they deal with consumption, they only deal with the demand side, and insofar as they deal with labour supplies, they only handle the supply side of the labour market. In practice, particularly for large tax changes, the resulting reallocation of resources may be expected to give rise to changes in factor prices. As mentioned earlier, it has so far not been possible to construct general equilibrium models having extensive household components, though experiments have been made involving linkages between different types of models.

This aspect of partial equilibrium models should always be kept in mind when considering simulation results. They describe what, under specified situations, may happen to only one side of the relevant market; they cannot produce a new equilibrium resulting from economy-wide adjustments. The models are also static in the sense that there is usually no attempt to model a time sequence of changes.

In a recent simulation, Buddelmeyer *et al.* (2004b) calculated a time path for the expected employment increase resulting from the increase in labour supply. Three different scenarios were presented for a four-year period, based on evidence from another policy change. This evidence was collected after the introduction of the change. The central scenario was based on the assumption that 85 per cent of the additional labour supply would be translated in additional employment after four years, whereas the pessimistic scenario assumed 65 per cent would find employment and the optimistic scenario assumed 95 per cent would find employment. This is of course a relatively *ad hoc* solution and a more formal process would be helpful to deal with this part of the simulation. The following two subsubsections suggest more formal procedures to incorporate general equilibrium adjustments into the predicted outcomes.

9.1.1 'Third Round' Effects of Tax Changes

In modelling terms there appears to be a dichotomy between large-scale tax microsimulation models and computable general equilibrium models. The former are partial equilibrium models, which replicate actual population heterogeneity and complex tax structures, while the latter typically have extremely simple tax structures and are based on a representative household.

In practice, the resulting reallocation of resources may be expected to give rise to changes in factor prices following a large tax structure change. This aspect of microsimulation models should be kept in mind; they describe what, under specified situations, may happen to the supply side of the labour market. It is useful to think in terms of the 'first round' effects of a tax reform, which arise in an arithmetic model in which labour supplies are fixed. The 'second round' effects, produced by a behavioural model, allow for labour supply responses, with wage rates held constant. The challenge is to take behavioural microsimulation analysis one step further, by modelling possible effects of a tax policy reform on wages.

Given a method of producing changes to the wage rate distribution arising from labour market effects, such changes could be fed back into the behavioural microsimulation model in order to obtain adjusted labour supply responses and government expenditure estimates: this gives what may be called the ‘third round' effects. Creedy and Duncan (2001) explored the use of a multi-stage procedure in which the simulated labour supply effects of a policy change are aggregated and combined with extraneous information about the demand side of the labour market. Their approach involves the concept of a ‘supply response schedule'. This is a numerical construction, based on simulated labour supply responses to wage changes, conditional on a given tax and transfer structure.

MITTS is used to obtain individuals' hours responses to a proportionate change in all observed wage rates. That is, the full wage distribution is perturbed, and the aggregate labour supply response to that perturbation is obtained. The advantage of this type of supply response schedule is that each point on the schedule is consistent with a distribution of wages, together with the underlying tax and transfer scheme and population characteristics. Movement along the supply response schedule arises from a shift in the entire wage distribution. While Creedy and Duncan demonstrated the potential usefulness of this extension to standard microsimulation, its practical application requires substantial disaggregated information about demand conditions. This extreme, in which wages must fully adjust to an unchanged demand for labour, provides a useful contrast to the opposite extreme, currently implied by MITTS, of no adjustment; and it can be modelled using the supply response schedule. This appears to be an area where links, rather than full integration, between general equilibrium models and behavioural microsimulation models could be exploited.

9.1.2 Alternative Extensions to Allow for some General Equilibrium Adjustment

Another area of potential extensions involves complementing the microeconomic approach of MITTS with analyses from recently developed macroeconomic models in which households have differing employment histories, levels of wealth, education, access to credit, or in general exhibit realistic degrees of heterogeneity. The Applied Macroeconomics research programme of the Melbourne Institute is in the process of adapting several of these models to the Australian context. It is anticipated that the interaction between MITTS and this class of macroeconomic models will be two-way: MITTS can provide guidance on the appropriate methods of calibrating existing models to be representative of Australian households, while the macroeconomic models can be used to provide a broader context in which to view the results of MITTS.

This strand of research could examine ways in which the capabilities of the MITTS model can be used in conjunction with a class of dynamic, stochastic general equilibrium (DSGE) macroeconomic models. Of particular interest are DSGE models, which incorporate heterogeneity among consumers. These models have not been as widely used as the benchmark 'representative agent' DSGE models, but are growing in popularity. A key feature of heterogeneous agent models, which makes them particularly attractive for use in this research, is that they generate equilibrium outcomes with non-trivial distributions of income, wealth, hours worked, and other variables of interest.

Early versions of heterogeneous agent models focused on environments in which consumers could not perfectly insure themselves against all idiosyncratic risk, because of liquidity constraints, incomplete markets, or other features. Examples include Imrohoroglu (1989, 1990), Hansen and Imrohoroglu (1992), and Aiyagari (1994); an overview of these models is in Ríos-Rull (1995).

More recently, models have been developed that incorporate a much richer degree of heterogeneity among households. Imrohoroglu, Imrohoroglu and Joines (1999a, b) present a model with overlapping generations of people who face both mortality risk and individual income risk. These agents also differ in their employment status and asset holdings. The authors use this model to examine the implications of an unfunded social security system and the optimal replacement ratio. Gourinchas and Parker (2002) analyse consumption decisions over consumers' life cycles in a model that features heterogeneity in occupation and education as well as income. Regalia and Ríos-Rull (2001) construct a model with both male and female agents, who make decisions about marriage and childbearing and invest in their children's human capital. They find that this model accounts very well for observed increases in the number of both single women and single mothers in the United States.

Using heterogeneous agent DSGE models in conjunction with MITTS has several other attractions. First, MITTS is calibrated to the Australian economy (with respect to wage and income distributions, for example), and so could provide guidance in how best to modify existing DSGE models in order to examine issues specific to Australia. Second, the general equilibrium nature of heterogeneous agent DSGE models may provide useful guidance on how best to incorporate dynamic features into MITTS. Third, heterogeneous agent DSGE models allow for more sources of uncertainty than does MITTS. For example, macro models could be used to incorporate business cycle shocks, monetary policy and productivity shocks into MITTS-based analyses.

9.2 Life Cycle Dynamics and Population Dynamics

Both the behavioural and arithmetic components of MITTS are concerned with a cross section of individuals at a single point in time, and behaviour is based on estimated utility functions that are defined in terms of current (single-period) levels of net income and leisure. This places an obvious restriction on the nature, or interpretation, of the types of counterfactual examined. MITTS-B provides the probabilities that individuals work a range of alternative hours levels, under the assumption that only net incomes at those hours are different from the net incomes in the sample period. Behaviour may in practice change because people get older or they anticipate future tax changes, perhaps as a result of government responses to expected population ageing.

This means that MITTS does not look at changes over the lifetime of individuals or at the aggregate situation in future years. A number of features of the tax and transfer system are nevertheless designed specifically with a longer period perspective in mind, so that concern is not so much with income redistribution in cross-sectional data but with redistribution over the lifetime. An obvious example relates to pension or superannuation schemes, but sickness and unemployment benefits, and many family-related transfer payments, are received by individuals at various stages of the life cycle rather than reflecting permanent features.

Longer period considerations are also relevant in designing policies to encourage labour force participation. For example, it is well known that mothers with young children reduce their hours of work or completely cease to participate in paid employment. To determine what influences this decision and investigate how it may be affected by tax policy, the impact of the current decision needs to be taken into account, not only on the current income level but also on future income levels. Individual's decisions are likely to be influenced by long-term plans as well as single-year impacts. Similarly, when studying retirement decisions, it is important to take into account the long-term nature of retirement planning. To study these issues, it is necessary to model individuals' life cycles.

As indicated earlier, population changes over calendar time are also important, in addition to life cycle changes, which take place for a variety of cohorts in a population over the same time period. Changes in population structure can be projected under particular assumptions regarding fertility, death and migration rates. Such projections can be used in conjunction with microsimulation models to provide a limited number of counterfactual analyses.[20]

The construction of life-cycle models is obviously much more demanding than that of cross-sectional models, in terms of conceptual, computational and data demands. It is therefore not surprising that earlier life-cycle tax models tended to concentrate on specific issues such as superannuation, using a single cohort and little heterogeneity in terms of household structures.[21] However, developments in computing facilities, data availability and an increased willingness to fund the teamwork necessary for the production and maintenance of large scale models has led to recent fruitful developments in dynamic simulation modelling.[22] There is therefore scope for combining some of the benefits of dynamic models with the advantages of a microsimulation model such as MITTS.

Unlike cross-sectional tax microsimulation models, a dynamic model requires some kind of demographic component to deal with life-cycle events such as marriage, fertility, divorce, and deaths. The ability to model these features is needed even if they are not endogenised, that is, made to depend on incomes and relevant characteristics of the tax and transfer system. It may be possible to use such a demographic model to age a cross-sectional dataset artificially, using details of, for example, marriage and fertility patterns in relation to a range of individual characteristics (in addition to age). If all the relevant characteristics of a person at a future point in time (that is, at a future age) were predicted in this way, then the amount of social security benefits or tax given a

[20] The use by Cai, Creedy and Kalb (2004) of ABS projections of the Australian age distribution in 2050, to simulate the effect on government expenditures and revenues assuming that the tax and social security system remains unchanged, is discussed briefly in Section 7 above.

[21] Australian examples are the cohort model of the complex superannuation and age pension scheme in Atkinson, Creedy and Knox (1996) and the analysis of indirect taxes and lifetime inequality in Cameron and Creedy (1995).

[22] For a survey of a range of dynamic models, see O'Donoghue (2001).

particular tax and transfer system could be calculated using MITTS. This could perhaps be done for a sequence of years up to an individual's entire lifetime and for different tax and transfer systems.[23]

In this way, a person's lifetime income from different income sources could be projected under different tax and transfer systems. Similarly, the accumulation of net worth over a person's life cycle could be simulated, assuming a particular saving rate or profile of saving rates.[24] Naturally, estimation of models regarding the decisions of individuals over the life cycle ideally requires longitudinal data over a long period of time. These are not available for Australia but even with relatively few 'waves' of survey data or using a pseudo cohort constructed built up from a sequence of cross-sectional surveys, models could be estimated for a prototype, which could be improved and extended in the future as more data become available.

The majority of dynamic models are discrete-time models given the large computational requirements of continuous time models. One type of modelling approach uses an annual transition matrix for the different lifetime transitions. Shortening the time period between transitions obviously increases the amount of information required and the time needed to calculate all variables in the model, and it is unlikely to provide significant benefits. It may be possible to combine this type of model with MITTS, particularly if the dynamic model produces data that are consistent with the form of input used within MITTS.

However, the use of transition matrices as the basic information on which life-cycle changes are generated makes it difficult to examine counterfactuals, given the large number of elements involved, which need to be changed. For example, it would be of interest to consider the implications of various changes in the age of marriage, or of associated fertility patterns. An alternative, more parsimonious, approach was adopted by Creedy and van de Ven (1999, 2001), where functional relationships were estimated and the parameters had clear economic or demographic interpretations, so that counterfactuals could easily be specified. Simulated life-cycle changes were based on

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[23] The 'ageing' of the individuals in the dataset must necessarily relate to a specific calendar-time period, over which exogenous changes, not only in the tax structure but for example also in inflation, real wage growth and nominal interest rates, need to be made explicit.

[24] This type of approach also requires explicit assumptions to be made regarding differences between cohorts as they age over the same calendar-time period. Such differences may be particularly important regarding fertility, for example.

random drawings from the estimated distributions underlying the functional relationships. Nevertheless, the Creedy and van de Ven approach was limited in the degree of heterogeneity modelled and, in addition, it did not model optimising behaviour (though a certain amount of endogeneity was in fact built into the simulations).

Allowing for optimising behavioural in dynamic models may perhaps more easily be incorporated if it is assumed that only past outcomes and the current time period's set of outcomes are relevant for the different decisions to be made, and the order of decision making is known (whereby some types of decision take priority or must necessarily occur before others). Simple assumptions about expectations formation would be needed. More interesting but also more complicated and computationally demanding would be to allow for behavioural responses to policy changes, allowing a long-term view when households make a particular decision, for example, whether or not they want to be in paid employment. The complication arises from having to calculate the effect of taking each possible path at each decision moment. There are many possible paths with different outcomes; one of these has the highest utility and is expected to be chosen. Solving this type of model requires the optimisation of intertemporal equations at each point in time where a decision is made; see Sefton (2000) for further discussion of this problem.

10 Conclusions

This paper has given an overview of tax microsimulation modelling in general, and the Melbourne Institute Tax and Transfer Simulator (MITTS) in particular. The focus has been on behavioural tax microsimulation modelling, which takes individuals' labour supply responses into account when analysing tax and transfer reforms. Microsimulation models are particularly useful in tax policy analysis and design as they are built to replicate closely the considerable degree of heterogeneity observed in the population.

After an illustration of the current uses of MITTS and the typical output it can provide, the paper showed that there are several opportunities for further extensions. This is due to the recent development of this type of model, which requires powerful computers to allow simulations to be run in a reasonable amount of time. Many of the proposed extensions would require a considerable amount of additional running time to carry out a simulation. Examples of valuable extensions are to allow for the demand side of labour, indicating whether new labour force participants are likely to find work; or to allow for life-cycle dynamics, which are important to deal with population-ageing issues or with female labour force participation.

All models have their limitations and these must be recognised when producing policy simulations. Indeed, the use of formal models helps to make the assumptions explicit. Reminders must regularly be issued regarding the need to treat models as providing, at best, tentative guidance about the possible implications of tax changes in well-specified circumstances. In addition, it can be important to run several simulations based on different assumptions. This allows an examination of the sensitivity of outcomes to alternative assumptions.

An important component of every microsimulation model is the dataset on which it is based and which has been used to estimate behavioural relationships. It is particularly important that the data are up to date, and that detailed information on income and hours of work are available. Without this, obtaining reliable results would be extremely complicated or perhaps even impossible.

Every tax policy change involves losers and gainers. Hence, distributional value judgements are unavoidable. It is argued here that the most useful role of models is in supporting rational policy analysis. By this is meant the examination and reporting of the implications of alternative policies, so that policy-makers can form their own judgements. It also involves the determination of the appropriate policies that are implied by the adoption of a range of clearly specified value judgements.

As always, given that no model is without its limitations, it is necessary to treat the output from microsimulation models with caution. Nevertheless, given the importance of the issues examined, such models can provide a valuable element of policy analysis and can thereby help to provide a counterweight against the rhetoric and special pleading that otherwise play a major role in tax policy debates.

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