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Decomposing Inequality and Social Welfare Changes: The Use of Alternative Welfare Metrics*

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Abstract

This paper presents two `non-welfarist' approaches and one `welfarist' approach to decompose changes in inequality and social welfare into three components. We distinguish the contributions of population, tax policy and labour supply behavioural effects. As an illustration, we decompose changes in inequality and in values of a social welfare function in Australia between 2001 and 2006. Inequality is first defined in non-welfarist terms as a function of disposable income: the independent judge places no value on leisure. Then this is modified to allow for evaluations using a weighted geometric mean of disposable income and leisure. This is seen to modify the evaluation of changes in important ways. Furthermore, the results are shown to be quite different from those obtained using a `welfarist' evaluation in terms of money metric utility, where separate behavioural effects cannot be isolated.

JEL classification: D63, H31, I31, J22

Keywords: Inequality decomposition, social welfare function, behavioural microsimulation, money metric utility

1 Introduction

In evaluating changes in inequality, or some other index such as a poverty measure, the usual situation is that the investigator has cross-sectional survey data for two years, marking the start and end of the period under investigation. It is desirable to distinguish the effects of government policy changes, particularly concerning the direct tax and transfer system, from those arising from changes in the structure of the population between the relevant years. Such population effects cover a wide range, including changes in the age, occupational, educational and demographic structure. A behavioural microsimulation model is particularly useful for this purpose, since it is able to provide information about the simulated labour supply (and the corresponding net incomes) of individuals in a range of counterfactual situations. A tax policy change designed to influence the distribution of net income may, for example, be frustrated by endogenous labour supply responses. Alternatively a tax change may be made in an attempt to influence labour supply, and it is important to be able to distinguish those changes from the redistributive effect of the tax structure alone. An illustration of the value of a microsimulation model for measuring different components of changes in the distribution of disposable incomes is provided by Bargain (2010), who decomposes changes following the framework proposed by Shorrocks (1999), which in turn is influenced by Shapley (1953).[1]

Components examined by Bargain (2010) include *ceteris paribus* changes arising from tax-induced changes to labour supply between the two periods, the *ceteris paribus* changes arising from the changing structure of the population itself between the two periods, and finally the *ceteris paribus* changes

[1]The Shapley value approach has also been implemented to decompose inequality by income source and population subgroups. For example, Mussard (2006) provides such decompositions for the Gini index using Italian data for 1989 and 2000. However, without a microsimulation model, it is not possible to disentangle the changes due to the changing structure of the underlying population and the changes due to other factors (such as policy changes). The static decomposition has been used by Deutsch *et al.* (2006) to examine occupational segregation. On the decomposition, see also Sastre and Trannoy (2002) and Cowell and Fiorio (2009). Gunatilaka and Chotikapanich (2006) examined inequality trends in Sri Lanka using the approach with a regression-based model.

arising from the change in the tax structure alone.[2] A crucial aspect of the decomposition is the need to distinguish carefully among the several alternative ways to obtain the *ceteris paribus* requirement, using a range of counterfactuals. Bargain used a structural discrete hours approach to labour supply modelling. The random utility component means that a probability distribution over available hours of work is generated for each individual, and Bargain based disposable incomes for each case on the arithmetic mean hours for each individual.[3]

Following Bargain (2010), the present paper provides a decomposition of the inequality of disposable income in Australia for the period between 2001 and 2006. However, instead of using each individual's expected hours of work, this paper bases inequality measures on the 'pseudo distribution' method proposed by Creedy, Kalb and Scutella (2006) to obtain a close approximation of the full distribution. The use of disposable income may be said to involve a 'non-welfarist' approach, in which the evaluation (made by a disinterested judge whose value judgements are summarised by the social welfare function implicit in the inequality measure) does not attempt to place any value on leisure consumed by individuals. However, going beyond this 'non-welfarist' approach is not straightforward given the fundamental difficulty arising in specifying a suitable welfare metric. Here, Bargain's approach is extended by proposing two alternatives, one of which is non-welfarist while the other can be described as 'welfarist'.

In the basic optimal tax model, the specification of a suitable welfare metric is straightforward given the choice of cardinalisation of utility, where there are common preferences, particularly for leisure. But heterogeneous preferences present serious difficulties when making social evaluations, as shown by Donaldson (1992) and Blackorby *et al.* (1993). One approach has recently been suggested by Aaberge and Colombino (2008) and Ericson and Flood

[2] Any change in inequality resulting from a 'growth effect' (an equal proportional change in incomes and all tax and benefit thresholds) is negligible. This homogeneity property is discussed further below.

[3] Bargain (2010, p. 8) suggested that 'averaging individual supply responses over a large number of draws provides robust transition matrices'. However, on limitations of using the average, see Duncan and Weeks (1998) and Creedy, Kalb and Scutella (2006), who provide comparisons using simulations.

(2009).[4] Both studies use a discrete hours structural approach to modelling labour supply, allowing for a substantial amount of population heterogeneity. However, the welfare metric used in their social welfare function is a value of utility based on an independently estimated utility function (expressed in terms of disposable income and hours of work) which is considered to be the same for all individuals; they regard it as a common utility function.[5] This may be viewed as 'welfarist', using a different utility function for the welfare metric compared with that used to obtain labour supply. Alternatively, the common 'utility' function can be viewed as simply a weighting function in a non-welfarist approach that gives some weight to hours of work as well as disposable income. The present paper proposes the alternative interpretation in which social welfare is expressed as a function of individuals' net income and leisure, using the same weighting function for all individuals, rather than attempting to use any kind of common utility measure.

The problems of aggregating heterogeneous preferences suggest that a cardinalisation of utility based on 'money metric utility' (for a given set of 'reference prices') is unlikely to satisfy the strong conditions needed to guarantee a concave social welfare function. However, for comparison purposes the present paper also reports the use of a decomposition based on money metric utility (taking the initial tax structure as reference). This is therefore a 'welfarist' approach. A modification to the decomposition method is needed because, in this case, separate behavioural and tax policy effects cannot be distinguished.

Section 2 explains the decomposition method used. This clarification is needed as the approach has received relatively little attention and, as shown here, much care is needed in setting out the alternative counterfactual cases. Section 3 reports results for Australia, using disposable income. Section 4

[4] For further explanation and discussion, see Decoster and Haan (2010). They compare alternative welfare metrics based on the use of various nested sets based on a 'real wage' metric, a 'reference wage' metric, and a 'Rente criterion' (based on net income intercepts of indifference curves).

[5] Blundell and Shephard (2009) adopt a social welfare function based on a common (isoelastic) utility transformation. They simplify the resulting expression for the aggregate, allowing for the stochastic utility component, which follows a Type-I extreme value distribution.

proposes a method of carrying out the decomposition using a social welfare function based on both disposable income and leisure. Results comparable with those of section 3 are also reported. Section 5 explores the use of money metric utility in a social welfare function. For each application, the simulation model used is the Melbourne Institute Tax and Transfer Simulator (MITTS), the only behavioural microsimulation model for Australia, which is described briefly in Appendix A. Conclusions are in section 6.

2 The Decomposition Method

Suppose that data are available for two periods, 0 and 1, and suppose it is required to decompose changes in an index of inequality. Disposable (net of direct taxes and transfers) income is used as the 'welfare metric'. For convenience, in this section the decompisition is discussed in terms of an inequality index. However, the same approach can be applied to measures of poverty or, as shown in the next section, values of a specified social welfare function. As explained in the empirical applications below, it is combined with an assumption of equal sharing within households and use of an adult equivalence scale. Let $M_i(.)$ denote the index of interest, calculated under tax structure i. The tax and transfer system (hereafter abbreviated to tax structure) is summarised by a set of parameters, including the tax rates and thresholds as well as the level of the transfer payments and their corresponding eligibility rules. In the following analysis the vector of thresholds for period 0 is always assumed to be adjusted in nominal terms to period 1 values, using an 'uprating' factor.

The values of disposable income are based on a population matrix, $y_{k,s}$, such that each row contains relevant information about each individual (including endogenous labour supply) under the tax regime operating in period k and for the population dataset of period s. Again, in what follows, $y_{k,0}$ values are assumed to be uprated to year 1 nominal values, using the same uprating factor as that used to obtain the corresponding tax threshold values.[6]

[6]Bargain (2010) introduced the uprating factor explicitly, along with a vector of tax and

The inequality measure can thus be written as:

$$M_i\left(y_{k,s}\right) \tag{1}$$

Importantly, i and k need not necessarily be the same. This means that gross income is calculated using the labour supply arising from tax structure k for dataset s. This gross income is rescaled (if necessary) so that it is expressed in year 1 values. Then the tax structure i is applied to those gross incomes in order to obtain a set of disposable incomes. The inequality measure is then computed as a function of the resulting disposable incomes.

The assumption is used throughout that the values of M are 'scale invariant', whereby a homogeneity property holds. That is, the index based on the tax structure in period 0 using unadjusted tax thresholds and transfer payments and the unadjusted values of $y_{0,0}$, gives exactly the same value as $M_0\left(y_{0,0}\right)$, given that the thresholds, transfer payments and incomes are adjusted using the same factor.[7] Hence the change in the index can be measured by:

$$\Delta = M_1\left(y_{1,1}\right) - M_0\left(y_{0,0}\right) \tag{2}$$

The populations of periods 0 and 1 are clearly different, reflecting for example differences in demographic, occupational, skill and taste characteristics. Individuals' labour supplies for a given population under the actual tax structure operating in that period are clearly observable, but a range of hypothetical distributions, and thus indexes, can be generated. For example, the predicted labour supply in period 0 of each individual in the period 1 population can be obtained 'as if' the tax regime of period 0 were to exist in period 1. This kind of counterfactual enables the change in (2) to be decomposed as follows.

The change in inequality can be divided into the three distinct effects mentioned above (since the assumption of homogeneity rules out any simple 'growth effect'). These reflect labour supply effects of the tax changes; those

transfer thresholds. However, the notation is clearer once it is recognised that parameters and disposable incomes are always uprated to the final year using a common uprating factor.

[7] This homogeneity property was directly tested, using the data discussed below, and found to hold. Bargain (2009) also found that it holds in the case of the UK.

arising from the changing structure of the population itself between the two periods; and finally the change arising from the change in the tax structure. In each case, there are several ways to obtain the *ceteris paribus* requirement, but these need to follow a particular sequence to ensure that the sum of the components adds to the total difference in (2).

Consider the contribution to Δ due to the labour supply adjustment to tax policy changes. This is reflected in the change in the index, M, that is attributed to changes in gross incomes arising from labour supply changes alone. It may be evaluated using different populations (datasets) and different tax regimes. Hence the behavioural change is given by:

$$B_{i,j} = M_j\left(y_{1,i}\right) - M_j\left(y_{0,i}\right) \tag{3}$$

for $i = 0, 1$ and $j = 0, 1$. The two terms in this expression differ only in the tax structure used to obtain labour supply. The combination of different tax regimes used to compute the index M and different datasets to obtain labour supplies means that there are four terms describing behavioural contributions to the overall change. These are displayed in Table 1.

Table 1: Behavioural Effects: B

Labour supply based on survey:	Tax regime of: Year 0	Year 1
Year 0	$M_0\left(y_{1,0}\right) - M_0\left(y_{0,0}\right)$	$M_1\left(y_{1,0}\right) - M_1\left(y_{0,0}\right)$
Year 1	$M_0\left(y_{1,1}\right) - M_0\left(y_{0,1}\right)$	$M_1\left(y_{1,1}\right) - M_1\left(y_{0,1}\right)$

Similarly, the contribution to the overall change in inequality contributed by the change in the structure of the population is measured by a change in which the only thing to vary is the population dataset. Hence these effects are given by:

$$P_{i,j} = M_j\left(y_{k,1}\right) - M_j\left(y_{k,0}\right) \tag{4}$$

for $j = 0, 1$ and basing the gross incomes on the labour supply under the tax structure, k, such that where i denotes the population dataset, $k = 1$ when $i = 0$ and $k = 0$ when $i = 1$. This particular configuration of subscripts relating to the tax structures used is necessary to ensure that when the population effects are combined with the behavioural effects, the appropriate terms cancel (so that the sum of the three effects is equal to total changes Δ). The two-by-two matrix of four population effects corresponding, cell by cell, to the behavioural effects is given in Table 2.

Table 2: Other (Population) Effects: P

Labour supply based on survey:	Tax regime of: Year 0	Year 1
Year 0	$M_0(y_{1,1}) - M_0(y_{1,0})$	$M_1(y_{1,1}) - M_1(y_{1,0})$
Year 1	$M_0(y_{0,1}) - M_0(y_{0,0})$	$M_1(y_{0,1}) - M_1(y_{0,0})$

When examining the contribution attributed to policy changes in the tax regime alone, the disposable incomes are based either on the tax regime 0 or 1, using its corresponding population dataset. Only two *ceteris paribus* changes are relevant here. Hence the tax policy change effects, T_j are given in Table 3.

Table 3: Tax Structure (Policy) Effects: T

Tax regime of: Year 0	Year 1
$M_1(y_{1,1}) - M_0(y_{1,1})$	$M_1(y_{0,0}) - M_0(y_{0,0})$

The four decompositions are thus, for $i = 0, 1$ and $j = 0, 1$:

$$\begin{aligned} \Delta_{i,j} &= B_{i,j} + P_{i,j} + T_j \\ &= M_1(y_{1,1}) - M_0(y_{0,0}) \end{aligned} \tag{5}$$

Consider, for example, the decomposition $\Delta_{0,0}$, which, by taking appropriate terms from the three tables is given by:

$$\begin{aligned} \Delta_{0,0} &= M_0(y_{1,0}) - M_0(y_{0,0}) \\ &\quad + M_0(y_{1,1}) - M_0(y_{1,0}) \\ &\quad + M_1(y_{1,1}) - M_0(y_{1,1}) \\ &= M_1(y_{1,1}) - M_0(y_{0,0}) \end{aligned} \tag{6}$$

The first three rows of (6) represent, in turn, the contributions of the behavioural effect, the population effect, and the tax policy effect to the overall change in the index. The first term in the behavioural effect cancels with the second term in the population effect and the first term in the population effect cancels with the second term in the tax policy effect. This leaves the overall effect as in the last line of (6).[8]

Following Shapley (1953) and Shorrocks (1999), the marginal effects of each component can be measured by their arithmetic mean values over all possible sequences (that is, attributing the same probability to each), given by:

$$\bar{B} = \frac{1}{4}\sum_{i=0}^{1}\sum_{j=0}^{1}\left[M_i\left(y_{1,j}\right) - M_i\left(y_{0,j}\right)\right] \tag{7}$$

$$\bar{P} = \frac{1}{4}\sum_{i=0}^{1}\sum_{j=0}^{1}\left[M_i\left(y_{j,1}\right) - M_i\left(y_{j,0}\right)\right] \tag{8}$$

$$\bar{T} = \frac{1}{2}\sum_{j=0}^{1}\left[M_1\left(y_{j,j}\right) - M_0\left(y_{j,j}\right)\right] \tag{9}$$

The following section illustrates the approach using data and a microsimulation model for Australia. However, some caution is needed in interpreting behavioural effects obtained by using such a model. Tax microsimulation models are partial equilibrium supply side models. Thus they are able to simulate the effect on each individual's labour supply of a change in the tax structure, but they do not allow for demand-side factors or for potential general equilibrium effects on wage rates. The actual wage rate changes thus appear as population effects. In addition, tax policy changes may affect fertility, household formation, migration, educational choice and other variables which, in the present approach, become subsumed under the population changes.

[8] The population effects, $P_{i,j}$, encompass all effects other than behaviroural effects or tax structure (policy) effects. They cover a wide range including changes in the age, occupational, educational and demographic structure. They also include the effect of non-uniform income growth, for instance, by occupation, sector, region or by income source.

3 Empirical Application: Australia 2000/01 to 2005/06

This section applies the approach described above to changes in inequality and values of a social welfare function, based on disposable incomes in Australia between the financial years of 2000/01 and 2005/06. The behavioural microsimulation model used is the Melbourne Institute Tax and Transfer Simulator (MITTS). This is a microsimulation model based on a structural discrete hours approach to labour supply, with a random utility component.[9] An important first question arises of how to deal with the fact that a probability distribution over hours for each individual is generated, instead of a single deterministic level of labour supply. Rather than using the arithmetic mean hours for each individual, over the discrete hours available for work, the following application uses the 'pseudo distribution' method proposed by Creedy, Kalb and Scutella (2006) for dealing with the complete distribution.

Table 4: Income Tax Schedules 2000/01 and 2005/06

2000/01 (uprated)		2005/06	
Threshold	Tax rate	Threshold	Tax rate
0 – 7,619	0	0 – 6,000	0
7,620 – 25,395	0.17	6001 – 21,600	0.15
25,396 – 63,488	0.30	21,601 – 63,000	0.30
63,489 – 76,186	0.42	63,001 – 95,000	0.42
>76,186	0.47	>95,000	0.47

Tables 4 and 5 present the changes in the income tax rates and thresholds and in the main benefit payments, respectively, over the period of interest. This lists only the main benefit payments but all payments together with the corresponding eligibility rules are used in the microsimulation model. To uprate tax and transfer parameters, as well as incomes, to 2005/2006, a wage index based on average earnings for full-time workers, provided by the Australian Bureau of Statistics, was used.[10] The index increased by

[9] For a more detailed description of MITTS, see Creedy *et al.* (2002). Creedy and Kalb (2006) describe some further features of MITTS.

[10] See Australian Bureau of Statistics (cat. no. 6302.0, Table 3, series ID A2734023X).

26.98 per cent during this period. Comparison of the income tax parameters reveals that only the second tax rate was adjusted between 2000/01 and 2005/06, decreasing by two percentage points. The adjustments in the tax thresholds were more substantial. The first two tax thresholds were reduced in real terms while the top tax threshold was substantially increased. These changes in the income tax parameters amount to an increase in the average income tax rates for (almost) all individuals on gross incomes below $86,000 a year and a decrease in taxes for incomes above this threshold.

Table 5: Changes in Main Benefit Payments Between 2000/01 and 2005/06

	Change compared with wage rates:	
	Payment levels	Taper rate
Family Tax Benefit-A	>5% above	Reduced
Family Tax Benefit-B	<5% above	Reduced
Age Pension	<5% below	-
Disability Support Pension	<5% below	-
Newstart Allowance	about 5% below	-
Youth Allowance	>5% below	-
Special Benefit	>5% below	-
Partner Allowance	>5% below	-

Family Tax Benefit-A is a transfer payment designed to deal with the cost of raising children. The benefit withdrawal, or taper, rate for maximum payment of this benefit fell from 0.3 to 0.2 over the period. Family Tax Benefit-B is a means-tested extra payment for single parents and families with one income earner. The taper rate for this benefit also fell from 0.3 to 0.2 over the period. Table 5 shows that while Family Benefit Payments increased faster than the wage index, growth in the other benefit payments falled behind that of the wage index. The use of a microsimulation model makes it possible to examine the combined effects of all these changes in the tax and transfer system.

In combination with these two sets of tax parameters, we use the 2000/01 and the 2005/06 Surveys of Income and Housing Costs (SIHC). Changes in population size and structure by demographic group between 2000/01 and 2005/06 are described in Table 6, although of course this is only one aspect

Table 6: Population Size (000s) in 2000/01 and 2005/06

	2000/01	2005/06	Change (per cent)
Couples	12,749	13,595	6.22
Single males	2,361	2,459	4.00
Single females	2,077	2,247	7.58
Single parents	1,559	1,531	-1.87
ALL	18,745	19,832	5.48

of the population change. The population totals are obtained using the SIHC weights, which are also used to obtain the inequality and social welfare measures reported here. The Australian population increased by 5.48 per cent over this period but population growth was not homogenous across demographic groups. Whereas couple families and single females grew at a faster rate, growth was slower for single males and the group of single parents experienced a reduction in size.

The inequality measures reported below are Atkinson measures, $A(\varepsilon)$, for three values of relative inequality aversion, ε. The social welfare values are for the associated abbreviated welfare function, $W = \bar{y}(1 - A(\varepsilon))$, where $\bar{y}$ is the appropriate arithmetic mean disposable income.[11] The unit of analysis throughout is the individual, where each individual in a household is assigned the total income per adult equivalent. Following Banks and Johnson (1994) and Jenkins and Cowell (1994), the adult equivalent size, s, is obtained using the following parametric scales:

$$s = (n_a + \theta n_c)^{\delta} \tag{10}$$

where n_a and n_c are respectively the number of adults and children in the unit, θ is the weight attached to children and δ represents the extent of economies of scale. The weight attached to children, θ, was set at 0.6 and the economies of scale parameter was set at $\delta = 0.8$.[12]

[11] The value of the abbreviated welfare function is thus the 'equally distributed equivalent' level of disposable income.

[12] These values produce scales that are similar to the OECD scales: for values corresponding to 29 different sets of equivalence scales, see Creedy and Sleeman (2005, pp. 77-79). The sensitivity of the results with respect to the economies of scale parameter is discussed further below.

Table 7 shows the baseline disposable income measures, that is $M_0(y_{0,0})$, and the total changes in inequality and social welfare between the financial years, 2000/01 and 2005/06. This table shows that, at the aggregate level, disposable income inequality, as measured by the Atkinson index, has decreased for $\varepsilon \leq 0.8$, and increased for the higher value of $\varepsilon = 1.4$. At the demographic group level the results clearly show a reduction in intra-group inequality for couples, whereas for single males, single females and single parents there is an increase in intra-group inequality. Both mean disposable income and social welfare increased over the period for all demographic groups except for single females who experienced a slight reduction in social welfare. The small increase in mean disposable income was not sufficient to compensate for the increase in inequality.

Table 7: Baseline Disposable Income Measures and Total Changes 2000/01 to 2005/06

		Atkinson index			Social Welfare		
	$\bar{y}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	26,609	0.0264	0.0965	0.1552	25,906	24,041	22,478
Single males	27,751	0.0299	0.1131	0.1859	26,921	24,613	22,593
Single females	23,133	0.0241	0.0904	0.1475	22,575	21,040	19,721
Single parents	18,153	0.0118	0.0442	0.0724	17,939	17,351	16,838
ALL	25,664	0.0268	0.0982	0.1580	24,977	23,144	21,610
				Total percentage changes			
		Atkinson index			Social Welfare		
	$\bar{y}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	11.21	-7.34	-6.48	-5.28	11.43	11.98	12.29
Single males	5.34	11.64	8.74	7.36	4.97	4.17	3.57
Single females	0.05	11.71	7.83	5.18	-0.24	-0.73	-0.85
Single parents	10.44	48.58	40.45	34.67	9.80	8.37	7.45
ALL	9.42	-0.26	-0.03	0.66	9.42	9.42	9.28

The decomposition of these changes is provided in Table 8. To limit the size of the table, only the arithmetic mean values obtained from equations (7), (8) and (9) are reported. All possible decompositions (at the aggregate level) are presented in Appendix B as an illustration of the extent to which they can vary. Table 8 presents the effects as percentages of the baseline values for each of the three components distinguished. Hence, for each index and each demographic group, the sum of the behavioural effects, B, the population effects, P, and the policy effects, T, is equal to the total changes reported in Table 7. This means, for example, that the policy effects indicate by how many percentage points each index would have changed between 2000/01 and 2005/06 if the tax structure were the only thing to have changed during this period.

To illustrate, consider the case of single males, for whom Atkinson's inequality measure, for $\varepsilon = 0.2$, was 0.0299 in 2000/01. This increased by 11.64 per cent between 2000/01 and 2005/06. Although the arithmetic mean disposable income increased by 5.34 per cent, social welfare increased only by 4.97 per cent due to the increase in inequality.[13] If only the population had changed, inequality would have increased by 7.42 per cent while social welfare would have increased by 6.71 per cent. If only the tax structure had changed, inequality would have increased by 4.79 per cent, and when combined with the reduction in mean disposable income of 1.94 per cent, social welfare would have fallen by 2.09 per cent. Finally, the changes attributed to the change in labour supply alone are very small. These imply a reduction in inequality by 0.57 per cent which, combined with an increase in arithmetic mean disposable income of 0.33 per cent, implies an increase in social welfare of 0.35 per cent. The three components of the change in inequality, for this aversion parameter, add to the total change of $11.64 = -0.57 + 7.42 + 4.79$.[14]

The results show that population effects account for most of the overall increase in social welfare at the aggregate level over this period. These population effects are the basis of a substantial increase in average disposable incomes accompanied by a limited increase in inequality. As mentioned above, these population effects cover a wide range so that it is not possible to attribute their contributions more precisely to any particular factor. By contrast, the decomposition allows a more precise determination of the contribution of tax policy changes and the induced labour supply adjustments.

[13] The percentage change in W is the percentage change in mean disposable income minus the product of $A/(1-A)$ and the percentage change in A.

[14] All components were obtained independently, so the fact that they sum precisely to the change in inequality is a useful check on the computations.

At the aggregate level, the results show that the changes in the tax and transfer system had barely any effect on inequality and a very small negative impact on mean disposable incomes. Behavioural effects contributed to a small increase in mean disposable incomes and to a reduction in inequality. This is consistent with labour supply responses to the policy changes inducing larger labour supply increases for low-income than for high-income households. Appendix C reports labour supply responses if a change from the 2000/01 to the 2005/06 tax structure is imposed on the 2000/01 population. It is shown that the proportions making a positive change in labour supply is higher for the lower deciles, with a higher proportion of individuals reducing labour supply in the higher income groups.

Table 8: Average Effects as Per Cent of Baseline: Disposable Income Measures

			Atkinson index			Social Welfare		
		$\bar{y}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	B	0.07	-0.44	-0.61	-0.75	0.08	0.14	0.22
	P	11.28	-5.11	-3.94	-2.61	11.43	11.76	11.83
	T	-0.13	-1.79	-1.94	-1.92	-0.08	0.09	0.24
Single males	B	0.33	-0.57	-0.54	-0.49	0.35	0.40	0.44
	P	6.95	7.42	4.53	3.14	6.71	6.32	6.16
	T	-1.94	4.79	4.75	4.70	-2.09	-2.56	-3.03
Single females	B	0.37	-0.22	-0.15	-0.08	0.37	0.38	0.38
	P	2.06	7.07	3.31	0.78	1.89	1.73	1.92
	T	-2.39	4.86	4.66	4.47	-2.50	-2.84	-3.15
Single parents	B	-0.30	1.44	1.27	1.10	-0.32	-0.36	-0.39
	P	10.89	49.72	42.10	36.71	10.24	8.74	7.73
	T	-0.15	-2.57	-2.92	-3.14	-0.12	-0.01	0.11
ALL	B	0.11	-0.33	-0.42	-0.50	0.12	0.16	0.21
	P	9.91	0.14	0.47	1.13	9.90	9.85	9.68
	T	-0.61	-0.07	-0.08	0.03	-0.60	-0.60	-0.61

The results reveal a large degree of heterogeneity at the demographic group level. While population changes are overwhelmingly the main contributors to the increase in social welfare for couples and single parents, policy changes play a substantial role for single males and females.[15] The population effects contributed to a very large increase in inequality among single parents. This increase is between 36.7 and 49.7 percentage points depending on the aversion for inequality. This result should be contrasted with the particularly low initial level of intra-group inequality for single parents (and the relatively small size of this group).

For both single males and females, tax policy changes had a negative effect on disposable income and they increased inequality. For single females, the negative effects of tax policy changes more than offset the positive effects of the changing structure of the population, resulting in a reduction in social welfare. The negative policy effects for singles reflects, to some extent, the regressive changes in income taxes discussed above. For couples and single parents, this effect would have been somewhat offset by the increased levels of family benefit payments which are largely means tested.

The behavioural responses to these policy changes rarely work in the same directions as the tax policy effects . For couples, single males and single females, behavioural effects contributed to a slight increase in social welfare through a combination of a reduction in intra-group inequality and an increase in average disposable incomes. Again, this is consistent with an overall increase in labour supply more concentrated at the low-end than at the high-end of the income distribution. By contrast, behavioural effects reduced disposable incomes and increased intra-group inequality for single parents and thus had a negative effect on social welfare. Hence, for single parents, the results point toward a reduction in labour supply which was more pronounced for low-income than for high-income single parents. These results clearly demonstrate the value of the decomposition, allied with a behavioural microsimulation model, for understanding changes over time.

Jenkins and Cowell (1994) showed that the effect on inequality of changing the scale economy parameter, δ, in the adult equivalence scales cannot be predicted *a priori*.[16] In the present context, a reduction in δ from 0.8 to 0.4

[15] The point made earlier, that some (non-labour supply and general equilibrium) tax effects appear in population effects, should also be kept in mind.

[16] Profiles of inequality plotted against δ can be U-shaped or reverse J-shaped, the turning point depending on the correlation between adult equivalent income and household size:

was found to increase absolute inequality levels but had little effect on the percentage changes and the decompositions reported above. However, at the aggregate level, the population effects on inequality were found to be larger than with $\delta = 0.8$, resulting in a clear increase in overall inequality between the two periods for all three values of ε (instead of only a small increase for $\varepsilon = 1.4$ with $\delta = 0.8$).

4 Allowing for Leisure

The use of disposable income in inequality and social welfare measures, as in the previous section, can be described as a 'non-welfarist' approach. It concentrates on interpersonal comparisons of disposable income. Some judges may take the view that an allowance should be made for leisure. In the standard optimal tax literature, this is achieved using a 'welfarist' approach whereby the social evaluation is based on a particular cardinalisation of each individual's utility, instead of simply their disposable income. The evaluation function used is typically an additive individualistic Paretean welfare function defined in terms of individuals' utilities and satisfying the principle of transfers (usually with an assumption of constant relative inequality aversion). Hence, if for example the Atkinson inequality measure is used, it is the same kind of welfare function that is used in the above comparisons, but uses utility instead of disposable income as the 'welfare metric'. This kind of cardinalisation, allowing inter-personal comparisons, raises relatively few problems in view of the fact that the vast majority of simple optimal tax models make an assumption of common preferences. Indeed, the only type of heterogeneity introduced into such models usually relates to abilities, or wage rates.

The use of a behavioural microsimulation model based on a cross-sectional survey of households is, however, motivated by a desire to allow for as much population heterogeneity as possible. A model which accurately reflects the variation in circumstances and tastes found in practice can provide the kind

see Jenkins and Cowell (1994) and Creedy and Sleeman (2005). Hence, inequality can decrease or increase when δ is increased.

of information that can be used in rational policy debate. However, as mentioned earlier it is known that the use of a welfare metric based on a cardinalisation of individual utility is problematic when preferences differ. This section proposes a non-welfarist approach as a modification of the treatment of disposable income, by allowing for the joint values of disposable income and leisure.

4.1 A Non-welfarist Approach

As mentioned in the introduction, one approach used to deal with aggregation problems with heterogeneous preferences was taken by Aaberge and Colombino (2008). They based labour supply behaviour on a discrete hours structural approach, allowing for preference heterogeneity and a random utility component, as in the MITTS model used here. But in examining social welfare functions, they used a welfare metric based on re-estimating the preference function without the observed heterogeneity terms; that is, they obtained a 'common' preference function. However, the use of an estimated 'common' preference function, or 'reference preference ordering' (different from those used to model behaviour) is just one possible approach to constructing the welfare metric for each individual.

An alternative approach arises from recognising that the 'reference preference function' can be viewed as being effectively a representation of value judgements of the independent judge, rather than any concept of utility. Hence, it is possible simply to impose a welfare metric which involves a common evaluation or weighting function applied to all individuals. The function represents the way the judge makes cardinal interpersonal comparisons. Since the use of social welfare functions essentially involves investigating the implications of adopting alternative value judgements, these do not have to be based on any type of common or estimated preference function. Indeed, when using a social welfare function in terms of disposable income, of the form $W = \sum H(y)$, with $H(y) = y^{1-\varepsilon}/(1-\varepsilon)$ for inequality aversion of ε, there is no pretence that $H(y)$ represents a 'common utility function', since it instead reflects a particular type of value judgement (such as adherence to the 'principle of transfers', along with the choice of y as the welfare metric).

In the previous section, the evaluation is based on disposable income, and is made in precisely this way. If the judge is assumed to take a view about leisure, then it is possible to use a slightly different evaluation function – one that is a function of both disposable income and leisure. In this framework, consider welfare functions based on, for each individual, the geometric average value of disposable income, y, and hours of work, h. The social welfare function may thus take the form:

$$W = \frac{1}{N} \sum_{j=1}^{N} \frac{\left\{ y_j^{\alpha} \left(T - h_j \right)^{1-\alpha} \right\}^{1-\varepsilon}}{1-\varepsilon} \tag{11}$$

where T is the maximum hours of work, so that $T - h_j$ denotes leisure over the relevant period, for income units $j = 1, ..., N$.[17] Atkinson inequality measures are thus based on the metric $z_j = y_j^{\alpha} \left(T - h_j \right)^{1-\alpha}$. The use of disposable income therefore corresponds to taking $\alpha = 1$ (that is, ignoring leisure in the evaluation).

4.2 Empirical Application

This subsection applies the approach described above to the decomposition of inequality and social welfare changes in Australia between the financial years of 2000/01 and 2005/06, again using the MITTS model. The results are contrasted with those obtained in the previous section, where leisure was ignored. Here, T is set at 80 hours per week and the parameter α, reflecting the view of the judge regarding the importance of leisure versus income, is set at 0.7.

Table 9 presents the baseline values and total percentage changes in inequality and social welfare between 2000/01 and 2005/06 for this welfare metric, z. At the aggregate level, the results show that when the judge takes a view about leisure, the increase in social welfare over the period is almost

[17] Alternatively, some judges may evaluate a policy change according to whether it increases the labour supply of certain groups, so that increases in leisure would be considered 'bad'.

Table 9: Baseline for Welfare Metric and Total Changes 2000/01 to 2005/06: Alpha=0.7

		Atkinson index			Social Welfare		
	$\bar{z}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	4,162	0.0104	0.0390	0.0646	4,119	3,999	3,893
Single males	4,010	0.0103	0.0390	0.0649	3,969	3,854	3,750
Single females	3,688	0.0071	0.0273	0.0458	3,662	3,587	3,519
Single parents	3,405	0.0043	0.0166	0.0278	3,390	3,348	3,310
ALL	4,027	0.0100	0.0374	0.0618	3,987	3,877	3,778
	Total percentage changes: welfare metric with $\alpha = 0.7$						
		Atkinson index			Social Welfare		
	$\bar{z}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	5.99	-5.80	-5.15	-4.35	6.05	6.21	6.31
Single males	1.19	6.91	6.21	5.85	1.12	0.93	0.78
Single females	-0.28	16.39	12.45	9.53	-0.39	-0.63	-0.73
Single parents	5.69	49.59	43.71	39.01	5.47	4.92	4.52
ALL	4.82	1.19	1.49	1.94	4.81	4.76	4.69

halved (compared with results in Table 7 which uses y) and inequality unambiguously increases. This indicates that the increase in the social welfare function based on disposable income measures was influenced to a substantial extent by its neglect of an increase in hours of work, and thus a reduction in leisure time. At the demographic group level, changes in social welfare are also reduced by the use of the allowance for leisure in the 'non-welfarist' evaluation, but the direction of the changes remains unchanged. In particular, the increase in social welfare for single males is reduced to 1.12 per cent for $\varepsilon = 0.2$ and 0.78 for $\varepsilon = 1.2$, while it was 4.97 and 3.57 per cent for ε of 0.2 and 1.4 respectively with disposable income measures.

The decomposition of these changes is presented in Table 10. Population effects remain the main contributors to the overall changes in social welfare at the population level and also for couples and single parents, as was the case with disposable income measures. For single females, the negative policy effects more than offset the positive population effects, as in previous results. For single males, policy changes now offset most of the increase in social welfare due to population changes, which explains the reduced increase in social

Table 10: Average Effects as Per Cent of Baseline: Welfare Metric with Alpha=0.7

			Atkinson index			Social welfare		
		$\bar{z}$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	B	0.03	-0.55	-0.65	-0.75	0.04	0.06	0.09
	P	5.95	-3.56	-2.79	-1.95	5.99	6.07	6.09
	T	0.01	-1.68	-1.71	-1.65	0.03	0.08	0.13
Single males	B	0.14	-0.39	-0.39	-0.38	0.14	0.15	0.16
	P	2.62	1.38	0.58	0.11	2.60	2.59	2.61
	T	-1.57	5.93	6.02	6.11	-1.63	-1.81	-1.99
Single females	B	0.15	-0.21	-0.18	-0.16	0.15	0.15	0.16
	P	1.43	10.48	6.62	3.76	1.36	1.25	1.25
	T	-1.86	6.13	6.01	5.93	-1.90	-2.03	-2.14
Single parents	B	-0.20	1.09	0.98	0.86	-0.20	-0.21	-0.22
	P	5.93	51.28	45.70	41.23	5.70	5.12	4.69
	T	-0.04	-2.78	-2.97	-3.09	-0.03	0.01	0.05
ALL	B	0.04	-0.42	-0.48	-0.54	0.05	0.06	0.08
	P	5.16	1.18	1.48	1.86	5.15	5.10	5.03
	T	-0.38	0.42	0.49	0.62	-0.39	-0.40	-0.42

welfare mentioned above. Table 10 also reveals that behavioural effects are reduced once the judge takes a view about leisure. Indeed, the contributions of behavioural effects to disposable income changes are necessarily offset, to some extent, by the corresponding changes in leisure time, whether labour supply responses are positive or negative.

5 Money Metric Utility

The acknowledged problems, when preferences differ, of using a welfare metric based on a cardinalisation of individual utilities has been mentioned above. It is nevertheless worth considering the use, for comparison purposes, of 'money metric utility', especially as it continues to be used in some applied studies. Indeed, as Donaldson (1992, p. 89) stressed, 'no methodology in applied welfare economics is perfect. Practical work is always limited by the availability of data and the problem of estimating the economic consequences of projects. Different evaluation procedures are, therefore, bound to be differentially useful in different situations'. The use of a welfare change measure in a 'welfarist' evaluation means that the decomposition method needs to be modified slightly, as there are fewer counterfactual processes. This is because money metric utility is defined in terms of 'reference prices', which are held constant at the base period values so that the end period value is obtained from the welfare change involved. This cannot be separated from the behavioural change in the way that is possible when disposable income is used. The first subsection describes a decomposition method for money metric utility, which is applied in the second subsection below.

5.1 Methodology

This section considers the decomposition of inequality changes in the case where the welfare metric is money metric utility, m, with reference prices set at period 0's tax structure. Define $M(m_{i,j})$ as the inequality index based on the distribution of money metric utility, for period i's tax structure using the population dataset of period j.

Using period 0 as reference prices, the value of $m_{0,0}$ is simply given by full income in period 0. This is defined as the net income which could be obtained if all the endowment of time were devoted to work at the going net wage rate. For each income unit, the net income at the assumed maximum number of hours per week by all adult members of the income unit under period 0's tax structure is calculated, giving full income for the income unit.

The term $M(m_{1,0})$ refers to the inequality measure based on money metric utility for each individual in dataset 0 after the tax change; this is the value of full income, $m_{0,0}$ minus the equivalent variation, EV, arising from the tax change; see Creedy, Hérault and Kalb (2011) and references cited therein.

In using money metric utility, a separate behavioural effect cannot be isolated in the way it can be separated for the use of disposable income. In that case, gross income, arising from one tax structure, could have a different tax structure applied in order to get disposable income. This is not possible when using money metric utility.

The term $M(m_{1,1})$ is the inequality index based on the distribution of money metric utility in period 1, for population dataset 1. Hence to obtain this, it is necessary first to compute full income for each individual in population dataset 1, using the tax structure (appropriately scaled) of period 0, to get the appropriate full income. Then $m_{1,1}$ is obtained as that full income less the EV from the shift to tax structure 1 (for the same population). However, computationally it is most convenient (given the calibration approach to microsimulation adopted here) to use the fact that the EV for a given tax change is the negative of the compensating variation for the opposite tax change.

Consider changes arising from the tax structure change between periods 0 and 1. There are two changes arising from the tax policy effects alone, depending on whether dataset 0 or 1 is used. These are:

$$T_0 = M(m_{1,0}) - M(m_{0,0}) \tag{12}$$

$$T_1 = M(m_{1,1}) - M(m_{0,1}) \tag{13}$$

for datasets 0 and 1 respectively.

Similarly, there are two decompositions of the population effect, depending on the tax structure used as base. These are:

$$P_0 = M(m_{1,1}) - M(m_{1,0}) \tag{14}$$

$$P_1 = M(m_{0,1}) - M(m_{0,0}) \tag{15}$$

There are thus two decompositions of the overall change, given by:

$$\begin{aligned}\Delta_0 &= T_0 + P_0 \\ &= \{M(m_{1,0}) - M(m_{0,0})\} + \{M(m_{1,1}) - M(m_{1,0})\} \\ &= M(m_{1,1}) - M(m_{0,0}) \end{aligned} \tag{16}$$

and:

$$\begin{aligned}\Delta_1 &= T_1 + P_1 \\ &= \{M(m_{1,1}) - M(m_{0,1})\} + \{M(m_{0,1}) - M(m_{0,0})\} \\ &= M(m_{1,1}) - M(m_{0,0}) \end{aligned} \tag{17}$$

The average values of the separate components can thus be obtained as $\bar{T} = (T_0 + T_1)/2$ and $\bar{P} = (P_0 + P_1)/2$.

Implementation of this approach requires the calculation of welfare changes, and hence money metric utilities, in the context of a discrete hours approach with a random utility component. The following analysis uses the approach proposed by Creedy, Hérault and Kalb (2011). The assumed maximum number of hours per week was again set at 80 hours of work.

5.2 Empirical Application

In line with the previous applications, this section applies the decomposition based on money metric utility to inequality and social welfare changes in Australia between 2000/01 and 2005/06. Baseline money metric values and total percentage changes are presented in Table 11. The corresponding decompositions are presented in Table 12.

Table 11: Baseline Money Metric Measures and Changes 2000/01 to 2005/06

		Atkinson index			Social welfare		
	Mean	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	56,880	0.0159	0.0569	0.0916	55,978	53,643	51,670
Single males	56,527	0.0115	0.0444	0.0759	55,876	54,017	52,236
Single females	51,489	0.0095	0.0365	0.0622	50,999	49,611	48,284
Single parents	39,615	0.0103	0.0393	0.0655	39,206	38,058	37,020
ALL	54,802	0.0151	0.0552	0.0902	53,973	51,776	49,860
	Total percentage changes						
		Atkinson index			Social Welfare		
	Mean	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	3.32	-7.95	-4.60	-2.61	3.45	3.60	3.59
Single males	-0.08	74.35	46.37	32.32	-0.94	-2.23	-2.73
Single females	-3.06	4.45	2.93	0.91	-3.10	-3.17	-3.12
Single parents	0.61	41.72	37.60	34.06	0.17	-0.93	-1.79
ALL	2.22	4.55	4.81	5.02	2.15	1.94	1.72

At the aggregate level, the increase in social welfare observed in the previous section is further reduced and the increase in inequality is larger. At the demographic group level, only couples are judged to experience an increase in

Table 12: Average Effects as Per Cent of Baseline: Money Metric Measure

			Atkinson index			Social welfare		
		Mean	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Couples	P	3.38	-6.49	-2.86	-0.67	3.49	3.56	3.45
	T	-0.06	-1.46	-1.73	-1.93	-0.04	0.05	0.14
Single males	P	0.88	71.08	43.26	29.18	0.04	-1.14	-1.53
	T	-0.95	3.27	3.11	3.14	-0.99	-1.09	-1.20
Single females	P	-1.99	2.28	0.69	-1.55	-2.01	-2.01	-1.88
	T	-1.07	2.17	2.24	2.46	-1.09	-1.16	-1.23
Single parents	P	0.69	45.14	41.19	37.75	0.21	-1.01	-1.98
	T	-0.07	-3.42	-3.59	-3.69	-0.04	0.08	0.19
ALL	P	2.51	5.19	5.64	5.96	2.43	2.17	1.90
	T	-0.28	-0.64	-0.83	-0.94	-0.27	-0.23	-0.19

social welfare, while for all other groups there is a decrease in social welfare (except for a small increase for single parents for $\varepsilon = 0.2$). Population effects remain the main contributors to the total changes in social welfare for couples and single parents. An important difference from previous results is that, for single males and single females, tax policy and behavioural effects reinforce, rather than offset, population effects. The consequence is that the reduction in social welfare previously observed for single females is reinforced, while the increase in social welfare for single males is turned into a clear reduction.

6 Conclusions

This paper provides a framework to decompose changes in inequality, and the value of its associated social welfare function, for the usual situation in which cross-sectional survey data are available for two years. The aim is to identify the separate contributions of population, tax policy and behavioural effects to the total changes observed over a given period of time. Two 'non-welfarist' approaches and one 'welfarist' decomposition approach are presented and applied to Australia over the period 2000/01 to 2005/06, using the behavioural microsimulation model, MITTS. First, where social welfare is non-welfarist, defined in terms of disposable income for each individual, the changes were decomposed into behavioural, population and tax policy changes, using the method adopted by Bargain (2010). However, in the context of preference functions with a random utility component, giving rise to a probability distribution for each individual over a set of discrete hours levels, the present approach used a 'pseudo distribution' method to obtain a close approximation to the complete distribution. This contrasts with the use of arithmetic means for each individual.

The application to Australia revealed that changes in inequality were small in aggregate, but social welfare increased by about 9 per cent. Most of the change was attributed to changes in the structure of the population. However, for separate demographic groups, a wider range of results were obtained, with single parents in particular experiencing the largest change in inequality, and with behavioural effects having an inequality-increasing influence. For single males and single females, policy effects were found to be substantial, with a negative impact on social welfare, which offset to a large extent the positive population effects. The policy-induced behavioural changes were generally found to act in the opposite direction from the direct effects of the policy changes.

The decomposition method was then extended to allow for a further non-welfarist social welfare function in which the independent judge attaches some value to leisure as well as disposable income. In this approach, a welfare metric was proposed that is equivalent to a weighted geometric mean of disposable income and leisure. Compared with the absence of any regard for leisure by the judge, this was generally found to involve larger percentage increases in inequality and smaller increases in social welfare. Hence, although social welfare based on disposable income had increased over the period, this was partly offset when the associated increase in hours of work (and the corresponding reduction in leisure time) was accounted for by the judge.

The difficulties of using a welfarist approach in the context of preference heterogeneity were discussed. The decomposition method was adapted to deal with the use of money metric utility as the welfare metric in the social welfare function. In this case a separate behavioural effect could not be isolated. The value of money metric utility for each individual was obtained using full income values for the initial period and equivalent variations resulting from the tax changes. The empirical results contrasted quite substantially with those obtained for the non-welfarist approaches, particularly for single males where inequality changes were largely above those obtained with the non-welfarist approaches.

The analysis has demonstrated the value of a behavioural microsimulation model in gaining a more detailed appreciation of the factors contributing to measured changes in inequality between two periods. Non-welfarist evaluations, either in terms of disposable incomes or some weighted average of disposable income and leisure, can be carried out, given a model that is capable of generating the various counterfactuals required. However, further investigation of methods of carrying out welfarist evaluations in the presence of preference heterogeneity seems warranted.

Appendix A: MITTS - The Melbourne Institute Tax and Transfer Simulator

This appendix provides a brief description of the Melbourne Institute Tax and Transfer Simulator (MITTS), a behavioural microsimulation model of direct tax and transfers in Australia. Since the first version was completed in 2000, and described in Creedy *et al.* (2002), it has undergone a range of substantial developments; For an overview of refereed publications and books relating to the MITTS model, see:
http://www.melbourneinstitute.com/labour/microsimulation/MITTS-publications.html.

MITTS is based on the Australian Survey of Income and Housing Costs (SIHC), 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. All results are aggregated to the population level using the household weights provided with SIHC. Pre-reform net incomes at alternative hours levels are based on the MITTS calculation of entitlements, not the actual receipt. Furthermore, MITTS applies only income tests, as there is at present no asset imputation in the model. All major social security payments, family payments, rebates and income taxes are included, ensuring a reasonable approximation to net income.

MITTS consists of two components. MITTS-A is the arithmetic tax and benefit modelling component and provides, using the wage rate of each individual, the budget constraints that are crucial for the analysis of behavioural responses to tax changes. For those individuals in the data set who are not working, an imputed wage is obtained. MITTS-B examines the effects of any specified tax reform, allowing individuals to adjust their labour supply. Behaviour is based on quadratic preference functions where the parameters are allowed to vary with individuals' characteristics. Individuals are considered as being constrained to select from a discrete set of hours levels. For singles, 11 discrete points are distinguished. For couples, a joint set of discrete labour supply points are used. The female hours distribution covers a wider range of part-time and full-time hours than the male distribution, which is mostly divided between non-participation and full-time work. Therefore, women's labour supply is divided into 11 discrete points, whereas men's labour supply is represented by just 6 points. The joint labour supply of couples is estimated simultaneously, unlike a popular approach in which female labour supply is estimated with the spouse's labour supply taken as exogenous. Thus for couples there are 66 possible joint labour supply combinations.

Simulations are probabilistic, as utility at each hours level is the sum of a deterministic component (depending on hours worked and net income) and a random component. Hence MITTS generates a probability distribution over the discrete hours levels. The self-employed, disabled, students and those over 65 have their labour supply fixed at observed hours. Simulations begin by recording the discrete hours level for each individual that is closest to the observed hours level. The deterministic component of utility is obtained using the parameter estimates of the quadratic preference function. To generate the random component, a draw is taken from the distribution of the error term for each hours level (an Extreme Value Type I distribution). The utility-maximising hours level is found by adding the two components of utility for each hours level and choosing the hours with the highest utility. Draws from the error terms are taken conditionally on the observed labour supply; that is, they are taken in such a way that the optimal pre-reform labour supply is equal to the actually observed labour supply. As a result, post-reform labour supply is simulated conditional on the observed pre-reform labour supply. A user-specified number of draws is produced.

For the post-reform analysis, the new net incomes cause the deterministic component of utility at each hours level to change, so using the same set of 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.

Appendix B: Further Details of Decompositions

Table 13 reports, for the population as a whole, the various decompositions of changes in the distribution of disposable income. The table illustrates the wide variations which can arise for the different decompositions. In some cases there are differences in the direction of changes.

Table 13: All Decompositions: Disposable Income 2000/01 to 2005/06

	Mean	Atkinson index			Social welfare		
		$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
$M_1(y_{1,1}) - M_0(y_{0,0})$	9.42	-0.26	-0.03	0.66	9.42	9.42	9.28
Behavioural effects							
$M_0(y_{1,0}) - M_0(y_{0,0})$	0.05	-0.01	-0.11	-0.19	0.05	0.06	0.09
$M_1(y_{1,0}) - M_1(y_{0,0})$	0.13	-0.24	-0.36	-0.46	0.14	0.17	0.22
$M_0(y_{1,1}) - M_0(y_{0,1})$	0.09	-0.42	-0.49	-0.52	0.11	0.15	0.19
$M_1(y_{1,1}) - M_1(y_{0,1})$	0.16	-0.64	-0.73	-0.79	0.18	0.24	0.31
Average	0.11	-0.33	-0.42	-0.49	0.12	0.15	0.20
Population effects							
$M_0(y_{1,1}) - M_0(y_{1,0})$	9.96	-0.15	0.27	1.02	9.97	9.93	9.75
$M_1(y_{1,1}) - M_1(y_{1,0})$	9.94	0.02	0.30	0.91	9.94	9.91	9.76
$M_0(y_{0,1}) - M_0(y_{0,0})$	9.91	0.26	0.65	1.35	9.91	9.84	9.64
$M_1(y_{0,1}) - M_1(y_{0,0})$	9.91	0.43	0.68	1.24	9.90	9.83	9.65
Average	9.93	0.14	0.47	1.13	9.93	9.88	9.70
Policy effects							
$M_1(y_{1,1}) - M_0(y_{1,1})$	-0.55	-0.10	-0.19	-0.16	-0.54	-0.53	-0.52
$M_1(y_{0,0}) - M_0(y_{0,0})$	-0.61	-0.04	0.02	0.22	-0.61	-0.61	-0.65
Average	-0.58	-0.07	-0.08	0.03	-0.58	-0.57	-0.58

Appendix C: Labour Supply Responses

As an example of labour supply responses, Table 14 shows, for males and females, the percentage changes in hours worked per week. These are obtained for changes from the 2000/01 to the 2005/06 tax structure, imposed on the 2000/01 population. The changes are given for deciles of the distribution of net income unit income per adult equivalent under the baseline.

Table 14: Labour Supply Responses: Tax Change Imposed on 2000/01 Population

Decile	Females			Males		
	Negative	Zero	Positive	Negative	Zero	Positive
1	0.1	70.5	29.4	0.2	64.0	35.8
2	0.0	91.0	9.0	0.3	85.3	14.4
3	0.6	79.6	19.7	5.6	72.0	22.4
4	5.5	61.6	32.9	12.5	60.5	27.0
5	12.6	65.0	22.4	16.4	66.9	16.7
6	25.6	55.2	19.2	21.5	60.4	18.1
7	29.1	52.0	18.9	24.6	58.5	16.9
8	32.6	48.3	19.0	27.0	53.9	19.1
9	36.2	47.9	15.9	34.0	47.7	18.3
10	33.6	41.7	24.8	28.5	45.5	26.0
TOTAL	17.1	61.7	21.1	18.2	60.0	21.8

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