

# **The Role of the Unit of Analysis in Tax Policy Reform Evaluations**

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# The Role of the Unit of Analysis in Tax Policy Reform Evaluations

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## **Abstract**

This paper examines the implications, for overall social welfare and inequality comparisons, of using different definitions of the unit of analysis - the income recipient - in computing summary measures. Comparisons are made using the Melbourne Institute Tax and Transfer Simulator (MITTS), a simulation model of the Australian direct tax and benefit system, of the effects of flattening the marginal tax rate structure. The reform was found to reduce inequality in all cases. However, it was not always judged to improve social welfare, depending on the degree of inequality aversion and the type of income unit chosen.

# 1 Introduction

A major advantage of tax microsimulation models is that they deal with the considerable heterogeneity found in populations. They can be used to examine the effects of a policy reform on a wide variety of types of person (distinguished, say, by household type, location, education, occupation or age). But this heterogeneity raises problems when making an overall evaluation of a policy change in terms of inequality or social welfare, 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’.<sup>1</sup>

Most studies regard the only relevant non-income difference as the household size and its composition.<sup>2</sup> 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. This method of constructing the ‘money metric welfare measure’ for individuals in a household has many well-known problems. However, it is taken as given here, where emphasis is placed instead on the choice of fictitious population.

The aim of this paper is thus to examine the implications for overall social welfare and inequality comparisons of using different definitions of the unit of analysis - the income recipient - in computing summary measures. Comparisons are made using the Melbourne Institute Tax and Transfer Simulator (MITTS). This is a simulation model of the Australian direct tax and benefit system; see Creedy *et al.* (2002).<sup>3</sup> The database used is the 1997/98 Survey of Income and Housing Costs (SIHC), made available by the ABS as

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<sup>1</sup>Cowell (1984) discussed nine alternatives, arising from a distinction between three types of income recipient and three income measures. A third decision concerns the time period of analysis, but this is not considered here: attention is restricted to annual incomes.

<sup>2</sup>The term household is used to avoid confusion here, though a further distinction needs to be made, when using survey data, between households and ‘income tax units’.

<sup>3</sup>MITTS is joint intellectual property of the Melbourne Institute of Applied Economic and Social Research and the Commonwealth Department of Family and Community Services.

a confidentialised unit record file (CURF). Net incomes can be calculated for each individual for different tax and transfer systems, allowing hypothetical and actual policy changes to be analysed.

The model is used to simulate the effects of flattening the marginal tax rate structure. No suggestion is made that the comparisons reflect general properties. However, it is useful to provide some indication of potential orders of magnitude in a realistic context. The present study therefore supplements that of Decoster and Ooghe (2002), who made extensive comparisons for a policy reform in Belgium.

The three units of analysis are discussed, and summary measures for alternative definitions of the income unit, are described formally in section 2. Section 3 examines the relationship between inequality and adult equivalence scales, for net incomes before the reform. The hypothetical policy reform is described in section 4.

The tax and transfer systems examined are based on the March 1998 system as the 1997/98 Survey of Income and Housing Costs was the latest data base publicly available at the time of writing. The MITTS model consists of a non-behavioural component, MITTS-A, and a behavioural component estimating the effect of changes in labour supply behaviour, MITTS-B. Numerical results using MITTS-A are reported in section 5. The effects of allowing for labour supply responses to tax changes are examined in section 6. Conclusions are in section 7.

## **2 Alternative Concepts and Measures**

This section introduces the notation and describes the alternative summary measures of inequality and welfare used. First, equivalence scales are defined in subsection 2.1. The three income units are discussed in subsection 2.2, and the resulting welfare functions and inequality measures are defined in subsection 5.

## 2.1 Adult Equivalence Scales

Let  $y_i$  denote the total income of the  $i$ th household, for  $i = 1, \dots, N$ . The number of individuals in the household is  $n_i$  and the demographic structure is denoted by  $d_i$ . Here  $d_i$  can be regarded as a vector indicating the number of people of each of a number of types defined by age and gender. The adult equivalent size of the income unit,  $m_i$ , can be expressed as:

$$m_i = m(n_i, d_i) \quad (1)$$

This is normalised such that  $m(1, d = \text{adult}) = 1$ . Thus a household consisting of one adult with an income of  $y$  is regarded as having the same ‘living standard’ as an  $n$ -person household with  $y$  multiplied by  $m(n, d)$ .

The form of  $m(n_i, d_i)$  needs to be specified. If there are  $n_{k,i}$  individuals of demographic type  $k = 1, \dots, K$  in the  $i$ th household, the adult equivalent size may be written:

$$m_i = \left( \sum_{k=1}^K \phi_k n_{k,i} \right)^\theta \quad (2)$$

The term  $\theta$  is regarded as a measure of economies of scale within the household. This formulation is an extension of the simple form,  $n_i^\theta$ , used by Buhmann *et al.* (1988) and Coulter *et al.* (1992) and modified by, for example, Cutler and Katz (1992), Banks and Johnson (1994) and Jenkins and Cowell (1994) who differentiated between adults and children.

The scales examined below are a special case of (2) which distinguishes the number of adults,  $n_{a,i}$ , and children,  $n_{c,i}$ , such that:

$$m_i = \{1 + \phi_1 (n_{a,i} - 1) + \phi_2 n_{c,i}\}^\theta \quad (3)$$

This makes a distinction between the ‘head’ of the unit, for whom the weight is unity, additional adults, where  $\phi_1 = 0.56$  and children, each of whom is given  $\phi_2 = 0.32$  irrespective of age and gender.<sup>4</sup>

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<sup>4</sup>This choice corresponds to the Whiteford (1985) scales. Adding the exponent,  $\theta$ , to this implies a smaller adult equivalent household size than intended in the Whiteford scales. This should be kept in mind when considering the results below.

## 2.2 Three Income Unit Concepts

A number of empirical studies have taken the household itself as the basic unit of analysis, usually with little discussion. This involves each household being assigned the living standard, defined above as total income per adult equivalent, and making no further allowance for the demographic structure of the unit. One way to describe this is to say that the living standard of each household is given a weight of  $1/N$  in computing inequality and welfare summary measures. While this approach appears to have little rationale, it is included for comparison purposes here.

An alternative, which appears to treat the income concept and the unit of analysis consistently, is to define the basic unit of analysis as the ‘adult equivalent person’.<sup>5</sup> The  $i$ th household contains  $m_i$  adult equivalent persons, each getting the living standard of  $y_i/m_i$ , where  $y_i$  is the household’s total income. This approach means that an individual’s contribution to inequality and social welfare depends on the composition of the household of which that person is a member. For example, an adult in a one-person household ‘counts for one’, but the same person in a household containing other adults and several children counts for ‘less than one’. A feature of this approach is that it satisfies the basic equity principle, associated with the principle of transfers, that a transfer of income to those worse-off results in a reduction in inequality (and an increase in social welfare). As a result, Lorenz and Generalised Lorenz curve analyses can be conducted using the resulting distribution.<sup>6</sup>

A third alternative is to treat the individual as the basic unit of analysis.<sup>7</sup> Each individual is assigned the living standard of the relevant household. Thus each individual effectively ‘counts for one’ irrespective both of the household to which he or she belongs and the person’s age or gender.

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<sup>5</sup>This approach is recommended by Pyatt (1990) and Ebert (1997) who suggested that of the alternatives, it is the ‘most recommendable’ (1997, p.243).

<sup>6</sup>Despite explicitly not treating individuals as the unit, but instead using adult equivalents, this actually leads to a recommendation for equal standards of living; see Ebert (1997, p.242).

<sup>7</sup>Jorgenson and Slesnick (1984) and Slesnick (1994) use this method, as does Glewwe (1991), who dismisses the use of adult equivalents in a footnote (1991, p.213). It is also preferred by Shorrocks (1997), Danziger and Taussig (1979) and Ringen (1991).

This approach therefore has the property of anonymity, such that welfare or inequality remain unchanged when one person (of whatever type) in the population is replaced by another person having the same living standard but belonging to any other type of household. This property was called the ‘compensation principle’ by Shorrocks (1997) and the ‘Pareto indifference principle’ by Decoster and Ooghe (2002).

This approach does not in general satisfy the equity principle (of transfers). As shown by Glewwe (1991), an income transfer from a poor to a richer (and larger) household can reduce inequality and raise social welfare.<sup>8</sup> Despite being based on individuals, the application of anonymity can lead to a preference for inequality: with economies of scale, large households are regarded as being ‘more efficient’ at generating welfare.

An important implication is that in this context of heterogeneous populations, the basic equity principle inherent in the principle of transfers and the concept of Lorenz dominance (whereby one Lorenz curve lies unambiguously closer to the diagonal of equality) are no longer equivalent. This equivalence is a fundamental component of welfare analysis for homogeneous populations.

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 incompatible value judgements. They can in principle lead to opposite conclusions about the effects of a tax policy change on inequality.<sup>9</sup> Before examining how they perform in a practical case, the approaches are described more formally in the following subsection.

## 2.3 Social Welfare Functions and Inequality

Social welfare is regarded as an additive function of income per equivalent adult,  $z_i = y_i/m_i$ , the living standard of each individual in the household.

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<sup>8</sup>Transfers of money do not correspond to transfers of ‘living standard’ units between individuals. Glewwe (1991, p.213) used a simple numerical example with three households. Decoster and Ooghe (2002, pp.3-4) also construct some illustrative examples using three persons.

<sup>9</sup>Shorrocks (1997) suggested that if concern is with equity, the use of adult equivalents is recommended, whereas if concern is primarily with social welfare, individuals should be the basic income unit. This places the disinterested economist in the position of being required to report results using both approaches.

In the case where the unit of analysis is the individual, that is where the principle of anonymity (referred to alternatively in terms of compensation, or Pareto indifference) is required, social welfare per individual is given by:

$$W_I = \frac{1}{\sum_{i=1}^N n_i} \sum_{i=1}^N n_i V(z_i) \quad (4)$$

where  $V(z)$  is increasing and concave.

If the unit of analysis is the adult equivalent person, that is where the equity principle (of transfers) applies, social welfare is:

$$W_E = \frac{1}{\sum_{i=1}^N m_i} \sum_{i=1}^N m_i V(z_i) \quad (5)$$

Finally, if the household is treated as the unit of analysis, where each household is assigned its income per equivalent adult, the welfare function is simply:

$$W_H = \frac{1}{N} \sum_{i=1}^N V(z_i) \quad (6)$$

Each of the three welfare measures is simply a weighted sum, over all  $N$  households, of a function  $V$  of the income per equivalent adult,  $z$ . The only difference concerns the choice of the weights, which are respectively  $n_i / \sum_{i=1}^N n_i$ ,  $m_i / \sum_{i=1}^N m_i$  and  $1/N$ . In practice, microsimulation models assign a sample weight to each household so that appropriate population values can be obtained. The weights are often those provided by the statistical agency which collects the data, but they may also be modified for specific purposes.<sup>10</sup> The survey weights can easily be added to the above expressions: for example if the survey weight for the  $i$ th household is  $w_i$ , the weights for treating the individual as the unit of analysis become  $n_i w_i / \sum_{i=1}^N n_i w_i$ . The  $w$ 's have been omitted from the above expressions for convenience only, however they are used in the numerical examples reported below.

The type of additive welfare function discussed above is known to be consistent with the Atkinson inequality measure,  $A$ , of income. In the analysis

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<sup>10</sup>See Creedy and Tuckwell (2003) for an example of survey reweighting for microsimulation purposes.



below, concern is with net incomes,  $z$ . The Atkinson measure is defined as the proportional difference between the equally-distributed-equivalent (net) income,  $\tilde{z}$ , and the arithmetic mean income,  $\bar{z}$ . Hence,  $\tilde{z}$  is the net income per equivalent adult which, if received by every ‘unit of analysis’, produces the same social welfare as the actual distribution, and:

$$A = 1 - \frac{\tilde{z}}{\bar{z}} \quad (7)$$

Although this may be used with any form of  $V$ , the most common form is:

$$V(z) = \frac{z^{1-\varepsilon}}{1-\varepsilon} \quad (8)$$

where  $\varepsilon \neq 1$  is the degree of constant relative inequality aversion of the decision maker. For  $\varepsilon = 1$ , (8) becomes  $V(z) = \log z$ . For example, in the case of the individual-based welfare function (4):

$$\tilde{z} = \frac{1}{\sum_{i=1}^N n_i} \left\{ \sum_{i=1}^N n_i z^{1-\varepsilon} \right\}^{1/(1-\varepsilon)} \quad (9)$$

It is useful to express the welfare function in ‘abbreviated’ form, that is in terms of the arithmetic mean and the measure of inequality, whereby in general,  $W = \bar{z}(1 - A)$ .<sup>11</sup>

### 3 Inequality and the Choice of Equivalence Scale

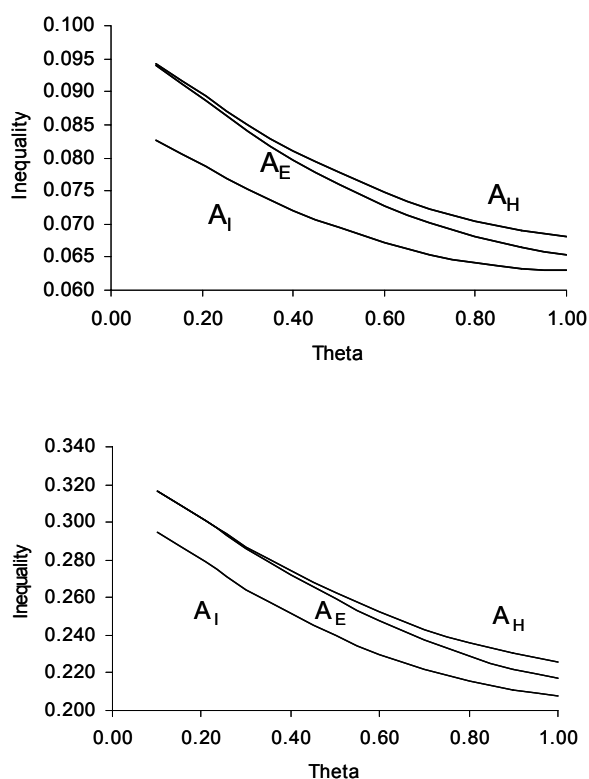
Before examining the tax reform, consider the variation in the Atkinson inequality measure as the economies of scale parameter  $\theta$  varies. Pre-reform inequality measures, for two values of inequality aversion of  $\varepsilon = 0.5$  and  $\varepsilon = 2.0$ , are shown in Figure 1. When  $\theta = 0$ , all  $m_i = 1$  so that the living standard is equal to total household income and the use of households and

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<sup>11</sup>In this form  $W$  is the equally distributed equivalent income, though strictly abbreviated welfare per ‘person’ is  $\tilde{z}^{1-\varepsilon}/(1-\varepsilon)$ . However, the trade-off between equity and mean income is the same in each case. On abbreviated welfare functions, see Lambert (2001).

equivalent adults as income recipients give the same value of inequality.<sup>12</sup> As  $\theta$  increases, inequality is seen to diverge, with household units giving higher inequality. The use of individuals gives lower measures of inequality. For the lower degree of inequality aversion, the values are in fact very close: the scale chosen for the two parts of the Figure 1 are different.

Figure 1: Pre-reform Inequality:  $\varepsilon = 0.5$  and  $\varepsilon = 2.0$



The systematic reduction in inequality as  $\theta$  increases may be compared with the results of Coulter *et al.* (1992), who examined the effects on the generalised entropy class of inequality measures of varying  $\theta$ , in the context of the simple scales  $m = n^\theta$ , using the individual as the basic income unit and

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<sup>12</sup>The term 'household' is used in this practical example to refer to the concept of an 'income unit' as defined by the ABS in the SIHC as units assumed to share income. This was undertaken so as to avoid confusion with the discussion on the three alternative units of analysis defined in Section 2 above.

total income per adult equivalent as the income measure. They showed that increasing  $\theta$  has two effects. First, if (as expected) unadjusted household income is positively correlated with household size, then for larger households the ratio  $y/m$  decreases by more than for smaller households, thereby producing an equalising effect. Second, there may be changes in the rank order of individuals, whose effect is equivocal. In general the net effect of these two influences is not obvious, but in their empirical work, Coulter *et al.* found U-shaped profiles of inequality as  $\theta$  increases, though some had reverse J-shaped profiles.

In a later study, allowing for the form  $m = (n_a + \eta n_c)^\theta$ , Jenkins and Cowell (1994, p.894) showed that ‘where indices have a U-shaped relationship with  $\theta$ , the U-shape will be less pronounced the smaller  $\eta$  is. In the example reported here, which uses (3), the term that is taken to the power of  $\theta$  is quite low, thereby largely explaining the failure of the above profiles to turn upwards. This is confirmed in Figure 2, which uses  $m = n^\theta$ . For this case the inequality measures for the use of individuals and equivalent adults as income recipients are always equal when  $\theta = 1$ , for which  $m = n$ .

Measured inequality clearly increases as  $\varepsilon$  increases: an example is provided in Figure 3, for  $\theta = 0.8$ . Further unreported results show that the pre-reform inequality of net income is systematically lower when individuals are selected as the unit of analysis, and that the use of households and equivalent adults produce very similar results, diverging only slightly for higher  $\varepsilon$ , for higher  $\theta$  values. For the (unrealistic) very low value of  $\theta = 0.2$  the inequality profiles for households and equivalent adults were found to intersect, though they remain very close indeed.

## 4 A Hypothetical Policy Reform

In the remainder of this paper a hypothetical policy reform is examined to highlight the practical significance of using the alternative income units, or weighting methods, to estimate inequality and social welfare. The policy

Figure 2: Pre-reform Inequality With  $m = n^\theta$ :  $\varepsilon = 0.5$  and  $\varepsilon = 2.0$

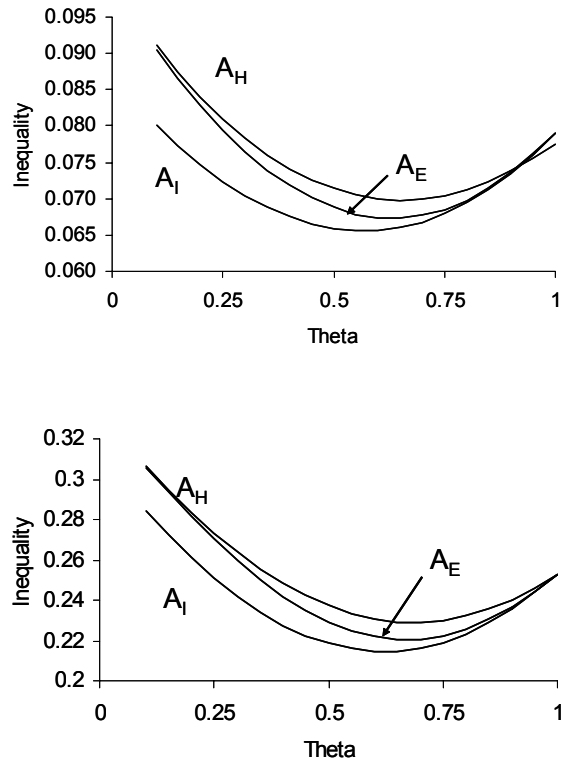
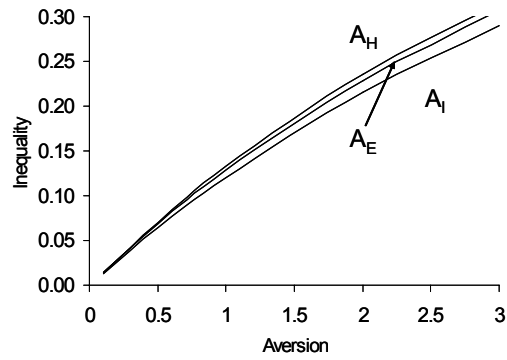


Figure 3: Pre-reform Inequality



change considered involves a flattening of the marginal rate structure of the tax and benefit system in Australia. The system of means-tested benefits and increasing marginal income tax rates is replaced by a combination of a basic (non taxable and non means-tested) income and a flat tax (BI/FT). The basic level of income replaces all existing basic social security benefits, and additional payments such as rent assistance, pharmaceutical allowance and family payments. The existing tax structure, which includes the Medicare levy and all tax rebates, is replaced with a constant marginal tax rate on all taxable income (that is, all non-benefit forms of income).

Details of the structure of the reform system are provided in Table 1. Basic income levels differ by individual characteristics. Characteristics that currently entitle individuals to a pension are used to determine whether an individual is entitled to a higher rate of basic income, which is here referred to as the pension rate. This group includes those of Age Pension age, those with a disability, carers, veterans and sole parents. This payment is then differentiated by marital status.

The remaining subset of the population receives a basic income level set at 1998 allowance payment rates. These payments differ by age. Singles aged 16-17 years receive a lower basic income than older individuals, with youths living at home receiving a lower rate again. Also, those 60 years and over receive a higher level than the 18-59 year olds. Each member of a couple is entitled to a lower payment rate than the single rate. The reform is approximately revenue neutral (prior to changes in labour supply) with a relatively high marginal tax rate of 54 per cent.

## **5 Numerical Results With Fixed Labour Supply**

This section examines the immediate effects on inequality and social welfare of the hypothetical tax policy reform, prior to any labour supply adjustments.

Table 1: Details of Basic Income Levels in Reform System

	\$ per fortnight
Pensioner group <sup>1</sup>	
Single	360.00
Couple (each)	298.50
Allowee group <sup>2</sup>	
Single: under 18 years, at home	145.40
Single: Under 18 years, away from home	240.00
Single: 18-59 years	321.50
Single: 60 years plus	347.80
Couple (each): under 18 years	240.00
Couple (each): 18-20 years	265.50
Couple (each): 21 years plus	290.10
Maximum rate of rent assistance <sup>3</sup>	
Couple (combined), no children	70.60
Single, no children	74.80
Couple (combined), Single: 1-2 children	87.40
Couple (combined), single: 3 children +	98.80
Single, in share accommodation	49.80
Additional payments for families with children	
Per child:	
Under 13 years	96.40
13 to 15 years	125.40

1) The pensioner group includes those who currently meet the eligibility requirements for a pension and consists of individuals over 65 years, individuals with a disability, carers, and sole parents.

2) The allowee group includes individuals who do not meet the eligibility requirements for any current pensions and thus cover the unemployed, individuals temporarily incapacitated from work, partnered parents, jobless individuals not falling under any other category and (as this is a universal payment) those employed who are not in the pension group.

3) The amount of rent assistance for which individuals are eligible is also determined by the amount of rent paid. The minimum levels of rent paid necessary to be eligible for rent assistance and the shade-in rates have been left at current levels.

## 5.1 Changes in Inequality

In considering the implications of using different income unit concepts, emphasis is placed on variations in the summary measures as the degree of inequality aversion is increased, for given values of  $\theta$ . For all values of  $\theta$  and  $\varepsilon$ , and for all three units of analysis, the reform was found to reduce inequality of net income. Figure 4 shows the absolute reductions in inequality as a result of the reform for the two cases of  $\theta = 0.3$  and  $\theta = 0.8$ . The top section of the figure, for  $\theta = 0.3$ , shows that the change in inequality is greatest, for all income unit concepts, for inequality aversion coefficients slightly above unity. While the use of households and equivalent adults produce similar changes, the choice of individuals as the income recipient produces larger absolute changes for most of the range of relative aversion shown. The upper value of  $\varepsilon = 3$  used here is in fact extremely large, and reflects a substantial tolerance of a ‘leaky bucket’ in the mental experiment of making transfers.<sup>13</sup>

The larger value of  $\theta = 0.8$ , as shown in the lower section of Figure 4, shows a greater divergence between the different income units, with the rankings remaining the same for all values of  $\varepsilon$ . The absolute inequality reductions are also larger for the larger  $\theta$  value. Furthermore, the maximum absolute reduction in inequality occurs in each case for relative inequality aversion around  $\varepsilon = 2$ .

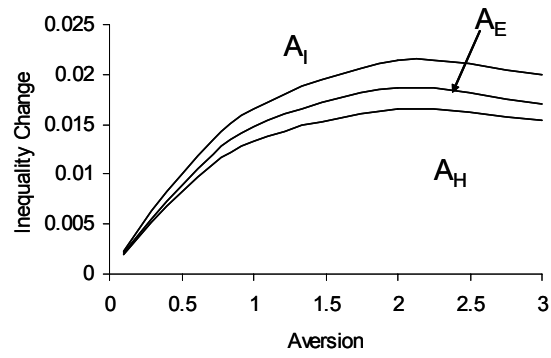
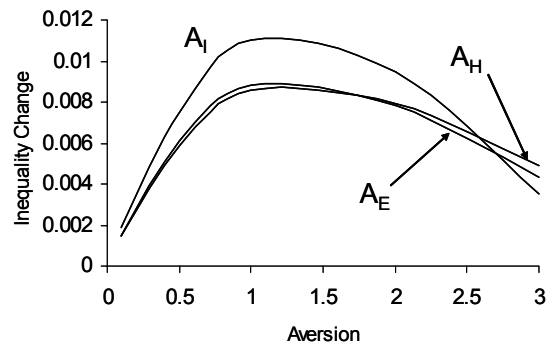
## 5.2 Social Welfare

Figure 5 shows absolute changes in social welfare, defined by the abbreviated social welfare function  $W = \bar{z}(1 - A)$ , for the two values of  $\theta = 0.3$  and  $\theta = 0.8$ , as inequality aversion varies. For all values of  $\theta$ , the increase in social welfare is highest when income recipients are individuals. The lowest increase occurs when households are used: when  $\theta$  is very low the use of equivalent adults and households give similar changes, not surprisingly since the adult equivalent size moves towards unity. The inequality aversion for which the increase in social welfare is greatest varies positively with  $\theta$ . For

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<sup>13</sup>Surveys have produced values close to 0.2 for the majority of respondents; see Amiel, Creedy and Hurn (1999).

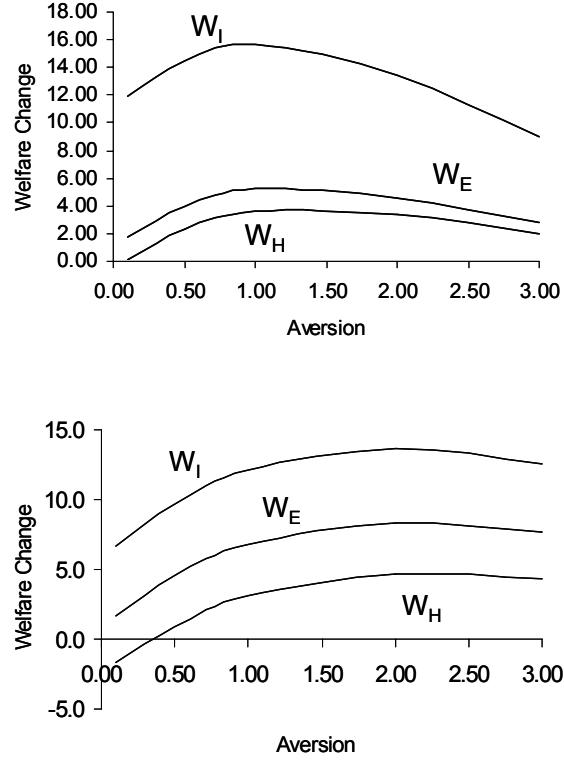
Figure 4: Reductions in Inequality:  $\theta = 0.3$  and  $\theta = 0.8$





the case of  $\theta = 0.8$ , shown in the lower section of the figure, the increase in social welfare is largest for inequality aversion of around 2.

Figure 5: Absolute Changes in Social Welfare:  $\theta = 0.3$  and  $\theta = 0.8$



For lower values of inequality aversion, the use of the household as the income unit actually results in the policy reform reducing social welfare slightly. This is despite the reduction in inequality that occurs. It may be thought that, in the present context of fixed labour supplies and a revenue neutral tax policy change, social welfare would always move in the opposite direction from inequality (since aggregate net income is unchanged). However, the value of  $\bar{z}$ , in the abbreviated welfare function, depends significantly on the choice of the income unit. Furthermore, the income concept itself is the ‘living standard’ rather than total net income.

## 6 Numerical Results With Labour Supply Responses

This section uses MITTS-B to examine the alternative summary measures once allowing for the adjustment of labour supply behaviour. First, it can be argued that the living standard, net income per adult equivalent, may not be the appropriate money welfare metric when labour supplies are variable. Given that the labour supply modelling explicitly involves utility being attached to leisure, the benefits of any increases in leisure (or costs of reductions) are not captured by the living standard measure.<sup>14</sup> Nevertheless, many descriptive studies use this measure when examining data that have obviously been influenced by labour supply variations. It is also of interest to provide a direct comparison with the non behavioural MITTS-A results.

Subsection 6.1 briefly describes the way in which labour supply is modelled in MITTS-B. Subsection 6.2 reports the main changes in labour supply arising from the policy simulation. Finally, subsection 6.3 examines the inequality and social welfare changes for the different income unit definitions.

### 6.1 Modelling Labour Supply in MITTS-B

Labour supply responses in MITTS-B are modelled using a discrete hours approach. The preference functions are quadratic, with parameters that vary with individuals' characteristics. These parameters were estimated for five demographic groups, which include married or partnered men and women, single men and women, and sole parents. For couples, two sets of discrete labour supply points are used. The female hours distribution is divided into 11 discrete points, whereas men's labour supply is represented by six points.<sup>15</sup> The couple's joint labour supply is estimated simultaneously.<sup>16</sup>

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<sup>14</sup>The production of money metric welfare measures based on the preference functions of households is beyond the scope of the present paper.

<sup>15</sup>This is because female hours cover a wider range of part-time and full-time work than the male distribution, which is mostly divided between non-participation and full-time work.

<sup>16</sup>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. However, some individuals are

The simulation is essentially probabilistic. That is, rather than identifying a particular level of hours worked for each individual after a policy change, a probability distribution is generated over the discrete hours levels used.<sup>17</sup> The simulations begin by taking the discrete hours level for each individual that is closest to the observed hours level. Given the preference parameters, a random draw is taken from the distribution of the ‘error’ term. This draw is rejected if it results in an optimal hours level that differs from the discretised value observed. The accepted drawings are then used in the determination of the probability distribution of hours worked after the policy change. In computing transition matrices showing probabilities of movement between hours levels, the labour supply of each individual before the policy change is fixed at the observed discretised value and a number of transitions are produced for each individual, equal to the number of successful draws specified.<sup>18</sup>

In some cases, the required number of random draws producing observed hours as the optimal hours cannot be generated from the model within a reasonable number of total draws. If so, the individual is left at the observed hours in policy simulations. In the following example, the maximum number of random draws is set to 5000 with 100 successful draws required.

## 6.2 Labour Supply Responses

Summary results for labour supply in the different demographic groups is provided in Table 2. The aggregate effect of the reform on labour supply is quite small, with many increases in labour force participation and hours of work counteracted by individuals decreasing their supply of labour. The increases

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excluded from the database if their imputed wage or their observed wage (obtained by dividing total earnings by the number of hours worked) is unrealistic. The wage functions are reported in Kalb and Scutella (2002) and the preference functions are in Kalb (2002): these are updated versions of results reported in Creedy *et al.* (2002).

<sup>17</sup>Some individuals, such as the self employed, the disabled, students and those over 65 have their labour supply fixed at their observed hours.

<sup>18</sup>When examining average hours, 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.

Table 2: Summary of Labour Supply Responses

Behavioural Response	Couples		Single		Sole
	Men	Women	Men	Women	Parents
Workers (% base)	58.4	45.3	54.9	44.0	42.7
Workers (% reform)	59.3	41.8	54.4	44.6	37.1
Non-work $\rightarrow$ work (%)	2.0	0.9	0.8	1.3	0.5
Work $\rightarrow$ non-work (%)	1.2	4.4	1.2	0.7	6.1
Workers working more	1.4	0.4	0.0	0.2	2.5
Workers working less	2.4	1.9	1.1	1.9	1.2
Average hours change	0.2	-1.7	-0.4	-0.2	-0.7

are largely contributed by those who previously faced very high marginal tax rates arising from the means-testing of transfer payments, whereas the reductions mainly arise from the increase in the income tax rate applied to all taxable income.

The overall effect on labour supply - in terms of average hours worked - is negative, with most of the changes coming from a reduction in the labour supply of married women. This is typical of studies of this kind as married women tend to have larger income elasticities and thus tend to decrease their hours of work with an increase in overall household income. Married men are the only group to experience an overall increase in hours worked, arising mainly from an increase in workforce participation. However the overall effect on hours worked is negligible once taking into account the reduction in hours worked for those already in the workforce.

More details of the variations in labour supply responses are shown by transition matrices showing the probability of movements between discrete hours levels. Table 3 reports matrices for single men and women. The transition probabilities for single parents and married women are given in Table 4, which clearly demonstrates the degree to which the policy change has differential affects on different parts of the hours distribution for these groups (despite the low aggregate change in average hours worked). The fact that there is a significant probability of married women leaving the labour market is explained by the budget constraint changes, shown in the Appendix. Table 5 gives the smaller matrix for married men.

Table 3: Transition Matrices: Single Men and Women

Hours		Hours post-reform										
pre-reform	Single Men											Total
	0	5	10	15	20	25	30	35	40	45	50	
0	98.3	0	0	0.1	0.2	0.3	0.4	0.4	0.2	0.1	0	45.1
5	-	100	-	-	-	-	-	-	-	-	-	2.6
10	-	-	99.5	-	-	-	0.5	-	-	-	-	4.1
15	-	-	-	100	-	-	-	-	-	-	-	1.8
20	0	-	-	-	100	-	-	-	-	-	-	1.4
25	0.1	-	-	-	0	99.7	0	0.1	-	-	-	1.1
30	-	-	-	-	0	0.1	99.8	0	-	-	-	1.6
35	0.4	-	0	0	0.1	0.1	0.1	99.2	0	0	0	4.5
40	3.9	0	0	0.1	0.3	0.7	0.8	0.6	93.6	0	0	22.6
45	3.5	-	0	0.1	0.4	0.6	1.2	1.4	0.7	92.1	0	5.1
50	1.3	-	0	0	0.2	0.3	0.7	0.7	0.4	0.2	96.2	10.1
Total	45.6	2.6	4.1	1.8	1.6	1.5	2.1	4.9	21.4	4.8	9.7	100

Single Women												Total
	0	5	10	15	20	25	30	35	40	45	50	
0	97.7	0	0	0.3	0.4	0.5	0.3	0.4	0.1	0.2	0	56
5	0	99.4	-	0.2	0.4	-	-	0	-	-	-	3.3
10	0	-	99.2	-	0.3	0.2	0.1	0.1	-	-	-	3.8
15	0.1	-	-	98.9	-	0.8	-	0.1	0	0.1	-	3.0
20	0.1	-	-	-	99.9	-	-	-	-	-	-	1.4
25	0	-	-	0	0.1	99.8	-	-	-	-	-	1.4
30	1.1	0	0.1	0.1	0.2	0.4	97.7	0.1	0	0.1	0.1	2.2
35	0.8	0	0	0.3	0.8	1.1	0.6	96.2	0	0	0.1	5.5
40	3.5	0	0.2	0.4	1.5	2.1	2.1	1	89.1	0.1	0.2	16.0
45	1.6	0	0.1	0.4	1.4	2	2.1	2.1	0.8	89.2	0.3	3.1
50	0.9	-	0.2	0.3	0.7	0.9	1.8	1.1	0.5	0.2	93.4	4.3
Total	55.4	3.3	3.8	3.2	2	2.2	2.9	5.8	14.4	2.9	4.1	100

Table 4: Transition Matrices: Sole Parents and Married Women

Hours	Hours post-reform											
pre-reform	Sole Parents											
	0	5	10	15	20	25	30	35	40	45	50	Total
0	99.1	0	0	0	0.1	0.1	0.1	0.1	0.1	0.1	0.3	57.3
5	13.2	79.2	-	-	0.1	0.9	0.9	1.4	2.2	1.3	0.9	3.5
10	47.3	-	39.3	-	0.2	0.4	1.8	3.2	2.2	2.6	3.1	3.3
15	47.5	-	-	38.9	0.1	0.8	0.7	3.2	2.5	3.3	2.9	2.7
20	7.3	-	-	-	72.2	0.9	0.8	7	3.3	4.5	3.9	3.8
25	15.3	0	0.7	0	-	79.7	0.1	0.5	0.8	1.4	1.5	3.8
30	13.5	-	0	0	-	-	82.4	0.6	0.6	1.5	1.4	3.3
35	4.4	-	-	0	0.4	0.3	0.8	92.3	0.3	0.3	1.3	3.9
40	10.2	0	0.1	0.4	0.5	1.4	1.9	1.3	82.3	0.4	1.5	12.1
45	1.1	0.4	0.2	0.8	-	0.9	2.3	0.9	0.2	92.6	0.6	1.0
50	1.6	-	0.1	0.3	0.3	0.6	1.5	1.9	1.3	0.6	92.1	5.4
Total	62.9	2.8	1.4	1.1	2.9	3.4	3.3	4.5	10.5	1.5	5.8	100

Married Women												
	0	5	10	15	20	25	30	35	40	45	50	Total
0	98.4	0.2	0.2	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	54.7
5	1.8	97.3	-	0.2	-	-	-	0.8	-	-	-	1.6
10	3.9	0.5	95.5	0.1	0	0	0	-	0	-	0	2.5
15	4.7	0.1	0.3	94.5	0.1	0.1	-	0.1	0.2	0.1	-	3.7
20	8.1	0.4	0.5	0.1	89.8	0.2	0.2	0.2	0.2	0.1	0.3	4.9
25	11.4	0.4	0.5	1	0.5	85.1	0.2	0.3	0.3	0.1	0.2	4.2
30	9.4	0.5	1.1	0.7	0.5	0.5	86.5	0.3	0.2	0.3	0.1	4.0
35	7.7	0.5	0.6	0.6	0.8	0.5	0.6	87.4	0.6	0.5	0.2	5.3
40	13.5	0.7	0.9	1.2	1.4	1.2	1	0.9	78.1	0.5	0.5	13.0
45	10.8	0.7	0.9	0.6	1.3	1.4	1.5	0.7	0.5	81.4	0.3	2.2
50	10.4	0.5	1.2	0.9	1.3	1.1	0.7	0.8	0.8	0.5	81.9	3.8
Total	58.2	1.9	2.8	4	4.9	3.9	3.8	4.9	10.3	2	3.3	100

Table 5: Transition Matrix: Married Men

Hours		Hours post reform						
Pre-reform		0	10	20	30	40	50	Total
0	95.1	0	0.1	0.9	2.6	1.3		41.6
10	-	98.3	-	-	-	-	1.7	1.3
20	0.2	-	93.9	0.8	2.2	2.9		1.3
30	2.4	-	0.2	90.8	3.7	2.9		2.9
40	2.2	0	0.2	2	92.1	3.5		32.2
50	1.8	0	0.3	2	5.7	90.2		20.7
Total	40.7	1.3	1.4	4	32.1	20.5		100

### 6.3 Inequality and Social Welfare

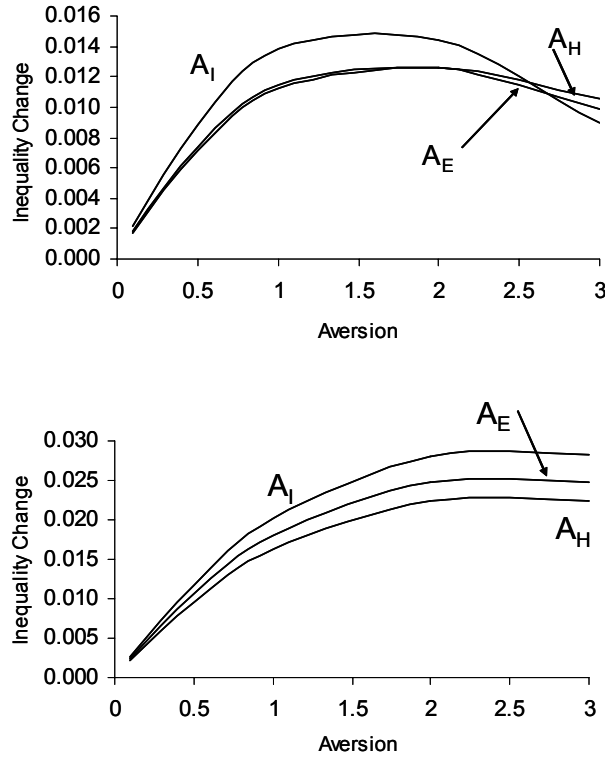
As mentioned above, microsimulation modelling using a discrete hours approach is essentially probabilistic. That is, it does not identify a particular level of hours worked for each individual after the policy change, but generates a probability distribution over the discrete hours levels used. As a result, individuals have a set of probabilities of being at different income levels and the usual formulae for poverty and inequality measures cannot be applied. The following results were obtained using an approach in which all possible outcomes for every individual are used as if they were separate observations. The outcomes are weighted by the (suitably normalised) individual probabilities of labour supply to produce a pseudo distribution.<sup>19</sup>

As with the case of fixed labour supplies, the reform has the effect of reducing overall inequality, whatever the type of income unit chosen for the analysis, and whatever the degree of inequality aversion (and value of  $\theta$ ). Figure 6 shows the absolute changes for two values of  $\theta$ , as inequality aversion varies. For the higher, and more realistic, value of  $\theta$ , the absolute reduction in inequality increases systematically with  $\varepsilon$  throughout most of the range considered, decreasing only slightly at the upper end. The change in inequality is consistently higher when individuals are chosen as the basic income unit, with households giving the smallest change. For the lower value of  $\theta$ , shown

<sup>19</sup>For a detailed investigation of this, and several other approaches to distributional analyses with discrete hours models, see Creedy, Kalb and Scutella (2003). In extensive comparisons, the pseudo distribution was found to perform well.

in the upper section of the figure, the ranking in terms of the absolute change in inequality changes at the top end of the range of inequality aversion. Not surprisingly, the changes for equivalent adults and households are similar with this low value, given that  $m$  moves towards unity as  $\theta$  falls.

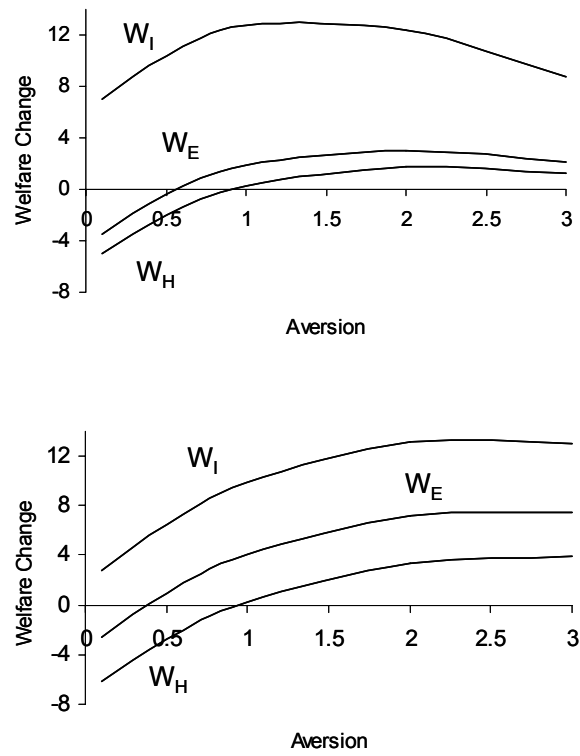
Figure 6: Reductions in Inequality:  $\theta = 0.3$  and  $\theta = 0.8$



Changes in social welfare measures arising from the reform are shown in Figure 7, again for two values of  $\theta$ , for variations in inequality aversion. For all values of  $\varepsilon$ , the use of individuals as the basic income unit gives the largest increase in social welfare, with the smallest increase being for households. Indeed, for the higher (and more realistic) value of  $\theta$ , social welfare is actually found to decrease for a substantial range of  $\varepsilon$  in the case of the household as the income unit. Even for the case of equivalent adults, social welfare falls (again despite the reduction in inequality) for lower values of inequality aversion.



Figure 7: Absolute Changes in Social Welfare:  $\theta = 0.3$  and  $\theta = 0.8$



The overall patterns of changes in inequality and social welfare for varying inequality and social welfare parameters are, however, similar for the fixed labour supply and endogenous labour supply cases. This perhaps reflects the finding that, overall, the policy reform is expected to have a small effect on average hours worked, despite substantial heterogeneity in the types of labour supply response.

## 7 Conclusions

This paper has investigated the implications for overall social welfare and inequality comparisons of using different definitions of the unit of analysis - the income recipient - in computing summary measures. Comparisons were made using the Melbourne Institute Tax and Transfer Simulator (MITTS) to examine a tax reform involving a substantial flattening of the marginal effective tax rate structure in Australia. The starting point was the fact that standard summary measures are designed for homogeneous populations, so that decisions must be made about the two concepts of income and the unit of analysis. It was taken for granted that the ‘living standard’ in a household, obtained by dividing income by adult equivalent size (for a given set of scales), is a suitable measure of income, despite the fact that this raises many complex issues.

In examining pre-reform incomes, it was found that the use of individuals as the basic income unit (the income recipient) generally gave the lowest inequality values, with the use of households giving the largest values. However, as  $\theta$  (the exponent in the equivalence scale function) became close to unity, the ranking was found to change: this cross-over point being higher for higher degrees of inequality aversion. For a given value of  $\theta$ , the absolute differences between the inequality measures for different income units were small, even for high degrees of inequality aversion. The higher inequality arising from the use of households occurs because the choice of this income unit gives more weight to smaller households and there is a positive correlation between household size and income.

The policy reform was found to reduce inequality for all measures. The

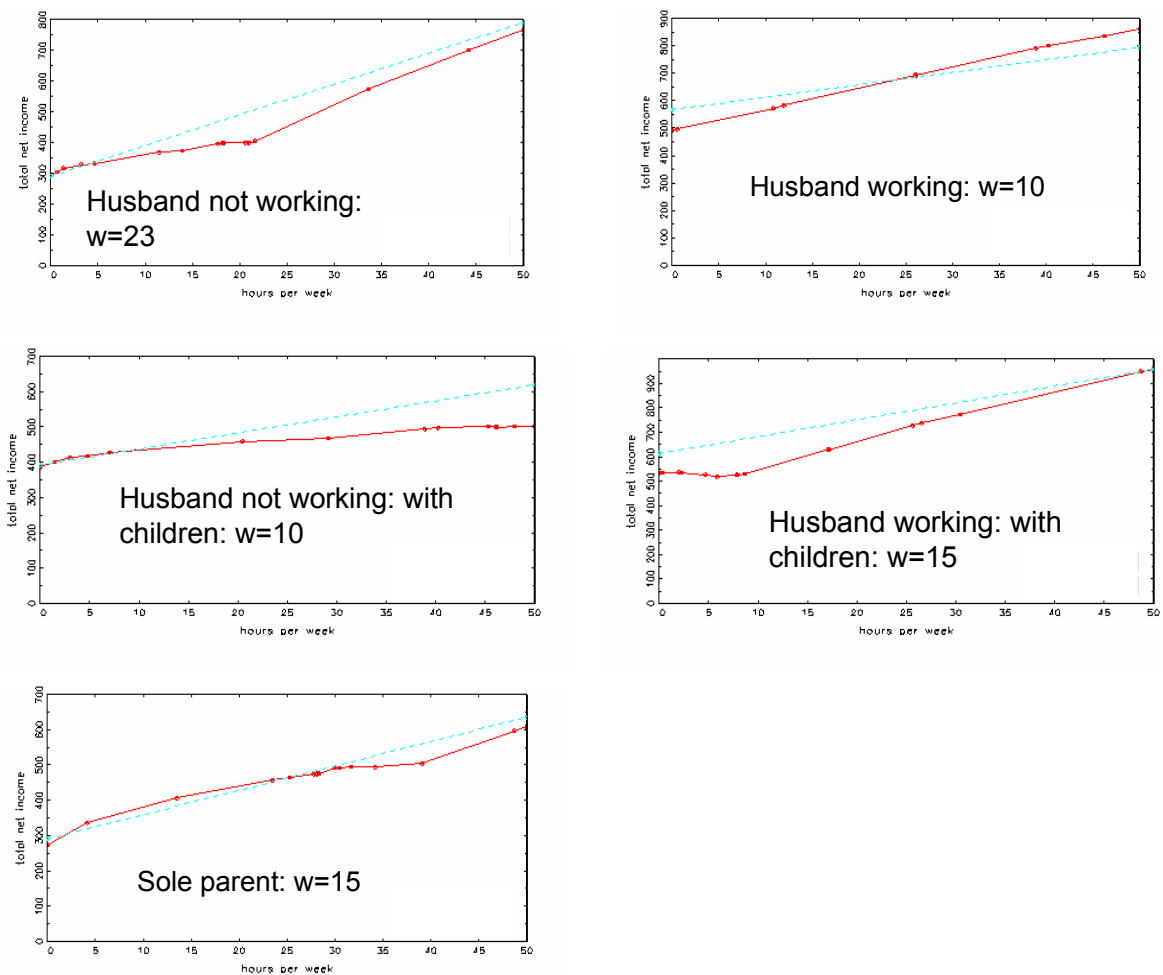
use of individuals as income units consistently gave the highest absolute changes, and this diverged as inequality aversion increased. The exception to this general result occurs when the value of  $\theta$  is unrealistically low. The policy change was also found to increase social welfare when individuals were used as income units, and this consistently gave the highest increases. The increase in social welfare was found to increase as inequality aversion increased from a low value, eventually reaching a maximum, and then falling with higher levels of inequality aversion. The value of  $\varepsilon$  giving the maximum welfare change was found to increase with  $\theta$ . When allowance was made for labour supply responses to the tax policy change, the use of equivalent adults (and households) was found to produce falls in social welfare (despite the reduction in inequality), for the lower ranges of inequality aversion.

The use of different income units was therefore found to lead to consistent rankings of the simulated policy change, for a wide range of inequality aversion coefficients (and values of  $\theta$ ). While the policy change - the flattening of the rate structure - was found to reduce inequality in all cases, it was not always judged to improve social welfare (depending on the degree of inequality aversion and whether equivalent adults were chosen as income units). The use of individuals as income units is known to satisfy the anonymity principle, while the use of equivalent adults satisfies the equity principle (of transfers), and with heterogeneous units these fundamental principles may well conflict. The choice is of course ultimately a value judgement, but Shorrocks (1997) conjectured that a main concern for inequality suggests the use of equivalent adults, while a major concern for social welfare leads to the use of individuals as the basic income unit. On this reasoning all those judges with a primary concern for social welfare would conclude that the policy change is welfare enhancing, while all judges would view it as inequality reducing.

## Appendix: Budget Constraints

Figure 8 shows the pre-reform and post-reform budget constraints for four examples of married women, and an example of a sole parent. The post-reform budget constraints are the fainter broken lines in the figures and are of course linear for all individuals. The constraints for married women whose husbands are not working clearly show higher net incomes at zero hours of work and higher marginal tax rates over the whole range (a flatter budget line). This contributes towards the movements from work to non-work shown in the transition matrix. Those with husbands not working, and on a low wage, have a clear incentive to increase labour supply, except for a short range at low hours of work. However the incentives are mixed for those with a higher wage and a non-working husband: those working lower hours have an incentive to increase labour supply, while those working above about 25 hours per week face a higher marginal tax rate. For sole parents, the tendency of some of those working lower part-time hours to move out of the labour market, along with some of those working full-time, is also clearly explained by the flattening of the budget constraint.

Figure 8: Some Pre-reform and Post-reform Budget Constraints for Married Women and Sole Parents



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