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Abstract

This present paper reports estimates of welfare changes and the marginal welfare cost of income taxation for a wide range of income and demographic groups in New Zealand, in the context of a uniform increase in all marginal income tax rates. The results are obtained using enhancements to the NZ Treasury's behavioural microsimulation model, Taxwell-B, which uses discrete hours modelling to examine the labour supply responses of all individuals to an income tax change. Considerable variation is found in the marginal welfare costs for different groups, with an overall value of 12 cents per extra dollar raised. The paper also demonstrates the use of a money metric utility measure in a social welfare function evaluation. A smaller reduction in 'social welfare' is obtained compared with the use of net incomes.

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[1] This paper is part of a larger project on `Improving New Zealand's Tax Policy via International Tax Transfer Model Benchmarking', funded by an Endeavour Research Grant from the Ministry of Business, Innovation and Employment (MBIE) and awarded to the CPF. The empirical work reported here was carried out while the authors were employed by the New Zealand Treasury.The views, opinions, findings, and conclusions or recommendations expressed in this Working Paper are strictly those of the authors. They do not necessarily reflect the views of the New Zealand Treasury or the New Zealand Government. We are grateful to Christopher Ball, John Freebairn, Norman Gemmell and Nicolas Herault for their constructive comments on an earlier version of this paper. Access to the data used in this paper was provided by Statistics New Zealand in accordance with security and confidentiality provisions of the Statistics Act 1975. The results presented in this study are the work of the authors, not Statistics New Zealand.

1 Introduction

The concept of the excess burden arising from the introduction of a tax or a tax change – loosely speaking the excess of the welfare loss over the extra revenue raised – is central in public finance analysis. In discussions of tax efficiency (in economic rather than administrative terms), the excess burden and associated concepts are crucial.[2] Yet there have been few attempts to measure excess burdens in New Zealand. And all previous attempts to measure the excess burden of income tax have been at a high level of aggregation.

The present paper reports estimates of welfare changes and the marginal welfare cost of income taxation for a wide range of income and demographic groups in New Zealand, in the context of simple income tax policy change. The results are obtained using enhancements to the NZ Treasury's behavioural microsimulation model, Taxwell-B. The database used is the 2011/12 New Zealand Household Economic Survey. Taxwell-B uses discrete hours modelling to examine the labour supply responses of all individuals to an income tax and benefit change. The discrete-hours specification, whereby individuals have the choice of working only a discrete number of hours levels, involves the assumption that utility functions have both deterministic and random components. This gives rise to a probability distribution for each individual over the available hours levels, which takes the multinomial logit form. This is particularly helpful in modelling labour supply because the econometric estimation of preference functions overcomes the endogeneity issues which plagued earlier attempts to estimate labour supply functions, in view of the fact that hours worked and the marginal tax rate faced are jointly determined in a piecewise-linear tax structure. Furthermore, by allowing the parameters of utility functions to depend on a wide range of characteristics, it allows for the considerable extent of population heterogeneity that exists. Added to this is the fact that estimation requires only net (after tax and transfer) incomes of individuals at the discrete hours levels used. It therefore allows the full complexity of the tax and transfer system to be considered.

The existence for each individual of a frequency distribution over hours levels, combined with the fact that budget constraints are highly nonlinear, means that convenient analytical expressions for the required welfare changes are not available. This paper applies the method devised by Creedy and Kalb (2005) for the deterministic case with nonlinear budget constraints, extended to deal with the stochastic utility case by Creedy, Herault and Kalb (2011).

Previous estimates of marginal welfare costs and excess burdens for NZ are discussed in Section 2. Section 3 briefly summarises the method used to compute welfare changes. The main results for a tax change involving a 5 percentage point increase in all marginal income tax rates are presented in Section 4. Marginal welfare costs are reported for a range of demographic and income groups. Section 5 goes on to examine an overall evaluation of the tax change using a social welfare function expressed in terms of money metric utility. Brief conclusions are in Section 6.

First, it is useful to summarise briefly the concepts used throughout the paper. For an individual taxpayer, the concepts of welfare change are the equivalent and compensating variations, EV and CV respectively. The former, EV, is the maximum amount of money the individual would be prepared to pay, after the tax change, to return to the old prices. The latter, CV, is the minimum amount of money needed to return the individual to the pre-

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[2] The welfare measurement does not account for administrative costs, avoidance costs, compliance costs, enforcement and rent-seeking costs.

change indifference curve, at the new prices (or new net wage rate in the case of an income tax change).[3]

The associated tax burden, or deadweight loss, concepts are the excess burden (EB) and marginal excess burden (MEB), evaluated using either the EV or CV. Where these measures are based on the equivalent variation, the marginal excess burden is simply given by MEB=EV-MR, where MR is the actual change in (net) revenue. In the case of the compensating variation, this is complicated by the fact that MEB=CV-MR*, where MR* is the revenue change allowing for the individual's behaviour after compensation has been paid (allowing individuals to return to their initial indifference curve at the new prices).[4] In view of this extra complication, the approach taken here is to base measures on the equivalent variation.[5]

The marginal welfare cost, MWC, is then defined as the marginal excess burden per dollar of extra revenue, MEB/MR. Attention is given here to the EV and the associated MWC concepts, which are unambiguously defined for individuals. However, aggregate values, for particular groups, are also reported.[6]

2 Previous Estimates for New Zealand

The earliest estimates of marginal welfare costs of taxation in New Zealand were produced by Diewert and Lawrence (1994, 1995), using a small general equilibrium model in which a representative individual allocates expenditure over four groups (motor vehicles, housing, leisure and 'general consumption').[7] They found marginal welfare cost values for income tax and general consumption tax of about 18 and 14 cents per extra dollar of revenue respectively for the early 1990s.[8]

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[3] As is conventional in the public finance literature, the welfare changes are defined to be positive where a loss is concerned. A negative EV, indicating a welfare gain, arises when relevant tax rates are reduced. In the present paper, as with all the estimates mentioned in the following section, government expenditure is not included in individuals' utility functions.

[4] Of course, the hypothetical compensation itself is not part of the net revenue calculation.

[5] The two measures are equal only for truly marginal changes, or where there are no income effects, but of course most tax changes are non-marginal.

[6] The associated concept that receives considerable attention in analyses of optimal taxation and expenditure is that of the marginal cost of funds, MCF, which is simply equal to 1+MWC. It is the MCF (at the aggregate level) that is important when considering the question of the 'optimality' condition regarding public expenditure, and the question of raising additional tax revenue to finance a government project. The value judgements behind an optimal position (the 'first-order conditions') necessarily depends on the views of the government, viewed as the 'decision taker'. They can be expressed as follows. The perceived value of an additional unit of public spending is referred to as the marginal value of public funds, MVPF, and is of course expected to exceed 1: a dollar or public expenditure produces more than a dollar's worth of 'public services'. The MWC of the tax-financed funds is valued by the government using the concept of the marginal social value, MSV: this reflects the weight attached by the decision taker to the welfare cost imposed on taxpayers. For example, if the extra tax revenue is raised by high-income taxpayers and the decision taker attaches little value to their loss of welfare, the MSV is relatively low. The optimality condition can be expressed as MCF=MVPF/MSV.

[7] See also Diewert et al. (1998). They referred to the 'marginal deadweight cost' or 'marginal excess burden' which they expressed in percentage terms, rather than per dollar of net revenue.

[8] A helpful summary of their approach is found in Small (2012) who found, using bootstrap methods and various modifications to the Diewert and Lawrence model, that the values were

McKeown and Woodfield (1995) examined welfare costs of income taxation, using an approach based on the standard approximation to the excess burden, in terms of the equivalent variation. Assuming a linear compensated demand curve for leisure, the excess burden arising from a small tax change is known to be equal to half the product of the compensated demand elasticity (here the demand for leisure) in the new position, the net wage income and the square of the tax-inclusive income tax rate.[9] Although McKeown and Woodfield (1995) looked at a range of income levels, they used a common tax rate obtained as an income-weighted arithmetic mean marginal tax rate (over the multi-rate income tax schedule, and including indirect taxation).[10] Using a tax reform consisting of a one percentage point increase in all marginal rates, and values of the compensated demand elasticity in the range 0.2 to 0.6, their illustrative calculations produced marginal welfare costs much higher than those obtained by Diewert and Lawrence (1994) and, as expected, they were substantially higher for the higher elasticities; see McKeown and Woodfield (1995, Table 3).

The next contribution to measuring welfare costs of income taxation was by Thomas (2007).[11] He based results on his estimate of the elasticity of taxable income, using information relating to the 1986 tax reform in NZ. These results are necessarily for a very high level of aggregation. The rapidly growing literature on the elasticity of taxable income, ETI, following Feldstein (1999), had established that, for those in the top income tax bracket and in the absence of income effects, the marginal welfare cost can be obtained as a simple function of the elasticity, the tax-exclusive income tax rate and a term equal to the ratio of average income in the top bracket to the excess of that average over the income threshold.[12]

Using estimates of the elasticity of taxable income obtained for the 2001 tax reform, Claus *et al*. (2012, p. 301) later reported a range of marginal welfare cost values for alternative assumptions about the extent to which taxable income is shifted to lower-taxed sources rather than being evaded.[13] However, a serious problem with this approach is that the results are very sensitive indeed to the value of the elasticity of taxable income, a term that has been very difficult to estimate with sufficient precision.

There have been fewer studies of the welfare costs of indirect taxes. As mentioned above, there are the highly aggregative estimates of Diewert and Lawrence (1994) for the broad

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typically not significantly different from zero. Other attempts to measure excess burdens, including the present paper, have not obtained confidence intervals.

[9] They refer (1995, p. 48) to the excess burden in some places as the 'total welfare cost'. They also write the formulae in terms of the gross income (the pre-tax wage multiplied by hours worked), rather than net income, so that their tax term is written as $m^2/(1-m)$, where m is the tax-exclusive rate. The tax-inclusive rate is $m/(1-m)$. For the approximation based on the compensating variation, the appropriate tax rate is the tax-exclusive rate, and elasticities and net incomes are pre-change values. The expression described above corresponds to the more common idea of the excess burden depending on the square of a tax rate (either the tax-inclusive or exclusive rate). Here net income is the product of hours worked and the gross wage rate multiplied by $(1-m)$. For more details of EV and CV approximations in consumption and income tax contexts, see Creedy (2004a).

[10] This meant that they used a rate for the post-1980s-reform period that was higher than for the pre-reform period, particularly given the role of built-in flexibility.

[11] In the published version of his paper, Thomas (2012) omitted estimates of the marginal welfare cost.

[12] The standard specification rules out income effects, and thereby considerably simplifies welfare measures. This result was extended to deal with all tax brackets, with numerical illustrations, by Creedy (2010).

[13] Examples were also produced by Gemmell (2009) for the Victoria University of Wellington Tax Working Group.

groups of housing, vehicles and ‘general consumption’. Creedy (2004b), using a partial equilibrium model allowing for extensive heterogeneity, computed marginal welfare costs of a simulated increase in the petrol excise tax, and these ranged between 35 and 55 cents per dollar of additional revenue, depending on the household type. Welfare costs arising from the Goods and Services Tax (GST) and other excise taxes in New Zealand were obtained by Creedy and Sleeman (2005) for a wide range of household types and income groups. As a broad-based tax, the GST was found to give rise to relatively low welfare costs for most household types.[14]

3 Measuring welfare changes

This section briefly describes the method used to compute welfare changes for each individual and household. Subsection 3.1 discusses the approach in a random utility framework. Subsection 3.2 examines the calculation of marginal welfare costs for individuals and groups, paying particular attention to the treatment of cases where the net tax paid by some individuals actually declines when income tax rates are increased, as a result of large labour supply responses.

3.1 Welfare changes in the random utility model

It was mentioned above that, in the discrete hours approach, direct utility functions are assumed to consist of a deterministic plus a random component, implying that each individual has a probability distribution over the available hours levels. Simulation involves the use of ‘calibration’, which ensures that each individual’s optimal labour supply under the actual tax structure corresponds to the observed (discretised) hours level. This means that the post-reform distribution of hours worked, and of welfare changes, is effectively a conditional distribution.[15]

The calibration approach proceeds as follows.[16] If a set of random utility terms (one for each hours level) is drawn from the distribution of the stochastic component of utility for an individual, the resulting utility levels can be computed.[17] These combine point estimates of the utility parameters and observed characteristics to calculate the deterministic utility components, to which are added the random components. Comparing the utility values at each labour supply point, optimal labour supply can be determined. In the calibration

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[14] In their analysis the effects of eliminating GST on food, Ball *et al*. (2016, p. 122) report values of the ratio of the change in tax to the equivalent variation, for a range of household types, from which the marginal welfare cost can easily be obtained. However, their policy change was designed to be revenue neutral in aggregate, so for some groups considered, the revenue change was found to exceed the welfare change.

[15] An alternative method would be to use the analytical expression for the unconditional distribution of hours worked and a corresponding analytical method to derive expected welfare changes (the numerical approach could be used to obtain the unconditional distribution as well). Preston and Walker (1999) and Dagsvik and Karlstrom (2005) use the unconditional distribution. The present approach has the advantage of simplicity combined with the benefit of being able to exploit observed behaviour in placing individuals at their pre-reform observed hours. In addition, the approach works equally well using the unconditional pre-reform expected labour supply.

[16] For a detailed introduction to modelling and estimation of labour supply, and the use of these models in behavioural microsimulation, see Creedy and Kalb (2005b).

[17] In the TaxWell-B simulations reported here, individuals and partnered women have the choice of 11 hours levels (0, 5, 10, … , 50 hours). Partnered men have the choice of six hours levels (0, 10, 20, … ,50). Hence partners jointly have a choice of 66 discrete hours levels.

approach, only those sets of error terms which result in the implied optimal hours being equal to the observed labour supply in the pre-reform tax system are retained.[18]

A new tax and transfer system gives rise to a new set of net incomes for each hours level, and each retained set of random draws produces a single optimal post-reform hours level. Pre-reform hours are always equal to observed hours but, using the retained sets of error terms, a frequency distribution of post-reform hours arises. The calibration approach is preferred in this case as it uses important information in the sample about each individuals' actual labour supply in a given base tax structure. The resulting conditional expected welfare change is also easily interpreted, as starting from a single hours level. It is thus relatively straightforward to embed the calculation of welfare changes in this process of simulating labour supply responses arising from policy reforms.

The compensating variation, for any set of random values, is obtained, as in Creedy, Herault and Kalb (2011), as follows. Utility for working hours level h_i, giving rise to net income of c_i under tax structure T_k, is equal to a deterministic component $U\left(c_i \middle| T_k\right)$ plus a random component v_i, so that total utility is:[19]

$$U_{i,k} = U\left(c_i \middle| T_k\right) + v_i \tag{1}$$

The usual indifference curve diagram used to consider welfare changes is no longer helpful because the indifference curves – obtained from the deterministic component of utility - through any particular combination of hours of leisure and net income for different values of v_i are identical in a two-dimensional graph, although they represent different levels of total utility. Hence indifference curves which are located further away from the origin (zero leisure and consumption) no longer necessarily represent higher total utility than indifference curves located closer to the origin, depending on the random components for each discrete hours level. A three-dimensional graph would be needed to present all relevant information. However, it is straightforward to explain the approach in terms of equation (1).

Suppose there are two discrete hours levels, and consider a single set of random utility draws, giving v_1 and v_2. With tax structure 0, hours level 2 is chosen if $U_{2,0} = U\left(c_2 \middle| T_0\right) + v_2 > U\left(c_1 \middle| T_0\right) + v_1$. Suppose the tax structure changes to structure 1. Using the calibration approach, the random terms are the same before and after the change. Hours level 2 continues to be chosen if $U_{2,1} = U\left(c_2 \middle| T_1\right) + v_2 > U_{1,1} = U\left(c_1 \middle| T_1\right) + v_1$, but hours level 1 is chosen if the inequality is reversed. In the case of the compensating variation, for this set of draws, conditional on hours level 2 being chosen under the initial tax structure and irrespective of the hours chosen after the policy change, the compensating variation is the smaller of two values of *CV*, obtained by solving each of the following two equations:

$$U\left(c_2 + CV_2 \middle| T_1\right) + v_2 = U\left(c_2 \middle| T_0\right) + v_2 \tag{2}$$

$$U\left(c_1 + CV_1 \middle| T_1\right) + v_1 = U\left(c_2 \middle| T_0\right) + v_2 \tag{3}$$

If, under the initial tax structure, hours level 1 had been chosen instead of level 2, the compensating variation would be the smaller of two values of *CV*, obtained by solving two

[18] In the simulations reported here, 100 sets of such draws are retained for each individual or couple.

[19] The Extreme Value Type I distribution is used for this random component.

equations similar to (2) and (3), but with the right-hand side of each replaced by $U\left(c_1 \middle| T_0\right)+v_1$. Thus in general, where there are *H* hours levels, suppose that level h_m is chosen in the base tax structure, *0*. After the shift to tax structure 1, calculate the *H* values of CV_j Where:

$$U\left(c_j + CV_j \middle| T_1\right)+v_j = U\left(c_m \middle| T_0\right)+v_m \tag{4}$$

and the *CV* is given by $\min(CV_1,...,CV_H)$. When these calculations are repeated for all sets of draws, a probability distribution is obtained, from which the expected value of *CV* for this individual can be calculated by averaging across all sets of draws. In the case of the equivalent variation, equation (4) is replaced by:

$$U\left(c_j - EV_j \middle| T_0\right)+v_j = U\left(c_m \middle| T_1\right)+v_m \tag{5}$$

and *EV* is given by $\max(EV_1,...,EV_H)$.

In carrying out the calculations, it is necessary to obtain the net income corresponding to a specified hours level and for a given utility level (computed from income and hours at an optimal position). In the present context, as mentioned above, quadratic utility functions are used, so that the well-known expression for the roots of a quadratic can be employed. The appropriate root is obvious, as this lies on the 'upward sloping' part of the utility function.[20]

In this random utility context, the application of this process to each set of random draws producing observed (discretised) hours as the optimal working hours, a conditional probability distribution of welfare changes can be obtained for each individual or family. The resulting arithmetic mean value is used where appropriate.

3.2 Calculating marginal welfare costs

3.2.1 Individuals

Consider a single individual, *i,* facing a linear income tax with marginal rate, t, supplying h_i hours of work and paying R_i in tax. An increase in the tax rate imposes a welfare loss (equivalent variation) of EV_i and an increase in tax of ΔR_i. The individual's marginal excess burden is thus:

$$MEB_i = EV_i - \Delta R_i \tag{6}$$

The marginal welfare cost, the marginal excess burden per dollar of extra revenue from that individual, is:

$$MWC_i = \frac{EV_i - \Delta R_i}{\Delta R_i} = \frac{EV_i}{\Delta R_i} - 1 \tag{7}$$

[20] A check is made at each hours level to ensure that utility increases when net income increases. In the empirical application below, there were no cases of this kind for couples and single men. For single parents, 0.7 per cent of equations did not satisfy this condition (remembering that 100 sets of draws are used for 11 hours levels for each individual). For single women, only 0.1 per cent of equations contained no feasible solution.

The most common case is for ΔR_i to be positive.[21] However, it is possible that labour supply falls sufficiently for the tax paid by the individual to fall. The following simple elasticity relationship holds:

$$\eta_{R_i,t} = 1 + \eta_{h_i,t} \tag{8}$$

Where $\eta_{a,b}$ in general denotes the elasticity of *a* with respect to *b.* Hence an increase in the marginal tax rate generates an increase in revenue from person *i*, so long as the elasticity of hours worked with respect to the tax rate is greater than -1.

In cases where tax revenue falls, it makes no sense to refer to a 'marginal excess burden' of taxation, despite the welfare loss. In practice, the tax and transfer system involves complex piecewise-linear budget constraints, depending for example on the extent of means-testing of benefits.[22] Effective marginal tax rates can decline (as certain benefits are exhausted) and increase (as the individual moves into a higher income tax bracket, or becomes eligible for a benefit that is subject to an abatement rate). It is possible for a small increase in a marginal rate to lead to a large reduction in labour supply and therefore for net tax payments to fall (that is, for tax net of benefit payments). This is more likely where the budget constraints for the particular group considered are dominated by non-convexities: this is relevant for lower-income groups who are recipients of means tested benefits. This applies in particular to sole parents: see the discussion in Section 4.1 below.

3.2.2 Aggregate measures

In aggregate, it may be expected that the New Zealand economy is on the 'right side' of the aggregate Laffer curve: that is, an increase in the marginal tax rate is expected to produce an increase, rather than a reduction, in revenue. Define $R = \sum_{i=1}^{n} R_i$ as aggregate tax revenue, for a population of size, *n*. Then ΔR is expected to be positive even though some components may be negative. Similarly, let $EV = \sum_{i=1}^{n} EV_i$ denote the aggregate welfare loss. Hence the aggregate marginal welfare cost is:

$$MWC = \frac{\sum_{i=1}^{n} EV_i}{\sum_{i=1}^{n} \Delta R_i} - 1 \tag{9}$$

In computing these aggregates, therea is no reason to omit those individuals for whom the marginal excess burden is not defined (that is, for whom the tax paid falls as a result of the marginal tax rate change). Omitting such people would understate the true aggregate welfare costs of the tax change.

In some contexts, it may be desired to report the *average* values for specified groups of individuals (those in well-defined demographic or income groups). In the case of the *n* individuals considered above, the population average, $\overline{MWC}$,would be obtained as:

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[21] In the expression for MWC there is clearly a possibility of a singularity where there is no change in tax paid. The same can apply when considering the aggregate MWC or groups of households. This situation arose in one case considered below, as noted in Table 4.

[22] For details of the complex range of social benefits in New Zealand, many of which are subject to means-testing, see: https://www.workandincome.govt.nz/products/a-z-benefits/

$$\overline{MWC} = \frac{1}{m}\sum_{i=1}^{m} MWC_i \qquad (10)$$

Where $m < n$ by excluding from the summation all those for whom ΔR_i is negative. Care is therefore needed in referring to aggregate or average values.

Even if all individuals in a particular demographic or income group were to have positive changes in tax payments when a marginal tax rate changes (that is, where $m = n$), the average marginal welfare cost of those in the group is not equal to the aggregate measure for those in the group. This is because the former involves an average of ratios (marginal excess burdens divided by marginal revenues). The latter effectively involves a ratio of averages, given that the above can be written as:

$$MWC = \frac{\frac{1}{n}\sum_{i=1}^{n} EV_i}{\frac{1}{n}\sum_{i=1}^{n} \Delta R_i} - 1 \qquad (11)$$

The above discussion is in terms of individuals only. In a microsimulation model with heterogeneous families, the welfare changes and revenue changes are all basically defined at the family level, given that for couples a single (joint) utility function is used. Simple aggregates of welfare changes and tax revenue changes therefore reflect total welfare losses and actual total revenue changes, so an aggregate MWC of taxation requires no adjustment for family size and composition.[23]

4 Empirical Results

This section presents the calculated welfare changes and marginal welfare costs for a simple hypothetical policy change involving an increase in all marginal income tax rates by 5 percentage points. This represents a substantial increase in taxation. Of course, in general the welfare effects depend on the precise nature of the tax structure change, so the results presented here are illustrative of the costs of raising extra revenue in this simple way. The base or pre-change income tax structure is shown in Table 1.

All results were obtained using the NZ Household Economic Survey for 2011/12 and the extended Treasury behavioural microsimulation model, TaxWell-B.[24]

[23] However, sample weights provided with the HES are used to obtain aggregate results.

[24] This model obtains the required net incomes for each hours level (before and after the tax change) from the Treasury's non-behavioural model, TaxWell-A. This assumes full take-up of welfare benefits, and ignores cash asset tests and other eligibility requirements for which no data are available. For details of the estimated preference functions and wage equations used in TaxWell-B, see Mercante and Mok (2014a, b).

Table 1 – Income tax rates

Income band ($ annual)	Marginal tax rate (%)
0 to 14,000	10.5
14,001 to 48,000	17.5
48,001 to 70,000	30
70,000 and over	33

4.1 Aggregate results

A summary of aggregate results for four demographic groups, and for all families combined, is given in Table 2. In obtaining these aggregates, the sample weights were used to 'gross up' the sample to total population values.[25]

Of course it is widely recognised that net income, considered as a welfare metric, does not capture leisure time. The fact that changes in net income 'overstate' changes in welfare is clearly shown in the final row of the table. The labour supply responses are such that income falls, but the increase in leisure is such that the welfare loss is less than the net income reduction. The differences are larger for single women and single parents, for whom the labour supply responses are relatively large.

The marginal welfare costs reported in Table 2 were obtained using equation (9), and thus measure the aggregate welfare cost per dollar of extra aggregate revenue. These results show large differences among the main demographic groups. The lowest MWC is for single men, at 4 cents per dollar of extra revenue. For single parents the aggregate MWC is very high, at 3.47 dollars per dollar of revenue. The reason for the high welfare cost in this case is that a substantial number of single parents reduce their labour supply by large amounts as a result of the tax rate increases, such that they experience a reduction in the net tax paid. They form a relatively small proportion of total population, and hence the aggregate MWC is much lower, at 12 cents per dollar.

A feature of labour supply responses of sole parents can be seen from the budget constraints for two hypothetical cases, shown in Figure 1. The pre- and post-change budget constraints are shown for two different wage rates, $16 and $28 per hour. These show how the marginal income tax rate changes reduce net incomes, particularly in the higher hours ranges. Although a discrete hours modelling approach is used, these constraints illustrate the net incomes over all work hours, showing more clearly the large range of hours for which the budget set is non-convex. An implication of this type of non-convexity is that even very small changes in the tax rates over the relevant range can lead to large changes in labour supply, involving large discrete 'jumps', in view of the convexity of indifference curves. The relevant range of hours for which the non-convexity applies is clearly much larger for the sole parent with the lower hourly wage rate.[26]

The fact that Taxwell-B uses a discrete hours approach, with a random utility component, means that there is a small probability that some higher hours levels are chosen as a result of the tax change. However, these cases are very small, as shown by the transition matrices shown in Tables 3 and 4, for single women and single parents respectively.

[25] The weights ensure that a range of totals, such as the number of individuals in various age groups, match independently obtained aggregates (referred to as 'calibration values').

[26] There is of course an additional non-convexity introduced by the existence of fixed cost of working. It is this fixed costs which explains why there are a number of shifts from working to non-working, rather than simply reducing the hours of work.

Table 2 –Aggregate income, revenue and welfare effects of tax rate increases ($m a year)

	Couples	Single men	Single women	Single parents	Total
Net government revenue (with labour response)	3,894	789	502	30	5,215
Net government revenue (labour supply fixed)	4,242	823	678	141	5,884
Aggregate net income change	-4,689	-865	-830	-196	-6,580
Equivalent variation (EV)	4,227	821	672	136	5,856
Marginal excess burden	333.0	32.7	170.6	105.3	641.6
Marginal welfare cost	0.09	0.04	0.34	3.47	0.12
% difference between net income change and EV	-9.9	-5.0	-19.0	-30.6	-11.0
Proportion of sample	0.46	0.24	0.22	0.08	1.0
Proportion of net revenue (with labour response)	0.75	0.15	0.10	0.00	1.0
Proportion of marginal excess burden	0.52	0.05	0.27	0.16	1.0

Figure 1 – Budget Constraints for two sole parents with two children

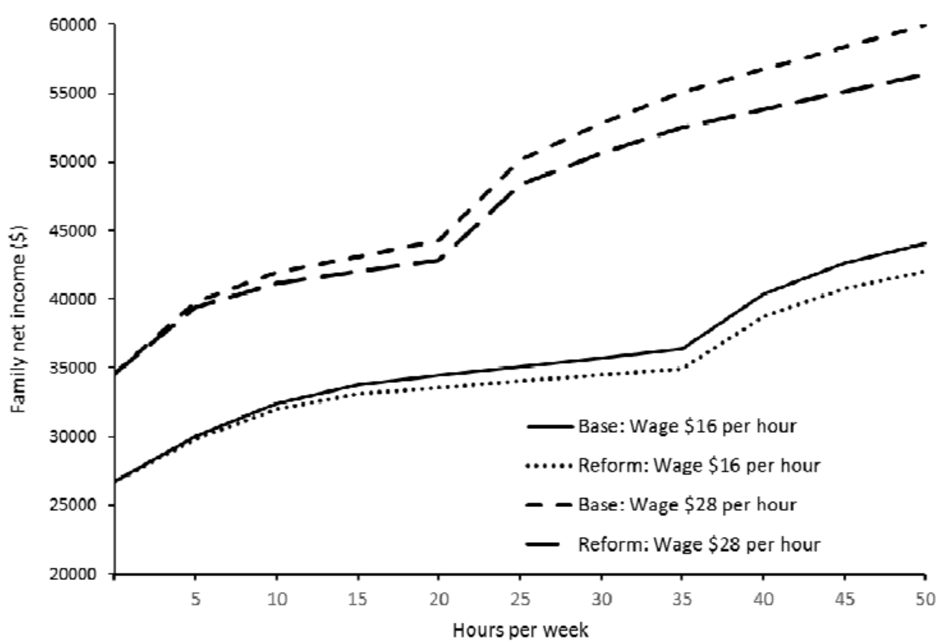

Table 3 – Single women labour supply transitions (row to column)

	Labour supply in hours per week											Total %
	Post-reform											
Pre-reform	0	5	10	15	20	25	30	35	40	45	50	
0	100	-	-	-	-	-	-	-	-	-	0	53.4
5	-	100	-	-	-	-	-	-	-	-	-	1.5
10	0.4	-	99.6	-	-	-	-	-	-	-	-	3.9
15	0.8	-	0	99.2	-	-	-	-	-	-	-	3.1
20	4.6	-	-	-	95.4	-	-	-	-	-	-	1.9
25	1.9	-	0.1	-	-	98	-	-	-	-	-	1.5
30	5.7	0	0.1	0.3	0.1	0.1	93.4	0	0.1	0.1	0.1	4.3
35	3.1	0.1	0.2	0.1	0.2	0.3	0.2	95.7	0.1	0	0.1	5.2
40	5.2	0.1	0.1	0.2	0.3	0.4	0.4	0.4	93	0	0	15.3
45	4.2	0	0.1	0.3	0.4	0.5	0.2	0.4	0.3	93.5	-	4.6
50	5.8	0.2	0.1	0.3	0.3	0.3	0.7	0.6	0.2	0.1	91.4	5.3
Total %	55.3	1.5	3.9	3.1	1.9	1.6	4.2	5.1	14.3	4.3	4.9	100

Table 4 – Single parents labour supply transitions (row to column)

	Labour supply in hours per week											Total %
	Post-reform											
Pre-reform	0	5	10	15	20	25	30	35	40	45	50	
0	100	-	-	-	-	-	-	-	-	-	-	62.6
5	2.7	97.3	-	-	-	-	-	-	-	-	-	3.1
10	6.2	-	93.8	-	-	-	-	-	-	-	-	5.3
15	6.4	0.2	0.3	89.4	0.2	1.7	1.6	0.3	-	-	-	3.3
20	7.7	0.3	0.4	0.1	91.4	-	-	-	-	-	-	2.4
25	10.9	0.1	0.5	0.2	0.1	88.3	-	-	-	-	-	2.8
30	9.7	0.4	0.8	1	0.6	0.1	86.4	0	0.1	0.4	0.7	4
35	11.9	0.3	0.6	0.6	0.7	0.5	0.3	84.6	-	0.2	0.2	3.1
40	10	0.3	0.6	0.6	0.7	1.3	0.7	0.7	85	-	0	8.2
45	1.8	0.2	0.4	0.3	0.2	0.3	0.6	1.3	-	93.1	1.9	1.9
50	8.5	0.4	0.7	0.3	0.7	1.0	0.9	1.2	1.3	0.1	84.8	3.2
Total %	65.6	3.1	5.2	3.1	2.3	2.7	3.6	2.8	7	1.8	2.8	100

A crucial feature of these transition matrices is that the distributions of work hours following the tax change, conditional on working a particular hours level before the change, are multimodal. Indeed, there are relatively large probabilities of moving from work to non-work. As mentioned above, such moves are associated with net reductions in tax paid. This contributes to the relatively small increase in aggregate net revenue and the high aggregate marginal welfare cost of funds for single women and single parents.

4.2 Welfare cost for subgroups

Information about the welfare changes and marginal welfare costs of the tax rate increases for a range of income and demographic groups is given in Table 5. Households in each demographic group are divided into quintiles by disposable income. The equivalent variations are arithmetic means (again weighted using HES sample weights) within each group. The MWC values are aggregates. It can be seen that, for some of the single women quintile groups and for most of the single parent quintile groups, the aggregate net tax revenue change is negative. However, aggregate revenue for each the demographic groups as a whole increases, as seen from the summary in Table 2. The majority of individuals in the single parent group thus appear to be on the 'wrong side' of their Laffer curves: further tax rate increases impose welfare *and* revenue losses. For the lowest quintile of single parents, the marginal welfare cost is very high, at 6.32, despite the average equivalent variation being quite small, again reflecting the small total net revenue increase within the group.

The lowest marginal welfare costs are for single males. Except for the lowest quintile – for which hours worked are on average very low – the MWC varies from 4 to 8 cents per extra dollar of aggregate revenue. Of course, many of those in the lowest quintile work zero hours in the labour market. MWC values for couples are relatively high, being around 20 cents per dollar of net revenue, except for the top quintile in each category.

Instead of decomposing by quintile, Table 6 gives corresponding results to those of Table 5, where groups are divided into tax brackets. As Taxwell-B uses only disposable incomes, individuals are allocated to the tax brackets according to those net incomes, rather than taxable incomes. Hence, it should be recognised that some individuals assigned to a bracket are not actually facing the relevant marginal rate, but may face a higher rate. Except for single men, the highest marginal welfare costs are found in the lowest two tax brackets, particularly in the large second bracket between $14,000 and $48,000.

A decomposition by age is shown in Table 7. In this case couples with and without children are classified by both the age of the male and the female partner in turn. However, it is clear that the differences are negligible, reflecting the high correlation between the ages of partners. When single women are classified by age, aggregate net revenue in each broad group increases, although clearly the MWC values are high. Here, the higher MWCs are found for younger couples with children and older couples without children.

Table 5 –Welfare measure by disposable income and demographic group[a]

Demographic group by income quintiles	Age of youngest child	Hourly wage rate[b] M F	Hours work/week[b] M. F	Equivalent variation (EV)	Marginal welfare cost (MWC)
Couples with children					
Quintile 1	6	14.96, 18.82	10, 6	553.59	0.17
Quintile 2	5	17.06, 18.87	34, 10	1907.23	0.17
Quintile 3	6	24.22, 20.51	43, 14	3392.66	0.23
Quintile 4	7	31.20, 37.86	46, 28	5330.80	0.23
Quintile 5	9	53.42, 33.71	46, 32	9344.14	0.10
Couples without children					
Quintile 1		17.0, 18.94	2, 5	279.79	0.51
Quintile 2		13.90, 15.94	29, 15	1555.52	0.20
Quintile 3		17.92, 17.70	36, 20	2514.67	0.19
Quintile 4		21.47, 18.82	43, 31	3823.01	0.18
Quintile 5		35.10, 27.79	44, 35	6710.05	0.09
Single men					
Quintile 1		18.56	1	50.23	0.00
Quintile 2		16.52	17	618.31	0.05
Quintile 3		14.88	39	1439.12	0.04
Quintile 4		19.14	42	2073.64	0.05
Quintile 5		35.91	44	4187.65	0.08
Single women					
Quintile 1		12.70	3	101.36	0.68
Quintile 2		14.19	22	776.25	-
Quintile 3		15.71	35	1317.24	-
Quintile 4		19.26	42	2034.81	1.56
Quintile 5		34.26	43	3905.71	0.08
Single parents					
Quintile 1	5	11.21	0	12.37	6.32
Quintile 2	6	12.25	4	146.63	-
Quintile 3	9	18.15	29	1331.46	-
Quintile 4	10	25.28	40	2553.99	-
Quintile 5	12	46.35	32	5399.25	-

Notes: a) Post-reform values and welfare changes are expected values b) The wage rates and hours worked for couples are male and female respectively.

Table 6 Welfare measure by tax bracket and demographic group[a]

Demographic group by income quintiles	Age of youngest child	Hourly wage rate[b] M F	Hours work/week[b] M F	Equivalent variation (EV)	Marginal welfare cost (MWC)
Couples with children					
0-14,000	5	14.63, 19.58	10, 3	477.47	0.17
14,001-48,000	7	25.85, 26.17	42, 19	3902.19	0.22
48,001-70,000	9	49.00, 32.83	45, 32	8483.24	0.09
>70,000	10	90.74, 47.04	50, 33	15997.14	0.06
Couples without children					
0-14,000		16.72, 18.48	1, 7	204.30	0.99
14,001-48,000		20.58, 18.78	40, 27	3417.88	0.16
48,001-70,000		33.11, 27.50	44, 36	6354.77	0.10
>70,000		57.22, 38.03	45, 34	10999.63	0.07
Single men					
0-14,000		18.24	1	74.71	0.00
14,001-48,000		17.76	39	1762.70	0.05
48,001-70,000		31.69	44	3654.54	0.07
>70,000		66.64	44	7797.16	0.11
Single women					
0-14,000		12.39	4	137.97	0.71
14,001-48,000		17.89	37	1689.20	2.25
48,001-70,000		34.76	43	3705.82	0.09
>70,000		41.38	47	5429.42	0.02
Single parents					
0-14,000	5	11.28	0	15.54	6.51
14,001-48,000	8	16.75	19	1000.06	-
48,001-70,000	12	48.64	28	5773.32	-
>70,000	Na	Na	na	na	na

Notes: a) Post-reform values and welfare changes are expected values b) The wage rates and hours worked for couples are male and female respectively.

Table 7 –Welfare measure by demographic group and age[a]

Demographic group by age	Age of youngest child	Hourly wage rate[b] M F	Hours worker/week[b] M F	Equivalent variation (EV)	Marginal welfare cost (MWC)
Couples with children: classified by age of male					
20-35	2	23.40,	41, 16	3460.92	0.30
36-50	8	30.45,	41, 20	4680.39	0.15
51-64	12	30.93,	40, 24	4921.08	0.19
Couples with children: classified by age of female					
20-35	2	24.62,	41, 16	3555.85	0.28
36-50	9	30.83,	41, 22	4855.67	0.15
51-64	13	31.77,	42, 20	4821.53	0.11
Couples without children: classified by age of male					
20-35		22.58,	39, 32	4119.79	0.07
36-50		29.62,	44, 32	5456.03	0.09
51-64		27.64,	39, 26	4661.50	0.17
Couples without children: classified by age of female					
20-35		23.78,	39, 32	4243.99	0.06
36-50		30.10,	43, 32	5710.71	0.08
51-64		27.27,	39, 26	4522.18	0.19
Single men					
20-35		19.84	34	1776.95	0.04
36-50		27.32	36	2630.68	0.07
51-64		26.16	34	2564.14	0.12
Single women					
20-35		18.79	34	1758.82	0.81
36-50		23.56	38	2434.86	0.55
51-64		22.87	30	1985.60	0.90
Single parents					
20-35	3	13.59	7	366.04	-
36-50	9	17.35	17	984.26	-[c]
51-64	15	18.17	20	2071.57	1.36

Notes: (a) Post-reform values and welfare changes are expected values. (b) The wage rates and hours worked for couples are male and female, respectively. (c) In this case the revenue change is positive but very small and, being close to the singularity, produces a meaningless MWC value.

5 Evaluating changes using a social welfare function

It is often desired to evaluate tax reforms in terms of their effects on specified demographic groups or for the population as a whole. The question then arises of the welfare metric and social welfare function to use. The complexities involved, particularly in the present context where there is considerable preference heterogeneity, are discussed by Creedy, Herault and Kalb (2011, pp. 17-18). One approach, used by Aaberge and Colombino (2008), and Ericson and Flood (2009) use a welfare metric in their social welfare function that is based on an independently estimated utility (or 'welfare') function which is considered to be the same for all individuals, although heterogeneity is recognised when dealing with labour supply behaviour. Hence, the utilities in their welfare metric may differ from the utility levels determining labour supply behaviour.[27]

The welfare metric investigated here is money metric utility per adult equivalent person, allowing fully for the fact that individuals have a probability distribution (conditional on being at observed hours in the pre-change or base tax structure). Money metric utility is the 'cost', here expressed in terms of 'full income', of achieving a specified utility level at a given set of 'reference prices'. The reference prices used are those applying in the 'pre reform' situation. While the difficulties associated with this metric are acknowledged, 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 results presented here are based on the use of money metric utility per adult equivalent, using modified OECD scales and the individual as the unit of analysis.

The procedure is as follows. For each income unit, the initial money metric utility, M_0, is obtained using pre-reform taxes as 'reference prices': conveniently, this is equal to full income under the pre-reform system. Assuming that 80 hours is the maximum number of hours that can be worked per week, net income at 80 hours of work by all adult members of the income unit under pre-reform taxes represents full income for the income unit. Then, given the equivalent variation, EV, resulting from the reform, post-reform money metric utility is computed as $M_1 = M_0 - EV$ for each set of error terms.[28] For each income unit, the adult equivalent size, s, is obtained and used to compute money metric utility per adult equivalent, $m_{j,i}$ for tax structure j and income unit, i. The probability distributions of $m_{0,i}$ and $m_{1,i}$ are used to make the social evaluations.

With the individual as the unit of analysis, each value of $m_{j,i}$ is weighted by the number of persons in the income unit. The welfare function is based on Atkinson's inequality measure, $A(\varepsilon)$, where ε is the degree of relative inequality aversion. The inequality measure is expressed as 1 minus the ratio of the equally distributed equivalent value to the arithmetic mean (Atkinson 1970). The equally distributed equivalent value is the value which, if obtained by everyone, gives the same social welfare as the actual distribution.

[27] Blundell and Shephard (2009) instead use utility (as in their labour supply specification) as the welfare metric, and adopt a social welfare function based on an iso-elastic transformation of utility.

[28] The equivalent variation divided by initial full income is thus the proportional change in money metric utility as a result of the tax change.

Using an additive welfare function based on constant relative aversion, the equally distributed equivalent value is in general, for a set of values y_i, (for i=1,…,n), equal to:

$$y_{ede} = \left(\frac{1}{n} \sum_{i=1}^{n} y_i^{1-\varepsilon} \right)^{1/(1-\varepsilon)} \tag{15}$$

Results can be obtained for a range of inequality aversion parameters, ε. Finally, social welfare in each system is obtained using the abbreviated welfare function, associated with the Atkinson inequality measure, in general given by $W = \bar{y}(1 - A_\varepsilon)$. This means that social welfare W is the equally distributed equivalent level of money metric utility.

Results are given in Table 8 where, as before, HES sample weights are used. Results are given for two values of the inequality aversion parameter. Table 8 also reports results using net income as the welfare metric, rather than money metric utility. In the former case, no value is attached to leisure (non-work) time. The percentage reductions in ‘social welfare’ resulting from the tax rate increases for net income are almost double those for money metric utility. A high aversion to inequality implies a slightly larger percentage reduction in social welfare than a low aversion, when money metric utility is used. However, this is reversed when using net incomes. In the case of money metric utility, there is no change in inequality as a result of the uniform five percentage point change in all marginal tax rates.[29] The reduction in average money metric utility implies an unambiguous reduction in social welfare with this metric.

Table 8 –Social welfare function evaluations of income tax rate change

	Mean	Atkinson’s index		Social welfare	
		ε=0.2	ε=1.4	ε=0.2	ε=1.4
Pre-reform net	29,880	0.032	0.230	28,911	23,014
Pre-reform money	50,874	0.050	0.328	48,342	34,207
Post-reform net	28,004	0.031	0.221	27,145	21,813
% change using net incomes	-6.28	-3.13	-3.91	-6.11	-5.22
Post-ref money metric	49,208	0.050	0.328	46,758	33,071
% change using money metric	-3.28	0	0	-3.28	-3.32

Note: Money metric utility and net income are measured in per adult equivalent terms. Social welfare is the equally distributed equivalent level of money metric utility, or net income: this is the abbreviated welfare function for the Atkinson inequality measure.

[29] The table gives inequality measures to three decimal places, but the Atkinson measures for money metric utility did change slightly at the sixth decimal point and was thus considered to have remained constant.

In the case of net incomes, which attach no value to changes in leisure, social welfare is necessarily much lower than for money metric utility. Bigger relative changes therefore result from the tax changes. Untaxed welfare benefits make a larger contribution to low-income groups. In this case measured inequality falls. There are small labour supply responses of single men and individuals in couples, but it has been seen that many single women and single parents display substantial reductions in labour supply, which imply that their net tax payments fall (after allowing for higher benefits). This again contributes to the reduction in the measured inequality of net incomes. However, this reduction in inequality of net incomes is not sufficient to outweigh the larger reduction in arithmetic mean welfare.

6 Conclusions

This paper has reported estimates of welfare changes and the marginal welfare cost of income taxation for a wide range of income and demographic groups in New Zealand, using an enhanced version of the Treasury's behavioural tax microsimulation model, TaxWell-B. The tax change context was one in which all marginal income tax rates were increased by five percentage points, and calculations were based on the 2011/12 Household Economic Survey.

Previous estimates for New Zealand have been at a high level of aggregation, using either a general equilibrium model or aggregate estimates of the elasticity of taxable income, or have been based on a standard approximation for the excess burden of an income tax. The present approach computes 'exact' welfare changes, making full allowance for the complex nonlinear nature of the budget set facing each individual or family. It also uses an approach, developed by Creedy, Herault and Kalb (2011), to deal with the fact that a discrete-hours structural approach is used to model preferences, in which individuals and families have preference functions containing both deterministic and stochastic components.

The paper has also demonstrated the use of a money metric utility measure in a social welfare function evaluation of the policy change. It was found that a smaller reduction in 'social welfare' is obtained, compared with the use of net incomes.

The results suggested that the marginal welfare cost of income taxation varies substantially among household types. They range from only about 5 cents for most single men to over six dollars for low-income single parents. However, single parents in aggregate have a marginal welfare cost of about three dollars and fifty cents, for each additional dollar in tax revenue. Single women also face high marginal welfare costs, which are as high as 90 cents per dollar for those in the higher age groups. For all single women combined, the marginal welfare cost was found to be 34 cents. Couples face a welfare cost of about 10 cents overall, but this conceals large variations. Those with children in the middle quintile income groups have costs of about 23 cents, while high-income couples have lower costs, of 10 cents. Low-income couples without children have a marginal welfare cost of about 50 cents, which higher-income couples face a cost of about 20 cents per extra dollar of revenue.

These results therefore display considerable variation around the aggregate marginal welfare cost of 12 cents per extra dollar of revenue raised. In considering these results it should also be borne in mind that they are specific to the particular tax policy change considered. Comparisons with earlier results are therefore extremely difficult. It was mentioned that Diewert and Lawrence (1994), using a general equilibrium model with a representative household, found a marginal welfare cost for income taxation of 18 cents, while McKeown and Woodfield (1995), using an approximation (along with an assumed compensated labour supply elasticity of between 0.2 and 0.6) found values for income tax and GST combined of between 25 and 45 cents. The considerable heterogeneity revealed by the present results is similar to that obtained for Australia by Creedy, Herault and Kalb (2011), although their aggregate marginal welfare cost is higher, at 25 cents. In comparing this with the present aggregate value, it must be remembered that the Australian tax and welfare system is very different from that in NZ, and in particular the income tax structure displays a higher degree of rate progression, along with higher top marginal rates.

In view of the large variation in marginal welfare costs faced by different individuals and families, it would be of interest to explore particular tax and benefit reforms that are capable of reducing the higher excess burdens observed in some cases. This is a potential benefit of this kind of behavioural microsimulation model that can be used to obtain welfare changes for selected demographic and income groups.

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