Working Paper Series

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ECINEQ WP 2018 - 468

ECINEQ 2018 - 468
May 2018

www.ecineq.org

Microsimulation analysis of optimal income tax reforms. An application to New Zealand*

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Abstract

This paper examines the optimal direction of marginal income tax reform in the context of New Zealand, which recently reduced its top marginal income tax rate to one of the lowest in the OECD. A behavioural microsimulation model is used, in which social welfare functions are defined in terms of either money metric utility or net income. The model allows for labour supply responses to tax changes, in which a high degree of population heterogeneity is represented along with all the details of the highly complex income tax and transfer system. The implications of the results for specific combinations of tax rate or threshold changes, that are both revenue neutral and welfare improving, are explored in detail, recognising the role of distributional value judgements in determining an optimal reform.The potential impact of additional income responses is also examined, using the concept of the elasticity of taxable income. Results suggest, under a wide range of parameter values and assumptions, that raising the highest income tax rate and/or threshold, would be part of an optimal reform package.

Keywords: Optimal taxation, tax reform, behavioural microsimulation, social welfare function, money metric utility.

JEL Classification: D63, H21, H31, I31, J22.

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*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. 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. We have benefited from comments by participants at the Microsimulation Workshop in Wellington, March 2018, and the CPF Public Economics Research Day, Wellington, April 2018.

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1 Introduction

This paper examines reforms which move income tax settings towards an optimal structure, where the latter is defined in terms of the maximisation of a social welfare function, defined over either money metric utility or net income. A key objective is to consider the implications of adopting particular value judgements, rather than seeking to make specific policy recommendations. The aim is to examine the *optimal direction* of changes to the parameters of an existing income tax-transfer system, rather than the properties of an optimal structure. It is argued that helpful practical policy advice regarding the effects of tax changes can be based on a behavioural microsimulation model in which a high degree of population heterogeneity is represented along with all the details of complex tax and transfer systems, rather than using the simple stylised forms of standard optimal tax models.[1] Hence, while solving for an optimal tax and transfer system in a microsimulation model is generally impractical, it is possible to identify small changes which can be described as welfare-improving.[2]

The context considered here is the New Zealand income tax structure, and the analysis is carried out using the Treasury's behavioural microsimulation model, TaxWell-B. The approach initially examines small changes in individual marginal tax rates and income thresholds in the income tax schedule, allowing changes that are both revenue neutral and welfare improving to be explored, and highlighting the role of value judgements. This involves the computation of social welfare changes per dollar of revenue, for changes in each existing marginal income tax rate, using explicit forms of the social welfare function. The analysis is then extended in two main directions. First, the range of possible tax reforms considers welfare-improving *combinations* of tax rate and threshold changes. Second, insights from the literature on the elasticity of taxable income are used to examine the effect of addi-

[1] The optimal tax models may be divided into two types, referred to as structural and reduced form approaches. The former includes the long line of analyses starting from Mirrlees (1971), where the government is considered to maximise an explicit welfare function, allowing for a government budget constraint, and individuals maximise utility functions specified in terms of net income and leisure. The reduced form approach relies on few parameters, with a central role given to the the elasticity of taxable income and an optimality condition expressed in terms of marginal benefits and costs of a tax change; see, for example, Saez (2001), Kleven et al. (2009), Pickety and Saez (2013) Pickety et al. (2014), and for an application to New Zealand, see Creedy (2015).

[2] On microsimulation modelling, see Creedy and Kalb (2005, 2006). Examples are in Decoster and Haan (2015), Dagsvik et al. (2014), Thoresen (2004) Thoresen and Vattø (2015). Capéau et al. (2016) provide a detailed discussion of Australian and European tax microsimulation models. When using such models it is nevertheless important to be aware of their limitations. In particular, they deal only with the supply side of the labour market and, despite modelling labour supply, have no genuine dynamic element. Furthermore, they deal only with financial incentive effects rather than administrative behaviour and monitoring features designed to reduce moral hazard.

tional income responses, other than those driven by labour supply changes. These results show that there is much scope for marginal tax reforms in New Zealand that are for both revenue neutral and welfare improving, depending on the distributional value judgements adopted.

Examining the direction of welfare-improving reforms in Australia using, the MITTS behavioural microsimulation model, Creedy and Hérault (2012) report that, for a range of social welfare modelling assumptions, an optimal marginal reform involves a reduction in the top marginal rate, which was around 47 percent (in 2003/04). Unlike Australia and most other OECD countries, New Zealand has a relatively low top marginal income tax rate, of 33 percent since 2009-10. There is no tax-free zone and few deductions are allowed, so that the tax base is relatively broad. The income tax is combined with an array of social transfers with abatement rates generating a wide range of effective marginal tax rates for low-to-middle income earners.[3] This makes New Zealand an especially interesting context in which to examine the optimal direction of tax reform using a microsimulation model. It is of interest to consider whether optimal reform in New Zealand is similar to Australia in generally supporting less marginal rate progression (a flattening of the rate structure), or whether New Zealand's relatively low top rate implies marginal reforms producing more rate progression.

The microsimulation methods used are discussed in Section 2. This is complicated by the existence of highly nonlinear budget constraints facing individuals, which affect the computation of welfare changes and also leads to an asymmetry in the effects of tax rate increases and decreases. Section 3 presents aggregate results relating to reforms to the New Zealand income tax structure. Changes to the income tax rates are examined in Section 4, while changes to income thresholds, as well as combined tax rate and threshold changes, are discussed in Section 5. Brief conclusions are in section 6.

2 Computation of the Welfare Metric

An important modelling requirement is to specify a suitable welfare metric and social welfare function. In the basic optimal tax model, this is straightforward given the choice of cardinalisation of utility, where there are common preferences and homothetic utility functions are usually used.[4] The conditions required for welfare functions to possess basic properties

[3] On effective rates in the New Zealand income tax and transfer system, see Nolan (2017).

[4] Optimal income tax models maximise a social welfare function, subject to a government budget constraint. The partial equilibrium environment usually consists of individuals with identical preferences but different abilities (reflected in exogenous wages rates), and the welfare function is specified as a variant

turn out to be highly restrictive: see, for example, Donaldson (1992) and Blackorby, Laisney and Schmachtenberg (1993).[5] Further complications are raised by differences between individuals in their preference for leisure: it is known that with preference heterogeneity, standard welfare functions based on money metric utility can violate certain conditions, such as the principle of transfers. One approach was suggested by Aaberge and Colombino (2008) and Ericson and Flood (2009), who used a discrete hours structural approach to model labour supply, allowing for a substantial amount of population heterogeneity. However, the welfare metric used in their social welfare function is a value of utility based on an independently estimated utility function, which is considered to be the same for all individuals.[6] While recognising the potential difficulty, the approach used here is to retain preference heterogeneity when producing money metric utility.

Starting from the actual tax structure, and considering small changes in a range of tax parameters, a microsimulation model is used to obtain values of welfare and revenue changes, denoted ΔW and ΔR respectively, for each tax parameter in turn. The direction of an optimal reform is indicated by relative orders of magnitude of these ratios. Computation of money metric utility for each individual, in a discrete hours context, follows that proposed by Creedy and Kalb (2005), and implemented and extended to the calculation of money metric utility in the presence of a random utility component, by Creedy, Hérault and Kalb (2011). The behavioural simulations produce a frequency distribution of post-reform hours for each individual, conditional on the individual's optimal pre-reform hours being equal to observed discretised hours. Similarly a frequency distribution of welfare and net income changes is obtained for each individual. The approach has the advantage of ensuring consistency between the welfare evaluations and the estimated labour supply responses.

Value judgements concern three aspects: the welfare metric, the form of the social welfare function to be used and the definition of the unit of analysis. As mentioned above, money metric utility is used here as the welfare metric, but is also compared with the use of a metric based on net income. The choice of welfare function is closely related to value judgements regarding inequality, and different values of inequality aversion are used in the analyses in this paper. Any evaluation for a broad group of income units involves comparisons of units of different size and composition. The reported results are based on the use of money metric

of the basic utilitarian form, allowing for inequality aversion. The welfare metric is thus utility, which is necessarily considered to be cardinal and interpersonally comparable.

[5] Even a minimum requirement of homotheticity is not satisfied by the types of direct utility function used in practical labour supply analyses. This has led to the adoption of non-welfarist approaches, such as that proposed by Fleurbaey and Maniquet (1999).

[6] Blundell and Shephard (2009) simply adopt a social welfare function based on a common (isoelastic) utility transformation.

utility per adult equivalent, using parametric equivalence scales described below.

The steps in the social evaluation are as follows. For each income unit, the initial money metric utility, M_0, is obtained, using pre-reform taxes as 'reference prices'. This is equal to 'full income' under the pre-reform system, defined as the net income which could be obtained if all the endowment of time were devoted to work at the going wage rate. For each income unit, the net income at 80 hours of work (the assumed maximum number per week) by all adult members of the income unit under pre-reform taxes is calculated, giving full income for the income unit. Following the approach introduced by Creedy, Hérault and Kalb (2011), the equivalent variation from a tax policy change, EV, is obtained by searching all discrete labour supply points for the minimum value for each conditional draw, while taking into account the non-linearity and non-convexity of the budget constraint. Then, given the equivalent variation resulting from the reform for each of the discrete hours levels, money metric utility is computed as $M_1 = M_0 - EV$. A probability distribution of EVs and thus money metric utilities is obtained for each unit.

For each income unit, the adult equivalent size, s, is obtained, following Banks and Johnson (1994) and Jenkins and Cowell (1994), using the following parametric scales:

$$s = (n_a + \theta n_c)^\alpha \tag{1}$$

where n_a and n_c are respectively the number of adults and children in the unit, θ is the weight attached to children and α represents the extent of economies of scale. The size of each unit, i, s_i, is used to compute money metric utility per adult equivalent person, m_i. The distributions of pre-reform and post-reform money metric utility can be used to calculate social welfare measures.

In computing inequality and welfare measures with the individual as the unit of analysis, each value of m_i is weighted by the actual number of persons in the income unit, n_i. This paper uses Atkinson's inequality measure, $A(\varepsilon)$, where ε is the degree of relative inequality aversion. The inequality measure is the proportional difference between the arithmetic mean, $\bar{y}$, and the equally distributed equivalent value, y_{ede}, where the latter is the value which, if obtained by everyone, gives the same social welfare as the actual distribution; hence $A(\varepsilon) = 1 - y_{ede}/\bar{y}$. Using an additive welfare function based on constant relative inequality aversion, ε, of the form:

$$W = \frac{1}{1-\varepsilon}\sum_{i=1}^{n} y_i^{1-\varepsilon} \tag{2}$$

the equally distributed equivalent value, y_{ede}, is in general, for a set of values y_i, for $i =$

$1, \ldots, n$, equal to:

$$y_{ede} = \left(\frac{1}{n} \sum_{i=1}^{n} y_i^{1-\varepsilon} \right)^{1/(1-\varepsilon)} \tag{3}$$

Results can be obtained for a range of inequality aversion parameters, ε. Finally, social welfare in each system is most conveniently obtained using the abbreviated form of the welfare function in (2), given by:[7]

$$W = \bar{m}\,(1 - A(\varepsilon)) \tag{4}$$

where $\bar{m}$ is the arithmetic mean value of the money metric utility per adult equivalent. The use of the abbreviated form, showing the trade-off between 'equity and efficiency', is convenient because it ensures that W is positive for all values of ε. In view of the discrete hours approach to labour supply used here, the summary measures of the various distributions are evaluated using the 'pseudo distribution' approach of Creedy, Kalb and Scutella (2006). This provides more accurate results than taking, say, the arithmetic mean values for each person.

The important question arises of what range of values should be considered when examining the sensitivity of results to ε. In the analysis below, results are reported for values ranging from 0.1 to 1.4. These orders of magnitude can be interpreted by considering the 'leaky bucket' experiment of making a transfer from a richer to a poorer person. A transfer from person 2 to person 1, in the context of incomes, $y_2 > y_1$, which leaves social welfare unchanged is given by:

$$\left. \frac{dy_1}{dy_2} \right|_W = - \left(\frac{y_2}{y_1} \right)^{-\varepsilon} \tag{5}$$

Hence if, for discrete changes and a transfer of 1 from the richest person, $\Delta y_2 = -1$, and if incomes are such that $y_2 = 2y_1$, then the amount which must be given to the poorest person is $\Delta y_1 = 2^{-\varepsilon}$.

For example, if $\varepsilon = 0.1$, a leak of 7 cents is tolerated from the dollar taken from person 2, so that person 1 receives 93 cents. For $\varepsilon = 0.2$, the leak increases to 13 cents. Where $\varepsilon = 0.5$, $\Delta y_1 = 0.71$ and a leak of 29 cents from the dollar is tolerated. A value of ε of 1.4 may thus be considered extremely high, since $\Delta y_1 = 0.39$ and the judge is prepared to lose 61 cents from the dollar. The tolerance for leaks clearly depends on the assumed ratio of incomes of transferor and transferee. For example, if $y_2/y_1 = 3$, then when $\varepsilon = 0.1$, $\Delta y_1 = 0.90$ and a leak of 10 cents is tolerated, and if $\varepsilon = 0.2$, $\Delta y_1 = 0.80$ and the maximum

[7] On abbreviated forms see, for example, Lambert (1993).

leak tolerated is 20 cents.[8]

The following simulation results are based on the New Zealand tax and transfer system for the financial year of 2011/12. Population values were obtained by using the sample weights. The income tax structure is given in Table 1, where t_i is the marginal rate applied above an annual income of a_i, for $i = 1, ..., 4$. Consider taking \$1 from someone in the top tax bracket with \$100k, and making a transfer to someone in the bottom tax bracket with \$10k, so that $y_2/y_1 = 10$, For values of ε of 0.1, 0.2, 0.8 and 1.4, the leaks that would be tolerated are respectively 20, 37, 84 and 96 cents. The higher value of ε therefore approaches 'extreme' inequality aversion, where the 'judge' is willing simply to confiscate income from the richest person.[9] If the \$1 taken from the person with \$100k is used to make a transfer to someone in the second tax bracket with, say, \$25k, the leaks tolerated for the same set of εs are respectively 13, 24, 67 and 86 cents. In this case the richest person is paying a marginal tax rate that is almost double that faced by the person in the second tax bracket.

A distinguishing feature of the New Zealand income tax is that there is no tax-free income range, so that the first rate of 10.5 per cent applies from the first dollar, although various rebates also apply. The marginal income tax rates, particularly in the lower-income ranges, do not reflect effective marginal tax rates in view of the existence of a range of means-tested benefits with various taper or abatement rates. The present approach can also be used to examine small changes in benefit levels and associated abatement rates though that is not pursued here.

Table 1: The New Zealand Income Tax Structure: 2011/2012

No.	Income threshold (in NZ\$)	Marginal tax rate
1	$a_1 = 0$	$t_1 = 0.105$
2	$a_2 = 14,000$	$t_2 = 0.175$
3	$a_3 = 48,000$	$t_3 = 0.30$
4	$a_4 = 70,000$	$t_4 = 0.33$

The simulations reported are for small tax changes, such that each of the marginal rates was in turn decreased by one percentage point, and then increased by one percentage point, and the resulting changes in total revenue and social welfare were obtained. The use of small changes means that the labour supply adjustments are expected to be quite small, given the use of a discrete hours approach.

[8] Some surveys have found an average inequality aversion in the context of the Atkinson inequality measure of about 0.2; see Amiel, Creedy and Hurn (1999).

[9] Indeed, with $\varepsilon = 3$, the leak tolerated is 99.9 cents, virtually the whole of the \$1 taken from person 2.

3 Aggregate Effects

Tables 2 and 3 present summary information about aggregate effects for, respectively, increases in each marginal tax rate by one percentage point, and increases in thresholds by \$1000. The effects of reductions in marginal rates and thresholds are shown in Appendix B, in Tables 12 and 13. These are obtained by adding all expected EV and net incomes across all income units without equivalising the amounts. All monetary values are in \$million per year. Values in the tables are given to two decimal places, but in computing all changes, more decimal places were of course used. The threshold changes are for a_2, a_3 and a_4 only, as $a_1 = 0$. Changes in net government revenue account both for changes in income tax revenue and for consequent changes in expenditures on social security. Indeed, government spending on pensions, allowances and rebates is affected by changes in income taxes and labour supply. The tables also presents labour supply responses by demographic group. For couples, the first amount relates to the male partner while the second amount is for the female partner.

Following the convention used in the public finance literature, equivalent variations, and hence marginal welfare costs, are defined such that they are positive for tax increases and welfare losses. Hence, in Table 3, for threshold increases, tax revenue and equivalent variations are negative, indicating welfare gains: hence the marginal welfare costs are negative.[10] In the case of sole parents, there are several tax changes where the excess burden concept is not appropriate: these arise where the change in revenue in absolute terms is less than the change in welfare (measured by the EV). These cases arise for an increase in t_4, a reduction in t_1, an increase in a_2 and a reduction in a_4, and reflect the large labour supply responses; hence in the case of the tax increase, revenue rises by a relatively small amount.[11]

Increases in marginal tax rates have the expected negative effects on labour supply, although changes in t_4 have the smallest labour supply effects for all groups. Labour supply responses more broadly are relatively small except for sole parents, a result consistent with the findings of Creedy and Mok (2017). Table 3 (and 13 in Appendix B) shows that these small labour supply effects are nevertheless associated with substantial marginal welfare costs, ranging from around 7 to 14 per cent for the various 1 percentage point or \$1,000 tax reforms considered. This serves to highlights the empirical importance here of the known theoretical result that small observed net labour supply effects on average are consistent with substantial marginal excess burdens associated with tax changes.

The tables also allow evaluation of the effects on welfare of tax-induced changes in

[10] Similarly for Table 13 in Appendix B, which relates to marginal rate reductions.

[11] This kind of situation is discussed further in the New Zealand context by Creedy and Mok (2018).

Table 2: Marginal Tax Rate Increases of One Percentage Point

	Couples	Single men	Single women	Sole parents	Total
Increase in 1st tax rate					
Net government revenue change (LS fixed)	236.03	50.52	50.73	7.27	344.55
Net government revenue change (incl. LS)	218.39	49.43	39.17	2.20	309.19
Average hours change in hours per week	-0.02,-0.02	0.00	-0.05	-0.05	-0.02
Equivalent variation	235.96	50.51	50.68	7.25	344.40
Marginal Welfare Cost	0.08	0.02	0.29	2.30	0.11
Aggregate net income change	-259.24	-51.62	-57.58	-9.88	-378.33
Diff b/w net income change and EV (%)	8.98	2.15	12.00	26.59	8.97
Increase in 2nd tax rate					
Net government revenue change (LS fixed)	370.88	72.55	61.89	15.10	520.42
Net government revenue change (incl. LS)	334.42	70.61	45.23	4.40	454.66
Average hours change in hours per week	-0.03,-0.05	-0.01	-0.09	-0.12	-0.05
Equivalent variation	370.61	72.53	61.78	15.04	519.96
Marginal Welfare Cost	0.11	0.03	0.37	2.42	0.14
Aggregate net income change	-425.75	-74.97	-78.80	-22.83	-602.35
Diff b/w net income change and EV (%)	12.95	3.25	21.61	34.14	13.68
Increase in 3rd tax rate					
Net government revenue change (LS fixed)	108.96	15.15	12.19	3.04	139.33
Net government revenue change (incl. LS)	98.39	14.13	10.52	1.95	124.98
Average hours change in hours per week	-0.01,-0.01	0.00	-0.01	-0.01	-0.01
Equivalent variation	108.89	15.15	12.17	3.03	139.24
Marginal Welfare Cost	0.11	0.07	0.16	0.55	0.11
Aggregate net income change	-123.97	-16.95	-15.31	-3.30	-159.53
Diff b/w net income change and EV (%)	12.17	10.62	20.51	8.13	12.72
Increase in 4th tax rate					
Net government revenue change (LS fixed)	132.53	26.33	10.82	2.77	172.45
Net government revenue change (incl. LS)	123.50	25.38	8.81	3.20	160.89
Average hours change in hours per week	-0.01,0.00	0.00	-0.01	0.00	0.00
Equivalent variation	132.42	26.32	10.80	2.77	172.31
Marginal Welfare Cost	0.07	0.04	0.23	-0.14	0.07
Aggregate net income change	-142.92	-28.09	-14.54	-1.80	-187.35
Diff b/w net income change and EV (%)	7.34	6.30	25.70	-53.42	8.03

Table 3: Threshold Increases of 1000

	Couples	Single men	Single women	Sole parents	All
Increase 2nd threshold					
Net government revenue change (LS fixed)	-112.28	-24.15	-24.30	-4.07	-164.80
Net government revenue change (incl. LS)	-107.49	-23.23	-20.05	1.58	-149.19
Average hours change in hours per week	0.00,0.01	0.00	0.02	0.08	0.01
Equivalent variation	-112.29	-24.15	-24.32	-4.09	-164.85
Marginal Welfare Cost	-0.04	-0.04	-0.21	-	-0.10
Aggregate net income change	122.94	25.21	26.81	8.01	182.97
Diff b/w net income change and EV (%)	8.66	4.23	9.30	48.90	9.91
Increase 3rd threshold					
Net government revenue change (LS fixed)	-85.30	-12.02	-9.67	-2.56	-109.54
Net government revenue change (incl. LS)	-82.23	-10.86	-9.33	-2.08	-104.50
Average hours change in hours per week	0.00,0.01	0.01	0.01	0.01	0.00
Equivalent variation	-85.32	-12.02	-9.68	-2.56	-109.59
Marginal Welfare Cost	-0.04	-0.11	-0.04	-0.23	-0.05
Aggregate net income change	92.38	14.00	11.24	2.93	120.54
Diff b/w net income change and EV (%)	7.64	14.09	13.84	12.49	9.09
Increase 4th threshold					
Net government revenue change (LS fixed)	-9.65	-1.26	-1.08	-0.25	-12.24
Net government revenue change (incl. LS)	-9.08	-1.24	-0.86	-0.21	-11.39
Average hours change in hours per week	0.00,0.00	0.00	0.00	0.00	0.00
Equivalent variation	-9.65	-1.26	-1.08	-0.25	-12.24
Marginal Welfare Cost	-0.06	-0.02	-0.25	-0.22	-0.08
Aggregate net income change	10.78	1.33	1.51	0.20	13.82
Diff b/w net income change and EV (%)	10.52	5.00	28.55	-27.16	11.41

leisure, as distinct from effects on net incomes. For tax increases, reductions in welfare as measured by changes in aggregate EV are smaller than reductions in household income because welfare measures account for the increase in leisure and home production time, following the decrease in labour supply. Similarly, changes in welfare are smaller than changes in net income for tax reductions because welfare measures value the decrease in leisure and home production time.

It is clear that changes in welfare and net income resulting from the small tax rate and threshold reforms considered can be quite different; these differences again ranging from around 7 to 14 per cent. For example, an increase in t_3 is associated with a 12.72 per cent smaller welfare reduction compared to the fall in aggregate net incomes. The equivalent value for a reduction in t_3 is a 7.95 per cent smaller increase in welfare. Overall however, increases and decreases in tax rates have fairly symmetric effects on aggregate welfare and average hours worked.

Table 4: Behavioural Revenue Responses as Percentage of Mechanical Changes

		Demographic group				
Policy change		All	Couples	Single men	Single women	Sole parents
Tax rate						
t_1	Increase	-10.8	-7.8	-2.2	-25.9	-119.5
	Decrease	8.1	4.2	2.4	18.0	102.3
t_2	Increase	-13.5	-10.3	-2.7	-31.4	-123.3
	Decrease	9.8	6.2	5.0	19.7	149.1
t_3	Increase	-10.9	-10.2	-7.0	-14.7	-44.4
	Decrease	4.7	3.2	4.7	9.9	48.1
t_4	Increase	-6.9	-7.1	-3.7	-20.6	14.4
	Decrease	8.6	9.0	2.9	13.1	27.2
Threshold						
a_2	Decrease	-9.3	-6.2	-2.5	-22.3	-93.9
	Increase	10.0	4.4	3.9	19.2	138.8
a_3	Decrease	-12.8	-12.2	-7.6	-11.8	-78.3
	increase	4.7	3.7	10.1	3.6	20.8
a_4	decrease	-11.7	-12.5	-4.5	-24.5	20.1
	Increase	7.2	6.1	1.6	22.8	17.4

The effects on net revenue of allowing for labour supply responses are shown by the differences between the first and second rows of each block of the tables. These can be quite substantial, with this 'behavioural effect' on total revenue ranging from 5 to 13 per cent of the estimated 'mechanical effect', which holds labour supply fixed. Table 4 summarises these behavioural revenue responses in total and across population sub-groups. The values shown are the log-differences in the revenues given in Tables 2 and 3, and Tables 12 and 13 of Appendix B.

For example, the decrease in total revenue due to labour supply responses to an increase in the 1st tax rate is equivalent to (minus) 10.8 per cent of the mechanical revenue increase. Revenue effects are largest for increases in t_2 both in absolute amounts and in terms of percentage behavioural effects, shown in Table 4. Behavioural responses are also relatively large for decreases in the 3rd tax threshold, suggesting that the responsiveness of the relatively dense part of the income distribution facing t_2 below the $48,000 threshold is especially important overall.

The contribution of the four household types to the behavioural revenue responses can also be seen to vary considerably, though the values for sole parents should be treated with caution since they are based on less than 10 per cent of total sample households and a much smaller fraction of total revenue changes. Nevertheless, it is clear that one of the consequences of the larger labour supply responses generally observed for single women is that their behavioural revenue responses are also relatively high, compared for example with those of single men.

4 Changes to Marginal Tax Rates

4.1 Changes in Welfare per Dollar of Revenue

Table 5 shows the resulting absolute values of the changes in welfare per dollar of revenue, $|\Delta W/\Delta R|$, for increases and decreases in each marginal tax rate by one percentage point. Results are shown using money metric utility and net income, for two values of the economies of scale parameter, α, in the parametric adult equivalence scales, and three values of inequality aversion, ε. The weight attached to children, θ, was set at 0.6. In considering these values of $|\Delta W/\Delta R|$, it should be recognised that the revenue responses to tax changes arise only from labour supply changes. In practice, reported taxable income changes may be larger because of a range of other possible responses involving income shifting and under-reporting.[12] These effects are considered in sub-section 4.4.

The table indicates that marginal welfare gains and losses per dollar of revenue are not symmetric. Given ε and α, the welfare gain per dollar of revenue associated with a decrease in t_1 to t_3 are always smaller than the corresponding welfare loss associated with a tax

[12] Other changes are included in responses described by the concept of the elasticity of taxable income (ETI).

increase. The opposite result is found for t_4, with welfare gains from a tax rate reductions always larger than the welfare losses from tax rate increase. The results shown above, in Tables 2 to 12, suggest that aggregate EV values are approximately symmetric, along with changes in net government revenue.[13]

Table 5: Values of $\left|\frac{\Delta W}{\Delta R}\right|$ Using Money Metric Utility and Net Income

	Increase in t				Reduction in t			
	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Money metric utility								
Scale parameter: $\alpha = 0.8$								
t_1	1.369	1.379	1.371	1.570	1.333	1.342	1.332	1.521
t_2	1.397	1.367	1.091	0.850	1.349	1.319	1.052	0.818
t_3	1.356	1.290	0.855	0.537	1.276	1.214	0.805	0.504
t_4	1.262	1.153	0.614	0.319	1.284	1.173	0.623	0.322
Scale parameter: $\alpha = 0.4$								
t_1	1.806	1.820	1.817	2.094	1.758	1.772	1.766	2.028
t_2	1.877	1.837	1.458	1.097	1.812	1.773	1.406	1.056
t_3	1.865	1.772	1.153	0.676	1.755	1.668	1.084	0.635
t_4	1.745	1.594	0.829	0.399	1.776	1.621	0.841	0.404
Net income								
Scale parameter: $\alpha = 0.8$								
t_1	1.496	1.491	1.369	1.401	1.442	1.437	1.316	1.343
t_2	1.625	1.590	1.289	1.075	1.553	1.519	1.227	1.020
t_3	1.550	1.475	1.012	0.713	1.378	1.308	0.880	0.604
t_4	1.361	1.236	0.658	0.376	1.463	1.323	0.684	0.376
Scale parameter: $\alpha = 0.4$								
t_1	1.977	1.972	1.817	1.861	1.907	1.899	1.745	1.788
t_2	2.184	2.137	1.721	1.393	2.105	2.037	1.637	1.325
t_3	2.127	2.024	1.362	0.903	1.935	1.790	1.184	0.767
t_4	1.886	1.710	0.889	0.472	2.122	1.823	0.923	0.472

Welfare changes per dollar for reductions and increases in tax rates indicate the direction of welfare-increasing changes to the tax system. In the simple case where it is required to obtain a small increase in revenue by adjusting one rate, the appropriate strategy is to increase that marginal rate resulting in the smallest welfare cost. Conversely, for a small reduction in revenue, a reduction is made in the tax rate associated with the largest welfare gain.

[13] These results contrast with those for Australia reported in Creedy and Hérault (2012). They found that EV and inequality changes were roughly symmetric, while revenue changes were asymmetric.

However, it is important to examine adjustments to the tax system that keep total tax revenue unchanged, by combining an increase in a tax rate to fund a decrease in another tax rate. Such adjustments are of particular interest because they contribute to a movement towards an optimal tax system, at no cost for the government. The optimal change keeping total tax revenue unchanged is the one involving an increase in the tax rate with the lowest welfare cost per extra dollar of revenue combined with a decrease in the tax rate with the highest welfare gain per dollar of reduced revenue.[14] These are effectively revenue neutral changes, since they both consider changes per dollar of revenue.

In the case of money metric utility, consider the welfare gains and losses for the lowest inequality aversion parameter of $\varepsilon = 0.1$, along with the use of $\alpha = 0.8$ for the scale economy parameter in the adult equivalence scales. This suggests that a revenue neutral reform that increases the social welfare function could be achieved by raising t_4 and reducing t_2. For aversion parameters of $\varepsilon = 0.2$ and higher, the results suggest raising t_4 while simultaneously lowering t_1. These results are modified slightly with $\alpha = 0.4$. In this case the rise in the top marginal rate is accompanied by lowering t_1 for values of $\varepsilon = 0.8$ and higher. These results contrast with those obtained for Australia, reported by Creedy and Hérault (2011), which generally suggested that a flattening of the rate structure would increase the social welfare function. The Australian income tax displays considerably more rate progression than in New Zealand, including a much higher top marginal rate of 0.47 (in the Creedy and Hérault study).[15]

In the case of net income as the welfare metric, consider the case where $\varepsilon = 0.1$, and $\alpha = 0.8$. Here, the largest changes in welfare per dollar of revenue are associated with upward and downward movements in t_4. In cases where the same rate is associated with, say, both the lowest $|\Delta W/\Delta R|$ for a rate increase and the highest $|\Delta W/\Delta R|$ for a rate reduction, the rule used above is insufficient. It is appropriate to use a more general rule that the welfare-improving revenue-neutral change to the tax system is the one involving the largest difference between the welfare cost of the tax increase and the welfare gain of the tax decrease. In this case the optimal marginal change involves an increase in t_4 combined with a reduction in t_2. The same result follows for $\varepsilon = 0.2$, but for $\varepsilon = 0.8$ and higher, the largest gain per dollar from a rate reduction is for t_1.

[14] In cases where the same rate is associated with, say, both the lowest $|\Delta W/\Delta R|$ for a rate increase and the highest $|\Delta W/\Delta R|$ for a rate reduction, the rule used above is insufficient. It is appropriate to use a more general rule that the welfare-improving revenue-neutral change to the tax system is the one involving the largest difference between the welfare cost of the tax increase and the welfare gain of the tax decrease.

[15] However, it is important to distinguish rate progression from progressivity. The former refers to the schedule of marginal tax rates, whereas the latter refers to the extent of redistribution arising from the structure and depends on a wide range of further considerations.

If the evaluation function reflects a complete absence of inequality aversion, $\varepsilon = 0$, and the value of the abbreviated welfare function is simply the arithmetic mean money metric utility (or net income) per adult equivalent person. Setting $\varepsilon = 0$, it is found in all cases (that is, for both money metric utility and net income, and for the two values of α considered) that an optimal marginal reform involves a flattening of the tax rate structure. Hence, the optimal change is to lower the top marginal rate and raise the bottom rate. Hence, a small degree of aversion is sufficient to change the optimal policy substantially.[16]

It is important to stress that the results refer only to 'small' changes in tax rates and the direction of change; they can give no indication of the extent to which rates should be changed. Furthermore, it would not be appropriate to carry out simulations for larger tax rate changes. It would be possible for a large change in a marginal tax rate to move into the range where total revenue is decreasing, but where the change in revenue is nevertheless positive. That is, the movement could be from a point on the revenue-increasing side of the Laffer curve to a point on the revenue-reducing side, with an increase in total revenue arising from the large discrete change in the rate. It is then possible for the results to indicate, wrongly, that a further increase in the tax rate would be optimal.

4.2 Inequality Changes

The top panel of Table 6 reports percentage changes in Atkinson inequality measures of money metric utility and net income for increases and decreases in the marginal income tax rates. In the case of money metric utility, pre-reform value of the Atkinson index are 0.0224, 0.0498, 0.2355 and 0.3276 for $\varepsilon = 0.1, 0.2, 0.8$, and 1.4 respectively. the corresponding values for net income are 0.0115, 0.0324, 0.1863 and 0.2298. The table shows that inequality changes are approximately symmetric for tax rate increases and decreases.

In considering inequality changes, lowering t_1 gives the largest percentage reduction in inequality while, for rate increases, raising t_4 gives the largest percentage reduction. The introduction of more rate progression therefore unambiguously reduces the inequality of money metric utility. However the size of the inequality changes in Table 6 are very small in all cases. For example, the largest change is just over one-quarter of one per cent, for an increase in t_1 ($\varepsilon = 1.4$; $\alpha = 0.8$). This partly reflects the small size of the reform simulation.

Evaluation of the inequality effects of income tax reforms in practice is more often evaluated conducted in term of pre- and post-reform net incomes. It is therefore interesting to compare inequality reform outcomes for money metric utility with those based on net

[16] A zero aversion is of course consistent with a redistributive tax and transfer policy on 'efficiency' grounds, but it does not necessarily imply rate progression (that is, increasing marginal rates).

incomes in the lower panel of the table. As with money metric utility, these are generally symmetric between tax rate increases and decreases and similar for $\alpha = 0.8$ and $\alpha = 0.4$.

Table 6: Percentage Change in Atkinson's Index: Money Metric Uility and Net Income

	Increase in t				Reduction in t			
	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Money Metric Utility								
Scale parameter: $\alpha = 0.8$								
t_1	0.251	0.244	0.196	0.278	-0.249	-0.242	-0.194	-0.274
t_2	0.039	0.054	0.001	-0.067	-0.037	-0.052	0.000	0.069
t_3	-0.082	-0.068	-0.055	-0.072	0.082	0.068	0.055	0.072
t_4	-0.274	-0.226	-0.135	-0.134	0.276	0.227	0.135	0.134
Scale parameter: $\alpha = 0.4$								
t_1	0.244	0.236	0.193	0.268	-0.241	-0.235	-0.191	-0.264
t_2	0.069	0.079	0.015	-0.053	-0.068	-0.078	-0.014	0.054
t_3	-0.069	-0.056	-0.051	-0.066	0.069	0.056	0.051	0.066
t_4	-0.245	-0.202	-0.126	-0.121	0.246	0.203	0.127	0.121
Net Income								
Scale parameter: $\alpha = 0.8$								
t_1	0.283	0.295	0.189	0.254	-0.263	-0.280	-0.180	-0.241
t_2	-0.420	-0.149	-0.115	-0.307	0.445	0.169	0.124	0.314
t_3	-0.464	-0.283	-0.160	-0.224	0.470	0.289	0.163	0.225
t_4	-1.292	-0.814	-0.373	-0.417	1.422	0.899	0.411	0.456
Scale parameter: $\alpha = 0.4$								
t_1	0.273	0.293	0.196	0.265	-0.249	-0.277	-0.188	-0.256
t_2	-0.591	-0.182	-0.115	-0.293	0.614	0.199	0.120	0.291
t_3	-0.585	-0.312	-0.167	-0.220	0.587	0.315	0.168	0.219
t_4	-1.586	-0.884	-0.383	-0.400	1.732	0.967	0.419	0.434

Consider, for example, outcomes for the case of the one percentage point increase in the top marginal rate, t_4, for the alternative values of ε and α. This reveals that the apparent reductions in inequality (at all values of ε and α) when using net income as a basis for measurement are up to six times greater than when these are based on money metric utility. This is to be expected since any reductions in market incomes, associated with reduced labour supply resulting from the tax increase, exaggerate the decline when leisure or home production are suitably valued. However, it serves to highlight that commonly quoted income-based inequality statistics may be quite inaccurate as a measure of the inequality impact of tax reforms on a broader measure of utility.

A similar difference can be seen to apply to the measured inequality impacts of changes in t_2 and t_3, while the metric used makes little difference to inequality changes resulting from changes in t_1. This latter result would suggest that the main inequality impact of changes in the marginal tax rate applicable below \$14,000 is not primarily related to labour supply decisions and resulting net income/leisure substitutions. This is perhaps less surprising when it is recognised that, for many such very low income taxpayers, t_1 (= 0.105) is very different from applicable effective average and marginal rates given the array of benefits and abatement rates at such low income levels.

4.3 Welfare Changes and Simultaneous Changes in Two Tax Rates

Further insight can be obtained by examining the effects of specific combinations of changes in tax rates which maintain constant revenue. Thus, consider the case where rates t_i and t_j are changed together in opposite directions. The specific changes in rates for a revenue-neutral change involving an increase in t_i and a reduction in t_j can be obtained using:

$$\left.\frac{dt_i}{dt_j}\right|_R = -\frac{\partial R/\partial t_j}{\partial R/\partial t_i} \tag{6}$$

When rate, i, is increased and rate, j, is reduced to keep total revenue unchanged, the resulting welfare increase from such a revenue-neutral change is:

$$\frac{dW}{dt_i} = \frac{\partial W}{\partial t_i} + \frac{(\partial W/\partial t_j)}{dt_i/dt_j|_R} \tag{7}$$

Table 7: Changes Resulting from Tax Rate Changes

	$\left\|\frac{\Delta R}{\Delta t}\right\|$		$\left\|\frac{\Delta W}{\Delta R}\right\|$		$\left\|\frac{\Delta W}{\Delta t}\right\| = \left\|\frac{\Delta W}{\Delta R}\right\| \left\|\frac{\Delta R}{\Delta t}\right\|$	
	Raise	Lower	Raise	Lower	Raise	Lower
t_1	309.189	317.878	1.379	1.342	426.258	426.567
t_2	454.658	471.683	1.367	1.319	621.535	622.357
t_3	124.984	132.924	1.290	1.214	161.181	161.335
t_4	160.893	158.299	1.153	1.173	185.515	185.652

Consider the case where $\varepsilon = 0.2$, and a 1 percentage point change in tax rate i. The changes in total revenue, $\left|\frac{\Delta R}{\Delta t}\right|$, can be obtained from Table 2. Table 7 shows these changes, $\left|\frac{\Delta R}{\Delta t}\right|$, along with the relevant columns, $\left|\frac{\Delta W}{\Delta R}\right|$ taken from Table 5, the absolute value of $\frac{\Delta W}{\Delta t}$ for increases and decreases of one percentage point in each tax rate.

The top section of Table 8 shows the values of $\left.\frac{dt_i}{dt_j}\right|_R$. For example if an increase in t_4 is combined with a decrease in t_2, then $\left.\frac{dt_4}{dt_2}\right|_R$ =2.932. Finally, the lower section of Table 8 reports the resulting welfare changes from the various combinations. Clearly, the greatest welfare increase is for an increase in t_4 combined with a reduction in t_1, corresponding to the result found from Table 5.

Table 8: Tax Rate and Welfare Changes for Revenue Neutral Combinations of Tax Rate Changes

$$\left.\frac{dt_i}{dt_j}\right|_R = -\frac{\partial R/\partial t_j}{\partial R/\partial t_i}$$

raise\lower	t_1	t_2	t_3	t_4
t_1	0	1.525	0.430	0.512
t_2	0.699	0	0.292	0.348
t_3	2.543	3.774	0	1.267
t_4	1.976	2.932	0.826	0

$$\frac{dW}{dt_i} = \frac{\partial W}{\partial t_i} + \frac{(\partial W/\partial t_j)}{dt_i/dt_j|_R}$$

raise\lower	t_1	t_2	t_3	t_4
t_1	0	-18.302	-50.985	-63.643
t_2	-11.420	0	-69.700	-88.314
t_3	6.539	3.729	0	-14.599
t_4	30.391	26.774	9.767	0

4.4 Additional Income Responses

The extensive literature on the concept of the elasticity of taxable income, ETI, suggests that, in addition to labour supply responses, there may be other taxable income and hence revenue responses to marginal tax rate changes.[17] In some situations it could be possible for some taxable income to be shifted to other, lower-taxed, income sources or simply concealed from the tax authorities. To the extent that such responses do not involve real-resource losses, the main effect relates to revenue rather than welfare changes. This subsection considers whether the results reported above, concerning in particular the top marginal income tax rate, are modified by allowing for an elasticity of taxable income that exceeds responses arising from labour supply changes.

[17] The use of the elasticity of taxable income is complicated by the fact that it is not a fixed parameter in the usual sense, since it depends on the tax structure itself, including, for example, the costs of, and opportunities for, income shifting.

Consider the top tax rate only, and let $\bar{y}$ denote average taxable income of the n individuals above the income threshold, a. The total revenue obtained from the top marginal rate is thus:

$$R = t(\bar{y} - a)n \tag{8}$$

Define $z = (\bar{y} - a)\, n$, so that (8) can be rewritten as $R = tz$ and the change in tax revenue arising from a change in t is, supposing that it does not involve individuals moving to a lower tax bracket:

$$dR = zdt + tdz \tag{9}$$

The first term in (9) is the 'mechanical component', $dM = zdt$, arising from the effect of changing t with an unchanged taxable income, and the second term, $dB = tdz$, is the 'behavioural component' arising from the endogenous income change.[18] The mechanical component can be obtained from TaxWell simply by holding labour supplies fixed. For the top marginal rate increase, this is reported in the lowest block of Table 2, so that $dM = 172.45$. The same table gives the total change, allowing for labour supply variations, as 160.89: hence the behavioural component from labour supply responses alone is given by the difference, $160.89 - 172.45 = -11.56$.

Consider the relevant changes, when starting from the concept of the elasticity of taxable income, defined in terms of the net-of-tax rate, $1 - t$, so that values of η are expected to be positive. By definition:

$$\begin{aligned} \eta_{\bar{y},1-t} &= -\left(\frac{1-t}{t}\right)\eta_{\bar{y},t} \\ &= -\left(\frac{1-t}{t}\right)\frac{d\bar{y}}{\bar{y}}\frac{t}{dt} \\ &= -\left(\frac{1-t}{t}\right)\frac{dz}{n\bar{y}}\frac{t}{dt} \end{aligned} \tag{10}$$

since $dz = nd\bar{y}$, on the assumption, mentioned above, that individuals do not move to a lower tax bracket, so that a and n are constant in (8). Hence re-arranging gives:

$$\frac{tdz}{n\bar{y}dt} = -\left(\frac{t}{1-t}\right)\eta_{\bar{y},1-t} \tag{11}$$

Hence $dB = tdz$ can be written as:

$$dB = -\left(n\bar{y}\right)\left(dt\right)\left(\frac{t}{1-t}\right)\eta_{\bar{y},1-t} \tag{12}$$

[18] For a further decomposition of the behavioural component of revenue changes, and illustrations for New Zealand, see Creedy and Gemmell (2013).

An estimate of the aggregate behavioural change can therefore be obtained for a given value of the elasticity, $\eta_{\bar{y},1-t}$, and information about the total income of those in the top tax bracket. First, IRD data for 2011/2012 shows that a suitable value for $n\bar{y}$, the income of those falling into the top bracket, is \$50,950 million. Hence, with $t = 0.33$ and $dt = 0.01$, substitution in (12) gives:

$$\begin{aligned} dB &= -(50,950)(0.01)(0.5)\eta_{\bar{y},1-t} \\ &= -254.75\eta_{\bar{y},1-t} \end{aligned} \tag{13}$$

The elasticity of taxable income has been notoriously difficult to estimate with precision, but illustrative results can be used to show the sensitivity of the above results to different assumptions about the elasticity.[19] First, consider the elasticity of taxable income that is consistent with labour supply changes being the only form of response in the top tax bracket. Setting dB from (13) equal to the behavioural response of -11.56 reported above for labour supply changes, gives a value of $\eta_{\bar{y},1-t}$ equal to $11.56/254.75 = 0.0454$. Thus a change in which labour supply adjustments give a (negative) behavioural component of about 7 per cent of the mechanical component implies an elasticity of taxable income of only 0.0454.

If, instead, the elasticity of taxable income of those in the top bracket is equal to 0.2, the welfare change associated with a revenue neutral increase in the top rate combined with a reduction in the bottom tax rate falls from 30.391 (as in Table 8 for $\varepsilon = 0.2$) to 22.952: this remains the reform giving the largest increase in the social welfare function. A much higher elasticity of taxable income of 0.5 continues to give the biggest gain (though substantially lower at 8.515) to this marginal reform: this elasticity implies that the behavioural component of the tax change is 74 per cent of the mechanical component.

For $\eta_{\bar{y},1-t} = 0.6$ the behavioural component increases to 89 per cent of the mechanical component, suggesting that the top bracket is almost at the peak of the Laffer curve, and resulting in a welfare gain from an increase in the top rate of 3.703. This compares with the gain of 6.539 from raising the penultimate marginal rate, and lowering the bottom rate, but only if such a rise does not itself lead to strong behavioural changes in addition to labour supply responses.

In summary, it is often recognised that, among higher income earners or top rate income taxpayers, the primary responses to tax rate changes generally do not take the form of changes in hours worked. Rather they may be reflected in harder-to-measure work effort,

[19] An estimate of the former for New Zealand, reported by Carey *et al.* (2015) and based on the 2001 tax changes, is 0.66. In the present context this is seen to imply a very small revenue increase from a 1 percentage point rise in the top tax rate.

income shifting between tax codes, tax evasion etc. The results in this sub-section confirm that the TaxWell generates a relatively low and plausible elasticity of taxable income (around 0.05) as expected, when only labour supply (hours or participation) adjustments are modelled. However, other behavioural responses would have to be relatively large for the TaxWell-generated optimal direction of reform of the top tax rate to be reversed. Some estimates of that elasticity nevertheless suggest it could be quite large, at least as observed in association with the major income tax reform in 2001; see Carey *et al.* (2015).

5 Changes to Income Thresholds

The previous discussion has concentrated on adjustments to income tax rates. However, it is of interest to consider the effects of changes in income thresholds. Clearly, any change in tax thresholds which do not move an individual into a different tax bracket do not affect the marginal rate faced, but there is a change in net income if the threshold is below gross income (since a portion of lower income is taxed at a different rate). Individuals who are moved across thresholds experience changes in both marginal and average rates (at the pre-change gross income level). This section considers the welfare and inequality effects of threshold changes, along with the combination of rate and threshold changes.

5.1 Welfare Effects per Dollar of Revenue Change

Table 9 presents absolute values of marginal welfare changes per dollar of revenue, resulting from changes to the income thresholds of \$1000 used in the income tax schedule, again using values of α of 0.8 and 0.4 for the adult equivalence scale parameter (along with $\theta = 0.6$). The lowest threshold, $a_1 = 0$, as there is no tax-free range, and marginal changes are not considered in this case.

In the case of threshold changes, it is necessary to look for the highest value of $\left|\frac{\Delta W}{\Delta R}\right|$ when thresholds are increased, since this involves welfare gains as some people are moved into a lower-rate bracket. When thresholds are reduced, this involves welfare losses as some people are moved into a higher-rate tax bracket, so it is necessary to look for the lowest value of $\left|\frac{\Delta W}{\Delta R}\right|$. Using money metric utility (shown in the top half of the table), when $\alpha = 0.8$, the low $\varepsilon = 0.1$ implies raising a_4 and reducing a_2. For $\varepsilon = 0.2$ and higher, the optimal policy is to raise a_2 and reduce a_4. These outcomes are unchanged for the higher extent of economies of scale, $\alpha = 0.4$. Higher inequality aversion therefore implies moving more people into the top-rate bracket, and more people into the bottom tax bracket. Only the lower aversion parameter of 0.1 implies moving some people out of the top tax bracket.[20]

Table 9: Values of $\left|\frac{\Delta W}{\Delta R}\right|$ for Income Threshold Changes

	Increase				Decrease			
	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Money Metric Utility								
Scale parameter: $\alpha = 0.8$								
a_2	1.353	1.357	1.287	1.229	1.344	1.349	1.287	1.240
a_3	1.283	1.230	0.852	0.559	1.390	1.334	0.931	0.616
a_4	1.403	1.226	0.946	0.679	1.360	1.284	0.814	0.488
Scale parameter: $\alpha = 0.4$								
a_2	1.784	1.792	1.708	1.610	1.773	1.782	1.709	1.624
a_3	1.762	1.687	1.147	0.706	1.908	1.829	1.254	0.778
a_4	1.918	1.690	1.271	0.865	1.879	1.768	1.099	0.612
Net Income								
Scale parameter: $\alpha = 0.8$								
a_2	1.497	1.489	1.335	1.234	1.440	1.432	1.285	1.190
a_3	1.403	1.343	0.946	0.679	1.640	1.576	1.143	0.848
a_4	1.457	1.369	0.864	0.557	1.557	1.467	0.946	0.632
Scale parameter: $\alpha = 0.4$								
a_2	1.975	1.965	1.771	1.624	1.903	1.894	1.706	1.564
a_3	1.918	1.834	1.271	0.865	2.249	2.159	1.536	1.077
a_4	2.005	1.883	1.164	0.705	2.135	2.010	1.270	0.799

When net income is used as the welfare metric, the implications again differ compared with the use of money metric utility. For the higher inequality aversions of 0.8 and 1.4, and $\alpha = 0.8$, the smallest welfare loss per dollar of revenue arises from reducing the top income threshold, a_4, while the biggest gain arises from raising the threshold a_2. For $\varepsilon = 0.1$ and 0.2 the smallest loss is from reducing a_2, while the biggest gain is also from raising a_2.This means, as with the use of net income when considering marginal rate changes, that it is necessary to examine the largest net gain from all combinations of threshold increases and reductions. In the case of $\varepsilon = 0.1$, the only combination which gives a positive net gain is for raising a_4 while also lowering a_2. For $\varepsilon = 0.2$, the only combination giving a positive net gain involves raising a_2 combined with lowering a_4: this corresponds to the policy arising from the higher inequality aversion parameters.

[20]Instead of changing each threshold in turn, a policy of simultaneously raising all income thresholds by $1k was examined. In each case (that is, for both money metric utility and net income as the welfare metric, and each equivalent adult scale parameter) it was found that the welfare benefit per dollar of revenue reduction was not as high as when a single rate was raised.

Table 10 reports the inequality changes as the thresholds are changed. The top half refers to money metric utility while the lower half reports results for net income. In each case, the values of inequality change are, unsurprisingly, very small due to the small change of \$1,000 in each threshold simulated. Also, comparable to the case of the tax rate reform simulations described above, changes in the lower threshold, a_2, are similar whether net income or money metric utility is used (especially at lower values of ε), while changes in higher thresholds, a_3 and a_4, are relatively larger when based on net incomes. For example, increasing a_3 by \$1,000 increases the Atkinson index by 0.296 (0.180) per cent for $\varepsilon = 0.1$ (0.2), and $\alpha = 0.8$, based on net incomes, but by only 0.045 (0.036) based on money metric utility.

Table 10: Percentage Change in Atkinson's Index and Threshold Changes: Money Metric Utility and Net Income

	Increase				Reduction			
	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$	$\varepsilon = 0.1$	$\varepsilon = 0.2$	$\varepsilon = 0.8$	$\varepsilon = 1.4$
Money Metric Utility								
Scale parameter: $\alpha = 0.8$								
a_2	-0.104	-0.102	-0.073	-0.066	0.110	0.106	0.076	0.071
a_3	0.045	0.036	0.033	0.048	-0.044	-0.035	-0.033	-0.049
a_4	0.010	0.008	0.006	0.007	-0.010	-0.008	-0.006	-0.008
Scale parameter: $\alpha = 0.4$								
a_2	-0.104	-0.101	-0.074	-0.064	0.109	0.105	0.077	0.069
a_3	0.036	0.028	0.031	0.044	-0.035	-0.027	-0.030	-0.045
a_4	0.009	0.007	0.006	0.007	-0.008	-0.007	-0.006	-0.007
Net Income								
Scale parameter: $\alpha = 0.8$								
a_2	-0.105	-0.120	-0.070	-0.040	0.104	0.117	0.067	0.039
a_3	0.296	0.180	0.110	0.160	-0.289	-0.168	-0.101	-0.154
a_4	0.055	0.030	0.020	0.020	-0.056	-0.035	-0.019	-0.024
Scale parameter: $\alpha = 0.4$								
a_2	-0.103	-0.121	-0.074	-0.046	0.099	0.119	0.072	0.045
a_3	0.377	0.197	0.109	0.152	-0.376	-0.190	-0.107	-0.155
a_4	0.068	0.037	0.019	0.023	-0.068	-0.038	-0.019	-0.024

5.2 Rate and Threshold Changes Combined

Using the information provided in Tables 5 and 9, it is possible to extract combinations of rate and threshold changes that give rise to the largest welfare gains per dollar of revenue (for rate reductions and threshold increases) and the smallest welfare losses (for rate increases

Table 11: Values of $\left|\frac{\Delta W}{\Delta R}\right|$ Using Money Metric Utility for Combinations of Rate and Threshold Changes: Alpha = 0.8

	Threshold	Marginal rate
$\varepsilon = 0.1$		
Biggest gain	Raise a_4: 1.403	Reduce t_2: 1.349
Smallest loss	Reduce a_2: 1.344	Raise t_4: 1.262
$\varepsilon = 0.2$		
Biggest gain	Raise a_2: 1.357	Reduce t_1: 1.342
Smallest loss	Reduce a_4: 1.284	Raise t_4: 1.153

and threshold reductions). These are shown in Table 11 for the case where $\alpha = 0.8$. Hence, for the lower inequality aversion of $\varepsilon = 0.1$, the biggest gain arises from raising the income threshold, a_4, and combining this with the smallest loss, obtained by raising the top marginal rate, t_4. This means that some people would be moved out of the top tax bracket into a lower-tax bracket, while those remaining in the top bracket would face a higher rate. By contrast, for higher inequality aversion of $\varepsilon = 0.2$, the biggest welfare improvement arises from combining a rise in the threshold, a_2, (giving the biggest gain) with a rise in the top rate, t_4 (giving the smallest loss). Inequality aversion therefore influences the choice of group to be shifted to a lower-tax bracket.

6 Conclusions

This paper began by questioning whether optimal marginal changes to the structure of the income tax in New Zealand might involve increased tax rate progression, with a higher top marginal rate, or a flattening of the rate structure as suggested by results for Australia. The paper examined welfare-improving reforms using a behavioural tax microsimulation model and a range of assumptions concerning the social welfare, or evaluation, function. In looking for practical advice regarding marginal adjustments to tax parameters, behavioural microsimulation can provide the kind of detail needed, and captures the considerable complexity of actual tax-transfer systems and the large degree of population heterogeneity found in practice.

Welfare changes per dollar of revenue were obtained using additive Paretian welfare functions displaying constant relative inequality aversion. Two alternative welfare metrics were used in the social welfare function. One, for 'welfarist' functions, involves the use of money metric utility per adult equivalent person. The 'non-welfarist' alternative of net income, commonly used for tax policy advice in practice, was also investigated and compared.

It was found that, for a wide range of inequality aversion parameters used for the welfare function, and for different scale economies in adult equivalence parameters, optimal marginal reforms involved increasing the top rate of income tax, and reducing lower rates. It was shown how to combine these changes in a revenue neutral way. Additionally, larger welfare improvements were obtained when changes in income tax rates and thresholds are combined. The model also produced estimates of the behavioural component of revenue changes associated with the reforms simulated. In aggregate, these were shown to vary from around five to fourteen per cent of the mechanical revenue effects of reform, and with substantially larger variation across household types.

Identifying the optimal direction of reform as involving an increase in the degree of marginal rate progression contrasts with results from a similar microsimulation exercise for Australia. However, with a top marginal rate in New Zealand much lower than in Australia, these results may be consistent with optimal directions for reform in each country. Further, results for both countries were obtained from models in which labour supply adjustments are the only behavioural responses. Drawing on the literature on the elasticity of taxable income, which accounts for additional income responses such as tax evasion or avoidance and bargaining over salaries, it was found that these additional responses would have to be particularly large in this case to qualitatively alter results for the top marginal rate.

Finally, making welfare comparisons based on money metric utility rather than net income was shown to be potentially important for policy reform conclusions. For example, the inequality impacts of tax rate changes can appear to be much larger when net income rather than utility is used, highlighting the importance of recognising and calibrating the social welfare impact of changes in leisure time in the evaluation of alternative tax or transfer reforms.

Appendix A: TaxWell-B

The NZ behavioural microsimulation model, TaxWell-B, requires, for each individual in the database, net incomes for a range of work hours before and after a tax and transfer change. These are obtained using the arithmetic model, TaxWell-A, containing the details of the social security and personal tax system. Both models utilise the Household Economic Survey, a cross-sectional survey collected by Statistics New Zealand. This records, for each individual, income from current jobs and other non-wage income such as interest and dividends.

Given information about an individual's wage rate and a wide range of characteristics, it is possible to determine net income for each of a range of discrete hours levels. For those not working at the time of the survey, a wage rate is imputed, based on econometric estimates of wage functions for a range of demographic groups. Wage equations and preference functions were estimated separately for married men, married women, single men, single women and sole parents using pooled HES data from 2006/07 to 2010/11; see Mercante and Mok (2014a, 2014b).

Labour supply is based on a structural model where individuals are assumed to be able to work at only a number of discrete hours levels, rather than being able to vary hours of work continuously. Individuals are assumed to choose a combination of leisure and income to maximise utility. Preferences are assumed to have a deterministic component which is quadratic in work hours and net income, and where parameters vary depending on a range of characteristics. Utility is quadratic in net income and hours of work. The parameters are themselves specified as functions of a range of individual characteristics. Hours of work contribute negatively, while net income contributes positively to utility. The quadratic is extended to allow for households consisting of couples, where both partners simultaneously determine labour supply, by assuming that the couple maximises a single utility function; this is a reasonable assumption for households where the members pool their incomes. The joint labour supply of couples is estimated simultaneously, unlike a common approach in which female labour supply is estimated with the spouse's labour supply taken as exogenous.

A random utility component, from a Type-I extreme-value distribution, is added to the deterministic component, for example, to capture optimisation errors. This means that the model does not produce a single deterministic hours level for each individual following a change to the tax and transfer system. Each discrete hours level is associated with a probability for each person. The discrete hours approach has substantial advantages over the continuous hours model, in allowing the full details of the tax structure to be modelled and overcoming the endogeneity problem that would otherwise be raised by the fact that both the hours worked and the marginal tax rate faced are jointly determined when there are piecewise linear budget constraints.

Single men and women, sole parents and married women have working hours choices of 0, 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 hours of work. Married men have hours choices of 0, 10, 20, 30, 40 and 50 hours of work. Hence, couples have a total of 66 working-hour choices. For couples, the female hours distribution therefore covers a wider range of part-time and full-time hours than the male distribution.

In calculating net incomes, Taxwell-A assumes a take-up rate for welfare benefits and tax credits of 100 per cent, for both tax systems examined. This may lead to some overestimation of expenditure on the different payments in both pre- and post-reform. The simulated changes reported here are not expected to be biased as the policy changes did not expand eligibility to a large extent. All persons for whom labour supply is modelled, except sole parents, are potentially eligible for Unemployment Benefits. Sole parents are eligible for Domestic Purpose Benefit. The income-test rules are then applied to calculate actual benefit levels. The simulations presented below are based on the tax and transfer structure of New Zealand for the year 2008.

A policy simulation involves comparing the observed hours level of each individual in the base HES sample, facing the pre-reform tax and transfer structure, with the (conditional) expected value of hours for the individual obtained after the reform is imposed. It is important to ensure that the observed hours in the pre-reform case can be regarded as an optimal position for each individual. Hence, a 'calibration' process is used to select a large number of sets of random draws from the distribution of the stochastic component of utility which are used for post-reform computations. Briefly, this process is as follows, and for a detailed introduction to discrete hours modelling and the calibration approach in microsimulation, see Creedy and Kalb (2005).

The behavioural simulation procedure for each individual or couple begins by converting the observed working hours to the closest discrete level. Then, given the parameter estimates of the preference functions (which allow for observed heterogeneity), the deterministic components of utility for each hours level are calculated for the net incomes generated by the pre-reform tax and transfer system. A set of random draws, one for each discrete hours level, is then taken from the Type-I extreme value distribution. For each hours level, the total value of utility is determined by adding a random draw to the deterministic component of utility. The hours level giving maximum total utility can then be obtained for that set of random draws. The sets for which observed hours are equal to optimum hours in the pre-reform situation are retained and used to determine the conditional distribution of optimal hours levels after the reform for each individual. To obtain sufficient information regarding the post-reform hours distribution over the discrete hours levels for each individual, 100 such sets of draws are used in the simulations. The calibration approach also ensures that the results before the reform are comparable between TaxWell-A and TaxWell-B.

For the post-reform analysis, the new net incomes cause the deterministic component of utility at each hours level to change. Using the 100 sets of draws retained for each individual from the calibration procedure, a distribution of optimal hours of work is determined. This is essentially a conditional probability distribution over the set of discrete hours for each individual under the post-reform policy. Post-reform labour supply is obtained as the expected value of hours of labour supply after the change, conditional on starting from the observed hours before the change.

In some cases, the required number of successful random draws producing pre-reform observed hours as the optimal hours cannot be generated within the designated number of drawings. Under such circumstances, the individual's labour supply is held fixed at their observed hours. However, this problem arises for very few individuals in the sample.

Appendix B: Aggregate Effects: Reductions in Rates and Thresholds

Table 12: Threshold Reductions of 1000 Dollars

	Couples	*Single men*	*Single women*	*Sole parents*	*All*
Decrease 2nd threshold					
Net government revenue change (LS fixed)	114.25	24.45	24.47	4.04	167.21
Net government revenue change (incl. LS)	107.33	23.84	19.57	1.58	152.32
Average hours change in hours per week	-0.01,-0.01	0.00	-0.02	-0.03	-0.01
Equivalent variation	114.23	24.45	24.46	4.04	167.17
Marginal Welfare Cost	0.06	0.03	0.25	1.55	0.10
Aggregate net income change	-122.41	-25.15	-26.70	-5.38	-179.65
Diff b/w net income change and EV (%)	6.68	2.79	8.41	25.00	6.94
Decrease 3rd threshold					
Net government revenue change (LS fixed)	88.46	12.34	10.13	2.67	113.60
Net government revenue change (incl. LS)	78.31	11.44	9.00	1.22	99.98
Average hours change in hours per week	-0.01,-0.01	0.00	-0.01	-0.01	-0.01
Equivalent variation	88.42	12.34	10.12	2.66	113.54
Marginal Welfare Cost	0.13	0.08	0.12	1.18	0.14
Aggregate net income change	-104.75	-13.91	-11.77	-3.42	-133.86
Diff b/w net income change and EV (%)	15.59	11.33	14.08	22.23	15.18
Decrease 4th threshold					
Net government revenue change (LS fixed)	10.13	1.35	1.15	0.27	12.90
Net government revenue change (incl. LS)	8.94	1.29	0.90	0.33	11.47
Average hours change in hours per week	0.00,0.00	0.00	0.00	0.00	0.00
Equivalent variation	10.13	1.35	1.15	0.27	12.89
Marginal Welfare Cost	0.13	0.04	0.28	-0.19	0.12
Aggregate net income change	-11.73	-1.46	-1.65	-0.11	-14.95
Diff b/w net income change and EV (%)	13.67	7.38	30.36	-135.85	13.77

Table 13: Marginal Tax Rate Reductions of One Percentage Point

	Couples	*Single men*	*Single women*	*Sole parents*	*All*
Decrease in 1st tax rate					
Net government revenue change (LS fixed)	-236.05	-50.55	-50.76	-7.29	-344.65
Net government revenue change (incl. LS)	-226.33	-49.34	-42.38	0.17	-317.88
Average hours change in hours per week	0.01,0.02	0.01	0.05	0.10	0.02
Equivalent variation	-236.10	-50.55	-50.79	-7.33	-344.76
Marginal Welfare Cost	-0.04	-0.02	-0.20	-	-0.08
Aggregate net income change	255.42	51.96	55.77	12.05	375.20
Diff b/w net income change and EV (%)	7.57	2.72	8.92	39.17	8.11
Decrease in 2nd tax rate					
Net government revenue change (LS fixed)	-370.88	-72.55	-61.89	-15.10	-520.42
Net government revenue change (incl. LS)	-348.46	-68.99	-50.84	-3.40	-471.68
Average hours change in hours per week	0.02,0.05	0.02	0.08	0.18	0.05
Equivalent variation	-371.03	-72.55	-61.94	-15.18	-520.71
Marginal Welfare Cost	-0.06	-0.05	-0.22	-3.47	-0.10
Aggregate net income change	418.54	77.73	76.92	25.38	598.56
Diff b/w net income change and EV (%)	11.35	6.66	19.47	40.18	13.01
Decrease in 3rd tax rate					
Net government revenue change (LS fixed)	-108.96	-15.15	-12.19	-3.04	-139.33
Net government revenue change (incl. LS)	-105.55	-14.46	-11.04	-1.88	-132.92
Average hours change in hours per week	0.00,0.00	0.00	0.01	0.01	0.00
Equivalent variation	-108.98	-15.15	-12.20	-3.04	-139.37
Marginal Welfare Cost	-0.03	-0.05	-0.11	-0.62	-0.05
Aggregate net income change	115.69	16.40	15.32	4.00	151.41
Diff b/w net income change and EV (%)	5.80	7.63	20.39	23.86	7.95
Decrease in 4th tax rate					
Net government revenue change (LS fixed)	-132.53	-26.33	-10.82	-2.77	-172.45
Net government revenue change (incl. LS)	-121.10	-25.59	-9.49	-2.11	-158.30
Average hours change in hours per week	0.01,0.00	0.00	0.00	0.01	0.00
Equivalent variation	-132.63	-26.34	-10.82	-2.77	-172.56
Marginal Welfare Cost	-0.10	-0.03	-0.14	-0.31	-0.09
Aggregate net income change	154.70	27.91	13.45	3.73	199.79
Diff b/w net income change and EV (%)	14.26	5.64	19.55	25.80	13.63

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