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**Working Paper**

## Inequality in New Zealand 1983/84 to 2013/14

New Zealand Treasury Working Paper, No. 15/06

**Provided in Cooperation with:**

The Treasury, New Zealand Government

*Suggested Citation:* Ball, Christopher; Creedy, John (2015) : Inequality in New Zealand 1983/84 to 2013/14, New Zealand Treasury Working Paper, No. 15/06, ISBN 978-0-478-43658-7, New Zealand Government, The Treasury, Wellington

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<https://hdl.handle.net/10419/205684>

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# Inequality in New Zealand 1983/84 to 2013/14

Christopher Ball and John Creedy

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New Zealand Treasury Working Paper 15/06

June 2015

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NZ TREASURY  
WORKING PAPER  
15/06

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Inequality in New Zealand 1983/84 to 2013/14

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MONTH/YEAR

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June 2015

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ISBN (ONLINE)

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978-0-478-43658-7

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URL

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Treasury website at June 2015:  
<http://www.treasury.govt.nz/publications/research-policy/wp/2015/15-06/twp15-06.pdf>  
Persistent URL: <http://purl.oclc.org/nzt/p-1761>

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ACKNOWLEDGEMENTS

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We are grateful to colleagues for comments during a Treasury seminar, and Polly Vowles, Kristie Carter and Nicolas Herault for comments on an earlier draft.

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Access to data used in this paper was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the Statistics Act 1975. The graphs presented in this report are the work of staff at the New Zealand Treasury and not Statistics New Zealand.

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# Abstract

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This paper provides an empirical analysis of annual income and expenditure inequality in New Zealand over a thirty-year period from the early 1980s. The extent of redistribution through the tax and benefit system is also explored. *Household Economic Survey* data are used for each year from 1983/84 to 1997/98 inclusive, 2000/01 and 2003/04 , and for each year from 2006/07. Survey calibration methods are used to examine income and expenditure inequality on the assumption that a range of (approximately 50) population characteristics remain constant over the period. Furthermore, decomposition methods are used to examine the separate contributions to changing inequality of population ageing, changes in labour force participation and household structure.

**JEL Classification:** H23; H24; I3

**Keywords:** Income Inequality; Calibration Weighting; Decomposition

# Executive Summary

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This paper provides an empirical analysis of annual income and expenditure inequality in New Zealand over a thirty-year period from the early 1980s. The data are obtained from *Household Economic Survey* (HES) data for each year from 1983/84 to 1997/98 inclusive, and for each year from 2006/07.

The extent of redistribution through the tax and benefit system is also explored. The emphasis is on income measures, and no allowance is made for leisure or for other changes, such as the introduction of new goods or changes in the quality of goods and services over time, which may contribute to wellbeing. The aim is to provide a more detailed description of changing inequality over time and its components. The paper also demonstrates the difficulty of attributing precise causes to the distributional changes.

Sample weights are needed to produce population-level results from the survey data. The analysis used survey calibration methods to obtain consistent weights, by imposing independently obtained population totals for 47 population characteristics, covering demographic and labour force information for each year. Results were compared with the use of the HES weights provided by Statistics New Zealand, which are based on calibration using a much more limited set of population totals.

The results indicate an increase in the inequality of market and disposable income per adult equivalent person (using the individual as the unit of analysis) from the late 1980s to the early 1990s. Subsequently, inequality has – with some variability – remained either constant or has fallen slightly.

Comparisons with tax policy changes over the period suggest that some of the variability (particularly around the 2001 and 2010 policy changes) may be attributed to income shifting between time periods in anticipation of changes in the income tax structure.

The use of survey calibration methods makes it possible to examine changes in inequality using the ‘as if’ assumption that the structure of the population (as described by the 47 calibration totals) remains constant over the period. The variation in inequality can then be attributed to changes in the nature of the sample rather than those features of population and labour force structure that are held constant.

With the weights adjusted to ensure that the calibration totals remain constant

over time, the profiles of income inequality display different absolute values and somewhat different patterns, being higher in the earlier years when the calibration values for later years were used. Furthermore, with a constant demographic and labour force structure, the inequality of expenditure, though subject to year-to-year variations, displayed a 'flatter' profile over the period.

The paper also examines the contribution to changing inequality of particular components of the demographic and labour force change. A decomposition method was used involving five sets of variables (age/gender structure, labour force participation, household type, housing tenure type, and occupancy rate) along with the sample itself. To analyse the effects of these six components involved the use of 720 separate decompositions for each inequality change considered: arithmetic mean contributions to the overall inequality change were thus reported. The five 'non sample' variables were found to make a larger contribution to changes in the Gini measure of market income, though for disposable incomes those components were found to be relatively small, except in the cases where the Gini changed by very little or decreased.

Although it has been possible to examine the substantial differences between the distributions of market and disposable incomes in each year, reflecting the redistributive role of taxes and transfers, it has not been possible to isolate the role of changes in the tax structure from a range of other sample characteristics which may be expected to influence the distribution of income. Interesting questions about the precise causes of those changes remain a challenge for future research.

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# Inequality in New Zealand 1983/84 to 2013/14

## 1 Introduction

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This paper provides an empirical analysis of annual income and expenditure inequality in New Zealand over a thirty-year period from the early 1980s. The extent of redistribution through the tax and benefit system is also explored. However, in constructing welfare metrics, no allowance is made for leisure or for other changes, such as the introduction of new goods or changes in the quality of goods and services over time, which may contribute to wellbeing. The present paper uses *Household Economic Survey* data for each year from 1983/84 to 1997/98 inclusive, and for each year from 2006/07. Statistics New Zealand did not carry out annual surveys from 1998 to 2006, so that comparable information for 2000/01 and 2003/04 only are available during this period.

Access to these datasets, providing considerable information about the circumstances of individuals and families, has been extremely limited. Hence, despite the large amount of interest in inequality in recent policy debates, few studies are available allowing for consistent comparisons. The main analyses of redistribution, fiscal incidence and inequality have been carried out within government departments.<sup>1</sup> Extensive summary information regarding income inequality in New Zealand over a long period has been provided by the Ministry of Social Development: in particular, see the extensive report by Perry (2014), who comments (2014, p. 17) that, ‘The two distinctive features of the trend in income inequality in New Zealand in the last three decades are: the rapid and significant rise in income inequality from the late 1980s to the mid 1990s, taking New Zealand from well under the OECD average to well above at that time and; the fairly flat trend line

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<sup>1</sup> In particular, see Statistics New Zealand (1999). The New Zealand Treasury carries out regular fiscal incidence studies. An earlier description within the Department of Labour is Dixon (1996). Summary results for disposable incomes selected years (1981/82, 1985/86 and 1989/90) using the Jensen (1988) scales are reported in Saunders (1994). Decompositions by income source for 1983/84, 1991/92 and 1995/95, using gross (pre tax) incomes are reported by Podder and Chatterjee (2002), using household income per person as the income measure, with individual as unit of analysis. The selection of years gives a misleading picture of the inequality changes over the 1980s, as seen below. They incorrectly argue (2002, p. 11) that the ‘appropriate weight must be the number of members in the family’. However, on the choice of unit of analysis, see Glewe (1991), Decoster and Ooghe (2003), Shorrocks (2004) and Creedy and Scutella (2005).

from the mid 1990s to 2013'.<sup>2</sup>

One potential difficulty with estimates of inequality during the earlier years is that Statistics New Zealand did not supply population weights for each individual and household. Such weights are now routinely used with surveys and help to provide more reliable population aggregates based on the sample data. This would not matter if the weights that were subsequently used after 1987 are fairly uniform across households. However, there is considerable variation, reflecting the use of differential sampling and an allowance for systematic differences in response patterns. The present study uses calibration methods to obtain weights for the earlier years. In addition, where weights for later years are provided by Statistics New Zealand, these are revised using a consistent set of calibration totals. It is thus possible to investigate the effects on measured inequality of using different weights. The calibration totals are obtained from independent information about a range of population aggregates.<sup>3</sup>

Reference to sample survey weights leads to a further question investigated here. Comparisons of inequality measures over time generally show annual inequality where each year's value is obtained independently. However, attitudes towards changes in inequality are likely to depend on perceived reasons for the change. Inequality may change as a result of deliberate government policy, involving for example changes to income taxation and welfare benefits. Measured inequality may also be affected by a wide range of other population changes which may not be closely related to policy variables. They may reinforce or work against policy aims, making ex post evaluation of the efficacy of policies difficult. Such changes may include, for example, changes in the age distribution of the population, resulting from the demographic transition towards an older age structure, changes in the structure of households, along with changing patterns of labour force participation. A major contribution of the present paper is an attempt to disentangle the contribution of such changes to overall inequality changes. The type of question considered is thus: to what extent can the observed change in inequality over the period be attributed to the changing structure of households over time?

An analysis of this kind is subject to limitations. First, it is not possible, when dealing with a thirty-year period involving substantial changes to the surveys as well as the benefit system, to apply the full administrative details of the tax and

<sup>2</sup> The word 'significant' in the quote above does not refer to statistical significance. The income concept is a measure of household disposable income per adult equivalent (using the square root of the number of individuals in the household as the measure of size) and the unit of analysis is the individual.

<sup>3</sup> For a description of the integrated weighting used by Statistics New Zealand, see Statistics New Zealand (2001).

benefit system of one year to a sample survey of another year.<sup>4</sup> This means that the precise role of the tax structure cannot be isolated from other uncalibrated changes (such as changes in the occupational structure, the nature of age-income profiles and differential wage growth).

Second, it must also be acknowledged that tax and benefit changes may themselves lead to changes that are effectively being treated here as exogenous. For example, to attribute a component of the observed change in inequality to changes in fertility patterns, or changes in the structure of households (such as the growth of single-parent households), neglects the possibility that such demographic changes may themselves have been partly influenced by changes in government tax and benefit policies. While reference may not therefore strictly be made to 'ultimate causes', since not all changes are truly exogenous, it is nevertheless useful to be able to isolate a number of crucial components.<sup>5</sup> Such results can usefully also point to the need for further investigations of a different kind.

Section 2 briefly describes the welfare metrics and unit of analysis for which results are reported here. The changes over time were explored using a variety of inequality measures, welfare metrics and income units. Space limitations prevent a wide range of results being reported, and results are presented using Gini measures of income per adult equivalent person, with the individual as unit of analysis. Extensive additional results have been obtained as described in Appendix A. Although some year-to-year variations differ, the main comparisons over the period are not substantially affected by the choice of metric, unit or inequality measure. Section 3 reports basic results regarding the inequality of market and disposable income per adult equivalent person using the Gini inequality measure. The inequality measure is directly associated with an explicit statement of value judgements summarised in a so-called 'social welfare function' (an evaluation function representing the values of an independent judge). Section 3 therefore also examines variations in 'social welfare' over time and its decomposition into changes in arithmetic mean income and equality (defined as one minus the inequality measure).

Section 4 illustrates major changes in the population structure that took place over the period investigated. This motivates the examination in Section 5 of changing inequality over time, under the assumption of an unchanged population structure, defined by almost fifty demographic and labour force characteristics. Section

<sup>4</sup> However, this can be done for more recent selected years; see for example Creedy and Eedrah (2015).

<sup>5</sup> Of course, the recognition that, for particular purposes, a variable is being treated as exogenous is extremely common in both empirical and theoretical economic analyses. In any analysis of redistribution, it must be recognised that the pre-tax distribution is not itself exogenous.

6 attempts to disentangle the contributions to changing inequality of particular components of population change. Conclusions are in Section 7.

## 2 Welfare Metric and Unit of Analysis

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In any analysis of inequality, important questions concern the nature of the sample, the welfare metric and the unit of analysis.<sup>6</sup> Results were computed for a range of alternatives, as discussed in Appendix A. However, for presentation purposes, concentration here is on the analysis of household income per adult equivalent person, both before income tax and transfers (referred to as market income) and after tax and cash transfers (referred to as disposable income). In some cases, results are also shown for expenditure. The unit of analysis is the individual. This implies an equal sharing of income per adult equivalent person. In all cases the accounting period is the year.

The adult equivalence scale used is a two-parameter scale, allowing simply for a weight attached to children and economies of scale, as follows. Let  $n_a$  and  $n_c$  denote respectively the number of adults and children in the household, and let  $m$  denote the adult equivalent size of the household. Then:

$$m = (n_a + \theta n_c)^\alpha \quad (1)$$

where  $\theta$  and  $\alpha$  are parameters reflecting the relative 'cost' of a child and economies of scale respectively.<sup>7</sup> An advantage of this form is that it allows sensitivity analyses to be carried out easily, where the parameters have clear interpretations. Benchmark values of  $\theta = 0.5$  and  $\alpha = 0.8$  are used for adult equivalent scales.

Emphasis is given below to results for the standard Gini inequality measure although, as mentioned in Appendix A, alternative measures were also obtained.

## 3 Inequality over Thirty Years

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This section presents the main empirical results regarding measured inequality over the thirty year period. In each case the income measure is of total household

<sup>6</sup> For further discussion of the range of alternatives, see Creedy (2013) and Creedy and Eedrah (2014).

<sup>7</sup> This form was introduced by Cutler and Katz (1992) and investigated by, for example, Banks and Johnson (1994) and Jenkins and Cowell (1994). Creedy and Sleeman (2005) found that, despite its simplicity, it provided a close fit to 29 alternative sets of equivalence scales.

income or expenditure per adult equivalent person, using the two-parameter scale described in the previous section, and using the individual as the unit of analysis.

### 3.1 Gini Measures for Alternative Distributions

The Gini coefficients from 1984 to 2013 are shown in Figures 1 and 2, respectively for market income and disposable income. In viewing these and subsequent diagrams, it is worth keeping in mind that the vertical scales vary: to maintain a common vertical scale would involve losing important information. Furthermore, each diagram shows two profiles. The solid line uses the sample weights provided by Statistics New Zealand: before 1987 these were the same for all sample individuals but afterwards the weights ensure that the grossed-up population age and gender distributions match independently obtained demographic data. The dashed profile marked 'calibrated weights' represents Gini values using, for each year, a new set of sample weights. The weights were obtained using a total of 47 calibration values: that is, the population aggregates obtained from grossed-up sample values match independently obtained aggregates for 47 variables. These cover the age and gender distributions, labour force participation by age and gender, household type, number of individuals per household and housing tenure. It is not possible to include calibration values based on benefit totals, such as the number of individuals or households receiving a range of social benefit payments.<sup>8</sup>

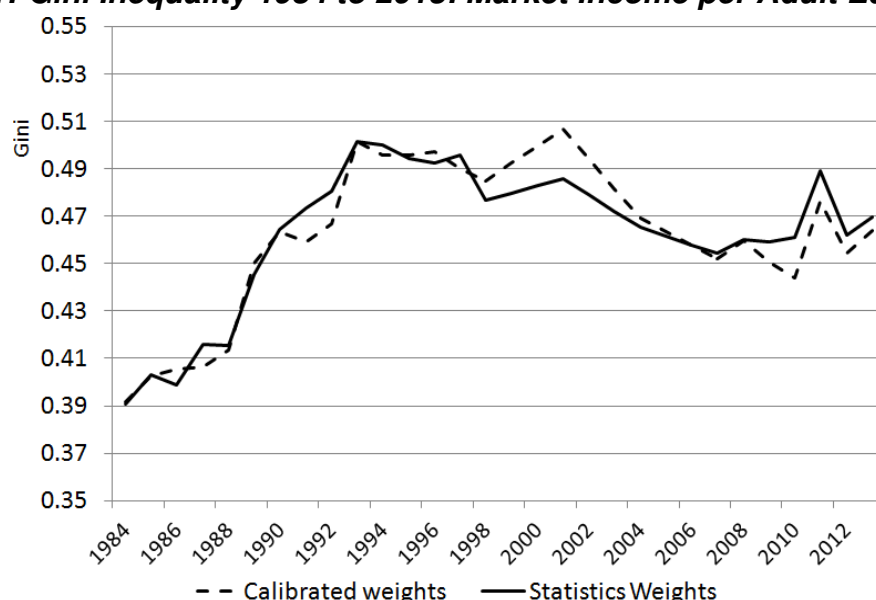
For market incomes per adult equivalent, the main differences are a somewhat higher Gini value for the calibrated weights in 2001, and a slightly more rapid subsequent decline, along with a slightly lower value in the early 1990s compared with the use of Statistics New Zealand weights. The Gini values of disposable income are generally slightly higher when using Statistics New Zealand weights rather than the calibrated weights (except for 2001).<sup>9</sup> Further investigation of the year for which the two sets of weights give the greatest difference showed that in 2001 the calibration weights increased for a substantial number of households with high incomes (over \$150,000). Although it is hard to identify causes of this temporary increase, this is discussed further below.

<sup>8</sup> In Sections 5 and 6 below, sample weights are obtained for each year using the calibration totals for all other years. This is straightforward for aggregates such as the number of people in an age and gender group, but the nature of benefits changes over time. New benefits are introduced, while others are abolished, while the regulations regarding benefit status and eligibility can change in significant ways over time.

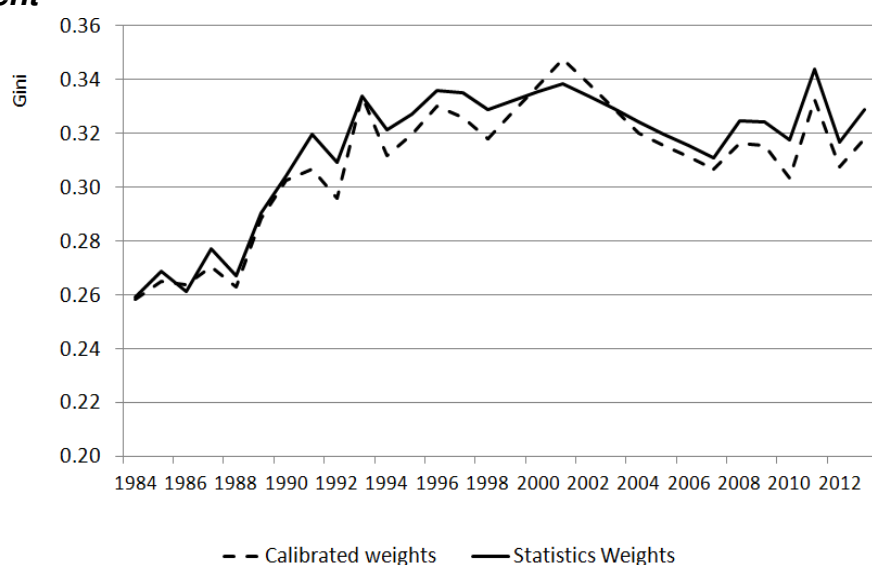
<sup>9</sup> The distributions of market income per adult equivalent obviously have a number of zero observations. Negative values were excluded, since the Gini is defined only for non-negative incomes. Zero and negative values of disposable incomes were excluded. These deletions involved a very small number of households.

Nevertheless the general patterns are broadly similar. The Gini measure of market incomes saw a steady rise through the second half of the 1980s to the early 1990s, from about 0.4 to around 0.5. Subsequently there has been a steady though less marked decline, with the exception of ‘spikes’ around 2001 and 2011. For disposable incomes, the systematic increase in the Gini measure does not appear to have started until the late 1980s, rising from about 0.27 to about 0.33 in the mid-1990s. The profile displays some variability subsequently, although generally it has been declining slightly. Comparisons with previous reported results are made in Appendix B. Interpreting these changes in a summary measure is not straightforward; see Creedy (2015) for further discussion. The implied ‘trade off’ between ‘equity and efficiency’ when using the Gini measure is discussed below.

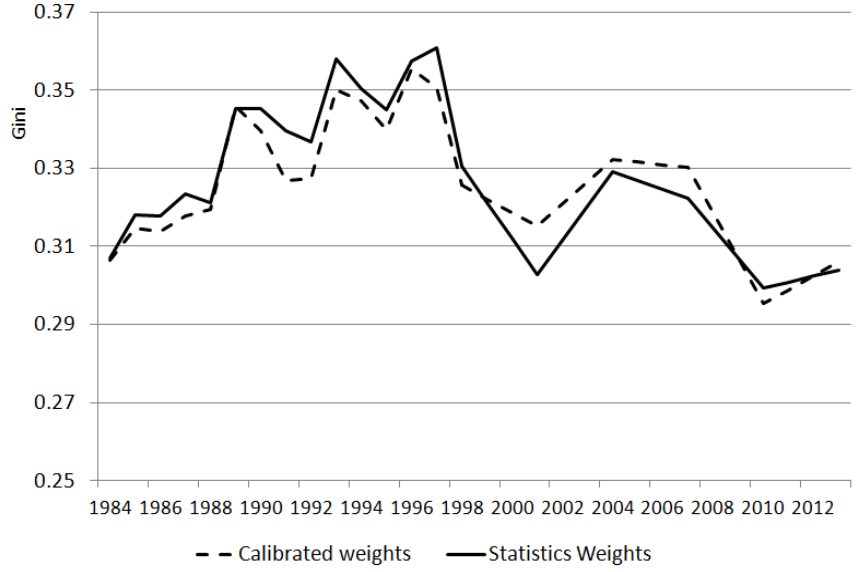
**Figure 1: Gini Inequality 1984 to 2013: Market Income per Adult Equivalent**



**Figure 2: Gini Inequality 1984 to 2013: Disposable Income per Adult Equivalent**



**Figure 3: Gini Inequality 1984 to 2013: Expenditure**



The income inequality profiles may be compared with Gini values of expenditure inequality, shown in Figure 3. In this case, the general movement is one of increasing inequality from 1984 until the mid-1990s, followed by declining inequality. Unlike the cases of market and disposable incomes, the Gini inequality of consumption had, by 2010, returned to being slightly less than the 1984 value. Generally the inequality of consumption is higher than that of disposable income until the late 1990s, after which the two are similar. This result contrasts with some other studies which find that inequality of expenditure is less than that of disposable income, and this is attributed to some form of consumption smoothing (whereby lower-income households have a higher tendency to dissave, while higher-income households save). However, the comparison is not unequivocal.

For simplicity, let  $s_i$ ,  $y_i$  and  $c_i$  denote  $i$ 's savings, disposable income and consumption respectively in a given period. Let  $u_i$  be an independently distributed random term. Suppose:

$$s_i = -a + by_i + u_i \quad (2)$$

Then:

$$c_i = (1 - b)y_i + a - u_i \quad (3)$$

Taking variances gives:

$$\sigma_c^2 = \sigma_u^2 + (1 - b)^2 \sigma_y^2 \quad (4)$$

The variance of consumption is higher than that of disposable income, such that  $\sigma_c^2 > \sigma_y^2$ , if:

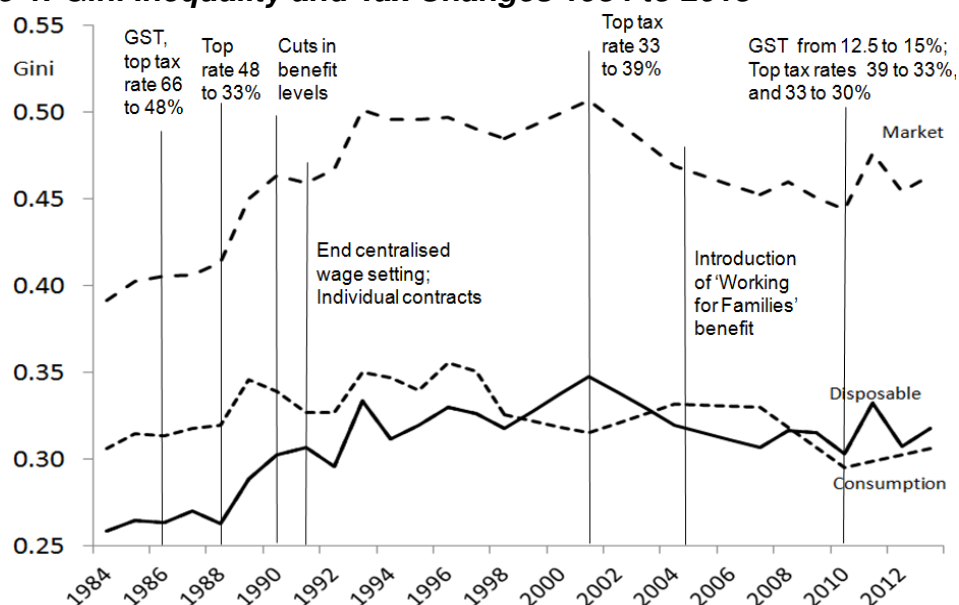
$$1 - (1 - b)^2 < \frac{\sigma_u^2}{\sigma_y^2} \quad (5)$$

Hence, although (2) suggests a tendency for savings to be positively related to disposable income, consumption inequality can exceed that of disposable income



if the variance of the random term is sufficiently high in relation to that of disposable income. Regressions of (2) were carried out for each year over the period. While the estimates of  $b$  were positive, the estimated values of  $\sigma_u^2$  were found to be from 1.2 to 2.5 times the variance of disposable income,  $\sigma_y^2$ , until the late 1990s when the ratio dropped to around 0.5. Yet the left hand side of (5) was generally around 0.3 to 0.6 during the 1980s and 1990s, after which it rose to around 0.8. Hence some form of consumption smoothing is indeed consistent with the inequality of expenditure exceeding that of disposable income, as a result of the high dispersion of  $u_i$ .

**Figure 4: Gini Inequality and Tax Changes 1984 to 2013**



It is of interest to consider the tax changes made over the period in relation to the inequality profiles.<sup>10</sup> Figure 4 places the three Gini profiles (market and disposable income, and consumption, per adult equivalent person) on the same graph, along with the dates of significant policy changes. It appears that the 1980s reforms – involving cuts in the top income tax rate along with benefit cuts and the ending of centralised wage setting – are associated with increasing inequality. The spikes in the market and disposable income profiles from 2000 may also be associated with changes in top income tax rates. In the first case (an increase from 33 to 39 per cent), the anticipation of the rate increase could have led to a certain amount of income shifting into the year before the increase. Much of the shifting is likely to have been by those in higher-income groups, and hence this contributes to the sudden increase in inequality, followed by a reduction. In the case of the 2010 reduction in the top rate, the opposite incentive effect operated. For direct evidence of the extent of income shifting in anticipation of the tax changes, see Claus *et al.* (2012). To the extent that high-income earners were able to delay income receipt

<sup>10</sup> For discussion of the policy changes during the 1980s and early 1990s, see Evans *et al.* (1996).



until after the tax reduction took effect, this would contribute to a dip in inequality followed by an increase in the Gini value immediately after the fall in the top rate. Some of the variability during the 2000s may thus perhaps be attributed to income shifting over time resulting from anticipated income tax changes.

## 3.2 Inequality and ‘Social Welfare’

The Gini inequality measure is associated with particular value judgements of an independent, disinterested judge. The judge is regarded as evaluating alternative distributions using an evaluation function, in terms of the individual incomes (or welfare metrics), that reflects views about ‘equity and efficiency’. This evaluation is usually referred to as a ‘social welfare function’, though of course care needs to be taken in using this term because it does not measure what many people may understand by the term ‘social welfare’. For the Gini measure this function takes the form of a weighted sum of incomes, where weights depend on the reverse rank order, with incomes ranked from lowest to highest. Thus the lowest income is given a weight of  $n$  (the number of people in the population) and the highest income is given a weight of 1.<sup>11</sup> The inequality measure is one of the class of measures defined in terms of the proportion difference between the arithmetic mean and the ‘equally distributed equivalent’ value, where the latter is that income which, if obtained by everyone, would give the same ‘social welfare’ as the actual distribution.<sup>12</sup> Importantly, the social welfare function,  $W$ , can be expressed in terms of the arithmetic mean and inequality as:

$$W = \bar{y}(1 - G) \quad (6)$$

where  $G$  denotes the Gini measure and  $\bar{y}$  is arithmetic mean.<sup>13</sup> This clearly shows the trade-off between equity (measured by  $1 - G$ ) and efficiency (reflected in  $\bar{y}$ ) made by a judge relying on the Gini inequality measure.

Figure 5 shows the profile of (6) along with the Gini measure of disposable income per adult equivalent person (with individual as unit). In calculating  $W$ , the real value of the arithmetic mean,  $\bar{y}$ , has been adjusted by dividing by its 1984 value.

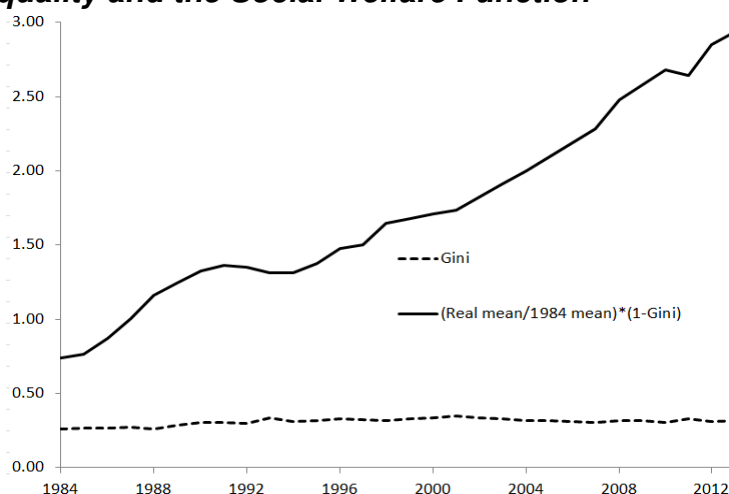
<sup>11</sup> These welfare weights are of course quite distinct from the sample weights used to obtain population values from the sample, and those used to deal with the unit of analysis.

<sup>12</sup> The Gini evaluation function is therefore not individualistic: each individual’s contribution to ‘social welfare’ depends on his or her position in the distribution. The Atkinson inequality measure takes a similar form, in terms of the proportional difference between an equally distributed equivalent value and the arithmetic mean, but with the income values weighted using  $x^{1-\varepsilon}/(1-\varepsilon)$ , for  $\varepsilon \neq 1$ , and  $\varepsilon$  is referred to as reflecting relative inequality aversion. In this case the equally distributed equivalent income is a power mean of order  $1 - \varepsilon$ .

<sup>13</sup> This is often referred to as the ‘abbreviated welfare function’, compared with the welfare function expressed in terms of individual values.

The positive growth in incomes during the late 1980s ensured that  $W$  rose over the period. However the post 1991 recession caused  $W$  to fall briefly. The small ‘dip’ around 2010 is associated with the temporary increase in the Gini measure and the anticipation effects of tax rate reductions, discussed above

**Figure 5: Inequality and the Social Welfare Function**



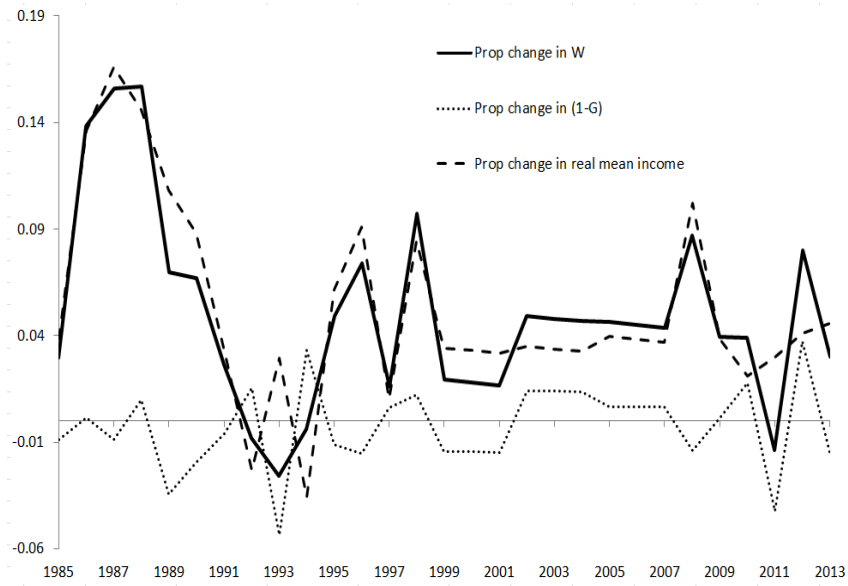
A clearer idea of the contributions of growth and changing inequality may be obtained by decomposing the changes in  $W$ , using:

$$\frac{dW}{W} = \frac{d\bar{y}}{\bar{y}} + \frac{d(1-G)}{1-G} \quad (7)$$

The change in  $W$ , along with the two components of the change in mean income and of equity, is shown in Figure 6. The positive growth of  $W$  from the middle 1980s until 1992 to 1994 is clearly closely associated with growth in  $\bar{y}$ , despite the reduction in equity,  $1 - G$ , in the late 1980s. The direction of change in  $W$  has clearly been dominated by the changes in  $\bar{y}$ , except for the short period around 1992 and 2010, when inequality increased temporarily. Judges whose values are similar to those reflected in the use of the Gini inequality measure would clearly regard the reduction in equity in the late 1980s, following the period of reforms, as being more than compensated by the associated positive growth in real incomes over the period.

The hypothetical independent judge is regarded simply as having an evaluation function which has an explicit trade-off between aggregate income and its inequality, where growth and equity are both regarded as desirable. There is, for example, no suggestion that increasing inequality is required for growth, or that growth necessarily involves increasing inequality. The judge is simply evaluating outcomes. Indeed, figure 7 shows the elasticity of equity,  $1 - G$ , with respect to arithmetic mean disposable income per adult equivalent person,  $\bar{y}$ . Positive values therefore imply that equity and mean income moved in the same direction, so that

**Figure 6: Components of Changes in Social Welfare Evaluation**



**Figure 7: Elasticity of Equity with Respect to Average Income**



social welfare unequivocally increases. During the periods when the elasticity was negative, an increase in  $\bar{y}$  was associated with an increase in inequality, and *vice versa*, and the overall evaluation depends on precise nature of value judgements.

## 4 Changing Population Structure

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The comparisons in the previous section involve inequality changes over time, based on cross-sectional Household Economic Survey data. These inequality changes are influenced by a range of factors associated with the structure of the population, which are expected to change over the relevant period. For example, there are systematic income changes over the life cycle, so that a change in the age structure of the population may be expected to affect cross-sectional comparisons even if no changes in age-income profiles take place. This section presents information about a number of relevant population changes in New Zealand since the early 1980s.<sup>14</sup>

The extent of population ageing is illustrated in Figure 8, which shows selected age pyramids over time. The top part of the figure is for 1984; the middle section is for 1995 and the bottom section is the pyramid for the year 2013. The changing composition of the labour force is shown in Figure 9. This shows the substantial increase in female labour force participation as well as the increase in participation among older males over the period. The decline in labour force participation among those aged 15 to 29 reflects, among other things, a substantial increase in participation in higher education.

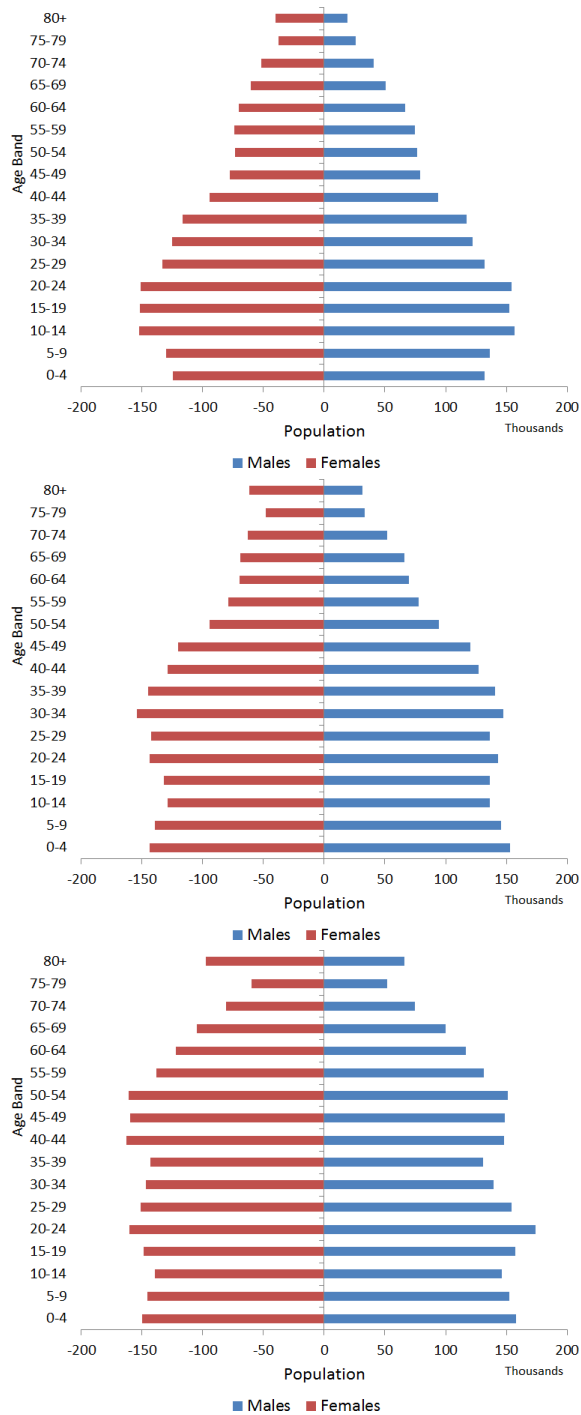
Substantial changes have also taken place in the structure of households, as illustrated in Figure 10. The main change is that the period from the middle 1980s to 2002 saw a steady decline in the proportion of couple parents, along with an increase in the proportion of single-person households. Following an increase during the 1980s, the proportion of sole parent households has remained steady. In addition, there has been a steady decline in the number of persons per household, as shown in Figure 11. The proportion of owner-occupied households has declined slightly from the early 1990s, as shown in Figure 12.

It is useful to know the extent to which the pattern of changes in measured cross-sectional inequality over the period has been influenced by these demographic and labour force changes.

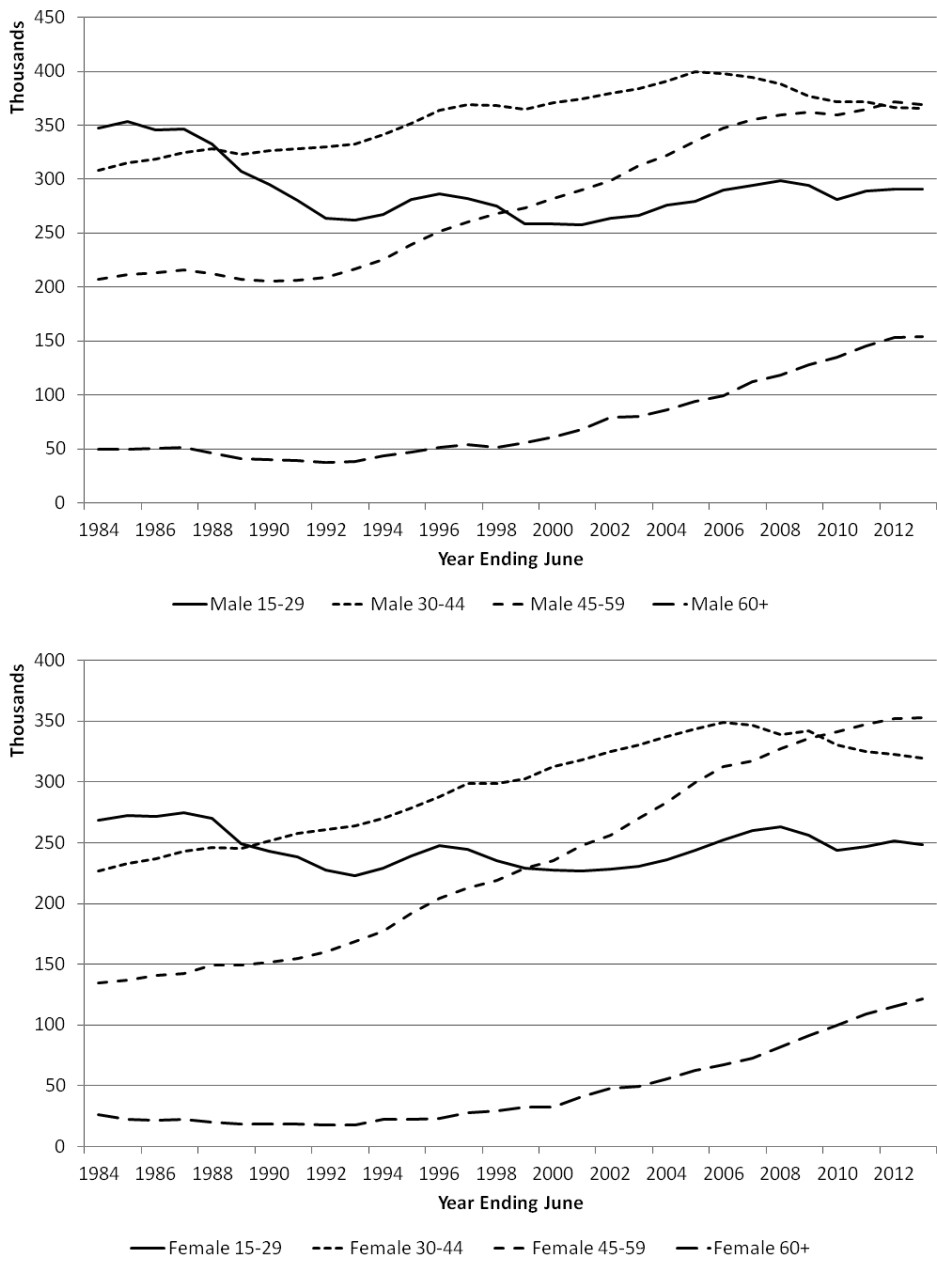
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<sup>14</sup> These types of change are also stressed by Statistics New Zealand (1999).

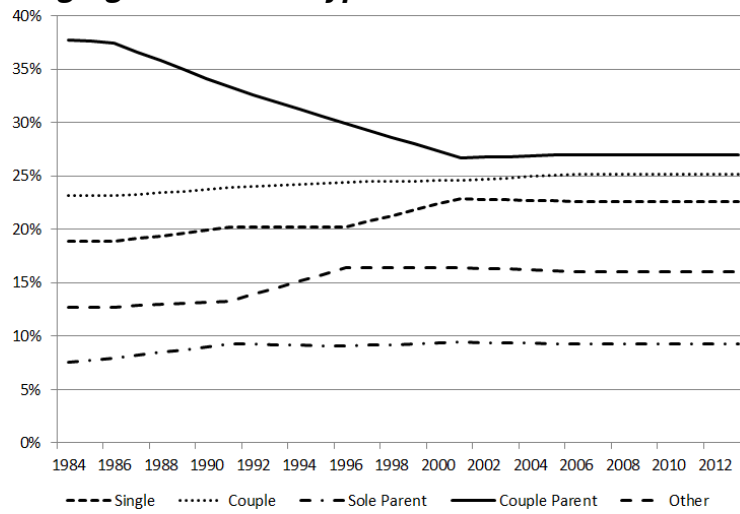
**Figure 8: The Changing Age Distribution: 1984, 1995 and 2013**



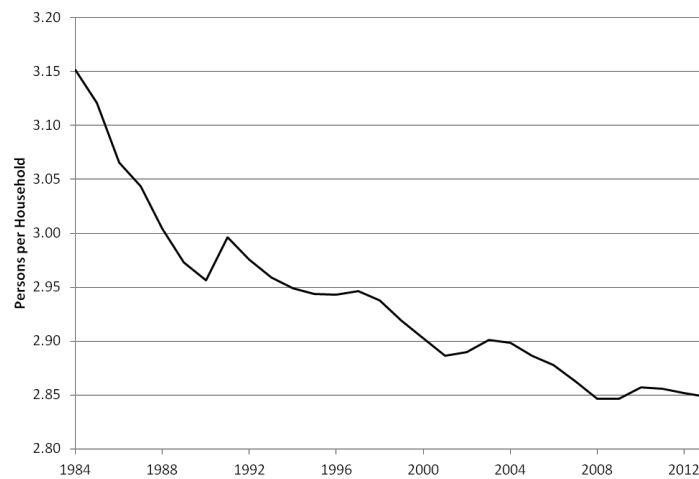
**Figure 9: Labour Force Participation**



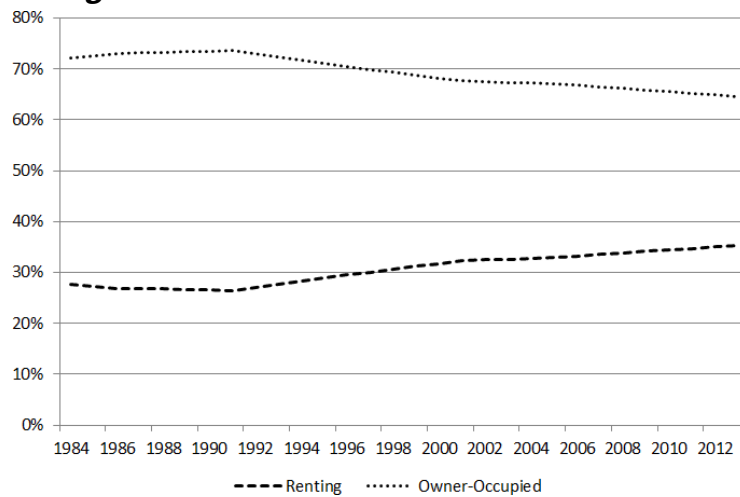
**Figure 10: Changing Household Types**



**Figure 11: Number of Individuals per Household**



**Figure 12: Housing Tenure**



## 5 Backward and Forward Looking Profiles

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The previous section has shown that a number of characteristics of the population have changed over the period 1984 to 2013. These changes are expected to affect measured inequality to some extent, yet it is not clear that their effects would be regarded as reflecting fundamental inequality changes. For example, a change in the age distribution of the population is likely to influence an aggregate measure of inequality, in view of the systematic income and other changes over the life cycle of individuals and families. Yet those contributions to inequality may not worry an inequality-averse judge. It is therefore useful to be able to make comparisons over time for the hypothetical case where a range of population characteristics remain in some sense fixed.

One way this can be achieved is by extending the use of survey calibration which, as discussed above, is used to produce weights for ‘grossing up’ from the sample survey to population values. By applying a set of calibration variables for one year to a sample survey that was obtained for another year, thereby obtaining a new set of survey weights, it is possible to make inequality comparisons which hold those population characteristics constant. The comparisons may thus be said to be, to some extent, *ceterus paribus* comparisons. It allows a range of ‘what if’ questions to be asked, such as: ‘what happens to measured changes in inequality if year 2’s population structure (described by aggregate age distribution and employment participation rates, and so on) were the same as year 1’s? The approach is discussed in the subsection 5.1. Empirical comparisons are given in subsection 5.2.

### 5.1 Alternative Profiles

Suppose an inequality or other summary measure of a chosen distribution in period  $t$ , where  $t = 1, \dots, T$ , depends on a number of population characteristics,  $x_{t,k}$  for  $k = 1, \dots, K$ , as well as the particular sample of households, denoted  $S_t$ , obtained in year  $t$ . The characteristics,  $x_{t,k}$ , can refer to calibration values, such as the total number of households or individuals of a given type in period  $t$ . Further information about sample weights and calibration is provided in Appendix C. Information regarding the individuals in households in sample,  $S_t$ , includes a range of characteristics along with their pre-tax incomes and disposable incomes. Suppose the measure of interest is the Gini inequality measure. This measure



for year  $t$  may thus be denoted by  $G(x_{t,1}, \dots, x_{t,K} | S_t)$ . This indicates that the Gini measure is obtained using sample,  $S_t$ , combined with the weights that are based on calibration values,  $x_{t,1}, \dots, x_{t,K}$ . This represents a typical inequality measure calculated for a given year,  $t$ , where the  $t$  subscript appears with every term in the expression.

Hence it is also possible to compute, for each sample, a different set of weights depending on the combination of calibration values used. The Gini measure based on year  $t$ 's sample, with weights based on calibration values,  $x_{j,1}, \dots, x_{j,K}$ , is thus denoted by  $G(x_{j,1}, \dots, x_{j,K} | S_t)$ . This gives rise to a range of alternative profiles of inequality over time. First, there are annual values of  $G(x_{t,1}, \dots, x_{t,K} | S_t)$ , for  $t = 1, \dots, T$ , and these were reported above in Section 3. It is possible to take the weights based on calibration variables of year  $j$ , and construct a series  $G(x_{j,1}, \dots, x_{j,K} | S_t)$ , for  $t = 1, \dots, T$ . Instead of having one time series of inequality measures, this produces a  $T$  by  $T$  matrix of values.

**Table 1: Matrix of Alternative Inequality Measures**

| Sample year | Calibration year                   |     |                                    |
|-------------|------------------------------------|-----|------------------------------------|
|             | 1                                  | ... | $T$                                |
| 1           | $G(x_{1,1}, \dots, x_{1,K}   S_1)$ | ... | $G(x_{T,1}, \dots, x_{T,K}   S_1)$ |
| .           | ...                                | .   | ...                                |
| .           | ...                                | .   | ...                                |
| $T$         | $G(x_{1,1}, \dots, x_{1,K}   S_T)$ | ... | $G(x_{T,1}, \dots, x_{T,K}   S_T)$ |

The alternatives are illustrated in Table 1. The actual inequality measures for each year are obtained from the entries in the diagonal. Consider holding the calibration values constant at those in the first year, that is, using weights based on  $x_{1,1}, \dots, x_{1,K}$  in combination with each sample,  $S_t$ , in turn for  $t = 1, T$ . This gives the first column of the matrix. It may be said to represent 'forward looking' values from period 1, where the HES sample changes and in each row the weights are based on calibration totals of year 1. Hence the changes in inequality that are measured down the first column show the effects of changes which are not associated with changes in the calibration values. Moving along the first row shows the effects on the first sample,  $S_1$ , of forward looking changes in the calibration totals; that is, it shows changing inequality as the measured aggregate features of the economy, represented by the  $x_{1,k}$ , variables, change. The final column of the matrix represents 'backward looking' values from year  $T$ . They hold the calibration values constant at those in the final year, while obtaining inequality measures using each sample and the associated weights. The sample weights used for each cell in the table are of course different, since each cell represents a unique combination of calibration totals and sample survey.

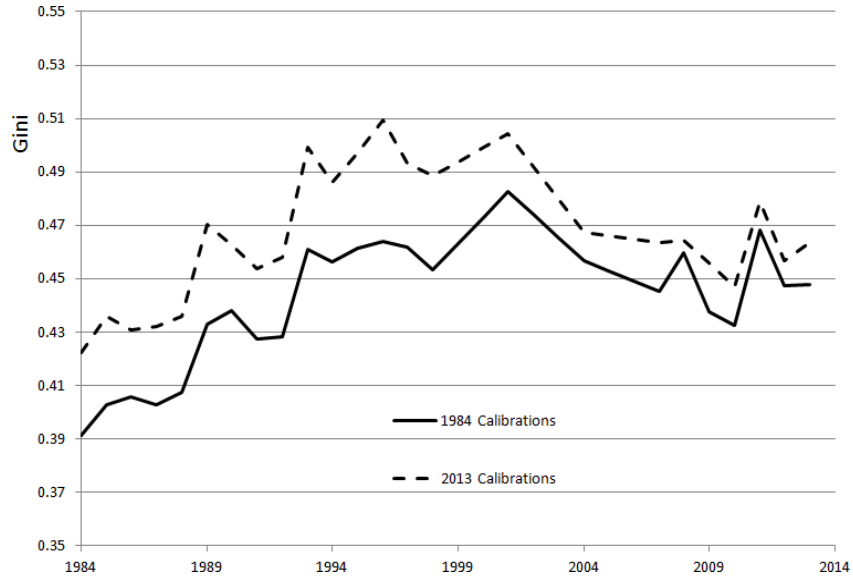
Clearly it is possible, rather than taking the first and last years as the basis for forward and backward looking changes, to make comparisons along any row and down any column. The movement down columns indicates the effects of ‘non-calibration changes’ over time, while movement along rows indicates the effects arising from changes in calibration variables describing those particular changes in the population structure.

## 5.2 Empirical Results

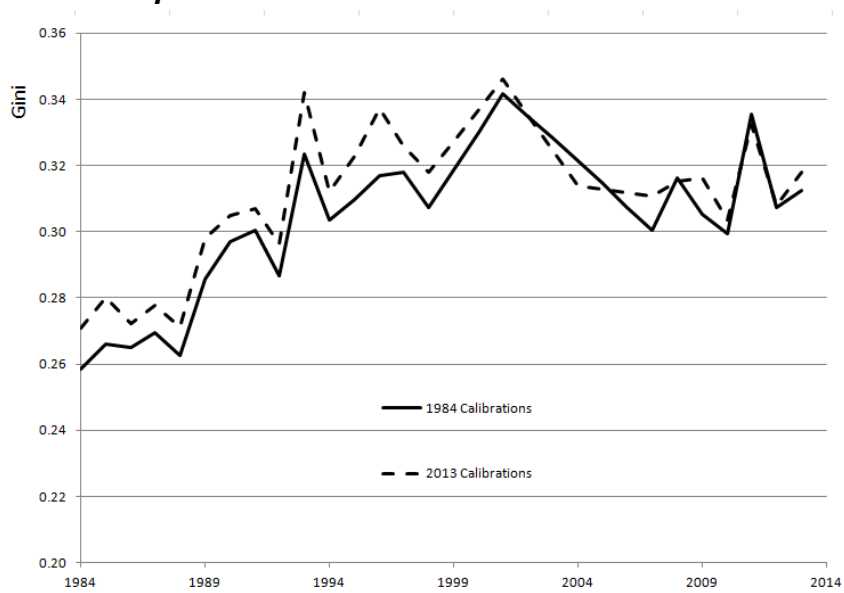
This section presents profiles of annual inequality on the assumption that a range of population characteristics remain constant over the period. As mentioned above, a total of 47 calibration variables were used, involving the age/gender structure, labour force participation, household size and structure, and type of housing tenure.

Figures 13, 14 and 15 show the variation in the Gini measure of inequality of, respectively, market and disposable income, and consumption expenditure, with unchanged population structures over the whole period. In all cases the measures are again of household values per adult equivalent person, using the individual as unit of analysis. The dashed line shows inequality ‘as if’ the population in each year were similar to the 2013 population for the 47 calibration variables used. The solid line shows how inequality varies if the 1984 calibration values apply in each year. The differences between the two profiles are greater for the inequality of household market income per adult equivalent, compared with disposable income. However, in each case the use of 2013 calibration values produces higher inequality in all years, except for several of the later years in the case of disposable income. If the population structure (as reflected in the calibration values) had remained as it was in 1984 the Gini measure of market income per adult equivalent person would not have risen by as much as shown by the standard annual measures. Hence changing population structure has contributed to increasing inequality, particularly over the 1980s and 1990s. The differences for the distribution of consumption expenditure are less clear.

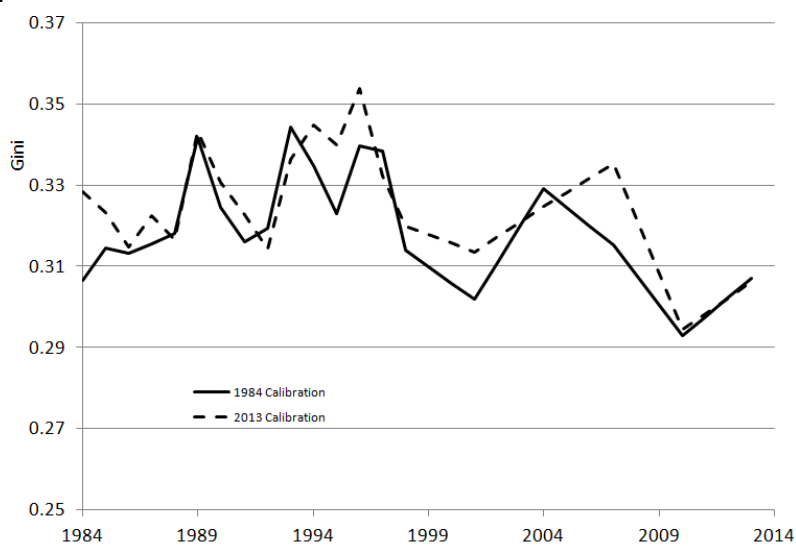
**Figure 13: Gini Inequality 1984 to 2013 with Fixed Calibrations: Market Income per Adult Equivalent**



**Figure 14: Gini Inequality 1984 to 2013 with Fixed Calibrations: Disposable Income per Adult Equivalent**



**Figure 15: Gini Inequality 1984 to 2013: Consumption with Fixed Calibration**



## 6 Inequality Decompositions

The time profiles discussed in the previous section can give an initial impression of the importance of a number of changes in the population structure (the calibration values) relative to the remaining factors such as changes in taxes and benefits and other non-calibrated variables. The question arises of the extent to which the differences can be attributed to particular calibration variables. For example, there was a drop in the proportion of households consisting of couple parents during a period when inequality was found to increase but, without further analysis, the extent to which the changes in household composition contributed to inequality changes is not clear. The present section therefore investigates the use of a more detailed decomposition of inequality changes.

The changes discussed in the previous section involved recalibration of each survey, using different sets of calibration totals. All values in a set of calibration totals are applied to the same year; that is, the set  $x_{t,1}, \dots, x_{t,K}$  is used for each  $t$ . However, it is also possible to change only one calibration value at a time. For example, sample weights can be obtained for the set,  $x_{j,1}, x_{j,2}, \dots, x_{j,K}$ , using any Household Economic Survey sample and combination of  $j$  and  $t$ . This allows for decompositions of changes. The approach is described in subsection 6.1 and in further detail in Appendix D. Results are presented in 6.2.

## 6.1 The Decomposition Method

Suppose for simplicity that there is just one calibration variable,  $x$ , and comparisons over only two periods, 1 and 2, are involved, so that  $x$  takes values  $x_1$  and  $x_2$  for the two periods and the samples are denoted  $S_1$  and  $S_2$ . The variable,  $x$ , may of course be a vector, representing a set of calibration variables relating to a particular feature of the economy (such as numbers in a range of age and gender groups). The change in inequality  $\Delta G$ , is expressed as:

$$\Delta G = G(x_2|S_2) - G(x_1|S_1) \quad (8)$$

The change in inequality arises from changes in the sample and changes in the calibration variable,  $x$ , which influence the weights applied to each sample. The separate effects of these two factors can be obtained as follows. Consider the following decomposition:

$$\Delta G = [G(x_2|S_2) - G(x_2|S_1)] + [G(x_2|S_1)] - G(x_1|S_1) \quad (9)$$

The first term in square brackets on the right hand side of (9) is the effect of changing the sample given the value of the calibration variable in period 2, and the second term in square brackets is the effect of changing the calibration variable, for the sample in period 1. However, there is another possible decomposition of the change in inequality, since:

$$\Delta G = [G(x_1|S_2) - G(x_1|S_1)] + [G(x_2|S_2) - G(x_1|S_2)] \quad (10)$$

The first term in square brackets on the right hand side of (10) is the sample effect given  $x_1$ , while the second term is the effect of changing the calibration variable for sample 2. Faced with two values for each of these effects, and since there is no special reason to select one as more important than the other, an approach is to obtain the unweighted arithmetic mean.<sup>15</sup>

In this example there are essentially just two things that influence inequality, the calibration variable,  $x_t$ , and the (combined) group of factors contained in the sample,  $S_t$ , for each period. This gives rise to two alternative ways of decomposing the change, as seen in (9) and (10). Appendix D extends the treatment to the case where there are three contributions to inequality change, which gives rise to  $3! = 6$  alternative decompositions. The number of possible decompositions increases rapidly as the number of sets of calibration variables increases. For example, three sets of calibration variables, along with different samples, gives rise

<sup>15</sup> This average is recommended by Shorrocks (2011), who links it to the Shapley Value, familiar from game theory. For further discussion of the decomposition and applications allowing for labour supply responses to tax changes, see Bargain (2012) and Creedy and Héroult (2015).

to  $4! = 24$  decompositions. Hence, although there are only four components to the decomposition, each is obtained as the arithmetic mean of 24 separate values.<sup>16</sup>

In the present application, six different sets of components are relevant. These are: age/gender; housing tenure; household type; occupancy rate; labour force participation by age and gender, and finally the sample. Hence  $6! = 720$  different compositions are needed and the components reported below are respective arithmetic means.

## 6.2 Contributions to Inequality Changes

The decomposition method described above was applied to changes in Gini measures of market and disposable income per adult equivalent for five separate periods, chosen to reflect different economic conditions and policies. The period 1984 to 2013 was thus divided into changes for 1984 to 1990; from 1990 to 1996; from 1996 to 2001; from 2001 to 2007; and 2007 to 2013.

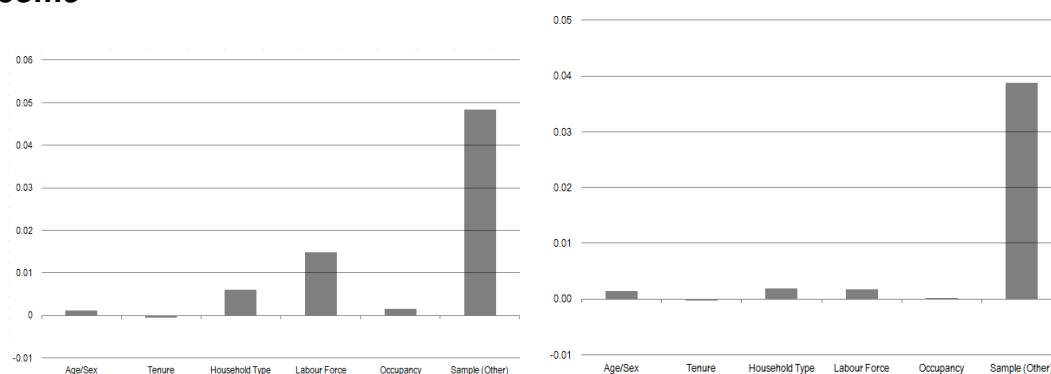
Figure 16 shows the components of the change in Gini over the period 1984 to 1990. The results for market incomes are shown in the left hand side diagram, and those for disposable incomes are in the right hand side diagram. For market incomes, labour force participation and household type make small contributions to the increase in the Gini over the period, but the main contribution is in the sample which contains all other factors that cannot be measured separately. Regarding the inequality of disposable incomes over this period, the separate contributions of household type and labour force participation are negligible.

The components shown in Figure 17, for the period 1990 to 1996, indicate that for both market and disposable incomes only the age/gender composition of the population is noteworthy. Figure 18 shows that when considering changes over the period 1996 to 2001, the separate components take on more importance for market incomes, with labour force participation changes and changes in the number of people per household actually contributing to reduce inequality. However, these contributions have much less importance for changes in inequality of disposable incomes.

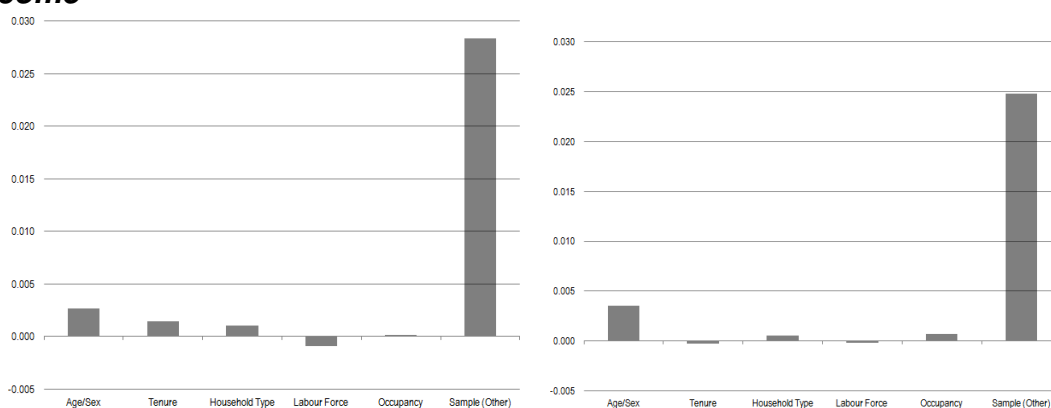
When inequality fell slightly over the period 2001 to 2007, as shown in Figure 19, only changes in labour force participation is identified as contributing to the fall for market incomes, and this component becomes negligible for disposable

<sup>16</sup> Again, some of the values are necessarily duplicated in obtaining the different decompositions; see Appendix C for further clarification.

**Figure 16: Decomposition of Gini 1984-1990: Market and Disposable Income**



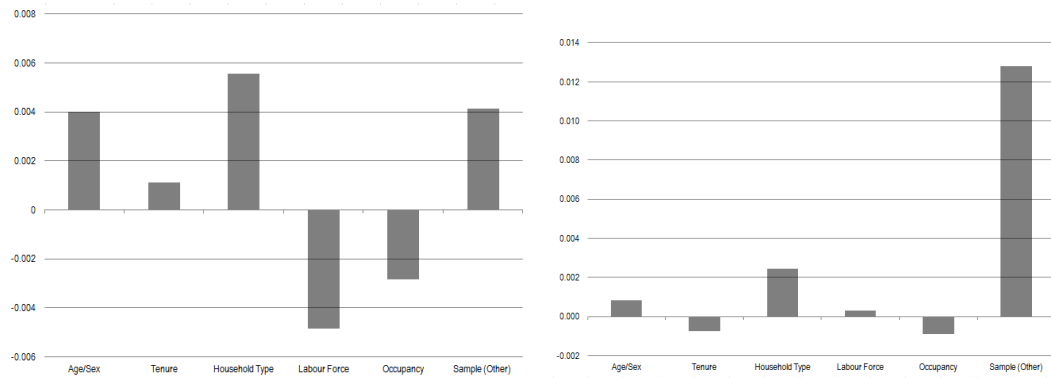
**Figure 17: Decomposition of Gini 1990-1996: Market and Disposable Income**



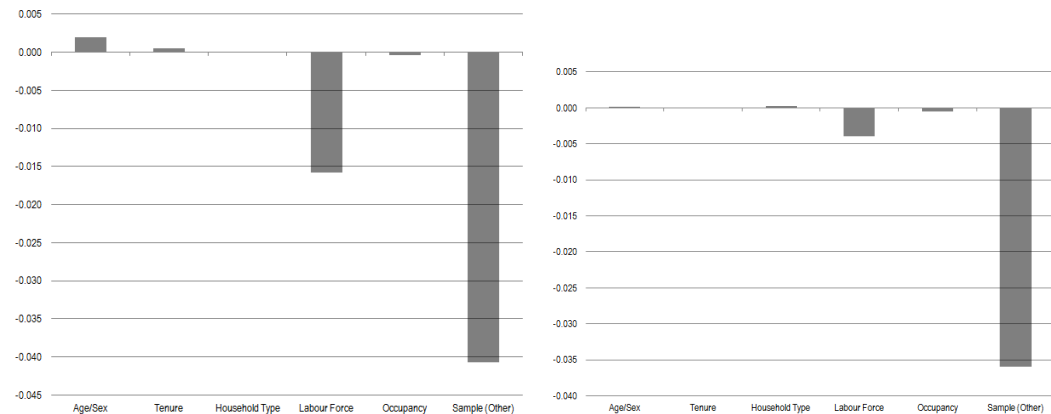
incomes. Figure 20 provides a somewhat different story. Here the change from 2007 to 2013 in the Gini measure of market income per adult equivalent can be largely attributed to changes in the age structure of the population and changes in labour force participation. Yet only the latter remains noteworthy when considering changes in inequality of disposable incomes.

In each case the changing sample characteristics contributed most to the change in inequality. This contains all those changes not captured by the other calibration components. As mentioned earlier, the separate contributions of the tax and transfer system cannot be isolated from other changes such as occupational change, age-income profiles and differential wage growth: for example the 2000 tax and transfer system could not be applied to the 1984 HES sample.

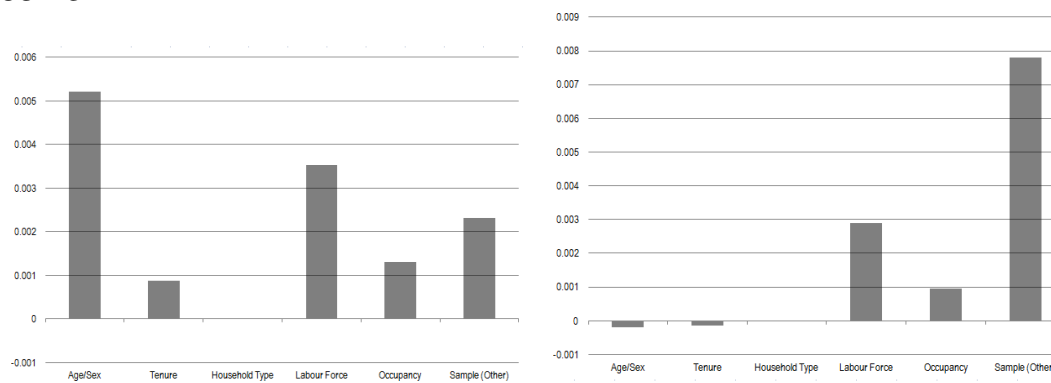
**Figure 18: Decomposition of Gini 1996-2001: Market and Disposable Income**



**Figure 19: Decomposition of Gini 2001-2007: Market and Disposable Income**



**Figure 20: Decomposition of Gini 2007-2013: Market and Disposable Income**





## 7 Conclusion

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This paper has reported the results of an extensive analysis of annual income and expenditure inequality in New Zealand over a thirty-year period from the early 1980s. The extent of redistribution through the tax and benefit system was also explored by comparing the inequality of market incomes with that of disposable incomes. *Household Economic Survey* data were used for each year from 1983/84 to 1997/98 inclusive, 2000/01 and 2003/04 , and for each year from 2006/07. The analysis has been conducted with the aim of obtaining a more detailed description of changing inequality over time and its components. It also demonstrates the difficulty of attributing precise causes to the distributional changes.

A distinguishing feature of the analysis is that survey calibration methods were used, by imposing independently obtained population totals for 47 population characteristics, covering demographic and labour force information for each year. Results were compared with the use of the HES weights provided by Statistics New Zealand, which are based on calibration using a much more limited set of population totals.

The results indicate an increase in the inequality of market and disposable income per adult equivalent person (using the individual as the unit of analysis) from the late 1980s to the early 1990s. Subsequently, inequality has – with some variability – remained either constant or has fallen slightly. Comparisons with tax policy changes over the period suggest that some of the variability (particularly around the 2001 and 2010 policy changes) may be attributed to income shifting between time periods in anticipation of changes in the income tax structure.

The use of survey calibration methods also makes it possible to examine changes in inequality using the ‘as if’ assumption that the structure of the population (as described by the 47 calibration totals) remains constant over the period. The variation in inequality can then be attributed to changes in the nature of the sample rather than those features of population and labour force structure that are held constant. With the weights adjusted to ensure that the calibration totals remain constant over time, the profiles of income inequality display different absolute values and somewhat different patterns, being higher in the earlier years when the calibration values for later years were used. Furthermore, with a constant demographic and labour force structure, the inequality of expenditure, though subject to year-to-year variations, displayed a ‘flatter’ profile over the period.

The inequality differences obtained using different calibration totals suggested that it would be useful to examine the contribution to changing inequality of particular components of the demographic and labour force change. A decomposition method was used involving five sets of variables (age/gender structure, labour force participation, household type, housing tenure type, and occupancy rate) along with the sample itself. To analyse these six components involved the use of 720 separate decompositions of each inequality change considered: arithmetic mean contributions to the overall inequality change were thus reported. The separate 'non sample' components were found to make a larger contribution to changes in the Gini measure of market income, though for disposable incomes those components were found to be relatively small, except in the cases where the Gini changed by very little or decreased.

Although it has been possible to examine the substantial differences between the distributions of market and disposable incomes in each year, reflecting the redistributive role of taxes and transfers, it has not been possible to isolate the role of changes in the tax structure from a range of other sample characteristics which may be expected to influence the distribution of income. The present paper has aimed to provide a more detailed description of the New Zealand income distribution and changes over the last thirty years, but interesting questions about the precise causes of those changes remain a challenge for future research.

## Appendix A: Alternative Metrics and Distributions

---

All the results reported above were obtained for ten different distributions, defined by the nature of the sample, the welfare metric and the unit of analysis. These are listed in Table 2, where  $H$  is the number of households,  $N$  is the total number of individuals, and subscripts  $W$  and  $E$  indicate the total number of workers (that is, those employed with positive market income) and the number of equivalent adults respectively.

**Table 2: Alternative Distributions**

| No. | Welfare metric               | Unit        | Sharing | Zeros | No.   |
|-----|------------------------------|-------------|---------|-------|-------|
| 1   | HH market income             | Household   | NA      | Yes   | $H$   |
| 2   | HH disposable income         | Household   | NA      | No    | $H$   |
| 3   | HH market income per AE      | Household   | NA      | Yes   | $H$   |
| 4   | HH disposable income per AE  | Household   | NA      | No    | $H$   |
| 5   | HH market income per AE      | Individual  | Equal   | Yes   | $N$   |
| 6   | HH disposable income per AE  | Individual  | Equal   | No    | $N$   |
| 7   | HH market income per AE      | Equiv indiv | Equal   | Yes   | $N_E$ |
| 8   | HH disposable income per AE  | Equiv indiv | Equal   | No    | $N_E$ |
| 9   | Individual market income     | Individual  | No      | No    | $N_W$ |
| 10  | Individual disposable income | Individual  | No      | No    | $N_W$ |

In addition to the standard Gini measures reported above, Atkinson inequality measures were also computed for different degrees of relative inequality aversion. Values used for the relative inequality aversion parameter are 0.2 and 0.9. In addition, comparisons were made using the ‘adult equivalent person’ as the unit of analysis. When using the individual as unit of analysis in combination with adult equivalence scales that allow for economies of scale, it is known that the ‘principle of transfers’ is not necessarily satisfied.

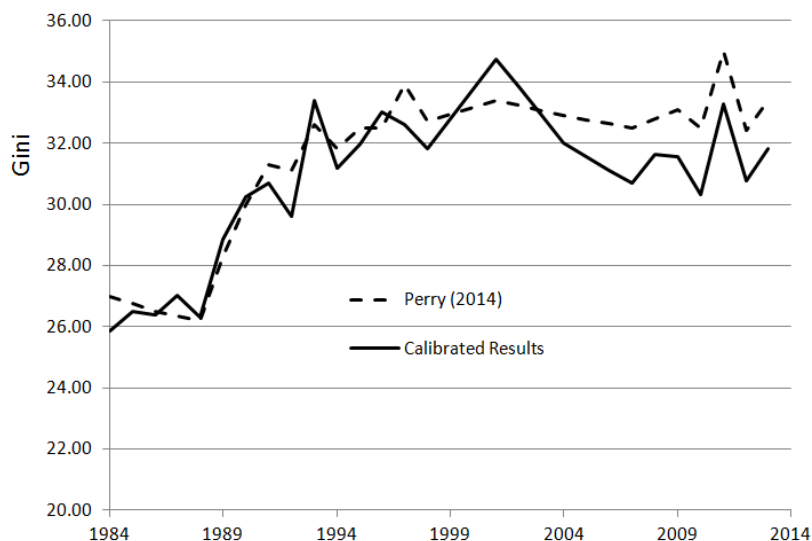
Some year-to-year comparisons of inequality changes and their decompositions differ slightly according to the income unit and welfare metric used. However, the main patterns over the period are similar.

## Appendix B: Comparisons with Earlier Results

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Figure 21 compares the Gini measures of inequality of disposable income per adult equivalent person, reported above, with the results from Perry (2014) for the same period. However, the values obtained by Perry used a different adult equivalent scale: his adult equivalent size of a household was calculated as the square root of the number of people in the household. Furthermore, negative values were set to zero (rather than being deleted, along with zero values, from the calculations). Perry (2014) used the sample weights provided by Statistics New Zealand.

**Figure 21: Comparison of Calibrated Values with Perry (2014): Disposable Income**



## Appendix C: Survey Calibration

---

The calibration problem can be stated as follows, following the standard approach of Deville and Särndal (1992). For each of  $N$  individuals in a sample survey, information is available about  $J$  variables; these are placed in the vector:

$$x_i = \begin{bmatrix} x_{i,1} \\ \vdots \\ x_{i,J} \end{bmatrix} \quad (\text{C.1})$$

These vectors contain only the variables of interest for the calibration exercise, rather than all measured variables. Many of the elements of  $x_i$  are likely to be

0/1 variables. For example  $x_{i,j} = 1$  if the  $i$ th individual is in a particular age group (or receives a particular type of social transfer), and zero otherwise. The sum  $\sum_{i=1}^N x_{i,j}$  therefore gives the number of individuals in the sample who are in the  $j$ th age group (or who receive the  $j$ th transfer payment).

Let the initial sample weights be denoted  $s_i$  for  $i = 1, \dots, N$ . These weights can be used to produce estimated population totals,  $\hat{t}_{x|s}$  based on the sample, given by the  $J$ -element vector:

$$\hat{t}_{x|s} = \sum_{i=1}^N s_i x_i \quad (\text{C.2})$$

Suppose that another set of population totals,  $t_x$ , is available. As in the present context, these may relate to another year, or they may relate to other extraneous sources. The problem is to compute new weights,  $w_i$ , for  $i = 1, \dots, N$  which are as close as possible to the initial weights,  $s_i$ , while satisfying the set of  $J$  calibration equations:

$$t_x = \sum_{i=1}^N w_i x_i \quad (\text{C.3})$$

It is thus necessary to specify a criterion by which to judge the closeness of the two sets of weights. In general, denote the distance between  $w_i$  and  $s_i$  as  $G(w_i, s_i)$ . The aggregate distance between the design and calibrated weights is thus:

$$D = \sum_{i=1}^N G(w_i, s_i) \quad (\text{C.4})$$

The problem is therefore to minimise (C.4) subject to (C.3). The Lagrangian for this problem is:

$$L = \sum_{i=1}^N G(w_i, s_i) + \sum_{j=1}^J \lambda_j \left( t_{x,j} - \sum_{i=1}^N w_i x_{i,j} \right) \quad (\text{C.5})$$

where  $\lambda_j$  for  $j = 1, \dots, J$  are the Lagrange multipliers, and  $t_{x,j}$  represents the  $j$ th element of the vector of known population aggregates,  $t_x$ . The first-order conditions generally give rise to nonlinear simultaneous equations which can be solved using numerical methods.

## Appendix D: Decomposing Changes: Further Details

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In Section 6, the decomposition method was introduced in the context of just two characteristics (one calibration variable and the sample). Suppose instead that there are two sets of calibration variables so that, with the addition of the sample, there are essentially three sets of factors determining inequality changes. For example, there may be labour force calibration totals represented by the vector,  $L_t$ , for  $t = 1, 2$ , where the elements of  $L$  give the total number of individuals in the labour force in each of a set of age groups. Furthermore, household characteristics in each period are represented by the vector  $H_t$ , whose elements give the total number in each of a set of household types. With these two sets of calibration variables, along with the sample,  $S_t$ , there are  $3! = 6$  different decompositions of the change in the inequality measure between the two periods. These are, in no special order:

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_1, H_2 | S_2) \\ &\quad + G(L_1, H_2 | S_2) - G(L_1, H_1 | S_2) \\ &\quad + G(L_1, H_1 | S_2) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.1}$$

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_1, H_2 | S_2) \\ &\quad + G(L_1, H_2 | S_2) - G(L_1, H_2 | S_1) \\ &\quad + G(L_1, H_2 | S_1) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.2}$$

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_2, H_1 | S_2) \\ &\quad + G(L_2, H_1 | S_2) - G(L_2, H_1 | S_1) \\ &\quad + G(L_2, H_1 | S_1) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.3}$$

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_2, H_1 | S_2) \\ &\quad + G(L_2, H_1 | S_2) - G(L_1, H_1 | S_2) \\ &\quad + G(L_1, H_1 | S_2) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.4}$$

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_2, H_2 | S_1) \\ &\quad + G(L_2, H_2 | S_1) - G(L_1, H_2 | S_1) \\ &\quad + G(L_1, H_2 | S_1) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.5}$$

$$\begin{aligned}\Delta G &= G(L_2, H_2 | S_2) - G(L_2, H_2 | S_1) \\ &\quad + G(L_2, H_2 | S_1) - G(L_2, H_1 | S_1) \\ &\quad + G(L_2, H_1 | S_1) - G(L_1, H_1 | S_1)\end{aligned}\tag{D.6}$$

In the first decomposition above, the first term,  $G(L_2, H_2|S_2) - G(L_1, H_2|S_2)$ , measures the change in  $G$  that is attributable to the change in the labour market structure, for given household structure and sample data for year 2. The second term,  $G(L_1, H_2|S_2) - G(L_1, H_1|S_2)$ , measures the change in  $G$  that arises from changing only the household structure, for the given labour structure in period 1 and the survey dataset from period 2. The final term,  $G(L_1, H_1|S_2) - G(L_1, H_1|S_1)$ , measures the effect on  $\Delta G$  of changing only the survey dataset, holding both the labour market and household structures constant at their values in year 1. The subsequent decompositions give alternative changes attributable to each of the three components, but for different combinations of given values of the other components. Since no component of the change in  $G$  can be viewed as being any more important than other components, an approach to providing a summary of the decompositions is simply to obtain the arithmetic means.

Hence, consider the arithmetic mean contribution of changing household structure to inequality over the period, which may be denoted,  $\Delta G_H|_{L,S}$ . This is obtained as an arithmetic mean of the relevant changes from the above six decompositions. Thus, taking the appropriate term from each decomposition above:

$$\begin{aligned}
6 \left( \Delta G_H|_{L,S} \right) = & G(L_1, H_2|S_2) - G(L_1, H_1|S_2) + \\
& G(L_1, H_2|S_1) - G(L_1, H_1|S_1) + \\
& G(L_2, H_2|S_2) - G(L_2, H_1|S_2) + \\
& G(L_2, H_2|S_1) - G(L_2, H_1|S_1) + \\
& G(L_1, H_2|S_1) - G(L_1, H_1|S_1) + \\
& G(L_2, H_2|S_1) - G(L_2, H_1|S_1)
\end{aligned} \tag{D.7}$$

Importantly, the terms  $G(L_1, H_2|S_1) - G(L_1, H_1|S_1)$  and  $G(L_2, H_2|S_2) - G(L_2, H_1|S_2)$  appear twice in (D.7). But all six terms must be averaged in order to ensure that the three component averages,  $\Delta G_H|_{L,S}$ ,  $\Delta G_L|_{H,S}$  and  $\Delta G_S|_{L,H}$ , add to the actual change in inequality,  $\Delta G$ , such that:

$$\Delta G = \Delta G_H|_{L,S} + \Delta G_L|_{H,S} + \Delta G_S|_{L,H} \tag{D.8}$$

The proportional contributions are thus obtained as  $\Delta G_H|_{L,S} / \Delta G$ , and so on.

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