Regression Estimates of the Elasticity of Taxable Income and the Choice of Instrument

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Abstract

This paper examines estimation of the elasticity of taxable income using instrumental variable regression methods. It is argued that the standard instrument for the net-of-tax rate – the rate that would be applicable post-reform but with unchanged income levels – is unsatisfactory in contexts where there are substantial exogenous changes in taxable income. Two alternative tax rate instruments are proposed, using estimates of the dynamics of taxable income for a panel of taxpayers over a period that involves no tax changes. The parameters derived from this procedure are then used to construct counterfactual post-reform incomes that would be expected in the absence of reform. The first method is based on the tax rate each individual would face if income were equal to expected income, conditional on income in two periods before the tax change. The second alternative uses the form of the conditional distribution of income for each taxpayer to obtain an instrument based on the expected tax rate. The methods are applied to the tax change in New Zealand in 2001. It is found that the proposed new instruments significantly outperform the standard instrument, in particular there are substantial improvements using the expected tax rate.

JEL Classification: H24, H31

Keywords: Income taxation; taxable income; elasticity of taxable income; instrumental variables; tax rate instruments.

Executive Summary

The ‘elasticity of taxable income’ (ETI) measures the response of taxable income to variations in the net-of-tax rate (one minus the marginal tax rate). It captures the combined impact of various economic responses to changes in marginal income tax rates. It is thus a crucial component of any investigation of the potential revenue effects of proposed income tax changes.

The estimation of the elasticity uses information about individuals’ taxable incomes before and after a tax reform. This is complicated by the fact that, with an income tax schedule having several marginal rates, changes in many individuals’ incomes can lead to changes in the actual marginal tax rate they face. These changes occur as well as the potential taxable income responses to tax rate changes that are of primary interest here. Furthermore, substantial income changes may take place that are unrelated to tax structure changes. To minimise these problems many investigators use the method of ‘instrumental variables’ but, as in most contexts, the choice of ‘instrument’ is not straightforward.

In this paper, two new tax rate instruments are proposed. The approach advocated here involves estimating the dynamics of taxable income for a panel of taxpayers, using data over a period that involves no tax changes. Instruments based on the expected income, and the expected tax rate, of each individual are constructed.

The proposed new instruments are used to estimate the elasticity of taxable income in New Zealand, using information about taxable incomes for a sample of taxpayers before and after the income tax rate changes in 2001. This reform provides an especially useful context in which to examine the performance of the three instruments, given the nature of that reform and the availability of suitable data to estimate income dynamics. The reform involved a convenient mix of marginal tax rate increases, decreases and no change across a wide range of incomes.

Comparing taxable incomes in 1999 and 2002, the paper first examines taxpayer responses in terms of observed correlations between income change and changes in the actual and instrumented tax rates. Secondly, instrumental variable regressions are examined. Thirdly, these results are compared with observed and predicted changes in key parts of the taxable income distribution between 1999 and 2002. All three approaches suggest that observed income changes after reform reflect the causal behavioural responses to tax reform predicted by the elasticity of taxable income literature. However, an instrument based on a standard approach of assuming unchanged income levels after reform is found to perform poorly. The new instruments, based on a model of income dynamics estimated using extraneous information on incomes over a three-year period without any tax structure changes, perform much better, particularly the instrument based on an expected tax rate for each individual.

The expected tax rate instrument produces an aggregate estimate of the elasticity of taxable income of 0.676 for all sources of income combined. The estimated elasticity of taxable income for those who have only wage and salary income is 0.414. This is around half of the value for those who have income from other sources, at 0.909. This latter value is similar to values found for the higher income groups by previous researchers and is consistent with the findings for other countries that taxpayers’ non-salary income appears to be especially responsive, via income shifting, to marginal tax rates and other tax parameters. The results have important implications for the design of the income tax structure, since elasticities of this size can imply high welfare losses from taxation as well as constraining the ability to increase revenue.

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1 Introduction

The 'elasticity of taxable income' (ETI), the response of taxable income to variations in the net-of-tax rate, $1 - \tau$, was proposed by Feldstein (1995) as a way of capturing the combined impact of various economic responses to changes in marginal income tax rates. The elasticity not only captures all responses to a change in the tax rate in a simple reduced-form specification, it provides, under certain conditions, a convenient method of calculating the welfare effects of tax changes.[1] It is thus a crucial component of any investigation of the potential revenue effects of proposed income tax changes. It has also been used, for example by Diamond and Saez (2011), to determine an optimal top marginal tax rate.

There has been a plethora of empirical estimates of the elasticity, mainly for the US and using a variety of methods. However, as the review by Saez et al. (2012) points out, estimation presents a number of challenges. In particular, they state that, 'in order to isolate the effects of the net-of-tax rate, one would want to compare observed reported incomes after the tax rate change to the incomes that would have been reported had the tax change not taken place. Obviously, the latter are not observed and must be estimated' (2012, p. 18).

This paper has two main objectives. First, it examines the use of instrumental variable regression methods. It is argued that the standard instrument for the net-of-tax rate − the rate that would be applicable post-reform but with unchanged income levels − may be unsatisfactory in contexts where there are substantial exogenous changes in taxable income.[2] This is in addition to acknowledged problems associated with controlling for income changes as part of the regression specification. Two alternative tax rate instruments are proposed. The approach advocated here to deal with the challenge posed by Saez *et al.* involves estimating the dynamics of taxable income for a panel of taxpayers, using data over a period that involves no tax changes.[3]

The parameters derived from this procedure are then used to construct hypothetical (or

[1] For an extensive review see, for example, Saez et al. (2012), and Creedy (2010) provides a technical introduction.

[2] Studies using the standard approach include, for example, Moffitt and Wilhelm (1998), Auten and Carroll (1995, 1999),Goolsbee (2000), Sillamaa and Veall (2000), Aarbu and Thoresen (2001), Gruber and Saez (2002), Selen (2002), Giertz (2004, 2007, 2010), Hansson (2004), Kopczuk (2005), Thomas (2012), Auten et al. (2008), Heim (2009). Carroll (1998) is based on the tax rate evaluated at the average taxable income over a seven year period.

[3] An approach concentrating on ensuring instrument exogeneity in the context of difference-in-differences estimation is examined by Weber (2011), who finds a point estimate of the US elasticity of 1.046, which is over twice as large as many earlier estimates.

counterfactual) post-reform incomes that would be expected in the absence of reform. From the resulting probability distribution of income for each taxpayer, two alternative net-of-tax rate instruments may be obtained. One instrument is based on the tax rate each individual would face if their income were equal to expected income, conditional on income in the previous two periods and knowledge of the process of relative income dynamics. The preferred alternative uses the form of the conditional distribution of income for each taxpayer to obtain an instrument based on their expected tax rate.

The second objective is to use the proposed new instruments to estimate the elasticity of taxable income in New Zealand, using information about taxable incomes for a sample of taxpayers before and after the income tax rate changes in 2001. This reform provides an especially useful context in which to examine the performance of the three instruments, given the nature of that reform and the availability of suitable data to estimate income dynamics.

Following a brief review of existing estimates obtained using instrumental variable and other methods in section 2, section 3 summarises the basic instrumental variable specification. Section 4 compares some key properties of the standard instrument and the two proposed alternatives. The construction of these alternatives is described in detail in Section 5. Section 6 applies the various instruments to a tax policy change in New Zealand in 2001 and discusses the resulting estimates of the elasticity of taxable income. Brief conclusions are provided in section 7.

2 Approaches to Estimation

In using regression methods, a constant elasticity specification is ubiquitous in the literature, whereby the logarithm of taxable income is expressed as a linear function of the logarithm of the net-of-tax rate. Fixed effects are generally eliminated by taking first-differences, so the form of equation to be estimated has the change in the logarithm of taxable income related to the change in the logarithm of the net-of-tax rate (these log-changes also providing approximations to the proportional changes), along with other available exogenous variables such as age. The approach therefore requires information about taxable income of a sample of individuals in at least two years (before and after a tax structure change), and the regression is cross-sectional.[4] A measure of initial or lagged income is often added as a regressor, to capture any tendency for proportional income changes to depend on income levels. All the observed change in income is attributed to the tax change and the exogenous variables included in the regression.

The reduced-form specification faces the well known problem that, with a nonlinear income tax function reflecting marginal rate progression, the change in the net-of-tax rate is itself endogenous. To overcome this problem numerous of authors have used an instrumental variable approach in which the instrument is, for each individual, the marginal net-of-tax rate which would be faced in the second period if there were no change in income.[5] The first stage involves a regression of the change in the actual log-net-of-tax rate on the change in the log-net-of-tax rate that would apply with no change in income, and other exogenous variables. This is used to obtain 'predicted' values of the log-change in the

4 Time-series regressions have also been examined, especially for tests involving changes over time in the income shares of various segments of the taxpayer income distribution in association with tax rate changes; see, for example, Saez (2004) and Saez et al. (2012).

5 See Giertz (2009) and Saez et al. (2012) and references cited there.

net of tax rate. The latter is then used in the second stage regression (with the change in the logarithm of income as dependent variable) instead of the actual change. Hence, the most commonly adopted 'standard instrument' involves using the tax rate that would apply post-reform to the taxpayer's pre-reform income. Where comparisons involve a number of years, annual incomes are often adjusted for inflation.[6] Alternatively, in determining the individual's reform-only change in marginal tax rates, some studies have adopted a common intermediate income between pre- and post-reform levels.[7]

As is well-known, following Feldstein (1995) relatively large estimates for the ETI (he found values between 1 and 3 for the 1986 and 1993 US tax reforms), subsequent studies have tended to find lower values in the 0.2–0.6 range. However, recent reviews by Giertz (2009) and Saez et al. (2012) have suggested that even the more rigorous recent studies, including those employing a variety of income controls, obtain a wide range of statistically significant ETI estimates. Results from five studies: Goolsbee (1999), Kopczuk (2005), Auten et al. (2008), Giertz (2009) and Saez et al. (2012), covering all major US tax reforms since 1924–25, are reported in Appendix A.

Even where small positive and plausible ETI estimates are reported, they generally form part of a suite of results that include a much wider range of values, including 'wrongly' signed estimates. Partly in response to the varied findings, Giertz (2010) concludes that 'it is incredibly difficult to isolate responses to changes in tax rates from income changes due to a myriad of other complex factors. While flexible income controls are intended to control for both mean reversion and divergence within the income distribution, it is impossible to conclude that these problems are adequately mitigated'. It is thus important to develop improved methods based on new instruments.

3 The Specification

Consider an income tax change between periods 1 and 2, involving changes in marginal rates, $t_{j,k}$, for periods $j = 1, 2$, and tax brackets $k = 1, ..., K_j$. The income thresholds may also change from period 1 to 2. Information is available about the taxable income, $y_{j,i}$ of $i = 1, ..., N$ individuals in each period. Let $\tau_{j,i}$ denote the marginal tax rate actually faced by individual i in period j. This is the appropriate rate, depending on $y_{j,i}$, from the set of rates $t_{j,k}$. Define:

$$x_i = \log(1 - \tau_{2,i}) - \log(1 - \tau_{1,i}) \tag{1}$$

which is an approximation for the proportional change in the net-of-tax rate, $1 - \tau$. The proportional change in taxable income, q_i, is approximated by:

$$q_i = \log y_{2,i} - \log y_{1,i} \tag{2}$$

The constant elasticity relationship between taxable income and the net-of-tax marginal rate, ignoring for the moment exogenous variables which may influence income changes, is:

$$q_i = \alpha + \eta x_i + u_i \tag{3}$$

6 However, this is not an innocuous adjustment for estimates of ETI responses. Since tax liability is defined in nominal terms, a nominal income increase involving no real income change could nevertheless be associated with a tax-induced income response where nominal fiscal drag pushes the taxpayer into a higher tax bracket. Indeed this is the identification method adopted by Saez (2003) to obtain ETI estimates from 'bracket creep'.

7 For example, Auten and Carroll (1999) use an average of pre- and post-reform incomes, while Blomquist and Selin (2009) use an intermediate year.

where u_i is a random variable and η is the elasticity of taxable income. There are inevitably income changes which would occur in the absence of tax changes. The challenge is thus to avoid attributing those exogenous income changes to the tax rate changes.

Estimation of the form in (3), augmented by further exogenous variables, presents a fundamental problem because of the endogeneity of the change in the log-tax-rate. This means that ordinary least squares estimates are biased and inconsistent. In order to avoid this problem, researchers have used the following instrumental variable approach in which the instrument, z_i, is used, defined as:

$$z_i = \log\left(1 - \tau^*_{2,i}\right) - \log\left(1 - \tau_{1,i}\right) \tag{4}$$

where $\tau^*_{2,i}$ is the marginal tax rate that would be faced by the individual in period 2 if taxable income were to remain constant at $y_{1,i}$.

The first stage involves a linear regression of x_i on z_i and all the exogenous variables in the model, and the calculation of the 'predicted' values, $\hat{x}_i$, using the parameter estimates (also indicated by 'hats') so that, again ignoring the other exogenous variables:

$$\hat{x}_i = \hat{\delta} + \hat{\theta} z_i \tag{5}$$

The second stage then involves estimating the elasticity of taxable income, η using ordinary least squares on:

$$q_i = \alpha + \eta \hat{x}_i + v_i \tag{6}$$

The question examined here is whether this is a reliable approach, bearing in mind that for z to be a good instrument, it must be correlated with x but independent of the errors, and uncorrelated with q other than via any effects on x.[8]

4 Alternative Instruments

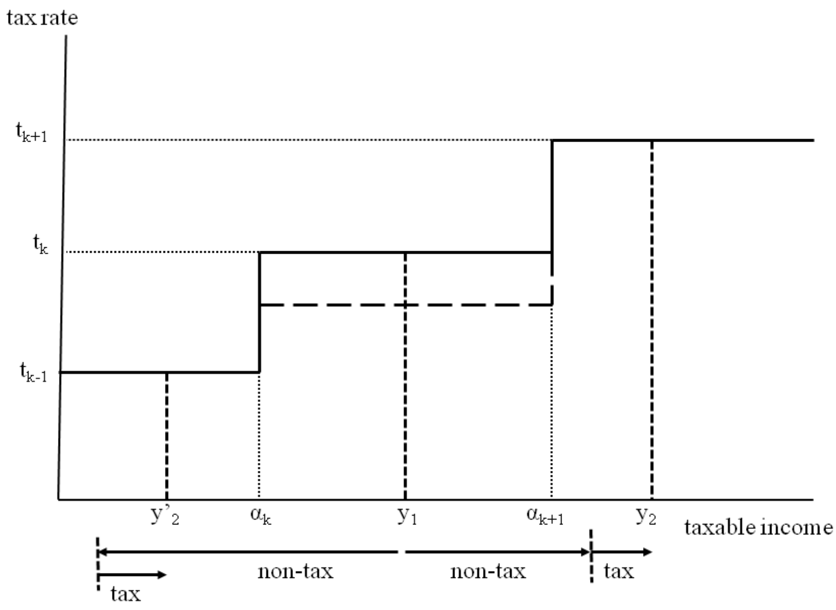
This section considers problems associated with the standard instrument and proposes two alternatives. It shows that with non-tax-related income changes – a ubiquitous feature of the income dynamics of most taxpayers – it is not surprising that a tax rate instrument that ignores those changes may perform poorly. Typically, exogenous variables are added to the basic specification in (6) to capture elements of income dynamics. However, the alternative approaches suggested here also involve the use of an independently estimated process of earnings dynamics in the construction of the instrument itself.

4.1 The Standard Instrument

Figure 1 shows a segment of a multi-step tax function. An individual in the kth tax bracket with initial (period 1) taxable income of y_1, faces the (pre-reform) marginal tax rate, t_k. A reform which decreases t_k in period 2, with thresholds unchanged, would be expected to increase taxable income. However, other exogenous influences on income, *ceteris paribus*, could either raise or lower period 2 income, yielding observed income in period

8 The regression of x on z implies (in the absence of other exogenous variables) that for $z_i = 0$, $\hat{x}_i = \hat{\delta}$. These different cases thus have values of q_i aligned along a straight line at $\hat{x}_i = \hat{\delta}$.

Figure 1: Income and Tax Rate Changes



2, y_2 or y_2' respectively. Thus, where exogenous income increases and the expected tax effect operate in the same direction, observed income increases to y_2. For an exogenous income fall, the expected tax response operates in the opposite direction to the income change, compensating for the exogenous income fall, as shown by the arrows around y_2'.

Therefore tax cuts are expected to be negatively correlated with observed income changes (the *a priori* relationship) for exogenous sources of income increase, but positively correlated for exogenous income decreases.[9] For a tax reform involving an increase, rather than a decrease, in t_k, these correlations are reversed. For any given reform, the problem for the empirical investigator therefore is to separate the two unobservable components of each taxpayer's observed income changes from periods 1 to 2. There can be a resulting bias in standard instrument estimates of the income response to a tax structure change in the presence of exogenous income changes for which allowance is not fully made. For example, an increase in τ_k is expected *a priori* to reduce income. The standard instrument avoids attributing to the tax reform any observed tax rate reduction induced by the income fall. However any exogenous increases in income would raise the taxpayer's marginal rate where that income change involves crossing a tax threshold. Failure to accommodate this second effect within the instrumented tax rate therefore risks attributing some of this positive association between exogenous income change and tax rates to the tax instrument. That is, the parameter on the tax rate term in an instrumental variable regression, attempting to capture the behavioural response to tax reform, is likely to be positively biased (less negative, or more positive).

As mentioned above, a number of existing studies of taxable income elasticities do attempt to control for other sources of income change, such as regression towards the mean, though this income change process is generally not allowed to affect the measurement

9 Additionally, some observed income increases could arise where an exogenous decrease is more than compensated by the increase in income in response to a marginal tax cut, and *vice versa*.

of the tax instrument.[10] Since imperfect controls for exogenous income changes could result in either over- or under-estimates of their effects, the resulting biases could be in the opposite direction to the 'no income control' cases above. However, estimates based on reforms involving tax cuts (increases in $1 - \tau_k$), in association with average nominal or real incomes increases (independently of tax reform) suggests the possibility of negative biases.

Hence it is important first to model non-tax induced changes in incomes as accurately as possible and without systematic bias. Second, where exogenous income changes are imperfectly captured, it is important to be aware of the different biases associated with estimates of tax-induced income responses. These depend on the type of tax reform and the exogenous income changes experienced. To the extent that income changes, in the absence of tax reforms, follow a systematic pattern, rather than being purely random, the biases can be substantial. The following subsection suggests how information about income dynamics can be used directly in the construction of a tax rate instrument.

4.2 Incorporating Income Dynamics

A partial solution to deal with potential biases was suggested by Saez et al. (2012, p. 27-8) , whereby, 'in situations with mean reversion, it is useful to include episodes of both increases and decreases in tax rates for identification, as mean reversion creates biases in opposite directions in the case of tax increases versus tax decreases'. Saez et al. (2012, p. 28) also find that 'panel regression estimates of taxable income responses are sensitive to the choice of instrument for the marginal tax rate', such that 'standard methods do not control adequately for mean reversion'. Indeed, as argued further below, these standard methods cannot capture more general features of income dynamics, and hence their ability to separate 'tax reform only' from 'non-tax induced' changes in income is questionable, especially given the potential for various, reform-specific, biases described above.

The key problem with the standard instrument is that it represents the simplest approximation of income dynamics, namely no change in (real) reported incomes in the absence of tax reform. The alternative approach proposed here involves modelling taxpayers' income dynamics using annual income data that, by construction, are unaffected by tax reform.

The method captures any exogenous regression to the mean and serial correlation in relative income changes over a number of years during which there are no tax changes, to yield predicted values of future incomes, given current and past income levels. This yields a conditional probability distribution of income for each future year and taxpayer. Using this information allows construction of two possible marginal tax rate instruments. First, the mean income from the conditional income distribution, given initial income for each taxpayer, for any post-reform year, j, $E(y_j)$, can be obtained (individual subscripts are suppressed). For this expected mean income, the associated tax rate is obtained from the post-reform tax code. This instrument is labelled $\tau^*_{E(y)}$.

Alternatively, the complete probability distribution of incomes for year j for each taxpayer can be used in conjunction with the post-reform tax code to obtain the set of tax rates associated with each income level. Using the full conditional income distribution to weight each tax rate appropriately yields an 'expected marginal tax rate' after reform which more fully incorporates information on income dynamics. This expected tax rate instrument is

[10] For example, Auten et al. (2008) use the tax rate associated with the paxpayer's taxable income in year $t - 3$ to capture 'reform-only' tax changes (tax reform in year t). As with other 'initial income' tax rate instruments, this will not necessarily measure the tax rate that the taxpayer *would have faced in the absence of reform.*

labelled $\tau^*_{E(\tau)}$.

In terms of Figure 1, a probability distribution of income, centred for example on y_2, potentially includes a wide dispersion of incomes with associated tax rates t_k and t_{k-1}, as well as t_{k+1} and any other higher or lower rates. Hence, whereas the set of 'expected income' based tax rates, $\tau^*_{E(y)}$, includes only the discrete set of rates specified in the tax schedule, 'expected tax rates', $\tau^*_{E(\tau)}$, can take a wide range of values, reflecting the income-weighting of each discrete rate.

4.3 Correlations among Measures

To explore the merits of these alternative instruments, consider their correlations with observed income changes. Of interest here is the observed changes in income, Δy, and tax rates, $\Delta\tau$, and the change in the relevant tax rate instrument, $\Delta\tau^*$. To simplify the exposition at this stage, changes in tax rates, τ, rather than net-of-tax rates, $1-\tau$, are considered.

Table 1 shows, for any individual, the possible combinations of Δy, changes in the actual tax rate $\Delta\tau = (\tau_2 - \tau_1)$, and the instrumented tax rate $\Delta\tau^* = (\tau^*_2 - \tau_1)$ between the pre- and post-reform periods (1 and 2 respectively). There are $3 \times 3 \times 3$ = 27 possible combinations of negative, zero or positive change. The zero income change cases are excluded from Table 1, leaving 18 possible cases.[11] Of the 18 cases, 2 are not feasible with a tax schedule with marginal rate progression everywhere; for example, a positive income change cannot be associated with an actual marginal tax rate decrease.

Given the 16 possible combinations of values for Δy, $\Delta\tau$, and $\Delta\tau^*$ in Table 1, Table 2 shows the unconditional partial correlations, ρ, between the income change and each of the three tax instruments, where $\Delta\tau^*_1$ is the (change in the) standard instrument discussed above, but applied to $\Delta\tau$ rather than $\Delta(1-\tau)$. Tax changes for the new proposed instruments are shown as $\Delta\tau^*_{E(y)}$ and $\Delta\tau^*_{E(\tau)}$.

The table identifies, with a tick (✓), those categories where the correlation between the income change and each tax instrument takes the expected, *ceteris paribus*, negative sign: $\rho < 0$. Other entries ('incorrect' zero or positive correlation: $\rho \geqslant 0$) are shown by a cross ($\times$). There are also several 'not feasible' cases. These arise either because of the increasing marginal rate nature of the tax schedule (cases 4 and 8) or because they are not feasible for the particular tax instrument in question. Table 2 also reveals that there are four cases (7, 11, 12, 15) for the standard instrument, which are not feasible, but which can be accommodated by the other two instruments. This reflects the property of the standard approach whereby the instrumented tax rate is always that which applies to initial income.

Section 6 below compares the regression-based performance of these three instruments in the context of the year 2001 tax reforms in New Zealand. But it is useful here to consider the numbers of New Zealand taxpayers who fall into each of the above categories. Table 3 shows the pre- and post-reform New Zealand tax rates. Of the four marginal rates in the tax schedule in 1999, the reform involved 0.75 and 3 percentage point decreases in two middle tax rates respectively (from 21.75 and 24 per cent to a common 21 per cent rate) and a 6 percentage point increase in the top rate (from 33 to 39 per cent) for incomes

[11] This keeps the number of cases more manageable and, in the empirical analysis below, less than 0.04 per cent of over 800,000 taxpayers had unchanged pre- and post-reform incomes (to the nearest $1).

Table 1: Outcomes for Income and Marginal Rate Changes

No.	Δy	$\Delta\tau$	$\Delta\tau^*$	Comment
1	>0	>0	>0	
2	>0	>0	0	
3	>0	>0	<0	
4	>0	0	>0	NA
5	>0	0	0	
6	>0	0	<0	
7	>0	<0	>0	
8	>0	<0	0	NA
9	>0	<0	<0	
10	<0	>0	>0	
11	<0	>0	0	
12	<0	>0	<0	
13	<0	0	>0	
14	<0	0	0	
15	<0	0	<0	
16	<0	<0	>0	
17	<0	<0	0	
18	<0	<0	<0	

above $60,000.[12] These represent approximate percentage changes in the three reformed tax rates (using log differences) of -3.5, -13.4 and $+16.7$ per cent.[13] This makes the New Zealand reform a particularly helpful one to analyse in this context because of the mixture of tax rate increases and decreases (and no change) across a wide range of incomes.

Based on pre- and post-reform years of 1999 and 2002, the framework in Table 2 can be used to compare each taxpayer's observed change in income with changes in their actual and instrumented tax rates; these years are chosen to avoid effects of income shifting between the announcement and implementation of the tax change; see Claus et al. (2012) for further discussion of this phenomenon.

Table 4 shows the numbers of taxpayers in each category, separated into those categories where $\rho \geqslant 0$ (columns 1–4) and $\rho < 0$ (columns 5–8), where ρ refers to the unconditional correlation between the income change and the change in the relevant tax instrument. The correlation of interest to identify behavioural responses to tax rate reform is the conditional correlation between the tax instrument and reform-related income change. However, since all three tax instruments considered here attempt, in their different ways, to control for income changes in defining each instrument, the sign on the unconditional correlation involving the total income change might be expected to provide a useful guide to the prospects of finding a similarly signed conditional correlation.

The final row of Table 4 shows that the total numbers of correlations involving the expected tax rate, $\tau^*_{E(\tau)}$, yield quite different outcomes from those involving the other two instruments: $\tau^*(y_1)$ and $\tau^*_{E(y)}$. In particular, there is a much higher ratio of incorrectly signed correlations ($\rho \geqslant 0$) to correctly signed correlations ($\rho < 0$) for the standard and expected income instruments. Around 54 per cent of correlations, 431 and 433 out of 803 respectively for standard and expected income instruments reveal $\rho \geqslant 0$.However, for $\tau^*_{E(\tau)}$ the ratio is only

[12] The lowest rate, applicable up to $16,000, remained at 15 per cent, with the 33 per cent rate applicable to incomes in the range $38-60,000.

[13] Equivalent percentage changes in the net-of-tax rate, $1-\tau$, are -1.0, -2.9 and $+9.4$ per cent.

Table 2: Correlations between Income changes and Tax Instruments

Cat.	$\rho(\Delta y, \Delta\tau^*_1)$	$\rho(\Delta y, \Delta\tau^*_{E(y)})$	$\rho(\Delta y, \Delta\tau^*_{E(\tau)})$
	$\checkmark = \rho < 0$;	$\times = \rho \geqslant 0$;	NA = not feasible
1	$\times$	$\times$	$\times$
2	$\times$	$\times$	$\times$
3	$\checkmark$	$\checkmark$	$\checkmark$
4	NA	NA	NA
5	$\times$	$\times$	$\times$
6	$\checkmark$	$\checkmark$	$\checkmark$
7	NA	$\checkmark$	$\checkmark$
8	NA	NA	NA
9	$\checkmark$	$\checkmark$	$\checkmark$
10	$\checkmark$	$\checkmark$	$\checkmark$
11	NA	$\times$	$\times$
12	NA	$\times$	$\times$
13	$\checkmark$	$\checkmark$	$\checkmark$
14	$\times$	$\times$	$\times$
15	NA	$\checkmark$	$\checkmark$
16	$\checkmark$	$\checkmark$	$\checkmark$
17	$\times$	$\times$	$\times$
18	$\times$	$\times$	$\times$

Table 3: New Zealand Income Tax Structure: 1999 and 2002

1999 Tax Structure		2002 Tax Structure	
Income range	Tax rate	Income range	Tax rate
$1 - 9,500$	0.15	$1 - 9,500$	0.15
$9,501 - 34,200$	0.2175	$9,501 - 34,200$	0.21
$34,201 - 38,000$	0.24	$34,201 - 38,000$	0.21
$> 38,001$	0.33	$38,001 - 60,000$	0.33
		$> 60,001$	0.39

Table 4: Number of Taxpayers by Correlation Category: 1000s

	$\rho \geqslant 0$				$\rho < 0$		
Cat	$\tau^*[y_1]$	$\tau^*[E(y)]$	$\tau^*[E(\tau^*)]$	Cat	$\tau^*[y_1]$	$\tau^*[E(y)]$	$\tau^*[E(\tau^*)]$
1	53	27	122	3	122	123	99
2	46	71	0	6	0	19	101
5	101	82	0	7	0	small	194
11	0	6	0	9	194	194	0
12	0	small	25	10	25	19	small
14	35	44	0	13	18	7	small
17	44	40	0	15	0	2	53
18	152	163	57	16	13	6	152
Total	431	433	204		372	370	599

25 per cent (204/803).

However, the expected tax rate does not out-perform in all categories, in the sense of having more negative correlations than the other instruments. Table 4 reveals that, across instruments, the numbers of positive or negative correlations can be different within each category. For example, there is a high number (122,000) of positive correlations in category 1 using the expected tax rate, whereas the alternative instruments have lower numbers: 53,000 and 27,000. An opposite ranking of instruments is observed for (positive) correlation category 18.

The main reason for the strong correlation performance of the expected tax rate instrument arises from its ability to reclassify 101,000 and 152,000 taxpayers in the positive correlation categories 5 and 18 respectively into negative correlation categories 6 and 16. These numbers provide a clue as to why regression results reported below appear strongly to favour the expected tax rate instrument over the alternatives.

5 Construction of Alternative Instruments

Subsection 5.1 describes the model of income dynamics used to construct the alternative instruments discussed in the previous section. Subsection 5.2 presents the instrument based on each individual's conditional expected income. Subsection 5.3 presents the expected tax rate instrument. The tax rate distributions using alternative instruments are examined in subsection 5.4

5.1 Income Dynamics

The model used here is a stochastic model which identifies two types of relative income change, arising from non-tax related factors. These are 'regression towards the mean' and serial correlation in relative income changes. From Creedy (1985), the two processes are captured by the following autoregressive form, where μ_j is the arithmetic mean of log-income in period j and u is a random error term with variance, σ_u^2:

$$\log y_{j,i} - \mu_j = \alpha_2 (\log y_{j-1,i} - \mu_{j-1}) + \alpha_3 (\log y_{j-2,i} - \mu_{j-2}) + u_i \tag{7}$$

This can be rearranged as:

$$\log y_{j,i} - \log y_{j-1,i} = (\mu_j - \alpha_2 \mu_{j-1} - \alpha_3 \mu_{j-2}) + (\alpha_2 - 1) \log y_{j-1,i} + \alpha_3 \log y_{j-2,i} + u_i \tag{8}$$

In addition, if the age-profile of μ_j is thought to be quadratic, then letting s_i denote i's age at time, j, (8) can be replaced by:

$$\log y_{j,i} - \log y_{j-1,i} = \alpha_4 + \alpha_5 s_i + \alpha_6 s_i^2 + (\alpha_2 - 1) \log y_{j-1,i} + \alpha_3 \log y_{j-2,i} + u_i \tag{9}$$

Thus (3) can be augmented by adding terms on the right hand side of (9). Alternatively, $(\alpha_2 - 1) \log y_{j-1,i} + \alpha_3 \log y_{j-2,i} = (\alpha_2 + \alpha_3 - 1) \log y_{j-1,i} - \alpha_3 (\log y_{j-1,i} - \log y_{j-2,i})$, so this is consistent with having terms equal to the base period log-income and the previous period's log-income change. In the empirical analysis below, as in Giertz (2009), these variables are used as additional exogenous variables.

Following the 2001 tax policy change the tax structure remained unchanged for a number of years. Hence estimation of equation (7) involves regressions based on post-reform years 2003 to 2005. Thus, the model regresses $\log y_{05,i} - \mu_{05}$ on $\log y_{04,i} - \mu_{04}$ and $\log y_{03,i} - \mu_{03}$, for the same individuals as used in the estimation of the elasticity of taxable income. The evidence in Claus et al. (2012), who examine taxpayer income share changes, suggests strongly that responses to the 2001 tax reform did not persist into the 2003-05 period.[14] The data are described in Section 6. The parameter estimates of α_2 and α_3 are 0.6677 and 0.1988, with t-values of 145.49 and 43.41, with $\sigma_u = 2.62144$.[15]

The above specification is consistent with a dynamic process with regression towards the mean of β, where $\log y_{j,i} - \mu_j = \beta (\log y_{j-1,i} - \mu_{j-1}) + u_{i,j}$, and first-order serial correlation of γ, where $u_{i,j} = \gamma u_{i,j-1} + \varepsilon_{i,j}$. Hence, $\alpha_2 = \gamma + \beta$ and $\alpha_3 = -\gamma\beta$; see Creedy (1985). It can be shown that $\beta = \left\{\alpha_2 + \left(\alpha_2^2 + 4\alpha_3\right)^{0.5}\right\}/2 = 0.891$ and $\gamma = \left\{\alpha_2 - \left(\alpha_2^2 + 4\alpha_3\right)^{0.5}\right\}/2 = -0.223$. These values imply a high degree of regression towards the mean along with negative serial correlation whereby, for example, those who experience a large income increase are more likely to have a subsequent decrease. These results are consistent with those obtained using New Zealand incomes from the early 1990s; see Creedy (1998, pp. 188-191).

5.2 Tax Rate Applied to Expected Income

The instrument based on expected income uses the estimates from the income dynamics model to construct for each person an expected income in period 2 (the post-change year being considered), by projecting forward for the required number of years. An instrument for the tax rate change can then be constructed using the tax rate applicable to the 'expected' income which would arise from the dynamic process alone (rather than, in the standard instrument, the rate that would apply to an unchanged income).

First, the parameter estimates from (7) are used to obtain values of $\hat{y}_{2,i}$ by projecting forward from period 1. This requires the values of μ_j for the relevant years (period 1 and period 2, as well as the two years before period 1). (For the tax change considered below, it is necessary to project several years ahead, as discussed in the following subsection.) The values of $E(y_{2,i})$ give the expected income values in the second period under consideration if the above process of income change were to apply in the absence of any tax changes. Then obtain the tax rate, $\tau_i^* [E(y_{2,i})]$ that would be faced by the individual, given $E(y_{2,i})$. Redefine z_i as $z_i = \log(1 - \tau_i^* [E(y_{2,i})]) - \log(1 - \tau_{1,i})$ and, as before, define x_i as $x_i = \log(1 - \tau_{1,i}) - \log(1 - \tau_{0,i})$, and let s_i denote age. Carry out a regression of the form:

$$x_i = \beta_1 + \beta_2 z_i + \beta_3 s_i + \beta_3 s_i^2 + ... + v_i \tag{10}$$

The exogenous variables other than age can be added to the right hand side of (10). Finally, using the parameter estimates from (10) to obtain the $\hat{x}_i$ values, carry out a regression of the form:

$$(\log y_{2,i} - \log y_{1,i}) = \gamma_1 + \eta \hat{x}_i + \gamma_2 s_i + \gamma_3 s_i^2 + ... + w_i \tag{11}$$

One problem arising from this method is that in projecting forward, it is necessary in the final stage to use μ_2, the mean log-income in the post-change year. In the intermediate stages only the terms $(\log y_{j,i} - \mu_j)$ are needed. Using the actual μ for year 2 is tantamount

[14] See Claus et al. (2012, Figures 1 and 2). Some individuals experience marginal tax rate changes resulting from fiscal drag. However, with low inflation, the majority of income changes over this period can reasonably be thought to reflect non-tax related income movements.

[15] The mean of logarithms of income in 2003, 2004 and 2005 are 10.311, 10.367 and 10.367, with standard deviation of logarithms of 0.9194, 0.9110 and 0.9651 respectively.

to assuming that it was not substantially affected by the tax change; that is, in aggregate the tax effects are small relative to the other influences on aggregate income growth.

5.3 An Instrument Based on Expected Tax Rate

Given a distribution of income for each individual, conditional on income in the two years preceding the tax change, it is possible to calculate an expected tax rate. This will not generally correspond to a statutory marginal rate in the multi-rate structure. As before, let $y_{j,i}$ denote individual i's income at time j, and let μ_j denote arithmetic mean log income at time, j. The process of relative income change is the same as described in (7) above, which allows for serial correlation and regression towards the mean in the process of relative income change. Rearranging this equation gives:

$$\log y_{j,i} = (\mu_j - \alpha_2\mu_{j-1} - \alpha_3\mu_{j-2}) + \alpha_2 \log y_{j-1,i} + \alpha_3 \log y_{j-2,i} + u_{j,i} \tag{12}$$

Assuming that $E(u_{j,i}) = 0$ and $V(u_{j,i}) = \sigma_u^2$ are the constant mean and variance of $u_{j,i}$ for all j, taking expectations gives:

$$E(\log y_{j,i}|\, y_{j-1,i}, y_{j-2,i}) = (\mu_j - \alpha_2\mu_{j-1} - \alpha_3\mu_{j-2}) + \alpha_2 \log y_{j-1,i} + \alpha_3 \log y_{j-2,i} \tag{13}$$

and the variance of logarithms of conditional income is:

$$V(\log y_{j,i}|\, y_{j-1,i}, y_{j-2,i}) = \sigma_u^2 \tag{14}$$

As explained earlier, in the context of the tax change in New Zealand, it is necessary to obtain values relating to 2002, given incomes in 1999 and 1998. Hence, moving forward one year gives:

$$\begin{aligned} E(\log y_{j+1,i}|\, y_{j-1,i}, y_{j-2,i}) &= (\mu_{j+1} - \alpha_2\mu_j - \alpha_3\mu_{j-1}) \\ &\quad + \alpha_2 E(\log y_{j,i}|\, y_{j-1,i}, y_{j-2,i}) + \alpha_3 \log y_{j-1,i} \end{aligned} \tag{15}$$

with a variance of logarithms of:

$$V(\log y_{j+1,i}|\, y_{j-1,i}, y_{j-2,i}) = \left(1 + \alpha_2^2\right)\sigma_u^2 \tag{16}$$

Finally, moving a further year forward gives:

$$\begin{aligned} E(\log y_{j+2,i}|\, y_{j-1,i}, y_{j-2,i}) &= (\mu_{j+2} - \alpha_2\mu_{j+1} - \alpha_3\mu_j) \\ &\quad + \alpha_2 E(\log y_{j+1,i}|\, y_{j-1,i}, y_{j-2,i}) \\ &\quad + \alpha_3 E(\log y_{j,i}|\, y_{j-1,i}, y_{j-2,i}) \end{aligned} \tag{17}$$

with a conditional variance of logarithms of:

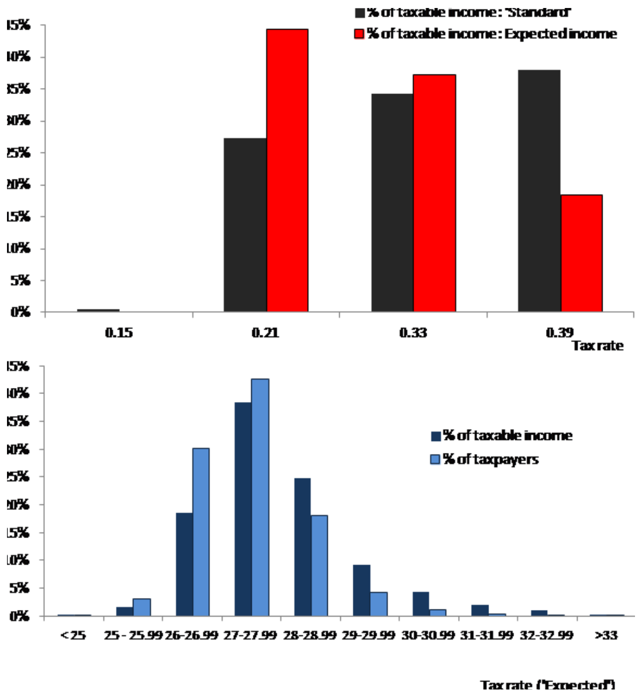
$$V(\log y_{j+2,i}|\, y_{j-1,i}, y_{j-2,i}) = \left\{1 + \alpha_2^2\left(1 + \alpha_2^2\right) + \alpha_3^2\right\}\sigma_u^2 \tag{18}$$

These last two expressions can be used to give the mean and variance of log-income in 2002 conditional on income in 1999 and 1998. The variance is of course the same for each individual.

The expected tax rate for the individual in period $j+2$, given a set of tax thresholds and rates, is obtained as follows. Suppose the income tax function has rates t_k for $k = 1, ..., K$ applying between income thresholds a_k and a_{k+1} where $a_1 = 1$ and $a_{K+1} = \infty$. First let $E(\log y_{j+2,i}|\, y_{j-1,i}, y_{j-2,i}) = \mu_{j+2,i}$ and $V(\log y_{j+2,i}|\, y_{j-1,i}, y_{j-2,i}) = \sigma_{j+2}^2$, with:

$$\xi_{j+2,k,i} = \frac{\log a_k - \mu_{j+2,i}}{\sigma_{j+2}} \tag{19}$$

Figure 2: Distribution of Tax Rate Instruments



On the assumption that the u are normally distributed, log-income is normally distributed and the probability that the individual falls into the kth bracket is:

$$P_{j+2,k,i} = N\left(\xi_{j+2,k+1,i} | 0,1\right) - N\left(\xi_{j+2,k,i} | 0,1\right) \tag{20}$$

where $N\left(h | 0,1\right)$ is the area to the left of h of a standard normal distribution. Here $N\left(\xi_{j+2,K+1,i} | 0,1\right) = 1$ and $N\left(\xi_{j+2,1,i} | 0,1\right) = 0$.

The expected tax rate for the individual, $E\left(\tau_{j+2,i}\right)$ is thus:

$$E\left(\tau_{j+2,i}\right) = \sum_{k=1}^{K} t_k P_{j+2,k,i} \tag{21}$$

This gives the expected tax rate instrument, $\tau_i^*\left[E\left(\tau_{2,i}\right)\right] = E\left(\tau_{j+2,i}\right)$, for each individual.

5.4 The Distribution of the Tax Rate Instruments

Each of the three methods yields a predicted tax rate in 2002 for each taxpayer. For the standard and expected income instruments these are represented by the four statutory tax rates in the 2002 schedule. For the expected tax rate instrument, being an income-weighted average, in principle these may take any number of possible values between the lowest and highest statutory rates.

The top half of Figure 2 shows the percentage of taxable income associated with taxpayers facing the respective marginal rates based on the first two instrumental variable measures. This 'taxable income share' distribution is more relevant for behavioural responses than the equivalent share of taxpayers. As can be seen in Figure 2, the share of income facing the four different rates is quite similar. However, whereas the standard instrument produces an increasing share of income across the 21, 33 and 39 per cent rates, the reverse is true for the expected income tax instrument. Taxpayers facing the 39 per cent marginal rate (based on these instruments) account for almost 40 per cent of taxable income using the standard instrument, but the corresponding proportion is less than 20 per cent based on the expected income instrument. This probably reflects the ability of the expected income instrument to capture the likelihood that some of those observed (pre-reform) in the top tax bracket, experience an income fall that pushes them into a lower tax bracket. The standard instrument cannot accommodate this aspect.

The lower half of Figure 2 shows the equivalent histogram for the expected tax rate instrument. Both the share of taxpayers, and the share of taxable income, are included for comparison. In each case the expected tax rate shown on the horizontal axis, for example, 24 and 25 per cent, represents the share of income, or taxpayers, having a tax rate instrument lying between 24.00 and 24.99 per cent, 25.00 and 25.99 per cent and so on. The resulting range of expected tax rates is narrower than for the other two instruments, lying between rates of 24 and 34. This reflects the weighting process across the probability distribution of possible tax rates with a minimum and maximum rate respectively of 15 and 39 per cent.

6 Applications: The 2001 Tax Change

Table 3 in section 4 shows the New Zealand income tax structure reforms in 2001. After a period with relatively few changes, the 2001 reforms represented a significant policy change, involving a number of tax rate changes, but especially an increase in the top marginal rate from 0.33 to 0.39 above $60,000. This policy change is examined using comparisons of top income shares by Claus et al. (2012). They show that the announcement of the tax changes led to a certain amount of income shifting between periods, so that a comparison between incomes in 2000 and those immediately after the change gives highly misleading results. Using a longer interval allows for these inter-temporal shifts in income to settle down.

The income dynamics model discussed above allows for the possible effect of regression towards the mean in generating relative income changes that are independent of tax changes, along with serially correlated changes. In examining the 2001 New Zealand tax change, period 2 refers to 2002. Period 1 refers to 1999, so that the use of lagged income terms requires information on incomes in 1998.

In addition to the age terms and income terms in the regression, a dummy variable to allow for the composition of income was set equal to zero if the individual received only wage or salary income in 1998, 1999 and 2002, the three years used in the regressions. The dummy was set equal to 1 if the individual received, either in addition to or instead of wage and salary income, any 'other income'.[16] Subsections 6.1 and 6.2 respectively describe the special dataset used here and the econometric properties of the instruments. Subsection 6.3 presents the regression results, while subsection 6.4 considers in further detail the characteristics of those who responded to the tax changes.

[16] Other income includes: dividends, trust and estate income, partnership, rental income, business or other income, shareholder employee income, and overseas income.

6.1 The Data

The database used here was constructed by randomly sampling the Inland Revenue Department's individual taxpayer population, and covers the period 1994–2009. The number of taxpayers in the random sample rises from 138,464 in 1999 to 139,420 in 2002. The sample is weighted to match the individual taxpayer population, which increased from 2,800,528 taxpayers in 1999 to 2,962,200 in 2002. The database is not constructed on a household basis. It contains welfare benefits data administered to individual taxpayers and family assistance provided to a nominated parent but not both parents. It is not possible to obtain estimates for households with different composition and income due to the lack of linking information.

For the regressions outlined below, various restrictions are imposed on the data. Age restrictions are imposed in order to remove those taxpayers likely to be in the very early stages of their careers as well as those becoming eligible for New Zealand superannuation. Only taxpayers aged 25-64 across the entire period are included. Income restrictions are also imposed, in order to remove very high income earners (over $1 million in 1999) and low-income earners under $16,000. The latter face benefit abatements rates which mean that their effective marginal tax rates differ significantly from those of a standard taxpayer.[17] Finally, those without sufficient income data across all relevant years (1998, 1999, 2002, 2003, 2004 and 2005) are necessarily excluded. As a result, the sample size is reduced to 38,744, which, when weighted up to reflect the population, represents 803,920 individual taxpayers. Further details of the data, the restrictions and the sampling process are given in Appendix B.

6.2 Instrument Properties

This sub-section considers the econometric merits of each instrument. For the case of a single instrumented variable, $\Delta \log (1-\tau)$, and instrument, over-identification tests are not feasible. However it is possible to examine the relative strength of each separate instrument in the first stage of the regressions, using parameter t-values, regression R^2s and partial-R^2s associated with each case.[18] Further, adding two, or all three, instruments to the first stage regression allows their relative contributions to be assessed and compared using an F-test for the validity of the instruments.

For the case of a single instrument the partial correlation among $\Delta \log (1-\tau)$ and the three instrumenting variables is also of interest. The partial correlation between $\Delta \log (1-\tau)$ and the expected income, or expected tax rate, instruments are much higher, at around 0.15, compared to that with the standard instrument, at 0.06. Also, while the standard instrument is correlated at $+0.50$ with the expected income instrument, the expected tax rate instrument is not highly positively correlated with the other two (-0.51, -0.05). The -0.05 correlation suggests that, using both the expected income and tax rate instruments, each instrument should contribute independent information.

Table 5 shows a set of additional diagnostics for the various instruments (all first stage regressions also include the exogenous variables Age, Age^2, $\log y_{99}$, $\log y_{99} - \log y_{98}$, and the 'other income' dummy). The top half of the table shows that the standard instrument

17 Furthermore the role of means-tested Working for Families, the NZ in-work tax credit, is not considered as this is based on family income. In addition, the major change to the tax schedule is the top income tax rate.

18 Hausman-Wu tests also confirm that the marginal tax rate variable, $\Delta \log (1-\tau)$, is endogenous in OLS regressions.

Table 5: Testing Instrument Validity

Dependent variable: $\Delta \log(1-\tau)$				
Instrument included	Parameter t-values	Regression Adj-R^2	Partial R^2	F-test (p-value) of over-identification.[a]
(1): 'Standard'	-0.1	0.023	0.0000	n.a.
(2): Expected income	25.7	0.039	0.0168	n.a.
(3): Expected tax rate	62.05	0.111	0.0905	n.a.
(1), (2), (3)	-1.43, 4.69, 55.4	0.112	0.0910	4.00 (0.018)
(1), (2)	-9.26, 27.34	0.041	0.0189	6.53 (0.011)
(1), (3)	0.28, 62.05	0.111	0.0905	6.14 (0.013)
(2), (3)	4.47, 56.20	0.112	0.0909	0.14 (0.710)

Note a: Critical values are: 5.99 (95%) and 9.21 (99%) with 2 df, and 3.84 (95%) and 6.63 (99%) with 1 df.

performs poorly (for example, $t = -0.1$) while the other two instruments appear statistically strong ($t = 25.7$ and 62.05). In addition when 2 or 3 instruments are included in the vector of instruments *and* the standard instrument is included (instrument '(1)' above), the instrument vector fails the over-identification F-test. That is, at least one instrument is invalid. However, for the combination of instruments (2) and (3), the F-test fails to reject the null hypothesis of instrument validity, further supporting the inclusion of either or both of the new instruments. The t-ratios in Table 5 also confirm that, when all three instruments are included, the expected income and tax rate instruments are highly statistically significant ($t = 4.69$ and 55.4, respectively), while inclusion of the standard tax rate instrument is rejected at usual confidence levels ($t = -1.43$). Hence, both new instruments are valid and potentially useful, but the expected tax rate instrument is expected to perform much better.

6.3 Regression Results

The results of applying the three alternative instruments to the sample described above are reported in Table 6. Each regression takes the form in (11) above and includes, in addition to the relevant instrument and the age terms, log income in 1999, the lagged change in log income and the 'other income' dummy described above. The resulting estimated elasticity using the standard instrument is a large negative number, -175 with a huge standard error (t-value $= -0.11$), so that it is obviously not significantly different from zero. Also, none of the coefficients on the age and income variables is significantly different from zero.

Introducing the first of the alternative instruments, the tax rate associated with expected income in 2002, in Table 6, radically changes the parameter estimates. In particular, using the expected income instrument, the estimate of the elasticity of taxable income becomes 0.575, (t-value $= 1.99$) and all variables are significantly different from zero at standard levels of significance.[19]

Using the expected tax rate instrument has a modest impact on the point estimate of the elasticity of taxable income (0.676 compared with 0.575) but more than halves the standard error, resulting in a t-value of 5.4. Similarly all variables in the regression now have higher coefficient t-values. The use of the expected tax rate instrument therefore appears to

[19] This value is in the range obtained by Claus et al. (2012), using non-regression methods.

Table 6: Regression Estimates using Alternative Instruments

Dependent variable: $\log y_{02} - \log y_{99}$			
Independent variables	Parameter estimate	Standard error	$t-$value
Standard instrument			
Intercept	26.704	236.297	0.11
$\Delta \log(1-\tau)$	-175.027	1630.677	-0.11
Age	-0.240	2.561	-0.09
Age-squared	0.004	0.045	0.10
$\log y_{99}$	-2.591	22.383	-0.12
$\log y_{99} - \log y_{98}$	1.897	18.733	0.10
Other income dummy	-2.312	21.883	-0.11
Instrument based on expected income			
Intercept	1.259	0.094	13.37
$\Delta \log(1-\tau)$	0.575	0.288	1.99
Age	0.036	0.003	13.04
Age-squared	-0.0005	0.00003	-14.67
$\log y_{99}$	-0.181	0.0077	-23.61
$\log y_{99} - \log y_{98}$	-0.121	0.0076	-15.86
Other income dummy	0.044	0.0078	5.71
Instrument based on expected tax rate			
Intercept	1.244	0.087	14.29
$\Delta \log(1-\tau)$	0.676	0.125	5.39
Age	0.036	0.003	13.12
Age-squared	-0.0005	0.00003	-14.99
$\log y_{99}$	-0.179	0.0068	-26.25
$\log y_{99} - \log y_{98}$	-0.123	0.0071	-17.25
Other income dummy	0.046	0.007	6.52

substantially improve the robustness of the estimated marginal tax rate effect on taxable income, with a plausible mean value. This is confirmed when using both the expected tax rate and expected income variables as instruments in the first stage regression. Using both instruments (not shown in Table 6) yields a parameter on $\Delta \log(1-\tau)$ of 0.673 (t-ratio $= 5.38$); that is, adding the expected income instrument has a negligible effect on the estimated elasticity of taxable income. This reinforces the results of the previous subsection.

Table 7: Regression Estimates: Expected Tax Rate Instrument with Slope Dummy

Dependent variable: $\log y_{02} - \log y_{99}$			
Independent variables	Parameter estimate	Standard error	$t-$value
Intercept	1.200	0.087	13.74
$\Delta \log(1-\tau)$	0.414	0.173	2.39
Age	0.036	0.003	13.54
Age-squared	-0.0005	0.00003	-15.45
$\log y_{99}$	-0.176	0.0068	-25.75
$\log y_{99} - \log y_{98}$	-0.121	0.0069	-17.65
Other-income dummy	0.054	0.0079	6.86
Other-income dummy$\times\Delta \log(1-\tau)$	0.495	0.232	2.13

The specification in Table 6 only includes an intercept shift dummy, allowing for observed income changes to differ for taxpayers with other income from those with only wage and salary income. However, it cannot capture the potential for different tax rate responsiveness by those with other income; for example, if other income is easier to shift, re-classify or evade for tax purposes. To allow for the possibility that the elasticity coefficient on $\Delta \log(1-\tau)$ depends on the composition of income, Table 7 adds an interaction term equal to the product of the dummy variable and $\Delta \log(1-\tau)$.[20]

The results suggest that the elasticity for those without other income is smaller, at 0.414 (t-ratio $= 2.39$) , while the coefficient on the interaction term is 0.495 and significantly different from zero (t-ratio $= 2.13$). That is, the estimated elasticity of taxable income for those who have only wage and salary income, at 0.414, is around half of the value for those who have income from other sources, at 0.909 ($= 0.414 + 0.495$). This latter value is similar to values found by Claus et al. (2012). for the higher income groups. It is consistent with the findings for the US by Saez (2004) that taxpayers' non-salary income appears to be especially responsive, via income shifting, to marginal tax rates and other tax parameters.[21] However, Saez (2004) shows evidence for the 1986 US tax reform was less clear regarding whether the observed growth of wage and salary income after reform represented a tax response.

To test this aspect further, the total sample was decomposed into taxpayers with and without at least one of the categories of non-wage-or-salary income sources (dividends, trust income and so on). If it is either easier to alter other income than salary income, or taxpayers have a greater propensity to do so, in response to tax changes, then it might be expected that those taxpayers with non-salary income would demonstrate a larger elasticity than taxpayers with no other income. Secondly, among the subset of taxpayers

20 Here the term $\Delta \log(1-\tau)$ in the table denotes the difference, $\log(1-\hat{\tau}_{02}) - \log(1-\tau_{99})$.

21 Although there is a considerable overlap in the income distributions of those with a zero dummy and those with a dummy equal to 1, income at the 90th percentile of the two distributions is $53,704 and $87,714 respectively. That is, the richest 10 per cent (in terms of total taxable income) of taxpayers with positive other income have substantially higher income compared to the richest 10 per cent of taxpayers with no other income.

with other income, the responsiveness of their other income to a change in marginal tax rates might be expected to be greater than the equivalent response for salary income.

This is likely to be important in the case of New Zealand's 2001 reform. Though all types of personal income (salary, dividends and so on) above the new $60,000 threshold after the reform were taxed at 39 per cent, rather than 33 per cent, income received by trusts and companies continued to be taxed at 33 per cent. Diversion of income to trusts, and incorporation, is relatively easy (with a low cost) in New Zealand, and the new 6 percentage point gap provided a strong incentive to shift income away from the personal tax code to those alternatives. This can be expected to have induced further reductions in other income received by individual taxpayers in the current sample in response to the tax rise.[22]

Table 8: Expected Tax Rate Instrument: Non-Wage Income

Dependent variable: $\log y_{02} - \log y_{99}$				
Independent variable: $\Delta \log(1-\tau)$	Parameter estimate	Standard error	t-value	Sample size
Taxpayers:				
All	0.676	0.125	5.39	38,743
With other income	0.514	0.141	3.65	28,435
Without other income	0.190	0.216	0.88	10,307
With other income in 1999 and 2002:				
Dep. variable: all taxable income	0.220	0143	1.53	22,415
Dep. variable: other income only	2.484	0.341	7.28	22,415

Table 8 shows the regression parameters on $\Delta \log(1-\tau)$ for the specification in Table 6 but for those taxpayer/income sub-samples.[23] The estimate for all taxpayers (0.676) is repeated from Table 6. Splitting the sample into taxpayers who had other income in at least one of the three years (1998, 1999, 2002), and those with only salary income gives a much larger parameter estimate of 0.514 for those with other income compared with the estimate of 0.19 for those with no other income. Only the former is statistically significant at conventional levels with much more noise associated with the 0.19 estimate.

Testing the sub-set of taxpayers with non-salary income both before and after reform (1999 and 2002), Table 8 confirms that the responsiveness of other income is substantially greater, with a parameter estimate on $\Delta \log(1-\tau)$ of 2.48 (t-ratio $= 7.28$) for other income, compared with 0.22 (t-ratio $= 1.53$) for salary income.

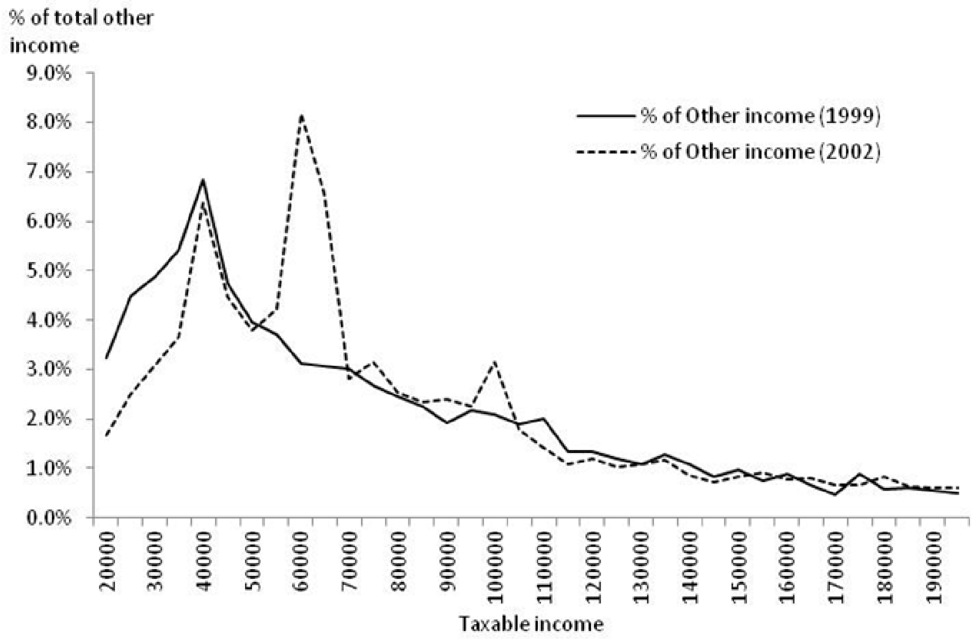
The importance of the other income component of total taxable income, and its response to the 2001 reform, can be seen in Figure 3. This shows the percentage distribution of all other income across ($5000) income bands both in 1999 and 2002.

The first point to note is that 'other income' is not especially concentrated among taxpayers with high taxable incomes; the bulk of other income is received by taxpayers in the $30-70$k$ taxable income range. This tends to suggest that the estimate above of high

22 There were additional complications associated with the reform that could induce income responses in either direction. For example, trust income received by trustees continued to be taxed at 33 per cent whereas it was taxed at 39 per cent if received by trust beneficiaries (with incomes over 60k$). There were also greater post-reform incentives for intra-household shifting of salary and other income, encouraging individual members facing lower marginal rates to declare a greater share of total household income.

23 These sample sizes refer to the sample of taxpayers randomly drawn from the distribution of all taxpayers and before being weighted (using Statistcis New Zealand population weights) to reflect the New Zealand population size and characteristics. This latter weighted sample covers 803,000 taxpayers.

Figure 3: The Distribution of Other Income



responsiveness of other income to tax rate changes is not exclusively a high-income earner phenomenon. Secondly, the clearest difference between the 1999 and 2002 distributions of other income is the new large spike in 2002 around the new \$60k threshold introduced in the 2001 reform. That is, a much larger fraction of other income in 2002 is accounted for by taxpayers with income around \$60k than was the case in 1999, with a compensating decrease in other income received by taxpayers with taxable incomes around \$25-35k.[24]

6.4 Who Responded to the 2001 Reform?

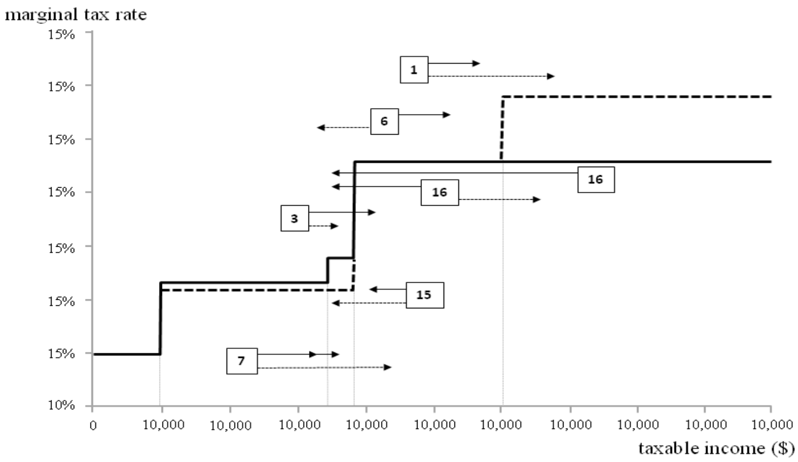
The above results suggest that taxpayers in receipt of non-wage and salary income responded especially strongly to the 2001 reform and, in particular, by altering the declared 'other income' component of their taxable income. This subsection considers whether these were exclusively, or mainly, those on higher incomes facing the 33 to 39 per cent tax rate change, or whether this response applied more generally.

Furthermore, the 2001 New Zealand tax reform involved a combination of constant, increasing and decreasing tax rates, so it is possible to identify the categories of taxpayer shown in Table 4 who contributed most to the observed responses. Table 4 shows that it was mainly taxpayers in categories 3, 6, 7, 15 and 16 whose incomes responded in the expected direction. These categories account for 75 per cent of all taxpayers in the sample. From the combinations of Δy, $\Delta \tau$, and $\Delta \tau^*$ which each category represents, it is possible to identify those tax brackets within the New Zealand tax system in which those taxpayers are located.

Figure 4 shows the tax schedules for 1999 and 2002, with tax rates rising for incomes above \$60,000, remaining constant between \$38,000 and \$60,000 and falling for taxpayers

[24] The data do not allow investigation of intra-household transfers of income. The evidence in Figure 3 may be indicative, in part, of previously low-income earners within a household (where the higher earner has income in excess of \$60k) taking a greater share of declared household income after reform. Thus, both household members move towards the \$60k threshold in opposite directions.

Figure 4: Tax Categories



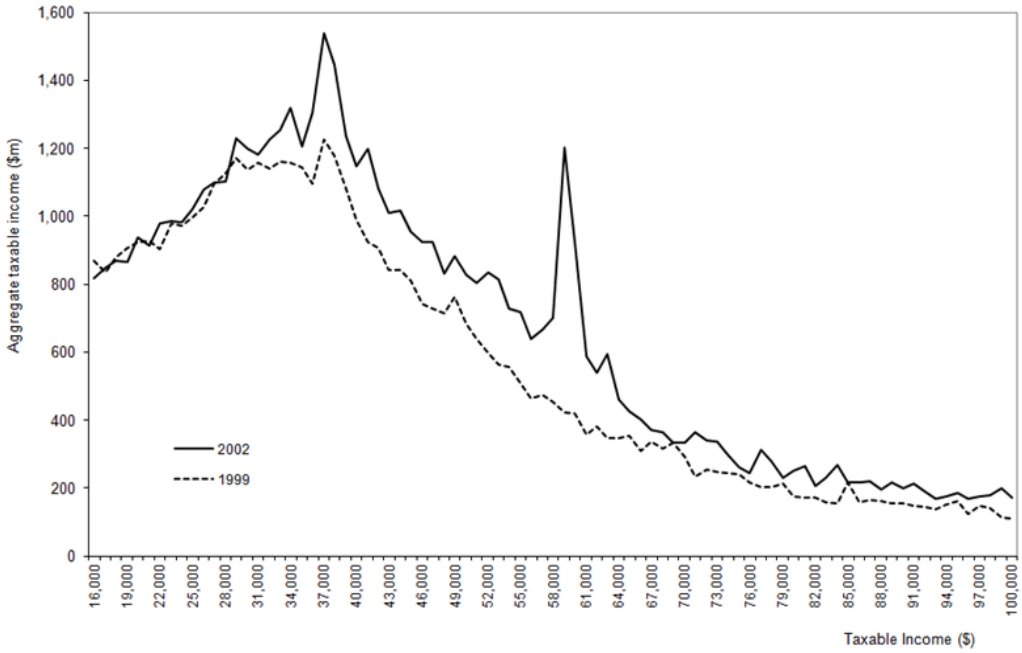
between $14,000 and $38,000. The Figure also shows the five categories of taxpayer of interest. The unbroken arrows indicate the observed movement in those taxpayers' incomes and marginal tax rates between 1999 and 2002; the broken arrows indicate the predicted movement in their 'expected tax rate' in the absence of reform based on the income dynamics described earlier.

For example, consider category 16, involving 152,000 taxpayers. Those taxpayers experienced a fall in their income and actual tax rate, while their predicted tax rate rose. This included two groups: taxpayers between \$38k and \$60k in 1999 whose incomes fell to below the \$38k threshold in 2002 but who were (in the absence of the reform) expected to move above the \$60k threshold. It also includes taxpayers with incomes above \$60k in 1999 whose 2002 income fell to less than \$38k. Their responses are discussed further below.

Category 7 is another large sub-set of 194,000 taxpayers. The experienced income increases took them towards the \$34.2k (1999) or \$38k (1999 and 2002) thresholds, but their predicted tax rate increase implies that they were expected to experience an income increase to above the \$38k threshold. Thus the higher jump in marginal rates at \$38k after 2001 (from 21 to 33 per cent instead of from 24 to 33 per cent) may have persuaded some taxpayers to declare lower income than otherwise expected, keeping their 2002 declared income below \$38k.

In addition to the categories listed above, category 1 in Table 4 captures a large number of taxpayers (122,000) where Δy, $\Delta \tau$, and $\Delta \tau^*$ are all positive. This includes taxpayers for whom their 'no reform' predicted income increase exceeds their actual income increase; that is, their response is consistent with a smaller declared income increase in response to the tax rate change from 33 to 39 per cent. This includes taxpayers below \$60k in 1999 and 2002 who would otherwise have crossed that threshold by 2002, and those above the \$60k threshold in both years, as shown in Figure 4. The standard instrument cannot account for the former group (below \$60k in 1999 and 2002) because of the restriction that the instrumented tax rate is based on unchanged income levels ($\Delta \tau^* = 0$ for incomes in the range \$38k and \$60k).

Figure 5: Distribution of Taxable Income



In summary, actual and expected taxpayer income movements, as depicted in Figure 4, suggest a large amount of crossing, and bunching around, the $38k and $60k thresholds. This is confirmed by an examination of the distribution of taxable income in 1999 and 2002. Figure 5 shows the two distributions of aggregate taxable income by $1000 income band over the $16k to $100k range (the range relevant to the analysis here). In addition to the general tendency for taxable incomes to rise over the three years (the 2002 profile generally lies above the 1999 version), a large spike can be seen to emerge around $60k in 2002 which did not exist in 1999. Further, the small spike evident around $38k in 1999 is considerable larger by 2002.

Figure 5 also suggests an increased concentration of taxable income in the $38k to $60k range in 2002 compared with 1999. The percentage of taxpayers and taxable income in this range rose from respectively 12 and 23 per cent to 15 and 26 per cent. Almost all of this reflected a net movement out of the $9.5k to $38k bracket. While the marginal tax rate in this bracket remained unchanged at 33 per cent before and after reform, the increased concentration here is consistent with expected behavioural responses to the combination of a reduced tax rate in the bracket below (24 to 21 per cent) and the increased rate in the bracket above (33 to 39 per cent). By itself, the increased bunching of taxable income around the two thresholds in Figure 5, and income growth within the $38k to $60k bracket, might be considered merely suggestive of responses to the 2001 reform. However, the regression evidence and the income movements identified in Table 4 offer strong confirmation that this reflects the predicted causal behavioural responses to tax reform when those predictions are based on modelling income changes that occur both with and without that reform.

7 Conclusion

This paper has examined estimation of the elasticity of taxable income using instrumental variable regression methods. It has argued that the 'standard instrument' for the net-of-tax rate – the rate that would be applicable post-reform but with unchanged income levels – is unsatisfactory in contexts where there are large numbers of taxpayers with exogenous changes in their taxable income. Two alternative tax rate instruments were proposed, based on estimates of the dynamics of taxable income for a panel of taxpayers over a period that involved no tax changes.

The parameters derived from that procedure were then used to construct hypothetical (or counterfactual) post-reform incomes that would be expected in the absence of reform. The first method is based on the tax rate each individual would face if their income were equal to 'expected income', conditional on income in two periods before the tax change. The second alternative uses the form of the conditional distribution of income for each taxpayer to obtain an instrument based on their 'expected tax rate'.

These methods were applied to the 2001 tax reform in New Zealand. This involved a convenient mix of marginal tax rate increases, decreases and no change across a wide range of incomes. Comparing taxable incomes in 1999 and 2002, the paper first examined taxpayer responses in terms of observed correlations between income change and changes in the actual and instrumented tax rates. Secondly, instrumental variable regressions were examined. Thirdly, these results were compared with observed and predicted changes in key parts of the taxable income distribution between 1999 and 2002. All three approaches suggest that observed income changes after reform reflect the causal behavioural responses to tax reform predicted by the elasticity of taxable income literature. However, an instrument based on the standard approach, of assuming unchanged income levels after reform, performed poorly. Instruments that are based on a model of income dynamics, estimated using extraneous information on incomes over a three-year period without any tax structure changes, performed much better, particularly the instrument based on an expected tax rate for each individual. Applying these instruments to analyses of income tax changes in other countries provides an interesting avenue for future research.

A Regression Estimates for US Tax Reforms

Table 9: Regression Estimates for US Tax Reforms

Tax Reform	MTR	Range of estimates			
	change	A: Regressions		B: Other	
		Low	High	Low	High
Goolsbee (1999)					
1924-25	↓	0.54	0.62	0.67	1.24
1932	↑	0.21	0.27	0.24	0.31
1935	↑	−0.83	−0.50	−0.46	−0.11
1935 (high income)	↑	−0.59	0.28		
1950-51	↑	0.10	0.17	0.03	0.44
1964	↓	0.00	0.04	−0.22	0.08
1971-72 (high income)	↓	−0.19	0.22		
1985-86	↓	0.88	1.15	0.22	2.07
Saez et al. (2012)					
1981 (top 1% & 9%)	↓	–		9%: 0.21	1%: 0.60
1986 (top 1% & 9%)	↓	–		9%: −0.20	1%: 1.36
1993 (top 1%)	↑			−0.39	0.45
1993 (next 9%)	↑	−0.37	0.46	without income controls	
1993 (next 9%)	↑	−1.67	2.42	with income controls	
1993 (next 49%)	↑	−1.87	3.35	with or without inc. controls	
1960-2006 (top 1%)		0.58	1.71	with time controls	
1960-2006 (next 9%)		−0.05	0.01	with time controls	
Kopczuk (2005)					
1980s	↓	−1.09	1.38	with or without inc. controls	
Auten et al. (2008)					
2001 and 2003	↓	0.26	0.67	with income controls	
Geirtz (2009)					
1990 and 1993 (weighted)	↑	−0.34	0.54	with income controls	
1990 and 1993 (unweighted)	↑	−2.90	0.23	with income controls	

B The Inland Revenue Data

The data used in this paper are personal income information sourced from the New Zealand Inland Revenue Department's (IRD's) tax returns and employer PAYE records. The database is a stratified random sample, including 2 per cent of all wage and salary earners (which in turn includes people in receipt of taxable welfare benefits) and 10 per cent of all other individual taxpayers, such as the self-employed. The database omits individuals with no personal taxable income (unless they filed a tax return), and those whose only income was from investments with the correct amount of tax deducted at source and no requirement to file a tax return. The former group are not of interest for this study, and the latter are expected to be a fairly small group representing a very small proportion of total taxable income. The database does not include income not attributed to natural persons, for example income held in companies or trusts.

Randomness is ensured by sampling taxpayers based on the last two digits of their unique 'IRD number', which are issued broadly sequentially and not reflective of the characteristics of the specific individual. In order to ensure these are representative of the total individual taxpayer population, weights are applied to each observation in the sample according to the characteristics of the individual. For 1999, the database includes a total sample of 138,464 individual taxpayers, representing a total population of 2,800,528 taxpayers. For 2002 the sample size increases to 139,420, representing a taxpayer population of 2,962,200.

The database covers the years 1994 to 2009, and allows users to follow individuals across time by use of their IRD number. Because filing requirements have changed across time, the dataset contains a number of structural breaks. These include a break across the 1999–2002 period considered here, when the pre-populated personal tax summary (PTS) replaced the old IR5 tax return. This had a minor impact on some income tax data collected, particularly with regards to dividend and interest income below a small threshold. Aside from salary and wage income data, the database also includes data on business income, trust income, interest, dividends, rental income, shareholder-employee salary, partnership income and other income. Expenses and losses claimed (including those through LAQCs) are also recorded, as well as information on demographic characteristics such as date of birth and gender. These data are taken from a range of sources, largely tax returns submitted to the IRD.

For the regressions in this study, various restrictions are applied to the data. Firstly, in recognition that various unrelated behavioural changes may bias the results, those taxpayers who were younger than 25 in 1999, or older than 64 in 2002, are removed from the sample. This fairly common restriction removes those taxpayers likely to be in the very early stages of a career, as well as those likely to have retired at the age of 65 (the age of eligibility for New Zealand superannuation). Secondly, those with 1999 taxable income less than $16,000 or greater than $1,000,000 are excluded from the sample. The first of these restrictions is particularly important in order to remove a significant segment of the population who received some form of government benefit, as abatement rates mean that these individuals face different effective marginal tax rates to standard taxpayers. Finally, the sample is necessarily reduced to only those individuals who have sufficient data in all six relevant income years (ending 1998, 1999, 2002, 2003, 2004 and 2005). Some taxpayers either entered or exited the tax system over this time, which means that their income dynamics cannot be estimated. A number of smaller, less significant restrictions are also imposed, such as the removal of zero or negative taxable income values and data entry errors (such as negative ages). Combined, these restrictions reduce the sample size to 38,744, which, when weighted up to reflect the population, represents 803,920 individual taxpayers (29 per cent of the original 1999 weighted sample).

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