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Population Ageing and the Growth of Income and Consumption Tax Revenue

Christopher Ball and John Creedy

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Population Ageing and the Growth of Income and Consumption Tax Revenue

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Abstract

This paper investigates the implications of population ageing and changes in labour force participation rates for projections of revenue obtained from personal income taxation and a consumption tax (in the form of a broad-based goods and services tax). A projection model is presented, involving changing age-income profiles over time for males and females. The model is estimated and applied to New Zealand over the period 2011-2062.

Executive Summary

This paper presents a framework for projecting income tax revenue, along with revenue from a broad-based goods and services tax. The major components of the model include a method of projecting the changing distribution of labour income with age for each cohort alive at each calendar date, for males and females. A simplified projection model of aggregate capital income is also used, based on the age-profile of the proportion of people receiving positive investment income and the (conditional) average of that investment income. Information about average benefits received (net of tax) over the life cycle are then combined with information about the changing propensity to consume with age, in order to project revenue both from personal income taxation and the Goods and Services Tax (GST) over the period 2011-2062.

Total revenue at each date is obtained by aggregating over the cross-section of all cohorts existing at that date. The components are estimated for males and females in New Zealand. The projections are in nominal terms in view of the taxation of nominal incomes in the NZ multi-rate structure.

The model can be used to examine the implications of alternative assumptions about population ageing, labour force participation, the general growth of incomes and the adjustment to tax thresholds.

It is found that as the baby-boomers move into retirement the burden of taxation is projected to have a compositional shift, from the current male modal age of 48 in 2010/11 to 43 in 2051/52. During the middle of the transition to retirement for the baby-boomers, the male modal age (in the distribution of tax revenue by age) is projected to fall to 40 in 2030/31. The distribution of the proportion of tax paid by females follows a similar pattern.

The projections of income tax revenue are also decomposed into 'pure ageing' and 'pure labour force participation' changes: for example, in the former case only the projected age composition of the population is allowed to change, while participation rates remain constant at their 2010/11 values. Ageing is found to reduce aggregate income tax revenue below the base model case. However, changing participation rates, particularly among women, imply higher tax revenue. The projected changes in the age distribution (with fixed labour force participation rates) reduce total tax revenue, below the base model case, by 2.4 per cent by the year 2061. However, the effect of changes in participation rates (with an unchanged age distribution) are projected to increase aggregate revenue above the base model case by 5.7 per cent.

The projected demographic and labour force participation changes are thus small, though not trivial. However, these effects are dwarfed by the much larger changes generated by income growth. Aggregate revenue projections are highly sensitive to changes in the overall rate of change in wages and capital income (affecting all cohorts), which is a major determinant of tax revenue growth, along with the assumption regarding indexation of income tax thresholds. The use of fiscal drag, which arises from not adjusting the thresholds, may not be sustained for long periods, otherwise a very large proportion of the population would move into the top income tax rate bracket. Hence the effect of periodic threshold adjustments was therefore examined.

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Population Ageing and the Growth of Income and Consumption Tax Revenue

1 Introduction

Much attention has been given to the potential effects on government social expenditure of population ageing, in view of the fact that many items of social expenditure are systematically and positively related to age.¹ However, less attention has been devoted to investigating the possible effects on income and consumption tax revenue. This is likely to be influenced by population ageing in view of the systematic variation in income and consumption over the life cycle and among cohorts. Furthermore, population ageing is expected to be accompanied by changes in age-specific labour force participation rates, especially by women.

The aim of this paper is to present a framework for projecting income tax revenue, along with revenue from a broad-based goods and services tax. The model allows for the changing age-income profile over time, and hence among cohorts, for income from employment. The major components of the tax revenue model include a method of projecting the parameters of the distribution of labour income (namely the mean and variance of log-income) for each cohort alive at each calendar date, for males and females. A simplified projection model of aggregate capital income is used, based on the age-profile of the proportion of people receiving positive investment income and the (conditional) average of that investment income. Then the tax system is applied and total revenue at each date is obtained by aggregating over the cross-section of all cohorts existing at that date. The effect on the overall effective average tax rate of population ageing can thereby be calculated. The age-income profiles models are estimated for males and females in New Zealand. With additional information about the changing propensity to consume over the life cycle, the model is used to project revenue both from personal income taxation and the Goods and Services Tax (GST) over the period 2011-2062. The approach may be seen as an alternative to 'ageing' a microsimulation model or using a highly aggregative time series projection model. The present approach specifies the structural components using relatively few estimated parameters, along with population and labour force projections by age and gender.

The basic way in which population ageing can affect tax revenue growth, and the components of the model used here, are introduced in Section 2. Section 3 presents the specification of the age-income profiles model and reports the estimates for New Zealand males and females. The method used to generate personal income tax revenue arising from wage and salary income, in the context of a multi-rate structure, is described in Section 4. The framework of analysis makes use of the distribution of income in each time period for each cohort, where it is necessary only to specify the form of the distributions

¹ For example, Creedy and Scobie (2005) examined expenditure projections for 14 age-related social expenditure categories.

and the relevant parameters. Here it is assumed that incomes can be approximated by the two-parameter lognormal distribution. This section also presents the projections for New Zealand under a variety of assumptions regarding indexation and the general growth of incomes. The model is extended in Section 5 to include GST revenue projections. In this case, in order to project changes in disposable incomes over time, it is necessary to estimate an additional age-income profiles model to allow for consumption financed from income arising from government benefits (net of any tax, as in the case of New Zealand Superannuation) other than wage, salary and self-employment income. The variation in average effective tax rates over time is considered in section 6. The model is extended in Section 7 to deal with capital income. In view of the complexities of dealing with capital income from a variety of sources, and the range of possible effective tax rates, a more aggregative approach is used here. Brief conclusions are in Section 8.

2 Tax Revenue and Population Ageing

This section discusses the main determinants of the variation in tax revenue and in particular the influence of population ageing. It describes the components which a tax revenue projection model must have. Tax revenue in any year is the sum of tax raised from many overlapping cohorts of different ages. Hence income and expenditure variations over the life cycle are of central importance. Population ageing, to the extent that it shifts more people into retirement, changes the balance between the tax bases for income tax and GST. The possible overall effect on tax revenue can only be evaluated with the use of a projection model that captures all the components discussed here.

2.1 Income Taxation

A crucial requirement of any analysis of income tax revenue changes over time is the ability to project the changing distribution of income over time for each cohort. Income projections must be in nominal, rather than real, terms because the income tax system is not automatically indexed. Within a single cohort (of individuals of the same age), the distribution of income varies over time as the members of the cohort age and as they move through calendar time: there are separate 'age' and 'time' effects. The systematic variation with age is such that mean incomes typically follow a 'hump' shape, reaching a maximum in late middle age (although the precise pattern differs for males and females). Furthermore, the dispersion of incomes generally increases with age. For projection purposes it is useful to have a model that is capable of describing these variations with relatively few parameters which can be estimated from available data.

Two strong assumption in what follows are, first, that the variations associated purely with age do not vary among cohorts (that is, there are no 'cohort effects' on earning, for example, associated with the size of cohorts) and, second, that the 'time' effect arises simply from the general growth of incomes, arising from productivity changes and inflation, which affects all age groups and cohorts similarly. The existence of general wage growth has two implications. First, for each cohort it delays the age at which average incomes reach a maximum over the life cycle. Second, it gives rise to an 'overtaking' effect whereby the incomes of succeeding cohorts are higher, at comparable ages, than earlier cohorts. Both of these effects imply an increasing tax base over time. The basic structure of age-income profiles is relatively stable over time, although the aggregate relationship may

change if there are substantial changes in the occupational composition of the labour force over time and if the profiles for specific occupations differ in their shapes. However, the general growth of wages and productivity can undergo short term variations which are less easy to predict: the projections assume a constant rate of growth over the whole of the projection period.

However, changes in the tax base do not depend only on the nature of age-income profiles. Importantly, the base is influenced by the changing age distribution of workers over time. That is, at any time, it depends on the age distribution of workers alive at that time (strictly on the age and gender distribution of workers). In turn the age distribution of workers results from the combined effect of the age-and-gender distribution of the population and age-and-gender-specific labour force participation rates. It is possible for changes in participation rates over time (that is, among cohorts) to compensate for, or modify to some extent, the changes arising from population age structure changes. Income tax revenue changes therefore depend crucially on detailed projections of the labour force. While there can be some confidence about population projections, labour force participation changes can undergo unforeseen changes.

The effects of a systematic increase in the average age of workers does not have obvious *a priori* implications for tax revenue changes. Clearly population ageing means that there are more people in retirement and hence in receipt of much lower taxable incomes. However, to the extent that ageing implies that relatively more people move to the age groups for which incomes are at their life-cycle peak, tax revenue is higher. And, in addition, higher general growth of incomes shifts the peak of the age-income profiles to a higher age. If the average age of workers moves from shortly before, to shortly after, the age of peak incomes, there may be very little effect on revenue.

The general shape of the age-income profile implies that individuals typically move into higher income tax brackets, and hence face higher marginal and average tax rates, as they approach the peak of incomes. A crucial factor in projecting income tax revenue is thus the extent to which the income thresholds in the multi-rate tax structure are adjusted over time. A lack of full indexation implies, through ‘fiscal drag’, a substantially higher revenue compared with indexation. Furthermore, the extent to which fiscal drag results in higher revenues when nominal incomes increase is determined by the degree of marginal rate progression in the system (which influences the difference between the average and the marginal tax rate at any income level, and in aggregate).

2.2 GST Revenue

Indirect tax revenue growth depends on the changing pattern of expenditure over the life cycle. Hence it is influenced partly by the income tax system, in conjunction with taxable income variations, in generating disposable incomes. But of course disposable incomes are also influenced by income from untaxed sources, in particular transfer payments or benefits, including superannuation. Where benefits are taxable, as for example in the case of New Zealand Superannuation, these are recorded net of tax. The projection of GST requires a life-cycle model of non-taxable income similar to that for taxable income, although of course it takes a different shape. In the New Zealand context, projections of GST revenue are considerably simplified by the fact that the GST base is extremely broad. Indeed, it is reasonable to assume for projection purposes that GST is a simple proportion of total expenditure. Without this simplification it would be necessary to have detailed information about the variation in expenditure patterns (the proportion of total expenditure devoted to goods and services which attract GST) with total expenditure and age.

A considerable difficulty is nevertheless introduced by the need to have information about saving patterns. A further simplifying assumption is that the proportion of disposable income that is spent depends on age but is independent of the absolute level of disposable income. By assuming a fixed proportion (depending on age), combined with the broad base of GST, it is necessary only to project the aggregate disposable income of each cohort in each year of the projection period: the distribution can be ignored.

Information about saving rates by age is notoriously difficult to obtain. In particular, there is little knowledge of the rate at which assets are drawn down in retirement (so that the propensity to consume out of disposable annual income exceeds one). The projection model used here uses a simple age-profile of saving rates, where they are calibrated to produce (for the start of the projection period) aggregate GST revenues that roughly match observed aggregates. The profile is then assumed to apply to all cohorts during the projection period.

3 Cohort Income Profiles

This section presents the age-income profiles model used, along with estimates for New Zealand males and females. This model is at the heart of the tax revenue projection method. The basic specification is in subsection 3.1, and empirical estimates are reported in subsection 3.2.

3.1 The Specification

Suppose the distribution of taxable income in each age group can be described by the two-parameter lognormal distribution. Let $\mu_{t,c}$ denote the mean log-income at time (calendar date) t for cohort c . Here c is the date at which the cohort enters the labour market. The model is applied to males and females separately below, but for convenience extra subscripts are omitted here. Similarly, let $\sigma_{t,c}^2$ denote the variance of log-income at time t for cohort c . With the assumption of lognormality, income, y , for cohort c at date t follows the distribution function denoted by $\Lambda(y | \mu_{t,c}, \sigma_{t,c}^2)$.²

At any date, t , a number of cohorts exists. For the cohort entering the labour market at t , then $c = t$. For those entering in the previous year, then $c = t - 1$, and so on. For example, if individuals enter at age 15 and leave at age 75, the oldest cohort alive at time t is $c = t - 60$.

Let d denote the number of years of experience in the labour market and suppose that average log-income at time t for those with experience of d , $\mu_{t,d}$, is generated from:

$$\mu_{t,d} = \alpha_0 + \alpha_1 d + \alpha_2 d^2 + \beta_1 t \quad (1)$$

This specification assumes that there are quadratic experience effects and a linear time effect, but no separate cohort effect, say arising from different sizes of cohorts. Nevertheless, different cohorts follow different profiles as a result of the shift over time.³

² On the lognormal distribution see Aitchison and Brown (1957).

³ It would be relatively simple to add quadratic time effects, if desired; see Creedy (1992, 1998).

Experience, calendar time and cohort are closely related as $d = t - c$. Hence mean log-income for cohort c at date t is given by:

$$\mu_{t,c} = \alpha_0 + \alpha_1 (t - c) + \alpha_2 (t - c)^2 + \beta_1 t \quad (2)$$

and:

$$\mu_{t,c} = (\alpha_0 - \alpha_1 c + \alpha_2 c^2) + (\alpha_1 + \beta_1 - 2\alpha_2 c) t + \alpha_2 t^2 \quad (3)$$

This describes the required evolution over time in the mean log-income of cohort c .

The quadratic specification has been widely adopted for male incomes, but for women in New Zealand, it has been found that a cubic experience effect is significant, so that (1) becomes:

$$\mu_{t,d} = \alpha_0 + \alpha_1 d + \alpha_2 d^2 + \alpha_3 d^3 + \beta_1 t \quad (4)$$

and (3) becomes:

$$\begin{aligned} \mu_{t,c} = & (\alpha_0 - \alpha_1 c + \alpha_2 c^2 - \alpha_3 c^3) + (\alpha_1 + \beta_1 - 2\alpha_2 c + 3\alpha_3 c^2) t \\ & + (\alpha_2 - 3\alpha_3 c) t^2 + \alpha_3 t^3 \end{aligned} \quad (5)$$

It is also necessary to describe the changing dispersion of income over time for each cohort. While extensive evidence suggests that mean incomes of succeeding generations are affected by real wage growth, giving rise to an ‘overtaking’ effect (the intercept in the profile of $\mu_{t,c}$ with t increases as c increases), a similar phenomenon does not appear to apply to the variance of log-income. Thus the overtaking involves a shifting age-income profile but not a spreading in incomes. Hence it is assumed here that there are only experience effects.

One approach to examining the changing dispersion of income with experience is to specify a dynamic process of relative income changes and derive the resulting profile of the variance of logarithms. For example, in the simplest case of a random process of relative changes (a Markov or, in the present context, a Gibrat process), it is known that the variance of log-income increases linearly with age.⁴ However, concern here is only with the form of the distribution at any date, so the approach taken here is simply to specify a particular functional form without being concerned with the dynamic process that may be consistent with that variation. Nevertheless, in estimating the model, it was found that a linear form was sufficient to describe the variation with experience for both males and females. Hence:

$$\sigma_{t,d}^2 = \gamma_0 + \gamma_1 d \quad (6)$$

and again using $d = t - c$:

$$\sigma_{t,c}^2 = (\gamma_0 - \gamma_1 c) + \gamma_1 t \quad (7)$$

Equations (3) and (7) provide the required information concerning the parameters of the appropriate lognormal distributions. The arithmetic mean income, $\bar{y}_{t,c}$ is given, from the basic properties of the lognormal distribution, by:

$$\bar{y}_{t,c} = \exp \left(\mu_{t,c} + \frac{\sigma_{t,c}^2}{2} \right) \quad (8)$$

The experience profiles of arithmetic mean income and other quantiles of the distribution are discussed further below.

⁴ On the implications of alternative dynamic processes for the variance-experience profile, see Creedy (1985, pp. 38-39).

3.2 Estimates for New Zealand

This subsection presents the estimates of the parameters of the income model for New Zealand males and females. In estimating the model an immediate problem arises from the fact that no distinction has been made regarding the hours worked by individuals. Furthermore, in considering labour force participation rates (when obtaining tax revenue below), information is used only about the number of participants in each age and gender. For example, part-time and full-time workers are not distinguished as separate categories.

The income data were obtained from the *Household Economic Survey* (HES). The approach used in generating values of μ and σ^2 was to make an adjustment to individual incomes which effectively removes variations attributed to differences in hours worked. First, the effective wage of each individual is defined as the total income from wages, salary and self employment divided by the total number of hours worked across all jobs.⁵

Pooled HES data for five years (2006/07 to 2010/11) were used to obtain average single-year-of-age values for people aged strictly between 20 and 65. Average annual values were used for those younger than 20 and older than 65. The effective wage rate for each individual was then multiplied by the mean total hours worked for the cohort in order to obtain incomes which were then used to compute corresponding μ and σ^2 values. These provided the data for estimating the parameters of the experience-income profile above. The parameter estimates, obtained by weighted least squares, are reported in Tables 1 and 2. The former table gives the estimates for the age-income profiles while the latter gives the results for the variance profiles. The values in parentheses are t -statistics. The age profiles of mean log-income display the usual ‘hump’ shape expected, although the profile for females shows that a cubic provides a better fit than the quadratic. For both males and females, a linear form was found to be sufficient for the variance of log-income, capturing the common finding that the relative dispersion increases systematically with age.⁶

Table 1: Age–Earnings Profiles for Males and Females

Coefficient	Males	Females
α_0	9.2485 (116.06)	8.789 (61.790)
α_1	0.1127332 (16.25)	1.579E-01 (6.995)
α_2	-0.0018119 (-14.02)	-4.474E-03 (-4.608)
α_3	—	3.710E-05 (3.068)
R^2	0.8808	0.8177

The way in which succeeding cohorts ‘overtake’ previous cohorts as a result of income growth over time is shown for males in Figure 1, which shows the profiles of arithmetic mean income with age, for four different cohorts, under the assumption that $\beta = 0.035$; that is, an annual nominal growth rate of 3.5 per cent for incomes. The existence of

⁵ This effective wage concept was used to decide how to treat outliers, removing anyone with a reported wage of less than \$2 per hour or more than \$350 per hour.

⁶ Higher-order terms were not significantly different from zero.

Table 2: Age Profiles of Variance Log-Income

Coefficient	Males	Females
γ_0	0.1392911 (5.799)	0.211834 (7.650)
γ_1	0.007318 (8.747)	0.003362 (3.477)
R^2	0.6456	0.2235

many overlapping cohorts at any point in time, each at a different stage in the life cycle, is illustrated in Figure 2, for male cohorts.

Figure 1: Examples of Cohort Profiles: Males

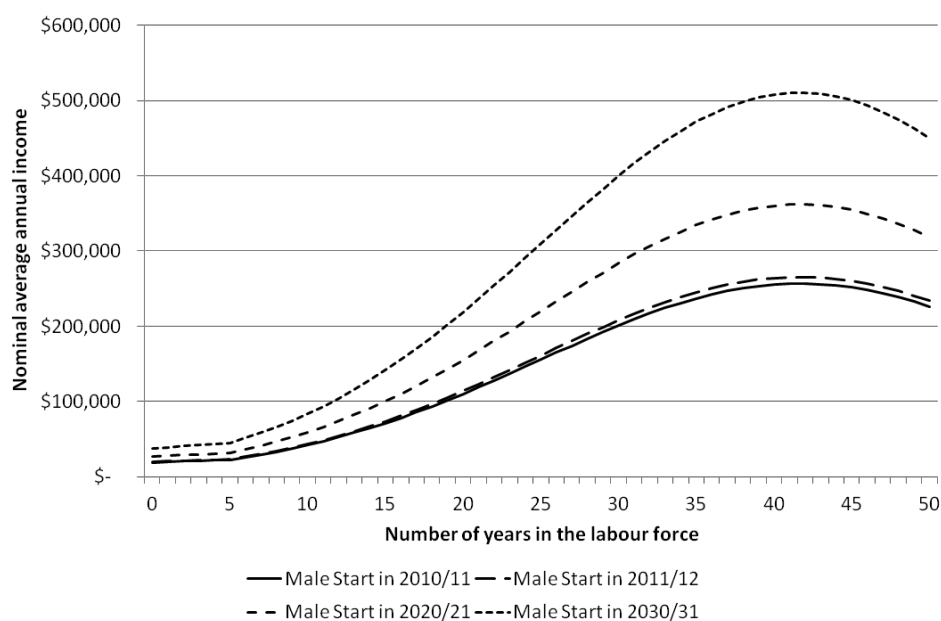
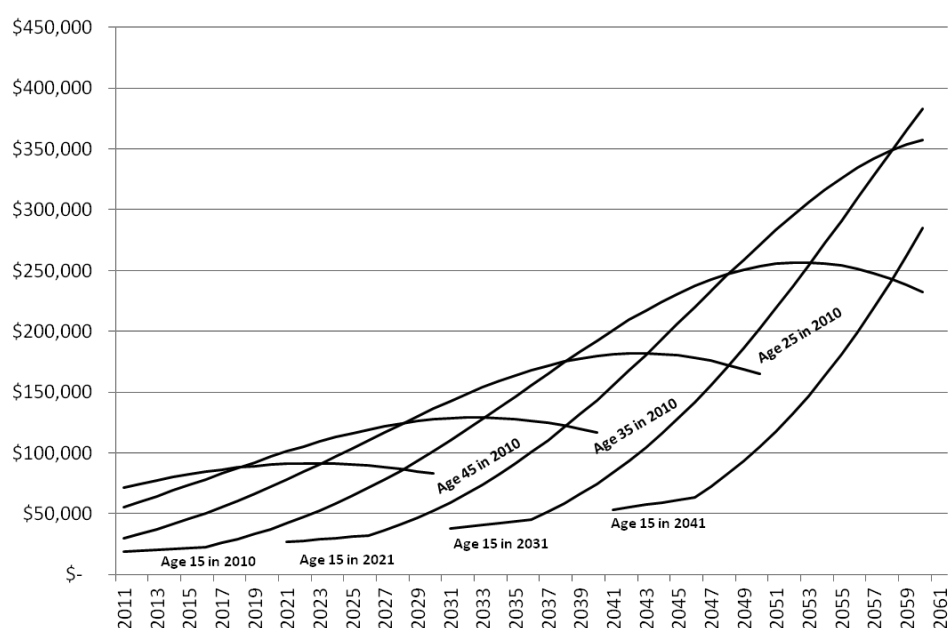


Figure 2: Time Profile of Mean Income: Various Male Cohorts



4 Income Tax Revenue

The model of the previous section described, in terms of the changing parameters of lognormal distributions, the age-income profiles of succeeding cohorts of males and females in New Zealand. The parameter estimates applied to incomes from employment and self-employment. The aim of this section is to make use of the income model to obtain total income tax revenue in a range of time periods, aggregated over all existing cohorts, where each cohort's age-earnings profile can differ as a result of the 'overtaking' phenomenon. In addition, population ageing means that, over time, the relative size of each cohort in the total population varies.

The basic framework and relationships are described in subsection 4.1. The calculation of total income tax revenue from a multi-step function, given the mean and variance of the relevant lognormal distribution, is then described in subsection 4.2. The accounting framework of analysis and the model of income profiles are applied separately to males and females, but for notational convenience the exposition here again does not make this distinction. Income tax projections for New Zealand are reported in subsection 4.3.

4.1 The Basic Framework

Suppose the income tax paid on an income of y is denoted $T(y)$. This function depends on a number of parameters, typically income thresholds and marginal rates, and these may change over time. But they need not be specified at the present stage.

Let $T_{t,c}$ denote the tax paid per employed person (for whom $y > 0$) in cohort c at time t . This is expressed as:

$$T_{t,c} = \int T(y) d\Lambda(y | \mu_{t,c}, \sigma_{t,c}^2) \quad (9)$$

where, as above, $\Lambda(y | \mu_{t,c}, \sigma_{t,c}^2)$ is the two-parameter lognormal distribution function. Let $P_{t,c}$ denote the number of individuals from cohort c who are alive at time t . Information on $P_{t,c}$ can be obtained from data on demographic projections. Furthermore, $w_{t,c}$ denotes the participation rate (the proportion of the cohort who work) of cohort c at time t .⁷

Let R_t denote total income tax revenue at time t . This is expressed as:

$$R_t = \sum_{c=t-100}^t T_{t,c} P_{t,c} w_{t,c} \quad (10)$$

The summation is indicated to begin at $t - 100$ to cover all cohorts alive at any time, assuming no one lives beyond 100 years.⁸ Total income at time t , denoted Y_t , can be written as:

$$Y_t = \sum_{c=t-100}^t \bar{y}_{t,c} P_{t,c} w_{t,c} \quad (11)$$

⁷ As explained in the previous section, no distinction is made here regarding different hours of work. An allowance was made when constructing the income data on which the profiles were estimated, rather than introducing separate treatments for workers in different hours categories.

⁸ However, in the application reported here the 75 and over age group was in fact aggregated into a single group.

where $\bar{y}_{t,c}$ is given by (8) above. The overall average tax rate, ξ_t , is thus:

$$\xi_t = \frac{R_t}{Y_t} \quad (12)$$

The following subsection explains how the $T_{t,c}$ values can be obtained for a multi-step income tax function.

4.2 A Multi-Step Tax Function

This subsection describes how the revenue per person can be calculated for a given population group, given the appropriate parameters of a lognormal income distribution, in the case of the multi-rate tax function. The approach is described in general terms, since it can be applied to any taxable income distribution. The multi-rate function is defined, omitting individual subscripts for convenience, by:

$$\begin{aligned} T(y) &= 0 & 0 < y \leq a_1 \\ &= \tau_1 (y - a_1) & a_1 < y \leq a_2 \\ &= \tau_1 (a_2 - a_1) + \tau_2 (y - a_2) & a_2 < y \leq a_3 \end{aligned} \quad (13)$$

and so on. If y falls into the k th tax bracket, so that $a_k < y \leq a_{k+1}$, and $a_0 = \tau_0 = 0$, $T(y)$ can be written for $k \geq 1$ as:

$$T(y) = \tau_k (y - a_k) + \sum_{j=0}^{k-1} \tau_j (a_{j+1} - a_j) \quad (14)$$

The expression for $T(y)$ in (14) can be rewritten as:⁹

$$T(y) = \tau_k y - \sum_{j=1}^k a_j (\tau_j - \tau_{j-1}) \quad (15)$$

Hence:

$$T(y) = \tau_k (y - a_k^*) \quad (16)$$

where:

$$a_k^* = a_k - \sum_{j=0}^{k-1} \left(\frac{\tau_j}{\tau_k} \right) (a_{j+1} - a_j) = \sum_{j=1}^k a_j \left(\frac{\tau_j - \tau_{j-1}}{\tau_k} \right)$$

Any multi-rate function can be written, for those in a particular tax bracket, as an equivalent single-rate structure applied to income measured in excess of a tax-free threshold. Using this result in (16), and in general for the distribution function, $F(y)$, aggregate tax revenue, T_Y , per person is:

$$T_Y = \sum_{k=1}^K \left[\tau_k \int_{a_k}^{a_{k+1}} (y - a_k^*) dF(y) \right] \quad (17)$$

This expression can be simplified further using:

$$\int_{a_k}^{a_{k+1}} dF(y) = F(a_{k+1}) - F(a_k) \quad (18)$$

and:

$$\int_{a_k}^{a_{k+1}} y dF(y) = \bar{y} \{F_1(a_{k+1}) - F_1(a_k)\} \quad (19)$$

⁹ On this formulation of the multi-step function and further applications, see Creedy and Gemmell (2006, pp. 25-26).

where \bar{y} is arithmetic mean income and $F_1(\cdot)$ denotes the first moment distribution function such that $F_1(y)$ is the proportion of total income obtained by those with income less than or equal to y ; therefore:

$$F_1(y) = \frac{\int_0^y u dF(u)}{\int_0^\infty u dF(u)} = \frac{1}{\bar{y}} \int_0^y u dF(u) \quad (20)$$

Thus:

$$T_Y = \bar{y} \sum_{k=1}^K \tau_k \left[\{F_1(a_{k+1}) - F_1(a_k)\} - \frac{a_k^*}{\bar{y}} \{F(a_{k+1}) - F(a_k)\} \right] \quad (21)$$

The first term in curly brackets is the proportion of total income obtained by those between the income thresholds, a_{k+1} and a_k , while the second term in curly brackets is the proportion of people between the same thresholds. In the case of the lognormal distribution, the required integrals can be obtained conveniently using the areas under a standard normal distribution. First, from the properties of the lognormal distribution, it is known that the first moment distribution has a mean of logarithms of $\mu + \sigma^2$ and variance of logarithms of σ^2 . Hence, where $N(y|0, 1)$ denotes the area below y of a standard normal distribution, the required integrals are given by:

$$F(a_k) = N\left(\frac{\log a_k - \mu}{\sigma} \middle| 0, 1\right) \quad (22)$$

and:

$$F_1(a_k) = N\left(\frac{\log a_k - \mu}{\sigma} - \sigma \middle| 0, 1\right) \quad (23)$$

Total revenue may be written more succinctly by defining the function $G_k(a_k)$ as the term in square brackets in (21) so that:¹⁰

$$T_Y = \bar{y} \sum_{k=1}^K \tau_k G_k(a_k) \quad (24)$$

When projecting revenues over long periods into the future a decision must clearly be made regarding the appropriate adjustment of the income thresholds.

4.3 Income Tax Revenue Growth in NZ

When using the above method to project tax revenues, it is necessary to obtain population and labour force projections by single year and gender. The population projections by gender and single year of age were obtained from Statistics New Zealand,¹¹ along with the labour force projections.¹² Figures 3 and 4 show the variations with age in the male and female populations, labour force participation rates and labour force in 2011. These clearly show the rapid decline in participation rates after 65, the age of entitlement to New Zealand Superannuation. The projected patterns show, in addition to some smoothing of the age profiles, slight increases in participation rates in the higher age groups.

The growth parameter, $\beta = 0.035$, has been chosen to be consistent with the long-term stable wage growth assumed in the Treasury Long-Term Fiscal Model.¹³ This consists of

¹⁰ The function G and variants is examined in detail in Creedy (1996, pp. 42-44).

¹¹ http://www.stats.govt.nz/tools_and_services/tools/TableBuilder/population-projections-tables.aspx The population projections aggregate the 90+ age group.

¹² http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment/NationalLabourForceProjections_HOTP06-61update.aspx

¹³ <http://www.treasury.govt.nz/government/longterm/fiscalmodel>

Figure 3: Male Population, Participation and Labour Force by Age: 2011

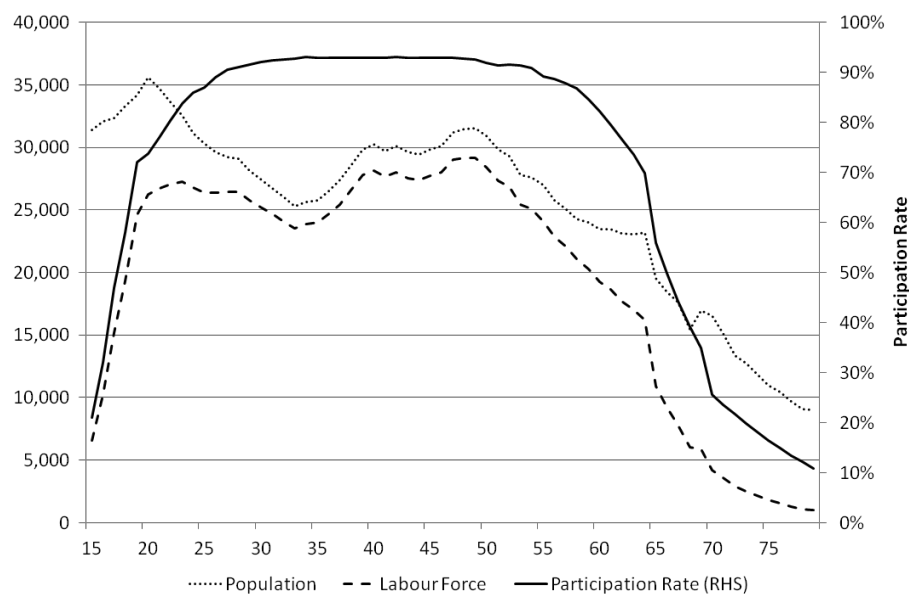
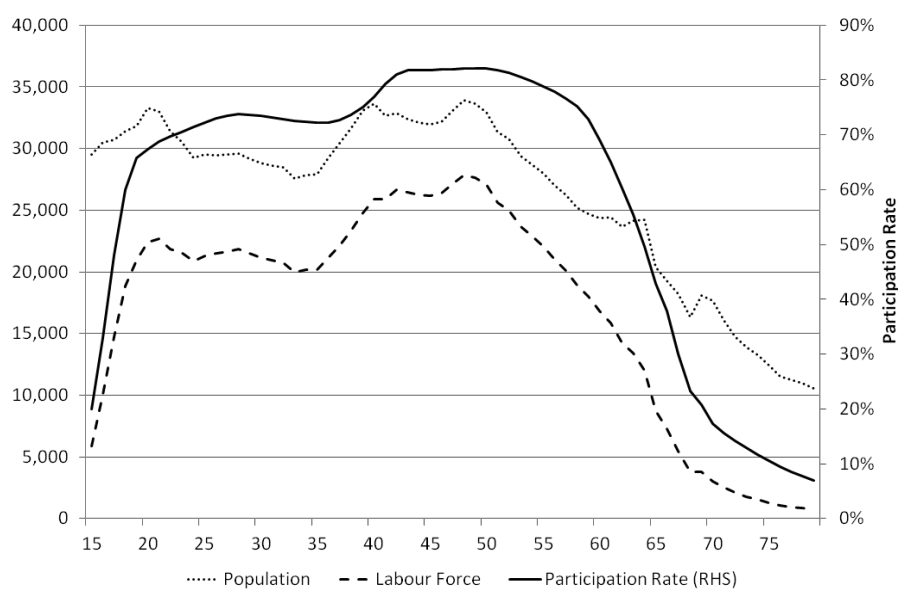


Figure 4: Female Population, Participation and Labour Force by Age: 2011



inflation of 2 per cent and real wage growth of 1.5 per cent per year. These assumptions, along with the income profile estimates reported earlier, were used to obtain the 'base model' results, in which the income thresholds are not adjusted over time. Hence 'fiscal drag' operates over the whole period. In addition, some sensitivity analyses were carried out as follows.

1. A 'no ageing' case holds the population age structure for males and females constant at 2010/11 proportions of population, for males and females respectively. The same aggregate male and female populations apply in the year, as do the same labour force participation rates.
2. A 'constant labour force participation' case holds the labour force participation rates frozen at the 2010/11 values.
3. A 'wage indexation' case adjusts the income thresholds of the tax function every year according to wage growth, starting in 2010/11.
4. A 'sawtooth' case allows fiscal drag to operate for 10 year periods, when the income thresholds are adjusted to the wage indexation values, allowing fiscal drag to occur between the adjustments.
5. In 'base model +1%' and 'base model -1%', the overall rate of wage growth is set at 1 per cent higher, and lower, than the long-term assumed rate of 3.5 per cent.

First, the base model is compared with the no-ageing and constant labour force participation cases in Figures 5 and 6, for females and males respectively. These demonstrate the small effect on income tax revenues of anticipated increases in labour force participation rates. Furthermore, population ageing reduces the revenue slightly, in view of the relatively larger number of males who are beyond their peak income-earning age groups. However, the effect is relatively small. Figures 7 and 8 show the profiles of the proportion of tax paid by each age group in three selected years, for females and males respectively. Relatively more tax is paid in the higher age groups in later years because of the increased labour force participation in those groups, the effect being larger for females. Clearly, relatively less tax is paid by those around 50 years of age in the later projection years. The nature of the changing labour force can also be seen from Figure 9, which shows the projected variation over time in the average age of male and female taxpayers. The role of female labour force participation changes is clearly evident in the early years. The very slight decline for males arises from the retirement of the baby-boom generation.

Figures 10 and 11 show the effects of alternative assumptions. The growth rate clearly has the most substantial impact on revenue. Indexing thresholds for wage growth reduces revenue substantially below the base case (of no adjustment). The periodic adjustment of thresholds, to bring revenue down to the full wage indexation profile every decade, leads not surprisingly to projections that are closer to the full indexation case than when fiscal drag is allowed to operate over the whole period.

Figure 5: Decomposition of Growth of Income Tax Revenue: Females



Figure 6: Decomposition of Growth of Income Tax: Males

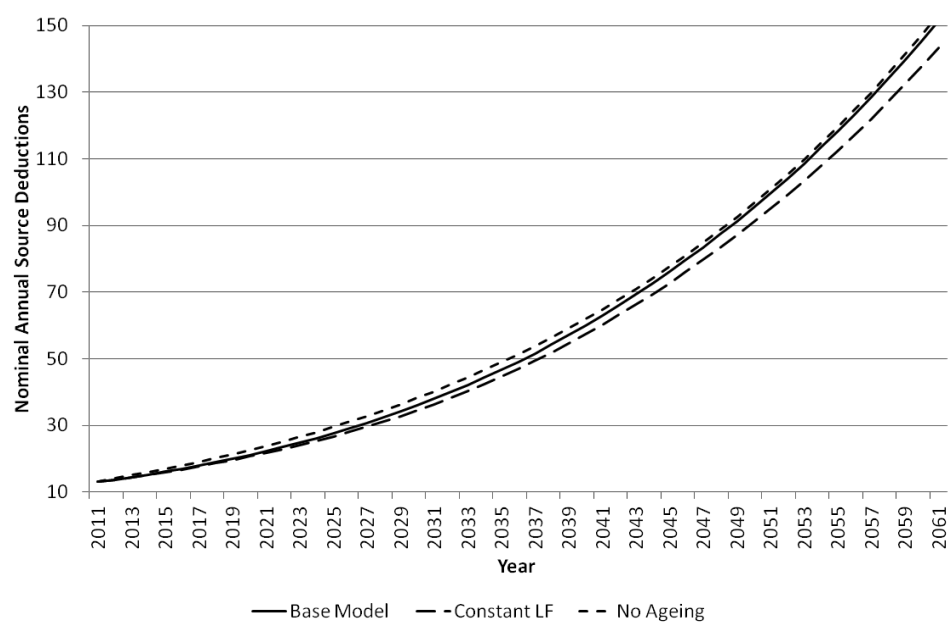


Figure 7: Proportion of Tax Paid by Age: Females

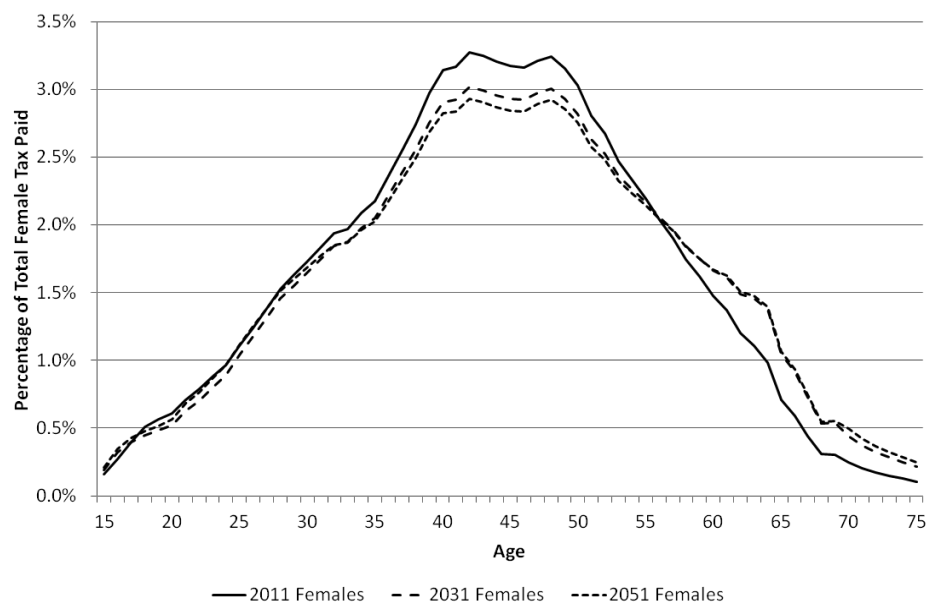


Figure 8: Proportion of Tax Paid by Age: Males

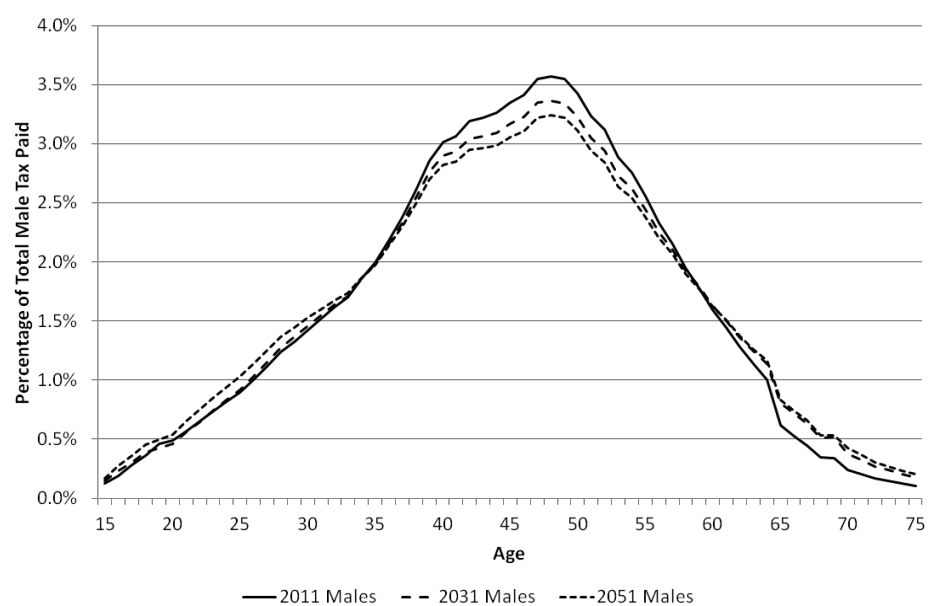


Figure 9: Average Age of Taxpayers

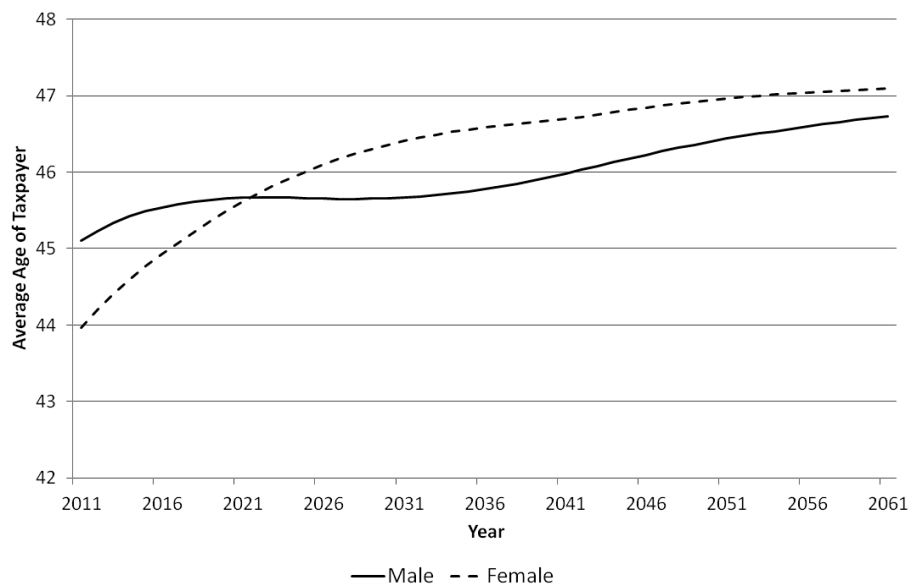


Figure 10: Growth of Income Tax Revenues for Alternative Scenarios: Females

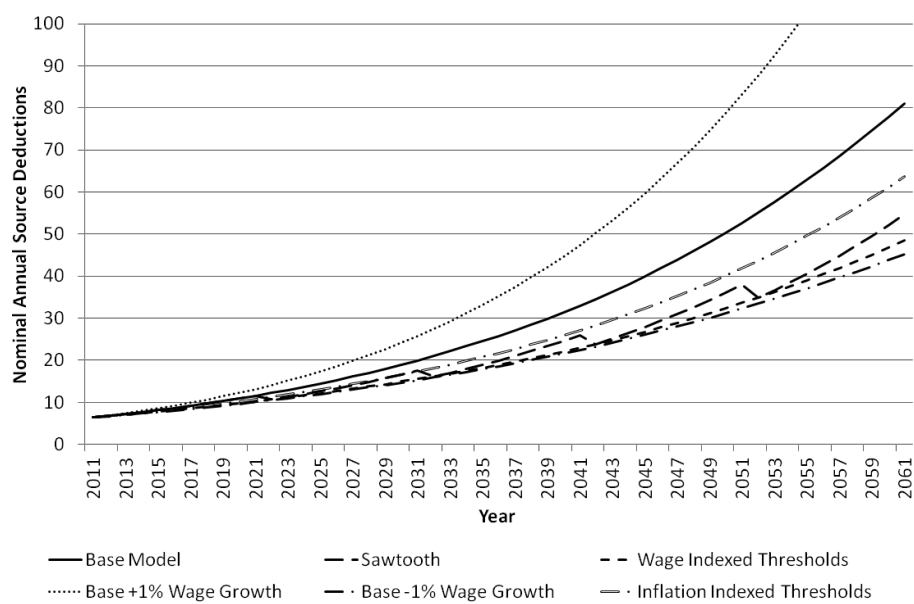
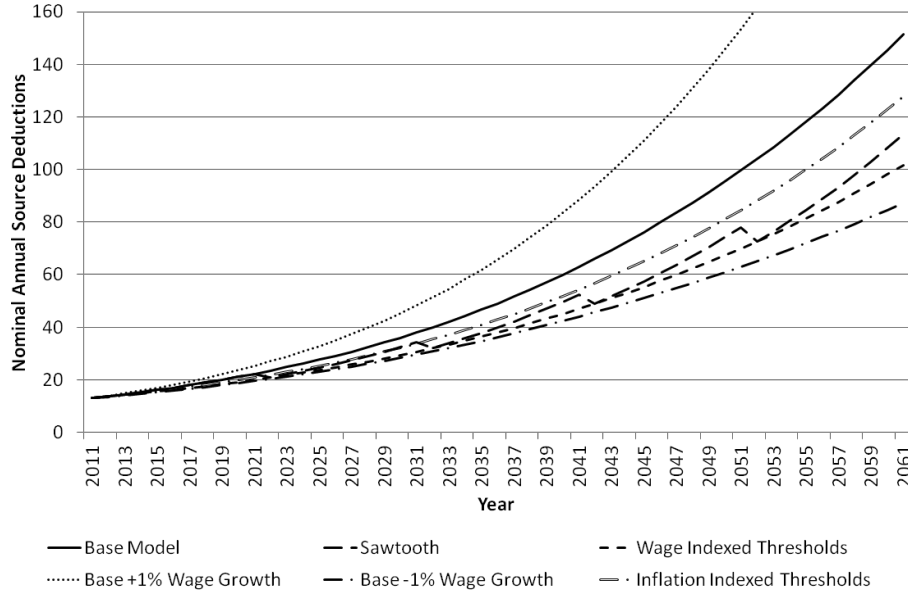


Figure 11: Growth of Income Tax Revenue for Alternative Scenarios: Males



5 Consumption Tax Revenue

This section extends the above model to consider consumption tax revenue projections. The approach is simplified by the fact that the GST in New Zealand is broad-based, so that it can be approximated by a proportional tax on total consumption. The basic framework is set out in subsection 5.1. An important difference from the treatment of income taxation is that it is necessary to consider disposable income, rather than simply income from wages, salary and self employment. Income profiles are augmented by an additional model of the variation in mean income from other (non-taxable) sources. The corresponding income profile estimates are reported in subsection 5.2. Subsection 5.3 reports projection results for New Zealand.

5.1 A Broad-Based Consumption tax

Suppose the tax exclusive rate of GST is v , so that the tax-inclusive rate is $v' = v / (1 + v)$. For a broad-based tax structure like the GST in New Zealand, it is reasonable to suppose that this rate applies to all consumption expenditure. Suppose that the proportion of disposable income that is spent by cohort c at time t is equal to $\delta_{t,c}$; that is, the simplifying assumption is made that this proportion is independent of the level of income. The average annual non-taxed income (including superannuation and other benefits measured net of any tax) received are equal to $b_{t,c}$, and it is assumed that all this is spent in the year it is received. The GST paid by cohort c at t is therefore given by:

$$G_{t,c} = v' P_{t,c} [\delta_{t,c} (\bar{y}_{t,c} - T_{t,c}) w_{t,c} + b_{t,c}] \quad (25)$$

The total income tax plus GST paid in year t , denoted T_t , is thus:

$$T_t = \sum_{c=t-60}^t P_{t,c} w_{t,c} \{T_{t,c} + v' \delta_{t,c} (\bar{y}_{t,c} - T_{t,c})\} + v' \sum_{c=t-85}^t P_{t,c} b_{t,c} \quad (26)$$

where the second summation is over a wider range of cohorts to allow for consumption by retired individuals.

5.2 Non-Taxable Income Profiles

As shown in the previous subsection, it is necessary to consider separately the age-profiles of non-taxable income, including after-tax New Zealand Superannuation and other benefit payments. In this case it was found that a cubic term is not needed to describe the age-income profiles for non-taxable income for women. The estimates of the non-taxable income profiles are shown in Table 3. Here it is not necessary to know the variance of this component of income, although there is a systematic decline in the variance of logarithms with age, associated with the large proportion of the higher-age groups in receipt of benefits and the considerable variability among the lower age groups in additional sources of income. The age-profile of consumption rates are in Table 4, based on Gibson and Scobie (2001). In the projections reported below, it is assumed that the values of b are adjusted in line with wage growth, rather than prices. The use of a lower indexation rate (for example, maintenance of their real value rather than a steady increase) would of course reduce the growth of GST revenue.

Table 3: Age-Income Profiles for Non-Taxable Income

Coefficient	Males	Females
α_0	8.547 (114.751)	8.805 (124.510)
α_1	-9.168e-03 (-1.782)	-3.229e-03 (-0.646)
α_2	4.353e-04 (5.872)	2.567e-04 (3.506)
R^2	0.8337	0.7024

Table 4: Consumption Rates by Age

Age group	Consumption rate, δ
15–18	0.95
19–24	0.95
25–34	0.89
35–44	0.89
45–54	0.94
55–64	1.01
65–74	1.16
75+	1.16

5.3 Consumption Tax Revenue Growth

Figures 12 and 13 show the growth of GST revenues for females and males respectively, for each of the cases discussed earlier. The projections for income tax and GST combined, and for males and females combined, are shown in Figure 14. The effect of pure ageing and labour force effects are shown for both taxes combined in Figure 15. By the year 2061, the projections show that the effect of ageing alone (constant participation ratios) is to reduce the total tax revenue by 2.4 per cent compared with the base model. The effect of projected labour force participation changes (with a constant age distribution)

is to increase total revenue above the base model by 5.7 per cent. While these are by no means trivial differences, they are small in comparison with the effects of changes in wage growth or the use of different threshold indexation rules. One reason why the 'pure ageing' projection of GST revenue is below that of the base model is that the latter has no indexation of income tax thresholds. This means that disposable incomes are lower than otherwise and hence that GST revenue is lower. In fact further results show that when the income tax thresholds are fully indexed for wage growth, and income tax revenue is correspondingly lower, the GST revenue from 'pure ageing' is actually higher than in the base model with indexation.

Figure 12: Growth of GST Revenue for Alternative Scenarios: Females

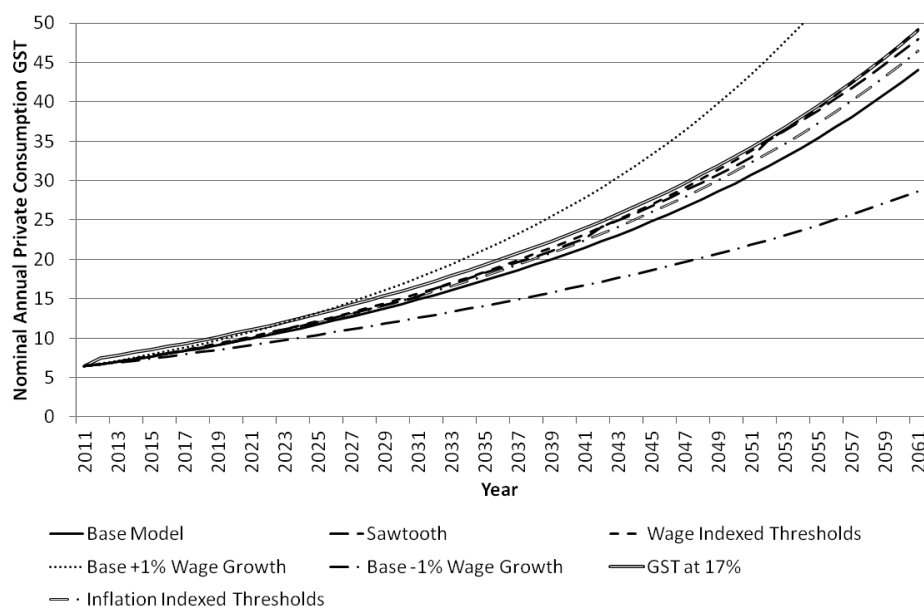


Figure 13: Growth of GST Revenue for Alternative Scenarios: Males

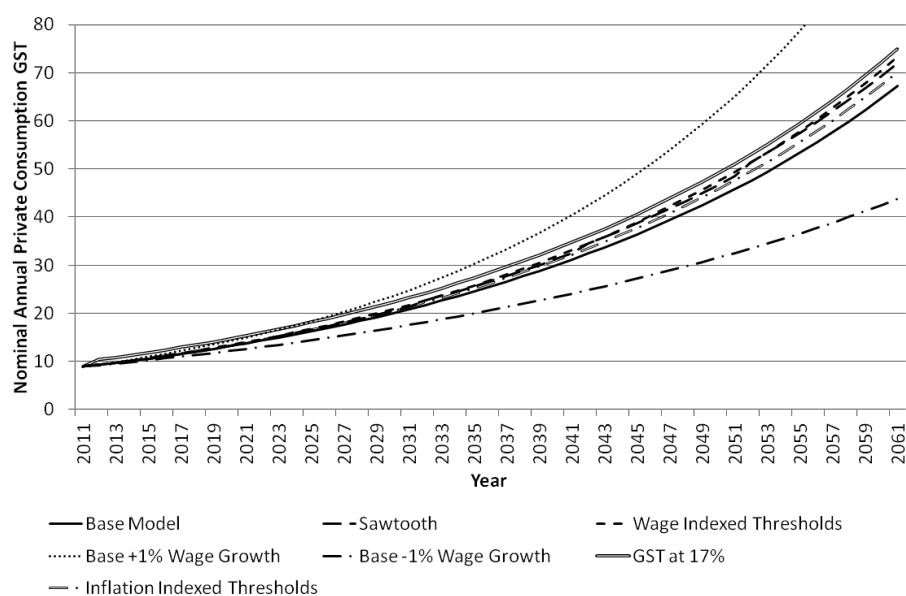


Figure 14: Income and GST Growth: Males and Females Combined

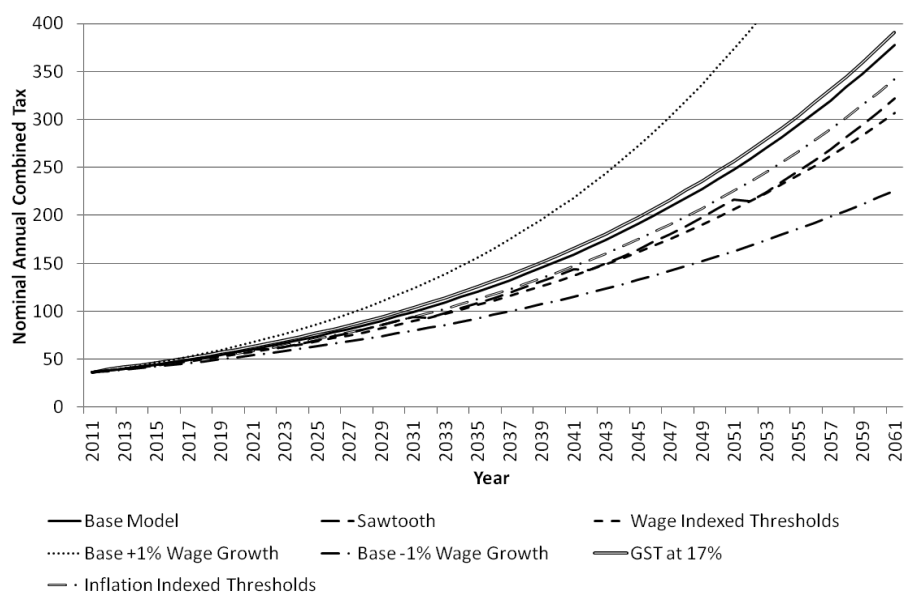


Figure 15: Effects of Ageing and Labour Force Participation: Male and Female and All Taxes Combined



6 Average Effective Tax Rates

Previous sections have concentrated on the growth of tax revenue over the fifty-year projection period, but it is instructive to measure the variation in the effective aggregate tax rate over time. Figures 16 and 17 display the time profiles of aggregate tax rates for females and males respectively. When income tax thresholds are subject to full wage indexation, the aggregate tax rate is virtually constant over the period. The absence of any indexation, as in the base case shown by the solid line, implies a substantial increase in the aggregate rate by approximately ten percentage points. This increase is considerably modified by the sawtooth pattern produced by periodic indexation. Without indexation, the aggregate tax rate profile begins to flatten as a large proportion of individuals move into the top income tax bracket over time. Figure 18 shows the aggregate tax rate for total revenue from income tax and GST, and for males and females combined. The effects of ageing and labour force participation changes alone, for both taxes combined, is shown in Figure 19. This shows that ‘pure population ageing’ has very little effect on the aggregate rate, while the increased labour force participation reduces the aggregate rate slightly. Although ageing alone implies less revenue, aggregate income is also lower, so that the overall effective tax rate is very slightly higher in the ‘pure ageing’ case compared with the base model.

Figure 16: Effective Aggregate Income Tax Rate: Females



7 Capital Income Tax Revenue

This section adds income tax revenue from capital income to the projection model. In view of the systematic increase in capital income over the life cycle, population ageing is expected to result in more revenue from this source, in addition to the consequent increase in indirect tax revenue. However, capital income tax is complicated by the existence of a range of sources (such as different types of investment, rental and interest income), where different rates apply. It is not possible here to model the changing distribution of different sources over the life cycle at the individual level. Hence, the present analysis of

Figure 17: Effective Aggregate Income Tax Rate: Males

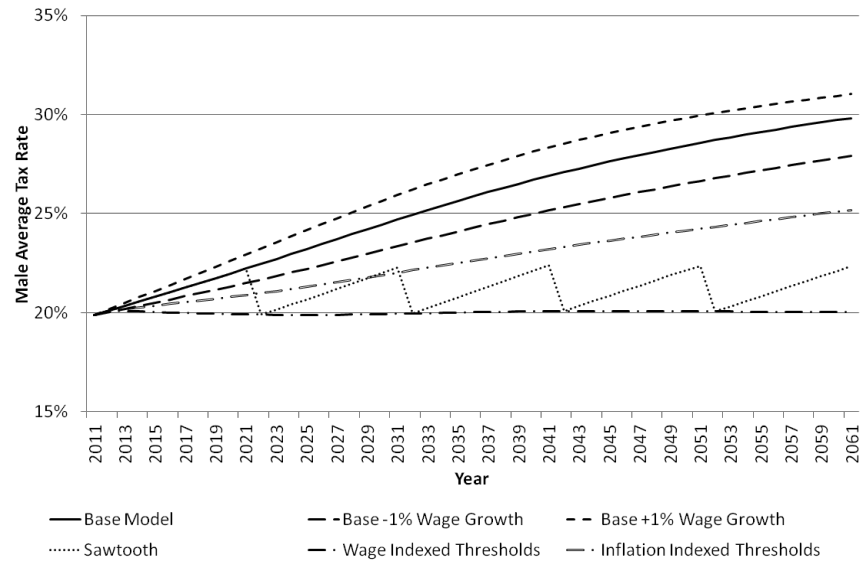


Figure 18: Effective Aggregate Tax Rate for Males and Females Combined: GST plus Income Tax

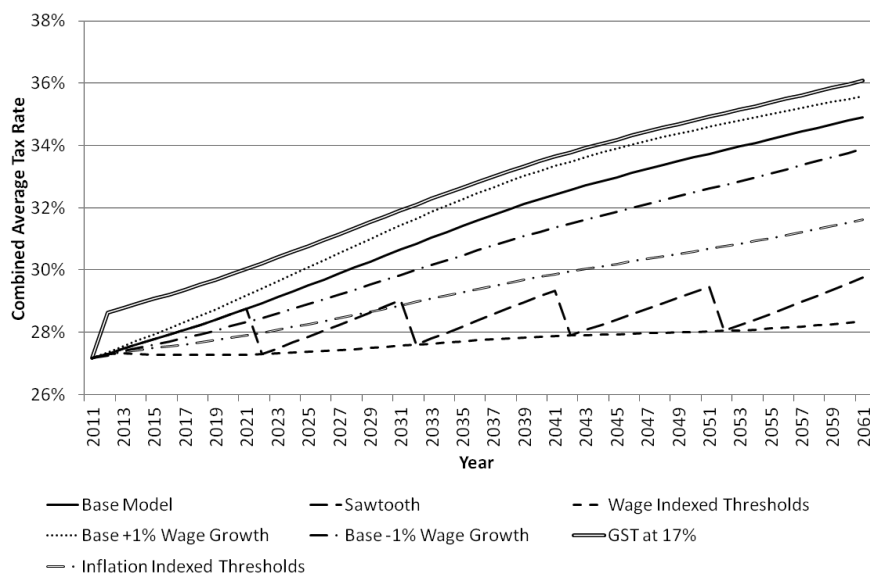
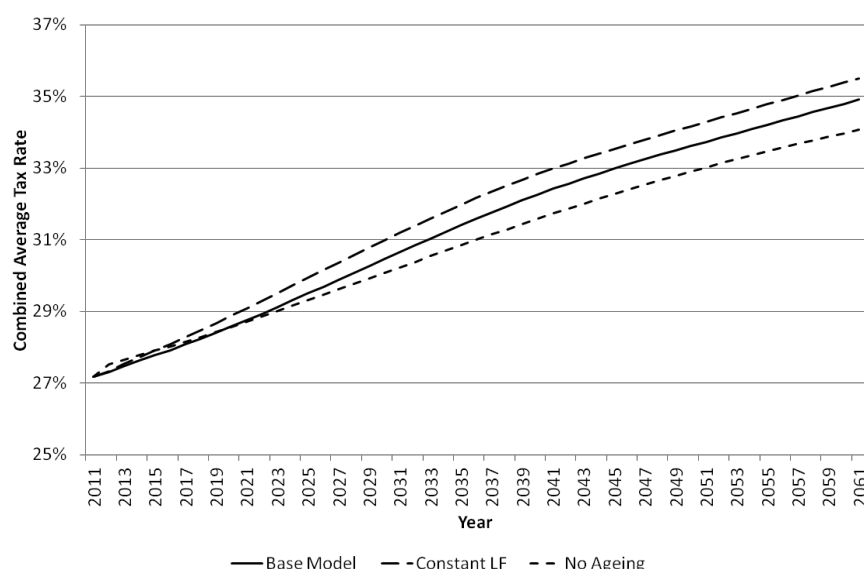


Figure 19: Ageing and Labour Force Participation Effects on Effective Aggregate Tax Rate



capital income taxation necessarily has to rely on strong assumptions and a high level of aggregation.

It is important to consider the changing proportion of people with positive investment income over the life cycle, so that appropriate allowance can be made for the changing demographic structure over time. The approach taken here is to use cross-sectional information from the Treasury's model, Taxwell, to obtain the arithmetic mean of investment income for each year of age, by gender, conditional on receiving some (positive) investment income. This is combined with corresponding information on the proportion of people receiving investment income, by gender and single year of age.¹⁴ In obtaining projections, the changing age distribution of the population over time can therefore be used in conjunction with the appropriate proportions, and conditional average capital incomes, to obtain the required aggregate values for each age and gender. It is then necessary to apply a single tax rate to the aggregate capital income. In the following simulations, a rate of 30 per cent was applied to all investment income. The aggregate net capital income was then added to aggregate disposable income from employment, in order (after allowing for saving and dis-saving behaviour) to obtain the base on which to apply GST.

Examination of the Taxwell data showed that both average (positive) investment income and the proportion receiving some capital income grow approximately linearly with age. Table 5 reports regression results.¹⁵ In the case of male investment income, there is considerable variability with age, as seen by the lower value of R^2 compared with that of females. To allow for cross-sectional and cohort differences, it was assumed that (nominal) investment income grows at 5 per cent per year: this means, for example, that a 20 year old in 2020 obtains 5 per cent more than a 20 year old obtained in 2019. This growth rate is thus slightly higher than the growth assumed above for labour incomes.

Figure 20 shows the projected total capital income tax revenue for each year under several assumptions. The only variations that affect the growth of capital income relate to the assumed growth of investment income over time. Corresponding to the assumed variations

¹⁴ As above, weighted aggregates were used, and cross-sectional data for different years were adjusted to 2010/11 values.

¹⁵ The negative constant term for the regression of female capital incomes means that for some of the lower age groups, the projected values could be negative: these were set to zero.

Table 5: Investment Income Age Profiles

	Investment income			Proportion with investment income		
	Constant	Age–15	R^2	Constant	Age–15	R^2
Males	1211.47 (834.20)	156.17 (20.57)	0.455	0.0391 (0.0137)	0.0085 (0.0003)	0.916
Females	-692.83 (268.18)	93.27 (6.61)	0.743	0.0175 (0.0131)	0.0086 (0.0003)	0.928

in productivity and hence wage growth when considering tax revenue from employment income, the figure shows the effects of 4 and 6 per cent growth rates, in addition to the benchmark 5 per cent. Figure 21 decomposes, for the benchmark assumptions, the growth of investment income for the case where there is no population aging. The variation in labour force participation has no effect in the present model because the variation in investment income is not linked directly to an individual model of capital accumulation over the life cycle. As suggested above, the effect of population ageing is to raise capital income tax revenue in view of the systematic increase in capital income, and the proportion of people receiving capital income, with age.

Figure 20: Total Capital Income Tax Revenue

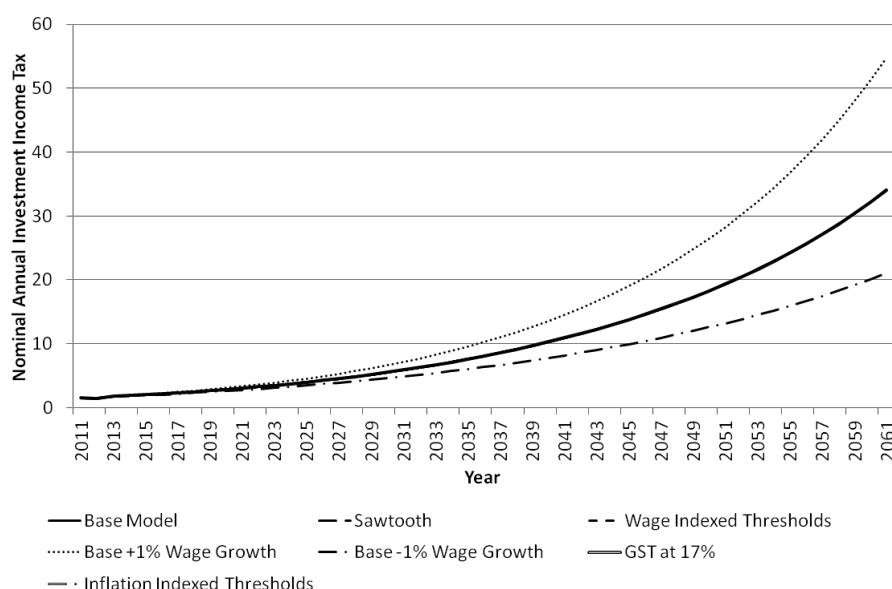


Figure 22 shows projections of the time path of the ratio of private source deductions (that is, personal income tax plus capital income tax revenue) to private GST revenue for the benchmark assumptions. In this case the projected variations in labour force participation do have an influence in view of their role in generating labour income. Total nominal tax revenue, from males and females and from all private income and consumption sources, is shown in Figure 23 for a range of assumptions, as described earlier when discussing labour incomes. The corresponding ratio of private source deductions to GST revenue, for the different projection assumptions, are shown in Figure 24.

Figure 21: Decomposition of Total Capital Income Tax Revenue

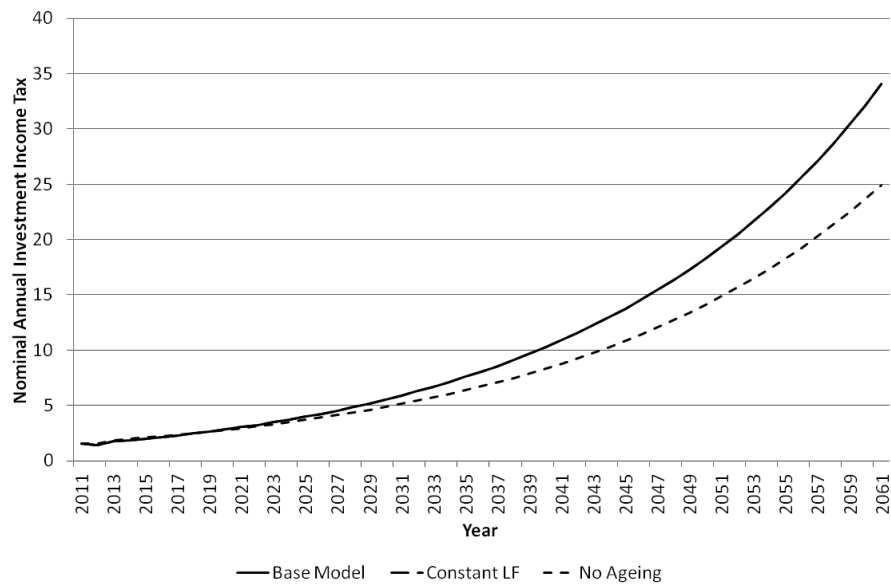


Figure 22: Decomposition of Ratio of Source Deductions to Private Consumption GST

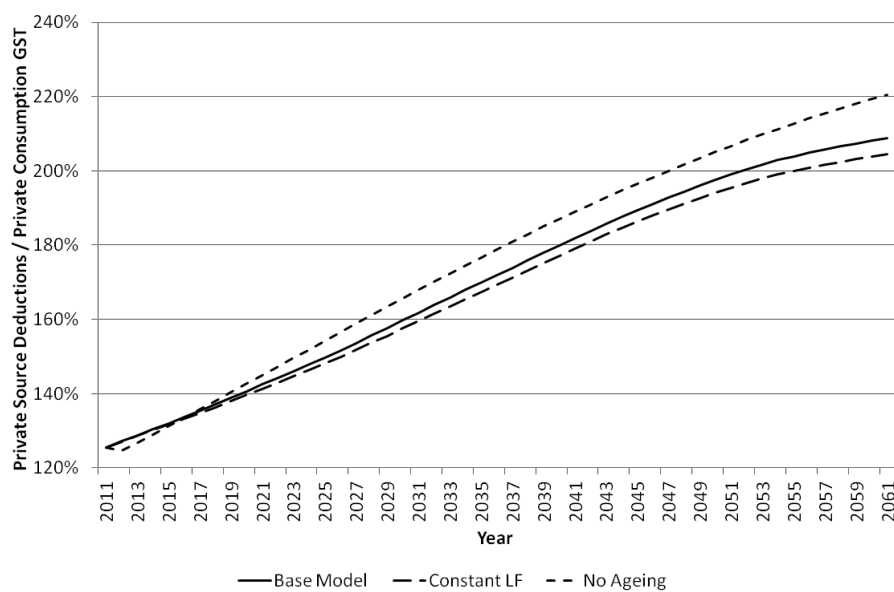


Figure 23: Total Tax Revenue

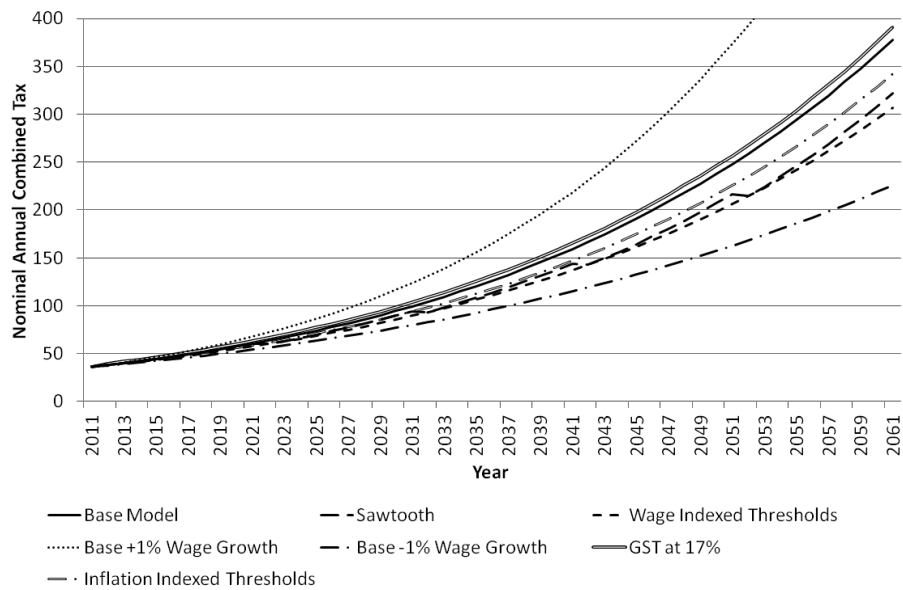
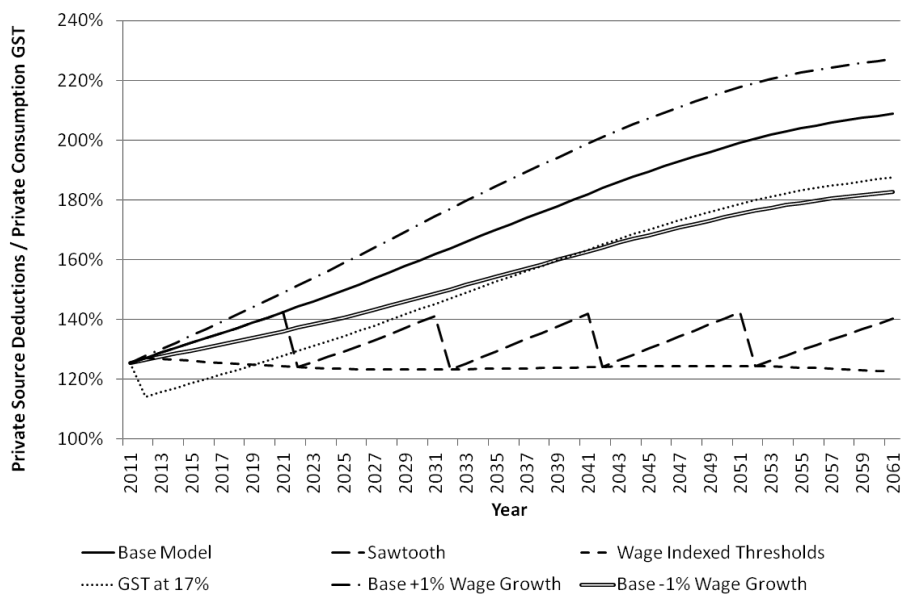


Figure 24: Ratio of Private Source Deductions to Private Consumption GST Revenue



8 Conclusions

This paper has investigated the effects of projected population ageing and changes in labour force participation on projections of income tax (from wage, salary and self-employment income, and capital income) and GST, for males and females separately in New Zealand. It was found that as the baby-boomers move into retirement the burden of taxation will have a compositional shift, from the current male modal age of 48 in 2010/11 to 43 in 2051/52. During the middle of the transition to retirement for the baby-boomers, the male modal age (in the distribution of tax revenue by age) is expected to fall to 40 in 2030/31. The distribution of the proportion of tax paid by females follows a similar pattern.

The projections of income tax revenue were also decomposed into ‘pure ageing’ and ‘pure labour force participation’ changes: for example, in the former case only the projected age composition of the population was allowed to change, while participation rates remained constant at their 2010/11 values. Ageing was found to reduce aggregate income tax revenue below the base model case. However, changing participation rates, particularly among women, imply higher tax revenue. The projected changes in the age distribution (with fixed labour force participation rates) were found to reduce total tax revenue, below the base model case, by 2.4 per cent by the year 2061. However, the effect of changes in participation rates (with an unchanged age distribution) are projected to increase aggregate revenue above the base model case by 5.7 per cent.

The projected demographic and labour force participation changes are thus small, though not trivial. However, these effects are dwarfed by the much larger changes generated by wage growth. Aggregate revenue was found to be highly sensitive to changes in the overall rate of change in wages and capital income (affecting all cohorts), which is a major determinant of tax revenue growth, along with the assumption regarding indexation of income tax thresholds. While the use of fiscal drag, which arises from not adjusting the thresholds, has been extensively used to increase income tax revenue in the past, it is most unlikely to be sustained for long periods, otherwise a very large proportion of the population would move into the top income tax rate bracket. Hence the effect of periodic threshold adjustments, a more realistic prospect, was examined.

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