This paper presents stochastic projections for 13 categories of social spending in New Zealand over the next 50 years. These projections are based on detailed demographic estimates covering fertility, migration and mortality disaggregated by single year of age and gender. Distributional parameters are incorporated for all of the major variables, and are used to build up probabilistic projections for social expenditure as a share of gross domestic product using simulation methods. Emphasis is placed on the considerable uncertainty involved in projecting future expenditure levels.

Keywords: population; projections; stochastic simulation; social expenditure; fiscal costs; New Zealand

1. Introduction

The aim of this paper is to produce stochastic projections of social expenditure in New Zealand over the next 50 years, based on the earlier work of Creedy and Scobie (2005). By their very nature, expenditure projections cannot possibly provide accurate information about future levels. A very large range of parameters are held fixed or are assumed to change according to simple trends over the projection period. In considering the question of, ‘what if recent trends were to continue and there were no endogenous policy changes?’, such projections can at best provide an indication of the kind of stresses that could arise. There will inevitably be responses to those changes, including ‘general equilibrium’ types of response arising, for example, from changes in wage rates resulting from labour market pressures. Projections can therefore stimulate and inform further analyses, considering, for example, whether market responses may be expected to mitigate or exacerbate the anticipated pressures.

Particular concern has been expressed regarding the consequences of the demographic transition in progress in New Zealand as in many industrialised countries. This involves the ageing of the baby-boom generations and, more importantly, the continued reductions in fertility and especially mortality, with the latter producing the phenomenon of the ‘ageing of the aged’. The fact that most types of social expenditure are age-related makes this category of government expenditure a particularly important area of investigation. Of course, the present transition is merely one stage in earlier extensive demographic transitions experienced by developed economies. Furthermore, there have been very large changes in tax and expenditure ratios that have been quite independent of demographic changes.2
In view of the uncertainty that is inevitably involved in making projections, it is important to provide some indication of the potential range of values which could arise. Indeed, in considering possible policy action, and in particular the timing of such intervention (which may include tax smoothing in anticipation of higher future government expenditure), it is important to have some idea of the probability of future contingencies as well as their possible size.\(^3\)

One approach is to consider a number of alternative ‘scenarios’, characterised by, for example, high labour force participation or higher mortality rates. However, there is no way to attach probabilities to such alternatives, and in the present context there are very many parameters to consider. The starting point of the present stochastic approach is to regard the parameters (fertility, labour force participation rates, age-specific per capita expenditures and so on) as being characterised by a distribution, rather than being fixed values. A large number of projections of the variables of interest (such as total social expenditure in relation to gross domestic product [GDP]) can thus be made, in each case taking a random draw from each of the specified distributions. This kind of ‘Monte Carlo’ approach thereby generates a distribution of values in each year of the projection period, whose properties can be examined.

In specifying the form of the distribution (along with, say, the mean and standard deviation) of each relevant parameter, Creedy and Scobie (2005) used information about its past variability, which clearly involved the collection and analysis of a great deal of data. This was helped by, among other things, the existence of the long-term data series, which was compiled within the Treasury. As this data series has not been maintained and regularly updated in more recent years (having been transferred to Statistics New Zealand), the present paper makes use of the growth rates and standard deviations obtained by Creedy and Scobie (2005). However, as indicated below, these were modified to some extent, either by ‘rounding’ a number of values or by using a priori assumptions.\(^4\)

Section 2 briefly describes the framework of analysis. Section 3 presents the benchmark results. Sensitivity analyses are reported in Section 4. Conclusions are in Section 5.

2. The projection model

This section provides a brief description of the projection model.\(^5\) Exogenous age and gender-specific rates are used and, as mentioned above, no allowance is made for possible feedback effects, which may, for example, be generated by general equilibrium changes in price and wage rates, or endogenous policy responses.\(^6\) The latter are clearly affected by the government’s budget constraint (see Buckle & Cruickshank, 2014).

The sequence of calculations is set out in Figure 1, where the grey boxes represent input data. The first stage is the production of projections for the size of the population, together with its distribution by age and gender. This requires projections of trends in fertility, mortality and net migration. Projected labour force participation rates are then combined with age- and gender-specific unemployment rates to generate the size of the workforce. This is multiplied by average productivity per worker to obtain GDP.

Social expenditures per capita are combined with population (by age and gender) to obtain total social expenditure on each of 13 categories for each age and gender group. The resulting social expenditures are finally expressed as a share of projected GDP. In moving through the sequence of calculations, a random draw from the distribution of each variable is made, as explained below. This process is repeated 5000 times, to produce a distribution of the social expenditure ratio for each projection year. The process,
therefore, also generates distributions of the population by age and gender, as well as for each category of social expenditure.

Consider a relevant variable, $x$, which could be, for example, an unemployment rate, a fertility rate for women of a given age, or an item of social expenditure. In cases where the variable may take positive or negative values, it is assumed to be normally distributed. Where a variable is necessarily positive, and the distribution is positively skewed, the distribution is assumed to be lognormal.7

Where a variable is normally distributed with mean and variance, $m$ and $s^2$, respectively, $x$ is distributed as $N(m, s^2)$. If $r$ represents a random drawing from $N(0,1)$, a simulated value, $x_r$, can be obtained using $x_r = m + rs$. In the lognormal case, $m$ and $s^2$ refer to the mean and variance of logarithms. A random draw is given by $x_r = \exp(m + rs)$, where $r$ is again a random $N(0,1)$ variable.

Each social expenditure projection is thus associated with its own demographic structure. The populations are necessarily derived using single-year age groups, but when calculating social expenditures and employment, some age grouping is necessary in view of the more limited data available for these variables.

The growth rates and standard deviations used in Creedy and Scobie (2005) were based on considerable information about past trends and the variability in several hundred fertility, mortality, migration, male/female birth ratios, labour force participation rates, unemployment rates and major categories of social expenditure. Their growth rates and standard deviations were estimated from the following regression:8

$$\log y_t = \alpha + \beta t + u_t$$  (1)
which implies an estimated constant growth rate of $\hat{\beta}$. Furthermore, $\text{Var}(\log y_t) = \sigma^2$, so the standard deviations are derived from the estimated standard error of the regression, $\hat{\sigma}_u$. The log-linear specification was found to provide a good fit to the historical data.\(^9\)

In producing the projections reported below, data were obtained for 2010 relating to male and female populations, inward and outward migrants by single year of age, along with male and female unemployment rates by 5-year age groups.\(^{10}\) The 2010 social expenditure costs per capita, again within 5-year age groups, were also obtained for 13 categories and are shown in Tables 1 and 2. The standard deviations for demographic components of the model were adapted from Creedy and Scobie (2005), in view of the lack of more recent data.

3. **Benchmark results**

This section presents the benchmark projections for the distribution of social expenditure as a proportion of GDP. The essential features are that all social expenditures are assumed to grow at 1.5% per year, the same rate as labour productivity. The results therefore refer to a ‘pure ageing’ assumption. Immigration is based on the average over recent years of 14,500 net immigrants each year (with total annual immigration of 82,500). Changes in mortality rates are assumed to continue for 15 years, after which they remain constant. Changes in labour force participation rates, taken from Creedy and Scobie (2005), are assumed to apply for 10 years. Fertility rates are assumed to change for 10 years, after which no further changes in these rates are projected. The standard deviation of productivity growth is assumed to be 0.02, reflecting a high degree of uncertainty about this variable.

For the social expenditure categories, the standard deviations (in each age, gender and expenditure category) were set at 0.05 for each category and age group and gender.

Figure 2 shows the projected population pyramids for 10-year intervals over the 50-year projection period (for plotting purposes, the results are arranged into 5-year age groups). The figures actually show the arithmetic mean values of the various distributions. As expected, the population projections are associated with a relatively small degree of uncertainty, in that the confidence intervals around the mean values are very small. For this reason they are not shown here.

Figure 3 shows the time profile of various measures of the distribution of the projected ratio of total social expenditure to GDP from 2010 to 2060.\(^{11}\) In addition to the mean, the profiles of upper and lower quartiles, and 5th and 95th percentiles are shown.\(^{12}\) This diagram may be compared with Figure 3 of Creedy and Scobie (2005), which covers the period 2001–2051. The latter, as expected, starts from a similar base, but the present projections display slightly smaller ‘spreads’ in the profiles over time. Nevertheless, the most striking feature of Figure 3 is the increasing uncertainty regarding the social expenditure ratio.

As with earlier projections, the arithmetic mean ratio of total social expenditure to GDP increases relatively sharply from around 2020, as a result of the movement of the post-World War II baby boomers into retirement and old age. In Creedy and Scobie (2005), the projected profile of this ratio becomes stable by around 2040. In the present case, the mean ratio falls very slightly after this date. Given the assumption that mean per capita growth rates of social expenditure are the same as that of (mean) productivity growth, the profiles are affected largely by the changing age composition over time. The slight reduction in the projected mean expenditure ratio in later years, therefore, seems
Table 1. Social expenditure per capita: males.

| Age | Personal health | Public health | Mental health | DSS | DSS 65 | Tertiary education | New Zealand Superannuation | DPB + WB | IB + SB | Family assistance | Accommodation | Unemployment benefit |
|-----|----------------|---------------|---------------|-----|--------|-------------------|-----------------------------|---------|--------|------------------|----------------|----------------------|
| 0–4 | 2788           | 127           | 6             | 0   | 99     | 0                 | 0                           | 0       | 0      | 0                | 0              | 0                    |
| 5–9 | 793            | 161           | 93            | 0   | 150    | 3089              | 0                           | 0       | 0      | 0                | 0              | 0                    |
| 10–14| 778            | 159           | 157           | 0   | 163    | 2955              | 0                           | 0       | 0      | 0                | 0              | 0                    |
| 15–19| 800            | 152           | 271           | 0   | 173    | 3913              | 2895                        | 0       | 0      | 291              | 7              | 167                  |
| 20–24| 718            | 153           | 420           | 0   | 194    | 0                 | 3144                        | 0       | 0      | 0                | 0              | 0                    |
| 25–29| 747            | 107           | 525           | 0   | 246    | 0                 | 3718                        | 0       | 68     | 468              | 735             | 463                  |
| 30–34| 834            | 105           | 525           | 0   | 289    | 0                 | 3741                        | 0       | 149    | 715              | 1162            | 331                  |
| 35–39| 905            | 103           | 473           | 0   | 289    | 0                 | 3806                        | 0       | 533    | 611              | 1619            | 431                  |
| 40–44| 1105           | 101           | 384           | 0   | 281    | 0                 | 4177                        | 0       | 103    | 1048             | 1373            | 237                  |
| 45–49| 1362           | 99            | 369           | 0   | 279    | 0                 | 4282                        | 0       | 161    | 1117             | 855             | 343                  |
| 50–54| 1758           | 98            | 265           | 0   | 283    | 0                 | 4189                        | 0       | 140    | 778              | 679             | 209                  |
| 55–59| 2302           | 97            | 212           | 59  | 355    | 0                 | 4219                        | 0       | 100    | 1509             | 196             | 251                  |
| 60–64| 3006           | 97            | 152           | 116 | 533    | 0                 | 3928                        | 30      | 80     | 1156             | 146             | 94                   |
| 65–69| 4215           | 97            | 138           | 326 | 0      | 0                 | 12,227                      | 70      | 72     | 11               | 216             | 134                  |
| 70–74| 5220           | 97            | 150           | 739 | 0      | 0                 | 14,226                      | 0       | 55     | 84               | 106             | 0                    |
| 75–79| 6202           | 97            | 168           | 1537| 0      | 0                 | 13,764                      | 0       | 42     | 0                | 163             | 0                    |
| 80–84| 6780           | 97            | 223           | 2801| 0      | 0                 | 14,401                      | 0       | 0      | 0                | 157             | 0                    |
| 85+  | 7190           | 96            | 235           | 5646| 0      | 0                 | 14,044                      | 0       | 0      | 0                | 302             | 352                  |

Notes: DSS, disability support services; NZS, New Zealand Superannuation; DPB, domestic purposes benefit; WB, widow’s benefit; IB, invalid’s benefit; SB, sickness benefit. Health expenditure data for categories one to five are from New Zealand Treasury Fiscal Strategy Model: http://www.treasury.govt.nz/government/fiscalstrategy/model Aggregate education (primary and secondary) expenditure data are from New Zealand Treasury calculations based on Ministry of Education administrative data. These data were disaggregated by age and gender using a weighted average approach according to the basic population demographic data in Table 1 for the relevant ages (4–17). Aggregate tertiary education expenditure data are from Statistics New Zealand: http://www.stats.govt.nz/browse_for_stats/education_and_training/Tertiary%20education/StudentLoanandAllowances_HOTP10/Tables.aspx These data were disaggregated by age and gender using a weighted average approach according to the basic population demographic data in Table 1 for the relevant ages (17–64). The aggregated data provided a value for individuals aged 60+. This value has been apportioned to the 60–64 age category. Data for social expenditure data categories 8–13 are calculated using New Zealand Treasury model TaxWell, based on HES 08/09 and HES 09/10.
Table 2. Social expenditure per capita: females.

| Age  | Personal health | Public health | Mental health | DSS 65 | Tertiary education | New Zealand Superannuation | DPB + WB | IB + SB | Family assistance | Accommodation | Unemployment benefit |
|------|-----------------|---------------|---------------|--------|-------------------|---------------------------|----------|--------|------------------|---------------|----------------------|
| 0–4  | 2411            | 127           | 4             | 0      | 73                | 0                         | 0        | 0      | 0                | 0             | 0                    |
| 5–9  | 697             | 161           | 35            | 0      | 81                | 2942                      | 0        | 0      | 0                | 0             | 0                    |
| 10–14| 664             | 159           | 127           | 0      | 97                | 2811                      | 0        | 0      | 0                | 0             | 0                    |
| 15–19| 1088            | 152           | 352           | 0      | 96                | 3717                      | 2735     | 0      | 556              | 315           | 366                  | 486 | 285 |
| 20–24| 1352            | 155           | 278           | 0      | 149               | 0                         | 2997     | 0      | 1474             | 288           | 900                  | 735 | 346 |
| 25–29| 1549            | 107           | 335           | 0      | 236               | 0                         | 3772     | 0      | 1476             | 311           | 1441                 | 837 | 446 |
| 30–34| 1774            | 105           | 408           | 0      | 242               | 0                         | 4049     | 0      | 1385             | 372           | 2357                 | 632 | 188 |
| 35–39| 1577            | 102           | 431           | 0      | 311               | 0                         | 4214     | 0      | 1759             | 786           | 3059                 | 772 | 252 |
| 40–44| 1327            | 101           | 405           | 0      | 278               | 0                         | 4543     | 0      | 1177             | 775           | 1998                 | 556 | 399 |
| 45–49| 1480            | 100           | 380           | 0      | 345               | 0                         | 4568     | 0      | 617              | 990           | 1235                 | 395 | 166 |
| 50–54| 1741            | 99            | 298           | 42     | 352               | 0                         | 4371     | 0      | 530              | 716           | 650                  | 368 | 107 |
| 55–59| 2138            | 98            | 275           | 76     | 448               | 0                         | 4372     | 0      | 651              | 973           | 281                  | 456 | 319 |
| 60–64| 2686            | 97            | 261           | 152    | 627               | 0                         | 4072     | 805    | 1037             | 1479          | 81                   | 299 | 147 |
| 65–69| 3588            | 98            | 213           | 378    | 0                 | 0                         | 13,119   | 97     | 260              | 26            | 201                  | 331 | 201 |
| 70–74| 4380            | 99            | 195           | 838    | 0                 | 0                         | 15,344   | 0      | 33               | 40            | 404                  | 0   | 0   |
| 75–79| 5104            | 99            | 212           | 1794   | 0                 | 0                         | 15,297   | 0      | 0                | 7             | 267                  | 0   | 0   |
| 80–84| 5590            | 98            | 254           | 3985   | 0                 | 0                         | 15,628   | 0      | 0                | 3             | 229                  | 0   | 0   |
| 85+  | 5965            | 98            | 217           | 9488   | 0                 | 0                         | 17,510   | 0      | 0                | 0             | 296                  | 0   | 0   |

Notes: DSS, disability support services; NZS, New Zealand Superannuation; DPB, domestic purposes benefit; WB, widow’s benefit; IB, invalid’s benefit; SB, sickness benefit.

Health expenditure data for categories one to five are from New Zealand Treasury Fiscal Strategy Model: http://www.treasury.govt.nz/government/fiscalstrategy/model

Aggregate education (primary and secondary) expenditure data are from New Zealand Treasury calculations based on Ministry of Education administrative data. These data were disaggregated by age and gender using a weighted average approach according to the basic population demographic data in Table 1 for the relevant ages (4–17).

Aggregate tertiary education expenditure data are from Statistics New Zealand: http://www.stats.govt.nz/browse_for_stats/education_and_training/Tertiary%20education/StudentLoanandAllowances_HOTP10/Tables.aspx. These data were disaggregated by age and gender using a weighted average approach according to the basic population demographic data in Table 1 for the relevant ages (17–64). The aggregated data provided a value for individuals aged 60+. This value has been apportioned to the 60–64 age category.

Data for social expenditure data categories 8–13 are calculated using New Zealand Treasury model TaxWell, based on HES 08/09 and HES 09/10.
Figure 2. Population projections.
to be explained by the fact that the baby-boom generations will have all died by that time. However, given the large degree of uncertainty (the high dispersion in the distribution of the expenditure ratio), these reductions cannot be treated as statistically ‘significant’.

The generally lower average social expenditure ratio in the present case is not explained by the much higher annual value of net immigration, compared with the earlier results (which were based on a long-term average of only 5000 (associated with gross immigration of 60,000), a value that has been substantially exceeded since 2001). Higher immigration has very little effect, although it must be recognised that in the present model migrants are assumed to acquire existing New Zealand mortality, fertility and labour force participation characteristics as soon as they arrive. And, although the average age of immigrants is slightly lower than that of the New Zealand population, there are of course substantial numbers of migrants in the older age groups.

To illustrate how the assumed standard errors of the per capita growth rates of social expenditures translate into standard errors of the costs, the projected growth in health and education costs per capita, for males and females separately, are shown in Figures 4 and 5. In each case, the mean is plotted, along with two standard deviations on either side of

Figure 3. Projected social expenditure as a share of GDP: 2010–2060 (benchmark case).

Figure 4. Health expenditure per capita: 2010–2060.
Health includes the five health categories aggregated, and education includes the two categories. The largest degree of uncertainty relates to unemployment benefits, since in this case the uncertainty also includes the age- and gender-specific unemployment rates. Unemployment costs per capita are illustrated in Figure 6.

4. Sensitivity analyses

This section explores the impact on the projected levels of social expenditure of variations to the assumptions used in the benchmark case. In order to concentrate on the effects of the anticipated demographic transition, the sensitivity analyses retain the use of a ‘pure ageing’ assumption (whereby average growth rates of the social expenditure categories are equal to average productivity growth).

First, it is of interest to examine the implications of having a higher age of eligibility for New Zealand Superannuation (NZS). The full effects cannot be modelled explicitly, but suppose that the age of eligibility is raised, for males and females, to age 70. To reflect this increase, the NZS costs per capita were changed: for males and females in age groups from 60 to 69, these were reduced to zero. For the age group 70–74, the annual per capita costs were changed to 10,000 and 12,000 for males and females, respectively. Associated with these changes, the labour force participation rates for males in age groups 55–59, 60–64, 65–69 and 70–74 were changed to 0.9, 0.9, 0.75 and 0.1, respectively. For females in the corresponding groups, the rates were increased to 0.8, 0.8, 0.75 and 0.1.

A related modification is a change to the assumed length of time over which mortality declines. This was changed from 15 to 30 years. The age-related health costs (disability support services [DSS] older) for age groups from 50 to 64 were also reduced to zero. The modifications to labour force participation and health costs were, for simplicity,
assumed to operate immediately. This modification from the benchmark case is thus one in which people continue to live longer, but this extra length of life is associated with improved health and hence also higher labour force participation. The extra longevity ultimately leads to higher stocks of retired individuals, though this is mitigated to some extent by the assumed higher labour force participation.

Figure 7. Projected social expenditure as a share of GDP: 2010–2060 (increased longevity and higher labour force participation of those aged over 55).

Figure 8. Projected social expenditure as a share of GDP: 2010–2060: no uncertainty regarding growth of all social expenditure categories.
The projected distribution of the ratio of social expenditure to GDP associated with increased longevity and higher labour force participation is shown in Figure 7. It is clear that these more optimistic assumptions imply a downward shift in the distribution, although the spread of values (between the 5th and 95th percentiles) remains similar to that of the benchmark case.

Clearly a wide range of alternative assumptions could be examined, as discussed in Creedy and Scobie (2005), but in view of the present emphasis on uncertainty, it is of interest to consider alternative assumptions about the standard errors of a number of the variables. First, the elimination of any uncertainty regarding demographic elements has very little effect, as expected; the resulting diagram (not shown here) is difficult to distinguish from the benchmark of Figure 3.

Two more cases are reported here. In the first variant, the standard deviations of expenditure categories in all age groups were set to zero. The uncertainty is thus attributed to demographic, labour market and productivity variations. In the second variant, the standard deviations of the unemployment and participation rates, and that of the productivity growth rate, were set equal to zero. The resulting projected distributions of the social expenditure to GDP ratio are shown in Figures 8 and 9. Comparison of these two figures shows that the spread of the distributions arising from labour market and productivity variations is substantially higher than that arising from the uncertainty with regard to per capita social expenditures (as reflected in the observed variability over earlier years).

5. Conclusions
This paper has projected social expenditures in New Zealand over 50 years, based on a stochastic approach using 13 categories of social spending, decomposed by age and gender. By allowing for uncertainty about fertility, migration, mortality, labour force participation and productivity, and all categories of social spending, it has been possible to...
generate projections with accompanying confidence bands. Focusing on ‘pure ageing’
results (whereby social expenditure costs per capita in each category grow at the same
rate on average as productivity growth), the projections reveal considerable uncertainty
regarding the ratio of total social expenditure to GDP as the time period increases.

A negligible part of the dispersion in this ratio is contributed by demographic uncer-
tainty. Much of the uncertainty was found to be contributed by uncertainty regarding
future unemployment and labour force participation rates, and the rate of productivity
growth. More optimistic assumptions regarding labour force participation and health costs
among the aged produced lower average ratios of expenditure to GDP. A consistent find-
ing was the tendency for the average expenditure ratio to fall slightly beyond around
2040, following the death of the post-World War II baby-boom generations.

It has been stressed that projections, by assuming that government policies remain
unchanged, can provide an indication of where stresses can arise and where reforms may
be needed, rather than attempting to predict market and government responses. They can
thereby provide a useful input to the policy debate. The present research was motivated
by the view that too often discussions are based on deterministic projections which give
no indication of the degree of uncertainty involved in policy planning. The present sto-
chastic projections actually understate the uncertainty since they make no attempt to
allow for cyclical effects or other unforeseen macroeconomic or environmental shocks to
the economy, which can of course be severe. Similarly, they do not allow for large
changes in productivity, either in industry more generally or, for example, in the provi-
sion of public services such as health care.

Deterministic projections which show an increasing ratio of social expenditure to
GDP, without commensurate tax revenue changes, necessarily suggest that immediate
government policy adjustments involve less future disruption. The case for tax smooth-
ing, by increasing present taxes and building up a fund which can be used to finance
future-anticipated higher expenditure, is thus easily made. However, once the huge uncer-
tainty around future costs is recognised, there is a potential ‘option value’ of waiting to
obtain further information before acting. This is because any current action must neces-
sarily impose costs on some individuals, and these people cannot be compensated if the
future costs are not as high as anticipated. Tax policy decision-making in the face of
uncertainty thus requires careful consideration of the probabilities involved along with
the potential future costs of various contingencies and the economic efficiency effects of
tax changes. The theoretical analysis of tax policy choice under uncertainty, by Ball and
Creedy (2014) in the present volume, can therefore be regarded as a sequel to the present
statistical analysis.

Notes
1. That paper produced the first demographic and expenditure projections for New Zealand and
provides a discussion of alternative approaches and related literature.
2. See, for example, contributions collected in Creedy (1995) and Creedy and Guest (2007).
3. For example, see Auerbach and Hassett (2000), and on tax smoothing, see Davis and Fabling
(2002).
4. The use of a priori values is examined in detail in Creedy and Alvarado (1998a). They
obtained stochastic projections of social expenditure for Australia but did not, unlike Creedy
and Scobie (2005) and the present paper, combine these with stochastic population
projections.
5. This section borrows heavily from Creedy and Scobie (2005).
6. Some policy responses may arise from changing voting patterns associated with population
ageing.
7. The assumption of lognormality was also made, for example, by Alho (1997) and Creedy and Alvarado (1998a).

8. This form is a simplified form of the more general Box–Jenkins type of time series specification used by Lee and Tuljapurkar (2000).

9. The use of past variability to reflect future uncertainty is of course just one possible approach. The same model could be used with a priori assumptions about the distributions, based on a combination of past information and a range of considerations concerning views of the future; see Creedy and Alvarado (1998a).

10. The full details are given in Creedy and Makale (2013).

11. These summary values were produced for 10-year intervals rather than each year of the projection period, to reduce computer run-times.

12. As in the previous analysis, the mean and median were found to be similar.

13. Comparisons with earlier results are not exact because the 14 social expenditure categories used by Creedy and Scobie (2005) are not precisely the same as the 13 categories used here, in view of data limitations.

14. The question of whether higher net immigration can to some extent substitute for higher fertility is examined in detail in the context of Australia by Creedy and Alvarado (1998b), who allow for ‘assimilation’ to take several generations. They found relatively small effects.

References

Alho, J.M. (1997). Scenarios, uncertainty and conditional forecasts of the world population. *Journal of the Royal Statistical Society, Series A*, 160, 71–85.

Auerbach, A., & Hassett, K. (2000). Uncertainty and the design of long-run fiscal policy. In A. Auerbach & R. Lee (Eds.), *Demography and fiscal policy* (pp. 73–97). Cambridge: Cambridge University Press.

Ball, C., & Creedy, J. (2014). Tax policy with uncertain future costs: some simple models. *New Zealand Economic Papers*. doi:10.1080/00779954.2013.874401

Buckle, R.A., & Cruickshank, A. (2014). The requirements for fiscal sustainability in New Zealand. *New Zealand Economic Papers*. doi:10.1080/00779954.2013.874393

Creedy, J. (Ed.). (1995). *The economics of ageing*. Aldershot: Edward Elgar.

Creedy, J., & Alvarado, J. (1998a). Social expenditure projections: A stochastic approach. *Australian Economic Papers*, 37, 203–212.

Creedy, J., & Alvarado, J. (1998b). *Population ageing, migration and social expenditure*. Cheltenham: Edward Elgar.

Creedy, J., & Guest, R. (Eds.). (2007). *New developments in the economics of population ageing*. Cheltenham: Edward Elgar.

Creedy, J., & Makale, K. (2013). *Social expenditure in New Zealand: Stochastic projections* (New Zealand Treasury Working Paper No. 13/07). New Zealand Treasury.

Creedy, J., & Scobie, G. (2005). Population ageing and social expenditure in New Zealand. *Australian Economic Review*, 38, 19–39.

Davis, N., & Fabling, R. (2002). *Population aging and the efficiency of fiscal policy in New Zealand* (Working Paper No. 02/11). Wellington: New Zealand Treasury.

Lee, R., & Tuljapurkar, S. (2000). Population forecasting for fiscal planning: Issues and innovations. In A. Auerbach & R. Lee (Eds.), *Demography and fiscal policy* (pp. 7–72). Cambridge: Cambridge University Press.