Reweighting the Survey of Income and Housing Costs for Tax Microsimulation Modelling

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Abstract

The aim of this paper is to develop a reweighting procedure that can be used to refine the weights or to update the weights for a current sample to represent the population of a later year. This paper describes a range of 'minimum distance' methods used to compute new weights for large cross-sectional surveys used in microsimulation modelling. Extraneous information about a range of population variables is used for calibration purposes. An iterative solution procedure is described. Two applications to the Australian Survey of Income and Housing Cost (SIHC) are reported. The first example examines whether reweighting can improve the current representation of the population of income support recipients in the Melbourne Institute Tax and Transfer Simulator. The second example explores the use of the method in simulations which need to account for expected demographic changes in future populations.

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1 Introduction

The Australian Survey of Income and Housing Costs (SIHC) is a large-scale cross-sectional survey which is used as the database in the Melbourne Institute Tax and Transfer Simulator (MITTS). This is a behavioural tax microsimulation model allowing detailed examination of the potential effects on government direct tax revenue and expenditure of policy reforms to the tax and transfer system.[1] As the SIHC is a sample of about seven thousand households, each household has a sample weight provided by the Australian Bureau of Statistics (ABS). The weights are used to 'gross up' from the sample in order to obtain estimates of population values. This applies not only to simple aggregates, such as income taxation, the number of recipients of a particular social transfer or the number of people in a particular age group, but the weights are also used in the estimation of measures of population inequality and poverty.

In arriving at a set of weights, the typical starting point is to use weights that are inversely related to the probability of selecting the household in a random sample, with some adjustment for non-response. It has become common for agencies, using 'minimal' adjustments, to produce revised weights to ensure that, for example, the estimated population age and gender distributions match population totals obtained from other sources such as census data.[2] However, there is no guarantee that weights calibrated only on demographic variables produce appropriate revenue, expenditure and income distribution results in microsimulation.

This paper therefore investigates the performance of the ABS weights provided with the SIHC in obtaining aggregate cost estimates and numbers in various categories. It then describes a calibration approach to sample reweighting, and applies the method to the SIHC. The calibration approach produces new weights which achieve specified population totals for selected variables, subject to the constraint that there are minimal adjustments to the weights. The need to revise weights arises not only where population aggregates (for variables which are not used for official calibrations) deviate substantially from population values obtained from other data sources, such as tax and

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1 For further details of the MITTS model see Creedy et al. (2002).

2 A detailed description of calibration and Generalised Regression (GREG) methods used in Belgium is given in Vanderhoeft (2001), which also describes the SPSS based program g-CALIB-S. Bell (2000) describes methods used in the Australian Bureau of Statistics household surveys, involving the SAS software GREGWT. Statistics Sweden uses the SAS software CLAN, described by Andersson and Nordberg (1998) and also used by the Finnish Labour Force Survey.

benefit administration data. It is often desired to reweight data when a survey from one year is used to examine the likely implications of, say, a tax and transfer policy in a later year. This need can arise if cross-sectional surveys are not carried out every year or if there are long delays in releasing data. Other administrative data may be available at more frequent intervals. It is also useful to be able to simulate the implications of changes in, say, the age distribution of the population or in aggregate unemployment rates over time.

A formal statement of the problem of obtaining 'minimum distance' weights and a general approach to the solution are described in section 2. The constrained minimisation problem must be solved using iterative methods, and an approach using Newton's method is described. Specific examples of types of distance measures and the corresponding solutions are discussed in section 3. Sections 2 and 3 are quite technical and could be skipped by readers who are mostly interested in the outcomes of reweighting. Section 4 applies the approach to the SIHC. It is possible for reweighting to cause non-calibrated variables to change in undesirable ways. This means that other checks need to be made on those variables.[3] Furthermore, the distribution (rather than simply the sum) of important variables, for example alternative sources of income, may be led to change as a result of reweighting. Attention needs to be given to these possibilities, involving comparisons of alternative distributions. These comparisons are also included in section 4. Section 5 examines the performance of the revised weights in the context of a policy simulation using MITTS. Reweighting to allow for population ageing is examined in section 6, followed by brief conclusions in section 7.

2 The Calibration Approach

This section discusses methods of calibration. Subsection 2.1 provides a general statement of the problem of minimising the overall distance between two sets of weights, subject to a set of calibration conditions. Subsection 2.2 examines a class of distance functions giving rise to a convenient structure. An iterative solution procedure is presented in subsection 2.3.

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[3] This point is also made by Klevmarken (1998). In addition, the precision of some survey estimates may be lowered, particularly where many calibration constraints are used: examples are given in Skinner (1999); see also Kalton and Flores-Cervantes (2003).

2.1 Statement of the Problem

For each of K individuals in a sample survey, information is available about J variables; these are placed in the vector:

$$x_k = \begin{bmatrix} x_{k,1} \\ \cdot \\ \cdot \\ \cdot \\ x_{k,J} \end{bmatrix} \tag{1}$$

For present purposes these vectors contain only the variables of interest for the calibration exercise. Many of the elements of x_k are likely to be $0/1$ variables. For example $x_{k,j} = 1$ if the k^{th} individual is in a particular age group (or receives a particular type of social transfer), and zero otherwise. The sum $\sum_{k=1}^{K} x_{k,j}$ therefore gives the number of individuals in the sample, who are in the age group (or who receive the transfer payment).

Let the sample design weights, provided by the statistical agency responsible for data collection, be denoted s_k for $k = 1,...,K$. These weights can be used to produce estimated population totals, $\hat{t}_{x|s}$, based on the sample, given by the J-element vector:

$$\hat{t}_{x|s} = \sum_{k=1}^{K} s_k x_k \tag{2}$$

The problem examined in this paper can be stated as follows. Suppose that other data sources, for example census or social security administrative data, provide information about 'true' population totals, t_x. The problem is to compute new weights, w_k, for $k = 1,...,K$ which are as close as possible to the design weights, s_k, while satisfying the set of J calibration equations:

$$t_x = \sum_{k=1}^{K} w_k x_k \tag{3}$$

It is thus necessary to specify a criterion by which to judge the closeness of the two sets of weights.

In general, denote the distance between w_k and s_k as $G(w_k, s_k)$. The aggregate distance between the design and calibrated weights is thus:[4]

$$D = \sum_{k=1}^{K} G(w_k, s_k) \tag{4}$$

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

$$L = \sum_{k=1}^{K} G(w_k, s_k) + \sum_{j=1}^{J} \lambda_j \left(t_{x,j} - \sum_{k=1}^{K} w_k x_{k,j} \right) \tag{5}$$

where λ_j for $j = 1, \ldots, J$ are the Lagrange multipliers.

2.2 A Class of Distance Functions

Suppose that $G(w_k, s_k)$ has the property that the differential with respect to w_k can be expressed as a function of the ratio w_k/s_k, so that:

$$\frac{\partial G(w_k, s_k)}{\partial w_k} = g\left(\frac{w_k}{s_k}\right) \tag{6}$$

The K first-order conditions for minimisation can therefore be written as:

$$g\left(\frac{w_k}{s_k}\right) = x_k' \lambda \tag{7}$$

Write the inverse function of g as g^{-1}, so that if $g(w_k/s_k) = u$, say, then $w_k/s_k = g^{-1}(u)$. In the case of the chi-square distance function used above, $g(w_k/s_k) = w_k/s_k - 1$, and the inverse takes a simple linear form. In general, from (7) the k values of w_k are expressed as:

$$w_k = s_k g^{-1}(x_k' \lambda) \tag{8}$$

If the inverse function, g^{-1}, can be obtained explicitly, equation (8) can be used to compute the calibrated weights, given a solution for the vector, λ.

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[4] Some authors, such as Folsom and Singh (2000) write the distance to be minimised as $\sum_{k=1}^{K} s_k G(w_k, s_k)$, but the present paper follows Deville and Särndal (1992).

The Lagrange multipliers can be obtained by post-multiplying (8) by the vector x_k, summing over all $k = 1, ..., K$ and using the calibration equations, so that:

$$t_x = \sum_{k=1}^{K} w_k x_k = \sum_{k=1}^{K} s_k g^{-1}\left(x_k'\lambda\right) x_k \tag{9}$$

Finally, subtracting $\hat{t}_{x|s} = \sum_{k=1}^{K} s_k x_k$ from both sides of (9) gives:

$$t_x - \hat{t}_{x|s} = \sum_{k=1}^{K} s_k \left\{g^{-1}\left(x_k'\lambda\right) - 1\right\} x_k \tag{10}$$

The term $s_k \left\{g^{-1}\left(x_k'\lambda\right) - 1\right\}$ is a scalar and the left hand side is a known vector. In general, (10) is nonlinear in the vector λ and so must be solved using an iterative procedure, as described in the following subsection.

2.3 An Iterative Procedure

Writing $t_x - \hat{t}_{x|s} = a$, the equations in (10) can be written as:

$$f_i(\lambda) = a_i - \sum_{k=1}^{K} s_k x_{k,i} \left\{g^{-1}\left(x_k'\lambda\right) - 1\right\} = 0 \tag{11}$$

for $i = 1, ..., J$. The roots can be obtained using Newton's method, described in Appendix A. This involves the following iterative sequence, where $\lambda^{[I]}$ denotes the value of λ in the I^{th} iteration:[5]

$$\lambda^{[I+1]} = \lambda^{[I]} - \left[\frac{\partial f_i(\lambda)}{\partial \lambda_\ell}\right]_{\lambda^{[I]}}^{-1} \left[f(\lambda)\right]_{\lambda^{[I]}} \tag{12}$$

The Hessian matrix $\left[\partial f_i(\lambda)/\partial \lambda_\ell\right]$ and the vector $f(\lambda)$ on the right hand side of (12) are evaluated using $\lambda^{[I]}$. The elements $\partial f_i(\lambda)/\partial \lambda_\ell$ are given by:

$$\frac{\partial f_i(\lambda)}{\partial \lambda_\ell} = -\sum_{k=1}^{K} s_k x_{k,i} \frac{\partial g^{-1}\left(x_k'\lambda\right)}{\partial \lambda_\ell} \tag{13}$$

which can be written as:

[5] The approach described here differs somewhat from other routines described in the literature, for example in Singh and Mohl (1996) and Vanderhoeft (2001). However, it provides extremely rapid convergence.

$$\frac{\partial f_i(\lambda)}{\partial \lambda_\ell} = -\sum_{k=1}^{K} s_k x_{k,i} x_{k,\ell} \frac{dg^{-1}\left(x_k'\lambda\right)}{d\left(x_k'\lambda\right)} \tag{14}$$

Starting from arbitrary initial values, the matrix equation in (12) is used repeatedly to adjust the values until convergence is reached, where possible.

As mentioned earlier, the application of the approach requires that it is limited to distance functions for which the form of the inverse function, $g^{-1}(u)$, can be obtained explicitly, given the specification for $G(w,s)$. Hence, the Hessian can easily be evaluated at each step using an explicit expression for $dg^{-1}\left(x_k'\lambda\right)/d\left(x_k'\lambda\right)$. As these expressions avoid the need for the numerical evaluation of $g^{-1}\left(x_k'\lambda\right)$ and $dg^{-1}\left(x_k'\lambda\right)/d\left(x_k'\lambda\right)$ for each individual at each step, the calculation of the new weights can be expected to be relatively quick, even for large samples.[6] However, a solution does not necessarily exist, depending on the distance function used and the adjustment required to the vector $t_x - \hat{t}_{x|s}$.

3 Some Distance Functions

This section considers a number of specifications of the distance function, satisfying the properties discussed in the previous section. Subsection 3.1 examines the chi-squared distance function and its modification to restrict the range of deviation in the revised weights from the original weights. The previous section has shown that it is not actually necessary to start from a specification of a distance function, since all that is needed is the form of the inverse function of the first derivative of the distance function. Subsection 3.2 examines some useful inverse functions.

3.1 The Chi-Squared Function

Consider the chi-squared type of distance measure, where the aggregate distance is given by:

$$D = \frac{1}{2}\sum_{k=1}^{K} \frac{\left(w_k - s_k\right)^2}{s_k} \tag{15}$$

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[6] Using numerical methods to solve for each $g^{-1}(u)$ and $dg^{-1}(u)/du$, for $u = x_k'\lambda$, for every individual in each iteration, would increase the computational burden substantially.

It is shown in Appendix B that an explicit solution can be obtained in this case. However, no constraints are placed on the size of the adjustment to each of the survey weights, and it is possible for some calibrated weights to become negative. Deville and Särndal (1992) suggested the following simple modification. Define r_L and r_U such that $r_L < 1 < r_U$. The objective is to ensure that, for increases, the proportionate change, $w/s - 1$, is less than $r_U - 1$, or that $r_U > w/s$. For decreases, the aim is to ensure that $1 - w/s$ (or the negative of the proportional change) is less than $1 - r_L$, so that $r_L < w/s$.

For the chi-squared distance function, $g^{-1}(u) = 1 + u$, where $u = x'\lambda$ and $g^{-1}(u)$ solves for w/s. Hence if $g^{-1}(u) = w/s$ is outside the specified range, it is necessary to set it to the relevant limit, either r_U or r_L, rather than allow it to take the value generated. Since $g^{-1}(u) - 1 = w/s - 1 = u$, it is clear that the limits are exceeded if $u < r_L - 1$ and if $u > r_U - 1$. In each case where the value of $g^{-1}(u)$ has to be set to the relevant limit, the corresponding value of $dg^{-1}(u)/du$ is zero. This approach ensures that weights are kept within the range, $r_L s_k < w_k < r_U s_k$.

3.2 Specification of Inverse Functions

The solution procedure requires only an explicit form for the inverse function $g^{-1}(u)$, from which its derivative can be obtained. Hence, it is not necessary to start from a specification of $G(w,s)$. Deville and Särndal (1992) suggested several convenient forms. First, consider:

$$g^{-1}(u) = \left(1 - \frac{u}{2}\right)^{-2} \tag{16}$$

for which the gradient function, $g(w/s)$, is given by solving for u, so that:

$$g\left(\frac{w}{s}\right) = u = 2\left(1 - \left(\frac{w}{s}\right)^{-1/2}\right) \tag{17}$$

The form of the distance function can be obtained by integrating (17).[7] This is referred to as Case A, and its properties are given in the first row of Table 1. The second row of the table, Case B, provides details for $g^{-1}(u)=(1-u)^{-1}$, and the final row gives the corresponding properties of the unconstrained chi-squared function.[8] A feature of these functions is that they do not require any parameters to be set.

Deville and Särndal (1992) also suggest the use of an inverse function $g^{-1}(u)$ of the form:[9]

$$g^{-1}(u)=\frac{r_L(r_U-1)+r_U(1-r_L)\exp\alpha u}{(r_U-1)+(1-r_L)\exp\alpha u} \tag{18}$$

where r_L and r_U are as defined above and:

$$\alpha=\frac{r_U-r_L}{(1-r_L)(r_U-1)} \tag{19}$$

Table 1 Alternative distance functions

Case	$G(w,s)$	$g(w/s)$	$g^{-1}(u)$	$dg^{-1}(u)/du$
A	$2\left(\sqrt{w}-\sqrt{s}\right)^2$	$2\left(1-\left(\frac{w}{s}\right)^{-1/2}\right)$	$\left(1-\frac{u}{2}\right)^{-2}$	$\left(1-\frac{u}{2}\right)^{-3}$
B	$-s\log\left(\frac{w}{s}\right)+w-s$	$1-\left(\frac{w}{s}\right)^{-1}$	$(1-u)^{-1}$	$(1-u)^{-2}$
Chi-squared	$(w-s)^2/2s$	$\frac{w}{s}-1$	$1+u$	1

7 Hence it is required to obtain $2\int\left\{1-\left(\frac{w}{s}\right)^{-1/2}\right\}dw=2\left(w-2\sqrt{s}\sqrt{w}\right)$, which can be written as $2\left(w+s-2\sqrt{s}\sqrt{w}\right)-2s$, and dropping the last term, which is a constant, this is equal to $2\left(\sqrt{w}-\sqrt{s}\right)^2$.

8 Deville and Särndal (1992) discuss the use of a normalisation whereby $g^{-1'}(0)$ is set to some specified value, but this is not necessary for the approach.

9 Singh and Mohl (1996), in reviewing alternative calibration estimators, refer to this ‘inverse logit-type transformation’ as a Generalised Modified Discrimination Information method. Folsom and Singh (2000) propose a variation on this, which they call a ‘generalised exponential model’, in which the limits are allowed to be unit-specific. In practice they suggest the use of three sets of bounds for low, medium and high initial weights.

Thus $g^{-1}(-\infty) = r_L$ and $g^{-1}(\infty) = r_U$, so that the limits of w/s are r_L and r_U. This function therefore has the property that adjustments to the weights are kept within the range, $r_L s_k < w_k < r_U s_k$, without the need to make checks during computation as is needed in the chi-squared modification.

The derivative required in the computation of the Hessian is:

$$\frac{dg^{-1}(u)}{du} = g^{-1}(u)\left\{r_U - g^{-1}(u)\right\}\frac{(1-r_L)\alpha \exp \alpha u}{(r_U - 1) + (1-r_L)\exp \alpha u} \tag{20}$$

Since $g^{-1}(u)$ solves for w/s, (18) can be rearranged, by collecting terms in $\exp \alpha u$, to give:

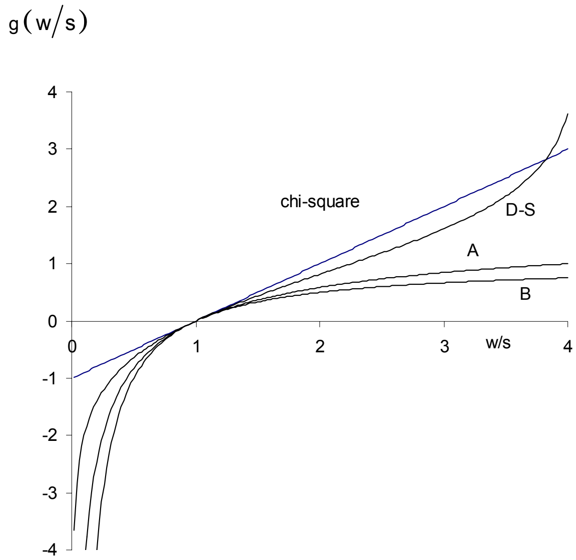
$$\frac{\frac{w}{s} - r_L}{1 - r_L} = \frac{r_U - \frac{w}{s}}{r_U - 1}\exp \alpha u \tag{21}$$

so that the gradient of the distance function is:

$$g\left(\frac{w}{s}\right) = u = \frac{1}{\alpha}\left[\log\left(\frac{\frac{w}{s} - r_L}{1 - r_L}\right) - \log\left(\frac{r_U - \frac{w}{s}}{r_U - 1}\right)\right] \tag{22}$$

The derivation of the corresponding distance function G is provided in Appendix C. The special nature of this gradient function is illustrated by the line D-S in Figure 1, which shows the profile of (22) for the wide range where $r_U = 4.1$ and $r_L = 0.01$ The first characteristic of the D-S function that is evident is the restriction of w/s to the range specified. Figure 1 also shows the function $g(w/s)$ for the other specifications discussed above. In all cases, the slope is zero (corresponding to a turning point of the distance function) when $w/s = 1$. Given the quadratic U-shaped nature of the chi-squared distance function, the gradient increases at a constant rate, being negative in the range $w/s < 1$. Cases A and B also imply U-shaped distance functions, but with the gradient increasing more sharply for $w/s < 1$ and more slowly than the chi-square function in the range $w/s > 1$.

Figure 1 Alternative Gradient Functions (with $r_U = 4.1$ and $r_L = 0.01$)



4 The Survey of Income and Housing Costs (SIHC)

The Melbourne Institute Tax and Transfer Simulator (MITTS) is based on cross-sectional SIHCs. We are interested in improving the performance of MITTS by obtaining simulated expenditures and numbers of recipients for the base data that are close to the official numbers. Therefore, this section examines the performance of the ABS weights provided with the SIHC, and reports revised weights based on an extensive set of calibration conditions. The most recent data set available for use in the Melbourne Institute Tax and Transfer Simulator is the 2001 SIHC data set, which is used in the example given in this section. Subsection 4.1 presents the calibration conditions. The effect of imposing restrictions on the degree of deviation from old to new weights, is considered in subsection 4.2 in the context of the chi-squared distance function. Subsection 4.3 presents results for the Deville-Särndal distance function, the preferred approach. The distribution of income is then considered in subsection 4.4.

4.1 Calibration Conditions

The different sets of calibration conditions consist of demographic variables, for which population information is taken from census data (ABS, 2002) and compared to information derived from the sample. Table 2 provides details of the age distribution of males and females from the 2001 census, and compares the frequencies with those estimated from the SIHC using the ABS weights. The differences are shown in the final column of the table. These show that the SIHC appears to have too many people in the lower age groups and too few in the higher age groups, particularly in the highest age group for women.[10]

Table 2 Population age distribution

	Required total from Census 2001[(1)]	Estimated total from SIHC using ABS weights	Difference
Population aged under 15[(2)]			
0-4	1,243,969	1,214,517	29,452
5-9	1,331,926	1,253,801	78,125
10-14	1,336,580	1,765,168	-428,588
Males			
15-19	677,513	713,250	-35,737
20-24	629,319	617,182	12,137
25-29	654,456	715,695	-61,239
30-34	688,049	719,950	-31,901
35-39	703,544	729,525	-25,981
40-44	705,817	720,095	-14,278
45-49	651,987	673,475	-21,488
50-54	624,315	628,445	-4,130
55-59	490,155	468,993	21,162
60-64	394,631	414,462	-19,831
65-69	322,901	302,613	20,288
70-74	292,636	280,859	11,777
75 and over	427,221	404,355	22,866
Females			
15-19	647,751	668,439	-20,688
20-24	611,763	607,638	4,125
25-29	664,501	696,427	-31,926
30-34	716,182	748,909	-32,727
35-39	728,089	676,943	51,146
40-44	730,838	789,864	-59,026
45-49	667,860	646,603	21,257
50-54	624,170	647,963	-23,793
55-59	480,580	485,004	-4,424
60-64	394,376	385,841	8,535
65-69	337,686	333,367	4,319
70-74	326,947	306,560	20,387
75 and over	663,487	546,531	116,956
Total	18,769,249	19,162,474	-393,225

(1) Source: ABS (2002).
(2) The number of children variables in SIHC for the different age categories is mostly censored at 2. Therefore, the exact number of children in the different age categories cannot be calculated using information from the SIHC. In this table, we treated the censored number as the actual number, which is unlikely to be far from the actual value given the available age categories in the SIHC (that is, 0-2, 3-4, 5-9, and 10-14 years of age).

[10] This is probably caused by the fact that the SIHC excludes people in institutions or people living in remote areas, whereas these groups are included in the Census. An alternative reweighting could be based on total numbers from the Census excluding these groups, if possible.

Family composition comparisons are shown in Table 3. Except for the group of sole parents with dependent and non-dependent children, all groups appear to be over-represented in the SIHC. The number of families in the group "other types of family" is omitted from the calibration conditions to avoid singularities and is not reported in the table.

Table 3 Family composition

	Required total from Census 2001(1)	Estimated total from SIHC using ABS weights	Difference
Couples without children	1,764,167	1,886,483	-122,316
Couples with dependent children only	1,661,963	1,767,752	-105,789
Couples with dependent and non-dependent children	242,159	285,577	-43,418
Couples with non-dependent children only	417,043	459,372	-42,329
Sole parents with dependent children only	465,932	530,460	-64,528
Sole parents with dependent and non-dependent children	64,037	58,827	5,210
Sole parents with non-dependent children only	232,663	250,421	-17,758

(1) Source: ABS (2002).

Table 4 compares the number of unemployed people by age. The ABS weights understate the number of unemployed men in all but the 15-19 and 35-44 age groups. In contrast, the ABS overstates the number of unemployed women in all but the 20-34 age groups. Income support recipients are shown in Table 5. Here the numbers of recipients are taken directly from the observed values in SIHC, according to self-reported responses.

Table 4 Number of unemployed people

	Required total from Census 2001[1]	Estimated total from SIHC using ABS weights	Difference
Males			
15-19 years	59,493	66,202	-6,709
20-24 years	67,585	53,863	13,722
25-34 years	93,416	84,334	9,082
35-44 years	74,300	80,405	-6,105
45-54 years	59,110	48,071	11,039
55-64 years	37,011	19,851	17,160
Females			
15-19 years	50,921	55,461	-4,540
20-24 years	45,704	36,408	9,296
25-34 years	61,263	54,502	6,761
35-44 years	56,553	60,112	-3,559
45-54 years	38,463	43,212	-4,749
55-64 years	12,319	16,831	-4,512
Total	656,138	619,252	36,886

(1) Source: ABS (2002).

Table 5 Number of income support recipients

	Required total from FaCS[1]	Estimated total from SIHC using ABS weights	Difference
A. DSP			
Couples			
Males with dependents	172,666	183,435	-10,769
Females with dependents	68,295	96,924	-28,629
Singles			
Males with dependents	219,688	175,091	44,597
Females with dependents	163,277	129,364	33,913
B. Parenting payments (single & couple)			
Males			
Under 39	29,634	28,824	810
40–49	18,641	14,647	3,994
50 and over	5,349	4,700	649
Females			
Under 29	180,100	196,069	-15,969
30–39	250,438	298,710	-48,272
40–49	137,478	182,098	-44,620
50 and over	17,695	16,195	1,500
C. Wife pension, carers payment and widow allowance			
Under 39	16,667	13,291	3,376
40–49	30,806	31,408	-602
50–59	91,354	107,956	-16,602
60 and over	32,480	31,083	1,397

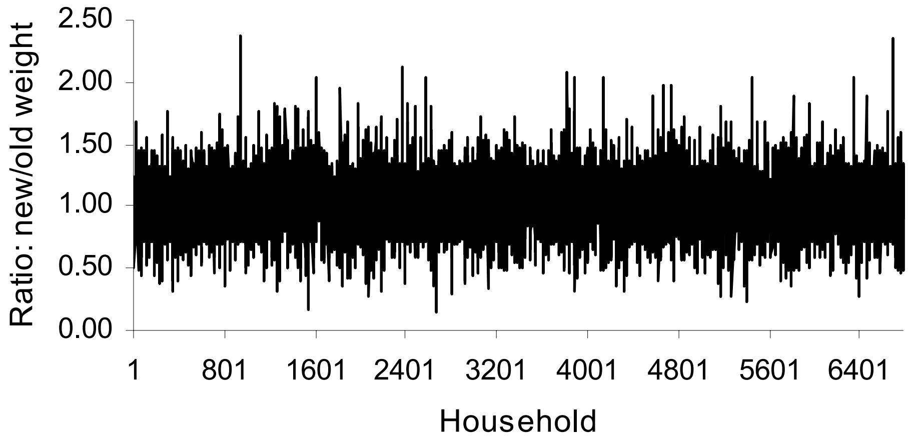
(1) Source: FaCS (2003).

4.2 The Chi-Squared Distance Function

Using the calibration information in Tables 2 to 5, it is possible to use the iterative method described earlier to calculate new weights for the SIHC. First it is useful to compare the effects of imposing constraints on the degree of deviation of the weights from the initial ABS weights. This can be done only for the Chi-squared distance function. The aim of the calibration approach is to find new weights that are as close as possible to the original weights while fulfilling the calibration conditions. Thus, ideally the ratio of revised to original weights is as close to one as possible.

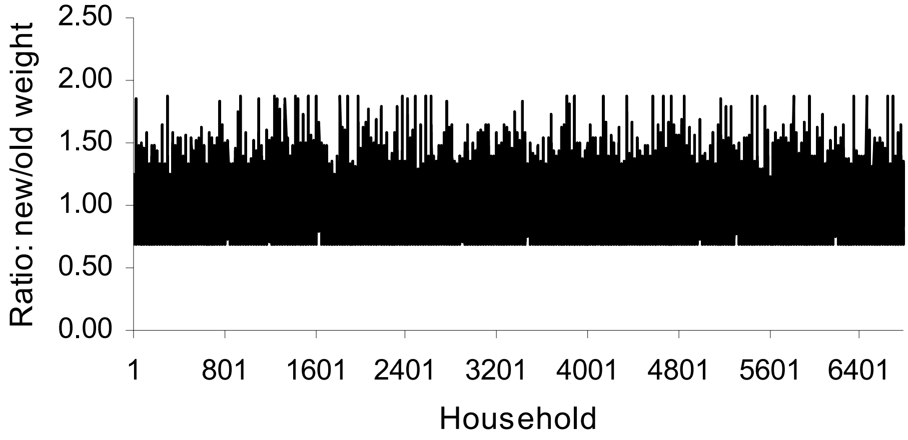
Figure 2 shows the ratio of revised to original weights for all households in the SIHC, obtained using the basic Chi-squared distance function. While no weights are negative, there is considerable variation, despite the fact that in general the calibration conditions do not differ substantially from the SIHC values.

Figure 2 Ratio of new weight to ABS weight using the unconstrained Chi-squared distance function



The effect of imposing limits is clearly seen in Figure 3, which shows the weights produced under the restriction that the ratios of the new weights to the old weights have to be in the interval [0.68, 1.87]. The limits used here were obtained after an extensive search process to find the smallest possible range for which the iterative procedure could still produce a solution. This clearly pushes a large proportion of weights to the minimum of their permissible range. These figures show that deviations from the original weight in the unconstrained case would be somewhat larger and more variable.

Figure 3 Ratio of new weights to ABS weights using the constrained Chi-squared distance function



4.3 Revised Weights Using the D-S Function

Experiments showed that the minimum range possible when using the (constrained) Chi-squared distance function also applied when using the Deville-Särndal distance function. However, the asymptotic nature of this function, as shown in Figure 1 in Section 3, means that no values are actually pushed exactly to the limits. The initial ABS weights and the new weights are illustrated in Figures 4 and 5. Figure 5 is similar to Figure 3, but it shows that the new weights are less frequently close to the lower boundary using this approach compared with the constrained Chi-squared Distance approach. For this reason, it was decided to use the results from the Deville-Särndal function to reweight the SIHC for use in MITTS.

Figure 4 ABS Weights and Weights Derived With D-S Function

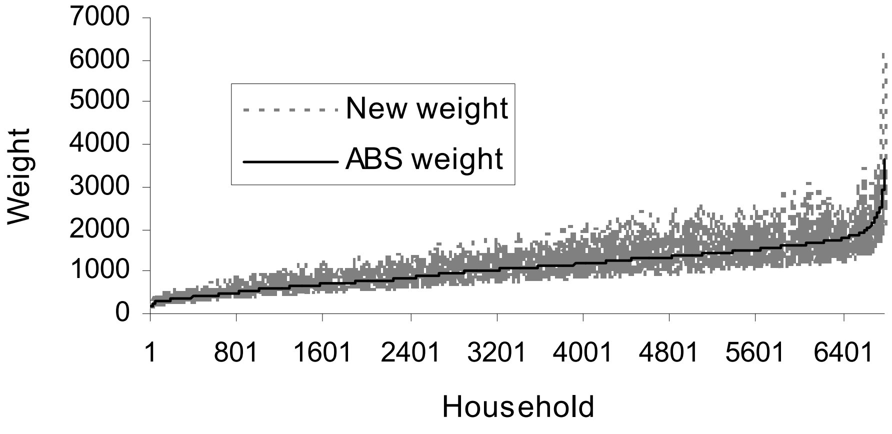
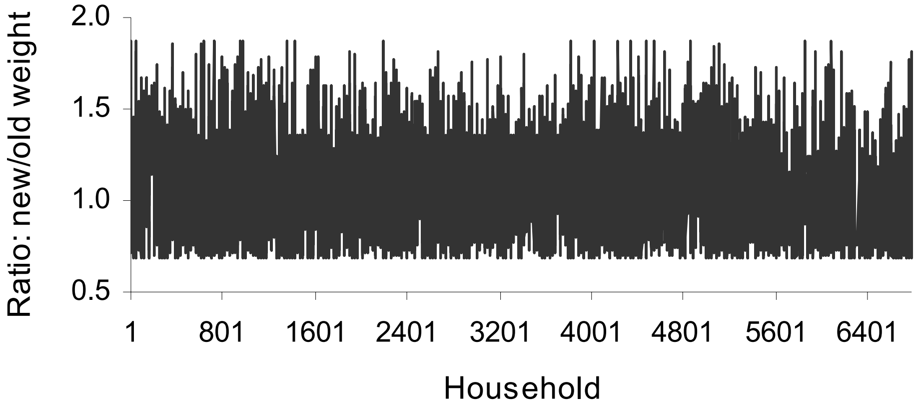


Figure 5 Ratio of new weight to ABS weight (lower bound 0.68, upper bound 1.87)



Before considering the performance of MITTS with these new weights, it is useful to compare a few summary measures resulting from calculations using the old and the new weights. First it is useful to consider the simulated number of income support recipients based on the old and new weights.

Comparing the actual and simulated number of recipients in Table 6 shows that the weighting has not much effect on most types of income support recipients. The two main exceptions are disability support pensioners, which show an improvement, and age pensioners, where the difference between actual and simulated numbers becomes bigger. The latter is caused by the reweighting on age, putting additional weight on the older age groups. The MITTS model overestimates the proportion of older persons eligible for age pension as a result of the lack of information on assets held by households. People over 60 are amongst those most likely to have built up assets in the form of superannuation or other investments.

Appendix D provides some alternative approaches. For example, Tables 19 and 20 in Appendix D show the simulated numbers when observed receipt is used as a requirement for take up of age pension and people with an eligibility for benefits under $10 per week are assumed not to take up these benefits. Using observed eligibility for age pension instead of assets (which are not observed) can improve the simulation of particular components, but in this case it does not improve the estimated expenditure.

Table 6 Actual and simulated numbers (×1000) of income support recipients

	Actual from FaCS(1) (1)	Simulated using ABS weights (2)	Simulated using new weights (3)	Difference between (1) and (2)	Difference between (1) and (3)
Parenting Payment (sgl & cpl)	639	674	602	-35	37
Sickness Allowance	11	21	22	-10	-11
Widow's Allowance	36	1	0	35	36
AUSTUDY/ABSTUDY	42	135	150	-93	-108
NewStart Allowance	541	660	690	-119	-149
Mature Age Allowance	39	47	47	-8	-8
Youth Allowance	393	674	671	-281	-278
Special Benefit	12	232	246	-220	-234
Partner Allowance	90	215	212	-125	-122
Age Pension	1,786	1,935	2,094	-149	-308
Disability Support Pension	624	575	615	49	9
Wife's Pension	78	101	93	-23	-15
Widow B Pension	9	41	38	-32	-29
Carer's Payment	57	33	33	24	24
Total	4,357	5,344	5,513	-987	-1,156

(1) Source: FaCS (2003).

The aggregate expenditures for a range of benefits produced directly by the SIHC for the old and new weights may be compared. That is, the actual benefits reported as being received by individuals in SIHC are used. Comparisons are shown in Table 7. Comparing the estimated expenditure obtained directly from SIHC when aggregated using the ABS weights and the revised weights in Table 7, there seems to be a slight overall improvement. However, when examining particular payment types separately, for some types the amount is now much further from the actual amount whereas for other types an improvement is evident.

Finally, the performance of MITTS with regard to expenditures using the different sets of weights is illustrated in Table 8. Table 8 is similar to Table 7 but compares the simulated expenditure based on the reweighted SIHC data with the simulated expenditure based on the original SIHC data. Comparing Tables 7 and 8, it can be seen that the difference between the actual expenditure and the simulated expenditure is smaller than the difference between the actual expenditure and the expenditure observed from SIHC. However, the reweighting does not improve the simulated expenditure. In fact, the difference between actual and simulated expenditure for 2001 is quite small with the initial weights, although there are a few exceptions. Regarding the Widow’s Allowance and the Widow B Pension it seems that the two payments cannot be separated as they should, but in aggregate the simulated amount paid on these is quite close to the simulated amount. Similarly adding the NewStart Allowance and the Partner Allowance seems to smooth out differences between actual and simulated amounts. That leaves us with AUSTUDY and Special Benefit. Both payments are overestimated in MITTS. The Special Benefit has strict requirements which cannot be easily tested in MITTS because not all necessary information is available in SIHC. For AUSTUDY, the recipient needs to undertake a qualifying study. This information is not available in SIHC.

Table 7 Actual and estimated expenditure on income support

	Actual from FaCS[1] (1) ($m)	SIHC using ABS weights (2) ($m)	SIHC using new weights (3) ($m)	Diff. between (1) and (2)	Diff. between (1) and (3)
Parenting Payment (single & couple)	5,327.0	4,911.3	4,303.7	415.7	1,023.2
Sickness Allowance	95.9	212.7	223.0	-116.8	-127.1
Widow's Allowance	330.2	402.5	369.1	-72.3	-39.0
AUSTUDY/ABSTUDY	255.6	n/a[2]	n/a		
NewStart Allowance	4,918.3	3,466.2	3,858.9	1,452.1	1,059.5
Mature Age Allowance	353.1	329.1	304.9	24.1	48.2
Youth Allowance	2,121.6	1,446.2	1,521.1	675.4	600.5
Special Benefit	113.8	150.5	164.9	-36.6	-51.1
Partner Allowance	717.1	605.2	668.2	111.9	48.9
Age Pension	15,571.8	14,233.9	15,681.1	1,337.9	-109.4
Disability Support Pension	5,837.4	5,182.7	5,656.3	654.7	181.1
Wife's Pension	680.0	491.7	445.0	188.3	235.0
Widow B Pension	75.3	n/a[2]	n/a		
Carer's Payment	478.3	605.2	582.3	-127.0	-104.0
Total	36,875.4	32,037.2	33,778.5	4,507.4	2,765.8

(1) Source: FaCS (2001).
(2) AUSTUDY and Widow B Pension cannot be identified from SIHC data.

An alternative approach would be to base the calibration exercise on numbers calculated by MITTS, which are based on entitlement to the various benefits according to individuals' characteristics. MITTS does not model the take-up behaviour of individuals, except for allowing the possibility that people do not claim small weekly amounts of benefits. Experiments were carried out using such alternative approaches (see Tables 17 to 20, comparing simulated recipient numbers and expenditures with the actual numbers, in Appendix D), but this still did not improve the performance of the new weights compared with the ABS weights. In addition, the simulated numbers are different from the actual numbers for reasons that have nothing to with the weights, and should therefore not be corrected by reweighting.

Table 8 Actual and simulated expenditure on income support

	Actual from FaCS[1] (1) ($m)	SIHC using ABS weights (2) ($m)	SIHC using new weights (3) ($m)	Diff. between (1) and (2)	Diff. between (1) and (3)
Parenting Payment (single and couple)	5,327.0	5,037.5	4,454.7	289.5	872.3
Sickness Allowance	95.9	181.7	193.6	-85.8	-97.7
Widow's Allowance	330.2	4.9	3.5	325.3	326.7
AUSTUDY/ABSTUDY	255.6	947.1	1,000.6	-691.5	-745.0
NewStart Allowance	4,918.3	4,268.1	4,562.9	650.2	355.4
Mature Age Allowance	353.1	221.2	244.3	131.9	108.8
Youth Allowance	2,121.6	2,475.7	2,463.7	-354.1	-342.1
Special Benefit	113.8	1,910.2	2,036.1	-1,796.4	-1,922.3
Partner Allowance	717.1	1,493.2	1,492.4	-776.1	-775.3
Age Pension	15,571.8	15,865.0	17,401.7	-293.2	-1,829.9
Disability Support Pension	5,837.4	5,133.8	5,610.6	703.6	226.8
Wife's Pension	680.0	792.9	729.9	-112.9	-49.9
Widow B Pension	75.3	398.2	360.5	-322.9	-285.2
Carer's Payment	478.3	274.1	272.4	204.2	205.9
Total	36,875.4	39,003.6	40,826.9	-2,128.2	-3,951.5

(1) Source: FaCS (2001).

It became apparent from these comparisons that imposing take-up conditions (which are related to the amount of payment for which each individual is eligible) and using observed age pension receipt as a condition for eligibility instead of the missing asset information improves the overall results using the ABS weights (see Tables 19 and 20 in Appendix D). However, at the individual payment level there is not much improvement. The overall effect is generated by compensating over- and under-estimates of expenditures.

4.4 The Distribution of Income

The impact of reweighting on the distribution of other important variables needs to be checked. Besides income recipient numbers and expenditure on the different payments, other income is also relevant when simulating policy changes. Income from employment (wages and salaries) is the largest component of most households' incomes. The frequency distribution of weekly income from wages and salaries is plotted in Figure 6 for the two weighting schedules, with the difference between the two approaches plotted in Figure 7.[11] This shows that the difference between using the ABS and the revised weight is minimal, except for a slightly larger group at zero wages and salaries when using the revised weights.

Figure 6 Frequency distribution of weekly wage and salary income

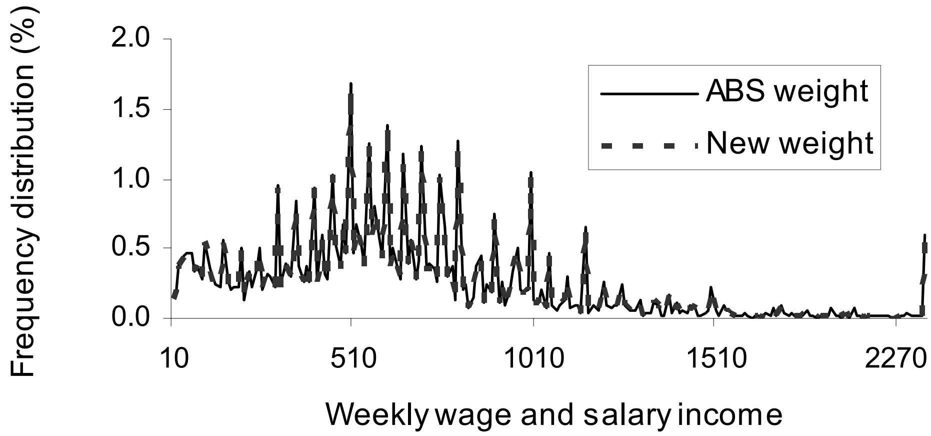
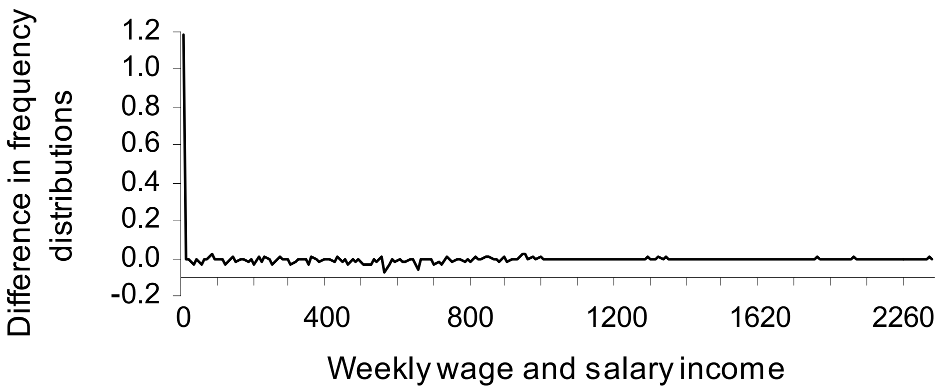


Figure 7 Difference in frequency distribution of weekly wage and salary income between using ABS and new weights



To check the effect of reweighting on the individual benefit payments, the frequency of weekly benefit income is graphed in Figure 8 and the difference between the two

[11] In Figure 6 the frequencies for zero wage and salary income are excluded. The frequency of zero income is 47.86 per cent with ABS weights and 49.05 per cent with new weights. To calculate these proportions, all respondents in SIHC of 15 years of age and over are included.

weighting schedules is shown in Figure 9.[12] As with the distribution of wages and salaries these are similar, except for the larger proportion on a weekly benefit of around $210 per week, which is consistent with the larger proportion without wage and salary income. This is likely to be the amount for a single income support recipient. From Figure 9, it is clear that there is a smaller proportion on zero benefits when using the new weights.

Figure 8 Frequency distribution of total weekly benefit income

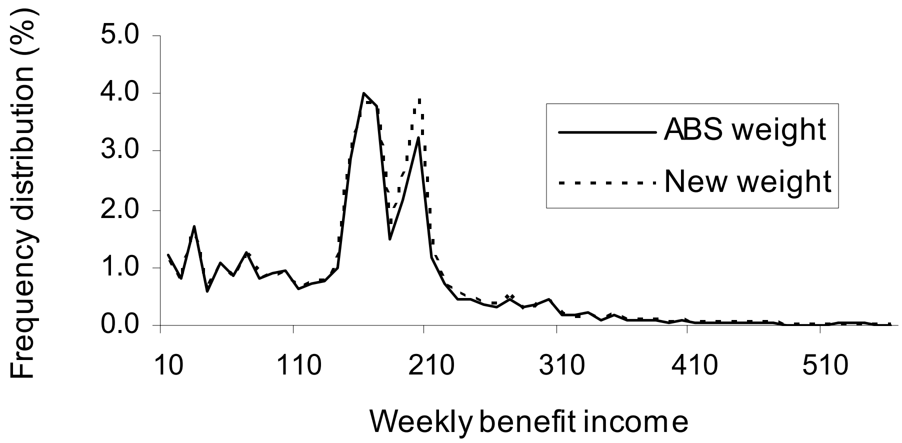
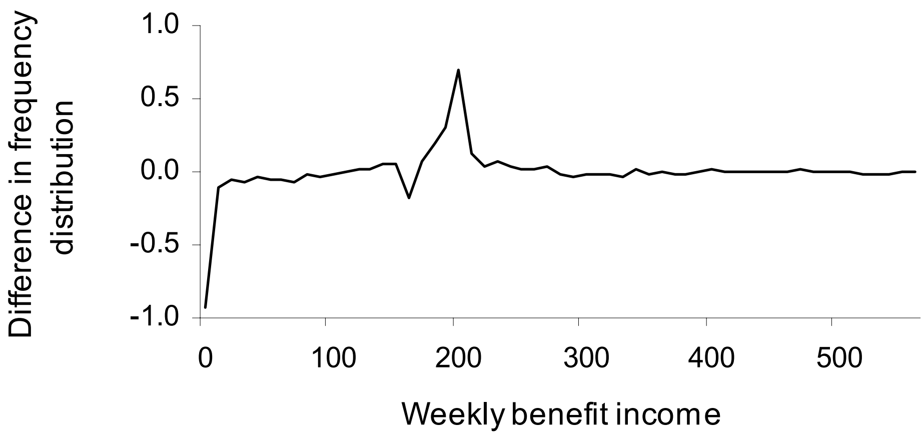


Figure 9 Difference in frequency distribution of total weekly benefit income between using ABS and new weights



[12] In Figure 8 the frequencies for zero benefit income are excluded. The frequency of zero benefit income is 62.46 per cent with ABS weights and 61.53 per cent with new weights. To calculate these proportions, all respondents in SIHC of 15 years of age and over are included.

5 A Policy Simulation

This section compares the results from a policy simulation when using the revised weights with a policy simulation when using the ABS weights. The policy simulation examined here is a straightforward reduction in all taper rates over 30 per cent to 30 per cent. First, the results from a non-behavioural simulation for which labour supplies are fixed, using MITTS-A, are presented in Section 5.1, followed by the results from a behavioural simulation, using MITTS-B, in Section 5.2.

5.1 Fixed Labour Supplies: MITTS-A Results

Tables 9 and 10 present the simulation results for the number of income recipients and expenditure for the two sets of weights. The different weights produce slightly different revenues and expenditures by payment type, as well as slightly different numbers of recipients. The difference is that the revised weights produce a population with lower incomes, which results in lower tax and Medicare revenues. In addition, more is spent on tax rebates and pensions, thereby increasing government expenditure overall. However, when looking at the percentage change in these numbers resulting from the policy change, the two approaches produce similar results. This is confirmed in Table 11, which presents an overview of the winners and losers from this policy change by income unit type, age and employment status. The use of the revised weights has hardly any impact on the estimated implications of the policy. The policy change is most beneficial to couples with dependents, followed by couples without dependents and to those who are employed.

Table 9 MITTS-A simulation results for a taper rate reduction (1): numbers of tax payers and transfer recipients

	ABS weight			New weight		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	(1000)	(1000)	%	(1000)	(1000)	%
Tax payers						
Income Tax	12,103	208	2	12,080	194	2
Medicare Levy	7,762	377	5	7,654	364	5
Transfer recipients						
Tax Rebates	6,294	-199	-3	6,398	-214	-3
FTP/FTB	1,935	0	0	1,765	0	0
Allowances	2,657	2,303	87	2,640	2,265	86
Pensions	3,102	54	2	3,325	55	2
Pharm Allowance	3,556	170	5	3,737	158	4
Rent Allowance	1,454	724	50	1,554	774	50
Allowance recipients						
Parenting Payment (single)	389	34	9	346	29	8
Parenting Payment (couple)	285	300	105	256	278	109
Sickness Allowance	21	1	5	22	1	5
Widow's Allowance	1	1	100	0	2	-
AUSTUDY/ABSTUDY	135	30	22	150	29	19
NewStart Allowance	660	1,571	238	690	1,573	228
Mature Age Allowance	47	79	168	47	73	155
Youth Allowance	674	131	19	671	135	20
Special Benefit	232	0	0	246	0	0
Partner Allowance	215	155	72	212	146	69
Pension recipients						
Age Pension	1,935	43	2	2,094	46	2
Dis.Support Pension	575	0	0	615	1	0
Wife's Pension	101	0	0	93	0	0
Widow B Pension	41	0	0	38	0	0
Carer's Payment	33	2	6	33	3	9
Veteran Pension	233	8	3	243	6	2
Veterans Dis.Pension	101	0	0	103	0	0
War Widows Pension	83	0	0	106	0	0
Rebate recipients						
Beneficiary Rebate	1,193	303	25	1,218	285	23
Pension Rebate	2,213	-31	-1	2,369	-37	-2
SP Pension Rebate	349	-12	-3	308	-10	-3
Low Income Rebate	8,715	-307	-4	8,785	-311	-4
Dep Spouse Rebate	416	-135	-32	394	-129	-33

(1) The policy change is a reduction of all pension and allowance taper rates over 30 per cent to 30 percent in the January 2001 System.

Table 10 MITTS-A simulation results for a taper rate reduction [(1)]: government revenue and expenditure

	ABS weight			New weight		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	Value ($m)	Value ($m)	%	Value ($m)	Value ($m)	%
Main Revenue and Expenditure						
Government Revenue						
Income Tax	79707.8	1378.6	1.7	77921.0	1387.6	1.8
Medicare Levy	5727.8	171.7	3.0	5620.3	168.6	3.0
Total Revenue	85435.6	1550.3	1.8	83541.3	1556.2	1.9
Government Expenditure						
Tax Rebates	2889.1	-174.3	-6.0	2999.4	-172.7	-5.8
FTP/FTB	9539.9	719.1	7.5	8886.2	672.6	7.6
Allowances	16539.6	7002.9	42.3	16451.6	6839.0	41.6
Pensions	26437.0	740.7	2.8	28795.5	792.7	2.8
Pharm Allowance	383.8	16.9	4.4	417.6	16.0	3.8
Rent Allowance	2033.5	850.3	41.8	2100.0	929.7	44.3
Total Expenditure	57822.9	9155.5	15.8	59650.3	9077.4	15.2
Net Expenditure	-27612.7	7605.2	-27.5	-23891.0	7521.2	-31.5
Allowances						
Parenting Payment (single)	3253.6	223.7	6.9	2885.2	199.6	6.9
Parenting Payment (couple)	1783.9	1004.5	56.3	1569.5	926.7	59.0
Sickness Allowance	181.7	9.5	5.2	193.6	7.4	3.8
Widow's Allowance	4.9	5.5	112.2	3.5	7.6	217.1
AUSTUDY/ABSTUDY	947.1	148.1	15.6	1000.6	173.2	17.3
NewStart Allowance	4268.1	4176.7	97.9	4562.9	4162.9	91.2
Mature Age Allowance	221.2	281.6	127.3	244.3	256.0	104.8
Youth Allowance	2475.7	260.3	10.5	2463.7	257.3	10.4
Special Benefit	1910.2	0.0	0.0	2036.1	0.0	0.0
Partner Allowance	1493.2	892.9	59.8	1492.4	848.2	56.8
Total Allowance Cost	16539.6	7002.9	42.3	16451.6	6839.0	41.6
Pension Costs						
Age Pension	15865.0	552.4	3.5	17401.7	598.3	3.4
Dis.Support Pension	5133.8	70.7	1.4	5610.6	72.1	1.3
Wife's Pension	792.9	18.0	2.3	729.9	15.8	2.2
Widow B Pension	398.2	6.7	1.7	360.5	6.1	1.7
Carer's Payment	274.1	14.1	5.1	272.4	18.0	6.6
Veteran Pension	1812.7	75.9	4.2	1910.2	79.1	4.1
Veterans Dis.Pension	1063.5	0.0	0.0	1104.8	0.0	0.0
War Widows Pension	1096.9	2.8	0.3	1405.3	3.3	0.2
Total Pension Cost	26437.0	740.7	2.8	28795.5	792.7	2.8
Rebate Costs						
Beneficiary Rebate	457.9	75.6	16.5	477.4	71.5	15.0
Pension Rebate	2388.3	-33.5	-1.4	2614.9	-37.8	-1.4
SP Pension Rebate	256.1	-10.2	-4.0	226.1	-8.7	-3.8
Low Income Rebate	1250.6	-44.3	-3.5	1261.8	-44.6	-3.5
Dep Spouse Rebate	423.3	-177.3	-41.9	400.9	-168.3	-42.0
Total Rebate Cost	4776.3	-189.7	-4.0	4981.2	-188.0	-3.8

(1) The policy change is a reduction of all pension and allowance taper rates over 30 per cent to 30 percent in the January 2001 System.

Table 11 MITTS-A simulation results for a taper rate reduction(1): income gainers and losers (2) by selected characteristics (row percentages)

	ABS weight					New weight				
	No change	Up $1-5	Up $5-10	Up > $10	Average	No change	Up $1-5	Up $5-10	Up > $10	Average
By income unit type										
Couple	61.8	2.7	2.8	32.6	19.9	61.6	2.8	2.9	32.8	19.8
Couple with Dependents	67.4	0.7	0.7	31.2	24.4	67.5	0.8	0.7	31.0	24.4
Single female	68.0	3.9	3.1	25.0	11.2	68.5	3.8	3.0	24.7	10.8
Single male	66.8	3.1	2.9	27.1	12.1	67.3	3.4	3.0	26.4	11.6
Sole parent	66.5	3.3	2.3	28.0	9.1	66.4	3.4	1.9	28.3	9.4
By age										
15 to 19	67.0	4.2	3.2	25.7	14.4	66.8	4.6	3.0	25.6	14.1
20 to 24	55.1	3.7	2.1	39.1	20.8	55.3	3.7	2.3	38.7	20.1
25 to 29	62.8	1.9	2.1	33.2	19.0	61.6	1.9	2.1	34.4	19.2
30 to 34	67.9	1.0	1.2	29.9	19.2	68.4	1.0	1.2	29.4	18.6
35 to 39	69.7	0.9	1.5	28.0	19.7	70.4	0.8	1.4	27.4	19.4
40 to 44	69.9	0.7	2.2	27.2	18.4	69.6	0.8	2.5	27.2	18.1
45 to 49	65.7	1.6	0.9	31.9	21.7	65.7	1.6	0.9	31.7	21.4
50 to 54	63.1	1.5	1.7	33.7	22.6	62.8	1.8	1.7	33.7	22.4
55 to 59	63.0	1.9	1.0	34.2	21.5	64.0	2.0	0.9	33.1	20.5
60 to 64	59.4	4.4	2.1	34.1	20.8	61.7	4.4	2.2	31.7	18.9
65 plus	70.2	5.1	5.1	19.6	6.1	70.8	5.1	5.0	19.1	5.8
By employment status										
Employed	60.5	2.1	2.1	35.3	21.5	60.0	2.3	2.1	35.6	21.3
Non-Participation	72.4	3.3	2.8	21.5	11.8	73.3	3.3	2.9	20.4	10.9
Unemployed	81.7	0.7	1.1	16.6	12.3	82.7	0.8	0.8	15.7	11.2

(1) The policy change is a reduction of all pension and allowance taper rates over 30 per cent to 30 percent in the January 2001 System.
(2) There are no losers for this policy change.

5.2 Endogenous Labour Supplies: MITTS-B Results

In this section, labour supply responses resulting from the policy change are presented, followed by the changes in the cost to government of the policy change, allowing for the effect of the expected labour supply responses. Table 12 reports the predicted labour supply responses when ABS weights are used. The reduction in taper rates has the expected positive effect on sole parents with the positive substitution effect from the reduced taper on earnings outweighing the negative income effect. The negative effect on married women is expected too, because the dominance of the income effect for married women when reducing the marginal effective tax rate is well-documented in the literature, although like here the effect is still relatively small (for example, Blundell et al., 2000; Blundell and Hoynes, 2000; Eissa and Hoynes, 1999). The much smaller effects for the other groups are commonly found in other simulation studies.

Table 12 MITTS-B Simulation results: labour supply responses

	Married men	Married women	Single men	Single women	Single parents
			ABS weight		
all workers (%base) (1)	71.67	55.42	62.04	50.06	49.62
worker, hrs known(%base)	58.08	48.61	54.94	47.09	42.64
worker, hrs known(%post)	58.68	48.02	55.57	47.68	45.81
non-work-->work (%)	1.24	0.62	0.76	0.66	3.38
work-->non-work (%)	0.64	1.22	0.13	0.06	0.21
workers working more	0.25	0.23	0.00	0.04	1.00
workers working less	1.04	0.69	0.83	2.01	1.35
average hours change	0.09	-0.35	0.08	-0.14	1.03
			New weight		
all workers (%base) (1)	70.88	54.79	59.89	49.27	49.4
worker, hrs known(%base)	57.23	47.91	52.92	46.27	42.68
worker, hrs known(%post)	58.00	47.31	53.71	46.82	45.78
non-work-->work (%)	1.38	0.66	0.92	0.61	3.32
work-->non-work (%)	0.62	1.25	0.13	0.07	0.22
workers working more	0.25	0.22	0.00	0.05	0.94
workers working less	1.04	0.67	0.79	2.01	1.39
average hours change	0.16	-0.35	0.15	-0.16	0.99

Note (1): This group includes the self-employed for whom no hours of work are observed. Only the effect for wage and salary earners is simulated in MITTS.

Comparing the first part of Table 12 with the second part, the reported effects are similar. The largest difference is found for men moving from non-work to work. This increases the overall effect of the policy change slightly and is possibly caused by the larger proportion of low-income couples in the re-weighted sample.

Table 13 presents the government's expenditure and revenue adjusted for the effect of expected labour supply changes. As a result of the labour supply response the cost of the policy change increases when these changes are taken into account. The total change in net expenditure resulting from the reduction in taper rates when using ABS weights increases from 7.6 billion dollars to 8.2 billion dollars and when using the revised weights it increases from 7.5 to 8.1 billion dollars. Similar to the results for the static simulation, the simulated amounts in the different categories are somewhat different in the two simulations, but the percentage change as a result of the taper rate reduction is quite similar. This indicates that in assessing the implication of this particular policy change the reweighting has not been important. It therefore seems that no advantage is to be gained from reweighting the SIHC for current year applications. Reweighting is most likely to be important when bringing a survey 'up to date' or for projections. An example where reweighting is necessary, concerning population ageing, is given in the following section.

Table 13 Simulation with behavioural responses: changes in revenue and expenditure

	ABS weight			New weight		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	Value ($m)	Value ($m)	%	Value ($m)	Value ($m)	%
Couples						
Government Revenue						
Income Tax	57,474.3	356.9	0.6	53,323.3	357.6	0.7
Medicare	4,023.6	96.4	2.4	3,723.5	91.8	2.5
Total Revenue	61,497.9	453.2	0.7	57,046.8	449.4	0.8
Government Expenditure						
Tax Rebates	1,537.6	-152.6	-9.9	1,465.5	-149.7	-10.2
FTP/FTB	6,006.6	893.0	14.9	5,697.2	866.4	15.2
Allowances	6,065.6	4,697.7	77.4	5,684.5	4,302.0	75.7
Pensions	13,641.1	465.0	3.4	12,889.1	446.9	3.5
Pharm Allow	134.0	8.0	5.9	126.8	7.1	5.6
Rent Allowance	647.3	231.2	35.7	589.0	205.0	34.8
Total Expenditure	28,032.1	6,142.2	21.9	26,452.2	5,677.6	21.5
Net Expenditure	-33,465.9	5,688.9	-17.0	-30,594.6	5,228.2	-17.1
Single Men						
Government Revenue						
Income Tax	12,839.4	288.4	2.2	13,574.9	332.0	2.4
Medicare	1,019.2	27.3	2.7	1,077.6	31.6	2.9
Total Revenue	13,858.6	315.7	2.3	14,652.4	363.6	2.5
Government Expenditure						
Tax Rebates	414.7	-19.4	-4.7	492.4	-24.8	-5.0
Allowances	4,298.9	1,051.5	24.5	4,670.9	1,059.0	22.7
Pensions	4,085.4	94.4	2.3	5,160.8	129.7	2.5
Pharm Allowance	65.8	1.8	2.7	83.2	2.1	2.6
Rent Allowance	465.0	397.3	85.4	570.7	431.5	75.6
Total Expenditure	9,329.8	1,525.6	16.4	10,978.1	1,597.4	14.6
Net Expenditure	-4,528.8	1,209.9	-26.7	-3,674.3	1,233.9	-33.6

Table 13: continued

	ABS weight			New weight		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	Value ($m)	Value ($m)	%	Value ($m)	Value ($m)	%
Single women						
Government Revenue						
Income Tax	7,510.5	131.4	1.7	9,365.1	146.6	1.6
Medicare	592.9	14.9	2.5	740.6	17.3	2.3
Total Revenue	8,103.4	146.2	1.8	10,105.6	163.9	1.6
Government Expenditure						
Tax Rebates	650.1	-17.2	-2.7	786.8	-20.2	-2.6
Allowances	2,633.9	956.8	36.3	2,933.4	1,123.2	38.3
Pensions	8,529.4	105.7	1.2	10,580.8	141.3	1.3
Pharm Allowance	124.8	1.9	1.5	154.9	2.3	1.5
Rent Allowance	344.1	280.7	81.6	429.9	351.4	81.8
Total Expenditure	12,282.3	1,327.9	10.8	14,885.7	1,598.0	10.7
Net Expenditure	4,178.9	1,181.7	28.3	4,780.1	1,434.1	30.0
Sole parents						
Government Revenue						
Income Tax	1,961.8	120.3	6.1	1,729.0	107.0	6.2
Medicare	93.5	11.0	11.8	81.9	10.2	12.5
Total Revenue	2,055.3	131.3	6.4	1,811.0	117.3	6.5
Government Expenditure						
Tax Rebates	291.8	-19.7	-6.8	259.0	-16.8	-6.5
FTP/FTB	3,508.7	82.4	2.3	3,155.9	70.1	2.2
Allowances	3,632.6	219.0	6.0	3,242.2	214.7	6.6
Pensions	210.3	-0.1	0.0	194.1	0.3	0.1
Pharm Allowance	59.3	6.4	10.8	52.8	5.5	10.4
Rent Allowance	575.0	6.4	1.1	510.5	5.4	1.0
Total Expenditure	8,277.6	294.4	3.6	7,414.6	279.2	3.8
Net Expenditure	6,222.3	163.1	2.6	5,603.6	161.9	2.9

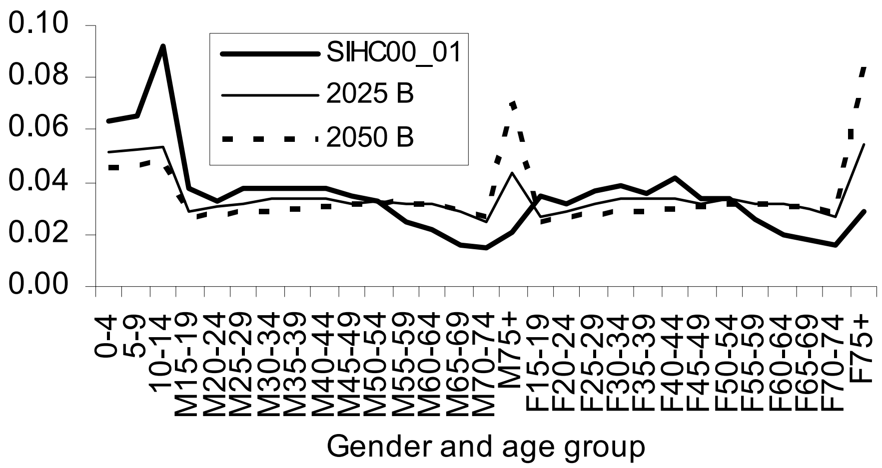
6 Population ageing

This section illustrates how MITTS can be used in combination with reweighting to examine the implications of population ageing. Projected population distributions by age and gender for 2025 and 2050 from the ABS (2003) are used to reweight the population in 2000/01 SIHC so the demographic composition is similar to the projection. However, to avoid the effects of changes in population size, it is assumed that the total population size does not change: only the proportion in each subgroup is used. The calibration conditions in the reweighting exercise then consist of the reallocated population totals by age and gender. In the two projections used here the proportion of older persons has increased relative to the younger age groups. Assuming that people's behaviour remains similar to current behaviour of comparable individuals, the effect on expenditure and revenue can be simulated. Under the same assumption, behavioural responses to policy changes can also be simulated. The reweighting procedure is discussed in section 6.1 and the results from simulations of the same taper rate reduction as in the previous section using the reweighted population are discussed in section 6.2.

6.1 Reweighting Procedure

The calibration conditions are constructed from the population projections for 2025 and 2050 by the ABS (2003). In the main text of the paper, we report the calibration conditions and reweighting results using the Series B population projection, a medium projection. The results using Series A and C, high and low projections respectively, are reported in Appendix E. Figure 10 presents the age and gender distribution of the 2000-2001 SIHC sample and the forecasts by the ABS for 2025 and 2050.[13] From the graph, it is clear that there is a decrease in the younger age groups (up to about 54 years) and an increase in the proportion of older Australians. This effect is strongest in 2050.

Figure 10 Gender and age distributions of current and projected populations – ABS projections for 2025 and 2050 are used



The proportions presented in Figure 10 (which are equivalent to the conditions on age and gender presented in Table 2) are used to calculate revised weights based on

[13] Up to age 14, only age can be observed in SIHC. Gender is not available for this group.

the original ABS weights. Given the low impact of the reweighting discussed in the previous section, the reweighting here is based only on the updated age and gender distribution. Figures 11 to 14 present the new weights resulting from this procedure relative to the ABS weights.

Figure 11 ABS weights and new weights for projected population structure of 2025 (sorted by ABS weights)

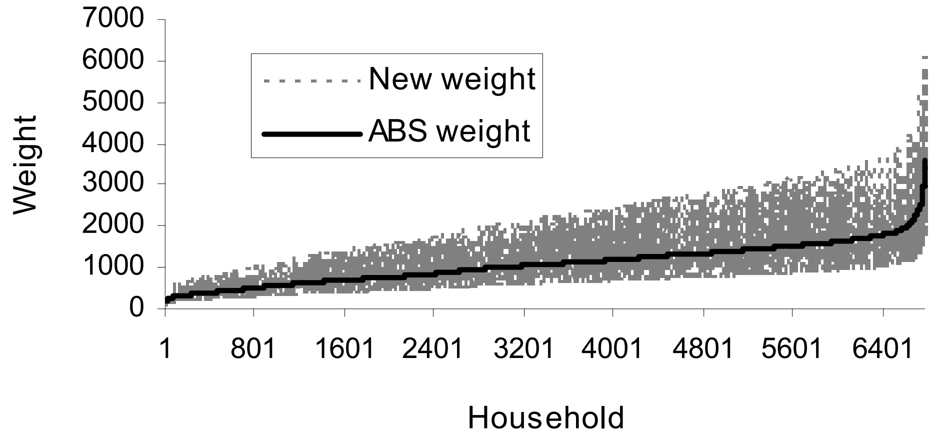


Figure 12 Ratio of new weight for the projection of 2025 and the ABS weight (lower bound 0.56, upper bound 2.1)

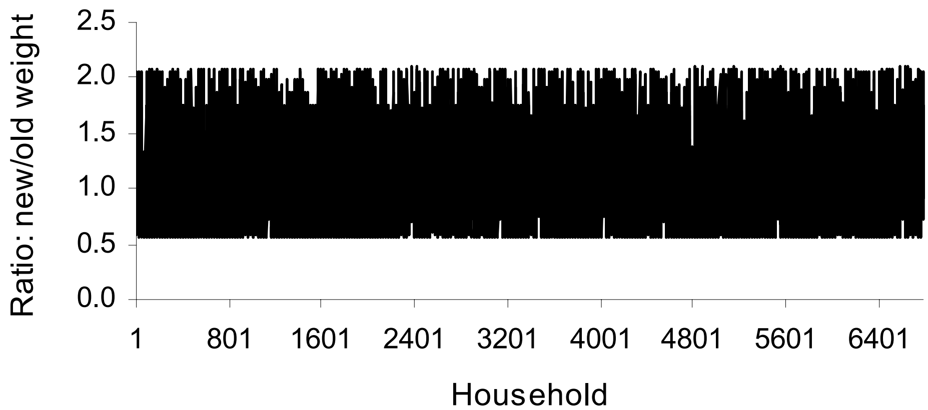


Figure 13 ABS weights and new weights derived for projected population structure of 2050 (sorted by ABS weight)

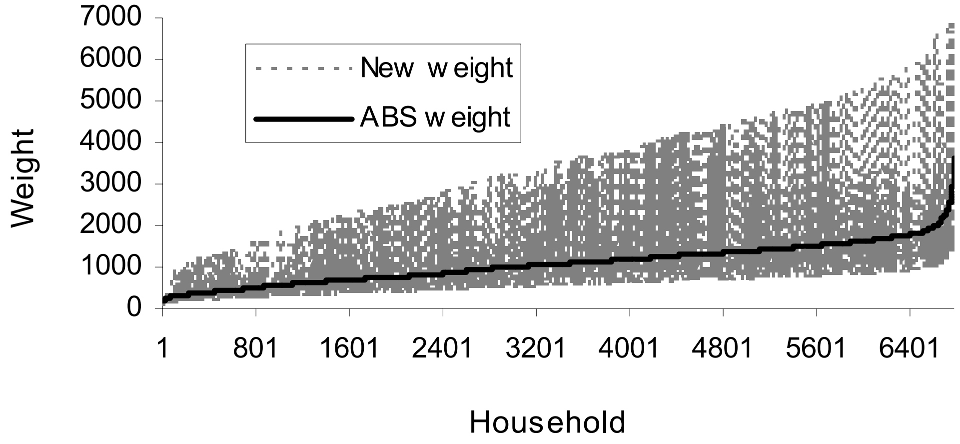
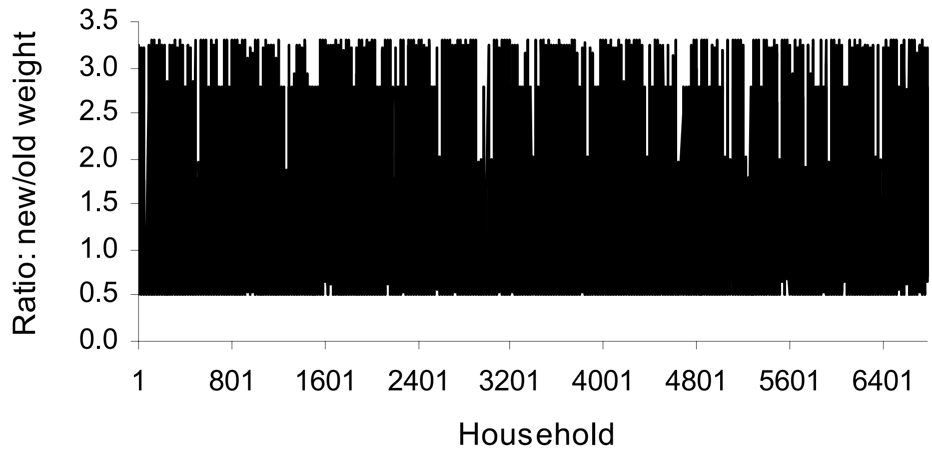


Figure 14 Ratio of new weight for projected population structure of 2050 and ABS weight (lower bound 0.51, upper bound 3.3)



Comparing these graphs to the earlier Figures 4 and 5, it is seen that the weights in this section deviate more from the ABS weights than the earlier revised weights (with a range of ratios of new to old weights of 0.68 to 1.87). This is of course as expected, given the projection forward where substantial changes can be seen in the age structure of the population requiring some age groups to be weighted up and others to be weighted down. The deviation is larger for the 2050 projection, where the age structure is more different from the SIHC 2000-2001 than in the 2025 projection. The minimum range that could be imposed in the D-S approach increased from [0.56, 2.1] for the 2025 reweighting to [0.51, 3.3] for the 2050 reweighting. The upper boundary seems relatively more affected by the difference in age structure, which can be explained by the relatively sharp increase that the older age group needs to make, compared with the smaller decrease of the other groups which is spread across a much larger age range.

The effect on the wage and salary income distribution of the new weights is illustrated by Figures 15 and 16.[14] As before, the reweighting for 2050 is more different than the reweighting for 2025. However, the general pattern of differences is similar. There is little change in the proportion of persons on very high wages, but the proportion on medium wage and salary incomes has decreased. Instead a larger proportion of people have no wage and salary income. This is as expected after an increase in the proportion of people over 60 and in particular the sharp increase of the proportion over 75 as can be seen from Figure 10.

Figure 15 Difference of frequency distribution of weekly wage and salary income using ABS weights versus new weights for projected population structure of 2025

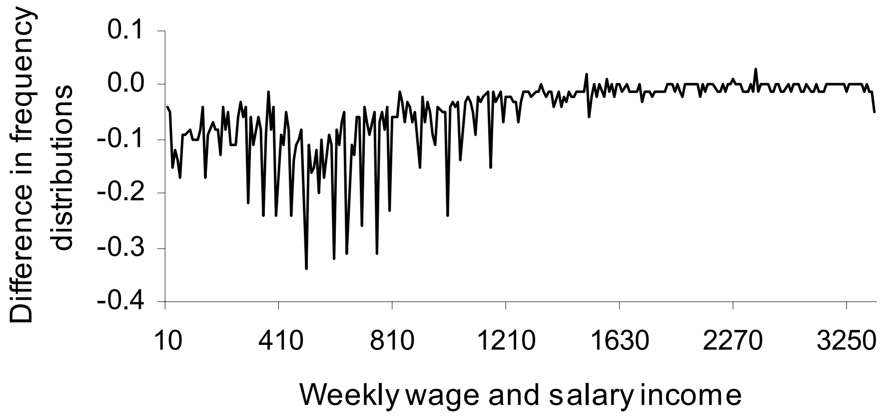
Appendix E presents the results for alternative projections by the ABS. From Figures 19 and 20, it can be seen that the proportion of young people is higher in the high population projection and lower in the low population projection and that the proportion of older individuals is highest for the low population projection and lowest for the medium population projection.[15] Comparing the restrictions on the bounds that can be achieved in the different scenarios in Figures 21 to 24, shows that the range is

[14] The difference at zero is 7.46 in Figure 15, and 12.08 in Figure 16.

[15] The proportion of the population aged 65 and over for series A, B and C is 28.03, 26.94 and 29.45 per cent, respectively.

narrowest for the medium population scenario. This may be explained by the fact that although series B has a higher proportion of people over 50 than the high population, the proportion of people over 75 is lower. This means that this relatively small group of people over 75 needs to have a larger increase in their weights in the low and high population scenarios. The income from wage and salary distribution is further from the 2001 distribution in both alternative scenarios as can be seen in Figures 25 and 26. A possible explanation for this is that the younger population has a larger proportion of children whereas the older population has a larger proportion of potentially retired people. The medium population, on the other hand, has the highest proportion in the working-age category, resulting in a larger proportion of the population on non-zero wage and salary income. [16]

Figure 16 Difference of frequency distribution of weekly wage and salary income using ABS weights versus new weights for projected population structure of 2050



6.2 Simulation with the updated population

This section examines the effect of population ageing on government expenditure and revenue, if the changed demographic structure of the population would have been realised in 2001. Table 14 presents the results. As expected, more people pay income tax (given that there are fewer children and dependent adolescents) but at a lower level, which results in a decrease in the revenue from taxation. Similarly the Medicare levy decreases, but rebates go up.

[16] The proportion of the working age population for series A, B and C is 56.71, 59.00 and 58.49 per cent, respectively.

Table 14 Simulated impact of population ageing on revenue and expenditure

	Simulation using ABS weight		Simulation using weights derived from projected population structure(1)			
			2025 Series B		2050 Series B	
	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)
Government Revenue						
Income Tax	79,707.8	12,103	75,639.9	13,072	71,294.3	13,411
Medicare Levy	5,727.8	7,762	5,438.9	7,611	5,102.2	7,271
Total Revenue	85,435.6		81,078.7		76,396.5	
Government Expenditure						
Tax Rebates	2,889.1	6,294	3,921.0	7,675	4,515.7	8,410
FTP/FTB	9,548.4	1,935	6,896.9	1,427	6,198.6	1,277
Allowances	16,539.6	2,657	15,189.1	2,400	14,222.8	2,239
Pensions	26,437.0	3,102	42,289.1	5,006	52,076.8	6,127
Pharm Allowance	383.8	3,556	554.6	5,381	665.9	6,472
Rent Allowance	2,033.5	1,454	1,953.9	1,535	1,971.1	1,597
Total Expenditure	57,831.5		70,804.6		79,651.0	
Net Expenditure	-27,604.1		-10,274.2		3,254.5	
Allowance						
Parenting Payment (single)	3,253.6	389	2,441.3	291	2,259.3	267
Parenting Payment (couple)	1,783.9	285	1,316.1	213	1,196.7	192
Sickness Allowance	181.7	21	185.4	21	176.3	20
Widow's Allowance	4.9	1	2.7	0	2.5	0
AUSTUDY/ABSTUDY	947.1	135	827.5	120	722.7	103
NewStart Allowance	4,268.1	660	4,084.7	628	3,811.2	584
Mature Age Allowance	221.2	47	319.0	65	303.0	60
Youth Allowance	2,475.7	674	1,972.1	530	1,820.4	491
Special Benefit	1,910.2	232	2,075.4	253	1,992.5	246
Partner Allowance	1,493.2	215	1,964.9	280	1,938.3	275
Total Allowance Cost	16,539.6		15,189.1		14,222.8	
Pension						
Age Pension	15,865.0	1,935	27,491.9	3,380	34,148.3	4,171
Dis.Support Pension	5,133.8	575	6,070.3	677	6,144.3	682
Wife's Pension	792.9	101	1,052.5	134	1,099.2	139
Widow B Pension	398.2	41	364.9	38	311.7	32
Carer's Payment	274.1	33	339.1	40	371.9	44
Veteran Pension	1,812.7	233	3,533.1	450	5,327.5	672
Veterans Dis.Pension	1,063.5	101	1,721.4	159	2,357.4	213
War Widows Pension	1,096.9	83	1,716.0	129	2,316.6	174
Total Pension Cost	26,437.0		42,289.1		52,076.8	
Rebate						
Beneficiary Rebate	457.9	1,193	459.6	1,190	433.5	1,119
Pension Rebate	2,388.3	2,213	4,061.7	3,808	5,137.6	4,781
SP Pension Rebate	256.1	349	192.2	263	177.7	243
Low Income Rebate	1,250.6	8,715	1,428.1	9,909	1,531.9	10,608
Dep Spouse Rebate	423.3	416	494.9	513	481.5	512
Total Rebate Cost	4,776.3		6,636.4		7,762.2	

(1). ABS population projection Series B (ABS, 2003) is used to derive the projected population structure.

On the expenditure side, the number of people on pensions increases substantially, while the number of people on allowances and on family payments decreases. The age pension sees the largest increase, in line with the ageing population and a smaller increase is observed for the disability pension, which also tends to be received by older individuals.[17] Amongst the allowances, only the mature age allowance and the partner allowance go up.

For these two new samples, representing forecasts for 2025 and 2050 population age structures, the same policy change of a taper rate reduction as in the previous section is introduced. The first row in Table 15 presents the percentage of workers in the pre-reform situation. Comparing this with Table 12, a decline in participation rates for all groups except sole parents is evident. The labour supply responses are similar to those in the previous section. For sole parents the change is minimal. This group may have become smaller, but the age composition of this group is unlikely to have shifted towards the 60 and over group to a large extent. Similarly, there is little change in the effect for singles. The negative effect for single and married women has become slightly smaller and the positive effect for single and married men has become slightly larger. For married men and women, the proportion moving to non-work or working fewer hours after the policy change has decreased in the aged population, possibly because they are already at a lower level of participation in the updated population. This causes the slightly more positive labour supply response for men and the slightly less negative labour supply response for women.

Finally, the effect on expenditure and revenue of the policy change is simulated. Table 16 shows these effects for the two years which can be compared with the results in the first columns of Table 13. Although the total expenditure on couples is projected to go up as a result of the population ageing, it is mostly through pensions. People on age and disability pensions are assumed to be non-responsive to financial incentives and most of them are not working at the moment, so that they do not benefit from the taper rate reduction. As a result the cost of the policy change is less for couples in these two projections than it was for 2000-2001. For single men and women the cost is similar to before, although the total expenditure has increased just as for couples. For sole parents both the total expenditure and the cost of the policy change is lower in the projected

[17] When the eligibility for age pension is based on observed receipt in SIHC, the expenditure on age pension becomes smaller (see Table 23 in Appendix E), but the relative increase in the expenditure due to population ageing is equal to the relative increase in Table 14.

populations. This is the result of a reduced number of sole parents as a proportion of the total population when the revised weights are used[18].

Table 15 Simulated impacts on labour supply of population ageing

	Married men	Married women	Single men	Single women	Single parents
	Projected population structure of 2025 Series B				
all workers (%base)	60.11	46.95	58.00	43.27	49.38
worker, hrs known(%base)	47.71	40.59	50.69	40.58	42.35
worker, hrs known(%post)	48.39	40.18	51.34	41.09	45.47
non-work-->work (%)	1.22	0.58	0.77	0.57	3.35
work-->non-work (%)	0.53	0.99	0.12	0.06	0.23
workers working more	0.21	0.18	0.00	0.04	1.01
workers working less	0.82	0.59	0.78	1.79	1.40
average hours change	0.15	-0.28	0.10	-0.14	1.01
	Projected population structure of 2050 Series B				
all workers (%base)	54.35	42.2	53.77	38.15	48.93
worker, hrs known(%base)	42.6	36.15	46.31	35.73	41.81
worker, hrs known(%post)	43.27	35.82	46.93	36.16	44.97
non-work-->work (%)	1.15	0.55	0.74	0.48	3.39
work-->non-work (%)	0.48	0.88	0.11	0.05	0.23
workers working more	0.18	0.17	0.00	0.03	1.00
workers working less	0.73	0.53	0.70	1.57	1.40
average hours change	0.16	-0.24	0.10	-0.13	1.02

[18] The weighted number of sole parents is 589,287 using ABS weights, 450,101 using weights derived from the projected 2025 population structure, and 411,727 with weights derived from the projected 2050 population structure.

Table 16 Simulated tax and transfer costs allowing for labour supply responses

	2025 Series B			2050 Series B		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	Value ($m)	Value ($m)	%	Value ($m)	Value ($m)	%
Couples						
Government Revenue						
Income Tax	52,732.6	523.7	1.0	48,841.7	548.80	1.1
Medicare	3,690.4	99.7	2.7	3,403.8	94.8	2.8
Total Revenue	56,423.0	623.4	1.1	52,245.5	643.6	1.2
Government Expenditure						
Tax Rebates	2,232.9	-206.5	-9.2	2,540.2	-214.9	-8.5
FTP/FTB	4,325.4	627.1	14.5	3,838.7	555.6	14.5
Allowances	5,970.6	4,511.6	75.6	5,627.7	4,144.7	73.6
Pensions	23,480.8	807.3	3.4	28,705.7	951.6	3.3
Pharm Allowance	229.0	12.1	5.3	276.7	13.3	4.8
Rent Allowance	589.6	216.1	36.7	570.7	192.6	33.8
Total Expenditure	36,828.2	5,967.7	16.2	41,559.7	5,642.9	13.6
Net Expenditure	-19,594.8	5,344.4	-27.3	-10,685.8	4,999.3	-46.8
Single Men						
Government Revenue						
Income Tax	13,181.4	309.4	2.3	12,882.7	316.8	2.5
Medicare	1,038.2	28.7	2.8	1,008.3	28.8	2.9
Total Revenue	14,219.6	338.1	2.4	13,891.0	345.6	2.5
Government Expenditure						
Tax Rebates	560.5	-24.3	-4.3	702.5	-29.1	-4.1
Allowances	4,150.5	1,029.6	24.8	3,993.8	980.4	24.5
Pensions	6,279.0	149.3	2.4	8,230.0	199.4	2.4
Pharm Allowance	100.4	2.5	2.5	131.0	2.9	2.2
Rent Allowance	534.8	388.3	72.6	578.8	371.2	64.1
Total Expenditure	11,625.2	1,545.3	13.3	13,636.1	1,524.8	11.2
Net Expenditure	-2,594.3	1,207.3	-46.5	-254.9	1,179.2	-462.5
Single women						
Government Revenue						
Income Tax	8,301.8	145.8	1.8	8,279.0	145.8	1.8
Medicare	642.6	15.8	2.5	629.3	15.4	2.4
Total Revenue	8,944.4	161.5	1.8	8,908.4	161.1	1.8
Government Expenditure						
Tax Rebates	909.3	-22.4	-2.5	1,071.0	-24.6	-2.3
Allowances	2,384.6	951.6	39.9	2,120.2	869.5	41.0
Pensions	12,394.8	172.6	1.4	15,030.6	214.5	1.4
Pharm Allowance	180.7	2.6	1.5	217.4	2.6	1.2
Rent Allowance	398.4	262.8	66.0	424.3	236.6	55.8
Total Expenditure	16,267.8	1,367.2	8.4	18,863.4	1,298.7	6.9
Net Expenditure	7,323.4	1,205.6	16.5	9,955.0	1,137.5	11.4

Table 16: continued

	2025 Series B			2050 Series B		
	Pre-reform	Change after reform		Pre-reform	Change after reform	
	Value ($m)	Value ($m)	%	Value ($m)	Value ($m)	%
Sole parents						
Government Revenue						
Income Tax	1,469.8	88.8	6.0	1,337.2	79.9	6.0
Medicare	69.9	8.0	11.4	63.2	7.2	11.4
Total Revenue	1,539.7	96.7	6.3	1,400.4	87.1	6.2
Government Expenditure						
Tax Rebates	222.7	-15.1	-6.8	205.2	-13.7	-6.7
FTP/FTB	2,547.6	54.4	2.1	2,338.1	49.6	2.1
Allowances	2,768.4	161.9	5.8	2,556.7	144.0	5.6
Pensions	182.5	0.5	0.3	159.8	0.5	0.3
Pharm Allowance	44.7	4.3	9.7	41.0	3.9	9.6
Rent Allowance	430.1	4.8	1.1	396.0	4.4	1.1
Total Expenditure	6,196.0	210.9	3.4	5,696.8	188.6	3.3
Net Expenditure	4,656.3	114.1	2.5	4,296.4	101.5	2.4

Appendix E presents two tables with the alternative population projection scenarios developed by the ABS. Compared to the current population structure, all scenarios imply an increase in cost to the government. Comparing the change in net expenditure between the three scenarios, the medium-sized population scenario turns out to be the least costly. The difference in net expenditure between the three scenarios is small in 2025, but has grown for the 2050 scenarios. In 2025, both government revenue and expenditure are in between the values for the other two scenarios. The low population scenario results in higher expenditure and revenue. In 2050, revenue is higher and expenditure is lower for the medium-sized population scenario than for the other two scenarios. This is caused by the larger proportion of the medium-sized population in the working age groups. Assuming similar employment rates as there were in 2000/01, a larger proportion of population B is therefore going to be self-sufficient without the need for government support.

7 Conclusions

This paper has investigated the performance of the ABS weights provided with the SIHC for use in obtaining aggregate cost estimates and numbers receiving various benefits. Reweighting may be needed where population aggregates, for variables not used for official calibrations, deviate substantially from population values obtained from other data sources, such as official administrative data on tax revenue and expenditure on benefits. A calibration approach to sample reweighting is described. This produces new weights which achieve specified population totals for selected variables, subject to the constraint that there are minimal adjustments to the weights. The constraint is described in terms of a distance function having reasonable properties. The resulting constrained minimisation problem must be solved using iterative methods, and an approach using Newton's method was described.

The method was applied to SIHC 2001, the most recent SIHC available. Reweighting may cause non-calibrated variables to change in undesirable ways, so that other checks need to be made on those variables. The distribution, rather than simply the sum, of important variables, for example alternative sources of income, may be led to change as a result of reweighting. Hence, checks on these characteristics were also applied. In addition, a policy simulation was carried out for a tax reform involving a general reduction in taper rates. It was found that reweighting using the current year's values did not improve the performance of the Melbourne Institute Tax and Transfer Simulator, which uses the SIHC as the basic dataset for microsimulation.

Greater benefits from sample reweighting arise when a survey from one year is used to examine the likely implications of, say, a tax and transfer policy in a later year. This need can arise if cross-sectional surveys are not carried out every year or if there are long delays in releasing data. Other administrative data may be available at more frequent intervals. A further application of the method involves simulating the implications of changes in, say, the age distribution of the population or in aggregate unemployment rates over time. As an illustration of this type of use of reweighting, the implications of population ageing were examined. These were based on population projections to 2025 and 2050, where a 'pure' change in the age distribution was examined by keeping the aggregate population fixed and changing only the relative frequencies in different age groups. Microsimulation provides an insight into the implications of changes in the population on government income tax revenue and social security expenditure. The effect of alternative scenarios could be examined, including for example changes in unemployment rates. This kind of approach offers substantial scope for further analyses.

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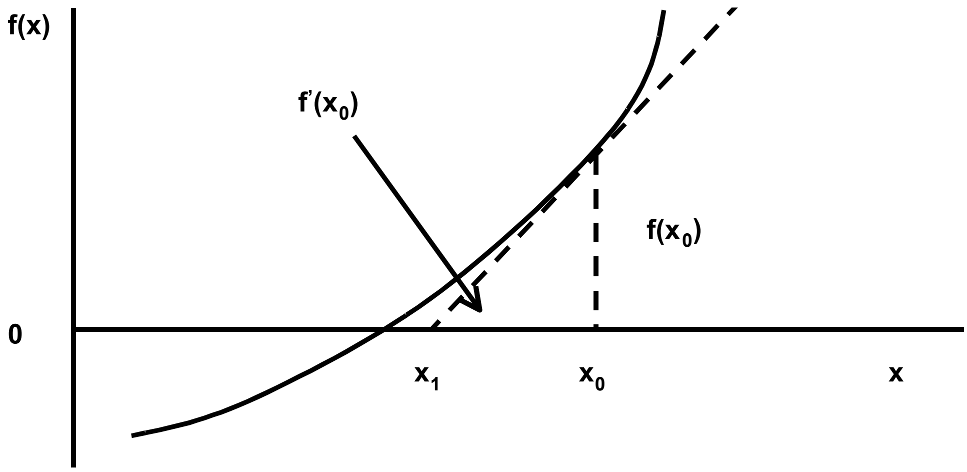
Appendix A. Newton's method

Consider finding the root of the single equation in one variable, $f(x)=0$, where $f(x)$ takes the form shown in Figure 17. Newton's method involves taking an arbitrary starting point, x_0 and drawing the tangent, with slope $f'(x_0)$. By approximating the function by the tangent, the new value is given by the point of intersection of this tangent with the x axis, at x_1. Selecting x_1 as the next starting point leads quickly to the required root.

Figure 17 Newton's method



From the triangle in Figure 17:

$$f'(x_0)=\frac{f(x_0)}{x_0-x_1} \tag{A1}$$

Hence, starting from $I=0$, the sequence of iterations is:

$$x_{I+1}=x_I-\left\{f'(x_I)\right\}^{-1}f(x_I) \tag{A2}$$

Convergence is reached when $x_{I+1}-x_I<\varepsilon$ and ε depends on the accuracy required. Newton's method is easily adapted to deal with a set of equations, $f_i(x)$, where x is a vector. The method involves repeatedly solving the following matrix equation, where $x^{[I]}$ now denotes the vector in the I^{th} iteration and $f(x)$ is a vector containing the $f_i(x)$ values.

$$x^{[I+1]} = x^{[I]} - \left[\frac{\partial f_i(x)}{\partial x_\ell} \right]_{x^{[I]}}^{-1} \left[f(x) \right]_{x^{[I]}} \tag{A3}$$

Appendix B. The Chi-Squared Distance Function

The constrained minimisation problem stated in Section 2 has an explicit solution for a distance function based on the chi-squared measure. Consider the chi-squared type of distance measure, where the aggregate distance is given by:

$$D = \frac{1}{2}\sum_{k=1}^{K}\frac{\left(w_k - s_k\right)^2}{s_k} \tag{B1}$$

The required Lagrangean is:

$$L = \frac{1}{2}\sum_{k=1}^{K}\frac{\left(w_k - s_k\right)^2}{s_k} + \sum_{j=1}^{J}\lambda_j\left(t_{x,j} - \sum_{k=1}^{K} w_k x_{k,j}\right) \tag{B2}$$

where the λ_j, for $j = 1,\ldots,J$, are the Lagrange multipliers, and $t_{x,j}$ represents the j th element of the vector of known population aggregates, t_x. Differentiation of (B2) gives the set of K first-order conditions:

$$\frac{\partial L}{\partial w_k} = \left(\frac{w_k}{s_k} - 1\right) - \sum_{j=1}^{J}\lambda_j x_{k,j} = 0 \tag{B3}$$

for $k = 1,\ldots,K$, along with the J conditions in (3). Rewriting $\sum_{j=1}^{J}\lambda_j x_{k,j}$ as $x_k'\lambda$, where the prime indicates transposition, and multiplication of each equation in (8) by s_k gives, after rearrangement:

$$w_k = s_k\left(1 + x_k'\lambda\right) \tag{B4}$$

for $k = 1,\ldots,K$.

To solve for the Lagrange multipliers, pre-multiply (B4) by x_k and rearrange, so that:

$$w_k x_k - s_k x_k = s_k x_k x_k'\lambda \tag{B5}$$

Summing (B5) over all K, and making use of the calibration equations, gives:

$$t_x - \hat{t}_{x|s} = \left[\sum_{k=1}^{K} s_k x_k x_k'\right]\lambda \tag{B6}$$

where the term in brackets on the right hand side of (B6) is a J by J square matrix. Hence, if this matrix can be inverted, the vector of Lagrange multipliers is given by:

$$\lambda = \left[\sum_{k=1}^{K} s_k x_k x_k' \right]^{-1} \left(t_x - \hat{t}_{x|s} \right) \qquad \text{(B7)}$$

The resulting values of λ are substituted into (B4) to obtain the new weights.[19]

[19] Write (B4) as $w_k = s_k \left(1 + \lambda' x_k\right)$ and (12) as $\lambda' = \left(t_x - \hat{t}_{x|s}\right)' T^{-1}$ with T as the symmetric matrix $\sum_{k=1}^{K} s_k x_k x_k'$. Given sample observations on the variable y_k, an estimate of the population total, $\hat{t}_y$, can be obtained as $\sum_{k=1}^{K} w_k y_k$. Substituting for w_k gives the result in Deville and Särndal (1992, p.377) that $\hat{t}_y = \sum_{k=1}^{K} s_k y_k + \left(t_x - \hat{t}_{x|s}\right)' B$, where $B = T^{-1} \sum_{k=1}^{K} s_k x_k y_k$. This provides the link between reweighting and the Generalised Regression (GREG) estimator. The production of asymptotic standard errors is often based on this estimator, in view of the result that other distance functions are asymptotically equivalent; see Deville and Särndal (1992, p.378). The present discussion concentrates only on reweighting.

Appendix C. The D-S Distance Function

The distance function is given by integrating (22) with respect to w. It is most convenient to apply the variate transformation $x = w/s$, so that $dw = sdx$, and it is required to obtain:

$$\frac{s}{\alpha}\int\left[\log\left(\frac{x-r_L}{1-r_L}\right)-\log\left(\frac{r_U-x}{r_U-1}\right)\right]dx \tag{C1}$$

Using the result that:

$$\int\log\left(\frac{x-a}{b}\right)dx = (x-a)\left[\log\left(\frac{x-a}{b}\right)-1\right] \tag{C2}$$

and:

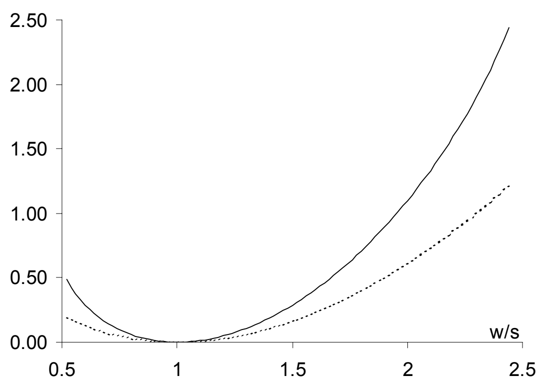
$$\int\log\left(\frac{a-x}{b}\right)dx = -(a-x)\left[\log\left(\frac{a-x}{b}\right)-1\right] \tag{C3}$$

substitution and rearrangement gives s/α multiplied by:

$$G(w,s) = \left(r_U - \frac{w}{s}\right)\log\left(\frac{r_U - \frac{w}{s}}{r_U-1}\right)+\left(\frac{w}{s}-r_L\right)\log\left(\frac{\frac{w}{s}-r_L}{1-r_L}\right) \tag{C4}$$

plus a term $(r_U - r_L)s/\alpha$, which, since it is a constant, may be dropped without loss. This is the result stated without proof by Deville and Särndal (1992, p. 378). Examples of this distance function are shown in Figure 18.

Figure 18 Deville-Särndal distance functions



Appendix D. Using Simulated Recipient Numbers in Calibration Conditions

Table 17 Actual and simulated expenditure on income support – new weights are derived using simulated recipient numbers in calibration conditions

	Actual from FaCS ($m)	Simulated using ABS weights ($m)	Simulated using new weights ($m)	Difference between actual and simulated using ABS weights	Difference between actual and simulated using new weights
Parenting Payment (single & couple)	5327.0	5037.5	4774.4	289.5	552.6
Sickness Allowance	95.9	181.7	208.7	-85.8	-112.8
Widow's Allowance	330.2	4.9	4	325.3	326.2
AUSTUDY/ABSTUDY	255.6	947.1	1032.9	-691.5	-777.3
NewStart Allowance	4918.3	4268.1	4573.6	650.2	344.7
Mature Age Allowance	353.1	221.2	251.3	131.9	101.8
Youth Allowance	2121.6	2475.7	2447.5	-354.1	-325.9
Special Benefit	113.8	1910.2	2083.6	-1796.4	-1969.8
Partner Allowance	717.1	1493.2	1419.1	-776.1	-702.0
Age Pension	15571.8	15865.0	14803.5	-293.2	768.3
Dis.Support Pension	5837.4	5133.8	5701.9	703.6	135.5
Wife's Pension	680.0	792.9	977.4	-112.9	-297.4
Widow B pension	75.3	398.2	449	-322.9	-373.7
Carer's Payment	478.3	274.1	378.2	204.2	100.1
Total	36875.4	39003.6	39105.1	-2128.2	-2229.7

Table 18 Actual and simulated numbers of income support recipients – new weights are derived using simulated recipient numbers in calibration conditions

	Actual from FaCS (1000)	Simulated using ABS weights (1000)	Simulated using new weights (1000)	Difference between actual and simulated using ABS weights	Difference between actual and simulated using new weights
Parenting Payment (single & couple)	639	674	640	-35	-1
Sickness Allowance	11	21	24	-10	-13
Widow's Allowance	36	1	0	35	36
AUSTUDY/ABSTUDY	42	135	155	-93	-113
NewStart Allowance	541	660	691	-119	-150
Mature Age Allowance	39	47	48	-8	-9
Youth Allowance	393	674	665	-281	-272
Special Benefit	12	232	253	-220	-241
Partner Allowance	90	215	203	-125	-113
Age Pension	1786	1935	1786	-149	0
Dis.Support Pension	624	575	624	49	0
Wife's Pension	78	101	125	-23	-47
Widow B Pension	9	41	47	-32	-38
Carer's Payment	57	33	46	24	11
Total	4357	5344	5307	-987	-950

Table 19 Actual and simulated expenditure on income support using eligibility and take-up conditions (1) – new weights are derived using simulated recipient numbers in calibration conditions

	Actual from FaCS ($m)	Simulated using ABS weights ($m)	Simulated using new weights ($m)	Difference between actual and simulated using ABS weights	Difference between actual and simulated using new weights
Parenting Payment (single & couple)	5327.0	5032.9	4900.6	294.1	426.4
Sickness Allowance	95.9	181.7	206.8	-85.8	-110.9
Widow's Allowance	330.2	4.9	3.6	325.3	326.6
AUSTUDY/ABSTUDY	255.6	946.9	1033.3	-691.3	-777.7
NewStart Allowance	4918.3	4148.9	4459.9	769.4	458.4
Mature Age Allowance	353.1	220.5	244.5	132.6	108.6
Youth Allowance	2121.6	2451.5	2433.9	-329.9	-312.3
Special Benefit	113.8	1947.1	2088.2	-1833.3	-1974.4
Partner Allowance	717.1	1511.3	1433.9	-794.2	-716.8
Age Pension	15571.8	15186.1	15099	385.7	472.8
Dis.Support Pension	5837.4	5133.8	5699.2	703.6	138.2
Wife's Pension	680.0	783.9	975.6	-103.9	-295.6
Widow B pension	75.3	398.1	430.5	-322.8	-355.2
Carer's Payment	478.3	274.1	389.9	204.2	88.4
Total	36875.4	38221.7	39398.9	-1346.3	-2523.5

(1) The eligibility and take-up conditions are: a) recipients working more than 30 hours per week become ineligible for income support; b) benefits of less than $10 are not taken up; c) eligibility for age pension is based on observed receipt status in the SIHC data.

Table 20 Actual and simulated numbers of income support recipients using eligibility and take-up conditions – new weights are derived using simulated recipient numbers in calibration conditions

	Actual from FaCS[1] (1000)	Simulated using ABS weights (1000)	Simulated using new weights (1000)	Difference between actual and simulated using ABS weights	Difference between actual and simulated using new weights
Parenting Payment (single & couple)	639	655	639	-16	0
Sickness Allowance	11	21	23	-10	-12
Widow's Allowance	36	1	0	35	36
AUSTUDY/ABSTUDY	42	134	154	-92	-112
NewStart Allowance	541	605	638	-64	-97
Mature Age Allowance	39	44	46	-5	-7
Youth Allowance	393	650	645	-257	-252
Special Benefit	12	244	260	-232	-248
Partner Allowance	90	218	205	-128	-115
Age Pension	1786	1821	1786	-35	0
Dis.Support Pension	624	575	624	49	0
Wife's Pension	78	100	124	-22	-46
Widow B Pension	9	41	44	-32	-35
Carer's Payment	57	32	47	25	10
Total	4357	5141	5235	-784	-878

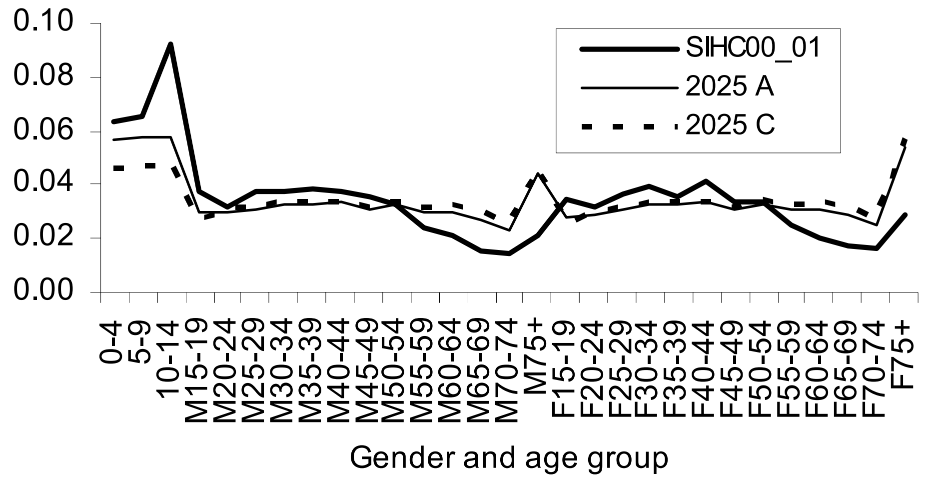
(1) The eligibility and take-up conditions are: a) recipients working more than 30 hours per week become ineligible for income support; b) benefits of less than $10 are not taken up; c) eligibility for age pension is based on observed receipt status in the SIHC data.

Appendix E. Reweighting using low and high ABS population projections

ABS (2003) presents three series of projections for 2025 and 2050. Series B presented in the main text results in a medium-sized stable population, based on a fertility rate of 1.6 babies per woman, a net overseas migration of 100,000 persons and a life expectancy at birth of 84.2 for men and 87.7 for women. Series A presents a larger population based on a fertility rate of 1.8 babies per woman, a net overseas migration of 125,000 persons and a life expectancy at birth of 92.2 for men and 95.0 for women. Series C presents a declining population size based on a fertility rate of 1.4 babies per woman, a net overseas migration of 70,000 persons and a life expectancy at birth of 84.2 for men and 87.7 for women.

Although we do not use the population size, the distribution across age groups is different for the three scenarios as well. Figures 19 and 20 show that the proportion of young individuals is lowest in series C and highest in series A. The proportion of older individuals is highest for series C and lowest for series B.[20] Finally, series B has the largest proportion of the population in the working age category.[21]

Figure 19 Gender and age distribution of current and projected populations – low (C) and high (A) ABS population projection for 2025



[20] The proportion of the population aged 65 and over for series A, B and C is 28.03, 26.94 and 29.45 per cent, respectively.

[21] The proportion of the working age population for series A, B and C is 56.71, 59.00 and 58.49 per cent, respectively.

Figure 20 Gender and age distribution of current and projected populations – low (C) and high (A) ABS population projection for 2050

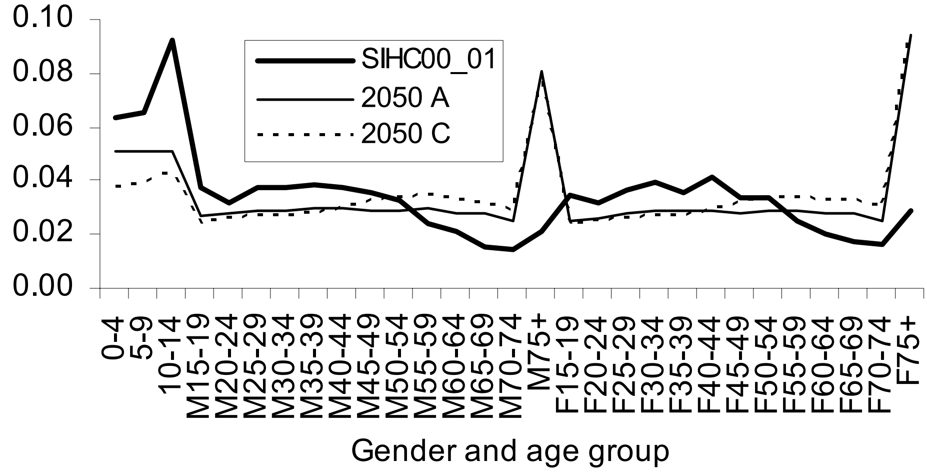


Figure 21 Ratio of new weight derived from the projected population structure of 2025 Series A and ABS weight (lower bound 0.61, upper bound 2.1)

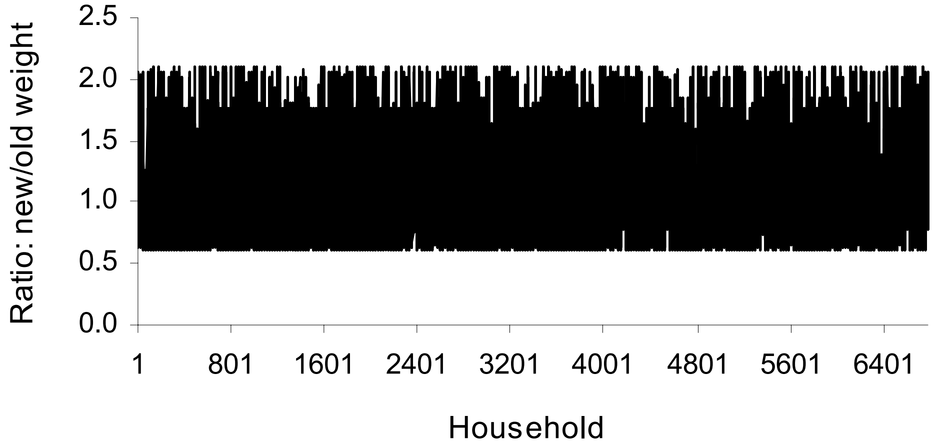


Figure 22 Ratio of new weight derived from the projected population structure of 2025 Series C and ABS weight (lower bound 0.50, upper bound 2.2)

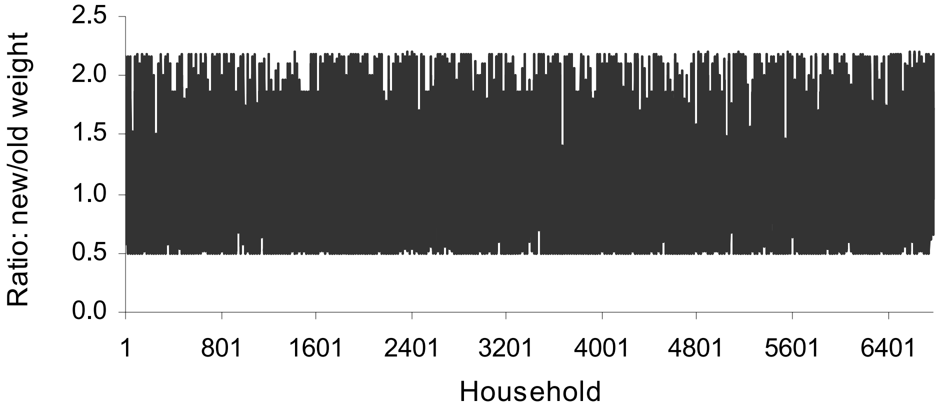


Figure 23 Ratio of new weight derived from the projected population structure of 2050 Series A and ABS weight (lower bound 0.54, upper bound 3.8)

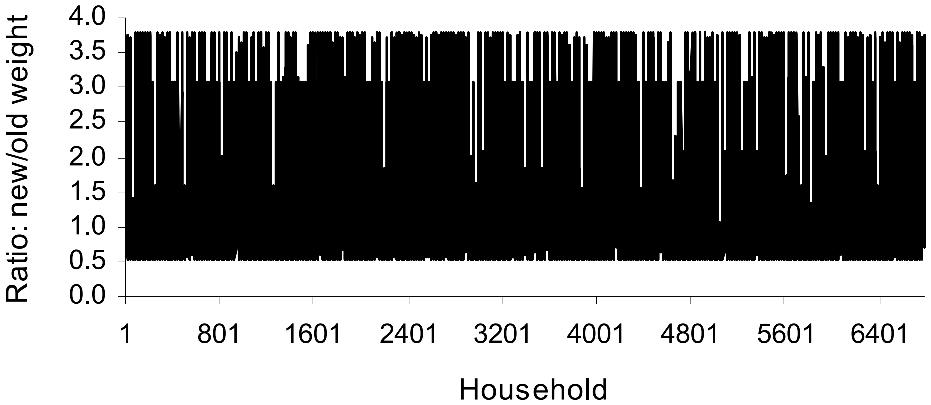


Figure 24 Ratio of new weight derived from using projected population structure of 2050 Series C and ABS weight (lower bound 0.45, upper bound 3.6)

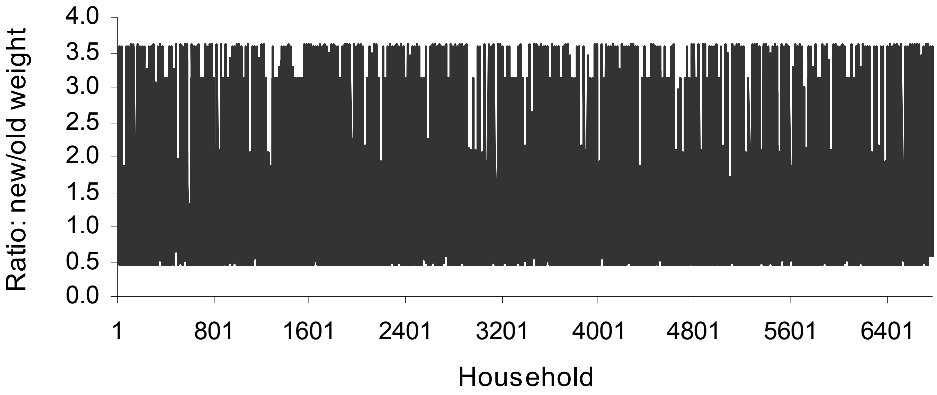


Figure 25 Difference of frequency distribution of weekly wage and salary income between using ABS weight and new weight derived from projected population structure of 2050 Series A (1)

Note: (1), Difference at zero is 13.17.

Figure 26 Difference of frequency distribution of weekly wage and salary income between using ABS weight and new weight derived from projected population structure of 2050 Series C (1)

Note: (1), Difference at zero is 13.55.

Table 21 Simulated government revenue and costs – using high population projection

	Simulation using ABS weight		Simulation using weights derived from projected population structure[1]			
			2025 Series A		2050 Series A	
	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)
Government Revenue						
Income Tax	79,707.8	12,103	74,123.2	12,794	68,629.0	13,230
Medicare Levy	5,727.8	7,762	5,309.8	7,403	4,889.2	7,005
Total Revenue	85,435.6		79,433.1		73,518.2	
Government Expenditure						
Tax Rebates	2,889.1	6,294	3,836.5	7,530	4,560.2	8,416
FTP/FTB	9,548.4	1,935	7,572.9	1,535	6,765.0	1,365
Allowances	16,539.6	2,657	15,234.6	2,407	14,004.8	2,206
Pensions	26,437.0	3,102	41,130.5	4,867	53,206.0	6,233
Pharm Allowance	383.8	3,556	544.2	5,263	683.0	6,592
Rent Allowance	2,033.5	1,454	1,979.1	1,526	2,029.2	1,622
Total Expenditure	57,831.5		70,297.8		81,248.2	
Net Expenditure	-27,604.1		-9,135.3		7,730.0	
Allowance						
Parenting Payment (single)	3,253.6	389	2,676.5	317	2,466.9	290
Parenting Payment (couple)	1,783.9	285	1,417.1	229	1,274.7	204
Sickness Allowance	181.7	21	177.2	20	158.9	18
Widow's Allowance	4.9	1	3.0	0	2.6	0
AUSTUDY/ABSTUDY	947.1	135	796.7	113	710.3	101
NewStart Allowance	4,268.1	660	3,971.6	611	3,631.0	554
Mature Age Allowance	221.2	47	305.9	61	271.8	54
Youth Allowance	2,475.7	674	2,018.8	544	1,878.2	507
Special Benefit	1,910.2	232	1,978.8	242	1,879.2	233
Partner Allowance	1,493.2	215	1,889.1	269	1,731.0	246
Total Allowance Cost	16,539.6		15,234.6		14,004.8	
Pension						
Age Pension	15,865.0	1,935	26,728.7	3,284	34,762.7	4,224
Dis.Support Pension	5,133.8	575	5,808.4	648	5,743.9	636
Wife's Pension	792.9	101	1,006.8	128	1,032.2	130
Widow B Pension	398.2	41	355.0	37	288.3	30
Carer's Payment	274.1	33	324.7	39	359.3	43
Veteran Pension	1,812.7	233	3,522.5	448	6,037.6	759
Veterans Dis.Pension	1,063.5	101	1,697.9	156	2,565.7	230
War Widows Pension	1,096.9	83	1,686.5	127	2,416.2	181
Total Pension Cost	26,437.0		41,130.5		53,206.0	
Rebate						
Beneficiary Rebate	457.9	1,193	448.3	1,164	413.5	1,066
Pension Rebate	2,388.3	2,213	3,962.5	3,712	5,310.4	4,913
SP Pension Rebate	256.1	349	210.1	287	193.5	264
Low Income Rebate	1,250.6	8,715	1,410.3	9,783	1,533.0	10,610
Dep Spouse Rebate	423.3	416	465.7	485	430.7	465
Total Rebate Cost	4,776.3		6,496.9		7,881.1	

Table 22 Simulated government revenue and costs – using low population projection

	Simulation using ABS weight		Simulation using weights derived from projected population structure(1)			
			2025 Series C		2050 Series C	
	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)
Government Revenue						
Income Tax	79,707.8	12,103	76,808.6	13,392	71,222.3	13,774
Medicare Levy	5,727.8	7,762	5,542.5	7,797	5,106.1	7,331
Total Revenue	85,435.6		82,351.1		76,328.4	
Government Expenditure						
Tax Rebates	2,889.1	6,294	4,063.9	7,892	4,814.7	8,811
FTP/FTB	9,548.4	1,935	6,164.2	1,298	5,309.0	1,111
Allowances	16,539.6	2,657	15,090.4	2,383	13,869.2	2,176
Pensions	26,437.0	3,102	44,343.9	5,246	56,644.3	6,658
Pharm Allow	383.8	3,556	575.3	5,598	715.4	6,972
Rent Allowance	2,033.5	1,454	1,933.2	1,551	1,940.6	1,620
Total Expenditure	57,831.5		72,170.9		83,293.2	
Net Expenditure	-27,604.1		-10,180.2		6,964.9	
Allowance						
Parenting Payment (single)	3,253.6	389	2,199.8	263	1,961.3	233
Parenting Payment (couple)	1,783.9	285	1,198.8	194	1,054.2	168
Sickness Allowance	181.7	21	192.4	22	185.5	21
Widow's Allowance	4.9	1	2.4	0	2.2	0
AUSTUDY/ABSTUDY	947.1	135	868.5	130	689.9	100
NewStart Allowance	4,268.1	660	4,175.7	640	3,831.1	586
Mature Age Allowance	221.2	47	331.3	67	320.0	63
Youth Allowance	2,475.7	674	1,912.0	512	1,697.2	458
Special Benefit	1,910.2	232	2,171.4	264	2,053.0	254
Partner Allowance	1,493.2	215	2,038.1	290	2,074.8	293
Total Allowance Cost	16,539.6		15,090.4		13,869.2	
Pension						
Age Pension	15,865.0	1,935	28,852.7	3,547	37,243.1	4,545
Dis.Support Pension	5,133.8	575	6,342.6	706	6,510.2	722
Wife's Pension	792.9	101	1,097.7	139	1,182.1	149
Widow B Pension	398.2	41	374.9	39	310.0	32
Carer's Payment	274.1	33	355.4	42	399.8	47
Veteran Pension	1,812.7	233	3,714.3	472	5,867.4	739
Veterans Dis.Pension	1,063.5	101	1,801.4	166	2,560.0	231
War Widows Pension	1,096.9	83	1,805.0	135	2,571.8	193
Total Pension Cost	26,437.0		44,343.9		56,644.3	
Rebate						
Beneficiary Rebate	457.9	1,193	469.4	1,212	437.0	1,125
Pension Rebate	2,388.3	2,213	4,260.0	3,992	5,605.0	5,211
SP Pension Rebate	256.1	349	173.7	238	154.6	211
Low Income Rebate	1,250.6	8,715	1,455.5	10,100	1,586.9	10,983
Dep Spouse Rebate	423.3	416	524.4	543	518.3	552
Total Rebate Cost	4,776.3		6,883.1		8,301.8	

Table 23 Simulated tax and transfer costs – using observed age pension eligibility

	Simulation using ABS weight		Simulation using weights derived from projected population structure			
			2025 Series B		2050 Series B	
	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)	Revenue or expenditure ($m)	Persons (1000)
Government Revenue						
Income Tax	79,635.1	12,049	75,515.7	12,975	71,143.5	13,286
Medicare Levy	5,720.6	7,739	5,426.6	7,571	5,087.4	7,223
Total Revenue	85,355.7		80,942.3		76,230.9	
Government Expenditure						
Tax Rebates	2,869.7	6,242	3,885.2	7,580	4,463.7	8,287
FTP/FTB	9,539.9	1,935	6,896.9	1,427	6,198.6	1,277
Allowances	16,539.6	2,657	15,189.1	2,400	14,222.8	2,239
Pensions	25,670.5	2,980	40,943.3	4,794	50,410.0	5,868
Pharm Allowance	371.5	3,433	533.8	5,167	640.7	6,211
Rent Allowance	2,008.2	1,431	1,913.9	1,499	1,925.8	1,558
Total Expenditure	56,999.5		69,362.2		77,861.5	
Net Expenditure	-28,356.2		-11,580.1		1,630.6	
Allowances						
Parenting Payment (single)	3,253.6	389	2,441.3	291	2,259.3	267
Parenting Payment (couple)	1,783.9	285	1,316.1	213	1,196.7	192
Sickness Allowance	181.7	21	185.4	21	176.3	20
Widow's Allowance	4.9	1	2.7	0	2.5	0
AUSTUDY/ABSTUDY	947.1	135	827.5	120	722.7	103
NewStart Allowance	4,268.1	660	4,084.7	628	3,811.2	584
Mature Age Allowance	221.2	47	319.0	65	303.0	60
Youth Allowance	2,475.7	674	1,972.1	530	1,820.4	491
Special Benefit	1,910.2	232	2,075.4	253	1,992.5	246
Partner Allowance	1,493.2	215	1,964.9	280	1,938.3	275
Total Allowance Cost	16,539.6		15,189.1		14,222.8	
Pension Costs						
Age Pension	15,187.1	1,826	26,319.4	3,192	32,733.9	3,947
Dis.Support Pension	5,133.8	575	6,070.3	677	6,144.3	682
Wife's Pension	783.9	100	1,036.7	131	1,082.4	136
Widow B Pension	398.2	41	364.9	38	311.7	32
Carer's Payment	274.1	33	339.1	40	371.9	44
Veteran Pension	1,749.8	224	3,404.9	432	5,125.2	644
Veterans Dis.Pension	1,046.8	99	1,692.1	154	2,324.0	208
War Widows Pension	1,096.9	83	1,716.0	129	2,316.6	174
Total Pension Cost	25,670.5		40,943.3		50,410.0	
Rebate Costs						
Beneficiary Rebate	457.9	1,193	459.6	1,190	433.5	1,119
Pension Rebate	2,404.9	2,210	4,089.0	3,801	5,168.8	4,771
SP Pension Rebate	256.1	349	192.2	263	177.7	243
Low Income Rebate	1,251.6	8,723	1,429.8	9,921	1,533.7	10,620
Dep Spouse Rebate	464.9	440	572.4	558	576.8	569
Total Rebate Cost	4,835.3		6,742.9		7,890.5	