ISBN 0 7325 0590 9

THE UNIVERSITY OF MELBOURNE

MODELLING OPTIMAL RETIREMENT DECISIONS IN AUSTRALIA

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RESEARCH PAPER NUMBER 21
June 1995

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JC-95-17

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1. INTRODUCTION

At the time of retirement individuals in Australia are faced with a complex set of inter-related decisions affecting future income provision. Recent Government policy advocates the introduction of compulsory occupational superannuation savings and wishes to encourage the provision of income, rather than lump sums, for the retirement years. Apart from the means-tested age pension, these benefits are largely provided by assets accumulated during the working years in the form of employer and employee paid superannuation contributions, or savings of other kinds.

At the date of retirement a complex taxation structure is imposed on the individual's accumulated assets, depending on how the individual disposes of them. The tax levied at retirement depends on the source of the accumulated assets, their absolute value and the proportion which is taken as a lump sum. The method of their dispersal also affects the income tax liability of the individual during the retirement years and the working of the means-tests which govern the age pension eligibility. Annuities which are purchased using superannuation assets are not taxed in the same way as annuities purchased by other savings, and a larger proportion is disregarded by the age pension means-tests. The details of the current tax and benefit system are described in Atkinson, Creedy and Knox (1994b).

In addition to the complexity imposed by the tax and benefit structure, subjective values affect the priorities that an individual may wish to exercise at retirement. Optimal behaviour for an individual may be defined by different criteria, for example in terms of maximising gross post-retirement income, or net consumption in retirement. The valuation criterion may or may not include the value of any estate remaining on the death of a retiree.

Atkinson, Creedy and Knox (1994b) examined the retirement income experience of individuals, representing a range of lifetime earnings percentiles, which arose from specified decisions at retirement. The equity and progressivity of various alternative tax and benefit structures have also been examined for a cohort on the assumption that all individuals follow the same route; see Atkinson, Creedy and Knox (1994c, 1994d). For example, each individual expends all assets on the purchase of an annuity, or a specified proportion on annuity purchase and the remainder on consumption. The ensuing retirement income experience of the cohort is compared for a range of decisions. It was found that, in analysing progressivity, there was little to distinguish the results of different imposed tax and benefit structures. The factors which significantly affected equity and progressivity were the choice of route at retirement and, most importantly, the mortality experience of the individuals. These analyses used the LITES (Lifetime, Income, Taxation, Expenditure and Superannuation) model, described in Atkinson, Creedy and Knox (1994a).

It would however be expected that individuals in a large cohort with widely differing earnings histories would make diverse choices at the time of retirement. This paper therefore makes use of a major modification to the LITES model which enables each individual to tailor the personal retirement choice to give the optimal retirement consumption stream, measured by a given criterion. The question of alternative retirement ages is not addressed here. Each individual in a cohort may make one of 47 choices regarding the disposal of accumulated assets at retirement. For each individual, the value of each of these routes is calculated using one of five criteria, and the individual adopts the strategy with the highest value. Hence, in terms of the specified criterion, each individual optimises the retirement choice.

The aim of this paper is to examine the effect on equity and progressivity for a cohort, allowing for optimal individual behaviour at retirement. The criteria involve a set of utility functions based on the net consumption in the retirement years, with or without regard to any remaining estate at the time of death. Section 2 describes the range of routes available at the time of retirement and the five optimisation criteria. It examines the numbers of individuals choosing each decision under each criterion, using two different mortality assumptions. Section 3 presents the results of a change in the structure of retirement income policy on the individually optimised behaviour. Section 4 compares the implications for lifetime redistribution of assuming that all members of a cohort make the same choice at retirement with those resulting from the assumption that individual optimisation is exercised. Section 5 presents conclusions. Appendix 1 describes the LITES model and the economic assumptions used in the simulations.

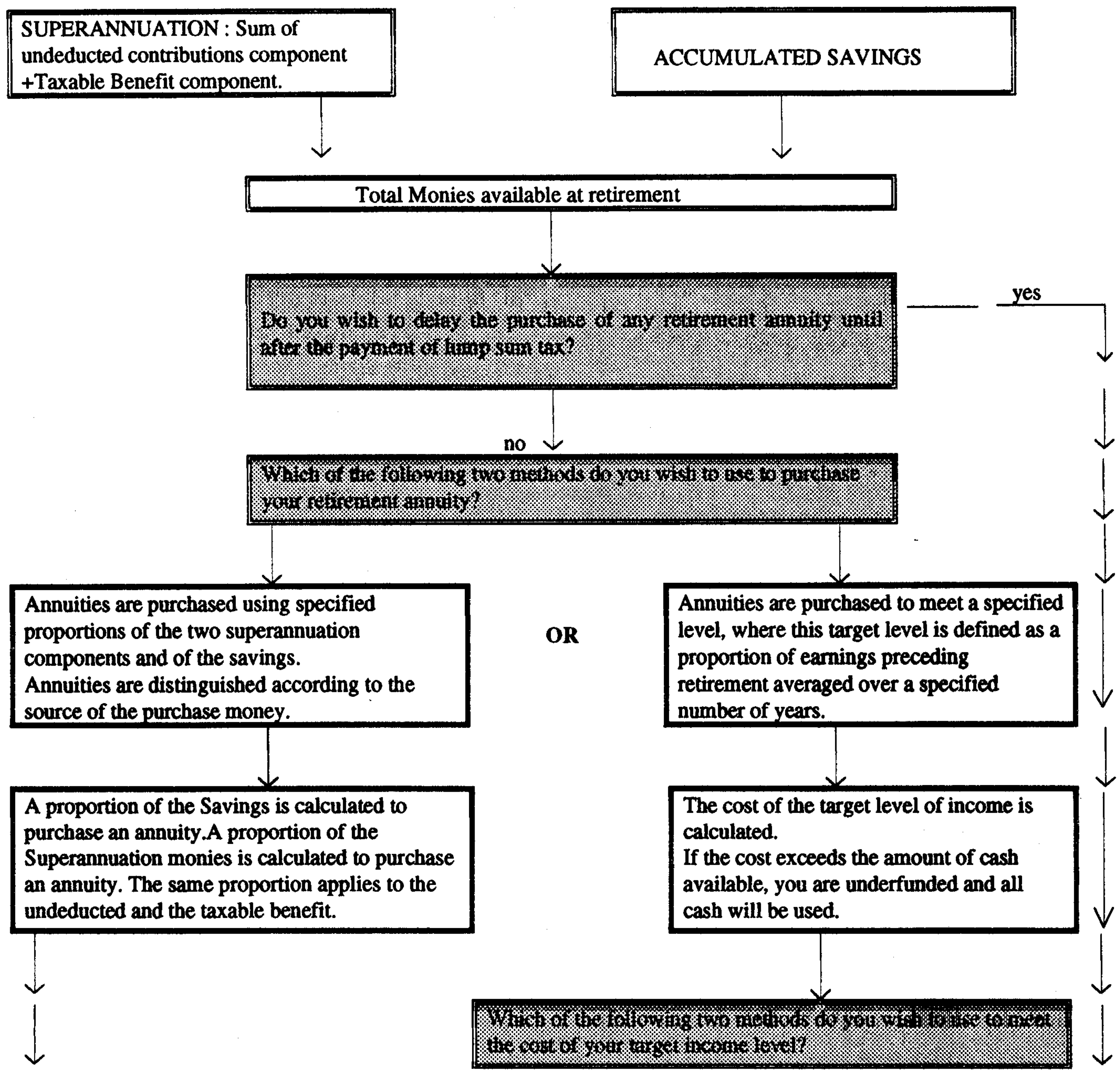
2. RETIREMENT DECISIONS

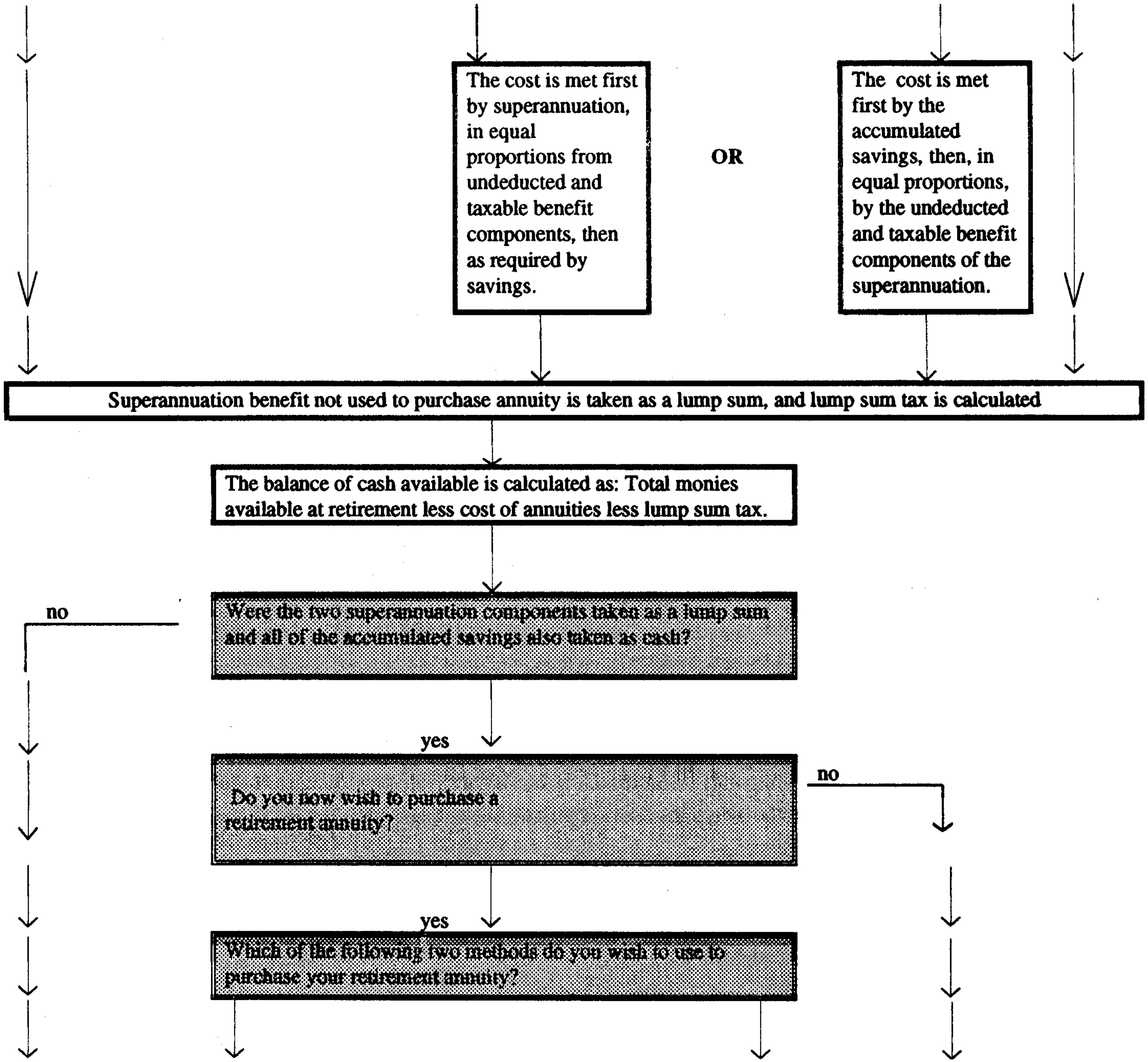
The Range of Routes Available

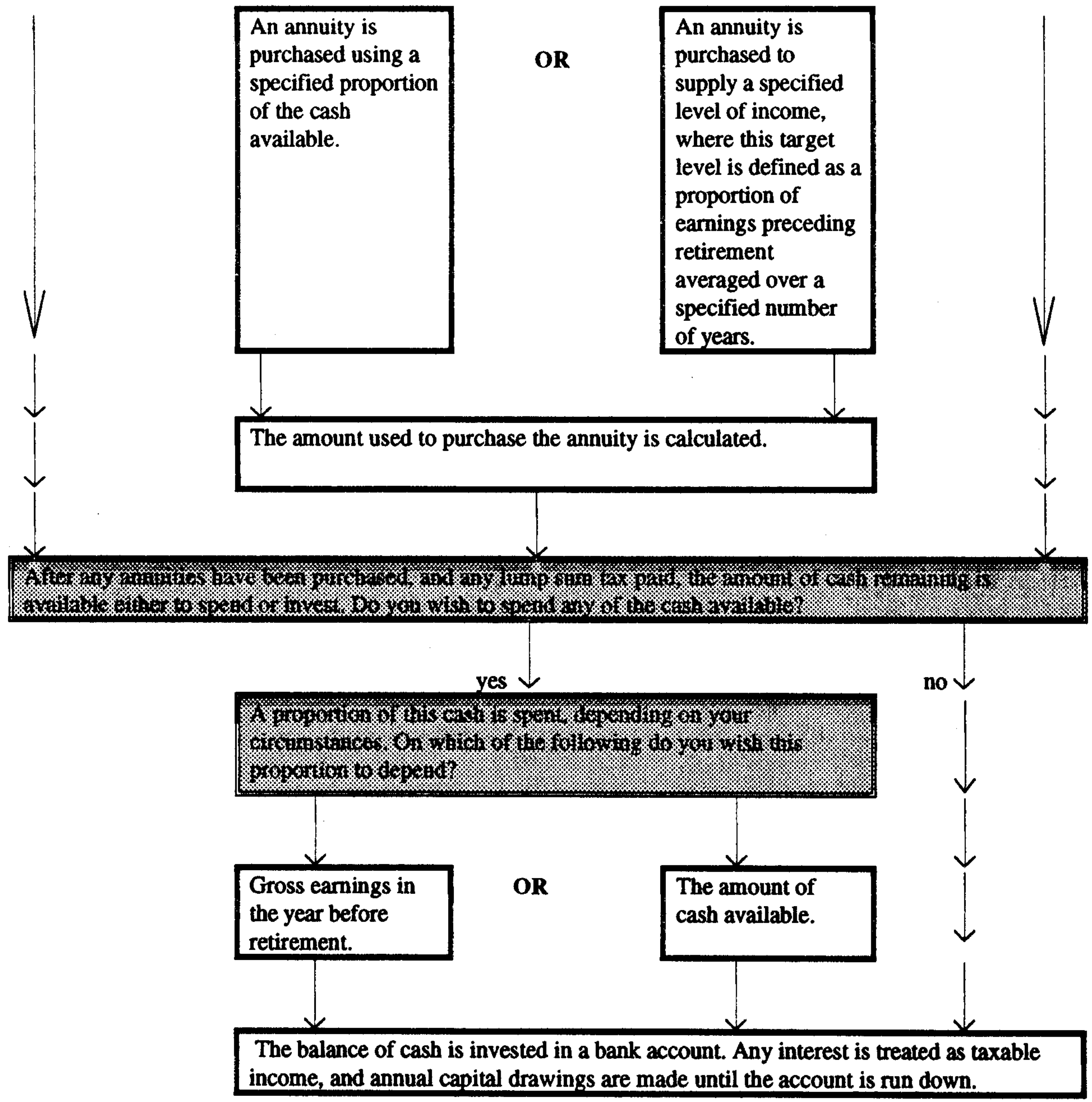
The simulation model follows the experience of cohorts of single males, who enter the workforce at age 20 and retire at age 65. At the time of retirement each individual has accumulated assets which may be classified in three ways. First, there is the sum of superannuation contributions arising from employee contributions of 3% of gross earnings throughout the working life. Secondly, there are accumulated employer contributions, known as deducted contributions, of 9% of gross earnings in each year plus all other investment income earned by the fund. These are treated in different ways for tax purposes and are known as the undeducted benefit and the taxable benefit respectively. Thirdly, each individual has accumulated savings at the rate of 5% of disposable income in each year. These assets are disposed of at retirement, and the initial disposal identifies amounts put to various uses thereafter.

Figure 1 is a flow diagram which describes the sequence and scope of the decisions available for each individual at retirement. In view of the complexity involved, it seems appropriate to refer to this set of decisions as a 'retirement maze'. The superannuation assets may initially be used in a combination of two ways. They may be used to purchase a lifetime annuity, or may be taken as a lump sum subject to lump sum tax. The other savings, and any superannuation lump sum taken, may be used in one of three ways. The LITES model allows for the after-tax cash amounts to be used to purchase an annuity, to be deposited in an interest bearing bank account, or put to immediate consumption. These three destinations are available in any combination. Annuities which are purchased are identified throughout retirement according to the source of the money which purchases them. This distinction governs the income tax rules which apply to them, and also the treatment under the operation of the age pension means tests. Annuities purchased by lump sum proceeds from the superannuation benefit are

FIGURE 1. DECISIONS AT RETIREMENT




The cost is met first by superannuation, in equal proportions from undeducted and taxable benefit components, then as required by savings.
OR
The cost is met first by the accumulated savings, then, in equal proportions, by the undeducted and taxable benefit components of the superannuation.
Superannuation benefit not used to purchase annuity is taken as a lump sum, and lump sum tax is calculated
The balance of cash available is calculated as: Total monies available at retirement less cost of annuities less lump sum tax.
Were the two superannuation components taken as a lump sum and all of the accumulated savings also taken as cash?
no
yes
Do you now wish to purchase a retirement annuity?
no
yes
Which of the following two methods do you wish to use to purchase your retirement annuity?



An annuity is purchased using a specified proportion of the cash available.
OR
An annuity is purchased to supply a specified level of income, where this target level is defined as a proportion of earnings preceding retirement averaged over a specified number of years.
The amount used to purchase the annuity is calculated.
After any annuities have been purchased, and any lump sum tax paid, the amount of cash remaining is available either to spend or invest. Do you wish to spend any of the cash available?
yes
no
A proportion of this cash is spent, depending on your circumstances. On which of the following do you wish this proportion to depend?
Gross earnings in the year before retirement.
OR
The amount of cash available.
The balance of cash is invested in a bank account. Any interest is treated as taxable income, and annual capital drawings are made until the account is run down.

treated in the same way as annuities purchased from other savings; both are considered to be purchased by after-tax money. The model allows for two basic methods of retirement income provision, the money purchase method, and the defined benefit method. In the former method, the proportion of the available amount used to purchase an annuity is specified, and in the latter the level of income required is specified. Defined benefit levels are described as a proportion of the average of the final three years' earnings before retirement.

After the purchase of annuities from pre- or post-tax money, an amount may be placed in an interest bearing bank account; the amount is specified as a proportion of the money available. The account attracts taxable interest payments at a constant rate, and is subject to annual drawings. The amount withdrawn at the end of each year is the balance of the account divided by the number of years remaining to age 80; thus the account is assumed to be extinguished at age 80. The final allocation at the time of retirement is to consumption. All money remaining after the above provisions for income and investment is spent immediately.

It is assumed that individuals do not know how long they will live. It is therefore possible that they will die leaving some money in the bank account; this provides a bequest. Other individuals will exhaust the bank account before they die. Hence bequests can exist in some cases, but they are not modelled as a deliberate decision of individuals.

Given the complexity of the maze of choices, there are in principle infinitely many routes which may be taken. In this paper a catalogue of 47 available routes through the maze has been constructed. The routes over which each individual makes the optimal choice are described in Tables 1 and 2. In Table 1, column 2 indicates the first call on the use of pre-tax superannuation assets. The initials 'LS' signify that the superannuation assets are taken entirely as a lump sum. Where this is given as 'A' the superannuation assets are used to provide an annuity to the defined level of income described in column four. If the superannuation assets are insufficient to purchase an annuity to the required level, then savings are drawn upon until the level is reached. Any balance of pre-tax money is then taken as a lump sum, and added to other post-tax money. If there is insufficient money to purchase the defined level of income, the individual buys as much as possible, so that all assets are devoted to annuity purchase.

TABLE 1.

Routes 1 - 24: Defined Benefit Cases

Route no.	Superannuation pre-tax destination	Savings and post-tax destination	Defined benefit % of Final Salary	% of Balance to Bank	% of Balance to consumption
1	A	A	85	-	100
2	A	A	75	-	100
3	A	A	65	100	0
4	A	A	65	50	50
5	A	A	65	-	100
6	LS	A	65	100	-
7	LS	A	65	50	50
8	LS	A	65	-	100
9	LS	A	60	-	100
10	A	A	50	100	-
11	A	A	50	50	50
12	A	A	50	-	100
13	LS	A	50	100	-
14	LS	A	50	50	50
15	LS	A	50	-	100
16	LS	A	45	-	100
17	A	A	35	100	-
18	A	A	35	50	50
19	A	A	35	-	100
20	LS	A	35	100	-
21	LS	A	35	50	50
22	LS	A	35	-	100
23	A	A	25	-	100
24	A	A	10	-	100

TABLE 2

Routes 25-47: Money Purchase Cases

Route no.	% of Superannuation to annuity	% of Savings and post-tax to annuity	% of Balance to Bank	% of Balance to consumption
25	100	100	Nil balance	Nil balance
26	100	0	100	0
27	100	0	50	50
28	100	0	0	100
29	50	50	100	0
30	50	50	50	50
31	50	50	0	100
32	50	0	100	0
33	50	0	50	50
34	50	0	0	100
35	LS	100	Nil balance	Nil balance
36	LS	85	100	0
37	LS	70	100	0
38	LS	70	50	50
39	LS	50	100	0
40	LS	50	50	50
41	LS	50	0	100
42	LS	0	100	0
43	LS	0	75	25
44	LS	0	50	50
45	LS	0	25	75
46	LS	0	10	90
47	LS	0	0	100

In Table 2, column 2 indicates the percentage of pre-tax superannuation assets used to purchase an annuity. The balance of superannuation assets is taken as a lump sum, and later pooled with any balance of the savings accumulation. If the superannuation assets are converted entirely to a lump sum, as in routes 35-47 inclusive, then the post-tax money is added to the savings accumulation and the stated percentage applied to the purchase of an annuity. Thus route 35 specifies that all superannuation is taken as a lump sum, and all the money then available is used to buy an annuity. Route 25 specifies that all benefits are used to purchase annuities, but one annuity arises from pre-tax superannuation assets while the other arises from post-tax savings and therefore involves a different tax and age pension treatment.

The route with the highest value for the specified criterion is chosen by an individual. The model operates a 'sieve' effect, whereby if there is more than one route with the same value, the highest route number is preferred. The range available is designed to be sensitive to changes in behaviour under varying conditions.

Individual Evaluation of Routes

There are many ways to evaluate the results of a given route. Since this paper is concerned with the consequences of action at the time of retirement, the evaluation criteria relate only to experience after that time. Any pre-retirement income or expenditure is independent of the retirement choice, and is therefore ignored. The simulation of earnings over the working life, along with the process used to allow for differential mortality (such that those with relatively higher lifetime incomes live relatively longer, on average), are described in the Appendix below. Results have been obtained for optimised behaviour for each of five different evaluation criteria. The valuations are all based on present values at the time of entry to the workforce.

All criteria are defined in terms of a utility function based on net consumption in each year of retirement. Individuals are assumed not to save from any disposable income during retirement. The amount of net consumption in any year is the sum of income from any purchased annuities, plus the age pension received, plus the amount taken from the bank account, less the amount of income tax paid, allowing for the appropriate rebates due. This amount is not the same, in general, as the net income in the year. Net income includes the interest earned on the bank account, but does not include the capital amount withdrawn from it.

Some of the criteria used take into account the value of the bequest, if any. This is the balance of the bank account at the time of death. Since the bank account is zero by age 80, the bequest is zero for any individual who survives this age.

Criterion 1 evaluates the present value of the stream of net consumption in retirement plus the present value of the bequest, b. In calculating the present values, consumption is assumed to occur uniformly throughout the year, and the bequest is valued at the end of the year of death. If c(t) is the net consumption in year t, the working life begins at age 20 when t=0, retirement begins at the end of year t=45, at age 65, death occurs in year d and the interest rate is denoted by i, Criterion 1 is defined as follows.

$$\text{Criterion 1} = \sum_{t=46}^{d} c(t)\,(1+i)^{-t+0.5} + b\,(1+i)^{-d} \quad (1)$$

The utility function used by Criterion 2 is the sum over the retirement years of the present value of the logarithm of net retirement consumption plus the bequest. Criterion 3 is the same as Criterion 2 but with no allowance for the bequest. Criterion 4 is the sum of the present values of net consumption raised to the power α, where the bequest is included in the consumption amount in the last year of retirement. Criterion 5 is the same as Criterion 4, but with no allowance for the bequest.

Thus :

$$\text{Criterion 2} = \sum_{t=46}^{d} (1+i)^{-t+0.5} \log c(t) + (1+i)^{-d} \log(b) \quad (2)$$

$$\text{Criterion 3} = \sum_{t=46}^{d} (1+i)^{-t+0.5} \log c(t) \quad (3)$$

$$\text{Criterion 4} = \sum_{t=46}^{d} (1+i)^{-t+0.5}\, c(t)^{\alpha} + b^{\alpha}(1+i)^{-d} \quad (4)$$

$$\text{Criterion } 5 = \sum_{t=46}^{d}(1+i)^{-t+0.5}\, c(t)^{\alpha} \qquad (5)$$

Criteria 2 to 5 are alternative ways of allowing for decreasing marginal utility in consumption. Such decreasing marginal utility implies that individuals prefer a more stable consumption stream, other things being equal. Hence, it is less likely that consuming all assets at retirement, and then living on the full age pension, will be optimal. This implication is clearly shown in the following results.

Optimal choice of route

The LITES model is used to simulate the lifetime experience of each of 3000 individuals. In each case the value of each criterion is evaluated for each of the 47 routes through the maze, and the route giving the maximum value of the relevant criterion is recorded. The simulation is repeated for the assumption of common mortality, such that all individuals live for 14 years after retirement, and for differential mortality whereby the relatively richer live, on average, relatively longer (and the expectation of life at retirement for the median individuals is 14 years). The routes giving the maximum values for each criterion are shown in Table 3. For example, the first column of the body of the table shows the number of times each route gives the maximum value using criterion 1, when differential mortality applies. The shaded areas of the table indicate those routes where, by definition, there can be no bequest (though in other cases some individuals may not leave a bequest, depending on their longevity).

Table 3 shows, not surprisingly, that the optimal route is sensitive to the criterion used and whether or not there is differential mortality. It is necessary at this point to stress that the evaluation of each route for each individual is ex post. That is, the criteria refer to the consumption stream and bequest actually received by the individual over the whole of the retirement period. Hence the 'optimal route' is the one that 'turned out' to be the best in the end. These results do not therefore directly indicate which routes are optimal ex ante, since it would be necessary to model explicitly the formation of expectations about the length of life. The two concepts coincide only if individuals know at retirement how long they will live.

The effect of allowing for decreasing marginal utility of consumption, irrespective of the form of the specification, is dramatic. With differential mortality and criterion 1, route 47 is optimal for one third of the individuals, where all assets are converted to a lump sum and consumed at retirement. With common mortality and criterion 1, almost two thirds of individuals have route 24 as the optimal route, where an annuity of only 10% of final salary is purchased at retirement and all other assets are consumed. In practice, such consumption may of course involve the purchase of durable goods which provide a flow of consumption benefits, but this aspect is not modelled here. With decreasing marginal utility (criteria 2 to 5), route 38 is optimal when there is common mortality for almost one half of individuals. This route involves taking all superannuation assets in a lump sum, and using 70% of the sum of the post-tax value and savings to purchase an annuity, with the remainder divided between a bank account and consumption. With differential mortality, there is a much wider spread of optimal routes. Under all criteria, about half of the cohort has an optimal route that is a defined benefit case, and approximately half has an optimal choice among the lump-sum money purchase routes 35-47.

TABLE 3. Optimal Routes (3000 individuals)

	DIFFERENTIAL MORTALITY					COMMON MORTALITY				
Route number	Crit 1	Crit 2	Crit 3	Crit 4 α=.25	Crit 5 α=.25	Crit 1	Crit 2	Crit 3	Crit 4 α=.25	Crit 5 α=.25
1	4	24	29	19	23	2	37	40	42	44
2	3	16	18	13	15	1	33	33	34	39
3	-	-	-	-	-	-	-	-	-	-
4	-	5	-	7	-	-	15	4	23	-
5	2	12	15	7	11	7	26	27	28	33
6										
7	-	181	82	139	29	-	454	371	327	190
8	65	183	483	201	520	6	274	331	339	476
9	38	88	189	100	205	3	167	170	199	205
10	-	-	-	-	-	-	-	-	-	-
11	-	10	-	7	-	-	4	2	22	-
12	6	1	7	2	7	50	3	4	4	6
13	-	-	-	-	-	-	-	-	-	-
14	-	115	6	100	1	-	32	17	19	4
15	49	55	122	63	171	-	93	105	129	136
16	68	18	73	13	65	-	34	34	46	47
17	-	-	-	-	-	-	-	-	-	-
18	-	-	-	2	-	-	-	-	1	-
19	39	-	14	-	12	167	1	1	1	1
20	-	-	-	-	-	-	-	-	-	-
21	-	99	1	98	-	-	8	6	5	1
22	219	1	32	2	54	-	2	3	6	8
23	94	-	15	-	24	502	-	-	-	-
24	579	-	12	-	38	1872	-	-	-	-
25	265	305	309	319	322	-	172	192	14	179
26	-	-	-	-	-	-	-	-	-	-
27	-	10	6	9	1	-	8	-	130	-
28	-	-	13	-	20	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-
30	-	3	-	2	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-
32	-	-	-	-	-	-	-	-	-	-
33	-	-	-	-	-	-	-	-	-	-
34	4	-	1	-	-	51	-	-	-	-
35	160	609	635	581	593	1	170	276	34	162
36	-	-	-	-	-	-	-	-	-	-
37	-	-	-	-	-	-	-	-	-	-
38	-	559	651	410	510	-	1467	1384	1597	1469
39	-	-	-	-	-	-	-	-	-	-
40	-	150	6	132	2	-	-	-	-	-
41	135	-	86	-	152	4	-	-	-	-
42	1	1	-	1	-	-	-	-	-	-
43	3	168	-	276	-	-	-	-	-	-
44	52	247	-	357	-	-	-	-	-	-
45	156	128	-	128	-	-	-	-	-	-
46	36	12	-	12	-	-	-	-	-	-
47	1022	0	195	-	225	334	-	-	-	-

shaded areas have no bequest by definition

3. THE EFFECT OF POLICY CHANGES

The results of the previous section have shown that the superannuation taxation and age pension system in Australia do not appear to provide a clear incentive for individuals to purchase retirement income streams from their superannuation assets at retirement. The optimal ex post decisions were found to be spread over a range of choices, many of which involved taking superannuation assets in the form of a lump sum. This section examines two policy structures as alternatives to the one currently operating. For further discussion of these alternatives, and the rationale behind them, see Atkinson Creedy and Knox (1994 c).

Alternative structures

The two alternative structures are referred to as Option A and Option B, and offer progressively radical simplifications. The major characteristics of the current scheme and the alternatives are summarised in Table 4. Both alternatives involve a reduced level of employer contribution, and a simplified rebate structure for employee's contributions. These, and the other major differences in structure, represent elements of the current debate on retirement incomes policy. Option A closely reflects an alternative structure which has been suggested by the Institute of Actuaries of Australia (1994). Both options provide a universal pension during retirement and a simplified taxation schedule for the superannuation benefits. The low income earners rebate remains in place. Option A taxes annuities in receipt as income in the same way regardless of their source. Option B exacts all superannuation taxation at the time of retirement, and superannuation annuities in payment are exempt from income tax.

Table 4: Description of Alternative Structures

DETAIL	CURRENT STRUCTURE	OPTION A	OPTION B
Accumulation period:			
Contribution rates	Employer 9% , Employee 3%	Employer 6% Employee 3%	Employer 6% Employee 3%
Contribution tax	15% on deducted Employer contributions	15% on deducted Employer contributions	15% on deducted Employer contributions
Employee Contribution rebate	10% of employee contributions, subject to tests on income (maximum rebate $100, maximum salary $32,000) and age related maxima on total contributions. Rebate may not exceed tax liability.	10% of employee contributions, subject to the same age related maxima but no other limitations, are refundable. Refund may exceed tax liability.	10% of employee contributions are refundable. No limitations apply.
Superannuation Fund Earnings	Nominal rate of tax of 15% (assumed to be an effective rate of 7.5% after allowance for credits).	Nominal rate of tax of 15%, (assumed to be an effective rate of 7.5%, after allowance for credits).	Nominal rate of tax of 15%, (assumed to be an effective rate of 7.5%, after allowance for credits).
At Retirement:			
Lump Sum Tax	Undeducted contributions not subject to lump sum tax[1] The taxable benefit included in the lump sum is subject to 16.4% tax on amounts in excess of a threshold ($77,796 in 1993-94). Excessive amounts taxed at 48.4%[2] Rates include the Medicare levy.	All Lump Sum benefits subject to tax schedule of: 0% on amounts < 2 x AWE[5] 20% on amounts 2 - 4 x AWE 35% on amounts > 4 x AWE Medicare levy of 1.4% on all amounts.	No Lump Sum tax as such. Total Superannuation benefit is subject to tax schedule of : 0% on amounts < 3 x AWE 20% on amounts 3 - 10 x AWE 40% on amounts > 10 x AWE No Medicare levy.
In Retirement:			
Age Pension	Taxable Pension payable subject to income and asset means-tests. Income tax rebate depending on income.	Universal pension, taxable, no means-tests. Income tax rebate depending on income.	Universal pension, taxable, no means-tests. Income tax rebate depending on income.
Annuities in payment	Superannuation annuity taxed as income, except UPP exempt.[3] Other annuities taxed as income, except the purchase price allowance which is exempt[4].	Superannuation and other annuities are taxed as income, except that the purchase price allowance is exempt.	Superannuation annuities are exempt from income tax. Other annuities are taxed as income, except that the purchase price allowance is exempt.
Superannuation pension rebate	15% rebate associated with contribution tax.	No rebate	No rebate

Notes:
1. 'Undeducted contributions ' are the sum of employee contributions which have not been taken as a deduction against income tax. The remainder of the benefit, which includes interest earnings, and those on the undeducted contributions, is the 'taxable benefit'.
2. Excessive amounts: The excesive proportion of a Lump Sum is that proportion in excess of a maximum 'reasonable benefit' level, $400,000. If less than 50% of the superannuation fund is taken as a lump sum, the maximum reasonable benefit level is $800,000.
3. UPP for a superannuation annuity in the current system is that part of the cost of the annuity attributed to undeducted contributions, divided by the expected term of payment.
4. Purchase price allowance is the cost of the annuity divided by the expected term of payment, (14.6 years for males aged 65).
5. AWE stands for average weekly earnings.

Results of optimal choices

The results of simulating the experience of 3000 individuals for the two options are shown in Tables 5 and 6, for the assumptions of differential mortality and common mortality respectively. It can be seen that these reforms have a dramatic effect on the allocation of routes through the retirement maze. In particular, the optimal route ex post is route 25 in many more cases, particularly for option B. This is the route that involves the use of all superannuation and savings to purchase an annuity.

Under an assumption of differential mortality, one of the immediately striking effects of Option A, and to a slightly lesser extent Option B, is the fact that routes involving the use of lump sum are rarely optimal. Option B does not tax lump sums per se, but does provide for tax exempt superannuation annuities. Both Options, through the provision of the universal pension, avoid the clustering of optimal routes around margins of the age pension income means test (routes 22-24 in particular).

About 40% of the cohort chooses route 25, irrespective of criterion of valuation as opposed to about 10% under the current scheme. Route 25, the 100% annuity purchase choice, is far more effectively targeted by Options A and B.

Table 6 presents the results based on a common mortality experience, and survival of 14 years after retirement. The most popular route under the current scheme is route 38, which takes all superannuation as a lump sum, uses 70% on annuity purchase and divides the remainder between the bank investment and consumption. This choice is probably driven by the income means test. Here the polarising effect is even more marked for Option B with far more, between about 50 and 80%, selecting route 25 as optimal. Option A, except for valuation criterion 1, results in route 25 being the most 'popular' optimal route.

Importantly both Options A and B concentrate optimal choices in routes which provide a high level of annuity. Generally the attraction of routes with high levels of immediate consumption are screened out by the assumption of common mortality, and 'bank' options have little advantage.

The primary result is simple. Both options are more effective at targeting behaviour towards the choice of purchasing annuities under the various sets of assumptions presented here.

However Option B also results in the high consumption route 47 being optimal for markedly more individuals under certain conditions and valuation criterion.

None of the lump sum routes 36-41 is optimal for any of the 3000 individuals for options A and B when there is differential mortality, and with common mortality routes 29-47 are optimal for very few individuals. Lump sum routes 6 to 9 and 13 to 16 are optimal for many individuals in the current scheme, but for very few in options A and B. Route 12, involving an annuity of one half of final salary, is much more frequent with options A and B than with the current scheme. Those choosing lump sum routes 42-46 under the differential mortality assumption appear to do so because value is put on the bequest arising from the bank account balance at death.

Given the stated government objective of encouraging the use of income streams in retirement, the results suggest that these reforms are worthy of serious consideration.

TABLE 5. Optimal Routes with Differential Mortality

	OPTION A					OPTION B				
Route no.	Crit 1	Crit 2	Crit 3	Crit 4 α =.25	Crit 5 α =.25	Crit 1	Crit 2	Crit 3	Crit 4 α =.25	Crit 5 α =.25
1	23	156	291	127	265		64	120	47	91
2	37	139	285	124	248	4	87	170	62	130
3										
4		157	4	148	1		66	8	49	2
5	91	117	285	102	267	3	109	223	74	200
6										
7										
8								6		6
9							1	23	1	13
10										
11		176	14	183	1		156	67	101	29
12	200	61	170	55	203	6	87	274	67	262
13										
14										
15								20		14
16			1					36		27
17										
18		100	3	131	2		115	40	103	27
19	212		33		57	8	43	131	34	134
20										
21										
22								23		31
23	152		19		28	1	2	40	2	49
24	95		15		25			22		36
25	1110	1080	1151	1119	1181	1485	1227	1323	1325	1405
26										
27		437	106	350	38		248	58	217	24
28	58		388		410			145		177
29										
30		23		12			33		18	
31			13		12					8
32										
33		78		93						
34	122		25		30			21		32
35										
36										
37										
38							2			
39										
40										
41								29		25
42	183	183		183		190	190		190	
43	10	160		201		5	425		528	
44	8	133		172		18	145		182	
45	28					25				
46	19					10				
47	652		197		232	1244		221		278

shaded areas have no bequest by definition

TABLE 6. Optimal Routes with Common Mortality

	OPTION A					OPTION B				
Route no.	Crit 1	Crit 2	Crit 3	Crit 4 α =.25	Crit 5 α =.25	Crit 1	Crit 2	Crit 3	Crit 4 α =.25	Crit 5 α =.25
1	123	484	503	495	520	28	217	217	214	214
2	146	424	445	455	473	35	284	295	289	294
3										
4		133	52	88	6		138	44	87	3
5	395	339	386	397	456	84	328	373	352	378
6										
7										
8							2	2	2	2
9			1				6	7	6	7
10										
11		125	43	116	22		261	84	147	7
12	880	133	154	158	189	150	284	326	311	343
13										
14										
15							2	2	2	2
16							2	2	2	2
17										
18		11	6	13	4		150	46	76	10
19	703	4	5	5	10	131	106	125	115	137
20										
21										
22										
23	169					24	5	5	5	5
24										
25	1	751	1245	510	1123	2474	1254	1471	1391	1595
26										
27		596	159	763	196		6		1	
28	32		1		1	73		1		1
29										
30										
31	2									
32										
33										
34	549									
35						1				
36										
37										
38										
39										
40										
41										
42										
43										
44										
45										
46										
47										

shaded ares have no bequest by definition

4. LIFETIME REDISTRIBUTION

The previous two sections have examined optimal routes through the retirement maze under the current Australian system and under two alternative systems. This section turns to the question of lifetime redistribution. Previous analyses have concentrated on examining alternative systems where all individuals are assumed to follow a common route. This assumption is relaxed here. Redistribution and tax progressivity are examined for the three tax structures on the assumption that each individual selects at retirement the route which is ex post optimal, for each criterion. While this is a strong assumption, it is useful to make comparisons with the case where all individuals take the same route. Before reporting results, however, the measures reported are briefly described in the following subsection.

The measures used

The present study compares progressivity and inequality based on present values of lifetime income, using the Kakwani progressivity index, K, and the Gini measure of inequality of net income, G. Other measures were calculated, but gave similar results and are therefore not presented. If individuals are ranked in ascending order, the Gini measure of pre-tax income, G_x, can be expressed in terms of the following covariance:

$$G_x = (2/\bar{x}) \ \mathrm{Cov}(x, F(x)) \qquad (6)$$

Where F(x) is the distribution function, and $\bar{x}$ is the arithmetic mean; see Jenkins (1988). The concentration index of net income, C_y, is given by:

$$C_y = (2/\bar{y}) \ \mathrm{Cov}(y, F(x)) \qquad (7)$$

The tax concentration index, C_t, may be obtained by substituting $\bar{t}$ for $\bar{y}$ and t(x) for y in (6). Kakwani's measure, K, is the difference between the tax concentration index and the Gini measure of x:

$$K = C_t - G_x \tag{8}$$

If two individuals have the same (present value of) gross lifetime income, the requirement of horizontal equity would be that they also have the same net income. Therefore, the re-ranking of individuals when moving from the distribution of x to that of y measures horizontal inequity. The Atkinson-Plotnick index, P, measures this using:

$$P = \frac{G_y - C_y}{2\,G_y} \tag{9}$$

The effective total tax ratio, g, is the difference between the present values of gross income and net consumption divided by the present value of gross income over all individuals. The various measures are related by:

$$G_x - G_y = K\{\, g/(1-g)\} - 2G_yP \tag{10}$$

Thus the redistributive effect of the tax and transfer system, G_x - G_y, is proportional to its progressivity, K, less a term that depends on the extent of re-ranking; see Lambert (1993). A change which increases tax progressivity need not necessarily reduce the Gini inequality of net income. This approach assumes that the pre-tax distribution is not affected by the tax system, and this assumption is made by the simulation model.

Simulation results

For comparison purposes, Tables 7 and 8 show, for differential mortality and common mortality respectively, the implications of having each individual follow a common route through the maze. Results are given for 5 alternative routes, representing substantial differences in the type of choice. The income concept used is the present value of lifetime consumption. Re-ranking only occurs to any significant extent when there is an assumption of differential mortality. Generally, these results show that there is little effect in the Gini inequality measures in moving from the current scheme to either of options A or B. There is a slight fall in the Kakwani progressivity measure, associated with a slight rise in the tax ratio. Options A and B produce a more stable value for the Kakwani measure over the range of routes, compared with the current scheme. The current structure thus appears to have progressivity implications which are more sensitive to route choice. However this effect is linked to the changes in the tax ratio which, under the current scheme, is much lower for the high consumption route 47 than for the annuity choice, route 25. The major difference between the results apply to the differences between the routes selected, and whether or not differential mortality is assumed. Although the reforms A and B involve major departures from the current system, they do not appear, other things being equal, to involve significant changes in regressivity or inequality in terms of lifetime consumption. They do seem more robust in effect under different route choices.

The optimal choice results, for each criterion and tax structure, are shown in Tables 9 and 10 for differential mortality and common mortality respectively. For comparison purposes, all measures are based on the same income concept, that is, the present value of lifetime consumption. Again the Gini measures of inequality show little difference between the tax structures, though it increases slightly in moving from the current scheme to option A. Progressivity falls in moving from the current scheme to option A, and then to B, but this is very small and may be associated with the concommitant increase in the tax ratio.. The tax ratios are, as expected, slightly lower when individuals follow optimal choices. The major result seems to continue to hold in these more extensive comparisons; that is, the tax structure alternatives have little effect on redistribution and the results are more sensitive to the assumption of differential mortality.

Table 7: Summary Measures of Lifetime Income with differential mortality and uniform choice

Case no:	**Kakwani**			**Gini measure**			**Total Tax Ratio**			**Atkinson-Plotnick**		
	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB
ROUTE 25	.2134	.2504	.2171	.2509	.2500	.2441	.1599	.1438	.1782	.0109	.0121	.0104
ROUTE 32	.3015	.3006	.2486	.2302	.2318	.2295	.1613	.1587	.1908	.0046	.0053	.0046
ROUTE 34	.3570	.3212	.2582	.2329	.2346	.2315	.1350	.1443	.1804	.0055	.0059	.0050
ROUTE 42	.3473	.3100	.2680	.2171	.2176	.2206	.1669	.1826	.1983	.0014	.0019	.0020
ROUTE 47	.4359	.3341	.2792	.2243	.2216	.2245	.1257	.1640	.1833	.0021	.00224	.0025

Note: Gini measure of pre-tax lifetime income is 0.286

Table 8: Summary Measures of Lifetime Income with common mortality and uniform choice

Case no:	**Kakwani**			**Gini measure**			**Total Tax Ratio**		
	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB
ROUTE 25	.3616	.4218	.3442	.2135	.2124	.2107	.1671	.1487	.1797
ROUTE 32	.3924	.4024	.3319	.2096	.2097	.2094	.1630	.1595	.1875
ROUTE 34	.4796	.4376	.3409	.2102	.2112	.2108	.1366	.1460	.1809
ROUTE 42	.4042	.3673	.3211	.2068	.2060	.2084	.1639	.1790	.1948
ROUTE 47	.5257	.4018	.3392	.2115	.2081	.2107	.1241	.1624	.1817

Note: Gini measure of pre-tax lifetime income is 0.286. The measure of re-ranking is zero in all cases.

Table 9: Summary Measures of Lifetime Income with differential mortality and optimal choice

	Kakwani			Gini measure			Total Tax Ratio			Atkinson-Plotnick		
	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB
Criterion 1	.4517	.3572	.2827	.2317	.2381	.2423	.1104	.1251	.1576	.0037	.0066	.0060
Criterion 2	.3754	.3334	.2727	.2333	.2398	.2424	.1287	.1303	.1615	.0058	.0077	.0068
Criterion 3	.3441	.3081	.2529	.2361	.2425	.2425	.1343	.1345	.1665	.0073	.0090	.0083
Criterion 4 $\alpha = .25$	.3881	.3385	.2749	.2325	.2393	.2424	.1259	.1293	.1607	.0052	.0075	.0066
Criterion 5 $\alpha = .25$	.3576	.3168	.2577	.2350	.2416	.2425	.1314	.1329	.1652	.0065	.0085	.0079

Note: Gini measure of pre-tax lifetime income is 0.286

Table 10: Summary Measures of Lifetime Income with common mortality and optimal choice

	Kakwani			Gini measure			Total Tax Ratio		
	Current	OptionA	OptionB	Current	OptionA	OptionB	Current	OptionA	OptionB
Criterion 1	.5415	.4385	.3441	.2109	.2128	.2107	.1218	.1432	.1796
Criterion 2	.4483	.4237	.3438	.2068	.2125	.2107	.1502	.1480	.1797
Criterion 3	.4484	.4234	.3439	.2067	.2124	.2107	.1503	.1481	.1797
Criterion 4 $\alpha = .25$	.4503	.4240	.3439	.2071	.2125	.2107	.1492	.1478	.1797
Criterion 5 $\alpha = .25$	.4515	.4238	.3440	.2068	.2125	.2107	.1493	.1479	.1797

Note: Gini measure of pre-tax lifetime income is 0.286. the measure of re-ranking is zero in all cases.

5. CONCLUSIONS

This paper presents results associated with the effects arising from individuals optimising their retirement behaviour under various conditions. It is found that the current structure of retirement incomes provision does not provide a clear incentive to purchase annuities, under either an assumption of common mortality experience after retirement, or differential mortality experience.

Further, it is shown that alternative schemes incorporating a universal pension polarise optimal behaviour away from choices which provide low levels of income (or none) driven by the means test. It is also shown that the current scheme has no clear advantage over these alternatives in terms of equality or progressivity.

The behaviour which, with hindsight, proves most valuable to an individual depends very largely on their accurate assessment of the number of years they survive after retirement. In this respect other schemes providing a universal pension are more successful in providing incentives to purchase annuities than the current one, and imply a lesser degree of penalty to those whose mortality experience is higher, typically those with lower lifetime earnings.

Appendix 1. THE LITES MODEL

The model is designed to calculate the costs and benefits associated with earnings, direct and indirect levels of taxation, savings and superannuation, under a variety of conditions. It enables examination of selected individuals or simulated cohorts, and produces alternative measures of inequality and progressivity. For a full description see Atkinson, Creedy and Knox (1994a).

Earnings profiles

Gross earnings in each year of working life are generated using a model of age-earnings profiles in which earnings in age group t are lognormally distributed as $\Lambda(\mu_t,\sigma_t^2)$, where μ_t and σ_t^2 are respectively the mean and variance of the logarithms of earnings. These two parameters are assumed to be quadratic and linear functions of t respectively, so that :

$$\mu_t = \mu_1 + \theta(+ g)t - \delta t^2 \qquad \text{(A1)}$$

$$\sigma_t^2 = \sigma_1^2 + \sigma_u^2 t \qquad \text{(A2)}$$

where g is the nominal growth rate of earnings which affects all age groups equally. The five parameters μ_1, σ_1^2,θ,δ and σ_u^2 were estimated using data for Australian males; see Creedy (1992), are $\mu_1 = 9.98064$, $\theta = 0.0385$, $\delta = 0.00086$, $\sigma_1^2 = 0.1817$, $\sigma_u^2 = 0.00575$, $g = 0.06$.

Age at Death

Where differential mortality is assumed, the number of years the individual survives after retirement, d, is obtained using the following formula:

$$d = \bar{d} + B \log \frac{\bar{X}}{M} \qquad \text{(A3)}$$

where $\overline{X}$ is the individual's annual average real earnings, M is the geometric mean value of the $\overline{X}$s, $\bar{d}$ is the average number of years individuals in the general population survive after retirement. The values used are: $\bar{d} = 14.6$ and $B = 8$. Further details are given in Atkinson, Creedy and Knox (1994a).

The major economic assumptions used in the simulation are as follows.

Tax on super fund investment income	7.5%
Tax on savings fund investment income	25%
Annual increase in AWOTE	6%
Annual increase in income tax thresholds	5.5%
Annual inflation rate	5%
Gross annual investment rate of return on Super accumulation	9%
Gross annual investment rate of return on Savings accumulation	7%
Gross annual rate of return on Bank account during retirement	5%
The purchase price of retirement annuities is	12.5
Annuities purchased escalate in payment at	5%

REFERENCES

Atkinson, M. E., Creedy, J., Knox, D. M., (1994a) Lifetime income, taxation, expenditure and superannuation (LITES) : a life-cycle simulation model. Centre for Actuarial Studies Research Paper no. 9

Atkinson, M. E., Creedy, J., Knox, D. M., (1994b) The superannuation maze and retirement income planning in Australia. University of Melbourne Department of Economics Research Paper, no. 443

Atkinson, M. E., Creedy, J., Knox, D. M., (1994c) Alternative retirement income strategies for Australia: a cohort analysis. University of Melbourne Department of Economics Research Paper, no. 425

Bateman, H., and Piggott, J., (1992) Australian retirement income policy. Australian Tax Forum, 9, pp. 1-26.

Creedy, J., (1992) Income, Inequality and the Life Cycle. Aldershot: Edward Elgar.

Institute of Actuaries of Australia (1994) Submission to the Select Committee on Superannuation. Sydney.

Lambert, P., (1993) The Distribution and Redistribution of Income. Manchester: Manchester University Press.

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