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A CRITIQUE OF DEFINED CONTRIBUTION USING A SIMULATION APPROACH

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1. Introduction

The provision of retirement income for employees has been traditionally initiated by the employer through a defined benefit scheme providing pension benefits. However, during the last decade, there has been a significant shift in many countries towards the provision of retirement benefits through defined contribution plans (or money purchase arrangements). The reasons for this trend vary between countries but include:

- the desire by some employers to reduce their risk implied within a defined benefit scheme;
- increasing legislation which has often made defined benefit plans more complex and costly to administer;
- the presence of surplus in many defined benefit plans and the related issues;
- the high rates of return in the 1980's which made defined contribution plans more attractive to members;
- the trend towards individual responsibility and the desire by many Governments for employees to accept greater responsibility in providing their retirement benefits;
- increasing levels of vesting and preservation required by many Governments; and
- changing taxation structures which permitted and encouraged defined contribution arrangements.

The extent of this trend varies between countries but it is present in sufficient countries to suggest a significant and long term direction.

For example, within the United States the number of defined benefit plans decreased by 16.7% in the 5 years to 1988 whilst the number of defined contribution plans increased by 36.5% (Turner and Beller (1992)). In the same period, the level of contributions to defined benefit private pension plans decreased by 43.2% to $26.3 billion in 1988 whilst the level of contributions to defined contribution plans increased by 79.7% to $64.9 billion in 1988. Turner and Beller (1992) note "the gradual but steady replacement of defined benefit by defined contribution plans as the primary vehicle for providing pension benefits." (p9)

Within the United Kingdom, the trend towards defined contributions plans has not been as strong. However, the introduction of personal portable pensions in 1988 with its associated legislation has meant that many individuals have been encouraged to contribute to a money purchase arrangement.

The recent Australian experience has also moved towards defined contribution plans. In 1987, a general industrial agreement was handed down granting most workers covered by an industrial award an employer contribution equal to 3% of earnings. As from July 1992, this approach was extended so that all employees received a minimum employer contribution of either 3% or 5% of earnings (depending on the size of the company). It is also planned to increase this minimum employer contribution to 9% of earnings by 2002. Although defined benefit plans are permitted and remain with many larger employers, the legislation expresses the minimum contributions in terms of current earnings which clearly represents a defined contribution approach.

This trend towards an increased reliance on defined contribution funds to provide employees' retirement benefits needs to be assessed in terms of the ultimate benefit provided to the member. Actuaries are fully aware that within a defined pension scheme, the employer bears the investment risk, the salary inflation risk and the longevity risk. However, within a defined contribution plan, where the employer's contribution is set as a fixed percentage of the employee's earnings and the final benefit represents the accumulation of these contributions, the employer bears none of these risks. Indeed, they have all been passed onto the employee. However, if employees are increasingly bearing these risks, it is essential that policy-makers, individual members and the pension industry fully understand these risks. With this objective in mind, this paper will analyse the defined contribution arrangements from the member's perspective.

The paper will consider the benefits that arise from a 12% contribution rate allowing for stochastic investment and inflation rates and changes in a number of parameters including contrasting investment strategies, different entry and retirement ages, fractional and full time employment patterns, and the impact of different annuity rates available at retirement. For comparison, the alternative defined benefit approach will also be reviewed. The 12% contribution rate has been chosen as it provides a reasonable retirement pension, on average, for a person who is a member for at least 40 years. It also represents the Australian Government's long term contribution objective which comprises a 9% compulsory employer contribution and a 3% compulsory employee contribution.

Section 2 of the paper will outline the basic equations used and various features of the model. Section 3 initially considers the results for a standard defined contribution approach before discussing results from the defined benefit approach. Finally Section 4 will summarise the findings.

2. The model used

2.1 The accumulation of contributions and the benefits arising

During an individual's pre-retirement years, it is assumed that contributions (expressed as a percentage of annual earnings) will be paid mid way through each year and investment income will then be generated until retirement age. Allowance is also made for any tax payments on contributions and investment income. It should be noted that within Australia both employer contributions and investment income are taxed at a rate of 15%, although the investment tax rate is normally reduced to a net rate between 5% and 10% due to the availability of various credits.

Equation (1) represents the accumulated amount available at retirement age for the provision of retirement income.

$$K\,(1\text{-}TAX_c)\sum_{t=0}^{R-1} F_t\ SAL_t\,(1+INV_t\,[1\text{-}TAX_I]\,)^{1/2}\prod_{u=t+1}^{R-1}(1\text{+}INV_u\,[1\text{-}TAX_I]\,) \qquad (1)$$

where K = the rate of contributions as a percentage of earnings
TAX_c = the rate of tax on contributions at the point of payment
TAX_I = the net rate of tax on investment earnings
F_t = the fraction of a full time year in employment in year t
SAL_t = the annual salary in year t
INV_t = the gross rate of investment return earned in year t
R = the number of years in the plan before retirement

For the purposes of this paper, it will be assumed that this accumulated amount will purchase an indexed annuity (or pension) payable for life from the age of retirement. The value of the pension purchased can be expressed as follows:

$$PEN\% * SAL_{R\text{-}1} * ANN_x \qquad (2)$$

where PEN% = the pension received, as a % of the individual's final salary
SAL_{R-1} = the salary received in the final year prior to retirement
ANN_x = the annuity factor for the retiree aged x (ie at retirement)

Equations (1) and (2) must equal each other as the accumulated amount at retirement provides the funds required to purchase a pension at a rate related to the person's age and sex. However, in any individual case, there are two unknowns: namely K (the rate of contribution) and PEN% (the pension received in terms of final salary). Within a defined contribution fund, K is defined and the pension can then be calculated based on the accumulated funds at retirement. In contrast, within a defined benefit pension fund, the pension percentage is defined (normally ignoring any tax on the pension) so that a recommended rate of K can be calculated using actuarial principles.

The above equations do not make any allowance for expenses in respect of any initial expenses, regular administration or investment costs or the costs associated with the purchase of an annuity. The impact of expenses will be considered in a future study.

The provision of retirement income from savings in the pre-retirement years requires funds to be accumulated over many years and, in terms of a model, a number of long term assumptions are therefore necessary. One approach is to use a deterministic approach and set pre-determined levels of inflation and investment return for each year. However, such an approach does not enable an analysis to be carried out in respect of the risk facing the individual member. Hence, to provide greater reality in this model, simple stochastic models for inflation and investment will be used.

2.2 The inflation and salary assumptions

The stochastic model used for inflation allows for a one year lag as expressed in Equation (3).

$$INFL_t = k * \{\text{a random selection from } N(\mu,\sigma^2)\} + (1-k) * INFL_{t-1} \qquad (3)$$

where $INFL_t$ = the rate of inflation in year t
k = a number between 0 and 1
μ = the mean of the normal distribution representing inflation
σ^2 = the variance of the normal distribution representing inflation

Of course, the appropriate levels for k, μ and σ^2 can be debated. After some empirical investigation into the inflation levels over the last 40 years in Australia, the following values provided a distribution of inflation values that was similar to the previous 40 years' experience:

$k = 0.5$ (that is, 50% of last year's inflation is carried into this year)
$\mu = 0.07$
$\sigma = 0.07$ (that is, the standard deviation)

Before proceeding, it is worth noting that the past history of inflation does not necessarily indicate future levels. In particular, Australia and most OECD nations have now moved into a low inflation environment, at least for the next few years. With this in mind, the results will concentrate on $\mu = 0.04$ and $\sigma = 0.04$, but will also consider the effects of higher inflation rates.

As indicated above, the model requires an assumption in respect of a person's salary in each of their pre-retirement years; that is, the pattern of the person's salary from entry into the workforce until retirement age. The approach that will be adopted is to consider that the annual change in a person's salary comprises the following three components:

- an increase related to inflation levels, which can be estimated from the inflation equation outlined above;

- an increase as a result of general productivity improvements within the economy, which may be expressed as a percentage rate per annum; and
- a promotional increase which may also be expressed as a percentage rate per annum.

2.3 Investment returns

The assumption of a single investment rate of return for a period of 20, 30 or 40 years to estimate the accumulated value of a person's retirement benefit is a very bold and heroic assumption and is almost certain to be wrong! To provide greater understanding of the range of possible results, each simulation assumes that each year's rate of investment return is randomly selected from a distribution which represents the assumed experience thereby allowing investment returns to vary on a year to year basis. It will also be assumed that the real rate of investment return in year t is independent from the rate of inflation in that year. Although this result may appear surprising, it is consistent with the finding of Carter (1991) and others.

It is also recognised that superannuation funds may adopt a range of investment strategies. With this in mind, the model will allow for the following three investment strategies, which are each represented by a normal distribution.

Strategy A: N (mean of 5% pa, standard deviation of 8% pa)
Strategy B: N (mean of 3% pa, standard deviation of 5% pa)
Strategy C: N (mean of 1% pa, standard deviation of 2% pa)

In each case, the expected rate of return is a real rate of return so that 1 plus the nominal rate of return in year t is the product of (1 plus the inflation rate for year t) and (1 plus the rate of return for year t), for the given investment strategy.

It should be noted that the three investment strategies outlined above represent, in broad terms, the following three investment options:

- Strategy A represents a managed or balanced fund with significant investments in equities and properties.
- Strategy B represents a capital stable fund with significant investments in fixed interest stocks.
- Strategy C represents a fund invested predominantly in cash and short term stocks.

The Towers Perrin Superannuation Pooled Funds Survey (1993) show, for the 3 years to 30 June 1993, standard deviations of 5.8%, 7.6% and 8.9% pa for the benchmarks for funds which have below average, average or above average volatility for their investment returns. In addition, Humphreys and Newman (1993) show a standard deviation of 8.2% for a fund with a balanced asset mix and a standard deviation of 4.8% for a fund with a stable asset mix.

As will be shown later, this model also permits individuals to change their investment strategies during their pre-retirement years, which is similar to the concept of age phasing discussed in Kingston, Piggot and Bateman (1992).

3. The results

3.1 The defined contribution approach

As indicated above, the model can assume a defined contribution or a defined benefit approach. Let us initially consider the retirement income benefits that will arise for a single male in his retirement from a defined contribution of 12% of salary throughout his career. It is assumed that the full accumulated benefit at retirement is converted into an inflation-linked lifetime annuity.

Table 1 sets out the results based on the following assumptions, except where an alternative assumption is noted.

<u>The basic assumptions</u>

Entry age:	20
Exit age:	65
Participation:	full time throughout
Inflation rate - mean:	4% pa
- standard deviation	4% pa
Investment strategy A - mean	5% pa real
- standard deviation	8% pa
Investment rate after retirement	1% pa real
Salary growth - productivity	1% pa
- promotion	1% pa
Mortality after retirement	Australian Life Tables 1985-87

The investment rate of return after retirement has been assumed to be 5% pa (i.e. 1% in excess of the mean long term inflation rate), as it is assumed that the institution offering the indexed lifetime annuity will adopt a reasonably cautious investment strategy.

To indicate the spread of results that arise from the one thousand simulations undertaken for each set of assumptions, Table 1 shows the mean, standard deviation, the 5th and the 95th percentiles for the 1,000 results produced under each scenario.

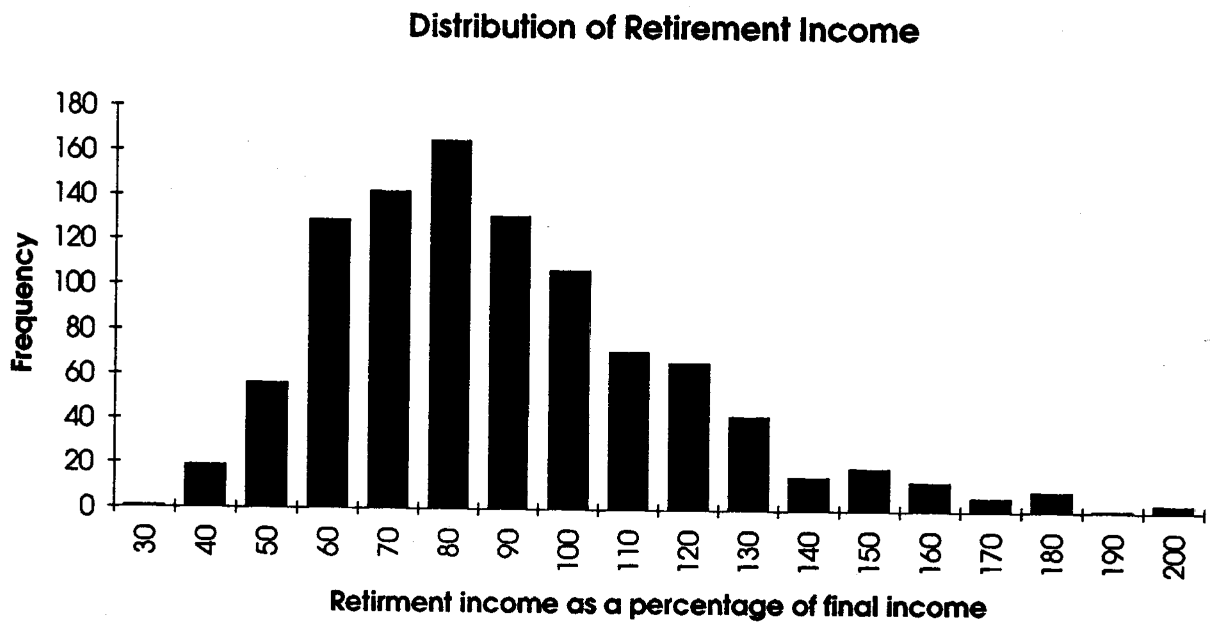
The most important result shown in Table 1 is the significant spread of the level of retirement income received by individuals who have contributed the same percentage of salary for the same number of years. For instance, using the base assumptions, the average retirement income arising from a contribution of 12% of salary for 45 years is an indexed lifetime annuity equivalent to 84.66% of the person's final salary. However, due to the uncertain investment returns achieved each year, there exists a considerable spread of results. In fact, the level of retirement income is equally likely to be 46% or 143% of final salary, and these are not the extreme values! Figure 1 shows the distribution of these results.

TABLE 1

The indexed retirement income that can be purchased with a 12% contribution rate

Assumption	Mean	Std. Dev.	5th percentile	95th percentile
	Retirement income expressed as a percentage of final salary			
Base assumptions	84.66	19.83	46.17	142.71
Female	67.81	24.42	36.82	114.15
Married male with spouse	62.12	22.44	33.74	104.60
Changes in entry or exit ages				
Retirement age 60	56.98	19.12	31.78	93.11
Retirement age 55	38.22	11.90	22.11	61.12
Ages of 25 and 60	45.52	14.05	27.16	71.76
Retirement age 60 (female)	46.52	15.74	25.56	76.17
Retirement age 55 (female)	31.91	10.03	18.43	51.37
Ages of 25 and 60 (female)	37.17	11.58	21.97	58.51
Changes in Investment strategy				
Strategy A with $\sigma = 6\%$	84.69	22.78	54.09	126.84
Strategy B	52.74	11.17	36.93	73.01
Strategy C	34.53	3.64	29.10	41.25
A for 35 years, then B	71.12	21.57	43.38	111.15
A for 35 years, then C	59.64	15.91	38.33	88.34
A for 25 years, then B for 10 years then C	51.81	11.10	36.29	71.44
Changes in participation rates (part time is considered to be 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	71.58	24.89	39.72	117.71
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	48.24	14.89	28.69	75.12
f/t to age 30, then p/t to age 40, then f/t (female)	57.33	20.08	31.90	94.14
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	38.63	12.03	22.92	60.69
Changes in inflation and annuity assumptions				
Inflation N(4%,6%)	84.81	31.46	45.63	143.62
Inflation N(7%,7%) with annuity at 8% pa	85.35	31.31	45.72	143.80
Annuity at inflation +0%	77.80	27.69	42.13	130.36
Annuity at inflation +1%	83.38	29.64	45.20	139.80
Annuity at inflation +2%	89.16	31.65	48.36	149.58
Career average - indexed (ie not final salary)	119.75	42.90	64.92	199.00

FIGURE 1



As indicated earlier, the model also allows for taxation on contributions and/or investment earnings. Table 2 shows the results assuming a 15% tax on contributions (which is the tax rate payable in Australia on employer contributions) and a 7.5% tax on investment income, represents a typical investment income tax rate paid by funds in Australia after allowing for dividend imputation and other credits. The tax on the resulting benefits is also reduced but this has not been shown as the tax rates vary by income and benefit size.

TABLE 2

The indexed retirement income that can be purchased with a 12% contribution rate after allowing for a 15% contributions tax and a 7.5% investment tax

Assumption	***Retirement income expressed as a percentage of final salary***			
	Mean	Std. Dev	5th percentile	95th percentile
Base assumptions	61.10	19.83	35.08	98.12
Female	48.94	16.02	28.10	79.28
Married male with spouse	44.84	14.73	25.69	72.77
Changes in entry or exit ages				
Retirement age 60	41.97	12.87	24.44	66.44
Retirement age 55	28.74	8.24	17.61	44.80
Ages of 25 and 60	34.24	9.70	21.54	52.05
Retirement age 60 (female)	34.27	10.61	19.76	54.27
Retirement age 55 (female)	24.00	6.96	14.66	37.42
Ages of 25 and 60 (female)	27.96	8.01	17.36	42.49
Changes in Investment strategy				
Strategy A with $\sigma = 6\%$	61.12	15.04	40.39	89.17
Strategy B	39.95	7.81	28.73	54.36
Strategy C	27.29	2.73	23.08	32.19
A for 35 years, then B	52.05	14.28	33.34	78.54
A for 35 years, then C	44.28	10.65	29.90	64.27
A for 25 years, then B for 10 years then C	39.01	7.55	28.56	52.39
Changes in participation rates (part time is considered to be 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	51.87	16.29	30.32	81.08
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	35.68	9.89	22.40	53.92
f/t to age 30, then p/t to age 40, then f/t (female)	41.55	13.16	24.25	65.67
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	28.58	8.01	17.83	43.73
Changes in inflation and annuity assumptions				
Inflation N(4%,6%)	61.29	20.84	34.56	99.87
Inflation N(7%,7%) with annuity at 8% pa	58.89	19.79	33.46	97.11
Annuity at inflation +0%	56.15	18.13	32.18	90.13
Annuity at inflation +1%	60.18	19.40	34.53	96.58
Annuity at inflation +2%	64.35	20.72	33.96	103.09

The major message coming from the results in Tables 1 and 2 and Figure 1 is that a considerable variation in the ultimate level of retirement income received by individuals occurs, even if a 12% contribution rate is assumed to be paid for 45 years. In essence, a system which defines a pre-set level of contributions cannot define the level of benefits received. With the trend towards defined contribution plans, it is critical that the fund members, employers and the policy makers appreciate that the prescribed level of contributions will not provide sufficient retirement income for many retirees, even if, *on average*, it is satisfactory under certain circumstances.

This result is not surprising when one recalls that within the operation of a defined contribution plan the rate credited to the member's account each year is normally linked to the fund's actual investment performance. Some funds may choose to smooth this rate but there is no doubt that the final benefit received by the individual is largely determined by the investment performance of the fund during the individual's working career. Hence, as is well known, the member is bearing the investment risk within a defined contribution plan. This is in contrast to a defined benefit fund where the retirement benefit is pre-defined in terms of final (or final average) salary and the employer's contribution rate is normally adjusted to reflect changes in the investment return. (Contribution rates for defined benefit funds will be discussed in the next section.)

Of course, one method to reduce the variability in the level of retirement income received by the individual is the adoption of an investment strategy with less volatility, as assumed for Strategy B or C. However, as shown in Table 1, whilst such an approach clearly reduces the variability in the ultimate level of income, a reduction in the level of retirement income also occurs. It is worth noting that the 95th percentile for the low risk strategy C represents a lower income than the 5th percentile for the higher risk Strategy A option.

A commonly suggested alternative is for individuals to reduce their level of investment risk, as they approach retirement. Again, Tables 1 and 2 show that, whilst such a move reduces the variability in the level of retirement income received, it also reduces the expected income to be received. Indeed, the expected income for the strategy involving the three investment options is actually below the 5th percentile for Strategy A. This result does not mean that a policy to reduce the volatility of investment return is inappropriate as individuals approach retirement. However, it does indicate that the likely impact of such a move on the resulting income must be recognised.

The results also highlight the importance of allowing for realistic assumptions in any modelling, including variations in the rate of return. It is interesting to note that if the variations in inflation and investment returns are removed, the level of retirement income is 84.97% of final earnings (that is, very close to the mean) but such a single figure provides no indication of the variability in the likely results.

Table 1 also confirms the following results:

- Early retirement causes a significant reduction in the level of retirement income due to the shorter accumulation period and the extended period of retirement. In fact, a retirement age of 60 causes a 32.7% reduction for males and a 31.4% reduction for females. (The corresponding Australian figures from Table 2 are 31.1% and 30.0% respectively.) With recent trends towards earlier retirement, these significant reductions in the level of retirement income must be appreciated.

- Later entry into the workforce, as is occurring with higher levels of youth unemployment and increasing years of education, also results in a lower level of retirement income due to the shorter period of accumulation.

- These two trends, of later entry and earlier retirement, can have a devastating effect on the ultimate level of benefit. For instance, the expected retirement income with an entry age of 25 and a retirement age of 60 is 54% for males and 55% for females of the income received by a similar person who enters at age 20 and retires at age 65. The corresponding Australian figures are 56% and 57% respectively.

- As mentioned above, changes in the investment strategy have the expected result with higher variability if the risk (as measured by the standard deviation) is increased and a reduced mean and variability if more conservative investment options are chosen. Indeed, if Strategy C is chosen, the mean retirement income is reduced by 59% whilst the standard deviation is reduced by 82%. In Australia, the mean income is reduced by 55% and the standard deviation by 86%.

- It is also noteworthy that if the standard deviation for Strategy A is reduced, which may occur due to the low inflation environment and/or greater smoothing of the investment returns, the expected value is almost unchanged whereas the standard deviation and the range between the 5th and 95th percentiles are both reduced by 25%.

- As is well known, female life expectancy is considerably higher than males. Based on the Australian Life Tables 1985-87, a 65 year old female is expected to live 18.56 years (or 27.1% longer than a male). Hence, when the retirement benefit is expressed in terms of a lifetime annuity, females receive a smaller level of income for the same level of contributions. Using the base assumptions, the expected level of income for a 65 year old female retiree is 20.0% below her male counterparts in both tables.

- The previous discussion related only to full time workers. As expected, those who experience some periods of part time work or out of the workforce have reduced retirement incomes. For instance, working in a part time capacity for 10 years from age 30 reduces the expected retirement income by 15.5% in Table 1 and 15.1% in Table 2, for both males and females. Naturally, larger reductions in the expected retirement income occur if the person spends time out of the workforce.

- Changes to the assumed mean of the inflation level do not cause a significant change to the results as the investment returns and salary increases are automatically adjusted. However, as expected, an increase in the standard deviation of the inflation distribution leads to an increased variability in the level of retirement income.

- Table 2 highlights the impact of a 15% tax on contributions and a 7.5% tax on investment income. The expected level of benefits are reduced by 27.8% for both males and females under the base conditions. Hence, even if there is a reduction in the taxation of the retirement income (as occurs in Australia, with a 15% tax rebate on pensions), it is very likely that the introduction of taxation during the pre-retirement period will result in a reduction in the actual level of retirement income received by the retiree.

- The annuity rates offered at retirement to convert the accumulated benefit to a lifetime annuity can have a significant impact on the ultimate level of retirement income. In particular, if the underlying interest rate used to determine the indexed annuity rate increases from 1% above the inflation figure in the year preceding retirement to 2% above this inflation rate, the expected level of the annuity increases by 6.9%.

This last result is important for members of defined contribution plans as the actual level of any lifetime annuity will depend on the annuity rates available at the date of conversion. This represents a one-off conversion. Hence, the annuity rate used becomes critical in determining the actual level of retirement income received, if the lump sum benefit is to be converted into an annuity stream at the date of retirement. In reality, such a system approximates a lottery where the level of retirement income can vary significantly due to the actual date of retirement, even when all other factors are identical. Most members of defined contribution plans are not aware of this 'annuity-rate risk' which they bear whenever their retirement benefit is not expressed as a defined pension in terms of final (or final average) salary.

3.2 The defined benefit approach

The previous section considered the results for a defined contribution fund with a fixed 12% contribution rate. The alternative approach is to select a defined benefit and assess the level of contributions that are necessary to fund the defined benefit over the individual's working career. For this exercise, we will assume that the pre-determined level of benefit is an indexed lifetime annuity of two-thirds of the person's salary in the year preceding retirement. Based on the assumptions set out earlier, Tables 3 and 4 show information in respect of the contribution rates required to be paid over the person's working years under a number of scenarios. As with the previous tables, Table 3 assumes that no tax is paid on contributions or investment income and Table 4 represents the taxation treatment in Australia.

In general terms, the required contribution rates are consistent with the results discussed earlier. That is:

- earlier retirement or later entry require higher contribution rates for the same level of benefits;
- a more conservative investment strategy with an associated lower variability in the rates of return means that a higher level of contributions is required to meet the defined benefit;
- periods of part time or no work mean that higher contributions have to be paid if the same benefit is to be received; and
- females require a higher contribution rate for the same benefit due to their longer life expectancy.

TABLE 3

The contribution rates required to purchase an indexed lifetime annuity of 66.7% of salary

Assumptions	Mean	Std. Dev	5th percentile	95th percentile
Base assumptions	10.60	3.63	5.61	17.32
Female	13.25	4.56	7.01	21.73
Married male with spouse	14.48	4.99	7.65	23.71
Changes in entry or exit ages				
Retirement age 60	15.61	5.21	8.59	25.18
Retirement age 55	22.96	7.19	13.09	36.18
Ages of 25 and 60	19.24	5.99	11.15	29.46
Retirement age 60 (female)	19.15	6.45	10.51	31.31
Retirement age 55 (female)	27.55	8.72	15.58	43.40
Ages of 25 and 60 (female)	23.61	7.42	13.67	36.40
Changes in Investment strategy				
Strategy A with $\sigma = 6\%$	10.11	2.64	6.31	14.79
Strategy B	15.83	3.26	10.96	21.67
Strategy C	23.42	2.45	19.39	27.49
Changes in participation rates (part time is considered to be 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	12.45	4.11	6.80	20.14
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	18.07	5.26	10.65	27.89
f/t to age 30, then p/t to age 40, then f/t (female)	15.57	5.17	8.50	25.08
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	22.59	6.63	13.19	34.91

TABLE 4

The contribution rates required to purchase an indexed lifetime annuity of 66.7% of salary after allowing for a 15% contributions tax and a 7.5% investment tax

Assumptions	Mean	Std. Dev	5th percentile	95th percentile
Base assumptions	14.41	4.47	8.15	22.80
Female	18.01	5.63	10.09	28.47
Married male with spouse	19.67	6.17	10.99	31.14
Changes in entry or exit ages				
Retirement age 60	20.84	6.35	12.04	32.73
Retirement age 55	30.11	8.64	17.86	45.44
Ages of 25 and 60	25.23	7.18	15.37	37.15
Retirement age 60 (female)	25.57	7.86	14.74	40.50
Retirement age 55 (female)	36.13	10.50	21.38	54.56
Ages of 25 and 60 (female)	30.95	8.91	18.83	46.08
Changes in Investment strategy				
Strategy A with $\sigma = 6\%$	13.86	3.30	8.97	19.81
Strategy B	20.77	3.94	14.72	27.84
Strategy C	29.62	3.00	24.86	34.68
Changes in participation rates (part time is considered to be 40% of full time)				
f/t to age 30, then p/t to age 40, then f/t	16.86	5.04	9.86	26.39
f/t to age 25, then zero to age 35, then p/t to age 45, then f/t	24.05	6.32	14.84	35.73
f/t to age 30, then p/t to age 40, then f/t (female)	21.09	6.34	12.19	32.99
f/t to age 25, then zero to age 35, p/t to age 45, then f/t (female)	30.07	7.98	18.30	44.89

The important difference in the results between the two tables due to the underlying tax assumptions should not be underestimated. Each of the costs shown in Table 4 is about 36% higher than the corresponding cost in Table 3. This is clearly a significant difference and means that employers would be faced with the options of reducing the level of benefits, increasing prices or cutting their other costs of production, including employment. Whilst some Australian employers were able to reduce future benefit levels in 1988, many left the benefits unchanged. Over the long term, this has resulted in a major increase in their superannuation costs.

Before leaving these results, it is also important to stress that the investment, annuity-rate and inflation risks associated with defined pension funds are not borne by the individual member. It is the sponsoring employer who has 'promised' to contribute at the required level to meet the defined benefits. However, the figures clearly show that this required level of contributions has significant variability. Although most sponsoring employers realise that their long term contribution rate has this inbuilt volatility due to the effect of changing economic circumstances, these results also highlight the risk that these employers are accepting when they choose to offer a defined pension benefits.

Of course, the risk associated with variable investment returns in the pre-retirement period cannot be removed without adopting a very conservative investment strategy. Such a decision would result in lower benefits or higher long term contribution rates. Neither of these results are optimal. Therefore an important question that is often forgotten but that needs to be addressed on a regular basis is: Who should bear the investment risk associated with the accumulation of contributions over the long term for the provision of retirement income? Should it be the employer, the individual, the Government or a combination of these parties?

Over time and in different countries, this question has been answered in a variety of ways. In some instances, the Government (and hence the taxpayers) has removed the investment risk with the development of a generous Social Security system. Of course, this approach introduces other risks, including demographic risk. Elsewhere, defined pension schemes are common and the sponsoring employer has therefore accepted the investment risk during the pre-retirement period. However, even in these instances, certain risks remain. As noted earlier, the trend towards defined contribution plans means that a higher proportion of the risks associated with the provision of retirement income is now being accepted by the individual member. It may be claimed that with greater individual responsibility and a relative decline in the importance of the 'welfare state', this represents an appropriate response. However, it is also important that individuals are made fully aware of the possible consequences of accepting the investment risk associated with defined contribution plans.

4. Summary and conclusions

In recent years, there has been a shift away from defined benefit schemes towards defined contribution schemes in several countries for a variety of reasons. However, this trend has placed a greater level of responsibility for retirement income on the individual member. As a result, members need to ask questions such as:

> What is an appropriate level of contribution?
> What are the major risks involved and who bears them?

The results in this paper, based on a simulation model using stochastic estimates for investment returns and the level of inflation, assist in preparing a response to these two questions.

4.1 What is an appropriate level of contributions?

A superannuation contribution rate of 12% of salary provides, *on average*, a reasonable retirement income in terms of final salary for a single male assuming that the contributions have been paid for at least 40 years. It is important to stress that this result is an average result and that some individuals who have saved for 40 or 45 years will receive an inadequate retirement income due to the variability of the investment returns during the pre-retirement period.

However, even if we concentrate on the average result (which does not represent the total story), a 12% contribution rate is not sufficient for many individuals. Some of the circumstances where a higher contribution rate is needed include:

- females who have longer life expectancies;
- members with dependent spouses;
- individuals who choose or are forced to take early retirement;
- individuals who enter the workforce later due to early periods of unemployment or increased education; and
- individuals who do not work full time throughout their career.

In many cases, an individual may be subject to a number of these factors (eg a female with some part time work experience who retires at age 60) which would result in the need for a very high contribution rate if a reasonable retirement income benefit is to be provided.

Indeed, when one considers the small proportion of the work force who will be in full time employment for 40 or 45 years and the variability in the investment returns over the long term, it is reasonable to conclude that a contribution rate of 12% will not provide an adequate level of retirement income for many retirees. This conclusion is strengthened when it is realised that the above figures exclude any allowance for expenses.

Of course, due to the enormous variety of individual circumstances, it is impossible to select a long term contribution rate that will be satisfactory to everyone. However, in view of the results, a total contribution rate in the order of 15% of salary may be a reasonable long term objective for many individuals. A contribution rate in excess of 15% would be required if the fund is subject to taxation during the pre-retirement accumulation period, as occurs in Australia. The introduction of a higher rate of defined contribution would provide greater financial security to a higher proportion of retirees.

4.2 What are the risks and who bears them?

These results also highlighted the investment and annuity rate risks borne by individual members of defined contribution funds. Before proceeding, it is helpful to identify the bearer of these risks for three different types of funds, as shown in Table 5.

TABLE 5
The risk bearer for three types of funds

Type of fund	*Investment risk*	*Annuity-rate risk*
Defined contribution	Member	Member
Defined benefit - lump sum	Employer	Member
Defined benefit - pension	Employer	Employer

As discussed in Section 3, a member of a defined contribution fund bears both the investment risk in the pre-retirement years and the annuity-rate risk on the date of converting their lump sum benefit into an income stream. The employer pays a constant contribution rate and bears no risk. In addition, the Government does not share in either risk directly, except where a means tested age pension is provided. For members of defined benefit funds, the investment risk is borne by the sponsoring employer during the pre-retirement years. However the annuity-rate risk remains with the member if a lump sum is provided at retirement. It is only within a defined pension scheme that the annuity-rate risk is borne by the sponsoring employer.

The question as to who should bear these risks has no easy answers. However, it is reasonable to suggest that employers (beyond a certain size) should be able to accept a proportion of these risks as their exposure to the investment and/or annuity-rate risks would be spread amongst their total workforce over several years and therefore more diversified than the risk borne by an individual employee. In effect, this occurs within a defined pension plan.

Within the Australian context, the Superannuation Guarantee Charge is currently expressed as a percentage of the employee's income. As such, it is clearly a defined contribution approach and has no direct link to the ultimate benefit produced.

An alternative approach would be to express the SGC as a minimum retirement benefit in terms of the salary paid in each year. That is, employers would be able to choose between a minimum contribution rate (as currently) or the provision of a minimum retirement benefit related to the person's salary. Certain limits may need to be introduced so that the employer is not forced to accept unlimited future liabilities. Nevertheless, the advantage would be that, at least within this defined benefit approach, the investment risk within the pre-retirement period could be shared between the employer and the member.

A relatively simple equivalence table could be drawn up so that employers have the choice between these two approaches. For illustrative purposes only, the choice could be between:

- contributing a minimum of 9% of this year's salary (the defined contribution approach);
- providing a minimum lump sum retirement benefit equal to 10% of this year's salary, with the salary then indexed at a minimum rate of inflation plus say 2% per annum until retirement; or
- providing a minimum retirement pension benefit equal to 0.9% of this year's salary, with the salary then indexed at a minimum rate of inflation plus say 2% per annum until retirement.

This approach differs from the existing SGC requirements which permit defined benefit funds to meet the SGC requirements, subject to an actuary's certificate. However, the existing arrangements in respect of defined benefits are implied and not specifically stated.

I believe that the major advantages of providing this defined benefit choice explicitly within the SGC arrangements are that the pre-retirement investment risk is seen to be shared between two parties and that the orientation of the system is changed from merely accumulating money to the provision of retirement benefits.

The objective of a retirement income system should be to provide a structure whereby funds are transferred from the pre-retirement earning years to the post-retirement years so that a reasonable level of secure retirement income is provided to the member. A system based on defined contribution plans does not meet this fundamental objective.

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