Take (Smoothed) Risks When You Are Young, Not When You Are Old: How To Get The Best From Your Stakeholder Pension Plan

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Abstract

Using stochastic modelling, we demonstrate that the best investment strategy for the accumulation phase of a defined contribution pension plan is one that limits the range of returns that are credited to the plan member's account. In particular, we show that with-profit accumulation programmes which make use of a smoothing fund to smooth out returns over time dominate unit-linked accumulation programmes. However, for the decumulation phase, we show that it is hard in practice for an investment-linked decumulation programme to beat the income and security provided by a standard annuity, although we again find that with-profit decumulation programmes dominate unit-linked decumulation programmes. Return smoothing is therefore a valuable feature of any long-term investment programme both during the accumulation and decumulation phases and this has important implications for the design of Sandler 'stakeholder' products.

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1 Introduction

The sponsors of a typical defined contribution (DC) pension plan will give the plan member a large choice of funds in which to invest contributions, ranging from 'low-risk' money market funds, through 'medium-risk' managed funds, to 'high-risk' equities. When the member retires and the decumulation phase begins, another wide range of choices is usually offered. On the one hand, the plan member might be offered income drawdown, whereby the accumulated assets remain fully invested, but an income is drawn from the fund, subject to minimum and maximum distribution rules. On the other hand, various types of life annuities might be offered, such as level, index-linked or investment-linked[1].

Is such a wide range of choices in the genuine interests of the plan member? This paper argues that it is not. Most plan members are likely to be conservative investors when they are young: they will be concerned about having a secure pension fund when they retire and will not want to take risks. This might lead them to invest in 'low-risk' funds for the accumulation phase of their plan. We would argue that this is an act of 'reckless conservatism'. It would be much better for them to invest in equities during the accumulation phase. This is because of the higher expected returns from investing in equities in comparison with money market funds or bonds. However, once retired, plan members might be encouraged to be somewhat more adventurous with their accumulated fund and take on a more aggressive investment posture than they did during the accumulation phase. This is more likely if they have other forms of secure retirement income, such as a social security pension. We would regard this as an act of 'reckless adventurism'.

If the primary purposes of a pension plan are to provide an acceptable replacement ratio in retirement at lowest cost and to eliminate the risk of outliving one's resources, then we will show that the best overall strategy is to do the precise opposite of what is indicated above, namely to assume (some) risk when young in order to benefit from higher expected returns during the accumulation phase and to limit the risk exposure during the decumulation phase. We also show that that the ability to smooth out returns over both the accumulation and decumulation phases by means of a smoothing fund is a very valuable feature of a well-designed and integrated pension plan.

The outline of the paper is as follows. Section 2 derives a stochastic pension fund model. Section 3 examines some key accumulation programmes, while section 4 investigates the main decumulation programmes. Section 5 concludes.

2 A Stochastic Pension Fund Model

2.1 Theoretical model

Assume that there is a single risky asset whose return, $r(t)$, is generated by an independent normal distribution[2] with mean, μ, and variance, σ^2. Consider the accumulation phase of a DC pension plan which begins with an initial investment $A(0)$ (which might be zero) and makes regular contributions of d per period. Returns are continuously compounded so that at any time t, the value of the assets in the fund will be lognormally distributed and determined by the following accumulation equation:

(1) $A(t) = [A(t-1) + d].\exp(r(t)).$

The first four non-central moments of the distribution of $A(t)$ are given by:

(2) $f(t) = E[A(t)]$
$$= E[A(t-1) + d].E[\exp(r(t))]$$
$$= [f(t-1) + d].m_1$$

(3) $g(t) = E[A(t)^2]$
$$= [g(t-1) + 2.d.f(t-1) + d^2].m_2$$

(4) $h(t) = E[A(t)^3]$
$$= [h(t-1) + 3.d.g(t-1) + 3.d^2.f(t-1) + d^3].m_3$$

(5) $k(t) = E[A(t)^4]$
$$= [k(t-1) + 4.d.h(t-1) + 6.d^2.g(t-1) + 4.d^3.f(t-1) + d^4].m_4$$

since $A(t\text{-}1)$, d and $r(t)$ are all independent and where:

(6) $m_j = E[\exp(j.r(t))] = \exp(j.\mu + 0.5.j^2.\sigma^2).$

The initial values for these iterations are:

(7) $f(0) = A(0), g(0) = A(0)^2, h(0) = A(0)^3, k(0) = A(0)^4.$

Variance, skewness and kurtosis at t are given by:

(8) $V[A(t)] = E[A(t) - f(t)]^2$

$\quad\quad\quad = g(t) - f(t)^2$

(9) $S[A(t)] = E[A(t) - f(t)]^3$

$\quad\quad\quad = h(t) - 3.g(t).f(t) + 2.f(t)^3$

(10) $K[A(t)] = E[A(t) - f(t)]^4$

$\quad\quad\quad = k(t) - 4.h(t).f(t) + 6.g(t).f(t)^2 - 3.f(t)^4.$

The value of the fund at t if it had been invested in a riskless asset with a constant return r_f is denoted $F(t)$ and is found using an equation similar to (1).

Eqn. (1) can also be used to determine the value of the remaining assets in the decumulation phase of the plan which begins on the retirement date with a fund worth $A(0)$ and makes regular pension payments of d per period: in this case $d < 0$ in (1). The relevant moments are also given by (2) and (8)-(10).

In some jurisdictions, the size of d is actuarially determined to ensure that the plan member does not exhaust his fund before the end of his life:

(11) $d = \dfrac{A(0)}{\ddot{a}(0)}$

where $\ddot{a}(0) = \sum_{t=0}^{\infty} {}_t p_0 \, e^{-r_f t}$ is the annuity factor at retirement age 0 and ${}_t p_0$ is the survival probability between retirement date 0 and time t.

It is straightforward, though cumbersome, to show that the effect of an increase in asset risk σ^2 (holding μ constant) during the accumulation phase is to:

- raise $E[A(t)]$
- raise $V[A(t)]$
- raise $S[A(t)]$
- raise $K[A(t)]$.

The effect of an increase in asset risk is therefore to raise both the expected value and also to increase the right skewness and fatten the tails of the distribution. This means that the distribution function of a fund invested in a high-risk asset (denoted $D(A(z;t,\sigma_H^2))$ below) will begin further to the left and so will initially be above that for a low-risk asset (denoted $D(A(z;t,\sigma_L^2))$ below), but will cross over the latter function at some point and

remain below thereafter. This means that a high-risk portfolio can never stochastically dominate[3] a low-risk portfolio, since the following condition for (second-degree) stochastic dominance will be violated for small x:

$$(12) \qquad \int_{-\infty}^{x} \left[D\left(A(z;t,\sigma_H^2)\right) - \left(A(z;t,\sigma_L^2)\right) \right] dz < 0 \qquad \forall\, x \in [-\infty, +\infty]$$

There therefore always remains a tradeoff between risk and expected return. This can be illustrated using the commonly used investment strategy of cost averaging. During the accumulation phase of an investment programme with regular contributions, the average size of the terminal fund will be higher if the fund is invested in assets with a large dispersion of returns than if it is invested in assets with a small dispersion of returns but with the same expected return. This is because there is a higher probability of buying assets at low prices and the increase in risk makes the terminal distribution of the fund more right skewed. At the same time, the tails of the distribution are fatter and this raises the variance of the fund's terminal value as well as the probability of both very low and very high terminal values occuring. Risk-averse plan members will be concerned to reduce the probability of low terminal values and this requires higher contribution rates with high-variance investment strategies than with low-variance investment strategies.

During the decumulation phase of the programme, when a regular income has to be paid from the fund, it is better to do this from assets with a low dispersion of returns than with assets with a high dispersion even if the expected returns are the same. This is because there is a bigger chance of having to sell assets at low prices and this may so deplete the fund value that even subsequent high investment performance may not be sufficient to compensate.

The best way of illustrating these results is through a specific example.

2.2 Parameterising the model

The following assumptions are used in the model below[4].

- Increase in retail price index (RPI)   2.5% pa
- Pre-retirement investment returns in excess of RPI:

Mean	4.5% pa
Standard deviation[5] (up to last 5 years)	15.94% pa
Standard deviation (last 5 years)	12.3% pa

The standard deviation for most of the accumulation phase is consistent with the historical standard deviation of the annual real returns on a portfolio allocated 60% to UK equities and 40% to UK gilts[6]. The standard deviation during the last 5 years is

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consistent with the historical standard deviation of the annual real returns on a portfolio allocated 100% to gilts. The standard deviations used have been chosen to correspond with a 'lifestyling' investment strategy, whereby the investments are moved systematically into lower volatility fixed-interest securities in the five years approaching retirement[7].

- Yield for purchasing annuity at retirement in excess of RPI:

Mean	3.5% pa
Standard deviation	0.63% pa

The standard deviation is consistent with the historical standard deviation of the real redemption yield of a portfolio of long dated UK index-linked gilts[8].

- Risk-free rate of interest in excess of RPI   2% pa
- Earnings growth in excess of RPI   1.5% pa
- Promotional increases   Nil
- Career breaks   Nil
- Pre-retirement expenses   1% pa of the fund
- Pre-retirement mortality:

    No assumption needed as benefit is assumed to be a return of fund

- Post-retirement mortality:

Male annuity rates	PMA92 (B=1975)[9]
Female annuity rates	PFA92 (B=1975)
Unisex annuity rates	50% of PMA92 (B=1975) + 50% of PFA92 (B=1975)[10]

- Profit loading on annuities   5%

The stochastically varying returns have been assumed to be drawn independently from normal distributions with the appropriate means and standard deviations (less fund management charges of 1% during the pre-retirement period). The analysis below is based on 5000 Monte Carlo simulations.

3 Stochastic Modelling of the Accumulation Phase of a Pension Plan

For illustrative purposes, we have chosen to model a DC pension plan which aims to pay a pension of £70 per week in 2000 prices.[11]

We assume an employee joins the plan in 2000 aged 25 and retires in 2040 aged 65. We make the following additional assumptions concerning the plan:

- Contributions increase in line with earnings.
- No spouse's pension.
- No other pension accrued to date.
- Target benefit of £70 per week in 2000 prices and wages.
- Benefit will increase in line with earnings pre-retirement.
- Benefit will increase in line with RPI post-retirement.

Table 3.1 presents projections of the annual contributions needed to meet the target benefit under the assumption that expected returns are realised in full, so that the standard deviation of returns is zero. It shows that, on average, male contributions of £930 per year for 40 years are needed to generate a pension of £70 per week, although by 2040, this will be equivalent to £127 per week in 2000 prices, since we are projecting that real earnings grow by 1.5% per annum. Female contributions, as a result of the greater longevity of women, average £1010 per annum or nearly 9% more than male contributions. However if unisex rates are used then male contributions rise by £40 per year and female contributions fall by the same amount. The pension can be met with contributions equal to 4.7% of NAE.

Table 3.1 Deterministic projections of the required contributions		
Type of annuity	Contribution needed to give an expected benefit equal to the target benefit (£ pa)	Proportion of national average earnings (%)
Male annuity rates	930	4.5
Female annuity rates	1010	4.9
Unisex annuity rates	970	4.7

In reality, of course, returns are stochastic and there is approximately a 50% chance of failing to reach the target pension with the contributions given in Table 3.1.

In practice, the performance credited to the pension fund account will depend on the type of accumulation programme chosen by the plan member. We consider two main types:

- unit-linked accumulation programmes and
- with-profit accumulation programmes.

The former are offered principally by mutual funds (unit trusts, investment trusts and open-ended investment companies), while the latter are offered exclusively by life offices.

3.1 Unit-linked accumulation programmes

Unit-linked programmes credit the full realised investment performance (however good or bad) to the plan member's account. Table 3.2 shows that male contributions need to increase by 71% to £1590 pa if a 75% chance of meeting or exceeding the target pension is required and by 132% to £2160 pa if a 90% chance is required. The corresponding increases for women are 84% and 156% respectively. When investment returns and annuity rates are stochastic, a higher level of contributions is needed if the target pension is to be achieved with sufficient confidence. The table clearly shows the cost in terms of additional contributions of reducing the risk of falling short of the target. A useful analogy might be a high jump with a bar that moves randomly up and down. Much greater effort needs to be made to clear the randomly moving bar than would be needed in the case of a fixed bar, even if the moving bar has on average the same height as the fixed bar.

Table 3.2   Stochastic projections of the required contributions with a unit-linked accumulation programme

	Contribution to give 75% probability of exceeding target benefit (£ pa)	Proportion of national average earnings (%)	Contribution to give 90% probability of exceeding target benefit (£ pa)	Proportion of national average earnings (%)
Male annuity rates	1590	7.6	2160	10.4
Female annuity rates	1860	8.9	2590	12.5
Unisex annuity rates	1730	8.3	2380	11.4

Figure 3.1 shows the distribution of the outcomes from the stochastic model in the case of a unit-linked programme where contributions of £970 per year are made and unisex annuity rates are used. This is the contribution amount needed on average to meet the target benefit (see Table 3.1) and as expected leads to approximately 50% probability of failing to meet the target pension of £127 per week. The range of outcomes varies from a pension of below £40 per week to one exceeding £400 per week.

Fig. 3.1   Cumulative distribution of the pension amount in 2040 from a unit-linked accumulation programme

Probability

Weekly pension (£, 2000 prices). Target £127 pw equivalent to £70 pw in constant earnings terms

3.2 With-profit accumulation programmes

With-profit programmes involve a declared bonus being added to the plan member's account. The declared bonus rates of any particular life office will depend on its own policy towards distributing surplus and also its financial strength. This means that a general stochastic model of with-profit business is unlikely to be an exact guide to the bonus experience of any particular life office. However, in general, the life office will declare bonuses based on 'smoothed' investment returns. In the model used here all the bonus rates quoted refer to bonuses in excess of inflation. We have assumed that the anticipated bonus rate is 3.5% in real terms, the same as the expected return on assets net of expenses. However, we assume that the declared annual bonus rate will lie in a range around the anticipated bonus range. We experimented with three ranges:

- 0 to +7%. This means that the declared bonus rate will equal the realised real return on the assets in the fund unless this is negative in which case a zero bonus rate will be declared or the real return exceeds 7% in which case a bonus rate of 7% will be declared. Returns in excess of 7% are placed in a 'smoothing fund' (which holds only risk-free securities); this is used to make refunds to the life office when realised real returns are negative.

- -2% to +6%. While the above symmetry in the declared bonus rate about 3.5% matches the symmetry of the underlying returns distribution, it is likely to result in higher average bonuses than would in practice be declared. This is because the life office uses the distribution of returns above the upper limit of the range to 'pay for' the distribution of returns below the lower limit. In effect the plan member has a put option which is exercised whenever realised returns fall below the lower limit and this put option is 'paid for' in full by the plan member granting a call option to the life office which is exercised whenever realised returns rise above the upper limit. It can be shown (see Blake, Cairns and Dowd (2000)) that this zero-cost option strategy (technically known as a 'zero-cost collar') is (approximately) symmetric about the risk-free rate (not the expected return on the risky assets)[12]. We assume that the real risk-free rate is 2%, so in this experiment, the range is 4 percentage points on either side of this rate.

- -4% to +8%. In this experiment, we widen the range to 6 percentage points on either side of the risk-free rate. Clearly, as the range extends out to $\pm\infty$, we will approach the limiting case of the unit-linked programme.

Table 3.3 shows the outcomes from these ranges in the case of unisex annuity rates with the unit-linked programme listed for comparison. Compared with the deterministic case where the contribution rate was £970 pa, the contribution rate rises to £1078 in the case of bonuses in the range 0% ~ 7% if a 75% chance of exceeding the target is required and £1179 if a 90% chance is desired. However, for reasons given above, the life office is unlikely to offer a range of returns that is symmetric around the expected return on the fund. It is more likely to offer a range that is symmetric around the risk-free rate. With a

range –2% ~ 6%, the contribution rate rises to £1404 if a 75% chance of exceeding the target is required and to £1539 if a 90% chance is desired. Increasing the range to –4% ~ 8% increases the contribution rate marginally. Figs. 3.2 and 3.3 show the distribution of the outcomes from the stochastic model in the case of the 0% ~ 7% and –4% ~ 8% with-profit programmes where contributions of £970 per year are made and unisex annuity rates are used. But the important point to note is that the contribution rate increases with the range: the highest contribution rate occurs with the unit-linked programme.

Table 3.3 Stochastic projections of the required contributions with a with-profit accumulation programme assuming unisex annuity rates				
	Contribution to give 75% probability of exceeding target benefit (£ pa)	Proportion of national average earnings (%)	Contribution to give 90% probability of exceeding target benefit (£ pa)	Proportion of national average earnings (%)
With-profit bonuses vary between 0% and 7% in real terms (symmetric around expected investment returns)	1078	5.2	1179	5.7
With-profit bonuses vary between –2% and 6% in real terms (symmetric around the risk-free rate)	1404	6.7	1539	7.4
With-profit fund vary between –4% and 8% in real terms (symmetric around the risk-free rate)	1458	7.0	1638	7.9
Unit-linked programme	1730	8.3	2380	11.4

Fig. 3.2 Cumulative distribution of the pension amount in 2040 from a with-profit accumulation fund with returns restricted to the range 0% ~ 7%
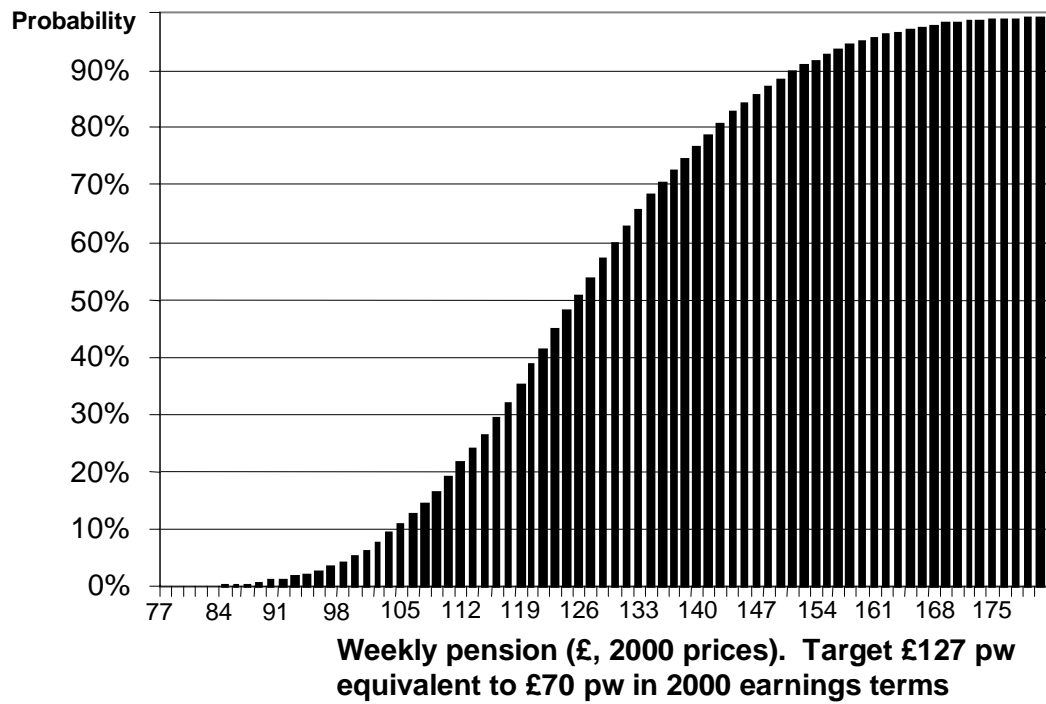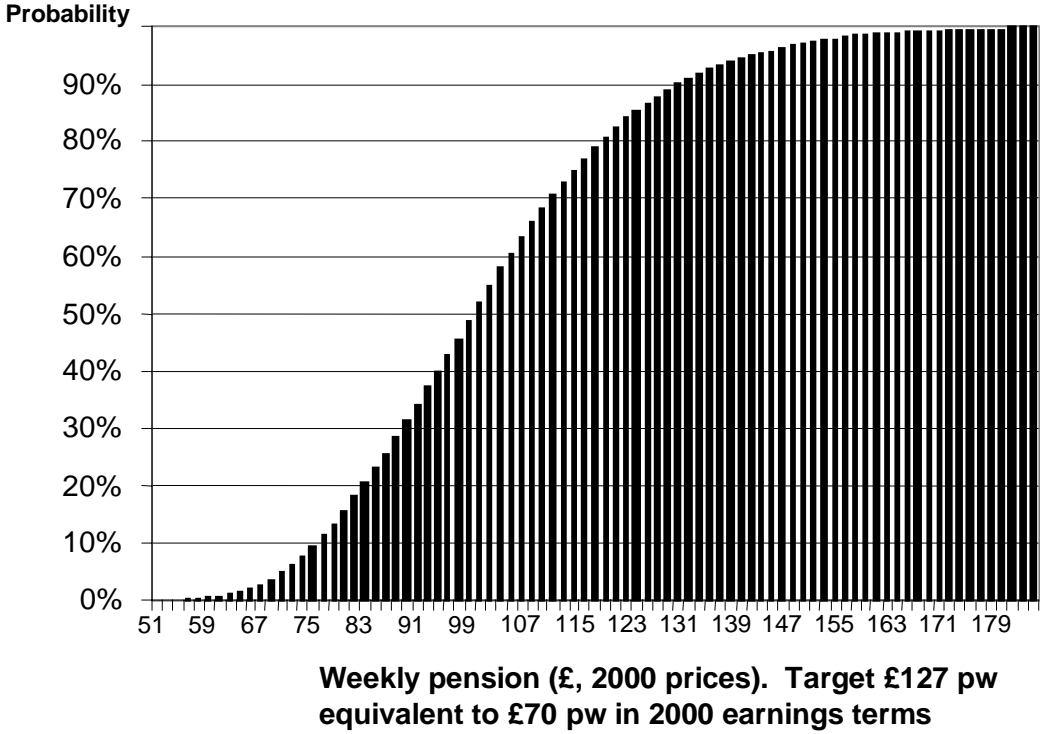

Weekly pension (£, 2000 prices). Target £127 pw equivalent to £70 pw in 2000 earnings terms

Fig. 3.3 Cumulative distribution of the pension amount in 2040 from a with-profit accumulation fund with returns restricted to the range −4% ~ 8%

Weekly pension (£, 2000 prices). Target £127 pw equivalent to £70 pw in 2000 earnings terms

4 Stochastic Modelling of the Decumulation Phase of the Pension Plan

Most people retiring with DC pension plans in the UK choose level annuities, thereby assuming inflation risk during retirement[13]. Similarly, if a 65-year old male annuitant chooses an indexed annuity, he will receive an initial cash sum that is about 30% lower than that from a level annuity, and, with inflation at 3% p.a., it would take 11 years for the indexed annuity to exceed the level annuity and 19 years before the total cash payments are equalised. Recently, a range of alternative vehicles have been introduced to provide an income in retirement. These alternatives are generally based on obtaining a substantial investment exposure to equities. A higher level of equity exposure will give rise to a higher expected return and, inter alia, a higher expected income than a standard annuity which provides an income related to the yield on bonds. However, there is also an increased risk and usually higher charges as well.

We consider five key alternatives to standard annuities:

- Income drawdown with an annuity purchased at age 75
- Income drawdown with a deferred annuity purchased at retirement age and coming into effect at age 75
- Unit-linked annuity
- Flexible unit-linked annuity
- With-profit annuity.

The last three are the main examples of investment-linked annuities. In each case, the projections are applied to a male retiring aged 65 in 2040. For illustrative purposes unisex annuity rates have been assumed. The individual concerned is assumed to have a fund at retirement sufficient to purchase an RPI annuity that will be equal £70 per week in 2000 prices. We will examine the possible outcomes from each of the five alternatives at age 75 with that which would have obtained had he purchased an RPI annuity at age 65.

4.1 Income drawdown with annuity purchased at age 75

In this case the fund remains fully invested when the individual retires at age 65 and an income is withdrawn each year equal to that which would have obtained had he purchased an annuity at age 65 (if there are sufficient assets in the fund).[14] At age 75 he uses the full remaining fund to purchase an annuity.[15]

Fig. 4.1 shows the cumulative distribution of the possible sizes of the annuity which could be purchased at age 75 as a proportion of the annuity payments he would have been receiving at age 75 had he bought an annuity on retirement at age 65. The figures show that the individual would be likely to do less well by taking the drawdown route, although there is a 27% chance that he will do better than the annuity if investment performance turns out to be strong. There is almost a 10% probability that his funds would be exhausted by age 75.

An investment return on the managed fund of approximately 9.5% pa in excess of RPI and expenses would be required to give a 75% probability of an individual adopting drawdown having an income at 75 in excess of that which could be achieved by purchasing an annuity at age 65.

4.2 Income drawdown with deferred annuity purchased at retirement age and coming into effect at age 75

In this case the individual purchases a deferred annuity at age 65 which will provide an income from age 75 equal to that which would be payable at that age from an immediate annuity bought at age 65. Having paid for the deferred annuity, the remaining fund is fully invested and an income is withdrawn each year equal to that from an annuity purchased at age 65 (if there are sufficient monies in the fund). The individual's income is secure from age 75, but the fund may be exhausted before he reaches this age.

Fig. 4.2 shows the cumulative distribution of the value of the remaining fund at age 75 as a proportion of his original fund at age 65. If the value of the remaining fund is positive at 75, the individual will be better off than he would have been had he simply purchased an annuity at age 65. The figure shows that there is a 65% chance that the funds will be depleted before the age of 75, but this means that there will be a 35% chance of doing better than the annuity.

An investment return on the managed fund of approximately 9.25% pa in excess of RPI and expenses would be required to give a 75% probability of an individual adopting this approach having a positive fund at age 75.

Fig. 4.1 Cumulative distribution of drawdown with annuity (Unisex aged 75 in 2050)
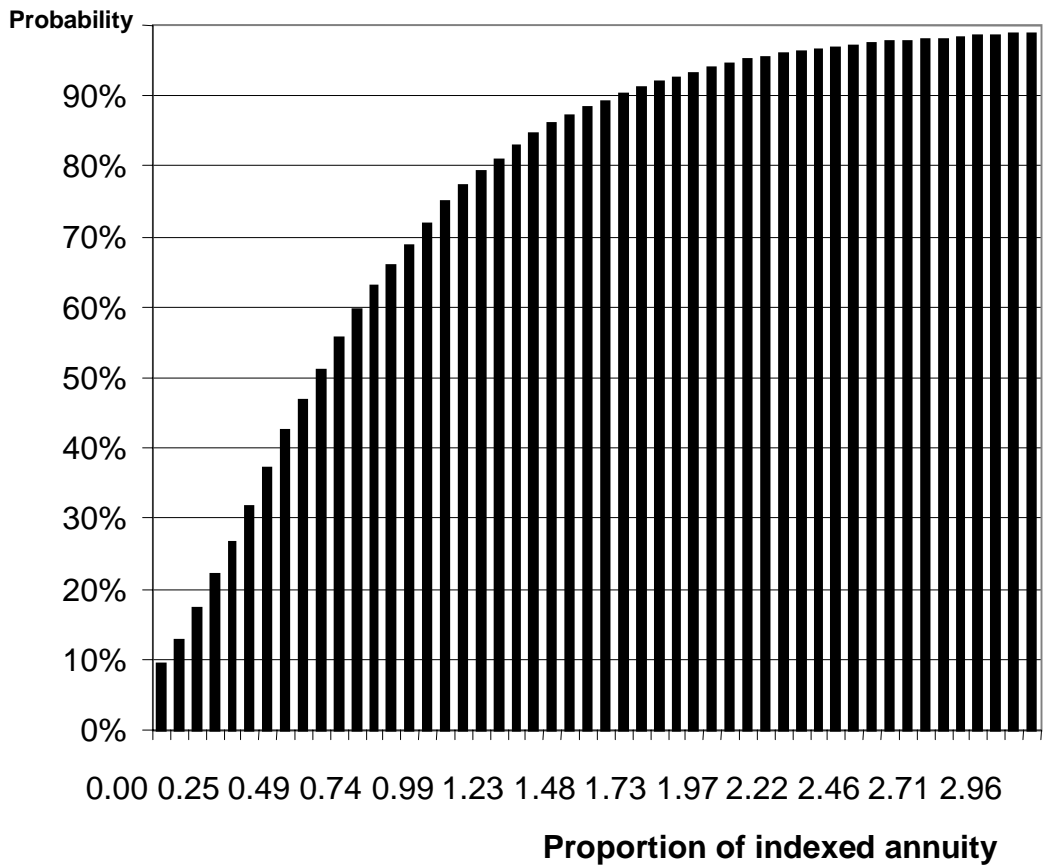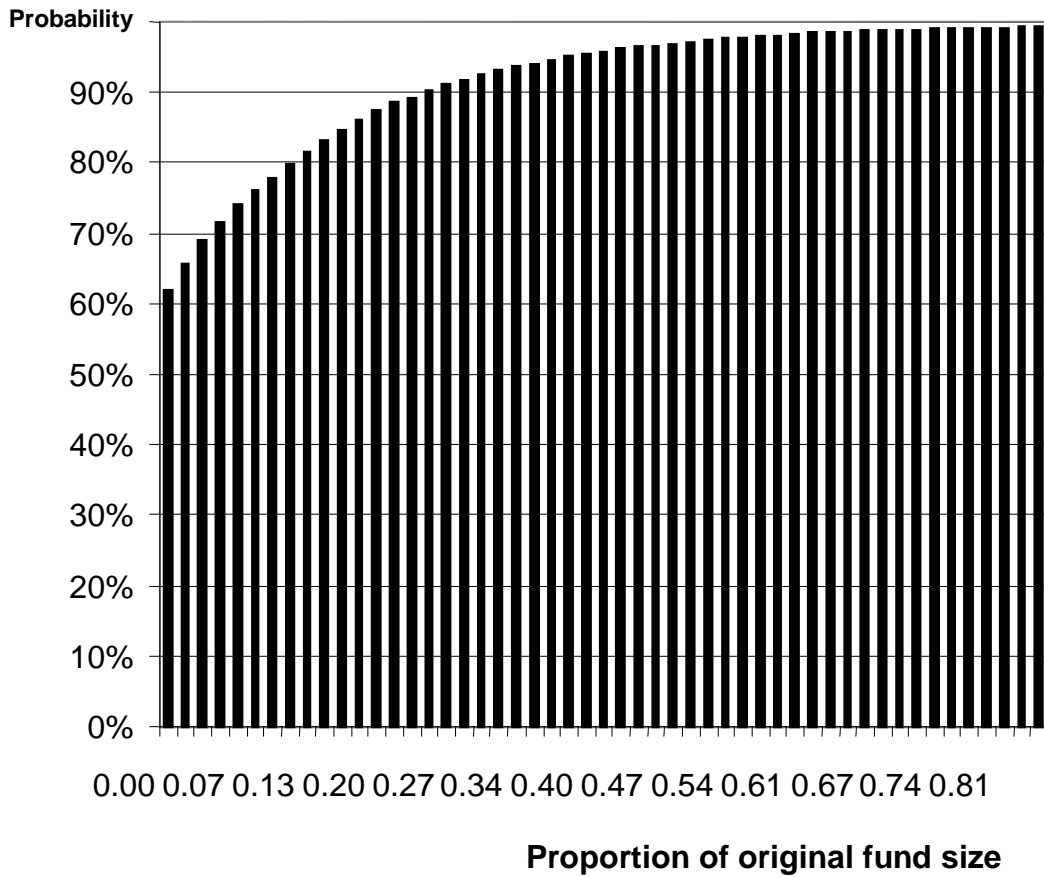
Fig. 4.2 Cumulative distribution of surplus fund after deferred annuity (Unisex aged 75 in 2050)

4.3 Unit-linked annuity

In this case the individual uses his retirement fund to purchase a unit-linked annuity at age 65. The fund is divided into a number of units depending on his life expectancy, and each year some of the units are sold to provide an income the size of which depends on the price received from the sale of the units. It must be recognised that the initial income payable to the individual will be less than that available from a non-linked annuity but this sacrifice will be offset by faster income growth with the unit-linked annuity if subsequent investment performance is strong.

Fig. 4.3 shows the cumulative distribution of the size of the payments from the unit-linked annuity payable at age 75 as a proportion of the annuity payments he would have received at age 75 had he bought an annuity on retirement at age 65. The figure shows that the individual has a 65% chance of doing less well by taking out a unit-linked annuity, although this implies that he has a 35% chance of doing better if investment performance turns out to be strong.
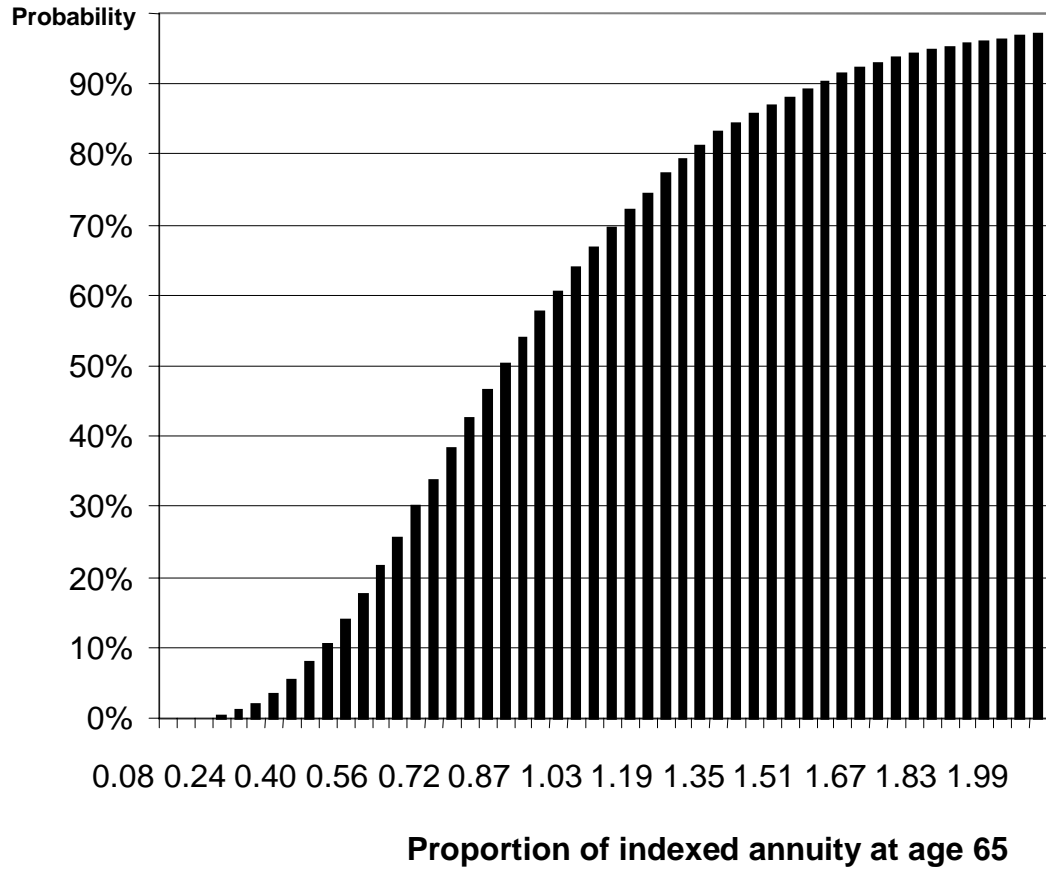
An investment return on the managed fund of approximately 8.75% pa in excess of RPI and expenses would be required to give a 75% probability of an individual adopting this approach having a larger income at age 75 than he would have obtained had he bought an annuity at age 65.
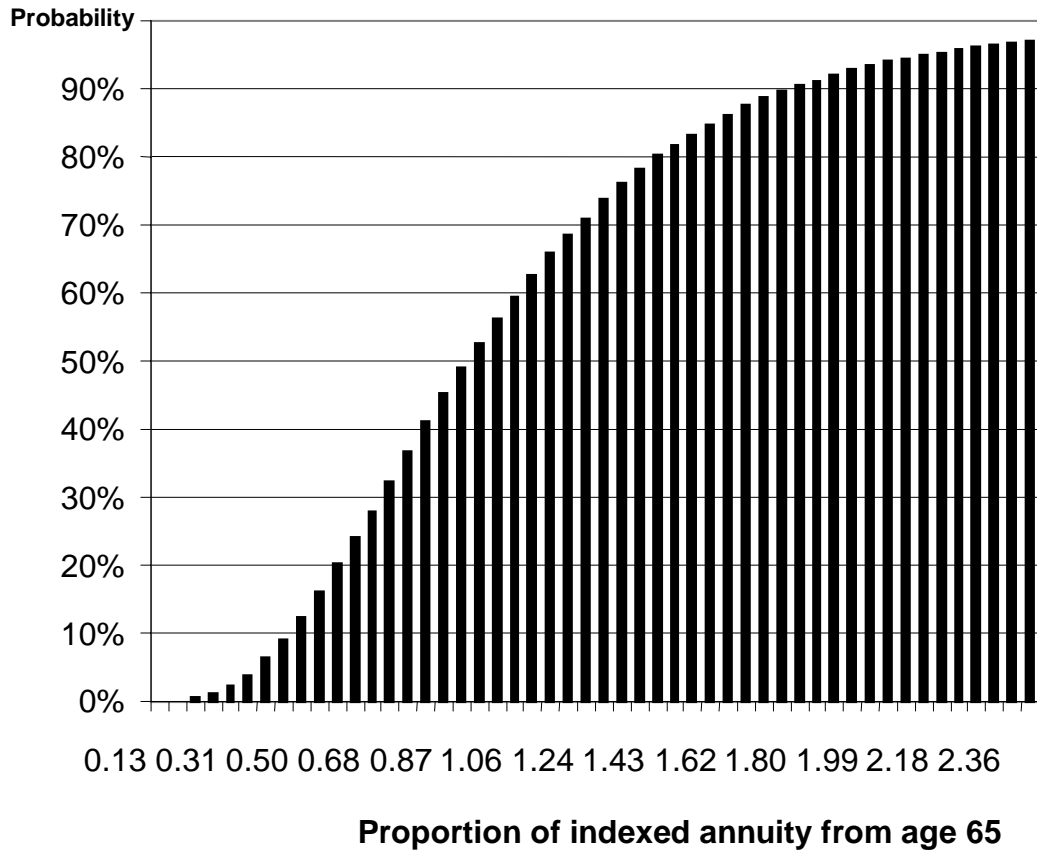
4.4 Flexible unit-linked annuity

In this case, the individual uses his retirement fund to purchase a flexible unit-linked annuity at age 65. Each year, he receives a payment from the fund equal to that available from an annuity purchased at that time, where the annuity amount is calculated using an interest rate based on the expected returns on the assets in the fund. This type of annuity therefore differs from a standard unit-linked annuity, since the payments to the individual are recalculated each year and will depend both on the size of the fund and the prospects for mortality at the time. The annual payment includes a 'survival bonus' to the individual to reflect the fact that he has survived for that year, whereas some other plan member will have died during the year. This bonus acts to offset the mortality drag that would otherwise be experienced. This type of annuity is also less risky than a standard unit-linked annuity from the provider's point of view, since it deals automatically with improvements over time in mortality.

Fig. 4.4 shows the cumulative distribution of the size of the payments from the flexible unit-linked annuity payable at age 75 as a proportion of the annuity payments he would have been receiving at age 75 had he bought an annuity on retirement at age 65. The figure shows that the individual has a 55% chance of doing less well by taking out a

Fig. 4.3 Cumulative distribution of unit-linked annuity (Unisex aged 75 in 2050)

Proportion of indexed annuity at age 65

Fig. 4.4 Cumulative distribution of flexible unit-linked annuity (Unisex aged 75 in 2050)

Probability

90%
80%
70%
60%
50%
40%
30%
20%
10%
0%

0.13 0.31 0.50 0.68 0.87 1.06 1.24 1.43 1.62 1.80 1.99 2.18 2.36

Proportion of indexed annuity from age 65

flexible unit-linked annuity, although there is a 45% chance of doing better if investment performance is strong.

An investment return on the managed fund of approximately 7.50% pa in excess of RPI and expenses would be required to give a 75% probability of an individual adopting this approach having a larger income at age 75 than he would have obtained had he bought an annuity at age 65.

4.5 With-profit annuity

In this case the individual uses his retirement fund to purchase a with-profit annuity at age 65. The initial payment on the with-profit annuity is calculated using an anticipated bonus rate. The subsequent annuity payments will rise or fall depending on the actual bonus rates declared by the life office, in precisely the same manner as for the accumulation stage.

Fig. 4.5 shows the cumulative distribution of the size of the payments from the with-profit annuity payable at age 75 as a proportion of the annuity payments he would have been receiving at age 75 had he bought an annuity on retirement at age 65. The figure shows that, as expected, the range of outcomes which might occur is smaller and less skewed than would result from a unit-linked annuity. There is a 54% probability of doing less well than with the annuity purchased at 65, but a corresponding 46% chance of doing better.

An investment return on the underlying assets of approximately 4.25% pa in excess of RPI and expenses would be required to give a 75% probability of an individual adopting this approach having a larger income at age 75 than he would have obtained had he bought an annuity at age 65.

None of these alternatives to annuities generates an assured income by the age of 75 that is higher than that from the annuity purchased at 65.   The probabilities of failing to do are summarised in Table 4.1: they range from 73% for income drawdown to 54% for the with-profit annuity. Corresponding to this, real returns (after charges) of between 9.50% and 4.25% on the investments need to be generated before these alternatives to the annuity dominate the annuity with a probability of 75%.

Fig. 4.5 Cumulative distribution of with-profit annuity (Unisex aged 75 in 2050)
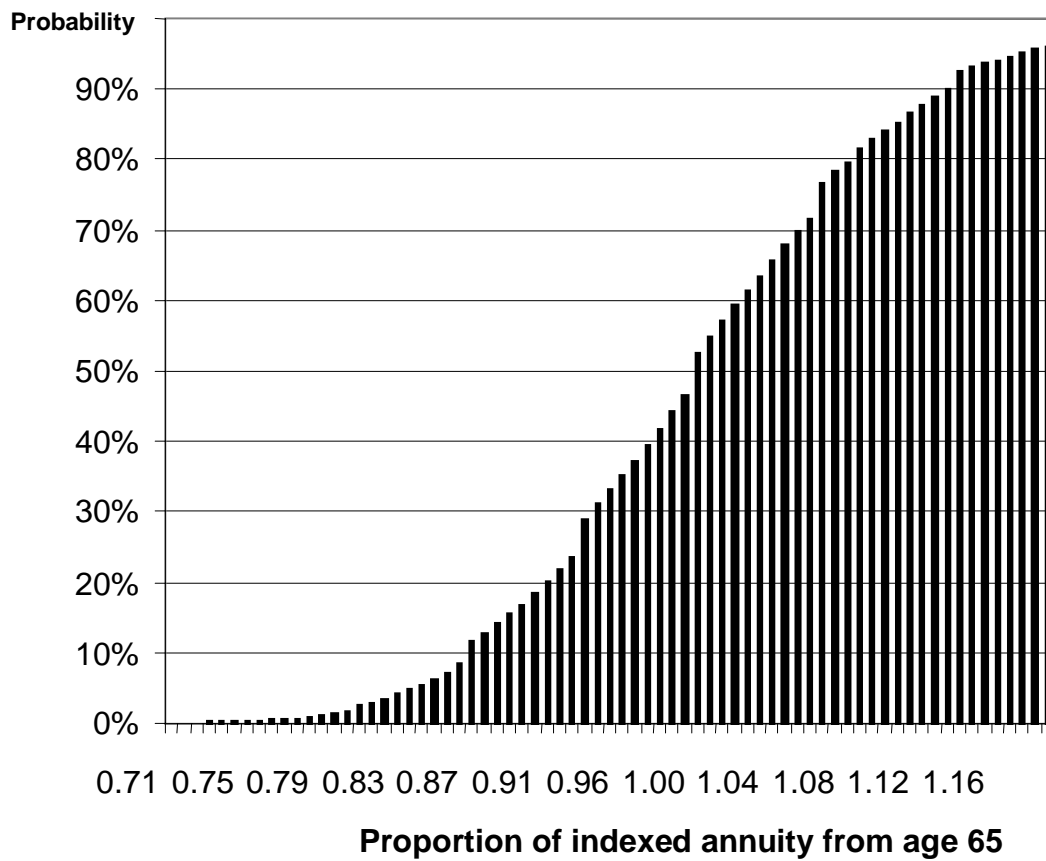
Probability

Proportion of indexed annuity from age 65

Table 4.1 The performance of the alternative vehicles to a standard annuity for a male aged 75			
	Probability of failing to do as well as the annuity purchased at 65 (%)	Probability of failing to do as well as 90% of the annuity purchased at 65 (%)	Real investment return (after charges) needed to give a 75% probability of doing better than the annuity purchased at 65 (%)
Income drawdown	73	68	9.50
Income drawdown with deferred annuity	65	NA*	9.25
Unit-linked annuity	63	53	8.75
Flexible unit-linked annuity	55	48	7.50
With-profit annuity	54	17	4.25
* Guaranteed to match 100% of the annuity purchased at 65 by means of a deferred annuity payable from age 75.			

The with-profit annuity dominates the other investment-linked vehicles. The explanation for this lies in the smoothed nature of the investment returns associated with with-profit annuities. When investment performance is disastrous and the value of the fund falls by a significant amount and assets still have to be sold to pay the pension, the remaining fund can become so depleted that even with good subsequent performance it might not recover sufficiently to maintain the pension in future years.[16] This means that high returns can never fully compensate for poor returns if the fund also has to pay an income stream regardless of investment performance. Therefore what is needed to achieve (with a high degree of probability) a higher pension with an equity-based investment than that from a standard annuity (which is based on the return on bonds) is to have the extremes of returns on the equity-based investment curtailed. This is precisely what happens with a with-profit annuity. This is confirmed by the second column of Table 4.1 which shows the probability of failing to do as well as 90% of the annuity purchased at 65: it is just 17% for the with-profit annuity and much higher for the other products.

The effect is the precise inverse of cost averaging during the accumulation stage of an investment programme with regular contributions. During accumulation, the average size of the terminal fund will be higher if the fund is invested in assets with a high dispersion of returns than if the fund is invested in assets with a low dispersion of returns but with the same expected return. This is because there is a greater probability of buying assets at

low prices. During the decumulation phase when a regular income has to be paid from the fund, it is better to do this from assets with a low dispersion of returns than with assets with a high dispersion even if the expected returns are the same. This is because there is a bigger chance of having to sell assets at low prices.

5 Conclusion

We have demonstrated in this paper that taking (some smoothed) risk during the accumulation phase of a DC pension plan can increase the expected terminal value of the pension fund and hence raise the expected value of the pension in retirement. This is basis of the simple investment strategy cost averaging. However, the variance of the terminal fund value is also raised and this raises the contribution rate into the plan if the plan member wishes to limit the shortfall risk. During the decumulation phase we showed that the probability of investment-linked strategies outperforming a conventional life annuity was fairly low. In both the accumulation and decumulation phases, however, with-profit products that limit the credited distribution of returns dominate unit-linked products that credit the full realised return.

These findings provide important guides to the good design of stakeholder pension plans. They lead to the following implications:
- the decumulation phase is as critical as the accumulation phase, so a stakeholder annuity product is essential component of a well-designed stakeholder pension plan, contrary to the assertion in the HM Treasury – Department of Work & Pensions consultation document "Proposed Product Specifications for Sandler 'Stakeholder' Products" (February 2003)
- during the accumulation phase, a with-profit–type investment strategy has a lower cost of beating a target pension than a unit-linked–type investment strategy; however, the stakeholder with-profit policy must have a considerably more transparent structure than existing with-profit policies (which are obviously designed to have no transparency at all)
- during the decumulation stage, the stakeholder decumulation product should probably be a standard life annuity with a transparent management charge; if an investment-linked decumulation product is also offered it should again be of the with-profit type. Further, because of the mortality risk associated with offering life annuities, life offices should be helped to hedge this risk by the government issuing 'survivor bonds'. These are life annuity bonds[17] whose coupon payments decline at the same rate as the population of 65-year olds on the issue date of the bond die out and so would provide an excellent hedge for mortality risk (see Blake and Burrows (2001))
- there is no reason at all why unit-linked policies could not also have smoothing funds attached to them in order to improve their suitability in stakeholder pension plans.

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Endnotes

[1] In some countries, such as the UK, it is a requirement to convert the pension fund into an annuity by a certain age, currently 75 in the UK.

[2] The assumption of independence is consistent with long-term mean reversion in asset prices: Poterba and Summers (1988) and Blake, Cairns and Dowd (2001) find evidence for this in the US and UK respectively. The assumption of long-term normality in asset returns is consistent with the central limit theorem: the fat tails that are commonly observed in empirical asset return distributions may well be the result of the smallness of the sample sizes used.

[3] See, e.g., Ingersoll (1987, p. 123).

[4] They are consistent with the assumptions required by the UK Financial Services Authority (FSA) for projections made by providers of retail financial services products, with the exception of the return dispersion assumptions about which the FSA is silent.

[5] The standard deviation measures the dispersion of investment returns about the mean return. In a given year, there is approximately a 1-in-6 chance that the actual investment return will be larger than one standard deviation above the mean return, and approximately a 1-in-6 chance that the actual investment return will be smaller than one standard deviation below the mean return.

[6] Credit Suisse First Boston (2003).

[7] While lifestyling would normally lead to a reduction in the expected return on the investments as well as in their risk, we have chosen to maintain a constant expected return as required by PIA guidelines.

[8] DataSTREAM.

[9] PMA92 and PFA92 are standard tables of mortality which have been compiled by the Continuous Mortality Investigation Bureau of the Institute of Actuaries and the Faculty of Actuaries. The tables refer to males and females respectively. The tables were derived from the mortality experience of life office pensioners in the period 1991 to 1994. The tables have been adjusted to allow for expected future improvements in mortality. The notation (B=1975) denotes that the version of the tables used is applicable to individuals born in 1975.

[10] This weighting anticipates the eventual convergence of male and female participation in the workforce.

[11] This is equivalent to the pension achieved by someone retiring in 2000 on average earnings and a full work record from the second-tier state pension scheme in the UK (i.e., the State Second Pension Scheme, formally the State Earnings Related Pension Scheme). Employees are automatically members of this pension plan unless they have been 'contracted out' into an eligible private sector plan. The objective of this section is to design a pension plan that replicates the pension from the second-tier state pension scheme.

[12] This implies that the policy above with a 0~7% range could not be offered 'free' to plan members, since the put is worth more than the call; it could only be offered if the life office additionally charged an annual fee of approximately 1.5%, the difference between the expected return on risky assets net of expenses and the risk-free rate.

[13] The costs and benefits of different types of annuity product are analysed in Blake (1999).

[14] It is important for the sake of an exact comparison that the same income is withdrawn as with an annuity, even though the income drawdown rules in the UK allow some flexibility over how much is withdrawn each year.

[15] Yaari (1965) and Fischer (1973) have shown that, under conditions of perfect capital markets and no bequest motive by individuals, it is optimal for individuals to annuitise *all* their wealth in retirement. However, Milevsky (1998) shows that it may be optimal to delay the purchase of an annuity and invest the accumulated assets in higher-yielding (if also riskier) investments until it is no longer possible to beat the mortality-adjusted rate of return from a life annuity (which increases with age as a result of mortality drag), so long as a minimum consumption stream can be secured in the meantime; although, as Brugiavini (1993) points out, the risk that an annuitant will live a very long time increases with the age at which he purchases the annuity.

[16] This is the problem faced by with-profit annuitants with the Equitable Life Assurance Society for example (see Blake (2001, 2002)).

[17] Annuity bonds pay coupon payments only: there is no return of principal. Life annuity bonds continue to make coupon payments until a specified set of lives dies out.