Comparing pension outcomes from hybrid schemes

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A report of research carried out by Mercer Human Resource Consulting on behalf of the Department for Work and Pensions
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Summary

This report presents the results of an analysis of what pension is likely to be paid to people at retirement, depending on their working history and the occupational pension schemes available to them. The scheme designs range from final salary to pure defined contribution, and have been chosen to illustrate the effects of different models of risk sharing between employer and employee. Their accrual rates have been selected so that overall they should cost employers the same.

The results also depend on several factors, including each individual’s working history and certain financial assumptions.

What pension to expect from particular scheme designs...

No single pension scheme design produces the ‘best’ outcome in all circumstances and the designs that can produce the highest replacement ratios are also those with the greatest variability in outcome:

• Pure defined contribution schemes can produce very high pensions relative to the basic cost, but they also give the highest probability of a poor outcome.

• Cash balance schemes that allocate bonus to members dependent on the underlying asset performance appear to mitigate the worst effects of pure defined contribution benefits. However, the design has echoes of with profit arrangements that are currently facing severe criticism for their opacity, since any increase in benefit in excess of the ‘guaranteed’ return depends on the scheme’s underlying investment performance and the formula used to allocate ‘out-performance’ between members.

• Both the pure defined contribution and the cash balance designs pass on all mortality risk to employees, whereas other risk sharing schemes, such as nursery and defined contribution top up schemes, share mortality, as well as the investment risk, with the employer. However, their degree of risk sharing differs according to age of joining (the nursery scheme) or rate of pay (the top up scheme).
• The final salary and career average schemes involve the least risk sharing and so
the least variability in outcome. Employees have to bear the risk of employer
insolvency (not considered in the report), to the extent that benefits are not fully
covered by the Pension Protection Fund, but this is true of all defined benefit
arrangements. In the career average scheme, there is also the risk that employees’
salary growth will be significantly greater than the rate benefits are revalued.

...and for which types of people?
• In general, a higher pension should be expected the longer an employee
contributes to a pension scheme. However, longer term investment is associated
with a wide variation in outcomes, with some cohorts of investor benefiting
from very high investment returns, but others doing very poorly. The results
from the model indicate a small (but statistically significant) probability of members
of the pure defined contribution scheme (based on largely equity based
investment) reaching retirement without having maintained the value of their
saving in real terms.
• The cross subsidy that final salary schemes are supposed to impose from people
with flat salary progression to those with higher salary progression is overstated.
Most employees cannot manipulate their pay or career in such a way as to
maximise the advantage from this design.
• Career average schemes provide close to final salary benefits for people with flat
salary progression and, if they have higher accrual, will give higher benefits for
people in this class.
• By pooling investment risks and managing bonus distribution, cash balance with
bonus plans are able to provide access to risky investments, and thus the possibility
of higher effective returns, without passing on all the downside risks to employees.
• Each design produces a different outcome and shares risk differently, depending
on age of joining, salary, working history and age of withdrawal – so no design
produces the ‘best’ solution for all types of employee.

Implications of sharing or not sharing risk
The degree to which the employer and employees share the risk that a ‘target’
benefit might not be delivered is fundamental to the variety of outcomes. The final
salary scheme, for example, produces a consistent outcome with very little variability,
but therefore misses some of the very good outcomes produced under the pure
defined contribution and cash balance with bonus schemes. This is because
employers that provide final salary (indeed defined benefit) schemes bear the
investment risk and in most cases we have implicitly assumed that any investment
out-performance from equities (compared to bonds) is used to compensate the
employer for the extra economic cost associated with taking that risk.
The defined contribution scheme, where the employee bears all of the risk, produces some of the best outcomes, but also the worst. Depending on the investment strategy followed, the probability of achieving a replacement ratio lower than that provided by the final salary scheme is high.

The other schemes provide intermediate results, with the employer effectively using part of the contribution that would otherwise have been paid to a pure defined contribution arrangement to protect itself against the cost of the guarantees it is contracted to provide.
1 Introduction

Summary
This report summarises the results of an investigation into what pension is likely to be paid to people at retirement. The analysis incorporates various working histories and pension scheme types with the outcomes also depending on the financial variables chosen: price inflation, salary inflation, return on equity investment and return on bond investment. This report summarises the main results from the underlying modelling, focusing primarily on investment risk.

This research report is one of three projects commissioned by the Department for Work & Pensions (DWP) into hybrid or risk sharing pension plans. The other two projects are:

- Hybrid Pension Plans: UK and International Experience, Kevin Wesbroom & Tim Reay, Hewitt Bacon & Woodrow, 2005
- The Optimal Allocation of Pension Risks in Employment Contracts, Dr David McCarthy, Tanaka Business School, 2005

All three reports are also summarised in the DWP publication; Risk Sharing & Hybrid Pension Plans (2005). The main objective of the research is “to increase the knowledge of risk sharing and hybrid pension plans compared to traditional final salary and pure defined contribution plans; and to promote discussion and better understanding of these within Government and the wider pensions world”.

The detailed terms of reference for this particular research were as follows:

- To consider a selected number of hybrid plans, and generate simulated outcomes of expected income and variation in income, for characteristic individuals.
- This should take account of the various risks and uncertainties as well as labour market characteristics (such as wage progression, job tenure, etc). These outcomes should be compared to outcomes under Final Salary and pure DC arrangements.
To achieve this, an analytical/statistical model was subsequently developed. This report summarises the results and illustrates:

- The effect of different degrees of risk sharing between employer and employee; and
- How the benefits provided by different pension schemes can vary according to working and salary histories;

The model can produce results on both a deterministic and stochastic basis. A parallel model has been used to illustrate the variety of outcomes that could have emerged based on actual market returns observed in the past. The scheme designs, which have been chosen as presenting different ways of sharing risk between the employer and employee, are:

- Final salary
- Defined contribution
- Career average
- Cash balance, with and without ‘bonus’ allocation
- Nursery
- Defined Contribution top up

Further detail of each scheme is given in Appendix I.

The pension schemes have been set up so that for an ‘average’ employee the cost of providing the benefit will be similar. However, each design imposes a different risk exposure on the employer and employees. The main risks that pension schemes carry are:

- The possibility that investments will perform less well than expected;
- The possibility that people will live longer than expected (schemes that provide death benefits also have to consider the risk that people will die sooner than expected, but this is not considered in this report);
- The possibility that salaries will increase faster than expected; and
- The possibility that inflation will be greater than expected.

Each risk is characterised by a possible upside, as well as the downsides mentioned above (for example, investments could perform better than expected). In defined benefit provision there is also the risk that the employer will become insolvent whilst the scheme has insufficient assets to secure the benefits¹, although the Pension Protection Fund limits this risk to some extent. Table 1.1 shows how the above risks are shared in each scheme design.

¹ The risk of employer insolvency is not explicitly considered in this report.
In a pure defined contribution scheme the employee has to bear the cost of all these risks; schemes that provide a lump sum benefit, like a cash balance plan, pass the longevity risk to the employee and some of the investment and salary risk; whereas in a final salary scheme the employer has to bear the cost of all the risks.

**Table 1.1 Risk sharing between employer and employee in certain scheme designs**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Investment</th>
<th>Longevity</th>
<th>Salary</th>
<th>Inflation¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final salary</td>
<td>Employer</td>
<td>Employer</td>
<td>Employer</td>
<td>Employer</td>
</tr>
<tr>
<td>Defined contribution</td>
<td>Employee</td>
<td>Employee</td>
<td>Employee</td>
<td>Employee</td>
</tr>
<tr>
<td>Career average</td>
<td>Employer</td>
<td>Employer</td>
<td>Employee</td>
<td>Employer</td>
</tr>
<tr>
<td>Cash balance</td>
<td>Employer</td>
<td>Employee</td>
<td>Employee</td>
<td>Both</td>
</tr>
<tr>
<td>Nursery</td>
<td>Both</td>
<td>Both</td>
<td>Both</td>
<td>Both</td>
</tr>
<tr>
<td>Defined contribution top up</td>
<td>Both</td>
<td>Both</td>
<td>Both</td>
<td>Both</td>
</tr>
</tbody>
</table>

The balance of risk is not one of the issues directly investigated in this research. However, it is partly taken into account in two ways:

i. The output from the stochastic simulations demonstrate how employees are more exposed to investment risk in some designs than others; and,

ii. The cost of defined benefit provision has been based on ‘least risk’ investment, that is, with advance funding using bonds to match the anticipated cashflows as far as practical. Any other approach would fail to recognise the extra risk to the employer of defined benefit provision underpinned with “risky” investments, such as equities, and the extra overall cost of capital likely to be incurred by an employer adopting such an approach.

Even on this basis the accrual is arguably over generous as the employer faces risks such as longevity that cannot be easily addressed through investment strategy. The report primarily concentrates on investment risks (in the accumulation phase and at the annuitisation point), but also considers salary and longevity risks. The underlying model can illustrate the effect of all the risks separately. The time spent in the relevant schemes, and hence the scheme service (required for service-related benefits) depends on the following three factors in our modelling:

- The retirement age – this report includes results for a retirement age of 65.
- The start age – this report includes results for people joining schemes aged 25 and 45.

² Inflation risk is the risk that the benefits received (on and after retirement) will be less valuable than when they were accrued (during employment) due to a high level of inflation in the time from accrual to payment. A high level of inflation may result in a reduced ‘real’ benefit level.
• The employment history – the employment histories included range from full time employment and full working lifetime with one employer, through full time employment and full working lifetime with several employers, to careers with breaks and periods of part time employment.

More detail about employment histories is given in Appendix 2. The model’s results also depend on the following financial variables:

• Price inflation
• Salary inflation
• Return on equity investment
• Return on bond investment

The assumptions for these and other factors used to produce the deterministic output are summarised in Appendix 3. They are based on current financial conditions and longevity expectations. To analyse the effect of variation in the primary variables, a simple stochastic model, based on mean reverting time series, has been used to generate these values for the simulated results (drawn from ‘The TY model’, Y H Yakoubov; M H Teeger; D B Duval, SIAS, November 1999). More detail is provided in Appendix 4.

For this report, the model has been used to produce various results for a small number of scenarios - different start ages, pension scheme histories and employment histories. Repeating the model for different combinations of these settings provides an understanding as to the value of the benefits the member will receive under different pension scheme structures.

Only a small number of the possible permutations of results that the model can produce are included in this report – that is, those that were considered most relevant for the questions at hand.

Section 2 describes the form of output from the model that is used to illustrate the results. Section 3 presents analysis based on the ‘deterministic’ returns; in Section 4 the output produced by the stochastic model is considered; and Section 5 comments on the output generated from the historic returns. In Section 6 we look at how people might be affected if a sudden ‘shock’ to financial markets or to the way occupational pensions are provided altered their anticipated benefit, and Section 7 is the conclusion.
2 The Indicators of Pension Outcomes

Summary

This report uses a variety of indicators to illustrate pension outcomes, based around the broad concept of a ratio of pension received at retirement compared to pay received before retirement.

‘Final pay’ ratios show the ratio of pension to final pay but will depend on whether you are looking at the pension before or after tax and if you are taking just the occupational pension only or are including state benefits.

‘Revalued pay’ ratios do not use final pay, instead they treat pay as the average pay over membership revalued to retirement.

‘Annualised pay’ ratios look at scaling up final pay for part-time employees so that a more direct comparison with full-time employees can be made. The report also looks at the probability that private pension replacement ratios meet a minimum target of 20%3.

2.1 Final Pay Ratio - replacement ratio at retirement

The ‘final pay’ replacement ratio is the ratio of the pension at retirement to salary just before retirement. Within this, three variants are considered:

- Total pension (both occupational pension and state pension), before tax, as a ratio of gross pay immediately before retirement.
- Net total pension (after tax) as a ratio of net pay immediately prior to retirement, after both tax and pension contribution.
- Occupational pension only, before tax, as a percentage of gross pay immediately before retirement.

3 This 20% is for illustrative purposes only and does not reflect any particular view on the appropriate level of private or combined private and state pension replacement ratio.
These ratios just consider the rate of pay prior to retirement, which obscures information about a person’s career history. For example, a low ratio could indicate that the scheme’s benefits are poor, or alternatively that someone has not had much time to contribute to, or accrue benefit in, an occupational scheme. Similarly, a high ratio could indicate that the scheme’s benefits are good, or alternatively that the person’s pay has fallen in the years immediately preceding retirement.

Because of these weaknesses, we also present replacement ratios based on average revalued pay, as described below. However, despite these limitations, the “final pay” ratios do provide useful information.

In particular, the ‘net total pension’ ratio is the only one that permits a sensible comparison of the after-tax effects of pension saving. These are important to understand, since the tax treatment of people before and after state pension age is different. People above state pension age often pay less tax, by virtue of an age related allowance, and also do not pay National Insurance contributions (which we class as taxes for this analysis).

The ‘total pension’ ratio is needed to provide a ‘gross’ comparison to the ‘net’ ratio. In addition, these show how an individual’s income changes solely due to retirement, which is useful to indicate where financial strains might emerge.

The ‘occupational pension only’ ratio is useful to indicate the different contributions state and private provision make to these comparisons.

For those working lifetimes that end with periods of part time employment, the replacement ratio provided by the occupational scheme only is recorded on annualised pay received as well as actual pay. The former will illustrate how well the pension enables the individual to enjoy a lifestyle comparable to a full time worker, whereas the latter demonstrates how well the pension enables the person to continue the contribution they made to household expenses as a part time worker.

2.2 Revalued pay ratio – replacement ratio over lifetime

This is the ratio of the occupational pension immediately after retirement to the average pay received by the individual over his or her working lifetime, where each year’s pay has been revalued in line with national average salary growth.

This replacement ratio enables a view to be taken of the comparative value of different pension schemes. A higher replacement ratio would indicate a better return than a lower ratio. This is the replacement ratio used most frequently in the report.

Note that statements about ‘value’ or ‘return’ say nothing about the overall efficiencies of the different scheme types, since costs are assumed to be the same in all scheme types, but rather the impact of redistributive effects and the rewards for investment risk taken.
2.3 Probability that the replacement ratio meets a minimum target

This is produced for the historical and stochastic output only, illustrating the likelihood that a minimum replacement ratio is reached. We have chosen to illustrate the probability for the ‘occupational pension only’ replacement ratio, and chosen a target of 20%. This figure represents the likelihood that the occupational pension at retirement is at least 20% of the salary just before retirement.

The 20% figure in the model can be altered to look at the likelihood of the pension at retirement exceeding other minimum replacement ratios. The statistic could also be applied to the other, ‘total pension’ replacement ratios, in which case it would be sensible to use a higher ratio than 20%.

It should be emphasised that for the purposes of this research the primary interest is in comparing replacement ratios across different schemes and different types of people. Different types of replacement ratios, the effect of state pensions and the tax system are discussed in various places in so far as they may have a bearing on the issue of primary interest. The research doesn’t set out to investigate replacement ratios in themselves nor does it consider more general notions of the adequacy of pensions.
3 Central Outcomes – analysis based on fixed financial assumptions

Summary

This chapter details selected results from the model using fixed financial assumptions – that is, a deterministic basis.

Different scheme designs produce different outcomes for people with different working histories due to, for example, age at joining, salary, rate of salary growth, inflation, periods away from paid work and periods in part time employment. Even a single design can give different outcomes depending on the circumstances of an employee’s working life. However, although people might use occupational pension provision as a criteria for selecting employment, having joined an employer they are unlikely to be able to select a different type of scheme just because the nature of their employment changes.

The most that can be expected is for employees to consider the extent to which the combination of the occupational scheme they have access to and their entitlement to state pensions is likely to enable them to meet their expectations of retirement. They can then assess the need for additional retirement saving, perhaps to a Stakeholder or personal pension scheme. Results show that contribution to an occupational pension scheme can effectively double the replacement ratio, hence benefit received compared to receiving only state benefit.

The most important lesson for employers considering occupational pension provision is to understand the consequences of the different types of risk sharing inherent in the hybrid designs included in the model, particularly given the nature of their workforce. For a given rate of contribution, late joiners tend to get higher benefits from pure defined benefit schemes, rather than pure defined contribution. By mixing defined benefit and defined contribution benefits, the design can be altered to share risk differently.
3.1 Replacement ratios based on deterministic assumptions

For some purposes, direct comparisons between different schemes are made easier if variability of outcome due to uncertainty in financial markets is ignored. Thus, in this section of the report, results are presented on a deterministic basis only (that is, using fixed financial assumptions). However, although a deterministic approach makes it very easy to see the differences between different scheme designs, by removing the ‘noise’ created by a stochastic model, it does not indicate the different risks members are exposed to under different designs. These are addressed in the section summarising the stochastic output from the model (section 4).

The investment assumptions underlying the deterministic calculations are consistent with those used for the stochastic model, in the sense that they are the ‘mean’ assumptions on which the time series projects were based. They are summarised in Table 3.1, but more detail is given in the appendices.

Table 3.1 Financial Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Assumption Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>2.5%</td>
</tr>
<tr>
<td>National average salary growth</td>
<td>4.5%</td>
</tr>
<tr>
<td>Equity returns</td>
<td>8.0%</td>
</tr>
<tr>
<td>Fixed interest returns</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

The different working histories, pension scheme designs and patterns of salary growth are described elsewhere (appendices 1 and 2). As explained in section 2, the model uses different definitions of ‘replacement ratio’, because they each measure slightly different aspects of pension provision – though mainly the revalued pay ratio is used in the rest of this report. Unless otherwise stated, all the replacement ratios are expressed gross of tax.

The deterministic calculations enable a simple comparison between the different ratios. For example, Chart 3.1 shows different ratios for an individual with the ‘part time and break’ working history. Like most of the charts in the report, unless we specifically say otherwise, state pensions are ignored and the outcomes are based on someone starting work with a salary of £20,000 pa and assuming that salary progression follows the ‘skilled’ path, described in Appendix 2.

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4 Only the ‘final pay’ replacement ratio is expressed on both a gross and net of tax basis; the ‘revalued pay’ and ‘annualised pay’ ratios are only expressed gross of tax.
Chart 3.1

In each case the replacement ratios follow the same pattern:

- Pension as a proportion of annualised final pay is lower than pension as a proportion of final pay. This is because people with the ‘part time and break’ working history are assumed to spend 80% of their time in paid employment immediately prior to retirement. So their actual final pay is less than their annualised final pay.

- Pension as a proportion of revalued pay is higher than pension as a proportion of final pay. This is because people with the ‘part time and break’ working history have long periods when they are not in full time paid employment. However, the proportion of time spent in paid employment increases as they approach retirement, so that their final rate of pay is high relative to pay at earlier ages and their average revalued pay is lower than their final pay.

Chart 3.1 shows replacement ratios for someone who joins their scheme aged 45 and, where there are defined contribution options, chooses to invest solely in bonds. This type of employee is close to the ‘average’ member of the model scheme used to establish the defined benefit designs, which is why there is not much difference between the replacement ratios recorded for each type of scheme. The defined contribution scheme replacement ratios are lower than the final salary ratios because in the first few years after age 45 a person with the working history assumed for the chart (‘part time and break’) spends a lower proportion of their time in paid employment, as well as taking a break from work, and so gets less advantage from investment returns in their first years of membership.

It is also important to remember that replacement ratios only provide a snap shot, taken at retirement, of how an individual might be able to maintain his or her
standard of living. In the majority of cases the pension at retirement (from all sources) will be an individual’s only source of income for the rest of their lifetime. The usual practice in occupational schemes is to provide, at best, pensions linked to inflation, and this is what we have assumed in the model (subject to a 2½% cap). However, some private pensions have fixed rate, or no, increases and increases to state pensions are only linked to prices (although governments have given extra increases to the basic state pension from time to time). Earnings tend to grow faster than prices, so the standard of living of those in retirement will decrease relative to the standard of those people still in work. Unless practice changes, this will be true of all scheme designs. The effect of this decrease, based on the model’s assumptions, is illustrated in Chart 3.2, which shows replacement ratios at different ages, allowing for both occupational and state scheme benefits.

Chart 3.2 shows the way inflation erodes the real, relative to earnings, value of pensions once someone is retired. The replacement ratios illustrated are for someone on a salary of £20,000, retiring age 65 after a full, full time, working history. In the cases that include an occupational scheme, the person joins age 25 and chooses to invest defined contributions solely in bonds. A comparison of the ‘state pension only’ replacement ratios with the others shows the contribution private or occupational retirement saving can make to the level of someone’s retirement income.

**Chart 3.2**

A high proportion of the people categorised as receiving ‘below average income’ is made up of single female pensioners\(^5\). This is partly because they did not accrue

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entitlement to occupational pensions, but also because, on average, women live longer than men and so feel the effect of earnings increasing faster than prices more acutely than men. As life expectancy grows, unless the rate at which retirement benefits are increased becomes greater than inflation, there is likely to be an increasing number of both men and women that will be caught in this trap.

3.2 Comparison of results by working history

We will begin the comparison of different scheme designs by looking at the replacement ratios achieved by schemes for members joining an occupational scheme aged 45, assuming (for schemes with a defined contribution element) that all investment is in bonds. Then we will go on to look at results for an employee who joins an occupational scheme aged 25.

Chart 3.3 shows the ‘final pay’ replacement ratios produced by the schemes, for the different types of working histories included in the model (for a full description, see Appendix 2).

![Chart 3.3](chart)

As we would expect, the ‘final pay’ replacement ratios are not very different for the alternative scheme types since each pension scheme was designed to cost more or less the same for this type of member and therefore should produce more or less consistent benefits for them also.

In each case the replacement ratio achieved by the person who phases their retirement by moving into part time employment is higher than the other ratios. This is because the ratios are calculated as a proportion of pay prior to retirement, rather
than annualised pay. Since the person with flexible retirement accrued a significant proportion of their pension during full time employment, their eventual pension is high relative to their final (part time) rate of pay. If their final pay had been annualised, the replacement ratio would be close to the equivalent full time ratio.

The ‘part time and break’ working history also ends with a period in part time employment, but this time there is a lower replacement ratio, even though final pay has not been annualised. This is because the ‘part time and break’ working pattern increases the proportion of time spent in paid employment as age gets closer to retirement, so most pension accrual is based on a lower level of pay than is received immediately prior to retirement.

Chart 3.4 shows ‘revalued pay’ replacement ratios. Revaluing pay removes the distortion in the results in Chart 3.3 caused by changes in pay throughout working life or immediately prior to retirement.

Chart 3.4 indicates that each member is getting more or less identical value from each scheme and that the benefits targeted by each scheme, for these particular groups, are reasonably consistent. As explained, this member scenario is a good proxy for the overall membership on which the scheme designs were calibrated, so that this result just confirms that the designs target similar benefits for the model scheme membership.

Differences start to emerge if we consider individuals who join the scheme at different ages and pursue different investment strategies, where they are given this choice. Chart 3.5 shows the revalued pay replacement ratio for someone who
joined their scheme age 25 and, where there was a defined contribution option, chose to invest 50% of their contributions in equities. However, few people are members of occupational schemes for their whole working lifetime, and many do not consider making any pension provision until they reach their 40s. Chart 3.5a shows the same ratios as Chart 3.5, but for fewer scheme designs and grouped differently, to make the differences in outcome between members with different working histories more apparent.

**Chart 3.5**

Revalued pay ratio for various schemes and work histories. A salary of £20,000 at a start age of 25. The retirement age is 65, salary increases are 'skilled' and investments are 50% bonds.

**Chart 3.5a**

Revalued pay ratio for various schemes and work histories. A salary of £20,000 at a start age of 25. The retirement age is 65, salary increases are 'skilled' and investments are 50% bonds.
The first thing to notice is that there are differences in replacement ratios depending on working history – those people with career breaks and/or part-time employment near the start of their working lifetimes receive pensions at lower replacement ratios than those with other working histories, under all designs.

- In the final salary scheme, the lower replacement ratios for people with career breaks are largely due to accrual prior to the period out of paid work being treated as deferred pension, so that the ‘final salary link’ is lost on this part of their benefit.

- In the defined contribution scheme, the difference is due to the break from paid work being during the early period of the individuals’ working lifetimes. Payments made longer before retirement contribute proportionately greater value than those made later, due to compound interest, so by either not contributing, or paying lower contributions, early on, it becomes more difficult to reach the ‘target’ replacement ratio.

- The differences in the career average replacement ratios are due to lower participation in paid employment at earlier ages, relative to later ages. This scheme also has lower replacement ratios relative to the other schemes for all classes of employment. This is due to the lower rate of revaluation on accrued benefits, relative to the rates experienced in the other types of scheme and relative to earnings growth.

- The fourth scheme included in Chart 3.5a is the cash balance with bonus plan. This has been included instead of the cash balance plan, since the latter behaves similarly to the career average scheme when deterministic assumptions are used and gives broadly the same results (unless annuity rates are varied). The cash balance with bonus plan produces replacement ratios between those of the final salary and defined contribution schemes, indicating the extent to which investment risk is shared between the employer and employee.

The other differences are between schemes. Schemes with some defined contribution element (except the defined contribution top up) are achieving higher replacement ratios than schemes that are entirely defined benefit. This is because in defined contribution arrangements the 15% contribution accrued solely to the member on whose behalf it is paid, whereas in defined benefit arrangements there is cross subsidy from younger to older members. Thus, all else being equal, a fixed contribution scheme will tend to provide a greater overall rate of return for employees who join at younger ages, whereas defined benefit schemes tend to provide higher implicit returns for those who join at older ages.

The investment strategy assumption also affects the replacement ratios under some of the pension schemes. The results presented in Chart 3.5 assume that 50% of each contribution paid to scheme with a defined contribution element is invested in equities, which the model assumes will provide a higher rate of return than bonds. Members in these schemes get the benefit of all this ‘out-performance’ and therefore are able to achieve higher replacement ratios than those with purely defined benefit schemes.
Chart 3.6 repeats the data presented in Chart 3.5, for someone who starts accruing pension aged 45. Because most of the differences between working histories are at earlier ages, there is less difference for members within each scheme. However, differences still occur. In particular, replacement ratios for schemes with some defined contribution element provide higher replacement ratios, because of the equity component in the investment strategy.

Results on a deterministic basis can only illustrate the consequence of the expected higher performance of equity investment and do not show the risk associated with that expected additional return. This feature is illustrated in section 4.

**Chart 3.6**

As explained above, normally defined benefit schemes give higher replacement ratios than the defined contribution arrangements to people who join schemes at older ages, but lower replacement ratios for those that join at younger ages. Chart 3.7 can be compared with Charts 3.5 and 3.6 to show this for someone who joins their occupational scheme aged 55. For late joiners, career average provides best ‘value’, because salary growth is expected to be no faster than inflation and the scheme has a higher accrual rate than the final salary scheme.

### 3.3 Deferral

Some pension designs target different pensions depending on whether an employee remains a member of the pension scheme continuously until they retire, or leaves the scheme prior to retirement. Final salary schemes have been particularly criticised for this because, on early withdrawal, the link to salary is lost. Instead, the almost
universal practice is to revalue the accrued benefit at withdrawal in line with limited price indexation6 (LPI). Since, on average, salaries increase faster than prices, the eventual benefit received is likely to be lower than it would have been otherwise.

Chart 3.7

Revalued pay ratio for various schemes and work histories. A salary of £20,000 at a start age of 55. The retirement age is 65, salary increases are 'skilled' and investments are 50% bonds.

The extent of the difference will depend on the actual salary progression the employee receives and in some cases will not be as great as might be imagined. Chart 3.8 compares the replacement ratios achieved by someone who joins the final salary scheme aged 25. Under the salary assumptions used in the model, the later someone joins their scheme, the less significant the effect will be, since real salary growth is assumed to tail off with age.

The ‘full time’ results are based on an employee who stays in one scheme throughout his or her working lifetime. The ‘deferred’ working history assumes that with each change of job the employee takes a deferred pension from their previous employer’s final salary scheme and joins a final salary scheme at their new employer.

6 Limited price indexation (LPI) is a statutory rate of increase that must, as a minimum, be applied to deferred pensions or to pensions in payment. When applied to deferred pensions it is inflation, but limited to 5% per annum compounded over the whole period of deferment; when applied to pensions in payment LPI currently is capped at 5% per annum. The Pensions Act 2004 reduces the cap applied to LPI on pensions in payment to 2.5%. Although this will only apply to pensions accrued after 6 April 2005, this is the rate we have used to produce the model’s results.
Of the other scheme designs, the career average and cash balance schemes would be unlikely to revalue deferred benefits at a different rate to ‘active’ benefits, so employment history will have less effect on benefits. In the nursery and defined benefit top up schemes, the effect will be mixed, since the final salary parts will discriminate, whereas the defined contribution parts will not and the outcome will depend on the extent to which the member accrued benefits in either section. However, for those employees who accrue benefits in both sections, the effect of job changes will be less than if they were solely members of the final salary section.

It is possible that, under the cash balance with bonus scheme, employers would be reluctant to bear any investment risk in respect of employees who leave the scheme prior to retirement. Indeed, since the scheme’s design is to stop carrying risk when members leave at retirement, it would seem inconsistent to continue bearing risk on behalf of early leavers.

The results in Chart 3.9 compare the replacement ratios achieved by the cash balance and the cash balance with bonus schemes, for a full time worker who joins the scheme aged 25, where the underlying investments are 50:50 bonds and equity. We would expect that employers providing cash balance with bonus schemes would design the scheme so that bonus is only distributed to members who are still in active service. Thus, a comparison between the replacement ratios provided by the two schemes illustrates the magnitude of the loss that might be faced by a worker who has many job changes.
3.4 Salary profile

The different schemes included in the model revalue accrued benefits in different ways. For example, in the defined contribution schemes revaluation is in line with investment performance, whereas in the career average scheme accrued benefits are revalued in line with LPI. This means that members are exposed to different ‘salary’ risks, depending on the difference between their own salary experience and the policy for revaluation within the scheme. Chart 3.10 illustrates this for people with a full time working history who join their schemes aged 25.
In nearly all cases the replacement ratio is lower (albeit only marginally in the final salary scheme) for people with higher rates of salary growth. This feature is not sensitive to the replacement ratio chosen to illustrate the outcome. Neither does the employee’s career history affect the relative outcomes significantly.

The differences arise because the gap between rate of growth in the accrued benefit and the rate of growth in pay is greatest for those with lowest assumed salary growth. For example, in the career average and cash balance schemes the accrued benefit is revalued in line with LPI and, except for the first 10 years of a ‘low skilled’ person’s working lifetime (that is, up to age 30), this is the same as their assumed rate of salary growth. However, the ‘professional’ person’s pay is assumed to grow not only faster than inflation, but faster than the ‘low skilled’ person’s pay, and for more years (until age 50)\(^7\). So the value of the accrued benefit, relative to the ‘professional’ person’s pay is not maintained as well as it is for the low skilled person.

In the defined contribution scheme, although higher salary growth means that the contribution paid by the ‘professional’ person will be greater than the ‘low skilled’ person’s contributions, the real rate of growth in the investments over the entire scheme membership (in excess of salary) is not high enough to provide a higher replacement ratio.

\(^7\) See Appendix 2 for more detail on salary growth assumptions.
Final salary schemes are often criticised for incorporating cross subsidy from those employees with low, or flat, earnings profiles to those with salaries that increase faster than average. However, the results of these calculations imply that the extent of any cross subsidy due to rates of salary progression is limited. In any case, ‘cross subsidy’ can only occur to the extent that the employer unwittingly pays contributions on behalf of low income employees that is actually required to fund the benefit of higher income employees. This is unlikely to happen—employers generally understand the structure of their pension schemes and the way costs are distributed across members, and employees are rarely in a position to manipulate their rate of pay to take advantage of the contribution paid by the employer.

The pattern changes in the defined contribution top up scheme, because both ‘professional’ and ‘skilled’ people’s higher rates of pay takes them above the pay ceiling, so they reach age 65 with both a final salary and a defined contribution pension. The ‘skilled’ person’s rate of pay is only ever marginally above the top up threshold, so the defined contribution top up only contributes a small amount to the eventual benefit. However, skilled people do relatively well under this arrangement. This is because the ‘top up threshold’ continues to increase in line with average earnings every year, whereas skilled people’s earnings are assumed to grow only in line with inflation after they reach age 50. Thus, the final salary part of their benefit continues to maintain its real value, relative to earnings, and they also receive a defined contribution top up annuity. When combined, the two parts of the benefit produce a higher pension than the straightforward final salary scheme.

People with a professional pay profile do less well in the defined contribution top up scheme. This is because their pay exceeds the cap on final salary accrual quite quickly, at an age when they are assumed to be receiving greater than average increases on their salary. The growth in the top up threshold does not compensate them for the loss of the final salary link and the defined contribution top up benefit is insufficient to compensate for this.

The results in Chart 3.10 appear to show that the rate of salary progression does not affect the value provided under the final salary design, which is different to the received wisdom. The difference arise for two reasons:

- The salary progressions used in the model are based on typical career progressions and do not cover more unusual patterns, such as people receiving large pay awards immediately prior to retirement. This salary profile would receive higher revalued pay ratios than the more usual histories represented, but the outcome would only apply to a very select group of employees.
• The results are presented based on someone retiring at the scheme’s normal retirement age. However, different scheme designs implicitly include different incentives for each additional year of pensionable service completed. As people approach a scheme’s normal retirement age, unless they are receiving high salary increases, each additional year of accrual in a final salary scheme will have less value than the previous year’s, since each extra year adds proportionately less to the final benefit. This is particularly true for people with long service, when it is possible for an additional year of accrual to add less value to the accrued benefit than an actuarial adjustment to maintain the value of the accrual without the additional year. This would not happen in a pure defined contribution scheme, since with each extra year of service the fund value is maintained (subject to investment performance) and an additional contribution is made, so new value is always added. Thus, final salary schemes implicitly encourage early retirement, at least for those that can afford to forgo their salary – so this design feature is also likely to create possibly perverse incentives for the select group of ‘high fliers’.

3.5 Nursery vs. Top Up schemes

Nursery and defined contribution top up arrangements both offer employers the opportunity to manage their exposure to risk, by combining defined contribution and defined benefit elements. The results from the model are based on a combination of final salary and defined contribution provision, although there is no reason why the balance of risk could not be modified further (for example by mixing career average with defined contribution, or final salary with cash balance). However, because the schemes split defined benefit and defined contribution accrual differently, the risk exposure varies under both arrangements.

Nursery schemes move employees from defined contribution provision at younger ages to defined benefit provision at older ages. The balance of risk for both employers and employees will depend on the overall design of the scheme. The scheme included in the model used to produce the results for this report has a base contribution rate of 15% paid into a defined contribution scheme for younger members (up to age 45) and a final salary scheme for older members which retains the 15% cost averaged over the entire membership. As a result, the Nursery scheme effectively provides a kind of lifestyling investment strategy, which under a deterministic approach will show good value for younger members but poorer value for people who join at older ages, since they do not get the same benefit from the relatively high contribution rate at younger ages. The relative benefits could be changed by altering the Nursery scheme design, for example, to

8 The contribution is described as ‘high’ at younger ages, since, due to the effect of compound interest, the earlier a contribution is made, the less it costs to provide a fixed benefit paid at retirement.
have a lower contribution to the defined contribution section and a higher rate of accrual in the final salary section, although this might be construed as age discrimination.

The net effect of a nursery arrangement is that everyone (that is, employers and all types of employee) can be exposed to all risks, but to a greater or lesser degree depending on their age, career and salary profile.

The defined contribution top up scheme balances the defined benefit and defined contribution risks differently, since people on low pay will never be eligible for the top up part of the scheme. Thus, low paid people who do not expect much real salary growth will only ever be defined benefit members, so that their employer bears all the risk (setting aside insolvency risk), whereas higher paid employees, particularly those with high expected rates of salary growth, will bear an increasing share of mortality, salary and investment risk.

Chart 3.11 illustrates this for employees with different pay profiles starting work at different levels of pay. It shows how all scheme designs apart from the defined contribution top up scheme broadly reward full time workers similarly, provided their salary grows at the same rate, because each employee’s annual benefit accrual then receives the same rate of growth, regardless of the level of salary. However, in the defined contribution top up scheme, risk sharing is asymmetric, in the sense that the higher paid are exposed to greater risks, so that both the level of pay as well as the rate of salary growth affect the eventual benefit, calculated in terms of replacement ratios, that will be achieved.

**Chart 3.11**

*Final pay' replacement ratios for various schemes and a 'full time' work history. Salaries of £20,000 and £40,000 at a start age of 25. The retirement age is 65, salary increases are 'skilled' and investments are 50% bonds.
The result is that higher paid members of the defined contribution top up scheme can achieve higher replacement rates, since they are assumed to get the benefit of equity out-performance in the defined contribution section of the scheme.

### 3.6 The effect of state pensions on replacement ratios

We have also used Chart 3.11 to illustrate how state pensions alter the balance of risk underlying retirement income. The basic state pension is flat-rate – that is, the amount received depends only on the number of contributions paid, rather than the amount paid. Also, the additional state pension (or State Second Pension (S2P)) is earnings related, but only up to an inflation linked salary cap (the Upper Earnings Level), which is £31,720 in 2004/5. In addition, S2P is designed to provide higher replacement ratios for those with lower levels of pay. Thus, combining pay related occupational pensions with state pensions should enable lower paid employees to achieve a higher replacement rate overall, compared to higher paid employees.

There is evidence\(^9\) that lower paid employees need higher replacement ratios in order to continue to maintain their standard of living in retirement. The effect of the defined contribution top up scheme seems to undermine this relationship. However, the outcome relies on higher paid employees having to bear greater risk (the replacement ratios in Chart 3.11 assume 50% exposure to equity investments) by accepting the real possibility that they will not achieve the higher replacement rates. This is illustrated in section 4 on stochastic results.

### 3.7 The effect of the tax system on replacement ratios

The change in status from ‘economically active’ to ‘retired’ does not just affect an individual’s source of income, it also changes the way income is taxed. Although pensions are taxed as earned income, there is no obligation to pay national insurance contributions. Also, once people reach age 65, they become eligible to additional tax allowances and after reaching state pension age pay no national insurance contributions anyway, regardless of the source of income. This means that the gross ‘final pay’ replacement ratios illustrated in Chart 3.11 underestimate the ‘take home pay’ replacement ratios, which are arguably the more important measures. Chart 3.12 illustrates this.

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Chart 3.12

‘Final pay’ replacement ratios for various schemes and a ‘full time’ work history. Salaries of £20,000 and £40,000 at a start age of 25. The retirement age is 65, salary increases are ‘skilled’ and investments are 5% bonds.

The net replacement ratio for lower paid employees is higher relative to the gross replacement rate than the equivalent comparison for the higher paid employees, because age related tax allowances are means tested. That is, they reduce by 50p for each £1 of income above £18,900 (in 2004/5). Thus, the small proportion of people with pensions greater than £21,600 have the same tax allowances as people of working age and the only difference for them is that they do not need to pay National Insurance contributions.
4 Variability I – analysis based on a stochastic financial assumptions

Summary

This chapter details selected analysis using a stochastic model for investment returns, that is, allowing for variance in the financial markets. This variance in turn produces variability in outcomes under the scheme designs.

Investment risk, together with cost of buying an annuity at retirement, is responsible for a large part of the variability in outcome for schemes with a defined contribution element. In contrast, employers carry the risk (or some of the risk) in schemes with a defined benefit element. This provides more stable outcomes for members but also removes the possibility of higher pensions if investment returns are favourable. Losing this possible ‘upside’ is a cost of the security.

Variability also depends on employees’ working histories. Employees who are able to join schemes at younger ages can expect higher benefits, but also greater variability in outcome, particularly if they rely primarily on defined contribution arrangements. Defined benefit schemes limit the variability, but also the possibility of getting an outcome much better than ‘average’. Schemes that combine defined benefits with defined contribution characteristics, such as the cash balance with bonus design, can limit the downside risk whilst still enabling good results with a relatively high probability.

A member joining a scheme at age 25 has both a higher mean and a higher variability of outcomes than an otherwise equivalent member who joins age 45.

4.1 Replacement ratios on a stochastic basis

We have already mentioned that the weakness of a deterministic approach is that it does not indicate the likely variability in outcome under each of the scheme designs, so we use this section to illustrate what that might mean for different classes of
member. The stochastic model only allows for variance in financial markets, and we look at these affects first. Also, since the consequence of volatile markets differs according to assumed salary and working histories, we look briefly at possible distributions of outcomes allowing for these two factors.

Most of the charts illustrate the distribution of outcomes by presenting the results in quartiles (for example, the lowest quartile contains the worst 25% of outcomes). The upper quartile is also further split to show the highest 5% of outcomes to illustrate the large spread of ‘very good’ results. We have not shown the lowest 5% of outcomes because the distribution was so narrow.

4.2 Investment returns

Chart 4.1 shows the outcome for someone with a full-time, ‘skilled’, working history under four different scheme designs. In each case the median result is a replacement ratio close to 20%\(^\text{10}\). However, the designs that are exposed to the underlying investment experience of the fund present a wide range of possibilities. The ‘pure’ defined contribution fund gives a spread of replacement rates from 10% to 35% and, although there is a 5% chance of getting a replacement ratio greater than 28%, there is a 25% chance that the replacement rate will be less than 13%.

The ‘Cash balance’ scheme provides an implicit return linked to LPI, with a 5% cap. Inflation and bond returns are closely associated in the stochastic model, and this is evident in the relationship between the pure defined contribution and cash balance outcomes. However, the spread of results under the cash balance plan is narrower, indicating the reduced exposure to investment risk.

The cost of buying an annuity at retirement also contributes to the variability in results under the defined contribution and cash balance plans, since annuity rates depend on bond yields at the time of purchase.

Chart 4.2 reproduces Chart 4.1, but with a different collection of scheme designs that includes the ‘Cash Balance with Bonus’ design, which incorporates a discretionary award of bonus depending on the underlying investment performance of the scheme. This design produces an outcome that is much closer to the pure defined contribution result but with a relatively protected ‘downside’. This outcome is achieved partly via the rules that allocate investment bonus, which aim to ensure that the fund can continue to meet its ‘guaranteed’ rate of revaluation even when it does not receive sufficient investment return during the year. Consequently, in years when investment return is high, not all of it is allocated to members. Even so there is

\(^{10}\) This is slightly higher than the replacement ratio produced by the deterministic results, which was 17%. This is because the stochastic results effectively truncate the underlying asset return distribution, since the value of the investments cannot fall below zero. This means that the results appear to have fewer very poor years, in terms of actual investment returns, than the nominal model would suggest, so the effective mean asset return is higher.
a risk that over an individual’s lifetime as a member of the scheme, the fund ends up with an insufficient reserve. This risk is borne by the employer and is recognised in the lower accrual rate relative to the straightforward cash balance design.

The effect on scheme members is that the distribution of outcomes under the simple cash balance scheme is narrower than that under the cash balance with bonus scheme.

**Chart 4.1**

The cash balance with bonus scheme is operating similarly to with profit business, except without the regulatory oversight that would apply to a life office. Our model assumes that the employer can find derivative products that hedge the risks that the underlying investments fail to meet the guarantee. The cost of this has been allowed for by reducing the rate of accrual relative to the simple cash balance design, but depends fundamentally on shareholders being willing to supply the additional capital needed when markets fail. Normal life office practice would be to invest part of the reserve representing guaranteed liabilities in low risk assets and establish a solvency margin in addition to this that can be invested less cautiously to maintain the level of bonus.

Neither approach is foolproof. Life offices that still sell with profit products have to operate them more openly than they did in the past, which could restrict their flexibility to protect their reserves. Similarly, shareholders are less willing to underwrite the risks employers adopted when they offered final salary schemes to employees.
The distribution of outcomes under the final salary and career average schemes is very limited, because the benefit is so closely linked to the salary definition used to calculate the ratio. Thus, provided each member anticipates a retirement benefit in terms of a proportion of their final pay, they should not be disappointed, but if they are more concerned with absolute amounts there would be more variation.

The result for the nursery scheme Chart 4.2 shows no variation because members joining at 45 automatically enter the final salary section, so the nursery and final salary schemes are virtually equivalent (apart from a small difference in the accrual rate which can be seen from the slightly lower mean replacement ratio in the nursery arrangement). The defined contribution top up scheme is also effectively final salary for the members in question, because their salary never exceeds the ‘top up’ level.

The variance in performance is even more evident when scheme membership is viewed over a longer term. ‘Long term’ investment is sometimes considered as lower risk than short term, but this is not necessarily the case. Whilst investment over the longer term gives some opportunity to recover from short term fluctuations, it also leaves investors more vulnerable to changes in sentiment that affect investment markets in a systemic way, as well as greater probability that they will be adversely affected by short term fluctuations.

Chart 4.3 shows the possible distribution of outcomes when investment is made over a longer period. Both the mean and the variability of outcomes have increased relative to the position in Chart 4.211.

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11 Note that the scale of each chart in this section might be different and this should be taken into account when comparisons are made.
The Charts so far have illustrated results assuming a conservative investment strategy (100% bonds) is followed throughout the accumulation period. Chart 4.4 indicates the results where more risk is adopted.

**Chart 4.3**

Revalued Pay Ratio statistics for various scheme types. Assumes a start age of 25, retirement age of 65, ‘full time’ work history and ‘skilled’ salary growth. The investment strategy is 100%:0% (bonds:equities).

**Chart 4.4**

Revalued Pay Ratio statistics for various scheme types. A start age of 25, retirement age of 65, ‘full time’ work history and ‘skilled’ salary growth. The investment strategy is 30%:70% (bonds:equities).
In Chart 4.4, the ‘downside’ risk is still underpinned by the 30% investment in bonds and a lifestyle strategy that moves equities into bonds as the employee nears retirement.

Comparing the results presented in Charts 4.3 and 4.4 provides insight into how sharing investment risk between employer and employee affects outcomes.

- The pure defined contribution scheme has no risk sharing, but employees can mitigate their risk exposure by investing partly in bonds and by adopting lifestyling prior to retirement\(^{12}\). The more risk averse the member, the greater the proportion likely to be invested in bonds. As expected, this both reduces the mean outcome that could be achieved, which might not be desirable, but also the variability in outcomes, which is likely to be desirable.

- Nursery schemes share risk by limiting pure defined contribution saving to employees’ at younger ages, which is the period when the contribution is most valuable. At older ages, employees join a final salary scheme, where investment (and other) risks are entirely with the employer. The risk ‘trend’ is similar to lifestyling, in that risk reduces as the employee nears retirement, but more extreme. The value of the contribution at younger ages, accumulated to retirement, is such that this can give better results than pure defined contribution saving and the final salary period of membership provide better ‘downside’ protection (see Chart 4.4).

- The defined contribution top up scheme also combines pure defined contribution with final salary provision, but distributes the risk sharing differently. Those employees with lower rates of pay remain solely in the ‘risk free’ final salary scheme and only higher paid employees have to bear any investment risk. In Chart 4.4, which shows outcomes for someone with £20,000 starting pay, the outcome is largely driven by the final salary scheme. Chart 4.5 shows the effect for someone on higher rates of pay.

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\(^{12}\) It is usual for members of pure (occupational) defined contributions to have some choice over the nature of the assets in which their, and the employer’s, contributions are invested. The results of the 2003 NAPF survey (Twenty-ninth Annual Survey of Occupational Pension Schemes, NAPF, 2003) indicate that about 80% of defined contribution schemes offer four or more different fund options and 65% offer lifestyling.
Risk sharing under the cash balance with bonus scheme is independent of the employee’s characteristics (that is, it neither varies by age or by salary). In that sense, and because all the mortality risk is also passed onto employees, rather than being shared as it is in the nursery and defined contribution top up schemes, it is more similar to the pure defined contribution arrangement. However, by underpinning the employees’ funds, the employer bears extra cost over and above that imposed by pure defined contribution scheme. As the Charts show, this does not necessarily mean that employees will do worse in the cash balance arrangement, but the targeted benefit is likely to be lower. The potentially better outcome versus pure defined contribution is partly achieved because the investment fund that underpins the scheme is assumed to be pooled and so does not follow a lifestyling strategy. Chart 6.1 demonstrates how the lifestyling strategy depresses potential returns, and members of the cash balance with bonus scheme are assumed not to have to worry about this limitation (although the employer will have to).

Outcomes under the ‘plain’ cash balance scheme are also quite variable, but this is not to do with underlying investment returns, since the benefit depends only on inflation. So the variability arises from different inflationary outcomes, relative to salary growth, under the different projections and from the cost of buying an annuity at retirement.

The final salary and career average plans have a very narrow band of outcomes. If we had presented absolute pensions, rather than pensions relative to revalued salary, there would have been some variability due to different inflationary and salary growths.
A conclusion seems to be that pure defined contribution schemes can produce better results than most other designs, with a high degree of probability, even when the underlying investment strategy is low risk. Thus, defined contribution schemes are not inherently poor providers, as they are sometimes portrayed. The difficulty with many of defined contribution schemes that have been established over the recent past is that they have been used to replace final salary schemes that targeted a high level of benefit. However, the contribution being paid into them has frequently been low relative to that required to secure the benefits in the final salary scheme and, in some cases, people’s expectations of the benefits they are likely to receive from their new scheme have been poorly managed.

Pure defined contribution schemes also give employees the opportunity to achieve higher replacement ratios, but only by adopting more risk. The results show that, even under the 100% bond strategy, there is a significant probability (greater than 25%) that the replacement ratio that would be paid with a high degree of certainty under the final salary or career average schemes will not be reached. However, for those people that can bear the risk (for example, people who do not have to depend on defined contribution provision for their entire retirement income) the design has many attractions.

4.3 Salary growth

Charts 4.6, 4.7 and 4.8 show the central 50% of the distributions of outcomes, for different rates of salary growth. In each case the employee has a full time working history and the underlying investments are 30% bonds/70% equity.

Chart 4.6

Revalued Pay Ratio statistics for various scheme types. Assumes a start age of 25, retirement age of 65, ‘full time’ work history and ‘low skilled’ salary growth. The investment strategy is 30%:70% (bonds:equities).
The results show that:

- Under the pure defined contribution scheme, the median replacement ratio falls as expected salary growth increases. This feature was present in the deterministic results and occurs because of the difference between the rate at which investments grow and the rate at which salaries increase. Since the ‘real’ (relative to earnings) growth achieved on the fund is lower for people with higher salary growth, the eventual benefit is a lower proportion of final pay.
• Also under the pure defined contribution scheme, the range of outcomes narrows as expected salary growth increases. This is also due to the greater significance of contributions nearer the end of the career.

• The cash balance with bonus scheme mirrors the effects of the pure defined contribution scheme, but at a slightly lower level.

• For the low skilled salary history, the defined contribution top up scheme is effectively a final salary scheme and so there is very little range of outcomes. The skilled salary progression does achieve some defined contribution benefit, which enables a higher replacement rate, because of the assumed equity out-performance; the professional salary achieves even more defined contribution benefit, so that a higher range of outcomes can be seen as well as the higher median outcome.

• The median outcomes under the nursery scheme are quite different, varying between 59% for the professional and 81% for the low skilled employee. This is because the nursery arrangement picks up the periods from each of its underlying designs (that is, pure defined contribution and final salary) that provide best value for the low skilled employee (and worst for the professional).

4.4 Work history

The results in Chart 4.7 with Charts 4.9 to 4.11 enable a comparison between different work histories.

Chart 4.9
Chart 4.10

Revalued Pay Ratio statistics for various scheme types. Assumes a start age of 25, retirement age of 65, 'full time with break' work history and 'skilled' salary growth. The investment strategy is 30%:70% (bonds:equities).

Chart 4.11

Revalued Pay Ratio statistics for various scheme types. Assumes a start age of 25, retirement age of 65, 'flexible retirement' work history and 'skilled' salary growth. The investment strategy is 30%:70% (bonds:equities).
Apart from the amount of time spent in paid employment, one significant difference between the working histories is the rate at which people move from receiving salary to receiving pension. Under the full time working history there is steady receipt of salary followed by a sudden change to pension; under ‘flexible retirement’, the move is gradual; whereas under the ‘part time and break’ history the amount of paid employment increases towards retirement.

In terms of narrowing the likely range of outcomes under the pure defined contribution scheme, it seems that increasing contributions whilst approaching retirement produces the most effective result, because there is less time for the variability to make itself felt. However, it also gives rise to the lowest replacement ratio, because the most valuable contributions are (normally) those invested earliest (see Table 4.1, which is based on the data underlying Charts 4.9, 4.10 and 4.11).

**Table 4.1 Median and inter quartile ranges for defined contribution scheme. Assumes start age of 25, retirement age 65, skilled salary growth, Investment strategy 30%:70% (bonds:equities)**

<table>
<thead>
<tr>
<th>Working history</th>
<th>Median revalued pay ratio</th>
<th>Inter quartile(^{13}) range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full time with break</td>
<td>0.41</td>
<td>0.22</td>
</tr>
<tr>
<td>Part time with break</td>
<td>0.42</td>
<td>0.21</td>
</tr>
<tr>
<td>Flexible retirement</td>
<td>0.54</td>
<td>0.34</td>
</tr>
</tbody>
</table>

In terms of targeting replacement ratios, the flexible retirement strategy seems most effective, since this person seems to receive the highest (or one of the highest) replacement ratios in each scheme, albeit at the cost of a slightly greater range of outcomes.

### 4.5 Probability of ‘ruin’

Using the stochastic output, it is also possible to consider the likelihood that a particular target is not met. In insurance terms, this is sometimes referred to as the ‘probability of ruin’, since the target being measured is usually some form of solvency ratio.

The results already presented show that someone joining the pension scheme aged 45 can expect a pension of just under 20% of their final pay. In this sub-section we look briefly at the probability that a higher replacement ratio is achieved. Because the final salary and career average scheme designs have no (or very little) variability in outcome when expressed in terms of replacement ratios, these schemes never produce a higher replacement ratio. However, the other scheme designs do produce higher results with a fairly high probability (Chart 4.12). In all cases the cash

\(^{13}\) This is the difference between the upper quartile and the lower quartile.
balance plan produces a replacement ratio greater than 20% with the highest probability. Since its rate of accrual is 20% of revalued pay, this is largely due to the design's ability to protect downside risk. The times when it fails to achieve the target will be largely due to annuity risk.

The defined contribution scheme also produces replacement ratios greater than 20% with a reasonably high probability, which is what we would have expected given the nature of the risk exposure in the scheme.

The worst performer appears to be the cash balance with bonus plan. This is because it has a lower accrual rate than the plain cash balance plan, to compensate the employer for the additional risk its shareholders bear.

However, defined contribution schemes do not only give the greatest ‘upside’ variability. Chart 4.13 shows the probability of achieving a 20% replacement ratio for someone who first joined a pension scheme aged 25. For this group, a 20% replacement ratio would be a very poor result, and would mean that their savings had scarcely maintained their value whilst they were invested. The pure defined contribution scheme is now looking worse than both the plain cash balance and the cash balance with bonus schemes, which achieve this minimum target with 100% probability.

**Chart 4.12**

![Chart 4.12](image-url)
Probability ‘final pay’ replacement ratios are greater than 20% for various scheme types and working histories. Assumes a start age of 25, retirement age of 65 and ‘skilled’ salary growth. The investment strategy is 100%:0% (bonds:equities).
5 Variability II – analysis based on past investment returns

Summary

This chapter summarises results from the model using historical market indices rather than assumptions about the future. The results clearly show the variability in pension replacement ratios for scheme types where the employee takes on the investment risk. It is also apparent that, historically, the replacement ratio from an inflation linked pension falls substantially relative to national average earnings growth after retirement age.

Stochastic models such as the TY model, particularly when used to project results over several periods of time, can only produce results that fit a single economic paradigm. However, markets conditions can shift in ways that cannot be adequately captured by mathematical models, so this section has been included to illustrate what might actually have happened based on investment returns experience in the past. Chart 5.1 reproduces the results in Chart 4.1, but based on actual returns achieved over the past 40 years. The range of outcomes is quite similar, which indicates that the TY model, as adapted for use in this project, is a good fit for recent financial history. Since the parameters of the model were derived from recent market statistics, this provides corroboration that the stochastic results are not unreasonable. However, there is no reason to suppose it is an equally good predictor of the variance of future outcomes.

The data sources used to calculate the results presented in this section are described in Appendix 3. Monthly data points were gathered for the past 40 years. The distributions underlying the results presented in this section were produced by assuming people started and stopped saving at intervals one month apart. In each case the person is assumed to start saving at age 45 and retire at age 65. This sort of approach is necessary in order to illustrate the range of eventualities that could have been experienced. However, since there are a limited number of data points it does mean that the periods being compared within each distribution are not always
independent (since the data spans 40 years, only two periods of 20 years can be completely independent). For example, it is likely that a large proportion of the outcomes in the lowest quartile were a result of people assumed to reach retirement in 2002, when markets had fallen considerably, whereas a high proportion of results in the highest quartile will be due to retirements in 2000, just before the recent market crash (see Chart 6.3).

Chart 5.1

Although the historical results are mostly used to corroborate the stochastic output, by indicating outcomes that could actually have occurred they show graphically how vulnerable savers are to investment risk. For example, in Chart 5.1 even though a conservative investment strategy was followed, in about 25% of cases the defined contribution scheme does not even give scheme members back the money invested in real terms.

Because we have based the deterministic model and, although to a lesser extent, the stochastic model on a low inflation economy, the results they produce will tend to understate inflationary risks. The historical results enable these to be illustrated quite effectively, since any 20 year period since 1960 will include some time when inflation has been high. Chart 5.2 shows how an inflation linked pension has fallen in value relative to national average earnings growth.
The results in Chart 5.3 show another pattern missing from the stochastic results. In the stochastic model, the inflation and salary growth models are quite closely correlated, so any variance in the absolute outcome is considerably reduced by looking at the replacement ratio. However, the ‘historic’ results show a material variability in the replacement ratio achieved under the career average design. This could happen for several reasons.

- The revaluation rate prior to retirement in the career average scheme is LPI with a 5% cap. Because there have been periods of much higher inflation, the link between salary growth and career average revaluation has been broken in the past and employees have faced a greater salary risk than they would have had inflation been lower. This appears as a wider range of outcomes in the model’s results.

- Under the stochastic model, periods of hyper inflation do not occur, so the salary risk and therefore the variability in the results under the cash balance scheme are far less.

- It is possible that the close relationship between salary growth and inflation assumed by the stochastic model is too extreme, and that in the past the relationship has been less closely correlated.
Chart 5.3

Revalued Pay Ratio statistics for various scheme types. Assumes a start age of 45, retirement age of 65, 'flexible retirement' work history and 'skilled' salary growth. The investment strategy is 100%:0% (bonds:equities).
6 Unexpected events

Summary
This section investigates how outcomes might change if some event occurs that is unlikely to be predicted (a ‘shock’). The likely consequences can be mitigated by the choice of scheme design or, where the employee bears the risk, by judicious choice of investments. However, some risks cannot be removed entirely.

The most difficult risks to avoid are longevity risk, prior to annuity purchase, and longer term investment risks. These risks are borne entirely by employers in defined benefit schemes targeting pensions rather than lump sums (that is, the final salary and career average schemes). In defined contribution schemes, the employee bears these risks.

6.1 Background
This section investigates how outcomes might change if some event occurs that is unlikely to be predicted (a ‘shock’), such as a sudden and uncorrected fall in financial markets.

The deterministic model produces results assuming that the investment and other assumptions will follow predictable patterns. Similarly, the dominant features of the stochastic model are determined by the underlying time series, although we do assume that the financial assumptions will vary according partly to random events. Thus, neither set of results indicates what could happen if there were a sudden readjustment in financial markets, or if one of the fixed assumptions became inappropriate.
This section looks at how the results might be affected using three different scenarios:

- improvements in mortality are different than expected
- financial markets fall by 20% close to retirement
- the schemes are closed 5 years prior to retirement.

In each case we investigate the financial effect on the individuals involved. In some cases, because of the scheme design, there will be no, or limited, short term effect. However, members of schemes with some defined contribution element will be particularly exposed, particularly in the first two cases.

Over the longer term, falls in investment or increases in longevity are likely to produce some indirect effects for all pension scheme members, since employers might not be prepared to absorb the resultant increase in employment costs and choose instead to reduce the level of pensions they provide.

6.2 Improvements in mortality

Unexpected improvements in mortality pose two kinds of risk to people making retirement savings. Possibly the more significant of these is trying to estimate how much to save in order to provide an ‘adequate’ annuity at retirement, and we consider this first. The second risk faces those who do not annuitise at retirement, but choose to drawdown on their savings. Since we have not investigated drawdown as part of this model we will not cover it in much detail.

The cost of annuitisation

The mortality assumptions used in the model make some allowance for future improvements in longevity. Cohort studies carried out by the Continuous Mortality Investigation Bureau (CMIB) observed that the generation born in the 1930s and 1940s has been experiencing faster rates of improvement in longevity than earlier generations, and it appears that this generation’s mortality experience continues to be lighter than previous generations. The CMIB has produced three sets of mortality tables that assume this rate of improvement will, to some extent, be experienced by subsequent generations:

- A ‘short cohort’ table, which assumes that the faster rate of improvement will continue for 15 years, but then slow down;
- A ‘medium cohort’ table (called PA92 mc), which assumes that the faster rate of improvement will continue for 25 years, and then slow down; and
- A ‘long cohort’ table (called PA92 lc), which assumes that the faster rate of improvement will continue for 40 years, and then slow down.

---

We believe that the medium cohort table represents a best approximation to future longevity, and our ‘central’ set of results is based on this assumption. However, it is possible that rates of mortality will improve faster than has been allowed for, or that improvements included in the mortality basis used to produce the main set of results will continue for longer than expected. It is also possible (although we believe less likely) that longevity will not continue to improve\textsuperscript{15}.

In defined benefit schemes that target a pension, the cost of improvements in longevity will fall in the first place on employers. However, as mentioned above, as the cost of pension provision rises, it is likely that employers will cut back on the level of provision they make, so there is a secondary effect on employees (and some generations of workers gain while following generations get lower pensions). We have not allowed for this in this set of results. Instead we have concentrated on how the extra cost of annuitisation is likely to affect the pension which employees will be able to retire on.

The biggest effect will be in those scheme designs where the whole of the mortality risk lies on the employees’ shoulders—that is, the pure defined contribution scheme and the cash balance arrangements. The model can produce results allowing for different mortality assumptions, but in this part of the report we just present simple outcomes based on the different annuity rates that alternative mortality assumptions produce.

Table 6.1 shows the annuity rates that apply (using the model’s central financial assumptions) at 65, based on mortality rates that we expect would apply to the pensions of those people currently in retirement, compared with our ‘central’ mortality assumption, and the CMIB’s long cohort basis.

\textbf{Table 6.1 Annuity rates at age 65\textsuperscript{16}}

<table>
<thead>
<tr>
<th>Sex</th>
<th>PA92 base table rated by -3 years</th>
<th>PA92 medium cohort (YoB 1965)</th>
<th>PA92 long cohort (YoB 1965)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>18.487</td>
<td>20.732</td>
<td>21.878</td>
</tr>
<tr>
<td>F</td>
<td>19.431</td>
<td>21.584</td>
<td>22.764</td>
</tr>
</tbody>
</table>

By comparing the annuities under the PA92 base mortality table and the PA92 mc table, we see that (assuming our assumptions are borne out, and all else being equal) future generations of pensioner will have to pay about 12\% more for an annuity than the current cohort of retirees.

\textsuperscript{15} For example, there is more incidence of early onset diabetes, which could reverse recent improvements, and an influenza pandemic is (statistically) overdue.

\textsuperscript{16} The annuities allow for the pension to continue to be paid to a dependant on the death of the pensioners at the rate of 50\%, and increase in payment in line with LPI with a 2.5\% cap.
Comparing the annuities calculated using the PA92 lc and PA92 mc mortality tables, there is a further increase of about 6%. Thus, if rates of longevity improve for longer than we have anticipated in the central results of this model, resultant replacement rates under pension schemes that target a lump sum benefit (including pure defined contribution) would fall by about 6%.

Another way of illustrating this is to consider how costs would change if people’s longevity increased by one year. Under our assumptions, the cost of retirement at age 65 increases by about 2% for each extra year of life. This is relatively low, because the additional year of life is the last year of life and so the effect of inflation and investment growth makes it relatively easy to afford.

A limitation with this analysis, however, is that although improvements in longevity occur gradually, they have sometimes only been identified when they have become significant. If improvements occur faster than expected, they are therefore difficult to plan for, and consequently perceived as expensive to offset.

If improvements were to emerge gradually, then it would not be so difficult to adjust the level of saving or the age of retirement to compensate. A potentially more significant and abrupt change in annuity prices could occur if bond yields fell suddenly. The results in the model are based on a 2% real yield. If the real yield available from bond investments fell to 1%, the cost of a pension would increase by about 12%; if real yields increased to 3%, then the cost of the same pension would fall by about the same amount (see Table 6.2).

### Table 6.2 Annuity rates at age 65

<table>
<thead>
<tr>
<th>Sex</th>
<th>Real yield 1%</th>
<th>Real yield 2%</th>
<th>Real yield 3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>23.466</td>
<td>20.732</td>
<td>18.473</td>
</tr>
<tr>
<td>F</td>
<td>24.554</td>
<td>21.584</td>
<td>19.146</td>
</tr>
</tbody>
</table>

**Drawdown**

If people choose to drawdown their savings when they reach retirement, rather than buy an annuity, then they continue to be exposed to all the risks that they were exposed to previously (for example, investment and inflation). They also have to manage the timing of their annuity purchase (even if mortality expectations remain the same, annuity costs are dependant on bond yields, which could fall) and are exposed to two new risks: deciding the rate at which they drawdown on their saving and ‘mortality drag’.

As we have seen, the investment and inflation risks can be controlled by an appropriate choice of investment. However, the other risks are more challenging. The effect of former of these two new risks is obvious – if people underestimate their longevity then they will have no savings to support them in their final years. The latter is more subtle.
Mortality drag is the extra cost incurred by those who purchase their annuities at older ages, because they lose the benefit of cross subsidy from those purchasing at a younger age and dying earlier than expected. Under a drawdown arrangement, death at a young age creates funds for inheritance instead of contributing to the cross subsidy had the fund been annuitised – the drawdown system thus ‘leaks’ resources away from the cohort in retirement.

6.3 Fall in financial markets

The effect of a fall in financial markets will be felt most immediately, and most obviously, by those with pure defined contribution provision. It is trivial to see that members of pure defined contribution schemes, whose funds fall by 20% immediately prior to retirement, will only be able to afford a pension 20% less than they had previously expected. The effect of this would be mitigated if the fall was restricted to equity markets only, and the member had either invested largely in bonds or followed a lifestyling strategy in the years up to retirement. However, by pursuing this strategy, the member also has to forgo the opportunity of equity outperformance in the last few years of their working lifetime.

Chart 6.1 compares the difference in possible outcomes between two defined contribution scheme members, one of whom chose to switch into bonds in the 5 years prior to retirement and the other choosing to remain with 70% equity exposure. The distribution of outcomes is narrower for the lifestyling strategy and, whilst the no lifestyling strategy produces a small number of outcomes that are much higher than the lifestyling strategy, it also produces a significant number with replacement ratios that are lower. Which set of possible outcomes a member would find most appealing will depend on their attitude to risk.

Following retirement, there are different strategies open to members, provided the scheme rules do not require them to annuitise their fund immediately. For example, they could defer retirement and, if they are able, make additional pension savings. Alternatively, they could draw down on their fund, hoping that their investments will recover sufficiently to provide a larger pension eventually (bearing in mind this is not a risk free option, given the consequent risks mentioned in the previous subsection).

Members of cash balance schemes where part of the annual bonus depends on the fund’s performance will also be affected, but who is affected will depend on the scheme’s design. The model’s scheme has two triggers to determine bonus payment; first the underlying investments must amount to more than the member’s accumulated liability; secondly, the average surplus over the past three years must be positive. So any financial consequences arising from a fall will be shared over at least those members within three years of retirement, and possibly more, depending on the speed with which markets recover. Chart 6.2 illustrates the effect when the fall in the underlying investments occurs close to retirement. The results were obtained using fixed financial assumptions (i.e. the deterministic approach).
Members of other defined benefit schemes will experience the secondary effects described in the previous sub-section on mortality risks.

The consequences of a fall in investment markets can be mitigated if the member can defer retirement until their account balance recovers, although this is less likely to be an option in a cash balance scheme where the employer carries some of the
risk. However, under this design, members are protected against falls in their scheme’s investments. The ‘recovery’ could be via making additional contributions or through improved investment performance. There might also be a small gain from buying the annuity later (only about 3% for each year deferred at age 65 and less at younger ages, assuming the annuity basis remains the same). However, if the investment fall occurs only shortly before reaching the scheme’s normal retirement age, there might not be the opportunity to continue in work, which is likely to be a necessary condition for making additional contributions.

Large falls in investment values have not happened often since the middle of the 20th century and, when they did, markets tended to recover quite quickly. The crash in 2001 has been an exception to this general rule. The results in Chart 6.2 show how the cash balance and bonus scheme protect members against market falls, to some extent, particularly compared to pure defined contribution arrangements. If the majority of people with pension savings are going to be in defined contribution type schemes in the future, then this type of protection will become increasingly important, not just from the individual’s point of view, but also from a more general aspect.

Chart 6.3 shows how the FTSE all share total return index has performed over the past 20 years. Significant falls occurred in 1987 and 1998, but in both cases markets recovered within the year. However, the loss in investment values that occurred after 2000 has still not been recovered. It might be reasonable to view 1987 and 1998 as shocks that people could adapt to, for example by deferring retirement for a short period. In cases where retirement could not be deferred, only a relatively small number would have been affected since those retiring in the previous and the following year would have seen their investments recover. However, it is harder to defer retirement for extended periods and, with each year the market fails to recover, a new group of people reach retirement faced with the dilemma of retiring with a lower pension than they anticipated.

In 2000, people were retiring on historically high levels of pension, to the extent that pensioners, as a class, were no longer (proportionately) the poorest group. This affect was partly a consequence of mature final salary schemes with surpluses, which enabled employees to retire not only with long service, but in some cases with augmented benefits.

Since 2000 employers have become much more aware of the possible repercussions from this type of generosity and many more employees have access only to defined contribution schemes where there is no risk sharing. If the investment market trends apparent at the start of the 21st century continue and markets continue to stagnate,

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17 For example, if investment markets fall (or rise) unexpectedly, then those workers just reaching retirement will all be affected, leading to cohorts of relatively poor (or rich) pensioners.

or fall further, then future generations of retirees will drag down average pensioner incomes so that the elderly become exposed to disproportionately high levels of poverty. Once people have reached retirement, their opportunities to save are severely curtailed.

Pension scheme design on its own cannot prevent this occurring, although risk sharing between employees and employers via hybrid arrangements can mitigate its effect.

Chart 6.3

FTSE All Share Total Return Index

6.4 Scheme closure

A risk to employees that has often been understated in the past is that their scheme is wound up before they reach retirement. The greatest risk arises when defined benefit schemes are not sufficiently funded to buy out the accrued liabilities. The obligation recently imposed on solvent employers to fund wound up schemes to full buy out cost\(^{19}\), and the Pension Protection Fund established under the Pensions Act 2004\(^{20}\), have curtailed these risks. However, if a scheme closes to future accrual and there is no replacement, employees are still left without employer savings for the remainder of their working lifetime. They are particularly exposed if their employer becomes insolvent and, because of straitened financial circumstances, they lose the ability to contribute themselves.

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\(^{19}\) The Occupational Pension Schemes (Winding up and deficiency on winding up) (Amendment) Regulations 2004, SI2004/403

\(^{20}\) The Pension Protection Fund came into force on April 2005.
In this sub-section we look at how the results are affected if employees have to leave their pension scheme in the five years immediately prior to retirement. We assume that their accrued benefits will be ‘preserved’ under the rules that apply to the scheme they are a member of when it closes, until the members reaches the scheme’s ‘normal pension age’.

Chart 6.4 shows how the loss of the last five years of service can affect income in retirement. The cases illustrated are for a 45 year old in a scheme with a retirement age of 65. The ‘stayer’ remains in employment and continues to accrue pension until age 65; the ‘leaver’ stops accruing or contributing to their pension aged 60 but cannot receive pension until age 65, so 25% of the person’s potential ‘pensionable service’ is lost\(^{21}\). In each case the fall in the replacement ratio is about one quarter (that is, the benefit of the ‘leaver’ is about 75% of the ‘stayer’s’ benefit). This was expected, since we have assumed that at older ages there is little or no real salary growth and, in defined benefit arrangements, statutory revaluation ensures that the benefit will be increased in line with inflation (the LPI cap of 5% in deferment has no effect in the deterministic model).

The proportion of benefit lost for the member of the defined contribution scheme is less than 25%. This is because the closer contributions are paid to the time when benefit is drawn-down, the less they contribution to the total benefit, due to compound interest (as mentioned in section 3.19).

Chart 6.4

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\(^{21}\) This ignores the possibility that the employee continues to be employed and makes contributions to a personal pension scheme.
6.5 Conclusion

Shocks, by their nature, are difficult to avoid. The likely consequences to scheme members can be mitigated either by the employer through the choice of scheme design, or, where the employee bears the risk, by judicious choice of investments. However, some risks cannot be removed entirely.

The most difficult risks to avoid are longevity risk, prior to annuity purchase, and longer term investment risks. These risks are borne entirely by employers in defined benefit schemes targeting pensions rather than lump sums (that is, the final salary and career average schemes). In defined contribution schemes, the employee bears these risks, particularly if they defer annuitisation.

When a ‘shock’ becomes a long term shift in market values, which seems to be happening following the fall in equity markets in 2001/2, the cost of adjusting to the consequence is even harder. Employers have responded to the extra cost imposed by closing final salary schemes, sometimes replacing them with defined contribution schemes with lower contributions than would be required to maintain the final salary benefit. The contributions, however, would probably not be dissimilar from the estimated cost of their final salary schemes when they were first opened. Employees appear to be slow in understanding the effective reduction in pay this represents, and have not (so far) increased their own saving to compensate.
7 Conclusions

No single pension scheme design will suit everyone in every circumstance. The designs used to produce the results in this report cover the whole spectrum of risk sharing, from most risk placed on the employer (usually meaning its shareholders) in the final salary design, to most risk placed on the employees. The ‘residual’ risks in each case have not been considered in the report. These are:

- The risk that the employer will become insolvent whilst the scheme is underfunded, which would reduce benefits available to members of a defined benefit scheme;

- The risk that employees become disaffected by poor benefits secured under a defined contribution scheme, which could also become a problem for employers with hybrid schemes if the risks are not properly managed and explained.

The pure defined contribution scheme seems to produce the best outcomes in most cases, but also gives the highest probability of a poor outcome. The cash balance with bonus scheme appears to mitigate the worst effects of pure defined contribution benefits, but the design has echoes of with profit arrangements that are currently facing severe criticism for their opacity.

Both these designs pass on mortality risk to employees, whereas other risk sharing schemes, such as the nursery and defined contribution top up schemes shared this, as well as the investment risk, with the employer. However, their degree of risk sharing differed according to age of joining (the nursery scheme) or rate of pay (the top up scheme). Whether this is desirable (to employees or employers) will depend on various factors including:

- The employer’s objectives regarding pension provision;

- The employees’ age and salary profile.

The final salary and career average schemes involve the least risk sharing. Of the risks considered in this report, the only risk borne by employees is salary growth under the career average scheme, but as we have mentioned, employees also carry the risk that the employer will become insolvent when the scheme is not fully funded. This risk is reduced by the Pension Protection Fund.
However, the risks borne by the employer are quite extreme. Both the longevity risk and the long term investment risks, which cash balance plans pass on to employees, are difficult and expensive to mitigate. The consequence of this is demonstrated by the lower median replacement ratios these schemes provide, relative to pure defined contribution provision.

None of the results presented are unexpected, although the implications of different working and salary histories have probably not been fully thought through previously. For example:

- The cross subsidy that final salary schemes are suppose to impose from people with flat salary progression to those with higher salary progression is overstated due to the simplistic salary growth assumptions often used in funding bases.

- Career average schemes provide close to final salary benefits for people with flat salary progression and, if they have higher accrual, will give higher benefits for people in this class.

- By pooling investment risks and managing bonus distribution, cash balance with bonus plans are able to provide access to risky investments, and thus the possibility of higher rates of return, without passing on all the downside risks to employees.

- Each design produces a different outcome and shares risk differently, depending on age of joining, salary and working history and age of withdrawal – so no design can produces the ‘best’ solution for all types of employee.

For those employees who want a certain level of benefit, and measure the certainty in terms of fractions of final salary, only one type of scheme will do. But final salary schemes place all the risks of pension provision on the employer’s doorstep and shareholders are increasingly reluctant to provide the capital to support these risks. On the other hand, the simple solution for shareholders is a pure defined contribution scheme (putting to one side ‘soft’ issues to do with employee relations, for example), since they require no capital support, but these impose the greatest risks on employees.

Some form of risk sharing would seem a good compromise, but the ‘right’ balance of risk will be hard to quantify, as well as to allocate, not just between employers and employees, but also between different types of employee.
8 Appendix 1

Pension Scheme Structures

8.1 Background

The purpose of the project was to compare the risk and variability in outcome between different pension schemes. To enable a direct comparison between different scheme designs, it is important that they are each similar in terms of overall cost. However, because the pattern of accrual in defined contribution and defined benefit schemes can be very different, it is impossible for all the designs to have identical cost characteristics.

For example, when employees join a defined contribution scheme, usually they will be expected to make a contribution out of their salary and the employer will also make a contribution on their behalf. The total contribution paid determines the cost of providing the scheme benefits (ignoring administration and investment charges). In most simple designs, the level of employee and employer contribution is fixed and independent of age or service, so that the cost of providing benefit to an employee aged 30 is the same as the cost of providing the benefit to an employee aged 60.

When employees join a final salary scheme, whilst they might be expected to make a contribution and their employer will also contribute, it is probable that the combined contribution does not directly reflect the cost of accruing benefits. A 30 year old member will accrue benefit in respect of a year’s service that will not need to be paid as pension for perhaps 35 years, whereas a 60 year old on the same salary will accrue the same pension in respect of that year’s service, but the pension must be paid in 5 years’ time. Even after allowing for future salary growth, the cost of the 60 year old’s accrued benefit is higher than the cost of the 30 year old’s, all else being equal. However, both members will make the same contribution to the scheme and the employer will pay a single contribution rate on behalf of all scheme members.

To enable the comparison, we have devised a ‘model’ membership and chosen each scheme’s accrual rate so that its design gives rise to the same total liability as a straightforward defined contribution arrangement.
We have assumed that the total contribution rate paid on behalf of all employees will be 15% of pay. The contribution rate was chosen because the Pensions Commission’s report\(^2\) estimates that almost everyone over age 35 should be saving more than 10% of their pay to reach replacement ratios appropriate for their level of pay, taking into account their entitlement to state pension. However, the Commission’s analysis was based on investment assumptions that included an allowance for equity out-performance relative to more secure investments such as gilts or high quality bonds. Whilst this is a plausible investment strategy for long term savers to pursue, necessarily some groups will not hit their retirement goal. To introduce more certainty into our ‘benchmark’ pure defined contribution scheme, we have estimated a contribution rate that provides a reasonable target pension, together with state benefits, based on less risky investments.

To enable comparisons between schemes, however, the actual level of contribution is not important, since it is the relative values of each benefit that matters.

The model scheme membership was used to determine what the contribution would accumulate to if paid to a defined contribution scheme over the future service of all members, assuming the contributions were all invested in bonds. This value was taken as the ‘target’ liability and the accrual rates of the defined benefit, or hybrid, schemes were determined so that, given the same membership, the future service liabilities accrued would equal the size of the defined contribution fund.

This approach has certain difficulties. The most apparent is that, whilst the contribution rate paid to a defined benefit scheme is on average correct, for younger members it will be greater than is necessary to secure the benefits and for older members it will be less, as described in paragraph 3. The other side of this coin is that the contribution rate being paid to a defined contribution scheme will be ‘higher’ than necessary for younger members, but not big enough for older members, to secure the equivalent benefits in a defined benefit scheme. So when we look at the results for individuals who join at different ages, this must be taken into account. Table 8.1 indicates the contribution rate required at different ages, based on the model’s assumptions and the final salary scheme’s benefits.

### Table 8.1 Contribution rates at different ages required to fund the final salary benefit

<table>
<thead>
<tr>
<th>Age</th>
<th>Contribution rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>11%</td>
</tr>
<tr>
<td>35</td>
<td>13%</td>
</tr>
<tr>
<td>45</td>
<td>15%</td>
</tr>
<tr>
<td>55</td>
<td>17%</td>
</tr>
</tbody>
</table>

\(^2\) Pensions: Challenges and Choices; First report of Pensions Commission, HMSO, 2004
8.2 The model scheme membership

The model membership was taken from a composite of several schemes, with some adjustments to simplify the data and adjust for scheme closures. Membership and salary data has been grouped together in 10 year age bands. The average age of the scheme members, weighted by salary, is 44. The profile of the scheme, including average salary, is given in table 8.2.

### Table 8.2 Scheme membership

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Average salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>150</td>
<td>£20,100</td>
</tr>
<tr>
<td>30-39</td>
<td>370</td>
<td>£24,100</td>
</tr>
<tr>
<td>40-49</td>
<td>450</td>
<td>£28,200</td>
</tr>
<tr>
<td>50-59</td>
<td>260</td>
<td>£26,500</td>
</tr>
<tr>
<td>60-64</td>
<td>90</td>
<td>£25,500</td>
</tr>
</tbody>
</table>

The defined contribution liability used to determine the benefit structures in the other schemes was calculated assuming the total contribution was invested in bond type investments and accumulated to retirement age. Contributions were paid and accumulated over the entire future working lifetime of the membership, allowing for future salary growth and probabilities of survival, allowing for both death and withdrawal. The mortality assumption included some allowance for future improvements in mortality. The withdrawal assumptions approximate to those that would be used for a typical private sector scheme, although these tend to vary widely and are often not based on in depth analysis of individual scheme experience. For example, we assumed there was a 50% chance someone in their twenties would leave the scheme prior to reaching retirement age, and a 15% chance that someone in their forties would.

The cost of the benefit at retirement allows for Limited Price Indexation to the pension in payment, capped at 2.5% (that is, the LPI that the Pensions Act 2004 put in force for defined benefit scheme accrual after April 2005), and includes a 50% dependent’s pension.

Although some improvement in longevity has been allowed for in the annuity basis, we have assumed that the other costs of annuitisation will be similar to that today (that is, based on the bond rates and inflation assumptions used in the model, which are drawn from current market rates). The possibility of taking a lump sum has been ignored, since the aim of the model is to compare the income-producing potential of different designs.

In all cases, benefits on death or withdrawal have not been explicitly valued. Implicitly this means that the benefit paid would be equivalent to the reserve held in respect of the member, which is exactly the case under a defined contribution arrangement and broadly true in respect of withdrawal benefit from defined benefit schemes.
8.3 The pension schemes

There are seven pension scheme structures in the model.

**Defined contribution (DC)**

The employee’s contribution rate is 5% and the employer’s contribution rate is 10%. The contributions are invested in funds made up of a mixture of bonds and equities. The results include outcomes for a variety of investment strategies, ranging from 100% bonds to 70% equity and 30% bonds, and also include a Lifestyle strategy. At retirement, members are assumed to purchase an annuity that increases in line with LPI with a 2.5% cap, and has a 50% reversionary (dependent’s) pension.

**Final Salary**

The accrual rate is 1/107th of salary for each year of service; the employee’s contribution rate is 5%. Normal pension age 65, but it is possible to investigate the effects of early retirement also, since an early retirement reduction of 6% per annum has been included. The pension at retirement is assumed to increase in line with LPI with a 2.5% cap, and continues at 50% to a dependent on death.

**Career average**

The accrual rate is 1/104th for each year of service and the employee’s contribution rate is 5%. The pension accrued each year is revalued in line with prices with a cap of 5% per annum (that is, similar to statutory Limited Price Indexation for final salary pensions in deferment). The scheme’s normal pension age is 65. The pension at retirement is assumed to increase in line with LPI with a 2.5% cap, and has a 50% reversionary pension.

**Cash balance**

Results from two different cash balance plans have been included.

The first scheme targets a lump sum of 20% total revalued pay at 65, where the rate of revaluation is the same as applies in the career average scheme (that is, inflation with a 5% cap).

The second scheme targets a lump sum of 17.3% total revalued pay at 65. The rate of revaluation is the same as in the previous example, but the trustees aim to allocate a discretionary bonus from time to time depending on the performance of the underlying assets. The cost to the employer of maintaining the higher rate of bonus, relative to the ‘plain vanilla’ cash balance is recognised via the lower accrual rate.

In both cases, the member contributes 5% of their earnings. At retirement, in both cases, members are assumed to purchase an annuity that increases in line with LPI with a 2.5% cap, and has a 50% reversionary pension.
Nursery

At ages less than 45, members join the DC component of the nursery scheme with an employee contribution rate of 5% and an employer’s contribution rate of 10%.

After age 45 the member joins the final salary component of the nursery scheme, which has an accrual rate of 1/108th for each year of service.

The characteristics of the DC and final salary sections are the same as for the pure DC and pure final salary scheme, apart from the accrual rate in the final salary section.

Defined Contribution top up

Members receive both a final salary and a DC benefit.

The final salary section applies to members’ pay up to twice the Lower Earnings Threshold (LET) – which we will call the ‘top up threshold’. The LET is the point at which the accrual rate under the State Second Pension reduces from 40% to 10% and is indexed to earnings. It is £11,600 in 2004/5, so the top up threshold is roughly median earnings. The final salary benefits accrue at the rate of 1/107th for each year of service.

Those who are paid above the top up threshold have a contribution paid into a DC arrangement. The contribution totals 15% (as in the pure DC scheme) and is levied on salary above the top up threshold only.

In all cases pensions in payment are assumed to have Limited Price Indexation, with a cap of 2.5%, and include a 50% reversionary pension.
9 Appendix 2 – Employment history structures

9.1 Economic activity rates

Economic activity’, when applied to individuals, is a measure of those people of working age who are either in paid employment, or actively seeking paid employment. Colloquially, those who are economically active can be said to make up the ‘labour force’ although not all of them will be working at any given time. If someone is economically inactive, then it can be assumed that they do not seek paid employment. This could be out of choice, for example because they prefer to fulfil caring responsibilities such as raising children, or necessity, for example because they are not fit enough for work and are claiming incapacity benefit. People aged less than 16 or retired are also counted as economically inactive.

Economic activity rates vary by many factors. Those depending on individual circumstances include age, gender, area of residence and level of skill, but there are also macro economic influences, such as how efficiently the market system is operating. If we were to take all these variables into account the model would become very unwieldy. Since the intention is to consider outcomes for individuals, without regard to wider influences, we have ignored macroeconomic factors and chosen to concentrate on age and gender, since these are likely to be more important than the other factors that apply at the individual level.

9.2 Rates of economic activity amongst women

The rates at which women participate in the workforce are strongly influenced by societal, or cultural, norms. Young women are just as likely to be economically active as young men, but once they start having children they reduce their level of participation, either by removing themselves entirely from the workforce or by reducing the number of hours spent in paid employment. Amongst older women, other influences come into play, including more outdated notions about a ‘woman’s place’.
Changes in society will mean that these influences affect different cohorts of women differently. Since the Sex Discrimination Act was published in 1975 it has become less acceptable to expect women to leave work when they marry and improvements in employment protection following pregnancy mean that many women have remained in work once they have had children. If better childcare becomes more widely available, then we should expect the proportions of women remaining in the labour force will increase.

The current situation (shown in Chart 9.1) is that, between ages 25 and 34, women’s economic activity rate is 75% compared with men’s rate of 91%. At younger and older ages the difference between rates of participation on the labour market are narrower but, in general, women’s economic activity rates remain about 10% less than men’s²³.

The large gap between men and women’s participation in the labour force between ages 25 and 34 is probably due to family circumstances. Women are, on average, aged about 27 when they first give birth²⁴. Although a large proportion of women do return to work shortly after giving birth, they are about twice as likely to do so on a part time, rather than full time basis²⁵. However, more than 40% of those with children aged less than 5 do not enter the labour force at all.

²³ Labour Market Trends, Vol 112, No. 8, Office for National Statistics, August 2004, Table D1
²⁴ Social Trends 34, Office for National Statistics, 2004, Table 2.21
²⁵ Social Trends 34, Office for National Statistics, 2004, Table 4.5
Once a family’s youngest child has reached secondary school age, women’s participation rates have crept up a small amount: the trend appears to be that as children grow up mothers are more likely to enter the labour force, and more likely to be in full time employment. However, the proportion in part time employment is quite stable, particularly for mothers who are married or cohabiting.

The fall in those who are economically inactive is largely absorbed by an increase in those in full time work. It seems likely that those who have been in part time work increase the hours they work, whilst new entrants join the workforce on a part time basis, but we could find no hard evidence to support this.

Another factor that could explain why women remain in part time employment is that, women aged between 25 and 45 are much more likely to be ‘informal carers’26 (that is, care for someone other than their own able but dependent children). It is possible that they fall into this role by default, because they are, in any case, fulfilling a caring role. Then, even though their children have grown up, it is harder for them to relinquish the responsibility for their other dependents, and so they are less likely to return to full time paid work.

Women with no dependent children aged less than 18 have economic activity rates that are not significantly different from the average rates for men. However, although they are more likely to be in full time employment than other women, they are still about three times as likely as men to work part time27.

9.3 Job tenure

Since 1975 the average length of time spent with a single employer has not changed much28, but this masks changes in the underlying distribution of job tenure. Average job tenure (5½ years) has been buoyed by an increase in the time spent with a single employer by women with children, partly due to women taking advantage of improved maternity provision, whereas for men and for women with no children, the length of service has fallen.

9.4 Retirement from work

Although most pension schemes have a ‘normal pension age’ of 65, many people have left the labour force prior to this age. Above age 50, economic activity rates are about 10% less than they are between ages 35-49, for both men and women. It is likely that this move out of the labour force starts slightly after age 50 since the proportion of income due to wages and salaries received by those aged 35-44 and those aged between 45 and 54 is very similar (78% and 77%), whereas for those

26 Op cit, Table 8.3


aged between 55 and 59 it has fallen to 57%, although 10 percentage points of this fall is replaced by income from self employment. Above age 60, the percentage falls further, to 34%. Although again a small part of the fall is replaced by income from self employment\textsuperscript{29}, the picture is more confused since a high proportion of women stop work at or around 60, when they first become eligible for state pension.

Despite the heterogeneous group used to produce these tables, this pattern can be explained by people, sometimes voluntarily and sometimes not, ‘phasing’ themselves out of the labour market, starting from age 55, and then more steeply between 60 and 65. The average age of retirement is 63.8 for men and slightly less than this for women\textsuperscript{30}.

9.5 Working histories

Based on this analysis, we have chosen the following working histories, all starting from age 25:

- ‘Full time’ history where the individual is assumed to be in full time work throughout their working life (no breaks) until age 65.

- In addition, the ‘Full time with moves’ employment history (used in one particular stage in the report\textsuperscript{31}) will have job moves at ages 26, 28, 31, 36 and 46. Ignoring employment prior to age 25, the average tenure of this working history is 5.9 years, assuming people remain employed until age 65.

- ‘Part time and breaks’ will start with part time work until age 30 followed by 5 years out of the labour force and then a gradual return via part time work. Between ages 55 and 65 participation rates will be 80% of full time participation.

- ‘Full time and break’ will start with full time work until age 30 followed by 5 years out of the labour force and then an immediate return to full time work.

- ‘Flexible retirement’ will start with full time work until age 55, followed by 75% participation between 55 and 59 and 50% from ages 60 to 64 inclusive.

The first and latter three working histories do not involve job moves. In the second, the model assumes that they leave a deferred pension behind in their previous scheme. An alternative would be to assume that they take a transfer value to a personal pension scheme, for example. Notionally, the transfer value should provide a benefit of equivalent value to the deferred pension. However, transfer values are

\textsuperscript{29} Social Trends 34, Office for National Statistics, 2004.

\textsuperscript{30} Pensions: Challenges and Choices, the First Report of the Pensions Commission, HMSO, 2004, Table 2.8

\textsuperscript{31} This working history is compared with the ‘full time’ (without moves) working history to consider the effect of removing the salary link on accrued pension, in the context of the final salary scheme, when someone becomes a deferred member.
not calculated on a risk free basis and are usually used to provide benefits on a money purchase basis, so this will not always be the case.

9.6 Earnings growth

The average gross weekly earnings for full time employees climbs steadily with age, peaking between ages 40 and 49, after which it declines. This feature is shown in Chart 9.2. The pay of both men and women follows a similar pattern, but it is far more marked for men. This is largely a cohort effect, since most (but not all) people do not experience a fall in real (relative to prices) pay as they age.

The national average earnings index continues to increase, year on year, so it is likely that (at least to some extent) the dip in pay after age 50 is due to a cohort effect, rather than to falling rates of pay. We have tried to combine these features in our estimates of salary growth by allowing for promotional increases up to a fixed age, and inflationary increases thereafter.

However, not all groups of employees experience the same pay patterns during their working lifetime. For example, we can see from Chart 9.2 that, on average, women’s pay follows a flatter progression with age than men’s, increasing less fast, but falling back at a slightly lower rate. However, there are reasons other than gender for this difference.

Chart 9.2

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Chart 9.3 shows average weekly earnings by age, by a person’s highest educational qualification. The data in the chart is not directly comparable to Chart 9.2, since the age groups are different and people aged over 60 are excluded. However, it is clear that the ‘higher’ the qualification, the steeper the upwards slope of the earnings distribution is and the less the decline at later ages.

**Chart 9.3**

<table>
<thead>
<tr>
<th>weekly earnings of full time employees by highest qualification and age</th>
</tr>
</thead>
<tbody>
<tr>
<td>£</td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>700</td>
</tr>
<tr>
<td>600</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>300</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>21-25</th>
<th>26-30</th>
<th>31-35</th>
<th>36-40</th>
<th>41-45</th>
<th>46-50</th>
<th>51-55</th>
<th>56-60</th>
</tr>
</thead>
<tbody>
<tr>
<td>degree or equivalent</td>
<td>higher education</td>
<td>A level</td>
<td>GCSE</td>
<td>other qualifications</td>
<td>no qualifications</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chart 9.4 shows the obverse of Chart 9.3, that is, the rate at which earnings differ between age groups, broken down by qualification. Although this is based on a snapshot view, rather than following individual cohorts through their working histories, it seems clear that those with higher qualifications experience higher rates of earnings growth, and growth remains positive for longer.

Historically, men tended to gain higher levels of education than women, so part of the difference between men and women’s salary progression can be explained by educational differences. Women also tend to progress less far in their careers than men, and to revert to lower skilled jobs after maternity leave, which could also explain part of the difference. However, both these features might be partly due to cohort differences. In the past few years more women have entered higher education than men, and an increasing proportion of middle managers are now female, so it is possible that the differences in male and female career paths will decline.

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33 Graduate and non-graduate earnings from the Labour Force Survey (Spring 2003), www.prospects.ac.uk
Another complicating feature is the difference in salary progression between private and public sector workers.

This data seems to show that public sector workers do not experience the same falling off in pay as private sector workers. This could affect women’s pay profile, since a high proportion of public sector workers are female. It could also affect the
relative merits and costs of different pension scheme designs since, for example, final salary schemes are most valuable for those employees whose pay continues to increase close to retirement. However, these differences have not been allowed for explicitly in the model.

Earlier in this Appendix, when looking at economic activity rates, we noted that more women work part time than men. It is well known that part time employees tend to be paid at a lower rate than full time employees. However, we found no evidence to suggest that the rate at which part time pay increases is significantly different to the rate that full time pay increases. Chart 9.6, which shows the average gross hourly earnings for employees on adult wages at April each year, is reproduced from data in Social Trends34 to illustrate this.

**Chart 9.6**

![Chart 9.6](image)

We have allowed for the general features of salary progression in the model by building in three ‘typical’ salary progressions:

- ‘Professional’ earnings path, which assumes that real pay increases (that is, in excess of inflation) at 3% until age 50, after which pay increases in line with inflation only.
- ‘Skilled’ earnings path, which assumes that real pay increases at 2% until age 50, after which pay increases in line with inflation only.
- ‘Unskilled’ earnings path, which assumes that real pay increases at 2% until age 35, after which pay increases in line with inflation only.

The workforce is assumed to be constituted so that, on average and ignoring promotional increases, earnings grow by 1% per annum in real terms.

34 Social Trends 34, Office for National Statistics, 2004, Data for Figure 5.8
10 Appendix 3 – Assumptions and Investment strategy

The financial assumptions used for the deterministic model are set out in Table 10.1. They were based on market conditions as at 30 July 2004.

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price inflation</td>
<td>2.5%</td>
</tr>
<tr>
<td>Average salary increases above inflation</td>
<td>2%</td>
</tr>
<tr>
<td>Promotional salary increases</td>
<td>Between 1% and 3% over inflation</td>
</tr>
<tr>
<td>Equity return</td>
<td>8.0%</td>
</tr>
<tr>
<td>Fixed Interest return</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

Mortality assumptions allow for future increases in mortality and are based on PA92 tables with medium cohort improvements[^35]. Annuity rates have been calculated using fixed interest yields.

The data used to produce the historic results were largely drawn from Datastream:

- Price inflation was drawn from the UK Retail Prices Index
- Salary inflation was drawn from the National Average Earnings, whole economy, seasonally adjusted, index
- Equity returns were derived from the FTSE All Share total return index and the FTSE All Share price index
- The yield on fixed interest stocks was derived from the FTSE Actuaries Government All Stocks total return index

A fund will receive different returns depending on its investment strategy. In the model, therefore, we have to consider what strategy is to be used. This is relevant for the DC, Nursery, Underpin and top-up pension scheme structures. The options we will use in the model are set out in Table 10.2.

Table 10.2

<table>
<thead>
<tr>
<th>Investment Strategy</th>
<th>Percentage of fund invested in equities</th>
<th>Percentage of fund invested in bonds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>2</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>3</td>
<td>70%</td>
<td>30%</td>
</tr>
</tbody>
</table>

For strategies 2 and 3 in the above table, it is also possible to follow a ‘Lifestyle’ strategy where the percentage of the fund invested in equities is reduced in the 5 years prior to the set retirement age. This approach has been used for the results in this report. The reduction was spread evenly over the five year period. For example if the initial proportion in equities was 50%, 5 years before retirement this will reduce to 40% and a year later to 30%. The percentage invested in bonds will increase by the same amount as the decrease in equities.
11 Appendix 4 – The stochastic model

The stochastic output is produced by carrying out repeated simulations based on a stochastic investment model outlined in a paper by Yakoubov, Teeger and Duval36. The model provides equations that enable estimates of the forces of return of key economic variables. The equations were derived from an analysis of the relationships between different parts of the financial market, with the inflation model being at the core and the paper provides a full explanation of their derivation.

The model was chosen partly for convenience, since it is relatively straightforward to program and is well documented. Stochastic models have serious limitations and cannot be expected to predict future market outcomes. By using the model, we do not intend to indicate that it is better than any other, but it is useful in indicating the likely variability in results, which cannot be so easily achieved by any other route.

The equations for fixed interest and cash yields and for salary growth are developed directly from the inflation model. In turn, the yield on equities depends on salary and fixed interest yields. In this way the different parts of the simulation retain economically justifiable relationships, rather than being independent time series projections.

The parameters originally used in the equations were derived from annual data points between 1930 and 1997, but the authors comment on how they would expect them to behave in different economic conditions. We have taken this into account and tested the model against more recent data, adjusting some parameters to allow for expected changes in the behaviour of inflation and investment markets. Broadly this means that the expected values of the time series are based on current market conditions and some volatility has been dampened.

The expected values and variances of the time series are given in Table 11.1

### Table 11.1

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflation</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>Fixed Interest</td>
<td>4.5%</td>
<td>7%</td>
</tr>
<tr>
<td>Equity (total return)</td>
<td>8%</td>
<td>22%</td>
</tr>
</tbody>
</table>

Although the TY model allows for investment drift and is not simply mean reverting, like any stochastic model its projections are potentially compromised by the historic data used to estimate the parameters and the limitations of its formulae. In particular, there is a risk that stochastic models overstate the randomness of movements in investment markets, and thus produce a wider variation of results than we would expect in practice.

However, when put together with a deterministic approach, the output is useful for illustrating the different degrees of risk inherent in different pension scheme designs, under the various investment scenarios, even though they are not of direct practical relevance. To counter this, as well as producing results on a deterministic basis we have produced results based on historic returns, which we use to comment on the reasonableness of the stochastic output.

Charts 11.1 and 11.2 indicate the ranges within which the primary values lie. The range shown was generated from 500 simulations, where the model was used to project returns over a 40 year period. This is the longest period for which results are presented in the report. The results show equities outperforming fixed interest stocks by close to 3.5% on average, and the long term volatility of the yield is just over 20%.

Historically, equity yields have averaged 4% in excess of gilts, with volatility of between 18 and 20% and currently 3 year option prices imply a volatility figure of around 18%pa. We believe that the model provides a good enough fit for its purpose.
Appendices – The stochastic model

Chart 11.1

Chart 11.2