Original Article

The road to buy-out

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ABSTRACT Over the past few years a number of defined-benefit pension scheme sponsors have come to the view that the burden of this commitment is too great. The equity bear market that began in 2001 and which is still with us; the realisation that scheme members are likely to live much longer than previously anticipated; and new accounting rules have all played their part in convincing some scheme sponsors that the most attractive option for them is to have their scheme bought out by a third party. However, the road to buy-out for most schemes is strewn with obstacles. The most notable one is the deficit of assets to liabilities. To make it to their buy-out destination schemes typically either need a massive cash injection from the scheme sponsor, or an investment/contribution plan that would see asset values rise to a sufficient level relative to liabilities at some stage in the future. It is this second route to buy-out that concerns this paper. Here we consider both the likelihood of a typical scheme making it to a funding level where its liabilities could be bought out and quantify some of the factors that might make this more or less likely.

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INTRODUCTION

Defined-benefit (DB) pension schemes have been an important part of the United Kingdom's

pensions and corporate landscape for many years. However, over the last decade the apparent surpluses of the 1990s have given way to widespread deficits, to related concerns about scheme solvency and upon the degree to which schemes can rely on employer contributions. In at least a partial response to these issues the regulatory environment for DB schemes in the United Kingdom has changed, with the introduction of new accounting rules, the introduction of specific objectives for the Pensions Regulator (PR) in the 2004 Pensions Act and the creation of the Pension Protection Fund (PPF) to help insure scheme benefits for DB schemes in the event of bankruptcy of the scheme sponsor.

The extensive deficits, which are a function of the performance of equity markets in this century, the realisation that scheme members will live longer than previously anticipated and the new accounting rules have turned the spotlight not only on the trustees charged with looking after the interests of scheme members but also on scheme sponsors. The scheme sponsors have effectively issued a combination of a nominal and real bond, which will pay a coupon (pension) for as long as these bond holders (pensioners) live. For many the burden of this commitment now looks to be too great; as such many are looking at the option of having this commitment 'bought out' by a third party.

In this paper we use a model of a typical, closed DB pension scheme to analyse the impact of various strategies on reaching a position that would give the scheme sponsor the option to move to a buy-out, subject to the agreement of trustees and the Regulator. The model makes use of stochastic simulation techniques but differs from other models of this kind such as the one in Haberman *et al* (2003).¹ The approach taken by these authors is essentially analytical. Their set-up lends itself easily to stochastic analysis. By contrast our model is based upon a 'bottom-up' aggregation of the pension rights of both past and present scheme members that are all represented by cohorts. This 'bottom-up' approach mimics closely the way in which the liabilities of a typical scheme are constructed in practice by

consulting actuaries. Our approach potentially allows for greater fine tuning of certain parameters, allowing us, for example, to change the earnings or mortality profiles for particular cohorts enabling us to capture a very diverse range of cohort characteristics which, taken together, can facilitate the close approximation of the main features of any real world scheme.

Our model also differs from other models of DB pension provision because we incorporate the scheme sponsor, and its balance sheet, as a key element of the model's structure. This feature of the model allows us to specify a particular 'credit rating' for the scheme sponsor, can allow for the sponsor to fail and allows us to calculate the possible burden on the scheme sponsor given a certain contribution and/or asset allocation strategy.

All the elements of the model can be changed so that we can assess the marginal impact of any change on the probability of being able to move to buy-out over any given time horizon.

However, for the purposes of brevity we analyse the position of our representative scheme at a 10-year horizon as this accords with the Pension Regulator's preferred timeframe for eliminating scheme deficits.

The rest of this paper is organised as follows: we briefly review the related literature in the next section; in the subsequent section we describe the model we use as the basis for our simulations; in the penultimate section we describe the results of our simulations; and in the final section we conclude and summarise our work.

PREVIOUS LITERATURE

Despite the apparent severity of the funding situation faced by many of the United Kingdom's DB schemes today there has been relatively little work in this area aimed at modelling the problem and, in particular, understanding uncertainty. Exceptions to this include Haberman *et al* (2003) who develop a model of a DB scheme to investigate issues relating to contribution rates, asset allocation decisions and which allows for the development of risk-based performance measures and analytics. Driver and Selvaggi (2007)² use a

model of a representative DB scheme to explore: the choice of the discount factor used to evaluate the present value of liabilities; the possible use of cash flow analysis as an alternative to the current mark-to-market approach for analysing the DB funding problem; and the sensitivity of the funding position to changes in pension benefits.

Recent analysis by McCarthy and Miles (2007)³ suggests that the combination of low funding ratios with generous pension insurance may induce trustees to take more investment risk than they otherwise would. This is because trustees are hedged against downside risks but share any pension surplus with the sponsor, which provides incentives for risk exposure. This moral-hazard behaviour may be limited by risk-based levies that impose higher premiums on weaker schemes with riskier investment strategies that are more likely to rely on the public fund – an issue not considered by McCarthy and Miles (2007). The concern with regard to this issue is that this sort of behaviour might increase the potential burden on the PPF.

An exercise undertaken by Blake *et al* (2001)⁴ develops an analytical model of a Defined Contribution (DC) pension plan, in which the ‘benchmark’ is the retirement income that could be derived from membership of a typical company DB plan. Using stochastic simulations that take account not only of the various, relevant key risk factors such as asset returns and interest rates, but also of the risks associated with an individual’s future earnings and the risk of unemployment, the authors experiment with alternative asset allocation rules that are designed, *ex ante*, to achieve a certain, targeted retirement income. Using relatively conventional asset classes, they find that their results are highly sensitive to the choice of asset allocation strategy. Furthermore, Blake *et al* (2001) concluded that the risk inherent in a DC plan for an individual is far greater compared with an ‘equivalent’ DB plan. That is, given an equivalent length of service in the scheme and similar member contribution rates, the risks around achieving a particular level of pension are found to be greater in the case of the DC option. This is because the plan sponsor bears nearly all of

the risks in the DB pension plan; risks that all materialised for DB plan sponsors in the early part of this century.

The model used in this paper is a direct descendent of a model developed by Brigden *et al* (2008),⁵ which in turn builds on the model in Driver and Selvaggi (2007). The model in the Brigden *et al* paper introduces stochastic simulation techniques to the assets and liabilities of a typical UK pension scheme to gauge the impact of adopting a more diverse investment policy on the funding position of the scheme.

THE MODEL

The financial strength of a DB pension scheme depends upon the combination of several factors: the pension obligations it has committed itself to; the pension rights that members are expected to accrue in the future; the expected contributions from the scheme members and sponsoring employer (including any additional contributions needed to reduce pension shortfalls); and the asset mix held by the plan, together with the expected return on this portfolio mix.

Liabilities

In general the pension income received by a scheme member when (s)he retires depends on the following factors:

- their salary (either final or some sort of career average);
- the length of employment service with the corporate sponsor;
- the extent to which the pension promise is adjusted for inflation; and
- the pensioner’s life span.

The DB plan needs to build up enough financial resources to meet pension obligations as and when they fall due. Naturally, therefore, it is important to understand the nature of these obligations and their relationship with the scheme’s pension assets.

The main building blocks underpinning the evolution of the scheme’s pension obligations are similar to those set out in Driver and Selvaggi

Figure 1: Initial pension payments and liabilities (£ million).

(2007). For the sake of brevity, they are not repeated here. Suffice it to say that the liabilities are linked to the pension rights accrued by active and deferred members and to the payments being paid to current pensioners.⁶ Figure 1 shows the evolution of the scheme's expected pension payments and liabilities for our base case scenario. In each year, the pension liability is equal to the present discounted value of all the future pension payments using the AA corporate bond rate as the discount rate. The pension payments represent current payouts to pensioners. Our representative scheme is a relatively immature DB plan. At the start of the experiment, pensions in payment account for only 2 per cent of the overall pension liabilities. In fact the proportion of liabilities that relate to pensions in payment remain below 20 per cent in our baseline scenario for approximately 70 years.

Figure 2 shows, in turn, the initial breakdown of pension payments according to membership status. As pensioners grow older and then die, most of the pension payouts go to those who were deferred or active at the start of the experiment. Payments peak after 33 years and are mainly driven by the benefits associated with deferred members. To keep things simple, we assume our representative corporate sponsor does not expand its workforce during economic

booms or make staff redundant during downturns. In practice, we do not believe this to be a serious limitation since the pension fund we model here is closed to new members.

Following the FRS17 standard we use the current yield on AA-rated sterling corporate bonds to discount future pension promises and therefore calculate the scheme's liability at each point in time. The interest rate on conventional gilts is considered a proxy for the risk-free rate.

Pension assets

One of the key drivers of the pension scheme's funding position is the rate of return that it achieves on its assets and the volatility of these returns over time. In our benchmark case, we assume an initial funding ratio of 80 per cent of liabilities. The funding ratio is calculated as the marked-to-market value of assets divided by the pension liability. The evolution of the scheme's pension assets over time will depend upon the following future:

- investment returns;
- regular contributions from active members and corporate sponsor;
- 'deficiency' payments from the sponsor to reduce pension deficits; and
- future pension payouts.

Figure 2: Initial pension payments (£ million) by type of member.

The annual returns on pension assets depend on both the assumed asset mix and the actual returns on these asset classes. We assume that the scheme holds only five asset classes: cash and deposits, conventional government gilts, index-linked gilts, BBB-rated sterling corporate bonds, and equities. These categories are representative of the most common portfolios held by the UK DB pensions industry. The proportion of the pension scheme invested in each asset category at the beginning of the modelling period and the assumed mean return on each asset class are detailed in Table 1.

For expected returns we use as a benchmark the consensus view with regard to the likely mean return on UK cash, gilts, sterling corporate bonds and equities. For UK cash, an expected annual return of 5 per cent reflects current estimates of the long-term trend in growth rate and inflation for the UK economy. For the portfolio of medium-dated gilts the 5.25 per cent expected yield implies the assumed risk premium, largely related to the uncertainty surrounding future inflation, is 25 basis points. For BBB-rated sterling denominated corporate bonds we assume a credit spread over gilts of 150 basis points per annum. Finally we assume an equity market risk premium of 300 basis points, which

Table 1: Expected return and asset allocation in the baseline, by asset class

Asset class	Mean return (%)	Weight (%)
Cash and deposits	4.75	5
Conventional gilts	5.25	5
Index-linked gilts (Retail Price Index (RPI) adjusted)	2.25	10
BBB-rated corporate bonds	6.75	20
Equities	8.25	60

yields an expected return on UK equities of 8.25 per cent.

Our benchmark assumptions about investment strategy are broadly consistent with recent trends in the asset allocation decisions of DB pension schemes. For example, equities and fixed-income securities represented, respectively, 60 per cent and 29 per cent of the portfolios held by UK private sector DB plans included in the Purple Book 2007. Cash and deposits, in turn, accounted for 2 per cent of pension assets. Additionally, in our model the assets held in the fund are re-balanced every year so as to maintain the initial asset mix unless the fund exceeds its funding target for that year.

One of the main purposes of this paper is to understand the extent of uncertainty surrounding

the DB schemes. It is therefore necessary, not only just to look at the average returns on different asset classes, but also to look at their volatility and the links between different types of assets. To proxy for the risks surrounding future returns on the asset portfolio we assume that investment returns are stochastic with joint normal probability distributions. So the actual values in each year are drawn from a probabilistic distribution. We also specify an underlying variance–covariance matrix for expected returns (see Appendix A).

The scheme sponsor

Contributions to the DB plan come from both active members and the sponsoring employer, and both are paid with reference to the workforce's monthly, pensionable salary. In our baseline scenario both contribution rates are set equal to 6 per cent of this annual salary amount. In addition, the sponsoring employer⁷ is assumed to be a BBB-rated company at the start of the modelling exercise, although economic shocks may cause this credit rating to change. So it enjoys high creditworthiness at the outset of our modelling exercise. In our baseline case, the company's ratio of non-pension liabilities to total assets is equal to 33 per cent, whereas the ratio of pension liabilities to total assets is equal to 50 per cent.

The non-pension liabilities of the company evolve in line with the interest rate paid on its stock of corporate debt. The interest rate faced by the sponsor embodies a risk premium over the current yield on government bonds and this credit spread is, in turn, positively related to the company's leverage (that is, liabilities over assets). Every 3 years the company is required to re-finance its stock of debt at the prevailing rate of interest.

The company's assets are affected by two risk factors: (1) a capital market shock, which is given by the shock affecting the equity market where the pension fund invests part of its assets; and (2) a company-specific shock that affects the value of the sponsor's corporate assets in an idiosyncratic way.

In our model, the market value of the sponsoring company is also affected by the additional contributions that the sponsor makes and by revisions to the present discounted value

of future pension contributions. Therefore, when the value of the firm becomes negative we say that the sponsor is bankrupt.

Contributions and the recovery plan

In order to be realistic, we assume that when the scheme develops a deficit it must come up with a structured recovery plan aimed at paying its deficit off within the following 10 years. This framework sets out a schedule of contributions payable by the corporate sponsor over the stated period. As the scheme is assumed to have a funding gap at the outset, the first review period is in 10 year's time. A recovery plan is drawn up anew every 10 years, as long as the pension assets fall short of the pension liabilities.

In our baseline, the recovery plan is for the pension fund to achieve a 100 per cent funding position after 10 years, that is, at the end of the recovery plan. The scheme aims to close 10 per cent of its initial funding shortfall every year and so the target funding ratio rises linearly from 0.8 at the start of the projections to 1.0 10 years later.

In conjunction with the recovery plan we also adopt a triennial valuation process intended to mimic the way the PR assesses the plans submitted by schemes with funding gaps. This means that the financial health of our hypothetical DB plan is re-assessed every 3 years. Whenever its funding position is worse than the target funding level for that year set out in the respective recovery plan, the regulator must make a choice about how to handle the deterioration.

In our baseline, we assume that the review process triggers an automatic adjustment. Specifically, if in the review year the scheme's funding level lies below the target funding level for that year then the sponsor is obliged to inject additional cash to close 50 per cent of the gap in funding relative to the target. This review process, which takes place as long as the sponsor remains solvent, ensures the scheme does not drift away too far from the funding objective set out in the recovery plan. If, on the other hand, the funding position is above target, then we assume the plan reallocates part of its pension assets to conventional gilts to lock in its improved position. In particular, we assume that for every

percentage point that the scheme is above its funding target there is a 2 per cent increase in gilt holdings and a 2 per cent reduction in equity holdings.

Measuring and portraying uncertainty

Our model allows the DB pension fund to grow in line with the contributions received from both the sponsor and the employees and the stochastic (that is, risky) returns on the pension assets. Within such an uncertain environment, the fund faces insolvency risk because the pension assets may fall short of current pension payments at any given point in time. If a shortfall emerges, and the corporate sponsor is unable to plug this deficit, the pension scheme is economically insolvent.

Realistically, portraying the uncertainty associated with our DB scheme will therefore depend on our ability to model the risks within the system and the connections between them. For the purposes of this study we identify four key sources of uncertainty: the rates of return on different types of financial assets; an idiosyncratic, firm level shock; inflation; and productivity growth (which when combined with inflation will also determine nominal earnings growth). By specifying how these 'random' variables behave, we are therefore able to use Monte Carlo methods to establish the extent of the uncertainty facing the scheme.

Monte Carlo simulations work by repeatedly running (or replicating) a model using a different draw of possible outcomes for the random variables within the model for each replication. If enough replications are undertaken, it is possible to use these possible future outcomes to generate a picture of uncertainty. A key feature of Monte Carlo simulation is therefore the generation of a large number of random outcomes from a given probability distribution, or distributions, to represent and assess the role of risk in the system. In our asset–liability setting, we simulate ways in which the pension assets and liabilities may evolve over time. Each simulation therefore provides us with a possible path of our hypothetical DB plan over the next 100 years. We rely on the results of 2000 such simulations

to proxy for the true but unknown (probability) distribution of outcomes. This proxy distribution is then used to derive risk metrics.

We use these Monte Carlo simulation methods to repeatedly generate values of the following stochastic variables:

- returns on different classes of financial assets;
- an idiosyncratic, firm level shock;
- inflation level; and
- productivity growth.

A key risk measure used to interpret the output of our Monte Carlo simulations is value at risk ('VaR'). The VaR on a financial position represents the maximum likely monetary losses over a certain time period, at a given level of confidence. The confidence level refers, in turn, to the likelihood that we will get an outcome no worse than VaR. Hence, VaR summarises in a single number the risk of loss over a defined time horizon and a given confidence level, α , so that the probability of exceeding this loss is equal to $1-\alpha$.

We adapt the VaR methodology to make it more amenable to the pension problem being considered here. Particularly, for each set of simulations we calculate the terminal surplus or deficit of the scheme underlying each trial and then discount this value back to the starting point of the experiment. The final outcome is, therefore, a full distribution for the present values of surpluses and deficits for each set of 2000 forecasts. The terminal deficits are, therefore, those arising in the year in which the scheme runs out of assets.

However, one problem with VaR is that it captures how bad things can get, say, 99 per cent of the time but it says nothing about the damage caused by the outlying 1 per cent situations – the long tail of risk profiles. As VaR tells us nothing about likely deficits in the presence of very extreme outcomes, or 'tail risks', we also report the expected tail loss ('ETL') in each set of simulations. This risk metric is also referred to in the literature as expected shortfall or tail VaR, and represents the expected value of pension deficits in excess of VaR. Although the VaR provides information on the likely value of the

biggest pension deficit if a bad event does *not* occur, the ETL is what we expect the pension deficit to be if a bad event *does* occur.

The risk metrics complement each other well and together provide a good picture of the losses that may arise under different circumstances. One reason to use both metrics is that while VaR is more widely used, some academics have argued that ETL exhibits superior (coherence) properties to VaR.

Finally, we use these distributions to make statements about the probability of this representative fund making it to buy-out. We assume that a scheme and its sponsor can begin thinking about buy-out once the market value of the scheme's assets represent 125 per cent of the present value of the liabilities, where that present value has been calculated on an IAS19 consistent basis. We believe this to be a reasonable estimate of the cost of buying out a pension scheme, although in practice this value might vary with the shape of the yield curve and other factors and, in particular, longevity estimates.

RESULTS

In this section of the paper we present the results of our simulation experiment for the baseline pension fund in the section Baseline simulation with regard to the scheme's 'desire' to reach a buy-out position after 10 years, from a starting

point of being only 80 per cent funded at the outset of the experiment. In the section The impact of varying baseline assumptions we report on the impact of changing some of the baseline assumptions to show their impact upon the scheme's funding position after 10 year's and in particular the financial burden on the scheme sponsor of the same horizon.

Baseline simulations

Figure 3 indicates that, over the course of 90 years, in at least 95 out of 100 trials the DB plan builds up a sufficient surplus to allow the scheme to be bought out. The median funding ratio reaches 125 per cent in 16 years whereas the fifth percentile achieves this cut-off point 24 years later. The reason that the fifth percentile line is not smooth is because of the assumptions about the funding review that takes place every 3 years. Specifically, in a review year the sponsor of a scheme that is below funding target set by the recovery plan has to inject cash to close 50 per cent of the difference between the target and the actual funding ratio. Schemes at the bottom end of the distribution are more likely to be caught up by this rule, which effectively induces a discrete (upward) jump in the scheme's funding position in that year. The fifth percentile line is much smoother as the funding ratio

Figure 3: Funding ratios in the baseline – median, fifth and 95th percentiles.

approaches 1.0 because revisions are no longer binding.

To interpret the output of stochastic methods, it is important to realise that percentiles are not necessarily tracking the performance of the same fund through time. The scheme underpinning a particular simulation may find itself in different parts of the distribution of funding ratios as we move out further in time. So, for example, a pension fund that finds itself at the fifth percentile of the distribution before a review year might be pushed further down the distribution after the review period if the additional contribution forced its sponsoring employer into bankruptcy.

Figures 4 and 5, respectively, show the distribution of forecasted funding ratios at the end of the first recovery plan and the distribution of the present value of the sponsor's additional contributions over the entire period. These cash injections are extra payments made by the sponsoring company in review years to close part of any pension shortfall at that point in time.

With regard to additional payments, in our baseline scenario almost 50 per cent of the trials result in no additional contributions having to be made by the sponsor. On these occasions the pension scheme achieves well-funded positions without discretionary cash injections from the

sponsoring employer, and makes it to the situation where they might be able to move to a buy-out of the fund on around 28 per cent of occasions. Therefore the range of possible outcomes for our typical DB scheme suggests a relatively benign environment. The number of scheme bankruptcies remains quite low and fully funded positions are achieved in 75 per cent of cases before the end of the first review period.

The probability of making it to buy-out and/or making it to a situation where the scheme is fully funded is one issue. But we must also consider the downside risks in this particular road to buy-out. To illustrate these risks, we calculated the VaR and ETL at the 99 per cent confidence levels, and present these in Table 2. These two metrics are calculated from the distribution of the present value of the fund's terminal surplus or deficit (if the fund goes bust) across all 2000 simulations. We also present statistics that show the percentage of the trials in which the scheme or the sponsor became insolvent/bankrupt over the 92-year horizon together with the median of the sponsor's additional contributions in present value terms.

Our VaR results in Table 2 show that in 99 times out of 100 the pension shortfall of schemes that become economically insolvent will be no worse than about £10 million in present value

Figure 4: Distribution of funding ratios after 10 years – baseline.

Figure 5: Distribution of the present value of additional contributions – baseline. *Note:* This figure gives the distribution of the ratio of present value of additional employer contributions to initial market value of the assets held by the pension plan.

Table 2: Summary indicators – baseline

	<i>Scheme becomes insolvent (%)</i>	<i>Sponsor becomes bankrupt (%)</i>	<i>Median additional contribution £ million</i>	<i>VaR (deficit)</i>		<i>ETL (deficit)</i>	
				<i>£ million</i>	<i>As % assets</i>	<i>£ million</i>	<i>As % assets</i>
Baseline case	3	45	1.6	10	19	15	27

terms, which in our case amounts to 19 per cent of the scheme's initial pension assets. Furthermore, the average pension shortfall attached to schemes that do become insolvent because of extremely adverse outcomes ('tail risks') is in turn £15 million in present value terms, or 28.5 per cent of the scheme's initial assets.

The impact of varying baseline assumptions

But the road to buy-out may not be as smooth as outlined in the preceding subsection. We can see how bumpy that ride could be by adjusting some of the starting conditions and then by rerunning the Monte Carlo simulations. We undertake three thought experiments⁸ here, which relate to the

- initial asset allocation of the scheme;
- longevity of the scheme members; and
- the sponsor's covenant.

Asset allocation

An important source of uncertainty attached to the value of the scheme's financial position is the expected future return on pension assets. To illustrate the risks regarding the asset mix we consider a simple exercise where the initial fraction of assets allocated to equities is set at 20 per cent, rather than the 60 per cent allocation assumed in our baseline case. The 40 per cent withdrawn from equities is, in turn, re-allocated to conventional and index-linked gilts according to their original proportions in the benchmark. The scheme's asset allocation strategy at the beginning of this new set of Monte Carlo simulations is shown in Table 3.

Clearly, this is a much more conservative investment strategy, as 60 per cent of pension assets are invested in cash, deposits and gilts. Switching out of potentially faster-growing (by construction) assets such as equities and into

generally lower yielding fixed-income assets means both expected asset returns and the volatility of these returns are consequently lower.

Figure 6 shows how the median funding ratio for the 2000 simulations together with the fifth and 95th percentiles evolve over the 100 year simulation period, and how they relate to baseline projections. As can be seen, the distribution of funding ratios changes significantly: the range of outcomes is much less dispersed, but it now takes the scheme much longer to reach well-funded positions. The median outcome, for example, hits a funding ratio of 1.25 after 31 years, whereas in the baseline case this funding position was achieved after 15 years. The alternative asset allocation removes most of the upside potential represented by the equity return distribution and therefore even the top quartiles reach buy-out funding levels much later.

Table 3: Revised asset allocation

Asset class	Initial weight (%)	Revised weight (%)	Average return (%)
Cash and deposits	5	5	4.75
Conventional gilts	5	18	5.25
Index-linked gilts	10	37	7.50
BBB corporate bonds	20	20	6.75
Equities	60	20	8.25

However, initially at least, the reduction in the volatility of the return on assets achieved by a more conservative asset allocation means that the funding outcomes for the bottom 5 per cent of schemes (measured by the fifth percentile) are better. Eventually though, the impact of higher returns kicks in, so that the fund at the fifth percentile achieves the funding level needed for buy-out 5 years before the equivalent scheme with a more conservative asset allocation.

In Figure 7 we compare the profile of funding ratios and additional sponsor contributions with those corresponding to the baseline case. Likely outcomes differ markedly and our main findings are twofold. The first thing to note is that on no occasion does the scheme reach a position from which it could consider moving to buy-out. In this case then these starting assumptions lead to a dead end as far as the road to buy-out is concerned over this horizon. However, there is a greater ‘bunching’ of outcomes between a funding position of 90 per cent and just below the buy-out level. This asset allocation might be better suited then to a scheme wishing to take fewer risks and which did not have a 10-year plan to move to buy-out.

Figure 7 also shows that the tail risk is smaller with the greater weighting to bonds – a natural

Figure 6: Funding ratios with alternative asset allocation.

Figure 7: Distribution of funding ratios after 10 years when scheme holds only 20 per cent in equities.

consequence of holding fewer equities. But there is a cost to this greater conservatism with regard to asset allocation and that is that a greater burden is placed upon the scheme sponsor. Table 4 shows that the median additional sponsor contribution increases by 100 per cent in present value terms when compared with the base case (from 3 per cent to 6 per cent of the plan's initial assets). But it also shows the scale of the reduced 'tail risk' reflected in much lower VaR and ETL values.

Longevity

Assumptions regarding people's mortality experiences are extremely important because they impact on the expected amount of time that members will be drawing a retirement income from the scheme. The longer pensioners live the heavier is the financial burden faced by the pension plan and its sponsoring employer. Therefore in this section we study the longevity issue in the following way. We assume that pensioners are actually dying according to the increased longevity scenario. However, when assessing the liabilities of the fund, the trustees do not know this – yet. They believe members of the scheme are still dying according to the baseline scenario. Ten years down the line, the

trustees accept that mortality has improved causing a discrete jump in the present value of scheme liabilities.⁹ Table 5 displays, for the two arbitrary cohorts considered, the life expectancy assumptions underlying our baseline and alternative scenario (for comparison purposes we also show the CMI '92' year-of-birth long-cohort projections).

To examine how the investment strategy followed by the fund during the first 10 years affects its capability to cope with the unanticipated longevity revision we compare the two alternative asset allocations considered earlier; one more heavily invested in equities and the other more heavily invested in gilts. The former strategy offers more upside potential to counteract longevity risks whereas the latter is allegedly less risky. We examine the impact of the longevity shock for each of these investment strategies and the scheme's and the employer's fortunes once the shock to life expectancy becomes evident.

Figures 8 and 9 show the simulated funding ratios when the scheme follows the baseline investment strategy (60 per cent equity, 15 per cent gilts) and a much more cautious asset allocation (20 per cent equity, 55 per cent gilts), respectively. While the fifth percentile of the

Figure 8: Funding ratios with increased life expectancy and baseline asset allocation.

Table 4: Summary indicators – alternative asset allocation

	<i>Scheme becomes insolvent (%)</i>	<i>Sponsor becomes bankrupt (%)</i>	<i>Median add-cont £ million</i>	<i>VaR (deficit)</i>		<i>ETL (deficit)</i>	
				<i>£ million</i>	<i>As % assets</i>	<i>£ million</i>	<i>As % assets</i>
Equity alloc 20%	2	45	3.2	1	2	3	6
Baseline	3	45	1.6	10	19	15	27

Note: The VaR and ETL are measured at the 99 per cent confidence level.

Table 5: Life expectancy in the baseline and alternative cases

	<i>Life expectancy at age 65 for a male member currently</i>		<i>Life expectancy at age 65 for a female member currently</i>	
	<i>Aged 65 (years)</i>	<i>Aged 45 (years)</i>	<i>Aged 65 (years)</i>	<i>Aged 45 (years)</i>
Baseline	20	22	23	24
Increased longevity	25	26	27	27
PXA92 YOB long cohort	23	24	26	27

distribution falls into economic insolvency in both cases. The figures show that the adverse impact of the longevity shock persists longer when the scheme follows a conservative investment strategy. This is because the scheme is not able to reap the potential upside benefits of equity investments.

Lower expected investment returns ultimately translate into much larger pension additional employer contributions, as can be seen in Table 6. The median additional contribution rises from £7

million with the baseline asset allocation to £12 million when the fund follows the more conservative investment strategy – an increase of 70 per cent.

However, the more risky investment strategy also entails significantly higher tail risk. Our analysis highlights serious challenges in reconciling the interests of scheme, sponsor and regulator that need to be appropriately accounted for when investment strategies are designed and evaluated. Simplistic approaches are not likely to provide the

Figure 9: Funding ratios with increased life expectancy and conservative asset allocation.

Table 6: Summary indicators – increased longevity and alternative asset mix

	Scheme becomes insolvent (%)	Sponsor becomes bankrupt (%)	Median additional contribution £ million	VaR (deficit)		ETL (deficit)	
				£ million	As % assets	£ million	As % assets
60% equity, 15% gilts	6	49	7.0	18	33	23	43
20% equity, 55% gilts	7	48	12.4	11	20	14	26

Note: The VaR and ETL are measured at the 99 per cent confidence level.

right answers to an intrinsically complex problem faced by the different stakeholders.

The employer's covenant

We now examine the impact that different levels of sponsor contribution have on the funding position of the scheme and the overall solvency of the pension fund. Figure 10 shows the evolution of the projected fifth percentile of the distribution of funding ratios in four scenarios:

1. the baseline case;
2. the case where the sponsoring employer does not contribute annually 6 per cent of the salary bill for active scheme members each year;
3. the case where there are no additional contributions made by the sponsoring employer; and

4. the case where there is no contribution whatsoever from the sponsor.

Removing the employer's contributions that depend on current salaries paid to active scheme members has no material impact on projected funding ratios so long as the sponsor keeps making the regular additional contributions to close funding shortfalls. However, we find that if our typical DB scheme does not have access to additional contributions from its sponsor then the fifth percentile ends up in economic insolvency, as it runs out of pension assets. Projected outcomes further deteriorate when the sponsor makes no contribution whatsoever.

Figure 11 shows the distribution of forecasted funding ratios in three cases: the baseline case; when the sponsor makes no additional

Figure 10: Fifth percentile funding ratios with alternative contribution levels.

Figure 11: Distribution of funding ratios after 10 years with alternative contribution levels.

contributions; and when the sponsor makes no contribution whatsoever. As can be seen, limiting the sponsor's involvement leads to a significant deterioration compared to the baseline results. In a significantly higher proportion of cases the scheme remains less than 90 per cent funded after the first 10 years.

Finally, Table 7 highlights the importance of the sponsor's contributions for the financial health of the DB plan. The proportion of simulations in

which the scheme becoming insolvent during the period jumps from 3 per cent in the baseline to a stunning 17 per cent in the absence of additional employer contributions. Also, the VaR is twice as big as in the baseline. Outcomes deteriorate even further when the scheme receives no payment whatsoever from the sponsor. In this case, almost one out of four simulations results in an economically insolvent pension fund. Among these schemes, the maximum likely shortfall

Table 7: Summary indicators – different contribution levels

	Scheme goes bust (%)	Sponsor goes bust (%)	Median add-cont £ million	VaR (deficit)		ETL (deficit)	
				£ million	As % assets	£ million	As % assets
No contributions	23	40	0.0	28	52	31	58
No additional contributions	17	40	0.0	23	43	27	50
Baseline	3	45	1.6	10	19	15	27

Note: The VaR and ETL are measured at the 99 per cent confidence level.

amounts to about 50 per cent of the initial market value of pension assets.

Of course the flip side of the coin is that although the likelihood that the scheme fails increases, the likelihood of the sponsor becoming bankrupt falls. However, the improvement in sponsor solvency is limited in comparison, with only an 11 per cent reduction in the likelihood of the sponsor experiencing bankruptcy.

SUMMARY

In this paper we have attempted to quantify the uncertainty surrounding the road to buy-out for a scheme. We have also shown how fairly realistic changes to starting assumptions can increase this uncertainty further still. We believe this sort of analysis can help inform trustees, their advisors and scheme sponsors as they draw up plans to make it to buy-out, or indeed to positions where they might believe their scheme to be adequately funded. However, we should always remember the old maxim – garbage in equals garbage out. No matter how good the structure of the model, but if the assumptions relating to, for example, future equity returns or equity return volatility are garbage, then the results will be too. We have spent a great deal of time making sure that the key assumptions in our simulations are both very conservative and as consistent as possible with current industry thinking, and we are therefore satisfied that our conclusions are valid. However, despite this we intend to continue to use the model in the future to test the robustness of our results to changes in these assumptions.

REFERENCES AND NOTES

- 1 Haberman, S. *et al* (2003) A stochastic approach to risk management and decision making in defined benefit pension schemes. *British Actuarial Journal* 9: 493–618.
- 2 Driver, R. and Selvaggi, M. (2007) Understanding Companies' Pension Deficits. ABI Research Paper 3, March 2007.
- 3 McCarthy, D. and Miles, D. (2007) Optimal Portfolio Allocation for Pension Funds in the Presence of Background Risk. May 2007 (mimeo).
- 4 Blake, D., Cairns, A. and Dowd, K. (2001) Pensionmetrics: Stochastic pension plan design and value-at-risk during the accumulation phase. *Insurance: Mathematics and Economics* 29: 187–215.
- 5 Brigden, A., Clare, A. and Dhar, S. (2008) By how much can a diversified approach to investing improve the prospects of reducing a DB pension deficit? *Pensions: An International Journal* 13(July): 136–150.
- 6 Readers interested in the technical details underpinning our projections of the scheme's future pension obligations are referred to our previous research report and the appendices of this paper. In particular, Appendix A of this paper contains a list of modelling assumptions and Appendix B details our longevity assumptions.
- 7 A more detailed description of the main assumptions underlying our modelling approach to the corporate sponsor can be found in Appendix C.
- 8 For experiments of this nature see Brigden, A., Clare, A., Driver, R., McKersie, M. and Selvaggi, M. (2008) Coping with Uncertainty and the Importance of the Sponsor's Covenant. ABI Research Paper no. 9.
- 9 As an example, a 2008 survey published by the actuarial consultancy Watson Wyatt revealed that nearly half of the FTSE 100 companies sponsoring DB pension schemes have changed their underlying mortality assumptions, adding about £6 billion to their combined pension liabilities.
- 10 For example, the UK Pension Protection Fund (PPF) excludes indexation of benefits accrued before April 1997. The PPF is a UK Government-sponsored safety net scheme established in 2005 to protect members of private sector DB schemes whose firms become insolvent and have insufficient funds to meet their pension obligations.
- 11 The Pensions Regulator. (2007) *Recovery Plans: An Initial Analysis*. London: The Pensions Regulator. September 2007.
- 12 Cohort effects arise when the patterns of mortality improvement are linked to year of birth.

APPENDIX A

Modelling the Pension Scheme

To model key ingredients of the DB pension scheme we consider a number of variables, some of which are deterministic (or non-random) and others are stochastic (or random). Deterministic variables have fixed values throughout whereas the values of stochastic variables may change from one year to the next – their values are drawn from an underlying probabilistic distribution of future outcomes. Table A1 details the modelling assumptions made in this paper for our baseline case.

Non-random variables take the values detailed in this table unless we indicate otherwise. At any point in time, however, random variables may take values different from those shown above because they are constantly hit by (positive and negative) shocks that may create a wedge between annual

values and the long-term averages detailed in the table. Not only are these random shocks realistic, but they also play a crucial role in our analysis as they enable us to generate the necessary uncertainty about the future of the pension fund.

Table A2 contains the variance-covariance matrix corresponding to our nine random variables.

Our baseline scenario supposes that accrued benefits are indexed by RPI inflation since 1988. Hence, most of the payouts shown in the figure are made up of index-linked benefits. Figure A1 illustrates the evolution of indexed and non-indexed pension payments when, for example, the schemes adjust promises by inflation from 7 years before the start of the simulation. At the beginning payments are mainly driven by non-indexed pension benefits, but indexed payouts rapidly become increasingly important.

Table A1: Modelling assumptions for pension obligations

<i>Variable</i>	<i>Description</i>	<i>Type</i>	<i>Baseline assumption</i>
Workforce	Quantity of people employed each year by the corporate sponsor.	Non-random	1000 people
Demographic mix	Sex and age composition of the sponsor's workforce.	Non-random	ONS 2005 Annual Survey of Hours and Earnings (ASHE)
Staff turnover	Fraction of employees leaving the sponsor every year (fixed across age groups and through time).	Non-random	20%
Earnings profile	Salaries paid to the workforce in a base year, which are then used to roll annual earnings backward and forward.	Non-random	ONS 2005 ASHE
Earnings relativity	Whether the sponsor pays average, above average or below average national salaries, after controlling for age and sex.	Non-random	National average
RPI	Mean annual % change in RPI inflation.	Random	2.67%
Earnings growth	Mean annual % change in future nominal salaries.	Random	RPI + 1.50%
Accrual rate	Fraction of a member's final salary – or average salary over the last N years of employment – that is accrued as pension with each year of service.	Non-random	1/80th
Indexation year	Year from which accrued pension benefits are indexed by RPI inflation. ¹⁰	Non-random	1988
Min/Max indexation	Lower bound/cap on indexation of pension entitlements.	Non-random	Min 0%, Max 5%
Retirement age	Age at which scheme members may start drawing their pension.	Non-random	Men: 65 years old Women: 60 years old
Scheme status	Whether the pension plan is closed or open to new members or accruals.	Non-random	Closed to new entrants in 2005, but open to new accruals

Table A2: Variance–covariance matrix

	<i>Cash</i>	<i>Gilts</i>	<i>Index-linked gilts</i>	<i>Swap spread</i>	<i>BBB bond spread</i>	<i>RPI inflation</i>
Cash	0.0000082	0.0000016	0.0000011	0.0000021	0.0000008	0.0000023
Gilts	0.0000016	0.0000010	0.0000010	0.0000002	0.0000000	0.0000001
Index-linked Gilts	0.0000011	0.0000010	0.0000014	0.0000003	0.0000005	–0.0000008
Swap spread	0.0000021	0.0000002	0.0000003	0.0000013	0.0000012	–0.0000005
BBB bond spread	0.0000008	0.0000000	0.0000005	0.0000012	0.0000019	–0.0000013
RPI inflation	0.0000023	0.0000001	–0.0000008	–0.0000005	–0.0000013	0.0000065
	<i>Productivity growth</i>	<i>Increase in real wages</i>	<i>Equity returns</i>			
Cash	0.0000053	–0.0000038	–0.0000023			
Gilts	0.0000008	–0.0000002	–0.0000163			
Index-linked Gilts	0.0000003	0.0000011	–0.0000175			
Swap spread	0.0000017	–0.0000001w	–0.0000083			
BBB bond spread	0.0000006	0.0000011	–0.0000270			
RPI inflation	0.0000024	–0.0000085	0.0000438			
Productivity growth	0.0000076	–0.0000073	–0.0000460			
Increase in real wages	–0.0000073	0.0000170	–0.0000460			
Equity returns	–0.0000460	–0.0000460	0.0183658

Figure A1: Indexed and non-indexed pension payments (£ million).

APPENDIX B

Modelling Longevity

In the pension landscape, the term ‘mortality’ refers to scheme members’ probability of dying. Underlying mortality assumptions are extremely important because they determine people’s life expectancy and consequently the expected amount of time pensioners will be drawing their pension for. In the United Kingdom, corporate

sponsors of DB schemes are exposed to significant longevity risk owing to the rapid mortality improvements detected in recent decades for some ageing portions of the population. Increased longevity ultimately means the scheme’s pension liabilities have to go up.

Several sets of mortality or life tables are published in the United Kingdom. The Government Actuaries Department (GAD), for

Table B1: Life expectancy based on GAD mortality projections

	Life expectancy at age 65 for a male member currently		Life expectancy at age 65 for a female member currently	
	Aged 65 (years)	Aged 45 (years)	Aged 65 (years)	Aged 45 (years)
GAD 2006-based projections	20	22	23	24
GAD 2004-based projections	19	21	22	23

Source: GAD and author calculations.

Table B2: Life expectancy based on GAD mortality projections

	Life expectancy at age 65 for a male member currently		Life expectancy at age 65 for a female member currently	
	Aged 65 (years)	Aged 45 (years)	Aged 65 (years)	Aged 45 (years)
GAD 2006-based projections	20	22	23	24
PXA92 YOB medium cohort	19	22	24	25
PXA92 YOB long cohort	23	24	26	27

Source: GAD, CMI and author calculations.

example, publishes detailed information for the population as a whole, divided by gender and age. The GAD 2004-based mortality projections published in October 2005 were the basis for our 2007 report *Understanding Companies' Pension Deficits*.² In this research we switch to the most recent GAD 2006-based mortality projections published in October 2007. These revised projections give rise to the following life expectancies (Table B1) for two arbitrary cohorts in our model:

The GAD 2006-based tables therefore imply that our scheme members are likely to live about 1 year longer than when we build our model upon the GAD 2004-based projections.

CMI mortality projections

Mortality data for the UK population are also collected and published by the Institute of Actuaries, and analysed by the Continuous Mortality Investigation (CMI) Committee. These tables are specifically based on the experience of those people who have purchased life insurance. They deal with both the current mortality rates that are most appropriate for the scheme's membership and the expected reductions in those rates in the future.

The analysis of scheme's recovery plans undertaken by the PR in 2007 indicates that the vast majority of DB plans (97 per cent) used the '1992' CMI tables to project members' life expectancy, particularly the PMA92 (males) and PFA92 (females) forecasts.¹¹ These tables were often used in conjunction with the 'interim adjustments' to account for future reductions in mortality rates according to cohort effects.¹² As a result of rapid mortality improvements detected during the 1980s for a cohort of people born around 1925–1935 relative to cohorts born earlier or later, the 'short', 'medium' and 'long' cohort assumptions were created, which differ as to when the improvements in mortality observed in the post-1926 cohort are assumed disappear. The short cohort projections assume the mortality improvements tail off to zero after 2010, the medium cohort projections assume 2020 while the long cohort projections assume 2040.

Most of the 1138 schemes that submitted recovery plans to the PR relied on the year of birth method to account for mortality improvement and adopted a medium cohort allowance. As the resulting life expectancies for males and females are higher than the GAD

2006-based tables underlying our base case scenario, in the sensitivity analysis we consider decreases in mortality rates that bring life expectancy closer to the '92' projections with year of birth and medium and long cohort corrections (Table B2).

APPENDIX C

Modelling the Company

This appendix details how we model the corporate sponsor.

Basic set-up

Imagine a company without a DB pension fund attached to it. The company's market value in a given year (V_t) is given by the difference between its assets (A_t) and non-pension liabilities (L_t). Specifically,

$$V_t = A_t - L_t.$$

We assume that in each period two risk factors affect the value of the company's assets. Specifically, a macroeconomic shock (ε) operates on V and is the same as the equity market shock affecting the asset side of the DB pension fund. A company-specific shock ($\tilde{\varepsilon}$) reflects, in turn, idiosyncratic risks that impinge directly on the sponsor's valuation without affecting the valuation of other companies, or the market value of equities held by the pension fund. Formally,

$$\begin{aligned} A_t &= [V_{t-1}(1 + \varepsilon_t) + L_t](1 + \tilde{\varepsilon}_t) \\ &= [(A_{t-1} - L_{t-1})(1 + \varepsilon_t) + L_t](1 + \tilde{\varepsilon}_t). \end{aligned}$$

We assume $\tilde{\varepsilon}$ follows a normal distribution with mean zero and a standard deviation chosen such that the 1-year failure rate for a BBB-rated company is 0.14 per cent (a figure derived from Moody's for the period 1970–2000).

The company's liabilities in turn evolve according to the interest rate paid on its

stock of debt (i):

$$L_{t+1} = L_t \times (1 + i_t).$$

Implicitly more debt is therefore issued to meet interest payments. The company's cost of debt is based on a debt-rating approach. Using a combination of Moody's data, which describe the median debt-to-asset ratios for firms with ratings from AAA through to B, and time series data from EcoWin on the spread over government on corporate bonds rated AAA through to B, the relationship between leverage and credit spreads appears approximately linear. Hence, in this paper we define i as follows:

$$i_t = r_t + \alpha + \beta(L_t/A_t),$$

where r_t is the rate on BBB-rated corporate debt, α and β are parameters to be estimated and i is fixed for 3 years at a time. The final calibration of our model resulted in the following parameters: $\alpha = -0.0307$ and $\beta = 0.0968$. The L/A ratio was initialised at 33 per cent, the median value for a BBB-rated company according to Moody's data (Historical Default Rates for corporate issuers, 1920–1997).

The above relationships allow us to derive a time path for V , A and L .

The corporate sponsor – adding in the pension scheme

For a company sponsoring a DB pension fund, we also need to take into account additional employer contributions ($topup_t$) and revisions of the present discounted value of the expected future contributions into the scheme ($pdvcont_t$). In this case the value of the sponsoring employer ($\tilde{V}$) evolves according to the following expression:

$$\begin{aligned} \tilde{V}_t &= \tilde{V}_{t-1} + (V_t - V_{t-1}) - topup_t \\ &\quad - (pdvcont_t - pdvcont_{t-1}). \end{aligned}$$

We assume that if the value of ($\tilde{V}$) drops below zero in a given period then the corporate

sponsor goes bust and no more monetary contributions into the scheme are made.

The above modelling approach is simple, but at the same has the attraction that the sponsor's credit ratings, and therefore failure probabilities,

are effectively made endogenous. In addition, the worse is the performance of equity markets the lower will be the value of the company and hence the more likely it becomes that it will go bust.