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COPING WITH UNCERTAINTY AND THE IMPORTANCE OF THE SPONSOR'S COVENANT

The case of defined-benefit pension plans

**Report from ABI Research and Investment Affairs
departments, and Fathom Financial Consulting**

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EXECUTIVE SUMMARY

Defined-benefit pension schemes have been an important part of both the pensions and the corporate landscape for many years. However, over the last decade, problems have emerged linked to scheme solvency and exactly how the relationship between the corporate sponsor and the scheme should be treated. This in turn has led to a change in the regulatory environment for defined-benefit schemes in the UK, with the introduction of new accounting rules, the introduction of specific objectives for the Pensions Regulator (tPR) in the 2004 Pensions Act and the creation of the Pension Protection Fund (PPF) to help insure scheme benefits for defined-benefit schemes where the sponsor has gone bust.

This regulatory environment is still evolving. The aim of this paper is therefore to shed light on some of the issues underlying the regulatory framework and the operation of defined-benefit pension schemes. In particular we explore the impact of: alternative asset allocation strategies; underestimating life expectancy; a weakening in the scheme's corporate sponsor; and different aspects of the institutional framework including the frequency of top-up payments, the length of time needed for the recovery plan and a move to discount liabilities using the risk free rate. We do this by exploiting a model of a representative defined-benefit pension scheme to explore both the uncertainty of scheme outcomes and the link between the scheme and the corporate sponsor. In each case the results are compared to our assessment of the baseline outcomes for this representative scheme.

Our baseline case assumes that the scheme's sponsor is a BBB-rated firm and that the initial funding ratio (of scheme assets to scheme liabilities) is 80%. It is assumed that the regulator requires schemes to have a ten-year recovery plan that will allow the scheme to achieve full funding by 2017. Progress against this plan is reviewed every three years under the baseline scenario, and the corporate sponsor is required to make up 50% of any short fall in funding relative to target at that point. Under these assumptions, over a 90-year period, there is a 3% chance of the scheme becoming insolvent, compared to a 45% chance that the corporate sponsor will declare bankruptcy. In addition, there is a 75% chance of full funding being achieved by the end of the scheme's first recovery plan in 2017.

Moving to a more conservative asset allocation

A lot of the discussion about reducing risks in defined-benefit pension schemes has centred on the possibility of using alternative asset allocation strategies in order to reduce the variability of scheme outcomes. We explore this issue by assessing the impact of reducing the weight of equities within the asset allocation of the scheme from 60% to 20% and increasing the gilt allocation from 15% to 55%. This produces a small reduction in the probability that the scheme goes bust (to 2% compared to 3% in the baseline), with no change in the risks to the solvency of the corporate sponsor. At the same time the impact of bad outcomes, given by the value at risk (VaR) and

expected tail loss (ETL), are significantly reduced. However, this does come at a price. In particular, it takes significantly longer to achieve a 50% probability that the scheme can be bought-out. The median outcome is for the scheme to achieve a 1.25 funding ratio in 2038 under the more conservative asset allocation strategy, compared to 2022 for the baseline scenario.

Underestimating life expectancy

It is well established that underestimating life expectancy is one of the key risks that face defined-benefit pension schemes. Within the framework used here, the impact of underestimating life expectancy by roughly 5 years produces a small increase in the likelihood that the scheme will go bust (5% compared to 3% in the baseline). However, the downside risks associated with bad outcomes for the scheme are significantly higher. In addition the median top-up payment required of the sponsor increases sharply, from £1.6m in the baseline to £13.5m.

One of the problems with life expectancy assumptions is that mistakes often only emerge with a significant lag. We therefore explore what would happen if the improvement in life expectancy was only realised in 2017. We do this using two alternative asset allocations – the baseline version where 60% of assets are held in equities and a more conservative strategy where only 20% of the scheme's assets are in equities. There is a slight reduction in the probability that the scheme will go bust (6% compared to 7%) in the case where a higher proportion of the scheme's assets are in equities, but there is also a significant worsening in the downside risks, with the deficit associated with the expected tail loss almost doubling in the case where 60% of the assets are held in equities. How the authorities view the asset allocation decisions of schemes will therefore depend on whether they are more concerned about reducing the probability of scheme insolvency, or limiting the downside risks of bad outcomes.

The sponsor's covenant

One of the important innovations of this paper is that it is one of the first to jointly model the sponsor's covenant and the outcomes for the scheme. To explore the implications of this we investigate two scenarios: one where the assumed strength of the corporate sponsor at the start of our modelling exercise is downgraded from BBB to B; and one where we investigate the role of assumed top-up payments.

In the case where the creditworthiness of the sponsor is downgraded to a B-rating, there is a significant increase relative to the baseline in both the probability that the scheme (to 8% from 3%) and the sponsor (to 89% from 45%) go bust over the course of the 90-year life of the scheme. Compared to the doubling in insolvency risk, the deterioration in the VaR and ETL in the case of a B-rated sponsor is more moderate, with the downgrade resulting in roughly a 50% increases in the deficits associated with bad outcomes.

One of the key interactions between the scheme and the sponsor in our baseline scenario is the existence of top-up payments, which are triggered every three years in cases where the scheme's funding level is below the target assumed in the recovery plan. It is not clear, however, that the Pensions Regulator in the UK will automatically demand top-up payments. To explore what the impact of this would be we examine the case of no top-up payments and find that there is a huge deterioration in the likelihood of the scheme going bust (at roughly 17% compared to 3% in the baseline), but with only a modest 11% reduction in the likelihood of the sponsor going bust.

The institutional framework

Finally we look at three aspects of the institutional framework surrounding defined-benefit schemes: the frequency of possible top up payments; the length of the recovery plan; and the interest rate used to discount liabilities:

- For top-up payments, there is a significant deterioration in the likelihood of the scheme going bust (to 7% compared to 3%) if top-up payments only take place every 10 years. However, in the case where top-up payments are reviewed every 6 years, there is almost no change in the likelihood of the scheme going bust relative to the baseline (4% compared to 3%);
- Increasing the length of the recovery plan from 10 to 20 years has benefits. The probability that the scheme goes bust is unaffected, but the likelihood that the sponsor will become bankrupt is reduced, in part because the value of top-up payments falls significantly, with median top-up payments falling to £0.1m, from £1.6m. In addition there is a slight reduction in the tail risks associated with bad events, because the risk of the corporate sponsor going bust is reduced;
- Using the risk free rate, rather than AA-corporate bond rate, to discount liabilities sees a small reduction in the number of schemes that go bust (2% compared to 3% in the baseline) and a slight increase in the likelihood of the sponsor going bust (46% compared to 45% in the baseline). There is also a reduction in the likely downside risks. The key factor driving this is top-up payments, with the cost of the median top-up payment rising to £3.6m from £1.6m.

It can be seen from this discussion that the risks associated with defined-benefit schemes are complex. Trustees, shareholders and regulators need to understand how these risks interact when assessing either the strength of a given defined-benefit scheme, or a suggested regulatory change. In this paper we try to illustrate these complexities by exploring how the outcomes for a representative defined-benefit scheme evolve under certain key scenarios. This is a slightly different exercise to the case of looking at what the scheme's optimal reaction would be, because the model specifies the rules by which the scheme operates in advance, rather than determining what the optimal rule might be to deal with a given situation. However, it provides a

useful tool in assessing key sensitivities, by allowing us to look at the impact of one specific change at a time.

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1.0 INTRODUCTION

Weak capital market performance has refocused investors' attention on defined-benefit (DB) pension deficits. A Morgan Stanley report published in March 2008 estimated the FTSE 350 pension shortfall had increased by about £40bn as a result of declining equity markets and property values. The proposed change in accounting rules to a lower discount rate on accrued pensions, together with a more transparent recognition of improvements in mortality rates, may push accounting deficits even higher.

In our 2007 research report *Understanding Companies' Pension Deficits*, we argued that point estimates of the pension shortfall (e.g., FRS 17) are insufficient to assess whether or not a pension deficit represents a real problem. One key reason for this is that the way in which pension obligations fall due is very important.¹ By studying key sensitivities using cash-flow projections one can better identify factors that might trigger solvency problems in the future. The main risks faced by a typical DB plan are the returns on pension assets, members' earnings and life expectancy, macroeconomic environment (e.g. inflation), and the strength of the sponsoring employer.

Simple forecast methods will produce a single answer, but in reality we confront ranges of possible outcomes because the future is unknown. Uncertainty about future outcomes is an important feature of defined-benefit pension provision and is something that sponsors, regulators and trustees all need to understand. Almost as important as determining likely outcomes, is understanding the risks associated with them. We need metrics that allow us to identify, quantify and explain the likelihood of future asset-liability mismatches. In this paper we analyse pension risks and assess underlying uncertainty using three techniques: future value fan charts, which help depict the likely spread of outcomes; value-at-risk (VaR) methodology, which gives the likely maximum loss at a key cut-off point; and expected tail loss, which assesses the expected losses if the scheme is one of those that are amongst the worst performers, or the tail of the distribution.

1.1 Approach and main findings

This paper explores the following questions:

- Can we explain the uncertainties associated with different future outcomes?
- What impact does the sponsor's covenant have when thinking about risks?
- What might be the implications of all this for the scheme's investment decisions?

To answer these questions, we model a typical UK DB pension scheme and use stochastic methods to examine the most prominent risk factors and analyse the variability of likely outcomes. The initial market value of our representative scheme's

¹ See Driver and Selvaggi (2007).

assets is £54m and the initial pension liabilities amount to £67m. Pension assets and liabilities are projected forward over a 90-year period, taking into account investment returns, monetary contributions to the fund, and pension benefits paid. Computer-based (Monte Carlo) simulations of the future involve specifying probability distributions for key variables of interest and using these distributions to generate projections. By simulating thousands of times the trajectory of our typical scheme we can create robust and realistic distributions of future paths.

As well as estimating both sides of the fund's balance sheet, we also explicitly track the fortunes of its corporate sponsor. This important innovation allows us to shed new light on the discussion of funding outcomes and pension top-ups, by jointly estimating the likelihood of the scheme or employer going bust, and showing the degree of dispersion in our projections.

Among our most important findings are the following:

- The institutional environment plays an important role in determining the distribution of pension burdens between the scheme and its corporate sponsor. For example, reducing the frequency of scheme valuation reviews lowers the amount of sponsor's contributions without jeopardising the overall funding position of the plan. Further, recovery plans that last for 20 years, rather than 10 years as in the existing regime, imply on average much lower pension top-ups from the sponsor but no adverse side effects on the economic solvency of the plan;
- Our sensitivity and scenario testing indicates generally there is no clear-cut answer to a given issue and therefore pension regulators should take this complexity into account when evaluating the recovery plans and valuation reviews submitted by DB pension plans;
- Having a relatively high proportion of pension assets invested in equities allows the scheme to close its funding gap relatively quickly, without raising major risks so long as capital markets are not very volatile. Increases in the volatility of equity returns that are not accompanied by similar rises in the equity risk premium, however, may have adverse effects on the future solvency of the plan;
- Using the risk-free rate, rather than the yield on AA-rated bonds, to discount future pension obligations does have real economic effects because the size of sponsor's contributions goes up. Higher pension top-ups in turn translate into better-protected funding outcomes for the scheme. However, if the spread between rates widens the shift in discount factor may raise company failures;
- Receiving regular pension top-ups from the sponsoring employer plays a key role in ensuring the economic solvency of the plan. To illustrate, the fraction of trials in which the scheme goes bust over the period rises from 3 per cent in the benchmark to a stunning 17 per cent when the sponsor makes no top-up

contributions. In the absence of a sponsoring employer, in almost one out of four simulations the scheme falls into economic insolvency over the period.

1.2 Existing related literature

Our goal in this report is to improve our understanding of DB schemes' pension deficits and investment strategies. Despite the apparent severity of the funding situation faced by many of the UK'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 defined-benefit 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) 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 to analysing the DB funding problem; and the sensitivity of the funding position to changes in pension benefits.

A recent analysis by McCarthy and Miles (2007) suggests 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 question is whether this sort of behaviour by pension schemes may increase the potential burden on the PPF and what key factors currently drive DB schemes' investment policies.

An exercise undertaken by Blake et al (2001) develops an analytical model of a Defined Contribution (DC) pension plan, where the "benchmark" is the retirement income that could be derived from membership of a typical company DB plan. Using stochastic simulations that take account of the various, relevant key risk factors such as asset returns and interest rates, but also the risks associated with an individual's future earnings and the risk of unemployment, the authors experiment with alternative asset allocation rules which 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.

1.3 Our modelling approach

In this paper we use a cohort-based model of a typical, closed DB pension scheme to analyse the potential benefits that might accrue to both scheme members and sponsors from adopting a more diversified approach to the management of pension fund assets as trustees seek to reduce their pension deficits.² The model used here differs from the one constructed by Haberman et al. (2003). The approach taken by these authors is essentially analytical. Their set-up lends itself easily to stochastic analysis. By contrast, the model used in this paper 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.

The model described in Section 2 is a direct descendent of the model used by Driver and Selvaggi (2007). However, our main purpose here is to explore the relationship between the quality of the scheme covenant, asset allocation, contribution strategy and key DB funding metrics, an aspect of the funding issue that was not explored by Driver and Selvaggi (2007). In addition, the model presented here is adapted to use stochastic modelling techniques to capture the return and risk characteristics of the scheme’s assets and their relation with the scheme liabilities. Introducing these stochastic elements to the model allows us to focus on the risks around forecasted funding positions from various starting points.

² The model can easily be adapted to represent an open scheme too, but in the interest of simplicity we model a closed scheme here.

2.0 MODELLING A REPRESENTATIVE DEFINED-BENEFIT SCHEME

The financial strength of a defined-benefit 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 pension top-ups to reduce pension shortfalls); and the asset mix held by the plan, together with their expected returns. This section explains concisely how we have chosen to model these elements in the case of our typical UK defined-benefit pension fund. Further definitions of key variables together with technical details and assumptions can also be found in the appendices.

2.1 Pension payments and 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 how they evolve, and their relationship with the scheme's pension assets.

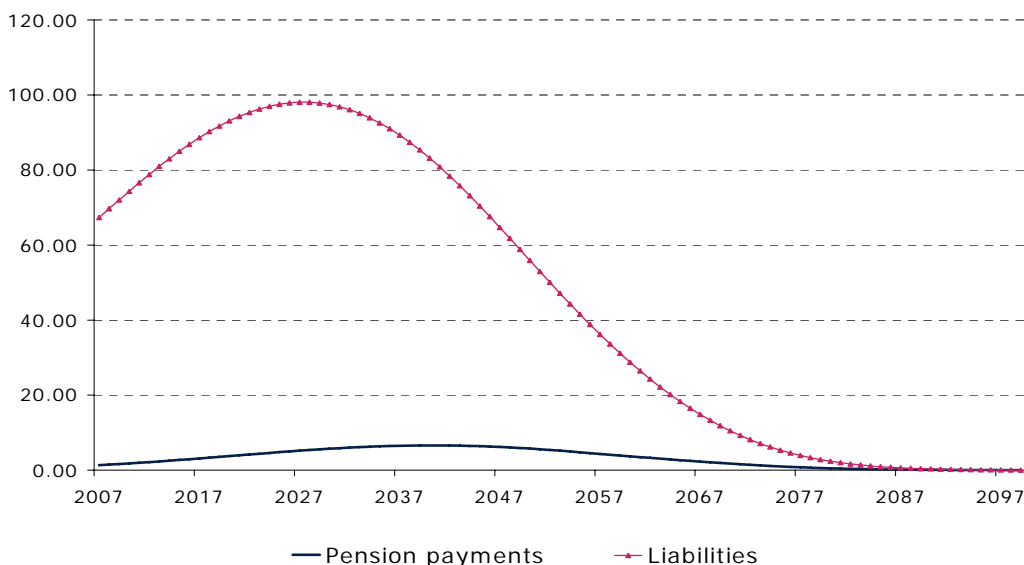
The main building blocks underpinning the evolution of the scheme's pension obligations are similar to those set out in our 2007 report *Understanding Companies' Pension Deficits*. For the sake of simplicity, they are not repeated here. Suffice to say that the liabilities are linked to the pension rights accrued by active and deferred members and to the pension payments being paid to current pensioners. 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 A2 of this paper contains a list of modelling assumptions and Appendix A3 details our longevity assumptions.

Figure 1 shows the evolution of the scheme's expected pension payments and liabilities for our base case scenario between 2007 and 2099.³ 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 discount factor. The pension payments

³ We assume the pension scheme meets its pension obligations as and when they fall due using the accumulated pension assets rather than purchasing an annuity when the scheme member retires.

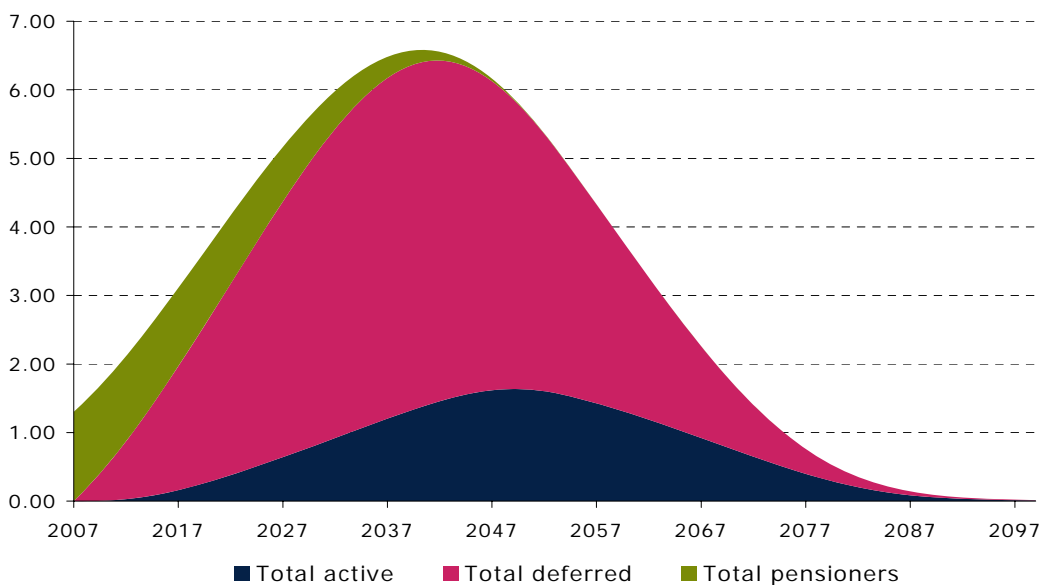
represent current payouts to pensioners. Our representative scheme behaves as a relatively immature DB plan. In 2007, pensions in payment account for only 2% of the overall pension liabilities. In fact the proportion of liabilities that relate to pensions in payment remain below 20 per cent in our baseline scenario for approximately 70 years.

Figure 1 Pension payments and liabilities (£m), 2007-2099



Source: ABI Research.

Figure 2 Pension payments (£m) by type of member in 2007, 2007-2099



Source: ABI Research.

Figure 2 shows, in turn, the breakdown of pension payments according to membership status in 2007. As pensioners grow older and then die, most of the pension payouts go

to those who were deferred or active in 2007. Payments peak in 2040 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 is a serious limitation since the pension fund is in any case 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.⁴ To keep things simple, the interest rate on conventional gilts is considered a proxy for the risk-free rate.

2.2 Pension assets

One of the key drivers of the pension scheme's funding position is the rate of return that it achieves on its pension assets and the volatility of these returns over time. Hence in this section we explain how these components are built in our model.

In our benchmark case, we assume an initial funding ratio of 80% of liabilities.⁵ The funding ratio is calculated as the marked-to-market value of assets divided by the pension liability.⁶ The evolution of the scheme's pension assets over time is uncertain and depends on the following factors:

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

The next two sub-sections spell out our assumptions concerning the first two factors in turn. Deficiency payments are then discussed in Sections 7 and 8. Future pension payments are discussed in Section 2.1.

2.2.1 Investment returns

The annual returns on pension assets depend on both the assumed asset mix, that is the composition of the pension fund portfolio, and the actual returns on these asset

⁴ This AA corporate bond yield is assumed to be random and its expected value in our model is 5.55 per cent.

⁵ It is useful to put this assumption into context. As at March 2007, the sample of defined-benefit schemes in deficit included in the Purple Book 2007 showed an aggregate funding ratio of 87 per cent on an FRS17 basis. For the whole Purple 2007 dataset of nearly 6,000 schemes, the average funding ratio is 95 per cent on an s179 basis (this is the metric used by the Pension Protection Fund for levy purposes) and 56% on a full buy-out basis (an estimate of the cost of buying-out with an insurer scheme benefits accrued up to the valuation date).

⁶ Pension schemes are subject to funding standards, which involves setting a smooth path for contributions that enable the fund to pay its promised benefits over the long run (see Blake et al., 2008). A funding standard is weaker than a solvency standard; for example, a well-funded fund could still develop deficits in the future that will need to be closed with money injections from the corporate sponsor.

classes. For simplicity, we assume the scheme may hold only five different 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 defined-benefit 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.

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 (RPI adjusted)	2.25%	10%
BBB-rated corporate bonds	6.75%	20%
Equities	8.25%	60%

Source: ABI Research and Fathom Financial Consulting.

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 yields an expected return on UK equities of 8.25 per cent. Again, this estimate is based upon a historical equity risk premium approach.

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 – this is explained in more detail below.

2.2.2 Modelling investment risk

One of the purposes of this paper is to understand the extent of uncertainty surrounding defined-benefit schemes. It is therefore necessary, not 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 generate market risk, we assumed

investment returns are stochastic with joint normal probability distributions.⁷ So the actual values in each year are drawn from a probabilistic distribution. As expected asset returns are obviously related we also specify an underlying variance-covariance matrix for expected returns.

2.2.3 Contributions

Ongoing monetary contributions into the DB plan come from two sources, active members and the sponsoring employer, and represent a fixed percentage of the workforce's monthly salary. In our baseline scenario both contribution rates are equal to 6 per cent.

Our representative DB scheme also receives discretionary cash injections from its sponsor in order to plug current pension deficits. These deficit-reduction payments take place in funding review years and so long as the employer remains economically solvent. The way we model the sponsor's balance sheet is explained in Section 2.3, whereas the assumed review process for the scheme's valuation is detailed in Section 2.4.

Where the cash inflow comes from makes no difference to the scheme's funding position, but could of course have a potentially large effect on the financial strength of its sponsor. The employer's covenant will depend, among other things, on the profile of pension cash flows and on the linkages between scheme's pension deficit and sponsor's insolvency risk. These issues are explained in more detail in Section 2.3.

2.3 The sponsoring employer

This section contains a brief non-technical description of the main assumptions underlying our modelling approach to the corporate sponsor. More technical details can be found in Appendix A.1.

In our baseline case, the sponsoring employer is assumed to be a BBB-rated company at the start of the modelling exercise, but economic shocks could 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.⁸

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

⁷ Both the assumed returns and variance-covariance matrix were derived from monthly data on actual asset returns over the period January 1998 to August 2007.

⁸ The choice of 33 per cent for the ratio of company's non-pension liabilities to total assets is based on Moody's data for BBB-rated companies. The choice of 50 per cent for the pension fund liabilities to assets ratio is more discretionary, as this figure is likely to vary substantially across the whole universe of DB sponsors. Nevertheless we think this is not an unreasonable assumption.

premium over the current rate on government bonds and this credit spread is, in turn, positively related to the company's leverage ratio (i.e., liabilities over assets). Every three 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 markets 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.⁹ The capital market risk factor is explained in Section 2.2.

In our model the market value of the sponsoring company is also affected by the size of top-up payments into the pension scheme and by revisions to the present discounted value of future pension contributions. Therefore when the value of the firm becomes negative we say the sponsor has gone bust.

2.4 Assumed 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 members and 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 2010. A recovery plan is drawn up anew every 10 years, as long as the pension assets fall short of the pension liabilities.

Modelling the scheme recovery plan explicitly represents an improvement compared to our earlier report *Understanding companies' pension deficits*, where a deficit in itself led to no revisions of the scheme's asset allocation or sponsor's contribution rate. In reality, however, underfunded DB schemes do have to submit a recovery plan to the Pensions Regulator setting out how the deficit is going to be eliminated. Our improved modelling approach attempts to take this into consideration more explicitly.

In our baseline, the recovery plan aims for the pension fund to achieve a 100% funding position in 2017, that is, at the end of the recovery plan. The scheme aims to close 10% 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 in 2017. To further simplify things, we assume that if the scheme achieves a 125% funding ratio then it is "bought out" in that year or, what is analytically similar, it adopts a perfect asset-liability matching strategy from that point onwards.

⁹ Technically, draws for the company-specific risk element come from a normal distribution with mean equal to zero and standard deviation chosen such that the one-year failure rate for a BBB-rated sponsor is equal to 10 per cent every 20 years.

2.4.1 Review of valuation process

In conjunction with the recovery plan we also adopt a triennial valuation process intended to mimic the way the Pensions Regulator assesses the plans submitted by schemes with funding gaps. This means the financial health of our hypothetical DB plan is re-assessed every three 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 device. 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 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 every percentage point by which the scheme is above funding target leads to a 2 per cent increase in gilt holdings. The sensitivity of our results to these assumptions is explored in Section 6.

3.0 CAPTURING UNCERTAINTY

The degree of uncertainty associated with predicted outcomes is an important element of any decision about how to deal with DB schemes. In this paper we use stochastic simulations and associated sensitivity and stress testing to assess the financial fortunes and vulnerabilities of our typical defined-benefit plan. This sort of analytical framework uses forecasts of the scheme's cash inflows and outflows to generate a whole range of possible future outcomes together with probabilities attached to them. Stochastic pension models improve on purely deterministic ones by enabling users, for example, to assess the likelihood that pension assets will grow fast enough to match the scheme's promises as and when they fall due. This is important because the timely identification of solvency issues in DB plans often requires examining the full profile and range of projected assets, contributions and pension obligations.

Our dynamic approach, by explicitly modelling cash-flow profiles, allows us to identify the risks that assets and liabilities change over time, know by how much, and with what likelihood. We complement all this with fan chart techniques and single-line risk measures to highlight underlying uncertainty and assess the relative riskiness of different economic environments. This enhanced toolkit proves useful to single out simulated scenarios that are likely to produce a future asset-liability mismatch, thus putting both pension scheme and regulatory framework more at risk.

To model the evolution of the corporate sponsor more realistically, we also contemplate the possibility that the sponsor may go bust during the period being examined. While the health of the pension fund is related to the strength of the sponsor, in our model the fund may in fact outlive its sponsor, so long as pension assets are sufficient to meet pension promises as they fall due. By bringing the sponsor's covenant back into the picture we can examine key pension issues more thoroughly, and thus provide a better guide to financial planning and policy making.

3.1 Assessing pension risks using simulation methods

Our model allows the DB pension fund to grow in line with the contributions received from both sponsor and employees and the stochastic (i.e., 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. In what follows we analyse the likelihood and magnitude of any potential economic insolvency.

3.1.1 Monte Carlo simulations

Realistically portraying the uncertainty associated with our defined-benefit scheme will therefore depend on our ability to model the risks within the system and the interlinkages 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 combined with inflation will also determine earnings growth).¹⁰ By specifying how these “random” variables behave, we are therefore able to use Monte Carlo methods to establish the extent of 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 outturns 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 period 2008 to 2099. We rely on the results of 2,000 such simulations to proxy for the true but unknown (probability) distribution of outcomes. This proxy distribution is then used to derive fan charts and the one-line risk metrics discussed in Section 3.2.

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

- Returns on different classes of financial assets;
- An idiosyncratic, firm level shock;
- Inflation level; and
- Productivity growth.

3.2 Value at risk (VaR) and expected tail loss (ETL)

A key risk measure used to interpret the output of our Monte Carlo simulations is value at risk (“VaR”).¹¹ The VaR on a portfolio represents the maximum likely monetary losses over 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.¹² Hence VaR summarises in a single number the risk of loss of a portfolio over a defined time horizon and a given confidence level, α , so that the probability of exceeding this loss is equal to $1-\alpha$.

¹⁰ Clearly another key risk for the scheme is the longevity of scheme members, see for example Driver and Selvaggi (2007). It is possible to assess the extent of uncertainty generated by longevity, see for example Blake et al (2008). However, unlike the other risks that we identify in this paper, the existing models of longevity uncertainty are not linked to outturns in the rest of the economy. For the purposes of this paper therefore, we do not allow for shocks to longevity. We do, however, provide some sensitivity analysis in Section 6, to assess the impact of underestimating longevity.

¹¹ This popular measure of market risk was developed by JPMorgan in the 1980s. Readers interested in technical details can see, e.g., Dowd (2002) or Crouhy et al. (2001).

¹² Particularly, the VaR is non-decreasing with the confidence level. The relationship between the VaR and time horizon used to compute it is more ambiguous though.

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 2007. The final outcome is therefore a full distribution for the present values of surpluses and deficits for each set of 2,000 forecasts.¹³ The terminal deficits are therefore those arising in the year in which the scheme runs out of assets.

A 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. While 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.

Both 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 better (coherence) properties than the VaR.¹⁴

¹³ Discounted surpluses and deficits are thus comparable to profit and loss values in standard VaR applications such as those used in the banking industry.

¹⁴ For elaborations of this point see, e.g., Blake et al. (2006b) or Dowd (2002).

4.0 THE BASELINE CASE

This section discusses the results of our benchmark scenario, where the scheme's pension assets and liabilities and its corporate sponsor behave in the way explained in Sections 2 and 3. We consider sensitivity and scenario analyses, where we change the value of some base case assumptions to draw analytical conclusions from their impact on the distribution of simulated outcomes, in subsequent sections.

The scheme's funding ratio, calculated as pension assets over pension liability, is a useful measure of the scheme's financial health at each point in time.¹⁵ Values of this ratio smaller than one indicate underfunding. Our representative DB plan is assumed to have a funding ratio of 0.80 at the beginning of the modelling exercise. Figure 3 shows the evolution of the funding ratio over the period of the median funding ratio together with the 5th and 95th percentiles for our 2,000 stochastic simulations.

The median represents a middle point of the set of funding positions after they have been sorted into ascending order, such that an equal number of observations lie above and below it. In other words, the median divides the distribution in half and so provides a central projection. Percentiles, in turn, divide the distribution into hundredths and capture the notion of dispersion. The 5th percentile reflects the worst possible outcomes since it divides the distribution of funding ratios such that 5% of the projected values lie at or below it.¹⁶ By the same token, the 95th percentile identifies the most favourable outcomes since only 5% of the projected funding ratios lie at or above it. To calculate medians and percentiles, we assumed a funding ratio of zero for schemes that go bust. Funding ratios are also capped from above at 1.25, because we assume that if the pension plan reaches this level of funding it is bought out. This is merely a simplifying assumption that facilitates our modelling.

4.1 Findings

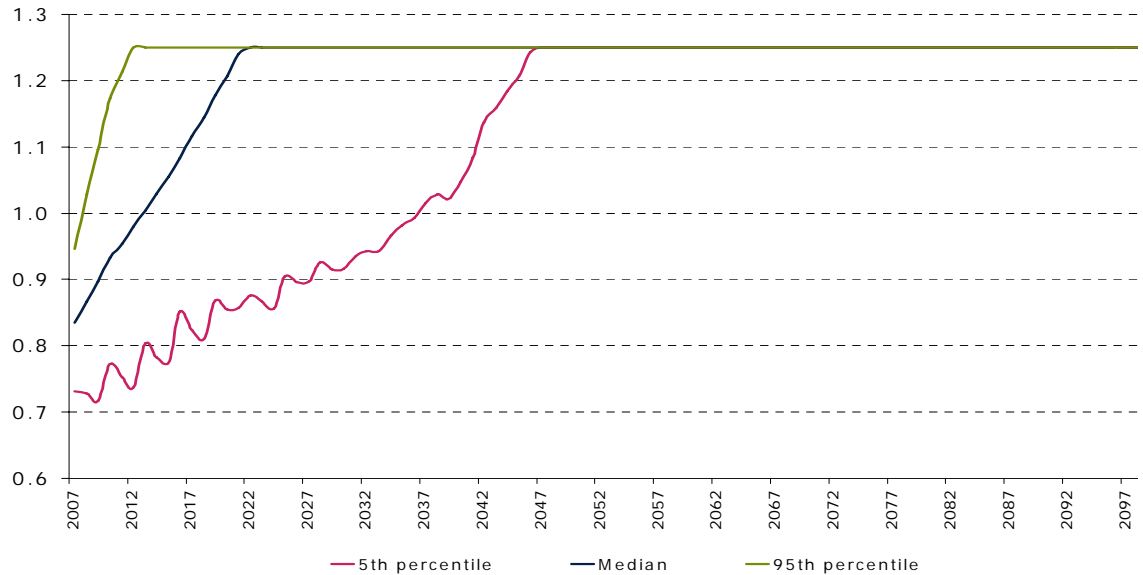
Figure 3 indicates that, over the course of 90 years, in at least 95 out of 100 trials the DB plan builds up a sufficient surplus to allow the scheme to be bought out. The median funding ratio reaches 125% in 2022 whereas the 5th percentile achieves this cut-off point 24 years later. The reason the 5th percentile line is not smooth is because of the assumptions about the funding review that takes place every three 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 5th percentile line is

¹⁵ Pension assets are marked to market whereas the pension liability is the present value of all expected future pension payments by the scheme.

¹⁶ Note that the median coincides with the 50th percentile.

much smoother as the funding ratio approaches one because revisions are no longer binding.

Figure 3 Funding ratios in the baseline – median, 5th and 95th percentiles

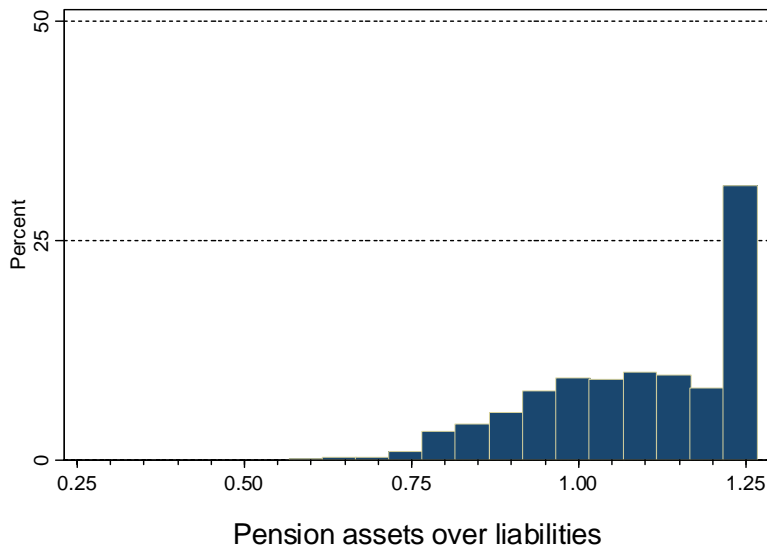


Source: ABI Research.

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 5th percentile of the distribution before a review year might be further pushed down the distribution after the review period if the top-up payment forced its sponsoring employer into bankruptcy.

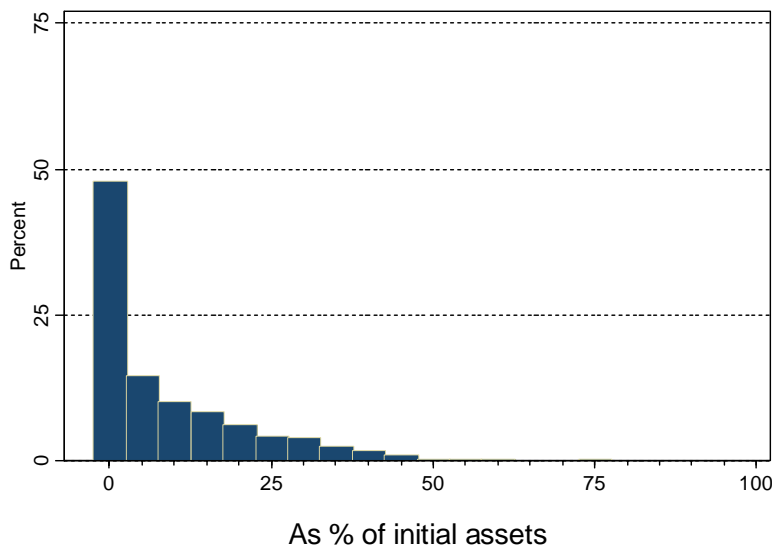
Figures 4 and 5 respectively, show the distribution of forecasted funding ratios in 2017 (that is, at the end of the first recovery plan) and the distribution of the present value of the sponsor's top-up payments over the entire period. These cash injections are extra payments made by the sponsoring company in review years to close part of the current pension shortfall.

Figure 4 Distribution of funding ratios in 2017 – baseline



Source: ABI Research.

Figure 5 Distribution of the present value of top-up payments – baseline



Note: This figure gives the distribution of the ratio of present value of pension top-ups to initial market value of the assets held by the pension plan.

Source: ABI Research.

In nearly 75 per cent of our simulations the pension scheme is fully funded by 2017. With regard to top-up 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. 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% of cases before the end of the first review period.

Table 2 contains some single-line indicators that help us summarise the key pension risks underpinning our stochastic simulations. Particularly, it shows the percentage of trials in which the scheme or the sponsor went bust over the 92-year period together with the median of the sponsor's top-up payments in present value terms. To illustrate downside risk, we also include the VaR and expected tail loss (ETL) at the 99 per cent confidence levels. 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 2,000 simulations.

Table 2 Summary indicators 2007-2099 – baseline

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Baseline case	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

Hence the results for VaR say that in 99 out of 100 times the pension shortfall of schemes that become economically insolvent is no worse than about £10m in present value terms, which amounts to 19 per cent of the scheme's initial pension assets. The average pension shortfall attached to schemes that go bust because of extremely adverse outcomes ("tail risks") is in turn £15m in present value terms.

4.2 Sensitivity testing

Defined-benefit pension schemes often have very lengthy time frames and therefore it is essential to gauge how sensitive projected outcomes are to changes in the value of key underlying assumptions. To analyse these aspects, in the remaining sections of this paper we focus on different sensitivity analyses and stress testing exercises. In particular, Section 5 looks at sensitivity to the scheme's investment policy and volatility of asset returns; Section 6 examines the importance of the mortality assumptions; Section 7 assesses the impact of the sponsor's covenant; and Section 8 considers changes to the institutional framework.

Finally, it is important to note, that in cases where the sensitivity testing involves changing assumptions about the scheme's liabilities, the monetary value of the scheme's initial asset allocation is kept constant and the funding ratio (which is assumed to be 80% in the baseline) is allowed to adjust. The key example of this is the treatment of the longevity assumptions in Section 6.

5.0 SENSITIVITY TO ASSUMPTIONS ABOUT ASSETS

In this section we consider two basic sensitivity analyses associated with the asset side of the pension fund. The first one examines an alternative initial asset allocation, where the majority of pension assets are invested in low-risk/low-return government bonds rather than equity. The scheme follows this investment strategy at each point in time so long as its funding ratio is not above target. If the funding ratio is above target then a fraction of pension assets are locked into bonds exactly as in the baseline case. The second scenario analysis looks at the impact of increased equity market volatility, assuming the fund's initial asset allocation remains as in the baseline case.

5.1 Altering the initial asset allocation to reduce exposure to equities

An important source of uncertainty attached to the value of the scheme's reserves is the expected future return on pension assets. To gauge some aspects of this risk 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. Therefore the scheme's asset allocation strategy at the beginning of this new set of Monte Carlo simulations is as follows:

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%

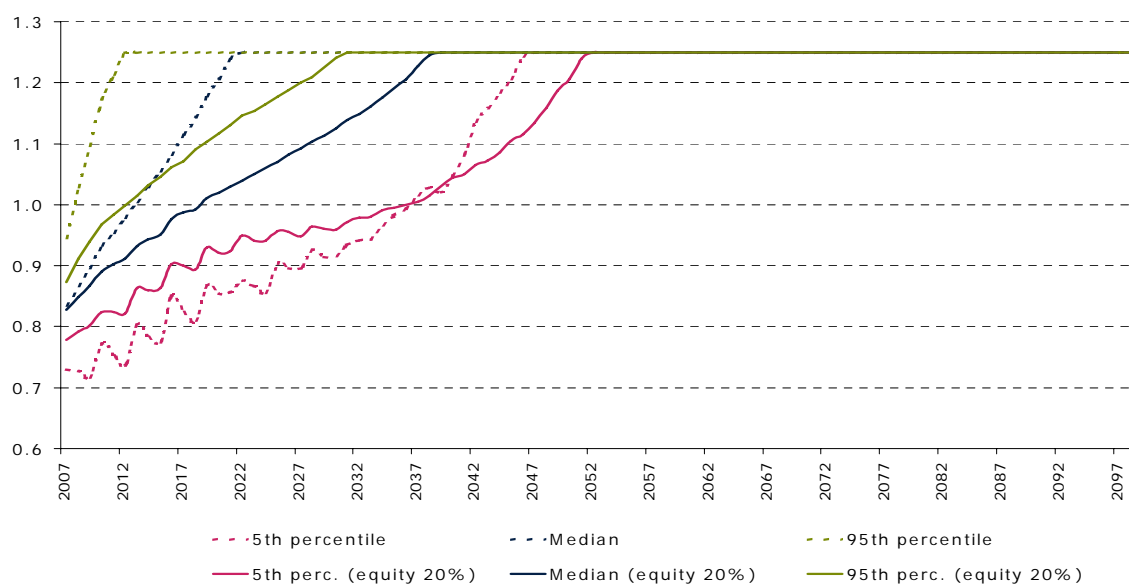
Clearly this is a much more conservative investment strategy, since 60 per cent of pension assets are invested in cash, deposits and gilts. Switching out of potentially faster growing assets such as equities and into generally lower yielding fixed-income assets means both expected asset returns and the volatility of these returns are consequently lower.

5.1.1 Findings

Figure 6 shows how the median funding ratio for the 2,000 simulations together with the 5th and 95th percentiles evolve between 2007 and 2099, 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 schemes

much longer to reach well-funded positions. The median outcome, for example, hits a funding ratio of 1.25 in 2038, whereas in the baseline case this funding position was achieved in 2022. The alternative asset allocation wipes out potential upside gains from relatively good equity performance and therefore even the top quartiles reach buy-out funding levels much later. 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% of schemes (measured by the 5th percentile) are better. Eventually though, the impact of higher returns kicks in, so that the fund at the 5th percentile achieves the funding level needed for buyout 5 years before the equivalent scheme with a more conservative asset allocation.

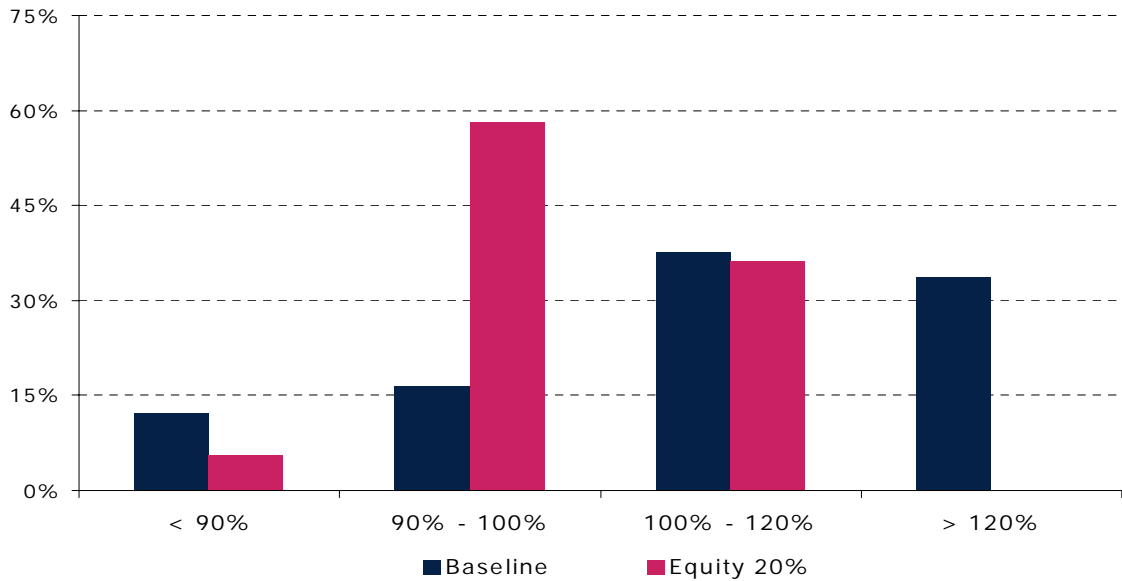
Figure 6 Funding ratios with alternative asset allocation



Source: ABI Research.

In Figure 7 we compare the profile of funding ratios and sponsor's top-up payments with those corresponding to the baseline case. Likely outcomes differ markedly and our main findings are twofold. First, as pointed out above, the pension plan achieves fully funded positions by 2017 in a significantly smaller fraction of trials if a more conservative asset allocation is used. Second, the likelihood that the sponsoring employer will have to make a positive deficit-reducing contribution over the period increases compared to the baseline, because the chances of the scheme being below funding target in a review year also go up. More frequent top-up payments from the sponsor are the flip side of the returns foregone on the scheme's assets due to the conservative investment strategy in place.

Figure 7 Distribution of funding ratios in 2017 when scheme holds only 20% in equities



Source: ABI Research.

Table 4 shows the median pension top-up 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). Yet this increase does not translate into significantly different insolvency forecasts for the scheme or sponsor. Instead, the extra conservatism from the asset side of the scheme gives rise to smaller pension shortfalls from failing plans. When the scheme goes bust it now shows much smaller pension deficits, and this reduced “tail-risk” is reflected in lower values for VaR and ETL.

Table 4 Summary indicators 2007-2099 – alternative asset allocation

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Equity 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% confidence level.

Source: ABI Research.

5.2 Higher equity volatility

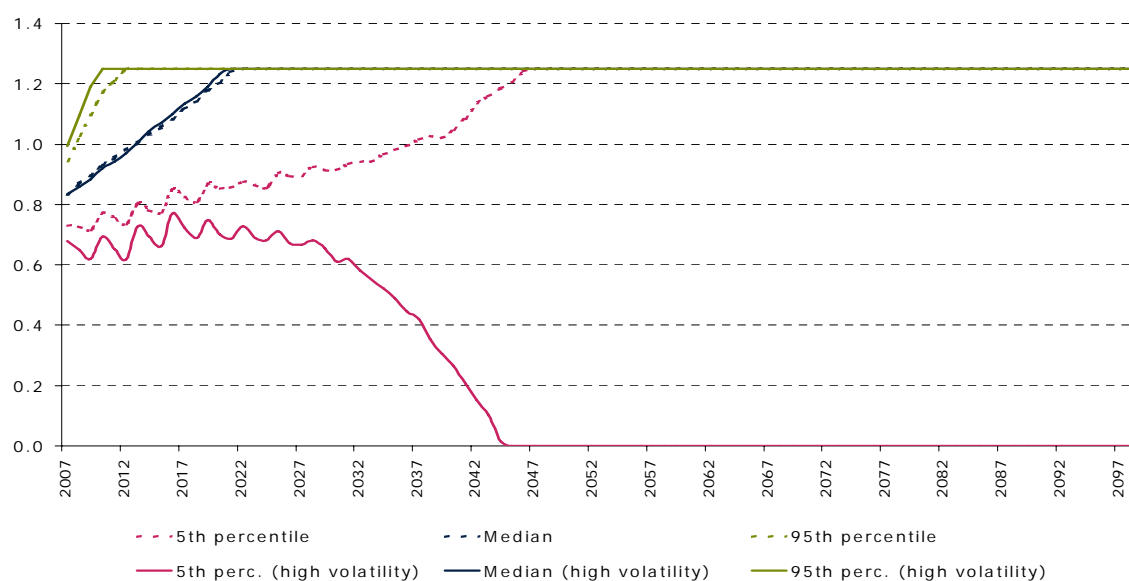
The recent turmoil in world’s financial markets has raised new concerns about the future viability of companies’ DB schemes. In this section we look at the fortunes of our typical defined-benefit plan in the context of higher volatility of equity returns. Specifically, we run our model assuming that the standard deviation of equity returns

is 50% higher than in the base case. This permanent increase in the standard deviation of equity returns implies a wider dispersion of possible outcomes around the long-term average return, which is the same as in the baseline case.¹⁷ Although admittedly simple, this thought experiment enables us to assess some of the key implications for DB schemes of operating within more volatile global capital markets.

5.2.1 Findings

Raising the volatility of equity returns underpinning our simulations has a huge impact on the final distribution of funding ratios. In effect the downside risk of economic insolvency increases significantly. As Figure 8 shows, in the 5% worst-case trials the pension scheme runs out of pension assets by 2045. However when the DB plan benefits from relatively favourable draws and high equity returns, a fully-funded position is achieved quicker than in the baseline case. As expected, increased equity volatility amplifies the dispersion of possible future outcomes.

Figure 8 Funding ratios with higher equity volatility



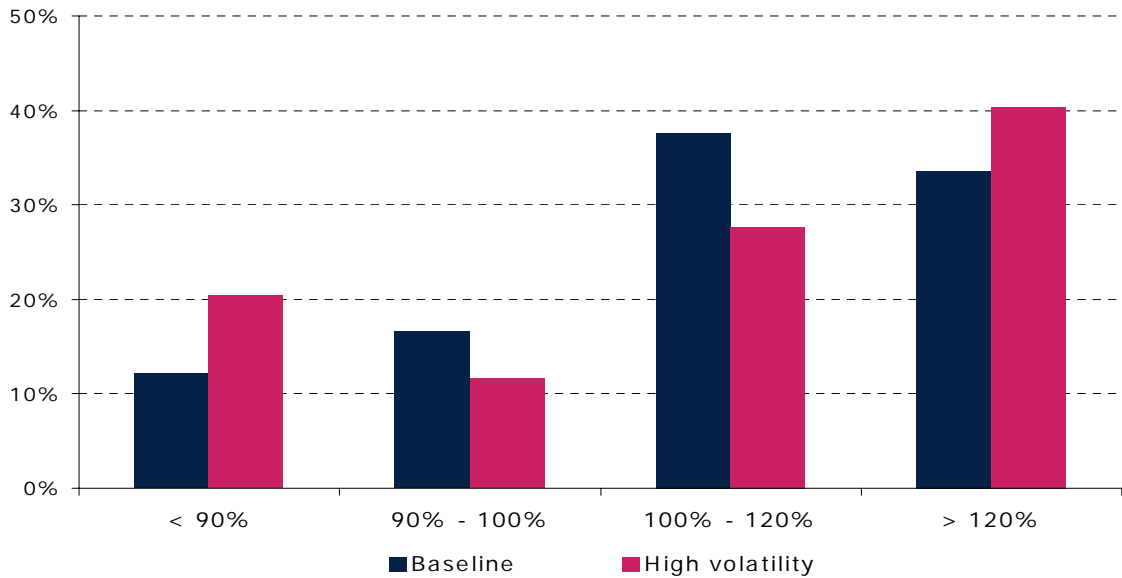
Source: ABI Research

This divergence of potential outcomes is not as pronounced however when one focuses on the distribution of funding ratios in 2017. This is shown in Figure 9. Relatively more trials than in the baseline case end up with very low or very high funding ratios. However, Table 5 indicates that the median top-up payment more than doubles (from 3 per cent to 8 per cent of the fund's initial assets) and insolvency probabilities also go up substantially. So too do tail risks. Not only are pension schemes and corporate

¹⁷ The covariance between equity returns and each of the other stochastic variables of our model are modified accordingly so that correlation coefficients are unaltered.

sponsors more likely to go bust as a result of the higher volatility in equity markets, but also the pension shortfall underpinning insolvent schemes worsens dramatically.

Figure 9 Distribution of funding ratios in 2017 with higher equity volatility



Source: ABI Research.

Table 5 Summary indicators 2007-2009 – high volatility of equity returns

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
High volatility	10%	62%	4.3	24	45%	31	57%
Baseline case	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

The above projections assume the expected return on equities remains unaltered over the time period. In reality, however, higher equity volatility is likely to be associated with a rise in the forward-looking equity risk premium – the additional return required by an investor for taking the risk of investing in equities. Schemes that are rebalancing their portfolios in response to the impact of market volatility and changes in equity valuation levels may be able to take advantage of this upward movement and then improve funding outcomes over time.

6.0 THE IMPACT OF UNDERESTIMATING LIFE EXPECTANCY

Assumptions regarding people's mortality experiences are extremely important because they impinge on the expected amount of time 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 longevity issues in two complementary ways. First, we consider a standard sensitivity analysis in which we simply raise our baseline longevity assumptions by about 5 years. We assume the increased life expectancy is known at the beginning of the modelling exercise and then we track the scheme's financial performance until 2099. In the second exercise we assume that the increase in longevity is only discovered in 2017, at the end of the first recovery plan.

Table 6 displays, for the two arbitrary cohorts considered, the life expectancy assumptions underlying our baseline and alternative scenarios (for comparison purposes we also show the CMI "92" year-of-birth long-cohort projections).¹⁸ Figure 10 in turn shows the underlying profiles of pension liabilities in the two cases we focus on. All our remaining assumptions are as in the benchmark.

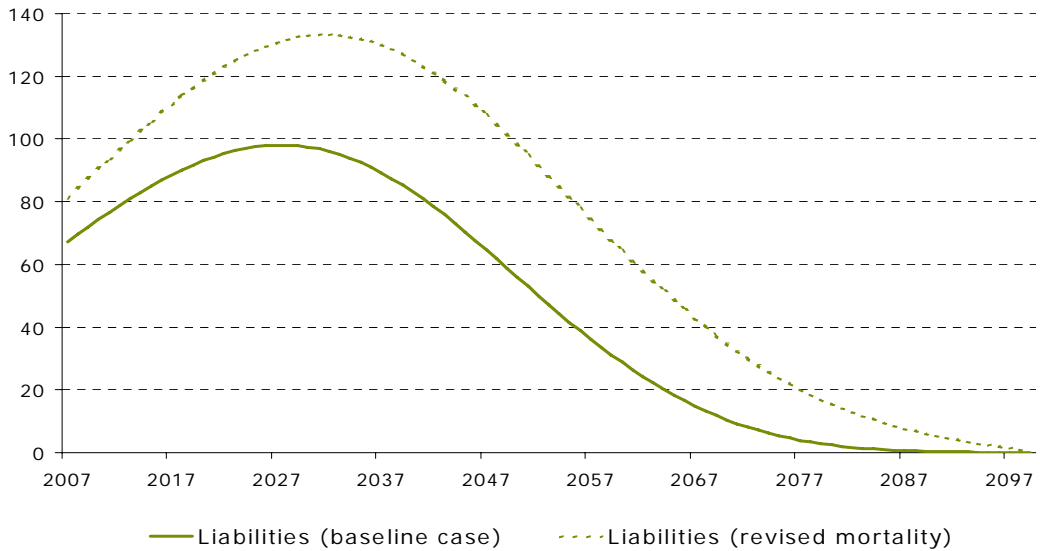
Table 6 Life expectancy in the baseline and alternative cases

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

Source: ABI Research.

¹⁸ See Appendix A3 for a discussion of the issues underlying life expectancy and the different assumptions used.

Figure 10 Effect of increased life expectancy on pension liabilities, 2007-2099



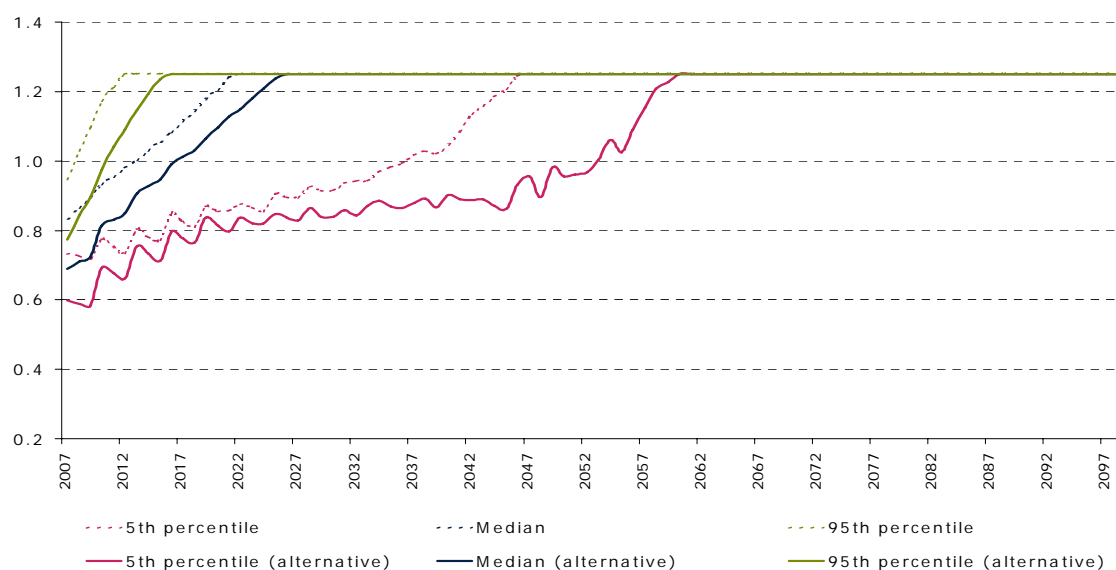
Source: ABI Research.

6.1 Higher life expectancy from the outset

This section studies an upward revision of our longevity assumptions of about five years, which is known about from the outset of the first recovery plan. Our sensitivity analysis helps us determine the impact of a recent proposal by the Pensions Regulator to calculate pension liabilities using assumptions about future life expectancy that are far more cautious than the ones often applied by DB plans. It has been argued these assumptions should genuinely reflect contemporary improvements in mortality rates. To illustrate, it is now known that healthier lifestyle and better diet have stretched the life span of today's 65-year-old British man by about two years over the last decade, the equivalent of five hours every day.

Figure 11 depicts the evolution of funding ratios over the time period. It now takes the 5th percentile much longer to be 125% funded, but we see no dramatic changes in economic insolvencies at the bottom end of the distribution. The 5th percentile reaches buy-out level approximately ten years later than in the baseline case.

Figure 11 Forecasted funding ratios with higher life expectancy



Source: ABI Research.

Other things being equal, improved life expectancy results in bigger pension shortfalls, which in turn lead to higher top-up payments from the sponsoring employer. As Table 7 shows, median pension top ups with the revised life expectancy assumptions are nearly £14m, up from £1.6m in the baseline. These additional cash injections translate into more frequent corporate bankruptcies. Tail risks also go up and in particular, the expected pension deficit of a DB scheme that goes bust due to high impact, low frequency events almost doubles in present value terms.

Table 7 Summary indicators 2007-2099 – increased longevity

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Higher longevity	5%	50%	13.5	17	31%	27	50%
Baseline	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

6.2 Increased longevity learnt in 2017

Uncertainty about expectation of life (longevity) is considerable and this represents a key risk factor for DB plans. Unlike other risks it is difficult to mitigate or avoid, or to value. In our second modelling exercise we investigate what happens if it takes time to learn about mortality improvements. 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.

We are then interested in assessing how the investment strategy followed by the fund during the first 10 years affects its capability to cope with the unanticipated longevity revision. To do this we compare the two alternative asset allocations considered in Section 5; 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' and employer's fortunes once the shock to life expectancy becomes evident.

Therefore in this section we examine the case where a life expectancy "shock" takes place in 2017, when the scheme discovers that it has underestimated life expectancy, and then track the evolution of the pension scheme under different investment approaches. This experiment can be interpreted as a sudden upward revision of the life expectancy assumptions or future mortality improvements used by our typical fund, or a scenario where current actuarial projections are no longer considered best practice.¹⁹ In this context, we focus on the impact alternative asset allocation strategies have on the forecasted evolution of the scheme's funding position and on the solvency of its sponsor.

The latest survey of UK pension funds by the National Association of Pension Funds shows a clear trend in asset allocation away from equities and into bonds. One of the alleged reasons for this shift of investment approach is asset-liability matching. This process of scheme "de-risking", whereby equity exposure is gradually reduced, restricts the volatility of future returns but does not mitigate the downside risk of liabilities being bigger than expected. As a result DB schemes that adopt liability driven investment dogmatically may end up being ill-equipped to deal with future adverse outcomes.

One of the reasons why the scheme's accrued liability might be bigger than anticipated is longevity risk.²⁰ Importantly, unlike equity, fixed-income assets offer no protection against unanticipated improvements in members' life expectancy because they have no potential to deliver higher future cash flows to match increased pension payments. The belief that bonds can perfectly match pension liabilities is therefore misplaced.

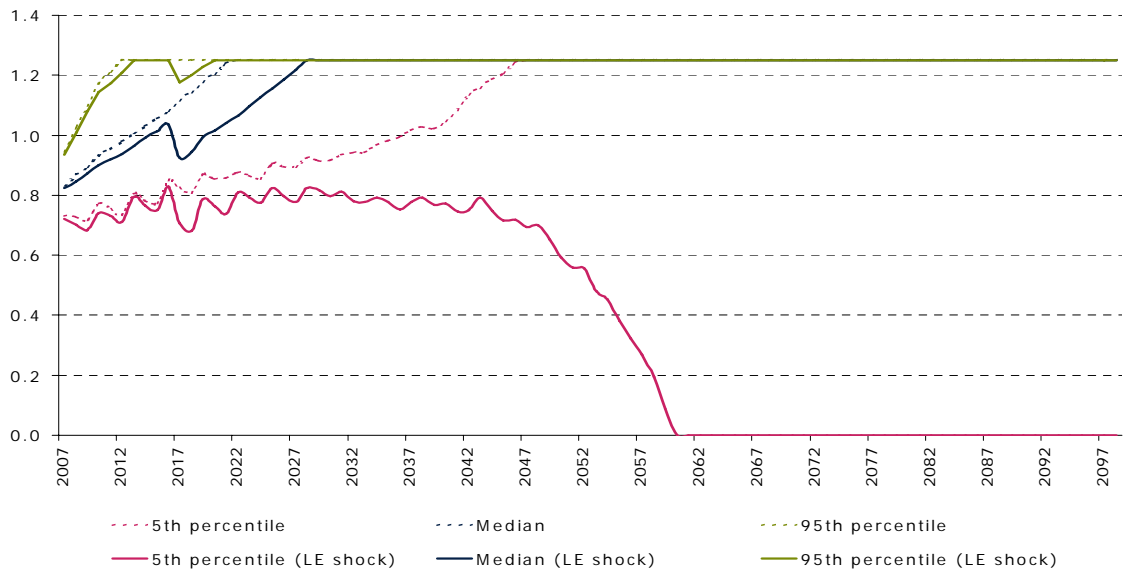
¹⁹ For example, a recent consultation paper published by The Pensions Regulator tries to provide guidance on good practice regarding life expectancy assumptions and projections of future mortality improvements used by defined-benefit pension schemes (see The Pensions Regulator, 2008).

²⁰ As an example, a 2008 survey published by the actuarial consultancy Watson Wyatt revealed that nearly half of the FTSE 100 companies sponsoring defined-benefit pension schemes have changed their underlying mortality assumptions, adding about £6bn to their combined pension liabilities.

6.2.1 Findings

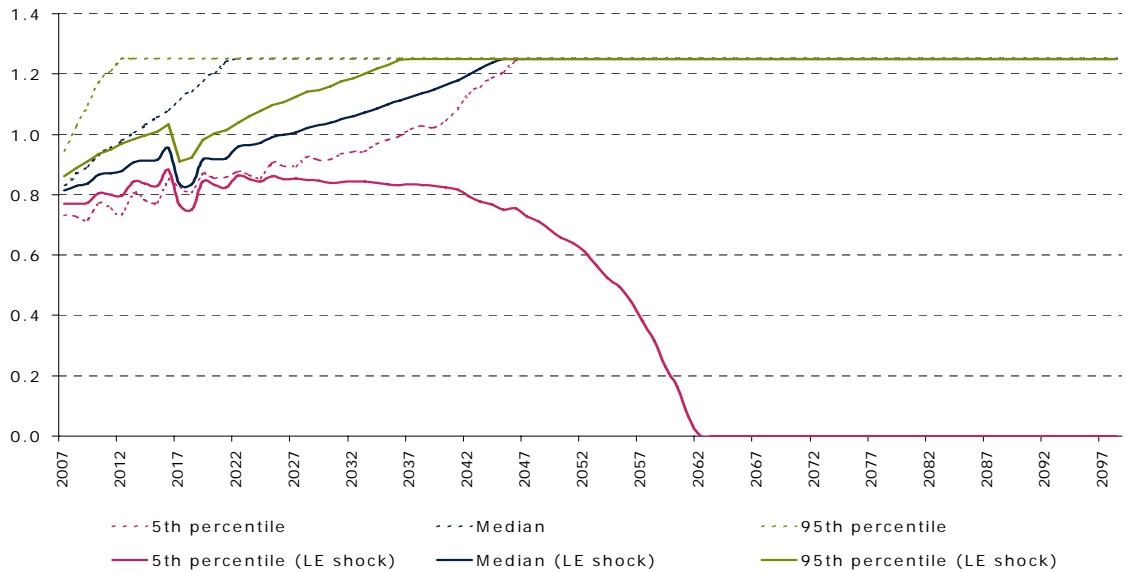
Figures 12 and 13 show the forecasted funding ratios when the scheme follows the baseline investment strategy (60% equity, 15% gilts) and a much more cautious asset allocation (20% equity, 55% gilts), respectively. While the 5th percentile of the distribution falls into economic insolvency in both cases, the adverse impacts of the longevity shock persist for 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.

Figure 12 Funding ratios with increased life expectancy and baseline asset allocation



Source: ABI Research.

Figure 13 Funding ratios with increased life expectancy and conservative asset allocation



Source: ABI Research.

Lower expected investment returns ultimately translate into much larger pension top-ups from the sponsoring employer, as can be seen in Table 8. The median top-up payment rises from £7m with the baseline asset allocation to £12m when the fund follows the more conservative investment strategy – an increase of 70 per cent.²¹

Table 8 Summary indicators 2007-2099 – increased longevity and alternative asset mix

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	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% confidence level.

Source: ABI Research.

However, the relatively more risky investment strategy also entails significantly higher tail risks for the regulatory system. Our analysis highlights serious challenges in reconciling the interests of scheme, sponsor and regulator that need to be

²¹ Table 8 shows a slightly higher probability of corporate failure when the pension scheme follows a more conservative investment strategy. However this difference in bankruptcy probabilities is not statistically significant

appropriately accounted for when investment strategies are designed and evaluated. Simplistic approaches are not likely to provide the right answers to an intrinsically complex problem faced by the different stakeholders.

7.0 THE SPONSOR'S COVENANT

The move towards more transparent pension accounting standards like the FRS 17 regime was partly driven by a desire to reduce subjectivity in the valuation of pension assets and liabilities of companies. There is no question that more robust rules for the disclosure and measurement of pension deficits are extremely important but, as we argued in our 2007 research report *Understanding Companies' Pension Deficits*, there is clear room for further improvement.

Two schemes may have similar FRS 17 deficits but in reality be in very different solvency positions depending on the "quality" of the sponsoring firm. Further, if it is certain that the employer is able and willing to make good any shortfall in pension assets from pension obligations, then members face no risk whatsoever and the scheme's investment strategy is by and large irrelevant for them. However differences in the sponsor's risk-bearing capabilities are not captured by static measures of pension deficits like FRS 17. These point estimates are misleading insofar as basic information about the sponsor's financial strength and creditworthiness is not factored in.²²

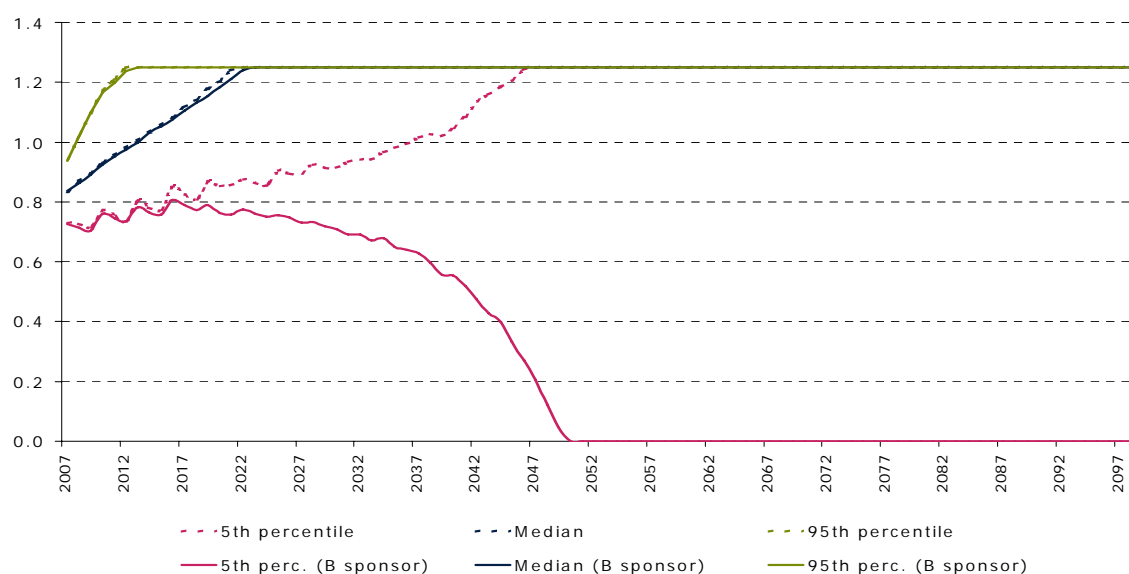
In this section we consider some sensitivity analysis around this important source of uncertainty affecting DB plans. As we explained in Section 2, the sponsoring company underpinning our simulations is constantly affected by financial and macroeconomic risks that impinge on the strength of its covenant. Within this milieu we examine the scheme's fortune in two different setups. The first consists of downgrading the creditworthiness of the sponsor by assuming a B-rated company, rather than a BBB-rated company as in the baseline. The second consists of changing the level of contributions from the sponsoring company. By comparing the different degrees of financial commitment from the employer we get an initial indication of the sponsor's role in shaping the plan.

7.1 Creditworthiness of the employer

Figure 14 shows the impact a lower-quality sponsor has on the forecasted median, 5th and 95th percentiles of the distribution of funding ratios across 2,000 simulations. Reducing the credit worthiness of the sponsor means that the scheme that represents the bottom 5th percentile of least favourable outcomes becomes insolvent in or before 2050 due to the weakness of the employer. However the behaviour of the forecasted median scheme is not significantly different from the median of the benchmark.

²² See for example Keating and Slater (2008) for a discussion of the importance of the sponsor's covenant.

Figure 14 Funding ratios with B-rated sponsor



Source: ABI Research.

If the sponsor is only B-rated, the scheme’s tail risks rise because corporate failures are now more likely, see Table 9. Both VaR and expected losses from extremely unfavourable outcomes increase significantly with respect to the baseline scenario. Yet, relatively speaking, these metrics do not increase nearly as much as the percentage of trials where the scheme goes bust as the result to being sponsored by a much weaker corporate.

Despite the increased risks of scheme bankruptcy, the average total top-up contribution is smaller than in the benchmark. As Table 9 shows, the reason for this is a huge increase in the fraction of simulations in which the sponsoring employer goes bust, since failed sponsors cannot make top-up payments. The dispersion of the funding ratios in 2017 and top-up payments over the whole period are not very different from the baseline case.

Table 9 Summary indicators 2007-2099 – weaker sponsor

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
B-rated sponsor	8%	89%	1.1	16	24%	21	39%
Baseline	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

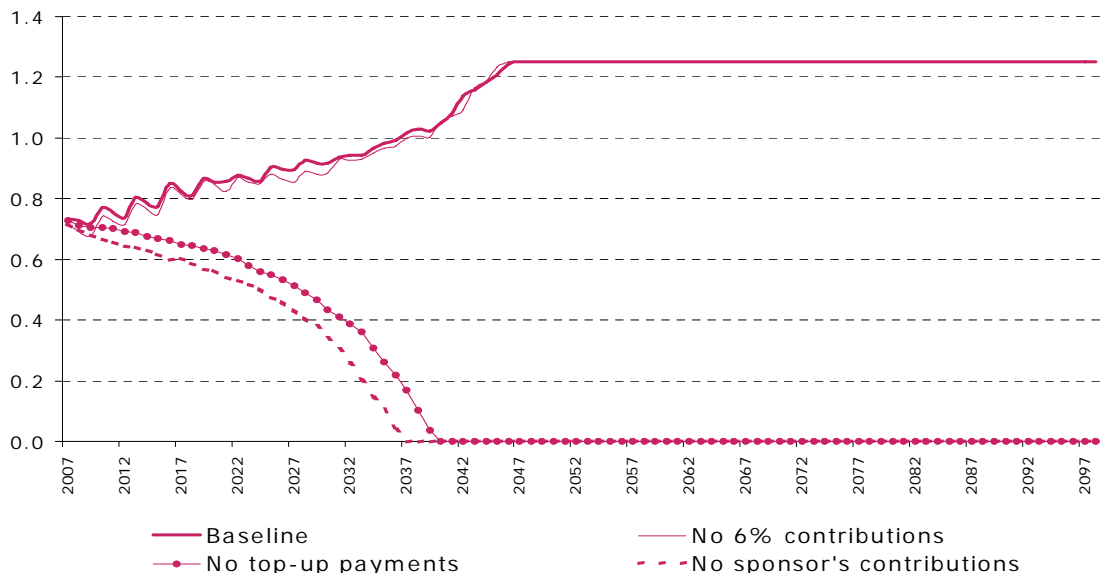
7.2 Altering contribution levels

One of the reasons that the strength of the corporate sponsor is so important is its ability to make contributions to the scheme, both in the form of on-going contributions on behalf of active members, and top-up contributions if the scheme gets into trouble. In this section therefore we examine the impact different levels of contributions from the sponsor have on the short-term funding position and overall solvency of the pension fund. Figure 15 considers the evolution of the projected 5th 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 top-up payments from the sponsoring employer;
4. The case where there is no contribution whatsoever from the sponsor.

Removing 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 regular top-up payments to close funding shortfalls. However, we find that if our typical DB scheme does not have access to pension top-ups from its sponsor then the 5th percentile ends up in economic insolvency, since it runs out of pension assets. Projected outcomes further deteriorate when the sponsor makes no contribution whatsoever.

Figure 15 5th percentile funding ratios with alternative contribution levels

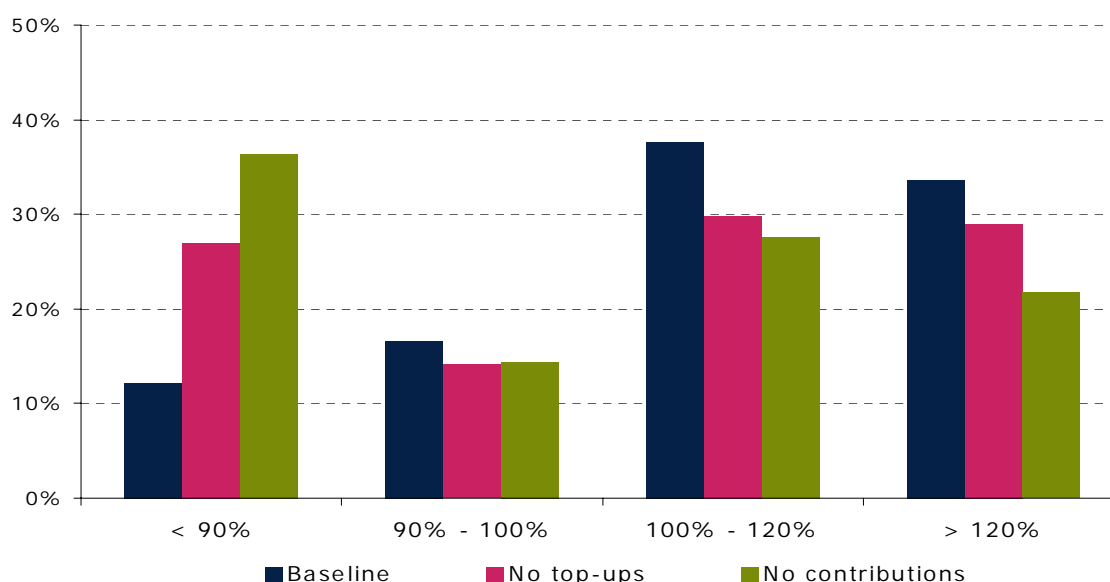


Source: ABI Research.

Figure 16 shows the distribution of forecasted funding ratios in three cases: the baseline case; when the sponsor makes no top-up payments; 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% funded by 2017.

Figure 16 Distribution of funding ratios in 2017 with alternative contribution levels



Source: ABI Research.

Finally, Table 10 highlights the importance of the sponsor’s contributions for the financial health of the DB plan. The proportion of simulations in which the scheme goes bust during the period jumps from 3 per cent in the baseline to a stunning 17 per cent in the absence of pension top-ups. 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 amounts to about 50% of the initial market value of pension assets.

Table 10 Summary indicators 2007-2099 – different contribution levels

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
No contributions	23%	40%	0.0	28	52%	31	58%
No top-ups	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% confidence level.

Source: ABI Research.

Of course the flip side of the coin is that although the likelihood that scheme goes bust increases, the likelihood of the sponsor going bust falls. However, the improvement in

sponsor solvency is limited in comparison, with only an 11% reduction in the likelihood of the sponsor going bust.

8.0 THE IMPACT OF THE INSTITUTIONAL FRAMEWORK

One of the key factors determining the interaction between a defined-benefit pension scheme and its sponsor will be the institutional framework in which it operates. In this section we investigate how that framework operates, in order to explore which aspects have the biggest impact. In particular we look at the impact of three different institutional factors, namely: different funding review periods; the length of time that the scheme has within its plan to achieve full funding; and the impact of changing the accounting rules to discount liabilities using the risk free rate rather than the yield on AA-rate corporate bonds.

8.1 Changing the timing of valuation reviews

As Section 7 illustrates, whether or not the corporate sponsor makes top-up payments has an important impact on scheme solvency. In particular, if the sponsor makes no top-ups the likelihood that the scheme goes bust increases from 3%, if top-ups are made every 3 years in cases where the funding ratio is below target, to 17%. In this section therefore, we explore different timings for top-up payments to see whether shifts in their frequency will have an impact.

Our baseline case assumed the DB scheme's finances were reviewed triennially. So every three years, if there exists a funding gap relative to the recovery plan, the corporate sponsor has to inject cash into the scheme to close 50 per cent of the existing shortfall. The timing of this adjustment mechanism seems roughly consistent with the way the Pensions Regulator monitors the recovery plans submitted by the UK universe of defined-benefit pension schemes.

A triennial review process is somewhat arbitrary since there is no clear evidence that this is indeed the optimal assessment regime. As a result, the question that naturally arises is whether requiring sponsors to plug pension shortfalls every three years is unduly harsh because equivalent solvency outcomes could be achieved even with longer gaps between revisions. Understanding the impact of top-ups is important because some pension experts contend that the requirement to plug pension deficits more often than is in fact needed may lead to otherwise avoidable corporate failures. This concern is especially pressing among smaller sponsoring employers. In addition, corporate resources are not unlimited and therefore pension top-ups do carry opportunity costs that also need to be taken into account

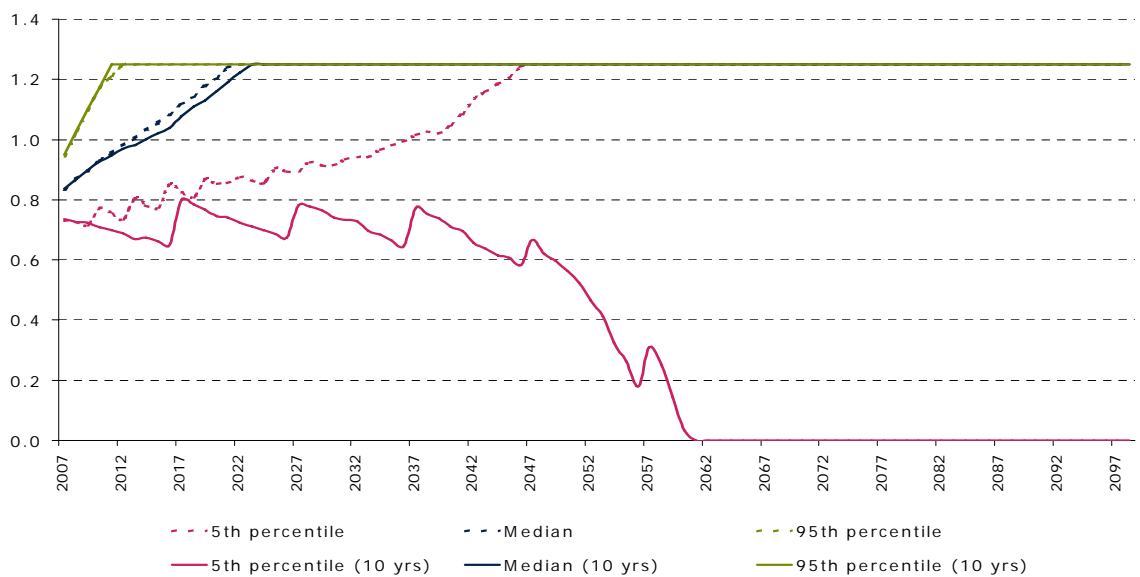
To supplement our analysis in the previous section, we therefore examine what impact varying the frequency of valuation reviews has on both schemes and sponsors. Specifically, we examine the case where the scheme's funding position is reviewed every ten years, rather than triennially as in the baseline. This means the plan receives pension top-ups from the employer significantly less often than in the base case. To provide a broader picture, other scenarios in which reviews that take place either annually or every six years are also considered. We then analyse the distribution

of projected outcomes in these alternative arrangements and draw some high-level conclusions about the UK's regulatory framework for DB pension funds.

8.1.1 Findings

Figure 17 shows how the median funding ratio together with the 5th and 95th percentiles evolve over the period for the case where top-ups can be triggered every 10 years, rather than every 3 years. Outcomes at and above the median projections are essentially as in the benchmark. However the bottom 5th percentile of the range of outcomes ends up in economic insolvency by 2060. The increased uncertainty makes the fan chart look wider. For schemes located at the bottom-end of the distribution, having a sponsor that cuts 50 per cent of the pension deficit every ten rather than three years is not stringent enough to ensure plan survival. If problems occur, ten-year reviews do not prevent scheme bankruptcy in a significant number of cases.

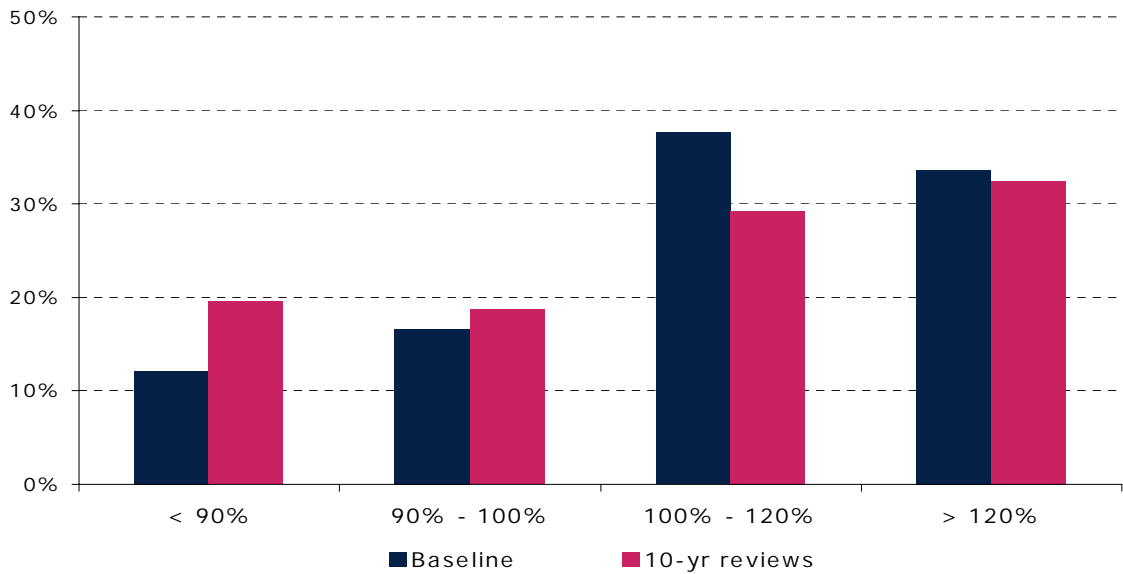
Figure 17 Funding ratios with 10-year valuation reviews



Source: ABI Research.

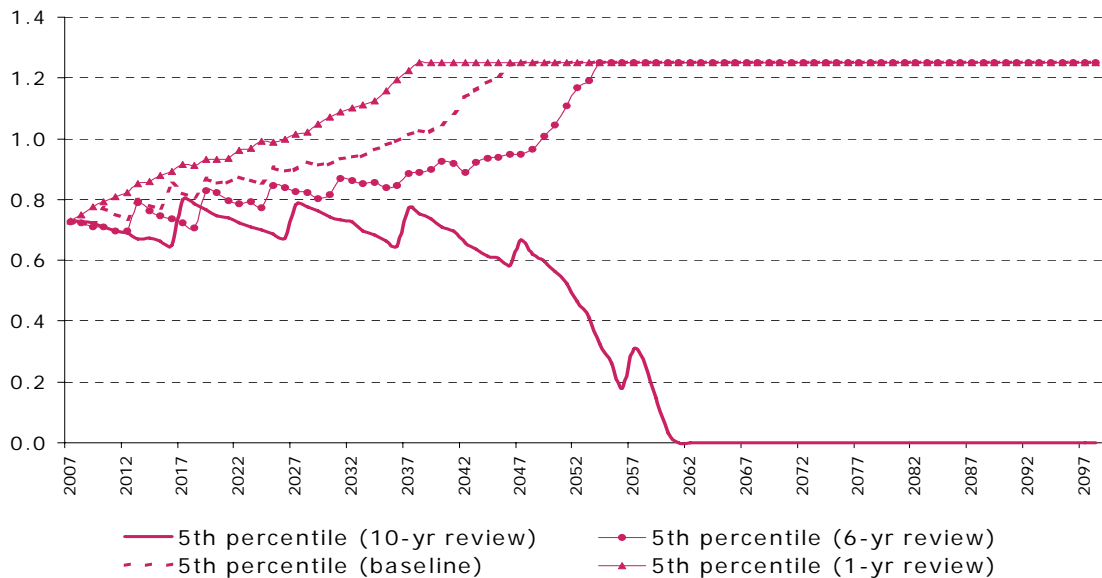
Figure 18 shows the distribution of funding ratios in the benchmark case and in the context of a ten-year review process. Unsurprisingly, in the latter case the pension plan is underfunded in a relatively higher fraction of cases because the sponsoring employer makes no additional deficit-reducing contributions during the 10-year period between 2007 and 2017. As a result the present values of top-up payments is also smaller.

Figure 18 Distribution of funding ratios in 2017 when valuation review occurs every 10 years



Source: ABI Research.

Figure 19 Funding ratios with alternative frequencies of valuation review – 5th percentiles



Source: ABI Research.

Clearly a ten-year gap between valuation reviews is also arbitrary and may be excessive. Therefore we examine the likely impact of different review periods on the funding position of the bottom-end of the distribution by comparing the forecasted 5th percentiles when the scheme gets top-up payments annually and every three (baseline), six and ten years. As Figure 19 shows, doubling the baseline number of years between reviews is stringent enough to maintain economic solvency. In this case

buy-out funding ratios are reached by 2055. So this analysis suggests that cutting by half the number of valuation reviews and associated top-ups UK pension schemes have to undertake may not significantly undermine their longer-term solvency outlook.

When valuation reviews occur every 10 years, the median of the present value pension top-ups over the whole period is zero. The same median is 3% of the plan's assets (£1.6m) in the baseline case. Table 11 also confirms that doubling the base case gap between review years has no noticeable impact on the dispersion of potential outcomes. This result deserves particular attention from a public policy perspective. Only when sponsors have to plug pension shortfalls as infrequently as every ten years do underlying "tail-risks" become prominent, since the percentage of schemes that cannot meet their pension promises increases from 3 per cent in the benchmark to 7 per cent.

However, it is also worth noting that increasing the time between review periods has a limited impact on the solvency of the corporate sponsor. The reason for this is that top-ups are still taking place for failing schemes.

Table 11 Summary indicators 2007-2099 – alternative review periods

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Review 10yrs	7%	44%	0.0	14	25%	17	32%
Review 6yrs	4%	44%	0.6	10	19%	15	27%
Baseline case	3%	45%	1.6	10	19%	15	27%
Review 1yr	1%	46%	3.8	2	4%	7	13%

Source: ABI Research.

A tougher solvency requirement whereby the scheme's funding position is set against the target every single year implies, in turn, that the downside financial risks to the scheme are reduced significantly. As a consequence the proportion of trials in which the scheme goes bust and the potential tail risks fall significantly. However, the enhanced protection for final-salary pension provision generates more strain on corporate earnings – the median top-up payment more than doubles from the baseline.

8.2 Length of the recovery plan

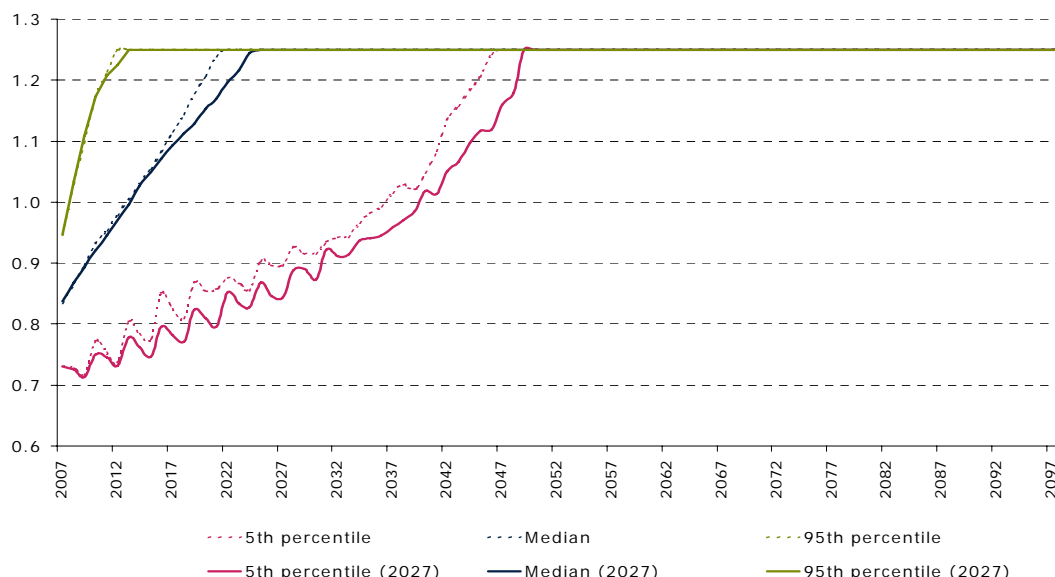
The findings discussed in the previous section are based on the assumption that the gap between review years, but not the length of the recovery plan varies across modelling scenarios. However marginal improvements could also be introduced into the institutional arrangement by, for example, providing DB schemes with more time to reach fully funded positions.

In this section we therefore consider what happens if we keep the gap between valuation reviews as in the baseline case, but instead double the length of the scheme's recovery plan. Specifically, we assume the plan's target is to be 100% funded in 2027 rather than 2017. A comparison of solvency outcomes across scenarios is then provided.

8.2.1 Findings

Figure 20 shows the forecasted distribution of funding ratios over the period in the base case and when the typical scheme is required to be 100% funded by 2027. The solid lines tracking the median and 5th and 95th percentiles shift to the right, suggesting as expected that the underlying scheme typically reaches buy-out funding levels later on. However, we do not see a major change in the solvency positions across most of the range of projected outcomes.

Figure 20 Funding ratios when recovery plan stretches over 20 years

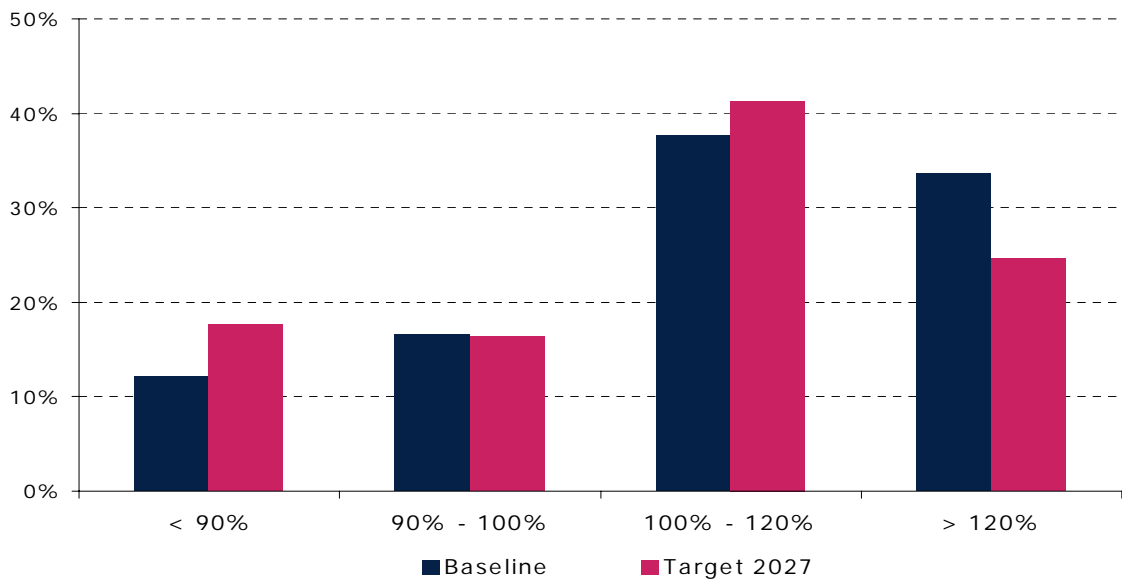


Source: ABI Research.

This can also be seen in Figure 21, which depicts the distribution of forecasted outcomes according to the scheme's funding ratio in 2017. The smaller level and slower pace of the pension top-ups from the sponsoring employer implies in a

relatively larger fraction of trials the plan remains underfunded by 2017 whilst in relatively fewer cases the scheme is at least 120% funded. However, the ultimate impact on the proportion of simulations in which the DB plan goes bust is limited, see Table 12. The results suggest that the likelihood of the sponsor going bust is reduced if the planning horizon is lengthened, but that there is no impact on the likelihood that the scheme will go bust. In addition, the impact of bad outcomes is reduced, because more sponsors remain in business, so the VaR and the ETL both fall. Doubling the prescribed length of the recovery plan also has an important impact on top-up payments, which in this case are substantially smaller than in the benchmark. For instance, the median pension top-up in the alternative case amounts to only 6 per cent of the median payment in the baseline.

Figure 21 Distribution of funding ratios in 2017 when recovery plan stretches over 20 years



Source: ABI Research.

Table 12 Summary indicators 2007-2099 – longer recovery plan

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Target 2027	3%	43%	0.1	9	17%	13	25%
Baseline	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

8.3 Discount rate

Defined-benefit pension schemes calculate their liabilities by discounting future expected pension obligations using the rate on AA-rated corporate bonds. This methodology, which underpins the ASB's FRS 17 regime, provides a snapshot of pension assets and liabilities at one point in time. This snapshot matters not just because it appears on the sponsor's balance sheet, but also because the pension liabilities drive the amount of capital needed in the scheme today to ensure the payment of members' future benefits.

The problem is that yields on corporate bonds have risen markedly in the recent past, due to rises in the perceived likelihood of corporate defaults as a result of the credit crunch. Paradoxically, the rise in corporate risk premium causes the liabilities of DB plans to fall, as future pension payments are therefore discounted more heavily. The fact that widened credit spreads reflecting poorer sponsor's creditworthiness translate into smaller pension liabilities prompted the ASB to suggest DB plans' promises should be discounted using the yield on gilts rather than AA bonds. While this approach inflates pension liabilities because the "risk-free" rate lies below the rate on AA bonds, it also eliminates exposure to yield spreads thus removing the link between falling corporate creditworthiness and declining pension deficits. Needless to say the ASB's proposal is contentious and has already sparked a great deal of debate within the pensions industry.²³

Therefore in this section we examine the impact changing the interest rate used to discount liabilities has on the financial health of our typical DB scheme and on the solvency of its sponsor. It has been argued that a change in the underlying discount factor entails accounting but not "real" effects on the scheme's funding position, because future cash outflows remain the same. Reality may be more complicated, though. In our model altering the discount rate does have important implications because the pension deficit changes and this in turn impinges on the size and frequency of the sponsor's top-up payments. As a result the likelihood that scheme or sponsor goes bankrupt changes.²⁴

8.3.1 Findings

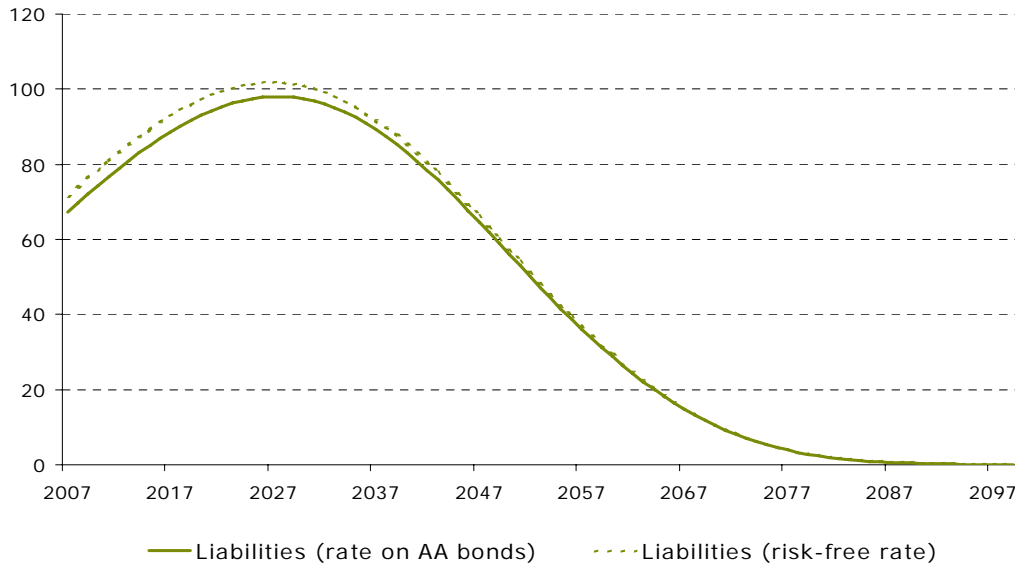
Figure 22 shows the forecasted value of the scheme's pension liability at each point in time when we use the expected risk-free rate rather than the yield on AA corporate bonds to discount future expected pension obligations. The underlying spread between these rates was assumed to be thirty basis points. The new value of the pension

²³ See also Klumpes (2008) for a discussion of the impact of different accounting methods.

²⁴ The mechanism at work seems realistic. There is clear evidence, for example, that financial analysts change the valuation of the sponsoring companies depending upon the size of the FRS 17 pension deficit reported in the company's financial statements.

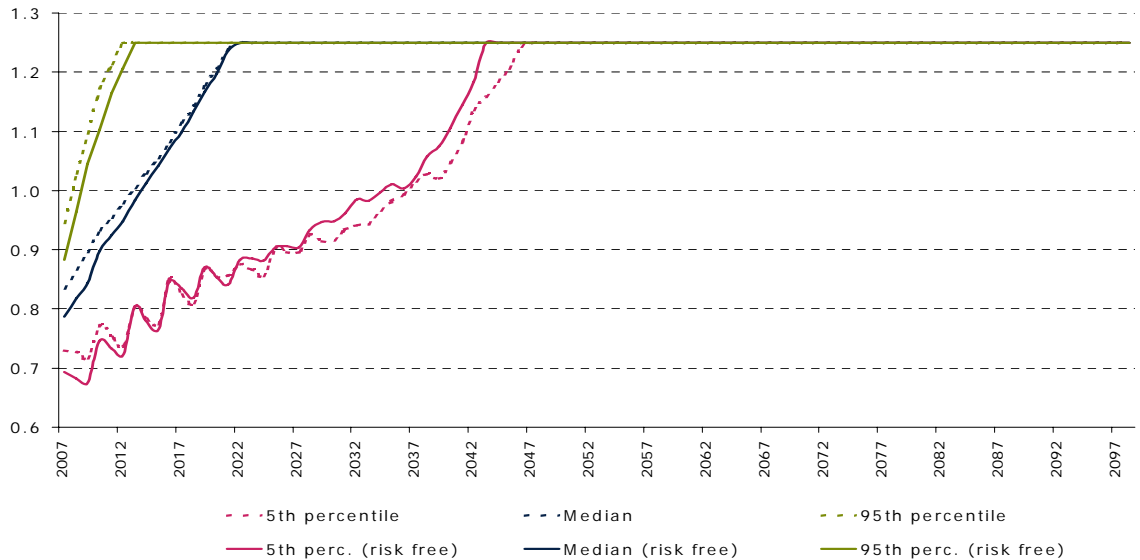
liability in 2007 is about £72m, up from £67m in the base case. This translates into an approximate increase of 6% in the initial pension deficit.

Figure 22 Impact of risk-free rate on pension liabilities, 2007-2099



Source: ABI Research.

Figure 23 Funding ratios with risk-free discount rate



Source: ABI Research.

The evolution of the median, 5th and 95th percentiles of funding ratios are shown in Figure 23. The increase in the initial pension shortfall triggers a downward shift in funding ratios for 2007. Weaker initial funding positions lead in turn to larger and quicker top-up payments from the sponsoring employer. In the end the distribution of

funding ratios and the speed with which the tracked percentiles reach buy-out outcomes are not very different from the benchmark. For example, in nearly 75 per cent of cases our DB scheme is 100% funded by 2017.

The impact of using the risk-free discount rate becomes more apparent if one considers the present value of the employer's deficit-reduction contributions. The average top-up payment in present-value terms goes up from £4.6m in the baseline case to £5.9m in the alternative – a 29 per cent increase in the average cash injection. The jump in the median top-up contribution is even starker since it more than doubles over the period, going from £1.6m in the base case to £3.6m in the alternative scenario being studied.

As using a risk-free discount rate means the plan receives more cash inflows than in the baseline, both VaR and ETL go down because even schemes that go bust are in better financial shape. This can be seen in Table 13.

Table 13 Summary indicators 2007-2009 – Risk-free discount rate

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Risk-free rate	2%	46%	3.6	7	13%	13	25%
Baseline case	3%	45%	1.6	10	19%	15	27%

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

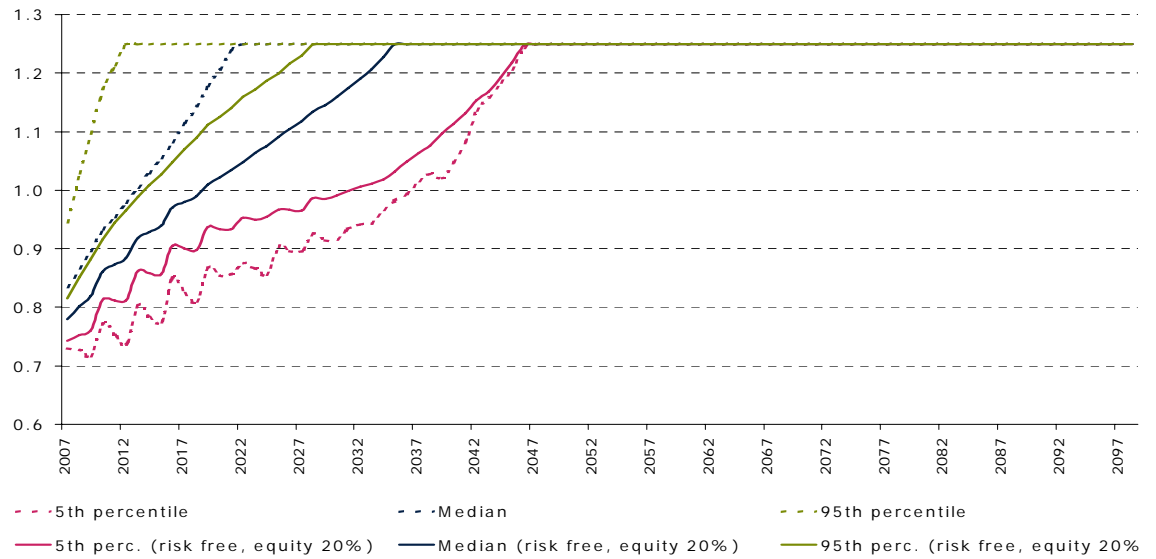
Source: ABI Research.

8.3.2 Shift in asset allocation strategy

Using the risk-free rate to discount future pension payments might also have unintended consequences. For example, it may induce DB plans to hold a larger proportion of fixed-interest gilts in order to reduce volatility in recognised surpluses and deficits. To examine the impact of a potential switch towards liability-driven investment strategy by our typical scheme, we look at the case where liabilities are discounted using the yield on government bonds and the scheme adopts an investment strategy whereby 20 per cent of pension assets are held in equities and 55 per cent in gilts.

The dispersion around projected funding ratios is shown in Figure 24. Forecasted outcomes for the bottom end of the distribution improves slightly because the DB scheme is more protected against adverse equity shocks. However, the cautious investment policy wipes out higher investment returns and therefore median and top-quartile outcomes reach fully funded positions much later on. This delay entails consequences for the sponsor.

Figure 24 Funding ratios with risk-free rate and conservative asset allocation



Source: ABI Research.

As can be observed in Table 14, the median of the present value of pension top-ups rises to £5.4m or about 10 per cent of the market value of assets at the beginning of the projections. Tail risks fall sharply and the VaR at the 99 per cent confidence level turns out to be negative – a surplus.

Table 14 Summary indicators 2007-2099 – Risk-free rate and 20% equity

	Scheme goes bust	Sponsor goes bust	Median top-up £m	VaR (deficit)		ETL (deficit)	
				£m	As % assets	£m	As % assets
Risk-free rate,							
20% equity	1%	44%	5.4	-0.5	1%	2	4%
Baseline	3%	45%	1.6	10	19%	15	27%

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

Source: ABI Research.

9.0 CONCLUDING REMARKS

In this paper we modelled a UK typical DB pension scheme and run sensitivity tests to assess key sources of uncertainty affecting the financial health of the fund and its corporate sponsor. The paper builds on previous ABI research looking at the impact of the timing of cash inflows and outflows on DB pension deficits. The paper:

- Analyses the drivers of funding gaps in DB pension plans;
- Uses stochastic modeling to highlight the uncertainty surrounding DB schemes;
- Assesses the impact on scheme solvency of investment policy, market and business risks, and changes in mortality expectations;
- Considers how the institutional arrangement affects projected outcomes for both pension scheme and sponsoring employer;
- Explores how the strength of the sponsor affects the fortunes of a typical UK defined-benefit scheme.

One important issue not considered in this paper refers to optimal asset mix decisions in DB plans. For example, it has been suggested employers take an integrated company-wide approach to risk management and portfolio allocation that takes pension assets and liabilities as integral part of their economic value and risk balance sheets.²⁵ In this unified framework both pension plan and sponsoring company are seen as a single risk unit – pension risks are corporate risks – and the DB scheme's asset allocation strategy is formulated accordingly.

However the specific UK institutional reality implies that asset allocation decisions are made by the trustees, who are responsible for managing the fund and are supposed to act in the scheme's best interest. As a consequence the scheme's optimal portfolio allocation will not normally coincide with the most preferred portfolio allocation decision from the firm's (and its shareholders') viewpoint. The extent to which the DB scheme's asset allocation strategy may differ from the sponsor's preferred strategy is likely to hinge on trustees' goals and risk tolerance, and on the existing institutional and regulatory environments.

Trustees' portfolio choices are also likely to be influenced by the existence of a pension lifeboat that provides scheme members with public insurance against corporate insolvency – for instance the Pension Protection Fund (PPF) in the UK. To some extent the impact pension insurance has on the scheme's asset allocation is reminiscent of the employer covenant: the more comprehensive and certain pension insurance is, the more irrelevant the scheme's asset allocation becomes as members' pensions are guaranteed irrespective of the value of the pension assets. This result holds independently of the risk appetite of trustees and members. However in a world where trustees are risk averse, the availability of partial insurance – either from the firm or

²⁵ See, for example, Merton (2006).

from a pension provider of last resort – makes the scheme's asset allocation more responsive to the equity risk premium than in the absence of insurance.

A1 MODELLING THE COMPANY

This appendix details how we model the corporate sponsor.

A1.1 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,

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

We assume $\tilde{\varepsilon}$ follows a normal distribution with mean zero and a standard deviation chosen such that the one-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):

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

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 initialized 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 .

A1.2 The corporate sponsor – adding in the pension scheme

For a company sponsoring a DB pension fund, we also need to take into account top-up payments ($topup_t$) 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:

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

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 time 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.

A2 MODELLING THE PENSION SCHEME

To model key ingredients of the defined-benefit 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 15 details the modelling assumptions made in this paper for our baseline case.

Table 15 Modelling assumptions for pension obligations

Variable	Description	Type	Baseline assumption
Workforce	Quantity of people employed each year by the corporate sponsor.	Non-random	1,000 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 Annual Survey of Hours and Earnings (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 Retail Price Index (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	1/80 th

Variable	Description	Type	Baseline assumption
Indexation year	Year from which accrued pension benefits are indexed by RPI inflation. ²⁶	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 yrs old Women: 60 yrs 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

Source: ABI Research

Non-random variables take the values detailed in Table 15 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 Table 15. 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.

The following table contains the variance-covariance matrix corresponding to our nine random variables.

Table 16 Variance-covariance matrix

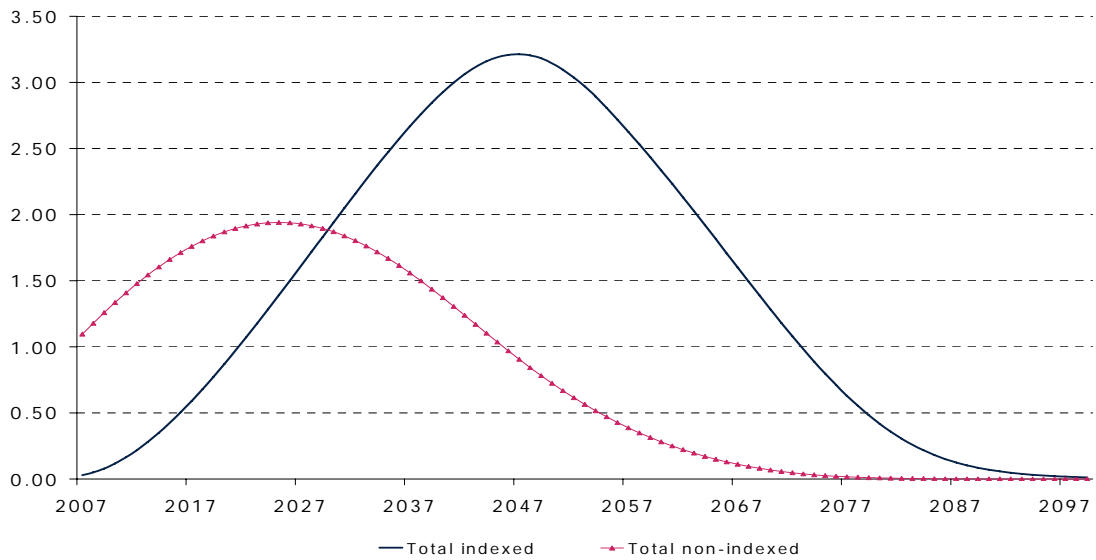
	Cash	Gilts	Index-linked gilts	Swap spread	BBB bond spread	RPI inflation
Cash	0.000082	0.000016	0.000011	0.000021	0.000008	0.000023
Gilts	0.000016	0.000010	0.000010	0.000002	0.000000	0.000001
Index-linked Gilts	0.000011	0.000010	0.000014	0.000003	0.000005	-0.000008
Swap spread	0.000021	0.000002	0.000003	0.000013	0.000012	-0.000005
BBB bond spread	0.000008	0.000000	0.000005	0.000012	0.000019	-0.000013
RPI inflation	0.000023	0.000001	-0.000008	-0.000005	-0.000013	0.000065

²⁶ 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.

	Productivity growth	Increase in real wages	Equity returns
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	-0.0000001	-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

Our baseline scenario supposes that accrued benefits are indexed by RPI inflation since 1988. Hence most of the payouts shown in Figure 25 are made up of index-linked benefits. Figure 25 illustrates the evolution of indexed and non-indexed pension payments when, for example, the schemes adjusts promises by inflation from 2000 onwards. At the beginning payments are mainly driven by non-indexed pension benefits, but indexed payouts rapidly become increasingly important.

Figure 25 Indexed and non-indexed pension payments (£m) when indexation starts in 2000, 2007-2099



Source: ABI Research and Fathom Financial Consulting.

A3 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 UK, corporate sponsors of DB schemes are exposed to significant longevity risk due 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 UK. The Government Actuaries Department (GAD), for 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*.²⁷ 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 for two arbitrary cohorts in our model:

Table 17 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:	
	<i>Aged 65</i>	<i>Aged 45</i>	<i>Aged 65</i>	<i>Aged 45</i>
GAD 2006-based projections	20 years	22 years	23 years	24 years
GAD 2004-based projections	19 years	21 years	22 years	23 years

Source: GAD and own calculations.

The GAD 2006-based tables therefore imply our scheme members are likely to live about one 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 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 Pensions Regulator in 2007 indicates that the vast majority of DB plans (97%) used the “1992” CMI tables to

²⁷ Driver and Selvaggi (2007).

project members' life expectancy, particularly the PMA92 (males) and PFA92 (females) forecasts.²⁸ These tables were often used in conjunction with the "interim adjustments" to account for future reductions in mortality rates according to cohort effects.²⁹ As a result of rapid mortality improvements detected during the 1980s for a cohort of people born around 1925-35 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 1,138 schemes that submitted recovery plans to the Pensions Regulator 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 of Section 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. Specifically;

Table 18 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:	
	<i>Aged 65</i>	<i>Aged 45</i>	<i>Aged 65</i>	<i>Aged 45</i>
GAD 2006-based projections	20 years	22 years	23 years	24 years
PXA92 YOB medium cohort	19 years	22 years	24 years	25 years
PXA92 YOB long cohort	23 years	24 years	26 years	27 years

Source: GAD, CMI and own calculations.

²⁸ The Pensions Regulator (2007): "Recovery plans: an initial analysis", September 2007.

²⁹ Cohort effects arise when the patterns of mortality improvement are linked to year of birth.

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