Impact of the Choice of Risk Assessment Time Horizons on Defined Benefit Pension Schemes

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Agenda

- Introduction
- Risk measurement framework
- Stochastic models
- Scheme profile
- Results
- Conclusions

Background

- Years of high inflation and good investment returns during the 1970s and 1980s created the illusion that DB pension schemes are easily affordable.
- Over the past decade or more, increasing life expectancy and steady fall in interest rates have meant that pension costs have increased.
- Regulatory developments: Basel 2/3, Solvency 2, Pensions Regulations.

Objective:

1. Quantify DB pension scheme risk from an economic capital perspective.
2. Ascertain the impact of choice of risk assessment time horizons on DB pension schemes.

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Economic capital

Economic Capital

Economic capital of a pension scheme is the proportion by which its existing assets would need to be augmented in order to meet net benefit obligations with a prescribed degree of confidence.
A pension scheme's net benefit obligations are all obligations in respect of current scheme members, including future service, net of future contributions to the scheme.

Notations:

- A_t: Value of pension scheme assets at time t;
- L_t: Value of pension scheme liabilities at time t;
- X_t: Net cash flow at time t (excluding investment returns);
- $I_{(s,t)}$: Accumulated value at time t of \$1 invested at time s;
- $D_{(s,t)}$: Discount factor, i.e. $D_{(s,t)} = I_{(s,t)}^{-1}$.

Formulation

Assuming annual cashflows and valuations, over a time horizon of T years, define:

$$V_0^{(T)} = A_0 - \sum_{t=0}^{T} X_t \, D_{(0,t)} - L_T \, D_{(0,T)},$$

as the amount of excess assets required to meet net cash outflow over $[0, T]$ and to set up reserves, L_T, as quantified by the valuation actuary at time T, to meet future obligations beyond time T.

Time horizons considerd in this research:

Long term run-off approach: $V_0^{(\infty)} = A_0 - \sum_{t=0}^{\infty} X_t \, D_{(0,t)}$, as $L_\infty = 0$.

Short term 3-year time horizon: $V_0^{(3)} = A_0 - \sum_{t=0}^{3} X_t \, D_{(0,t)} - L_3 \, D_{(0,3)}$.

Risk measures

Standardisation to account for currency and scale:

$$V_0^{(T)} \text{ expressed as a percentage of initial assets } A_0.$$

↳ Interpreted as the proportional increase in assets required to meet all future benefit obligations.

Using $V_0^{(T)}$, for a given probability p, economic capital can be quantified as:

- Value-at-Risk (VaR) defined as: $\mathrm{P}\left[V_0^{(T)} \leq VaR\right] = p$.
- Expected shortfall (ES) defined as: $\mathrm{E}\left[V_0^{(T)} \mid V_0^{(T)} \leq VaR\right]$.

↳ In our results, we will show entire distributions of $V_0^{(T)}$,
↳ highlighting the following percentiles: 50^{th} (median) and 10^{th}.

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Economic scenario generator: Graphical model

The individual economic random variables, Z_{it}s, are modelled as:

$$\mu_x = \mathbb{E}\left[X_t\right], \quad \text{(i.e. averaging over time);}$$
$$Z_t = X_t - \mu_x, \quad \text{for } t = 0, 1, 2, \ldots, H;$$
$$Z_t = \beta_x Z_{t-1} + e_{x,t}, \quad \text{for } t = 1, 2, \ldots, H; \text{ where } e_{x,t} \sim N\left(0, \sigma_x^2\right).$$

The error terms which are directly connected to each other are dependent, while those which are indirectly connected are still dependent, but more weakly so.

Stochastic mortality model

We use model M7 of Cairns et al. (2009):

$$\operatorname{logit} q(t,x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x-\bar{x}) + \kappa_t^{(3)}\left[(x-\bar{x})^2 - \sigma_x^2\right] + \gamma_{t-x}^{(4)}, \quad \text{where}$$

- $q(t,x)$ is the probability that an individual aged x at time t will die within a year;
- $\kappa_t^{(i)}$ is period effect;
- $\gamma_{t-x}^{(i)}$ is cohort effect.

The model is parameterised using

- data from Human Mortality Database;
- for both UK and US;
- for both males and females;
- for years 1961 – 2014;
- for ages 30 – 100.

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Membership profile: Model points

Table: USS membership profile as at March 31, 2014 (USS 2014 valuation report).

Membership types	Age	Number	Salary	Accrued service/benefit
Active	30	50,264	£25,500	7 years past service
	40	50,264	£42,500	11 years past service
	50	33,509	£52,500	15 years past service
	60	33,509	£58,500	19 years past service
Deferred	45	110,430		Accrued pension of £2,373 per year
Pensioner	71	70,380		Accrued pension of £17,079 per year

Other assumptions:

- 50:50 gender split.
- Promotional salary scale, withdrawal rates and proportion married assumptions are as provided in the valuation report.

Benefit structure

Retirement benefits

Cash lump sum $= 3 \times$ Annual pension.

Annual Pension (inflation-linked) $=$ Pensionable salary $\times$ Pensionable service $\times$ Accrual rate.

Accrual rate of 1.25% on final salary basis until 2014 and 1.33% on career revalued benefits basis post 2014.

Withdrawal benefits

- Deferred inflation-linked pension benefits are based on accrued service on withdrawal.
- Inflation indexation of salaries between the date of leaving and retirement is provided.

Death benefits

- On death of active member, lump sum payment of 3 times the annual salary is paid; along with
- spouse's pension of half the amount the member would have received on retirement.

On death of a pensioner, a spouse's pension of half the member's pension is payable.

Contributions, assets and liabilities

Contributions:	22.5% of salary
Liabilities:	£46.9b
Assets:	£41.6b
Asset allocation:	70% equities and 30% bonds

Scheme liabilities are calculated using the projected unit method, which is a prospective valuation method in which liabilities are estimated based on the past service accrued on the valuation date, taking into account future salary inflation.

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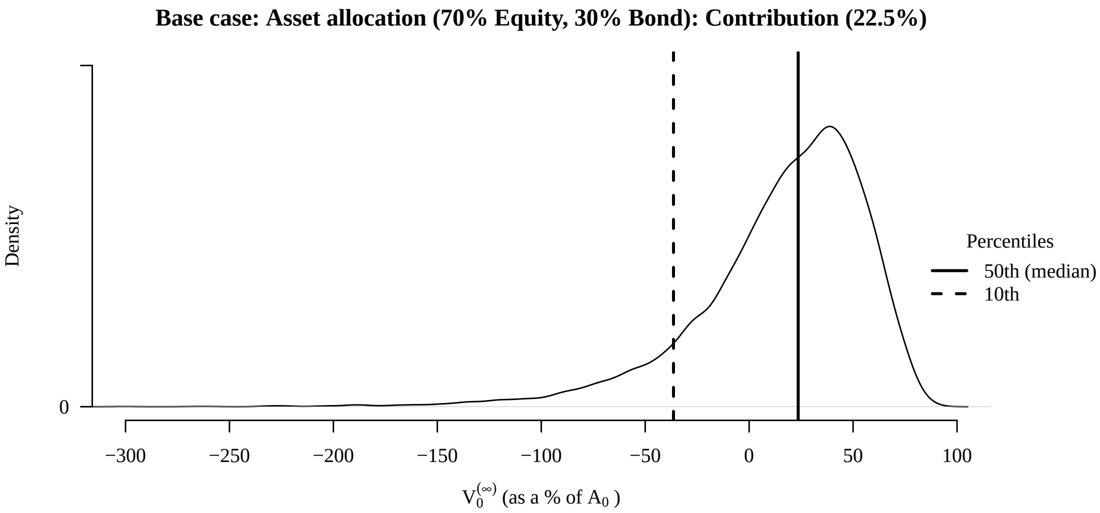
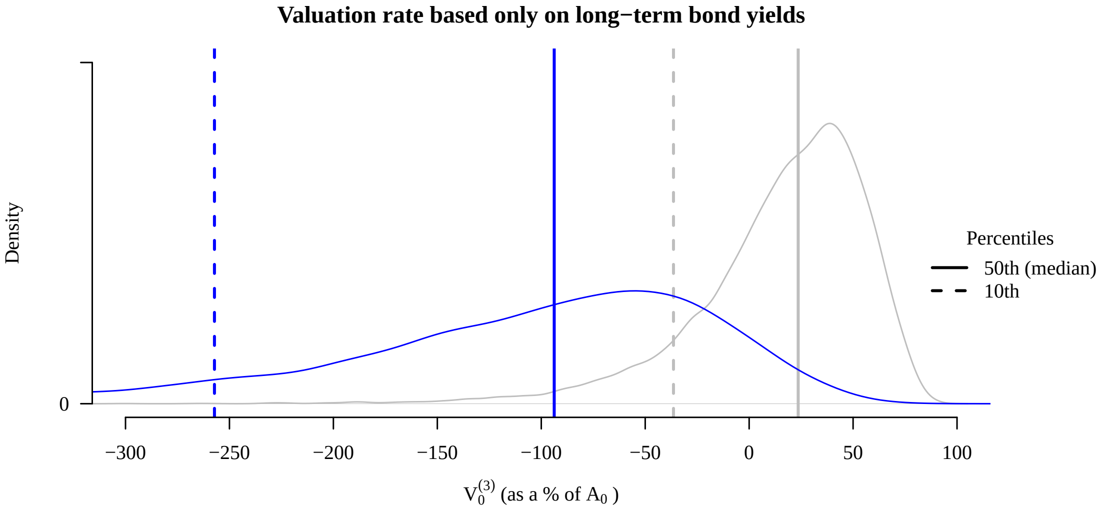
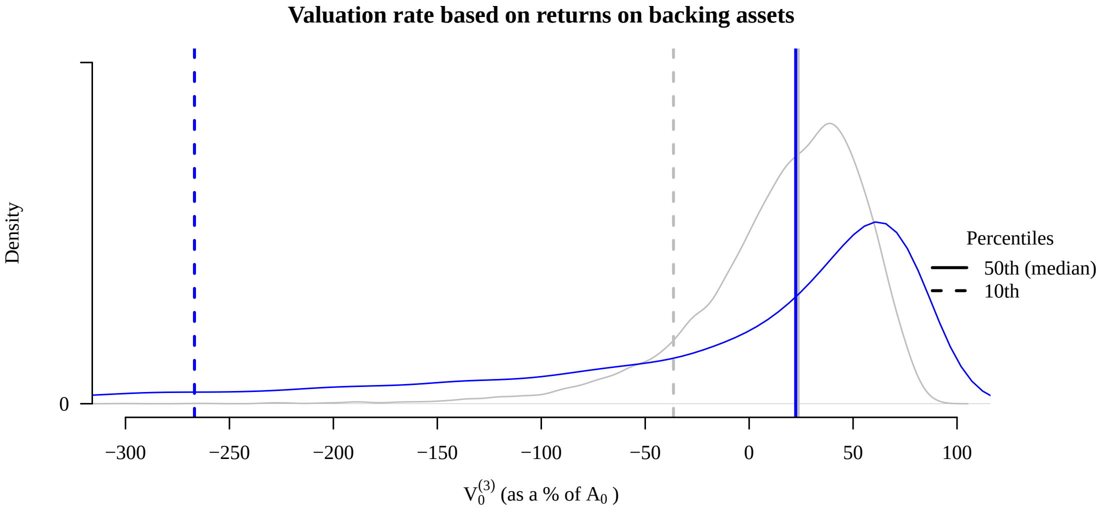
Base case: Run-off



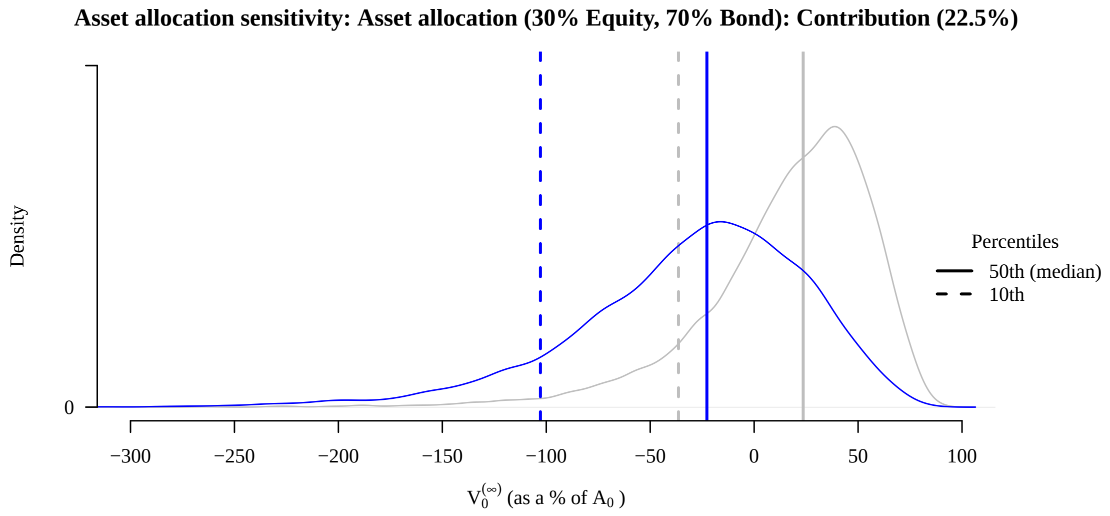
Base case: 3-year time horizon: Valuation rate based on bond yields



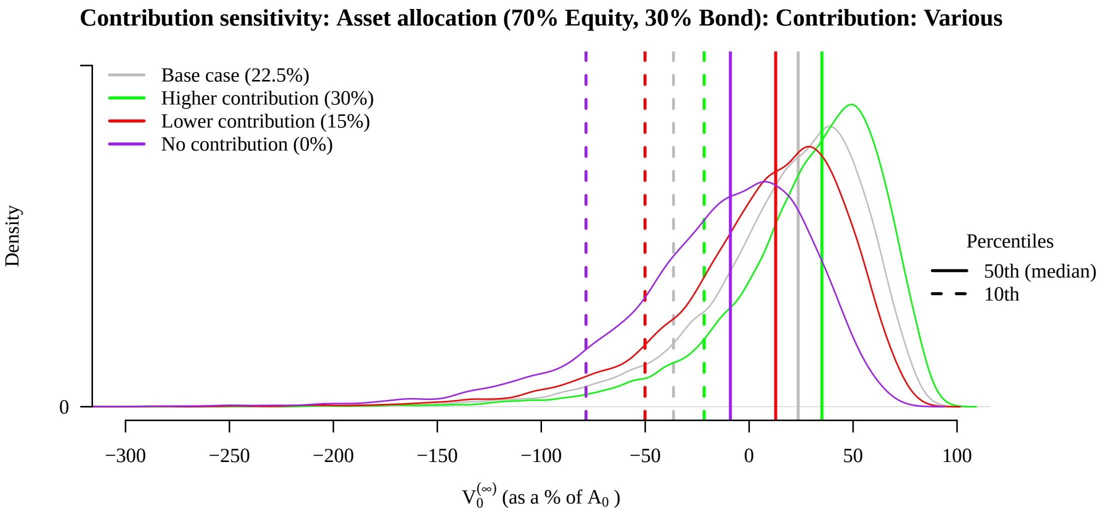
Base case: 3-year time horizon: Valuation rate based on backing assets



Asset allocation sensitivity: Run-off



Contribution sensitivity: Run-off



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Conclusions

- Range of results is very wide.
- Risk assessment time horizon has a significant impact on pension scheme risk quantification.
- Difference in time horizon generates different conclusions regarding the best approach to manage risk through changes in asset allocation.
- Impact of changes in asset allocation is much larger than for changes to scheme contributions.

Reference

ANDREWS, D., BONNAR, S., CURTIS, L.J., OBEROI, J. S., PITTEA, A. & TAPADAR, P. (2021). Impact of the choice of risk assessment time horizons on defined benefit pension schemes. *Annals of Actuarial Science*, **doi:10.1017/S1748499521000178**, 1–29. *Link to paper*.