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

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Longevity 17 Conference, September 2022

Acknowledgement:

This research is part of a larger project funded by the CIA, IFoA, SoA, SSHRC, University of Kent and University of Waterloo.

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. $D_{(s,t)} = I^{-1}_{(s,t)}$.

Formulation

Assuming annual cashflows and valuations, any surplus or deficit is given by:

Profit Vector: $P_t = L_{t-1} I_{(t-1,t)} - X_t - L_t$, with $P_0 = A_0 - X_0 - L_0$.

Over a time horizon of T years, the present value of future profits (PVFP):

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

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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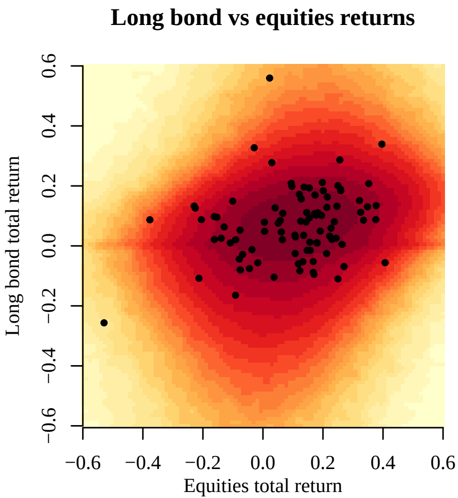
Economic scenario generator: Graphical model

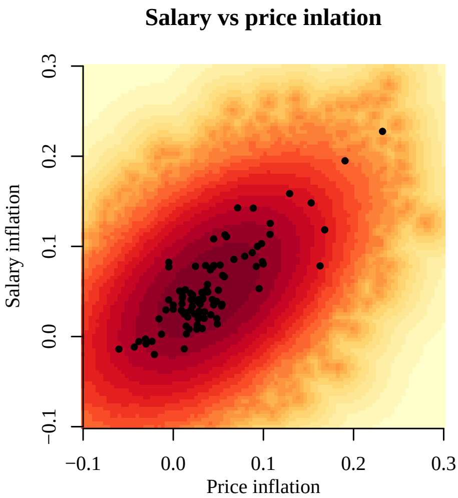
The individual economic random variables, Z_{it}s, are modelled as:

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

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.

Economic scenario generator: Simulation and historical data





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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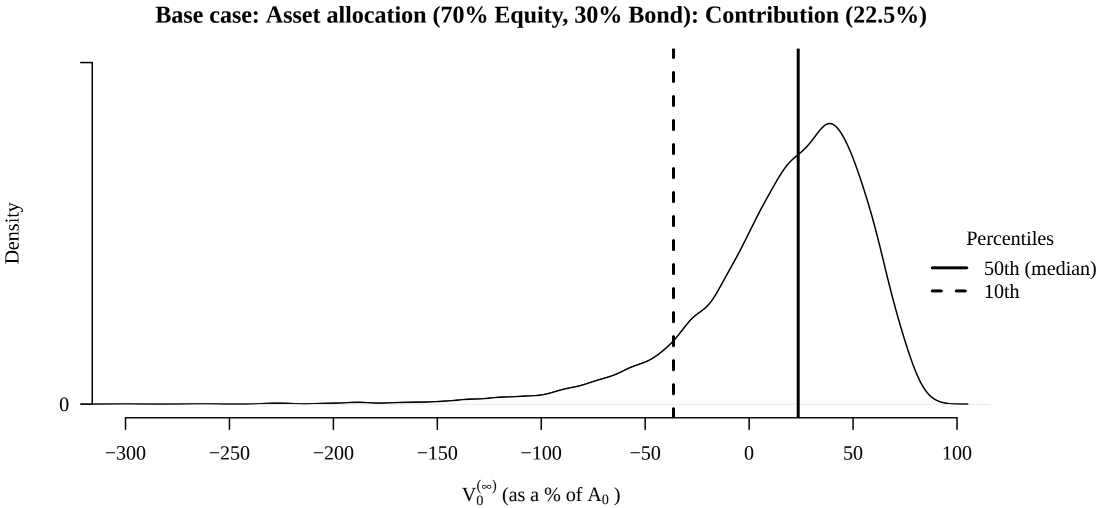
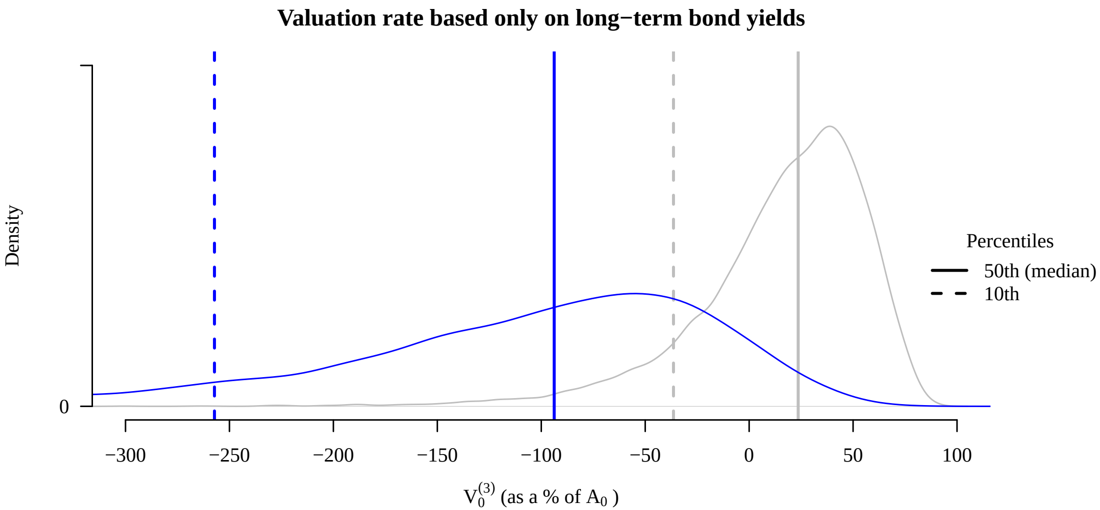
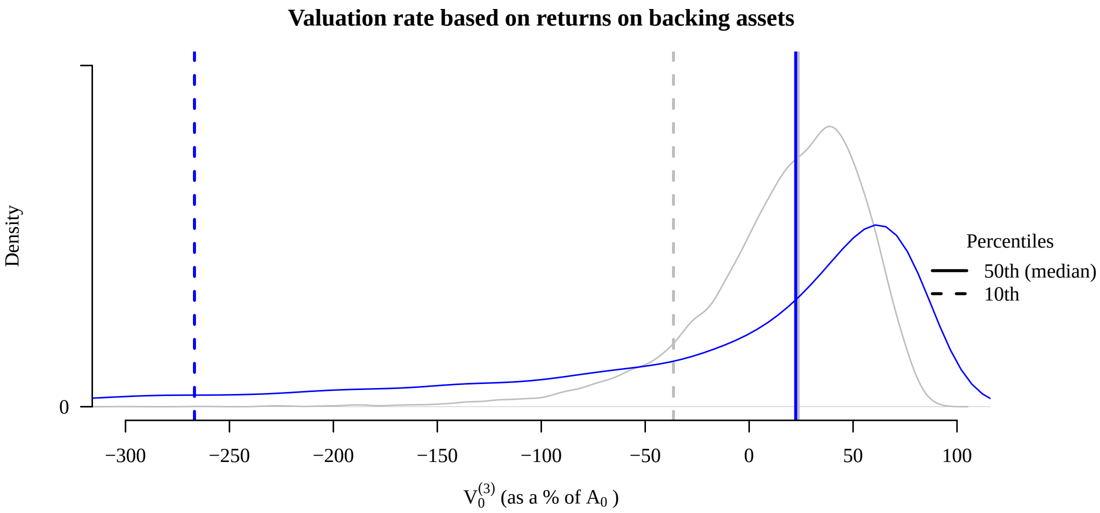
Base case: Run-off



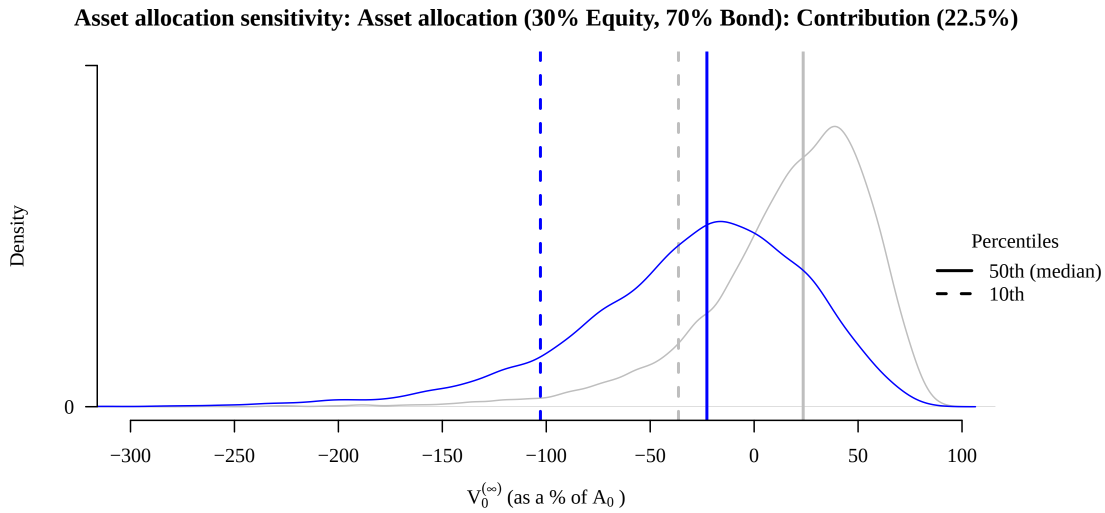
Base case: 3-year time horizon: Valuation rate based on bond yields



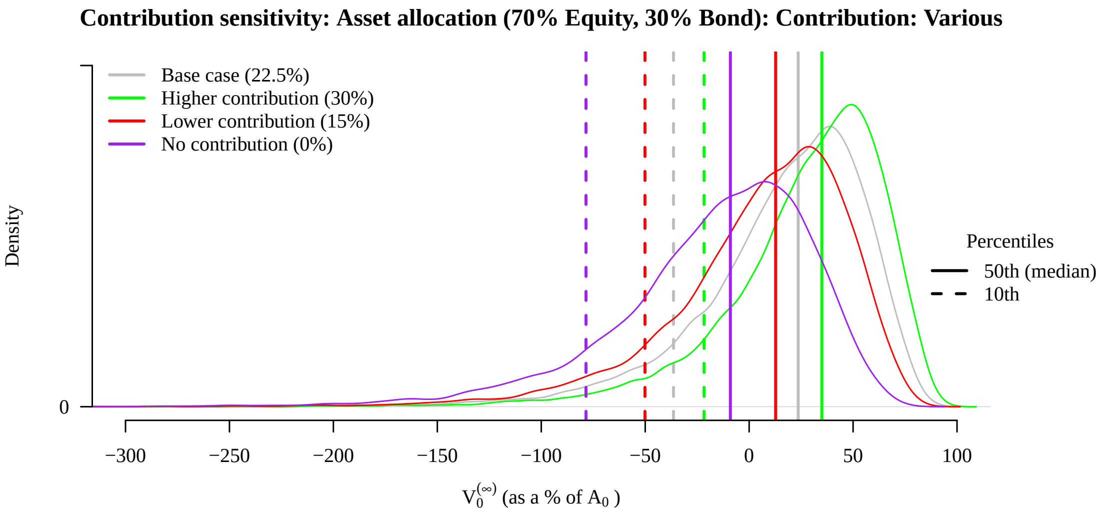
Base case: 3-year time horizon: Valuation rate based on backing assets



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*.