

A Tale of Two Pension Plans

Measuring Pension Plan Risk from an Economic Capital Perspective

Pradip Tapadar

Co-authors: Douglas Andrews, Stephen Bonnar, Lori J. Curtis, Jaideep S. Oberoi, Aniketh Pittea.

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Agenda

- Introduction
- Stochastic models
- Model assumptions
- Results
- Conclusions

Background

- Years of high inflation and good investment returns during the 1970s and 1980s created the illusion that DB pension plans 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:

Quantify pension plan risk from an economic capital perspective for:

- ① a UK pension plan: Universities Superannuation Scheme (USS); and
- ② a stylised US plan, with the same membership profile as USS but with plan provisions modified to reflect a typical US DB plan.

Risk Measurement Framework: Economic Capital

Economic Capital

The economic capital of a pension plan is the proportion by which its existing assets would need to be augmented in order to meet net benefit obligations (in respect of current plan members) with a prescribed degree of confidence.

Notations:

A_t : Value of pension plan assets at time t ;

L_t : Value of pension plan 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. $D_{(s,t)} = I_{(s,t)}^{-1}$.

Risk Measurement Framework: 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):

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

Given the long-term nature of pension plan risks, we propose a **run-off approach** (i.e. until the last of the current plan members dies), so that $L_T = 0$. Under this assumption:

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

Risk Measurement Framework: Risk Measures

Standardisation to account for currency and scale:

$$V_0^* = \frac{V_0}{A_0},$$

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

Based on V_0^* , economic capital can be quantified as either:

- **Value-at-Risk (VaR)** defined as $P[V_0^* \leq VaR] = p$; or
- **Expected shortfall (ES)** defined as $E[V_0^* | V_0^* \leq VaR]$;

for a given probability p .

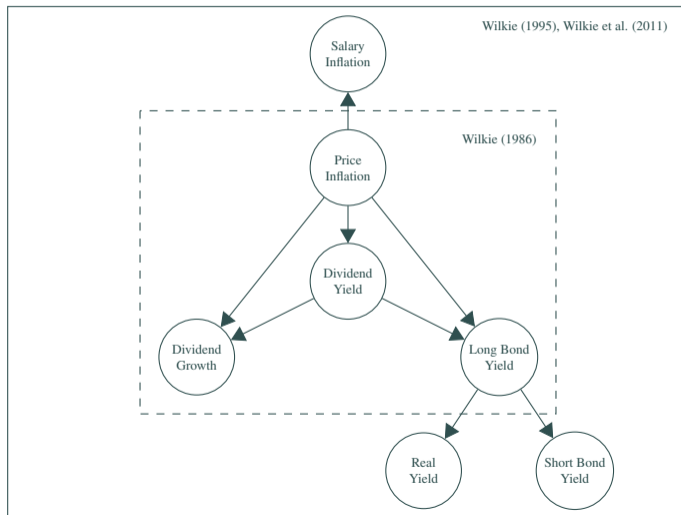
↳ In our results, we will show entire distributions of V_0^* ,

↳ highlighting the following percentiles: 50th (median), 10th and 0.5th.

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Economic Scenario Generator: Wilkie Model (UK only)

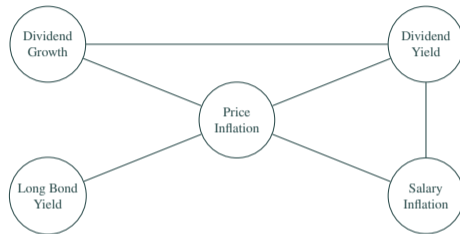


Economic Scenario Generator: Graphical Model (both UK and US)

UK Graphical Model



US Graphical Model



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

$$Z_{it} = \mu_i + Y_{it}, \text{ where } Y_{it} = \beta_i Y_{i(t-1)} + \varepsilon_{it} \text{ and } \varepsilon_{it} \sim N(0, \sigma_i^2).$$

The error terms

- which are directly connected to each other are dependent;
- which are indirectly connected are still dependent, but more weakly so. (Oberoi et al. (2019))

Stochastic Mortality Model

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

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

- $q(t, x)$ 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	Accrued service/benefit
Active	30	50,264	7 years past service
	40	50,264	11 years past service
	50	33,509	15 years past service
	60	33,509	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.

Retirement Benefits

USS

Annual Pension = Pensionable salary \times Pensionable service \times Accrual rate;

Cash lump sum = 3 \times Annual pension.

Simplified modelling approach:

- Until 2014, accrual rate of 1.25% on a final salary basis.
- Post 2014, accrual rate of 1.33% on a career revalued benefits basis.
- Annual pension increase in line with inflation.

Stylised US plan

- Accrual rate of 1.5% on a final salary basis.
- No cash lump sum on retirement.
- No indexation of pension during the payment period.

Withdrawal Benefits

USS

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

Stylised US plan

- A deferred pension, without any indexation, is provided based on accrued service on withdrawal.
- There is no indexation during the payment period.

Death Benefits

USS

On death of an active member

- Lump sum payment of 3 times the annual salary is paid on death.
- A spouse's pension of half the amount of pension the member would have received if survived till retirement.

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

Stylised US plan

On death of an active member

- Lump sum equal to the present value of the pension the member would have received if survived till retirement.

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

Contributions, Assets and Liabilities

	USS	Stylised US plan
Contributions	22.5% of salary	10.8% of salary
Assets	£41.6b	\$ 26.1b
Liabilities	£46.9b	\$ 32.6b

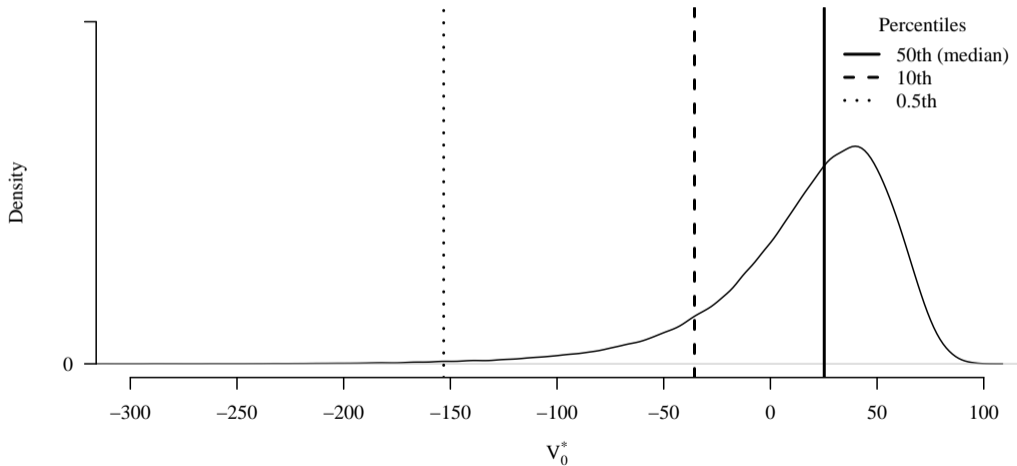
Asset allocation:

- **USS:** 70% equities and 30% bonds.
- **Stylised US plan:** 50% equities and 50% bonds.

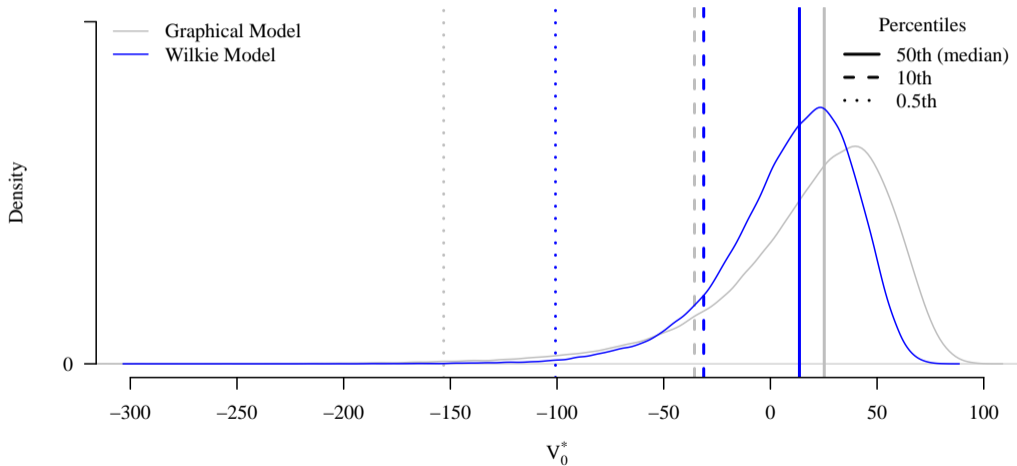
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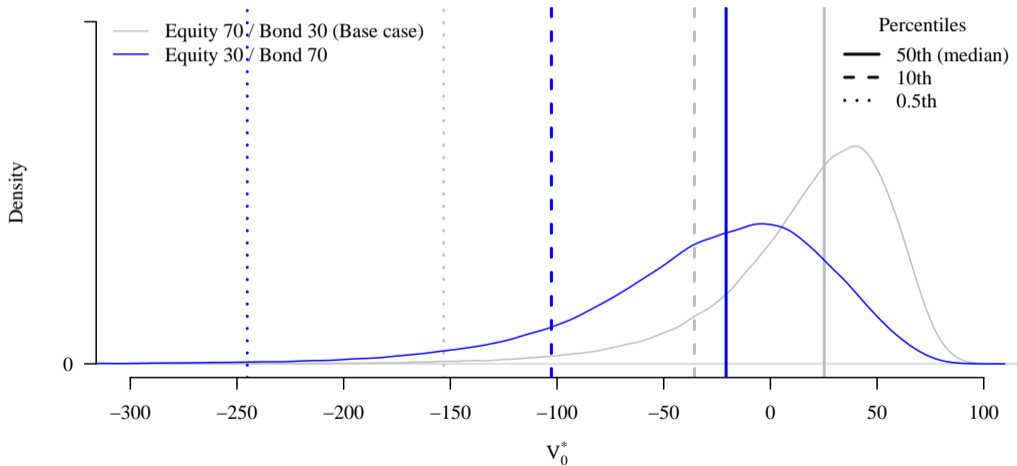
USS: Base Case Graphical Model



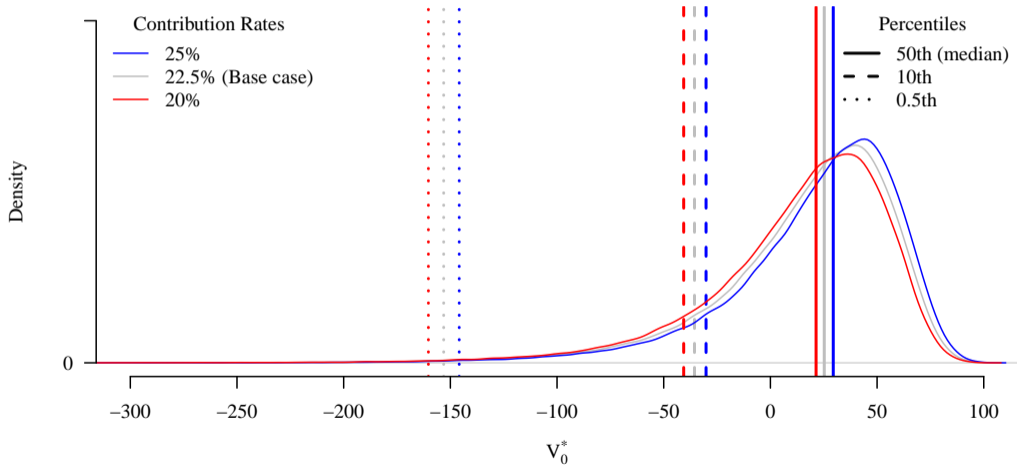
USS: Base Case Wilkie Model



USS: Sensitivity to Asset Allocation (Graphical Model)



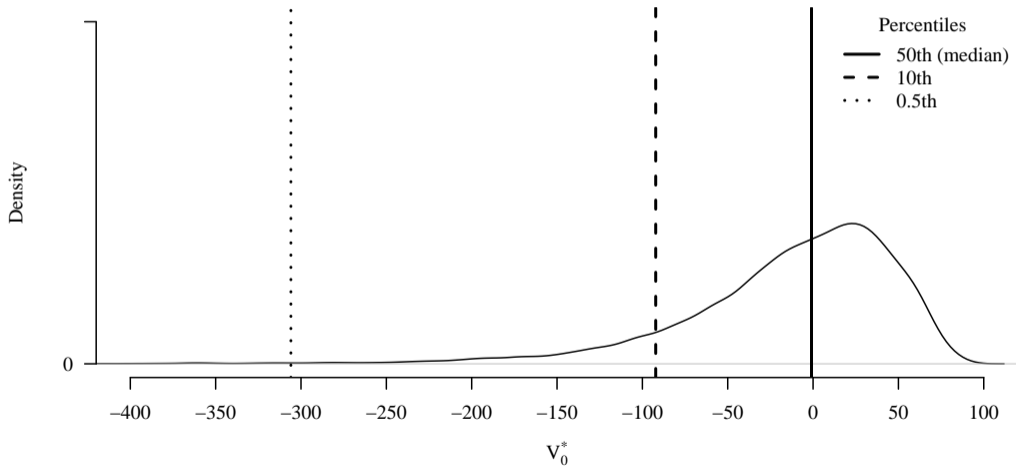
USS: Sensitivity to Contribution Rates (Graphical Model)



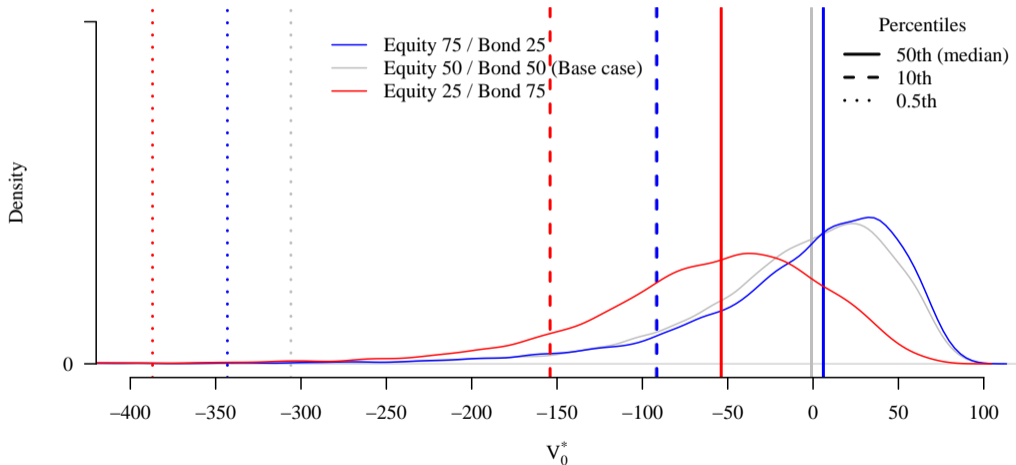
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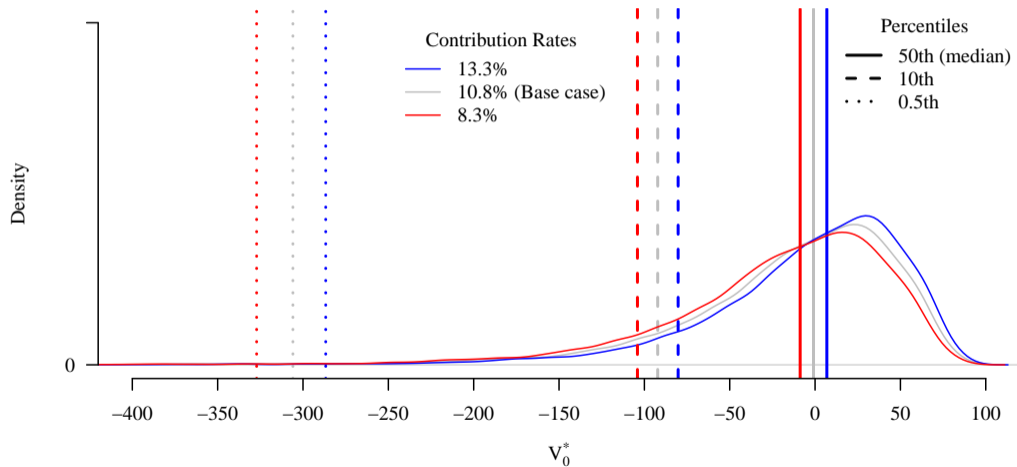
Stylised US Plan: Base Case Graphical Model (With Amortisation)



Stylised US Plan: Sensitivity to Asset Allocation (Graphical Model)



Stylised US Plan: Sensitivity to Contribution Rates (Graphical Model)



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Conclusions

- Range of results is very wide – this is a function of using the long run-off approach.
- Impact of changes in asset allocation is much larger than for changes to plan contributions.
- As a percentage of starting assets, stylised US plan is more volatile than the USS plan.
- Benefits of greater bond investment is greater for the stylised US plan than for USS.

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