Measuring Pension Plan Risk from an Economic Capital Perspective

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Acknowledgements

Motivation

- Typical pension plan valuation compares assets to liabilities

- This comparison looks at expected values (perhaps including some margin)

- One approach to pension plan risk assessment is Economic Capital [see Porteous, et al. (2012)]
  - Used for banking and insurance sectors under Basel 2, 3 and Solvency 2
  - Sufficient to cover 99.5th percentile outcome

Methodology

- Select a representative pension plan
  - Universities Superannuation Scheme (UK) 2014 Actuarial Valuation
  - Stylized US pension plan

- Select an economic model
  - Graphical Model [see Porteous (1995)]

- Select a mortality model
  - M7 from Cairns, et al. (2007)

- Quantify pension risk [see Porteous, et al. (2012)]

USS Pension Scheme – Benefits

- 1/80th final salary benefit for service to April 1, 2016

- 1/75th career revalued benefit for service from April 1, 2016

- Pension increases based on min [CPI, 5%]

Sylized US Pension Plan – Benefits

- Benefits based on USS pension scheme, except for the following

- 1.5% final average salary for all pension service

- No pension increases

Active Members	Number	167,545
	Average pensionable salary	£42,729
	Average age	43.8
	Average past service	12.5
Deferred Members	Number	110,430
	Average deferred pension	£2,373
	Average age	45.1
Pensioners (including dependents)	Number	70,380
	Average pension	£17,079
	Average Age	71.1

| Assets	Benchmark Allocation
UK equities	16%
Overseas equities	31
Alternative assets	19
Property	7
Total real	73%
Fixed interest	27
Cash	0
Total fixed	27%
Note: Modelled as 70% Equities and 30% Bonds	

Economic Model – Graphical Model

- The graphical model focusses on the correlation in the innovations between pairs of variables as illustrated in the figures on the following two slides (Porteous (1995)).

- The model selected is optimal based on the simultaneous p-values at a confidence level of $\alpha = 0.6$.

- Flexible model that can be calibrated to various economies. Currently it is calibrated to the UK and the US.

Model E6: Graphical model with 6 edges.
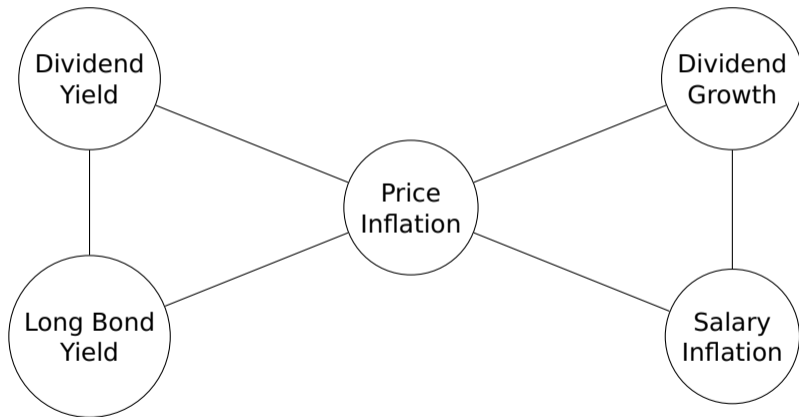
Model E6: Graphical model with 6 edges.
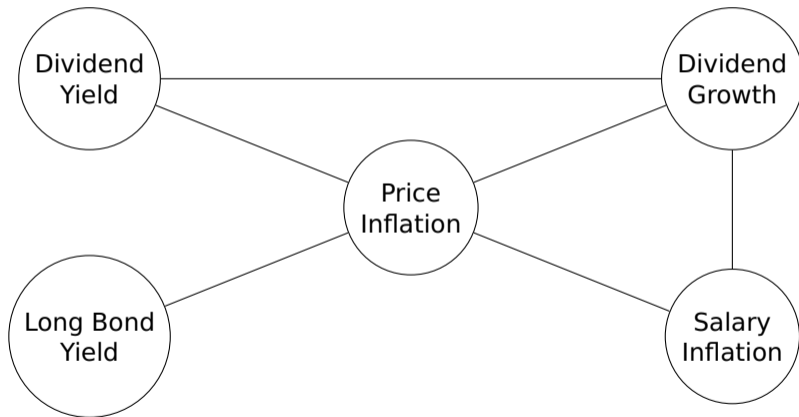
$$logit\ q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \kappa_t^{(3)}((x - \bar{x})^2 - \hat{\sigma}_x^2) + \gamma_{t-x}^{(4)}$$

- Model assumes a functional relationship between ages (and hence smoothness).

- One of the better fit models to England and Wales data (Cairns et al. (2007)).

Economic Capital Approach

- Use asset yield at time t, discount future benefits/expenses to obtain best estimate asset requirement

- Surplus/deficit at time t (profit vector) given by

$$P_t = L_{t-1}I_{t-1,t} - X_t - L_t$$
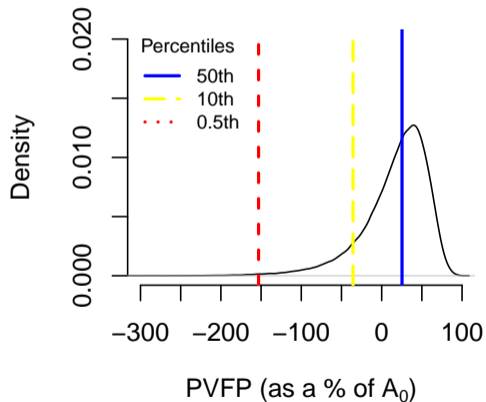
- Present value of future profits given by:

$$V_0 = \sum_{t=1}^{T} P_t D_{(0,t)}$$

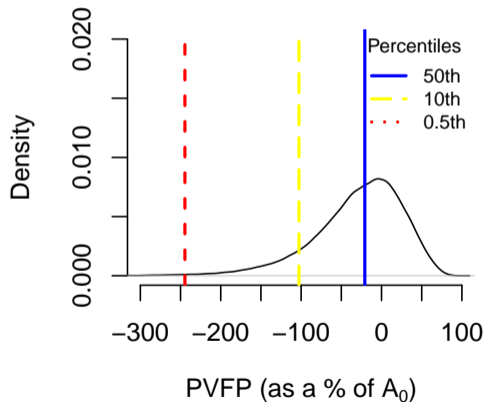- Present value of future profits, V_0, can also be expressed as follows:

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

- Repeat previous steps 10,000 times to obtain a distribution of V_0. The required economic capital is the 0.5th percentile of the V_0 distribution
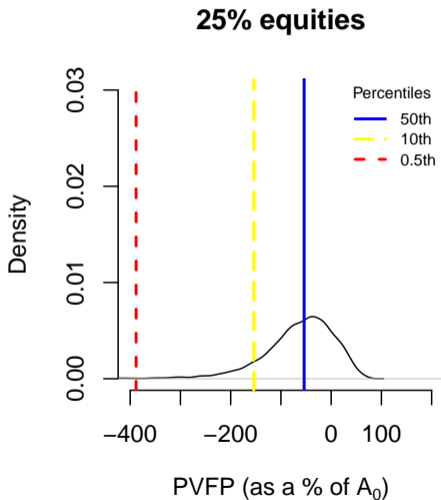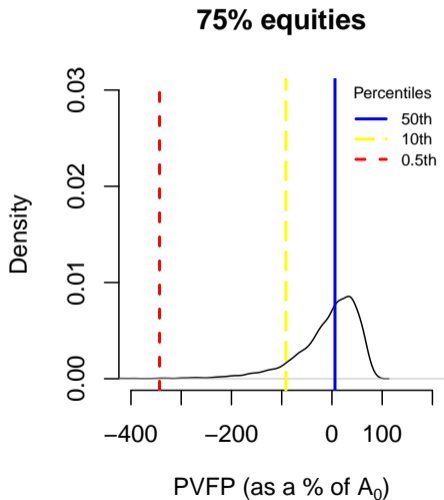
70% equities

30% equities

75% equities

25% equities

Summary

- There is a very large range of potential results

- The stylized US plan is more volatile than the USS
  - Economic capital twice as large as a percentage of starting assets
  - Economic capital also larger in absolute terms

- The beneficial effect on economic capital of increasing the allocation to long bonds is greater in the stylized US plan
  - Larger proportion of nominal (rather than inflation protected) benefits

References

- Cairns, Andrew JG, David Blake, Kevin Dowd, Guy D. Coughlan, David Epstein, Alen Ong, and Igor Balevich. A quantitative comparison of stochastic mortality models using data from England and Wales and the United States. *North American Actuarial Journal* 13, no. 1: 1-35, 2009.

- Porteous, Bruce T. *How to Fit and Use a Stochastic Investment Model*. Faculty of Actuaries Students' Society Paper, 1995.

- Porteous, Bruce T., Pradip Tapadar, and Wei Yang. Economic capital for defined benefit pension schemes: An application to the UK Universities Superannuation Scheme. *Journal of Pension Economics & Finance*, 11, no. 4: 471-499, 2012.