

A Tale of Two Pension Plans: Measuring Pension Plan Risk from an Economic Capital Perspective

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June 28, 2019

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- Motivation
- Overview
- Assumptions and Methodology
- UK's Universities Superannuation Scheme (USS)
- Stylized US Pension Plan
- Summary

Motivation

- Number of concerns regarding DB schemes across countries:
 - concerns of diminished asset returns
 - increasing longevity of pensioners
 - retirement of the baby boomers
- No widely accepted framework for DB pension schemes which is comparable to Solvency 2 for insurance companies or Basel 3 for banks.
- We propose a flexible and tractable approach to quantify the risks of DB pension schemes.

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Methodology

- Select a representative pension plan
 - Universities Superannuation Scheme (UK) 2014 Actuarial Valuation
 - Stylized US pension plan
- Select an economic model
 - Graphical Model [see Oberoi, et al. (2019)]
- Select a mortality model
 - M7 from Cairns, et al. (2007)
- Quantify pension risk [see Porteous, et al. (2012)]

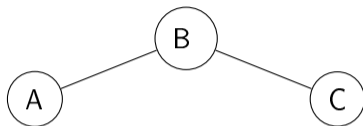
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Graphical Model - Background

- Graphical models are probabilistic models for which a graph expresses the conditional dependence structure between random variables.
- We use graphical models to simulate economic variables over long time horizons.
- The approach we use is:
 - transparent
 - flexible
 - easy to implement

Methodology - forecasting



- Assume 3 economic variables A, B and C.
- The individual economic random variables, Z_{it} s, are modelled as:

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

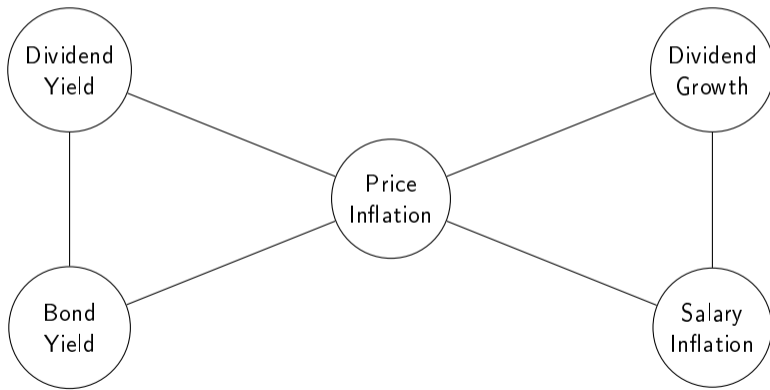
- Correlation of the **error terms** is represented by a graphical model.
- The error terms:
 - are assumed to be independently distributed across time t ;
 - which are directly connected to each other are dependent;
 - which are indirectly connected are still dependent, but more weakly so.

Methodology - selecting a correlation structure

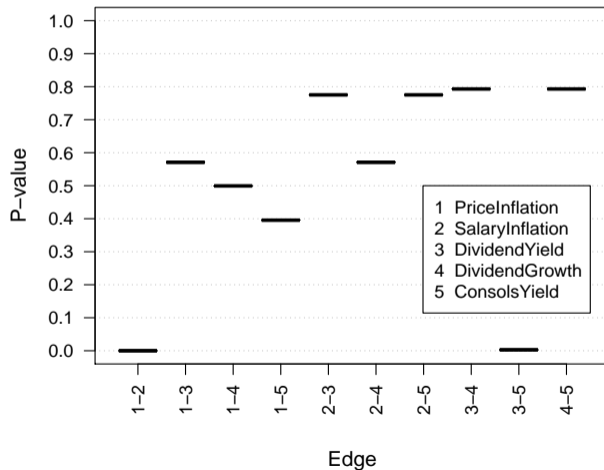
- We use simultaneous p-values to select a graphical structure.
- Hojsgaard et al. (2012). provide guidance on the use of packages written in R to estimate graphical models.
- We use the following UK and US economic time series data:
 - Price Inflation
 - Salary Inflation
 - Dividend Yield
 - Dividend Growth
 - Bond Yield

Economic Model – Graphical Model for UK

Model UK: Graphical model with 6 edges.

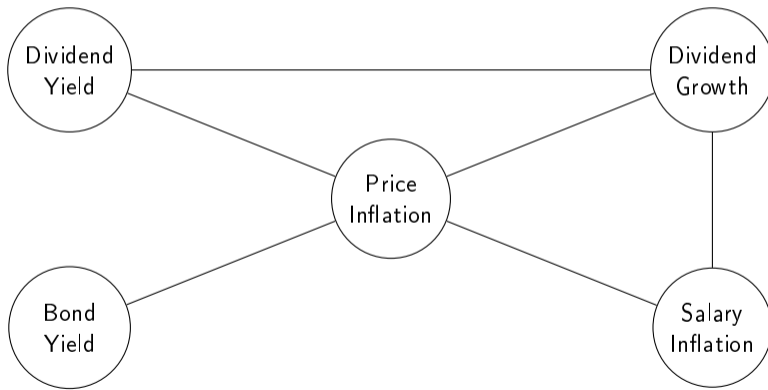


Corresponding P-Values



Economic Model – Graphical Model for US

Model US: Graphical model with 6 edges.



Joint distribution (1)

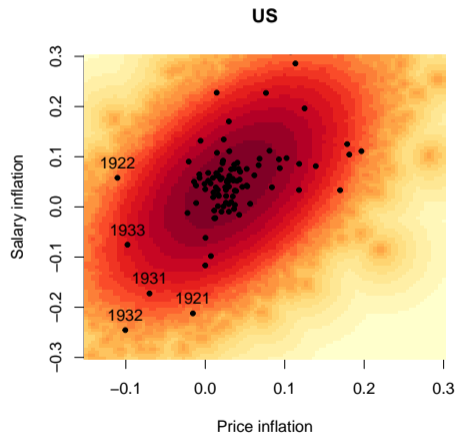
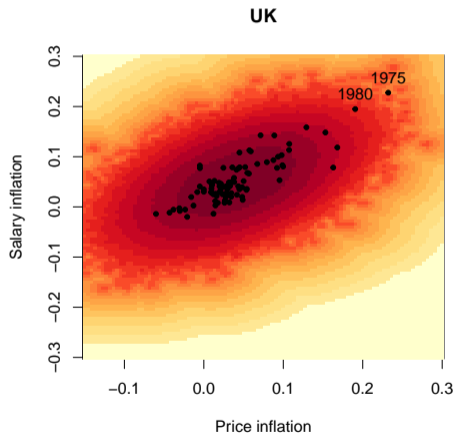


Figure: Plots of simulated price and salary inflation for UK and US.

Joint distribution (2)

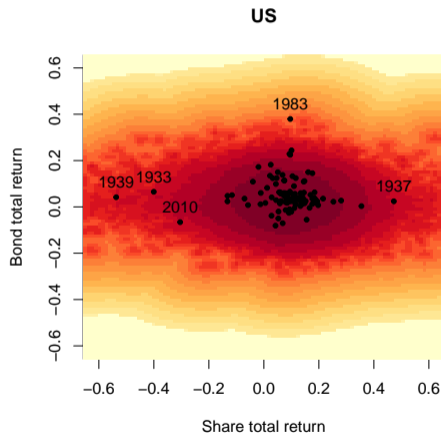
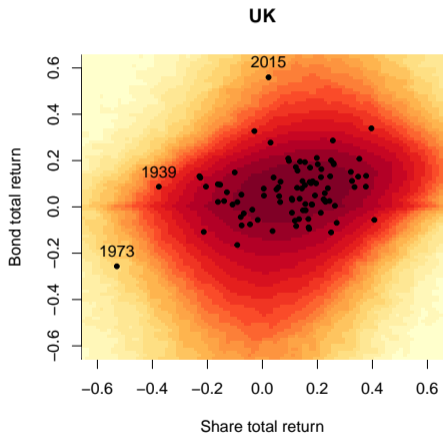


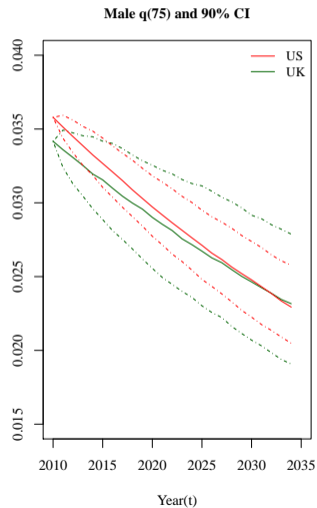
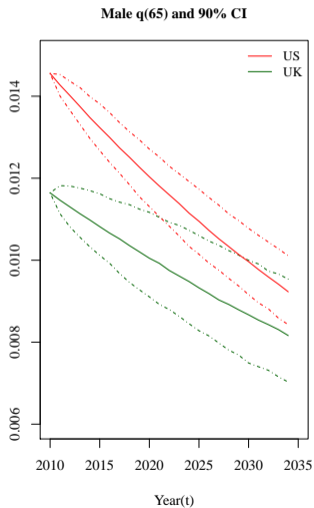
Figure: Plots of simulated share and bond returns for UK and US.

Mortality Model – M7 from Cairns, et al. (2007)

$$\text{logit } q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \kappa_t^{(3)}((x - \bar{x})^2 - \hat{\sigma}_x^2) + \gamma_{t-x}^{(4)}$$

- Model assumes a functional relationship between ages (and hence smoothness).
- One of the better fit models to UK and US data (Cairns et al. (2007)).

Mortality Model – M7 from Cairns, et al. (2007)



Economic Capital Approach

- We analyse the present value of future profits (PVFP) which is the present value of surpluses or deficits.
- The PVFP, V_0 , can be expressed as follows:

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

- We carry many simulations (say 10,000 times) to obtain a distribution of V_0 . The required economic capital is the 0.5th percentile of the V_0 distribution

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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
- Lump sum at retirement = $3 \times$ annual pension
- Pension increases based on min [CPI, 5%]
- Contribution rate: 24% of salary (8% employee + 16% employer)

USS Pension Scheme – Data

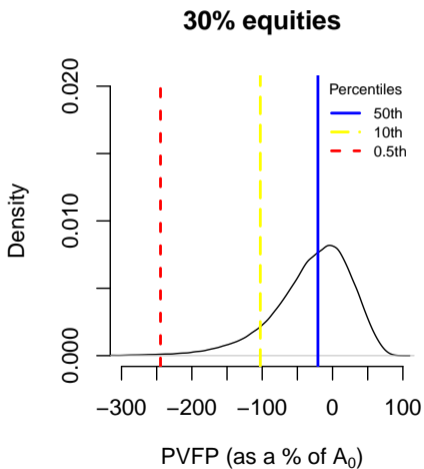
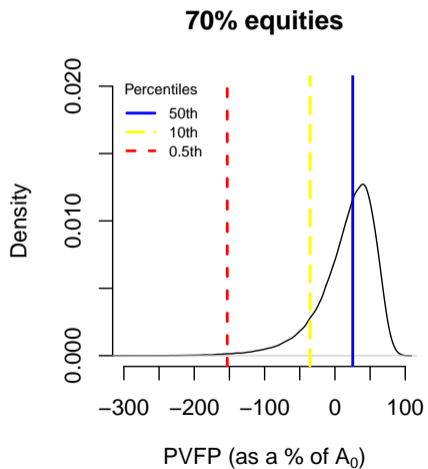
Active Members	Number	167,545
	Average pensionable salary	£42,729
	Average age	43.8
	Average past service	12.5
Deferred Members	Number	110,430
	Average deferred pension	£2,373
	Average age	45.1
Pensioners (including dependents)	Number	70,380
	Average pension	£17,079
	Average Age	71.1

USS Pension Scheme – Assets

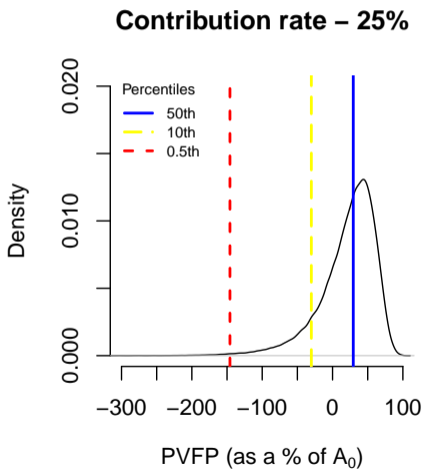
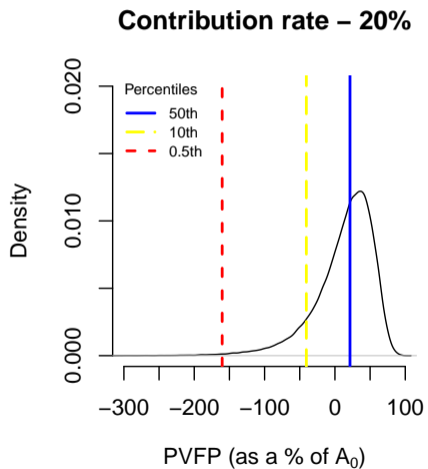
Assets	Benchmark Allocation
UK equities	16%
Overseas equities	31
Alternative assets	19
Property	7
Total real	73%
Fixed interest	27
Cash	0
Total fixed	27%

Note: Modelled as 70% Equities and 30% Bonds

USS Economic Capital – Sensitivity to Asset Allocation Strategy



USS Economic Capital – Sensitivity to Contribution Rates



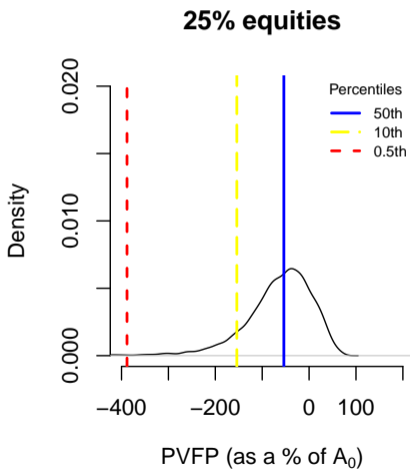
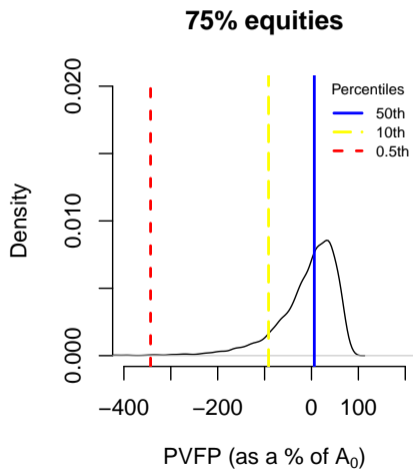
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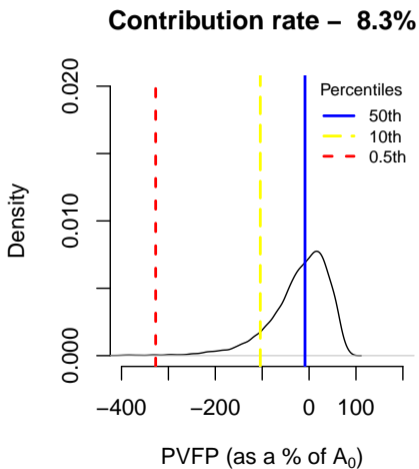
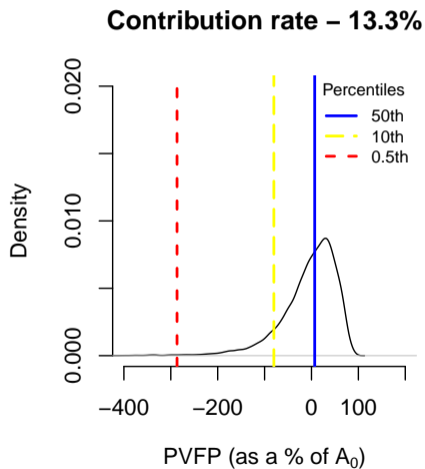
Stylized US Pension Plan – Benefits

- Benefits based on USS pension scheme, except for the following
- 1.5% final average salary for all pension service
- No lump sum payment on retirement
- No pension increases
- Contribution rate: 10.8% of salary

US Stylized Plan Economic Capital – Sensitivity to Asset Allocation Strategy



US Stylized Plan Economic Capital – Sensitivity to Contribution Rate



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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

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