

# Impact of changing population demographics on pension plans

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Institute  
and Faculty  
of Actuaries

# Agenda

- 1 Introduction
- 2 Economic capital
- 3 Stochastic model
- 4 USS Results
- 5 Updating the stochastic model
- 6 Conclusions

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# Background

- This research aims at quantifying the impact of a changing population demographics on pension schemes in UK, US and Canada.
- Some questions we need to answer are:
  - ▶ Will the retirement of the baby boomers deflate asset prices?
  - ▶ Will a shift in population demographics bring down asset returns?
  - ▶ To what extent will increasing longevity of pensioners affect pension schemes?
- In this presentation, we look at:
  - ▶ The economic capital of an eligible DB scheme;
  - ▶ The connections between a pension model, a mortality model and an economic model;
  - ▶ Simulations from mortality and economic models.

# Background

## Solvency 2

- Technical provisions consist of the best estimate of liabilities and a risk margin.
- Economic capital requirement is the 99.5% VaR of “basic own funds” over one year.

## Risk assessment of DB schemes

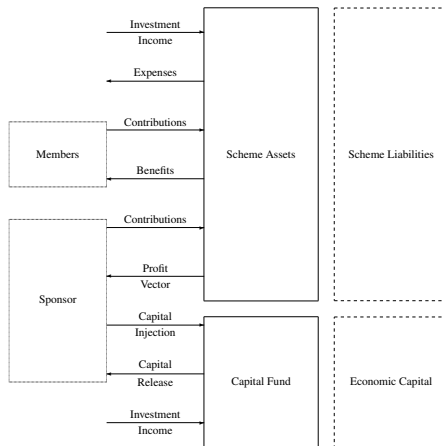
- Set within the Solvency 2 framework.
- Horizon is the time until the last member in the scheme dies and no further benefit is paid.

**Economic capital** is the excess of assets over liabilities in respect of accrued benefits required to ensure that assets exceed liabilities on all future valuation dates over a specified time horizon with a prescribed high probability.

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# Eligible Scheme Cashflow



# Economic Capital Formulation

## Notations:

$X_t$ : Net cash flow of the scheme;

$L_t$ : Value of s179 liability of the scheme;

$I_{s,t}$ : Accumulation factor;

$D_{s,t}$ : Discount factor.

## Building blocks

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

$R_t = \sum_{s=0}^t P_s I_{s,t}$ : Accumulated retained profits until time  $t$ ,

$V_t = \sum_{s=t+1}^T P_s D_{t,s}$ : Present value of future profits at time  $t$ .

## Economic capital

$C_t = \max[-\min_{s=t}^T V_s D_{t,s}, 0]$ .

Economic capital requirement:  $\rho(C_t) = \text{VaR}(C_t, p = 0.995)$ .



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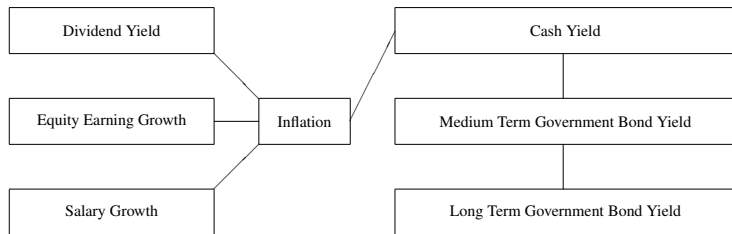
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- 3 Stochastic model**
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# Stochastic model: Mortality

The mortality model used is developed in three steps:

- Step 1:** Set PMA92Base and PFA92Base as the baseline mortality tables for males and females respectively.
- Step 2:** Project these base mortality tables from year 2006 to year 2012 using the mortality projection table published by the Institute and Faculty of Actuaries.
- Step 3:** Finally, model the future stochastic mortality improvements starting from 2012 by modelling stochastic uncertainty around the central mortality projection (Sweeting (2008)).

# Stochastic model: Economic



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

- 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.

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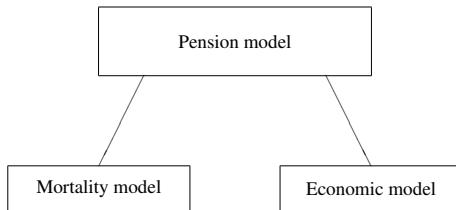
# Economic Capital: University Superannuation Scheme (USS)



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# Overview



- For our project, we need:

- ▶ A mortality model which allows for the cohort effect of the baby boomers;
- ▶ A flexible economic model which can be adjusted for demographic effects.

# Mortality: Formulation

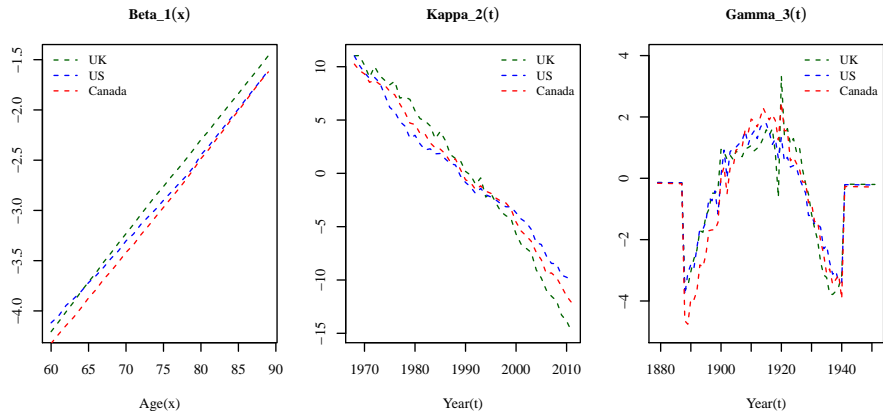
**Table:** Age-Period-Cohort models

Model	Name	Formula
M1	Lee and Carter	$\log m(t, x) = \beta_x^{(1)} + \beta_x^{(2)} \kappa_t^{(2)}$
M3	Currie	$\log m(t, x) = \beta_x^{(1)} + \kappa_t^{(2)} + \gamma_{t-x}^{(3)}$
M5	CBD	$\text{logit } q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x})$
M6	CBD(1)	$\text{logit } q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \gamma_{t-x}^{(3)}$
M7	CBD(2)	$\text{logit } q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \kappa_t^{(3)}((x - \bar{x})^2 - \hat{\sigma}_x^2) + \gamma_{t-x}^{(4)}$
M8	CBD(3)	$\text{logit } q(t, x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x - \bar{x}) + \gamma_{t-x}^{(3)}(x_c - x)$



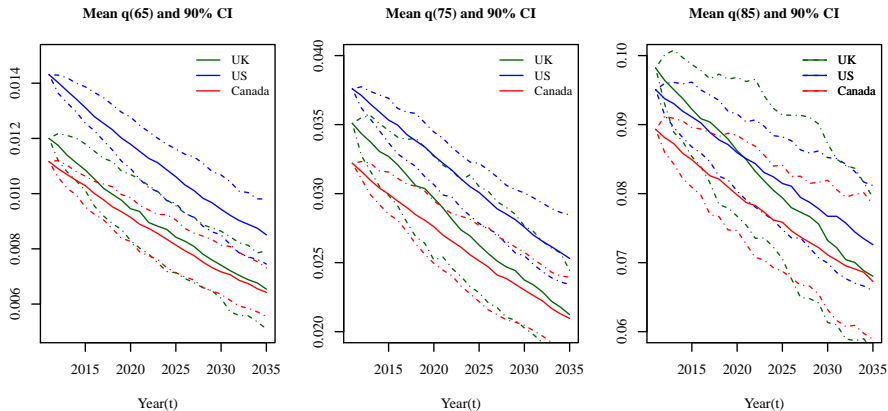
# Mortality: Parameter estimates

**Figure:** Parameter estimates of model M3 for UK, US and Canada fitted using males mortality data ages 60-89 and years 1968-2011

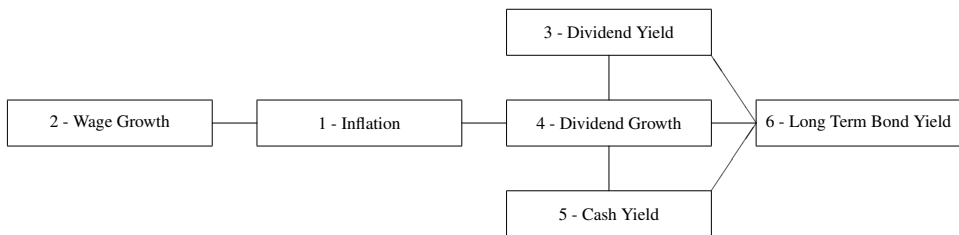


# Mortality: Simulated rates

**Figure:** Simulated mortality rates under model M5 for UK, US and Canada for males age 65, 75 and 85

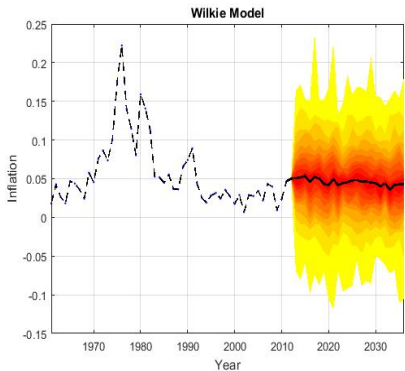
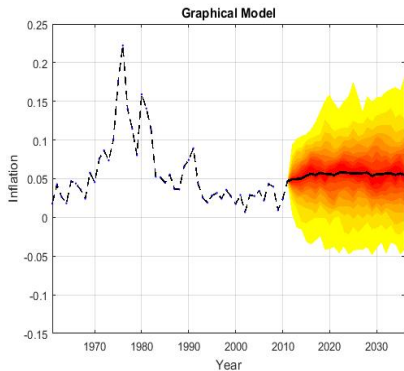


## Economic: New structure

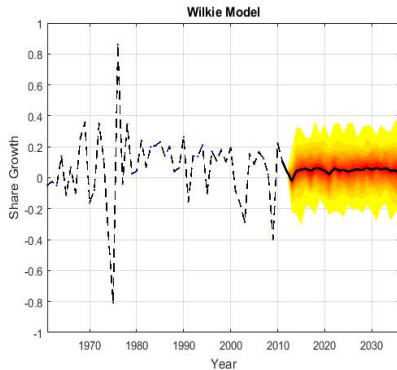
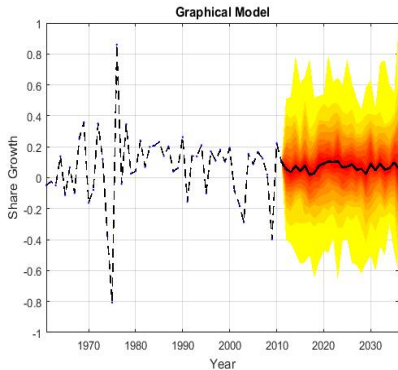


- UK Graphical Model based on p-values.
- Model is decomposable which is desirable.

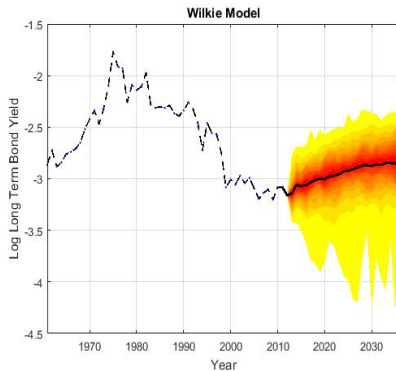
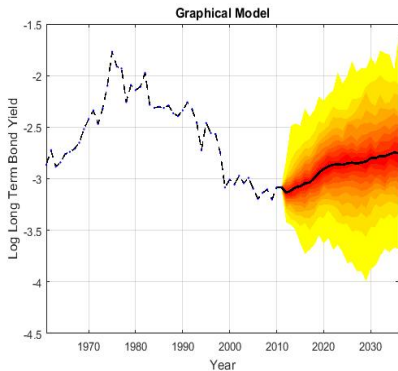
# Economic: Simulations



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# Conclusions

## Future work

- Quantify the uncertainty on asset returns caused by future movements in population demography.
- Incorporate the results in the pension model to see the impact on capital.
- Extend the results for the whole UK, US and Canadian pension systems.

## References

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- PORTEOUS, B.T., TAPADAR, P. & YANG W. (2012). Economic capital for defined benefit pension schemes: An application to the UK Universities Superannuation Scheme. *Journal of Pension Economics and Finance*, **11(4)**, 471–499.