# Impact of changing population demographics on pension plans

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# Agenda

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

# Agenda

# 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.

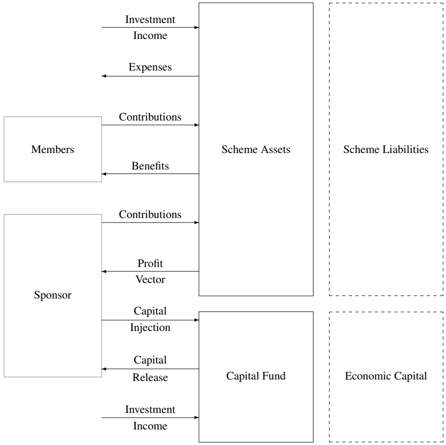
## Risk assessment of DB schemes

- 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.

# Agenda

# 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: $\rho(C_t) = VaR(C_t, p = 0.995)$.

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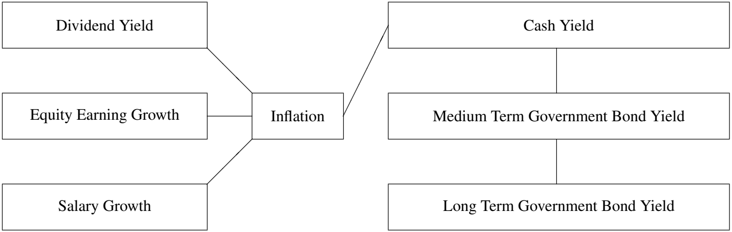
# Stochastic model: Mortality

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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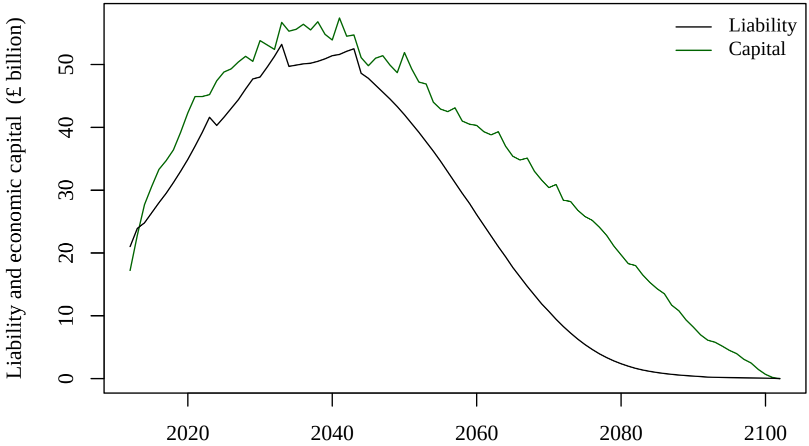
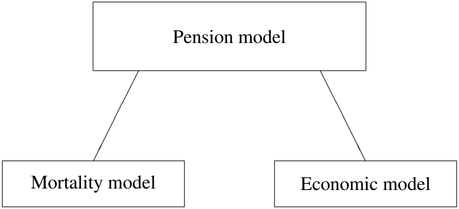
# Economic Capital: University Superannuation Scheme (USS)



# Agenda

# 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.

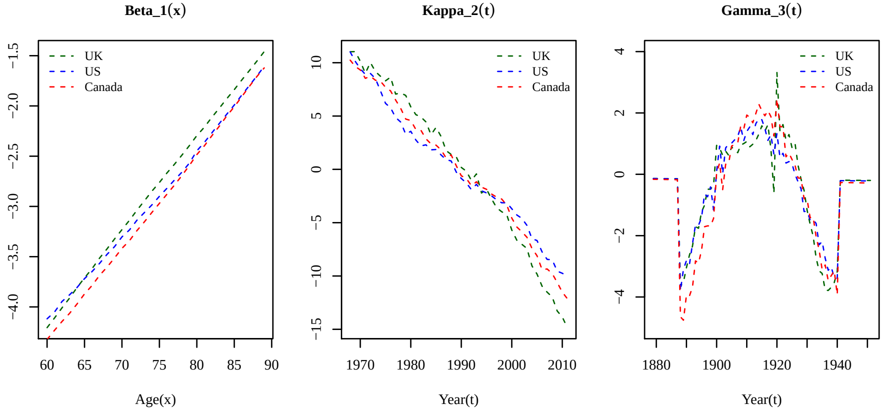
# Mortality: Formulation

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 | $\operatorname{logit} q(t,x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x-\bar{x})$ |
| M6 | CBD(1) | $\operatorname{logit} q(t,x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x-\bar{x}) + \gamma_{t-x}^{(3)}$ |
| M7 | CBD(2) | $\operatorname{logit} q(t,x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x-\bar{x}) + \kappa_t^{(3)}((x-\bar{x})^2 - \hat{\sigma}_x^2) + \gamma_{t-x}^{(4)}$ |
| M8 | CBD(3) | $\operatorname{logit} q(t,x) = \kappa_t^{(1)} + \kappa_t^{(2)}(x-\bar{x}) + \gamma_{t-x}^{(3)}(x_c - x)$ |

# 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

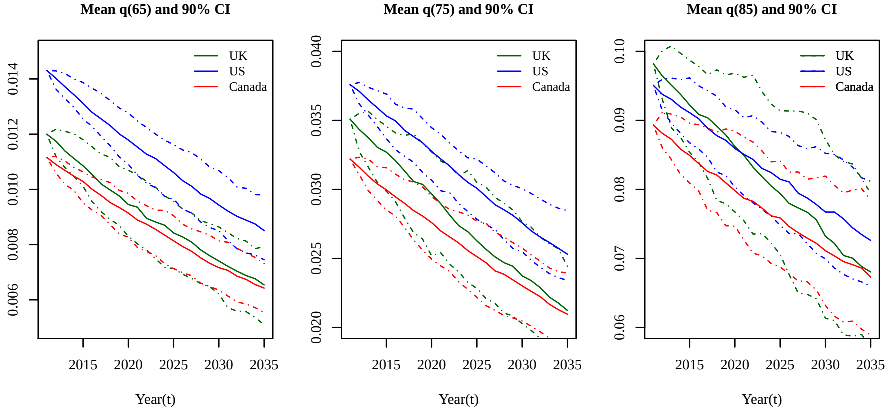
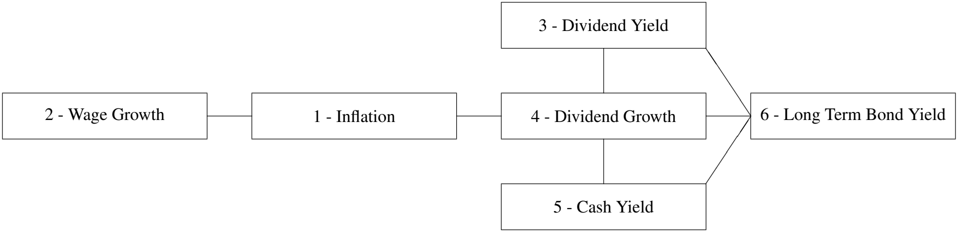


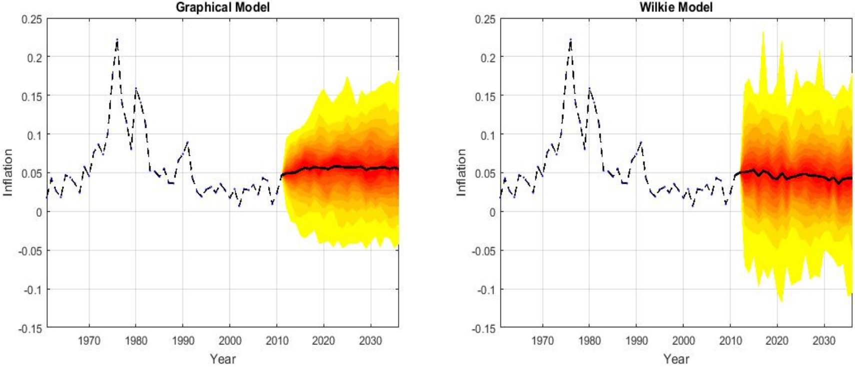

Figure: Simulated mortality rates under model M5 for UK, US and Canada for males age 65, 75 and 85

# Economic: New structure




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

# Economic: Simulations



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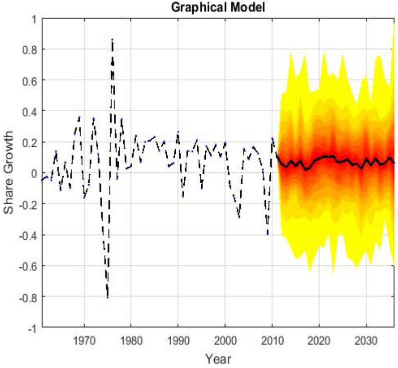


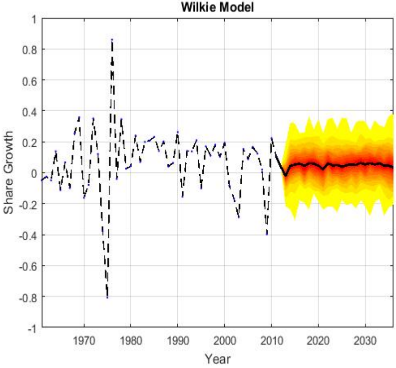

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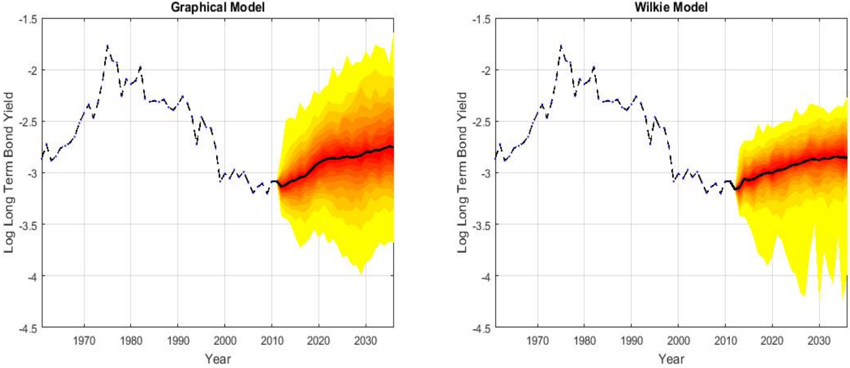

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# Conclusions

## 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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