PhD studentship output

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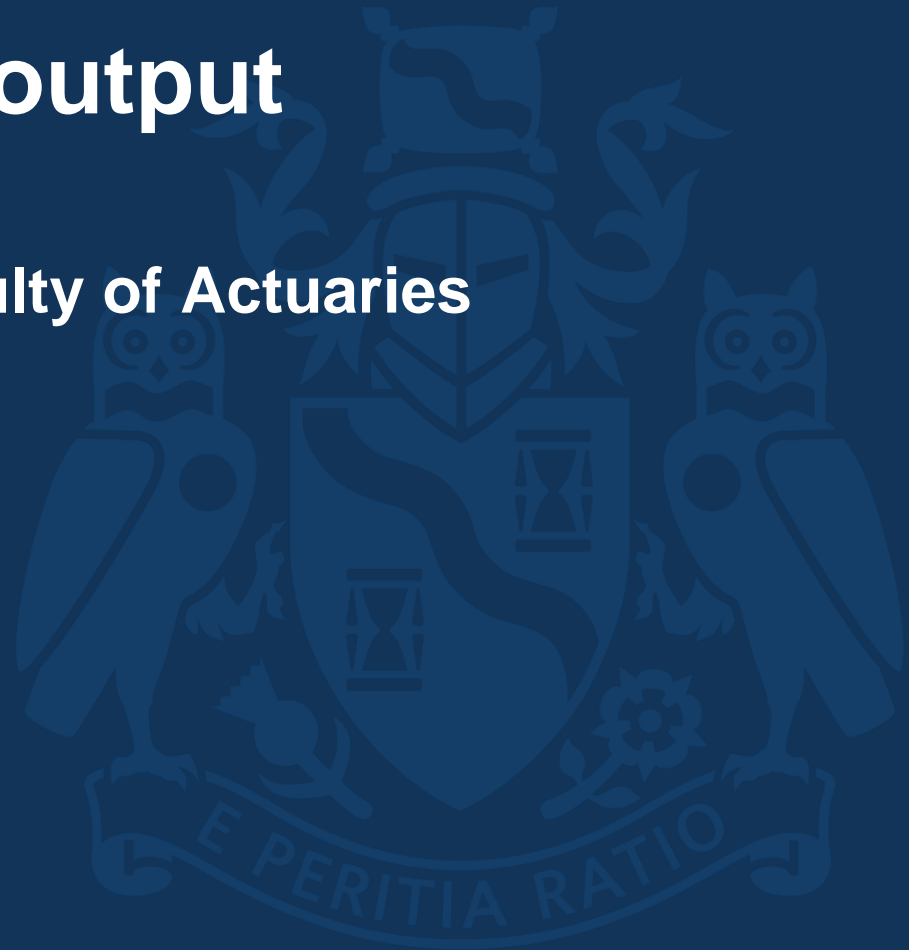
Impact of changing population demographics on penison plans

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Background

- The end of the 2nd World War brought a baby boom to many countries including the UK, US and Canada.
- The retirement of this boomer generation brings several questions such as:
    - Will assets backing pension schemes deflate in value?
    - Will this change in population demographics bring down asset returns below expected levels?
    - To what extent will increasing longevity of pensioners put further pressure on pension schemes?
- The project aims at carrying a risk assessement of pension schemes to answer these questions.

Background

- Multi-year, multi-disciplinary, international project with the following institutions involved:
    - University of Waterloo
    - University of Kent
    - Institute and Faculty of Actuaries (IFoA)
    - Canadian Institute of Actuaries (CIA)
    - Society of Actuaries (SOA)
    - Social Sciences and Humanities Research Council (SSHRC)
- Three modelling stages involved:
    - Economic demographic model
    - Asset pricing model
    - Pension model

Background
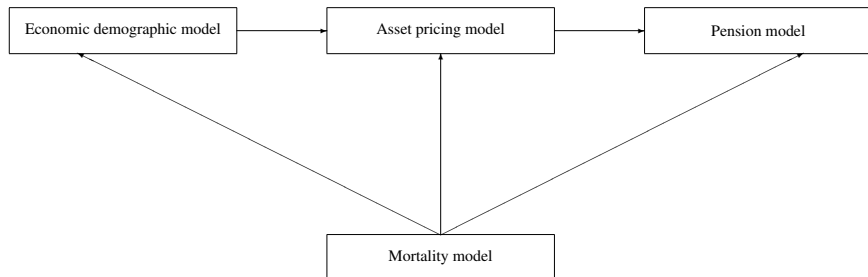
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Overlapping generations (OLG) model

- OLG model provides a framework to study the allocation of resources across generations.
- In a basic two-period OLG model:
  - ▶ Agents live for 2 periods (young and old)
  - ▶ Population grows at a constant rate
  - ▶ The young work and earn an income; income is allocated between consumption and savings
  - ▶ The old are retired and live off their savings
  - ▶ Firms use capital (savings) and labour to produce consumer goods

Overlapping generations (OLG) model

- Economic demographic modelling team working on an OLG model with:
  - ▶ many overlapping generations
  - ▶ reproduced demographic structure
  - ▶ aggregate productivity shock
  - ▶ endogenous labour supply
  - ▶ portfolio allocation between two assets
- OLG model to be used to study demographic effects on:
  - ▶ return on equities and bonds
  - ▶ portfolio allocation
  - ▶ generation risk sharing
  - ▶ business cycle moments

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Approaches to modelling

- Aim is to model demographic effect on:
  - ▶ Stocks
  - ▶ Government/Corporate bonds
  - ▶ Short/Medium/Long term bonds
  - ▶ Housing prices
  - ▶ Infrastructure
- Detailed structural approach:
  - ▶ Goyal (2004) provides a full OLG framework
  - ▶ Creates a theoretical framework to link demographic change to stock market returns and stock market inflows and outflows
- Risk factor approach:
  - ▶ Similar approach to Fama and French (1992)
  - ▶ Return = $\alpha + \beta$(Economy) + γ(Demography) + ε

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

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
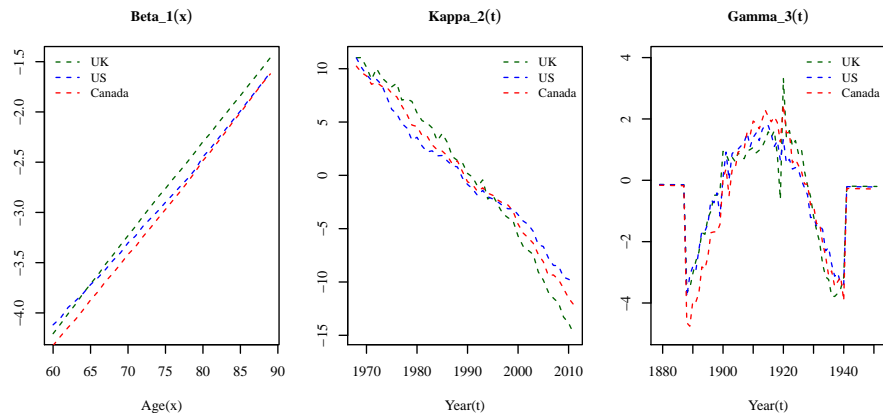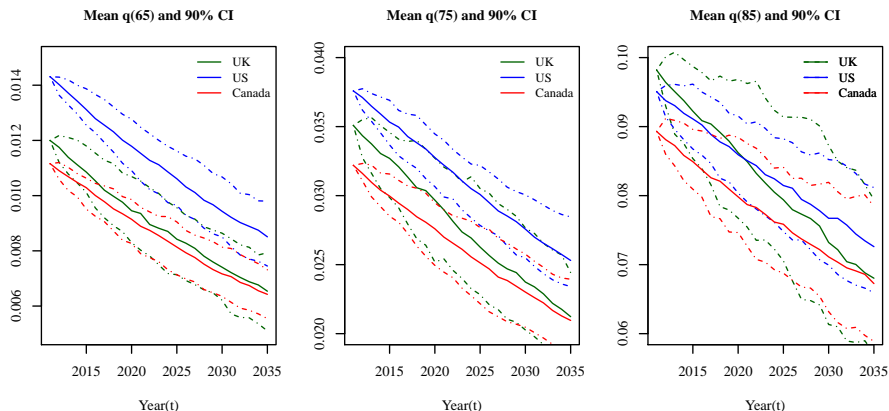
Ranking of models

Table: Models' BIC and rank

Model	UK	US	Canada
M1	-10925 (**4**)	-17362 (**4**)	-8299 (**5**)
M3	-14153 (**6**)	-28115 (**5**)	-9698 (**6**)
M5	-11876 (**5**)	-30134 (**6**)	-8216 (**4**)
M6	-8607 (**3**)	-13459 (**3**)	-7634 (**1**)
M7	-8488 (**1**)	-12781 (**1**)	-7698 (**3**)
M8	-8503 (**2**)	-13161 (**2**)	-7672 (**2**)

Simulated mortality rates

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

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Economic Capital Formulation

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.

Notations:

X_t: Net cash flow of the scheme;

L_t: Value of s179 liability of the scheme;

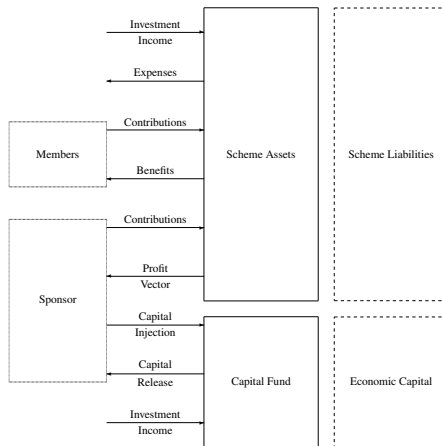$I_{s,t}$: Accumulation factor;

$D_{s,t}$: 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.

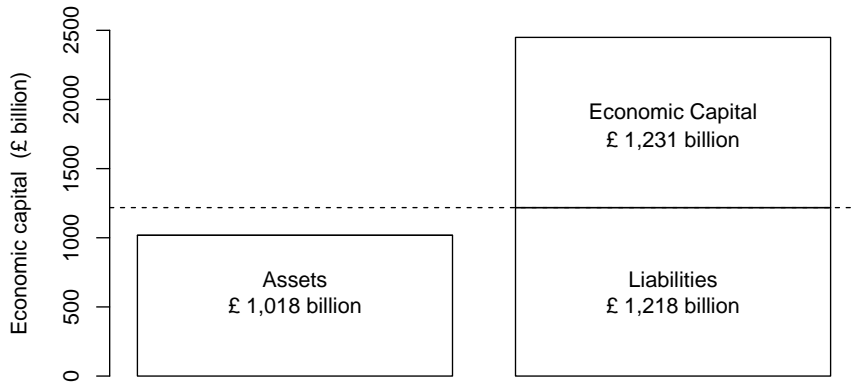# Eligible Scheme Cashflow and Capital Requirement

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

Economic capital requirement: $\rho(C_t) = VaR(C_t, p = 0.995).$
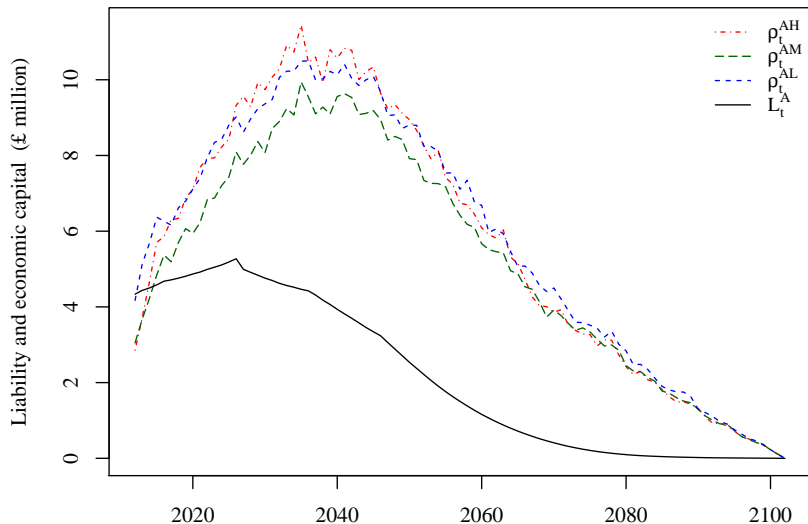
Aggregate Economic Capital for Eligible Schemes
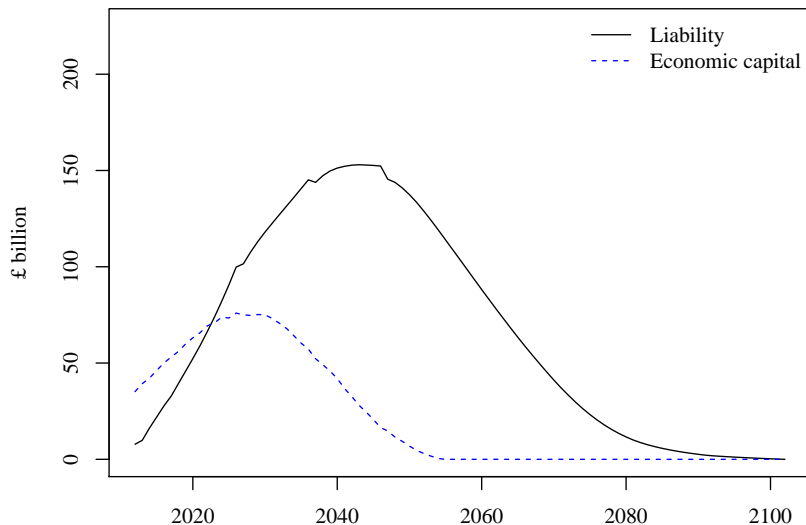

As at 31 March 2012

Economic Capital: Eligible Scheme in *A*

Membership group A

PPF: Base Case Results

PPF schemes liability and economic captial : Base case

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Conclusions

Summary

- The project aims at looking at the impact of population ageing on asset values and illustrates this impact by applying it to pension plans.
- Three modelling stages involved:
  - Economic demographic model
  - Asset pricing model
  - Pension model

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