Office of the Superintendent of Financial Institutions Canada
Bureau du surintendant des institutions financières Canada
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Social Insurance Follow-Up: Methodologies and Implications

Presentation to the Living to 100 International Research Symposium, Orlando, United States

8 January 2008

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Presentation Outline

- Stochastic Modeling in CPP #23
- Methods for Determining Mortality Improvements
  - Stochastic Method
  - 30/30 Method
- Results (Life Expectancy)
- Comparison of Life Expectancy with US and UK
- Sensitivity Analysis of Mortality Improvements

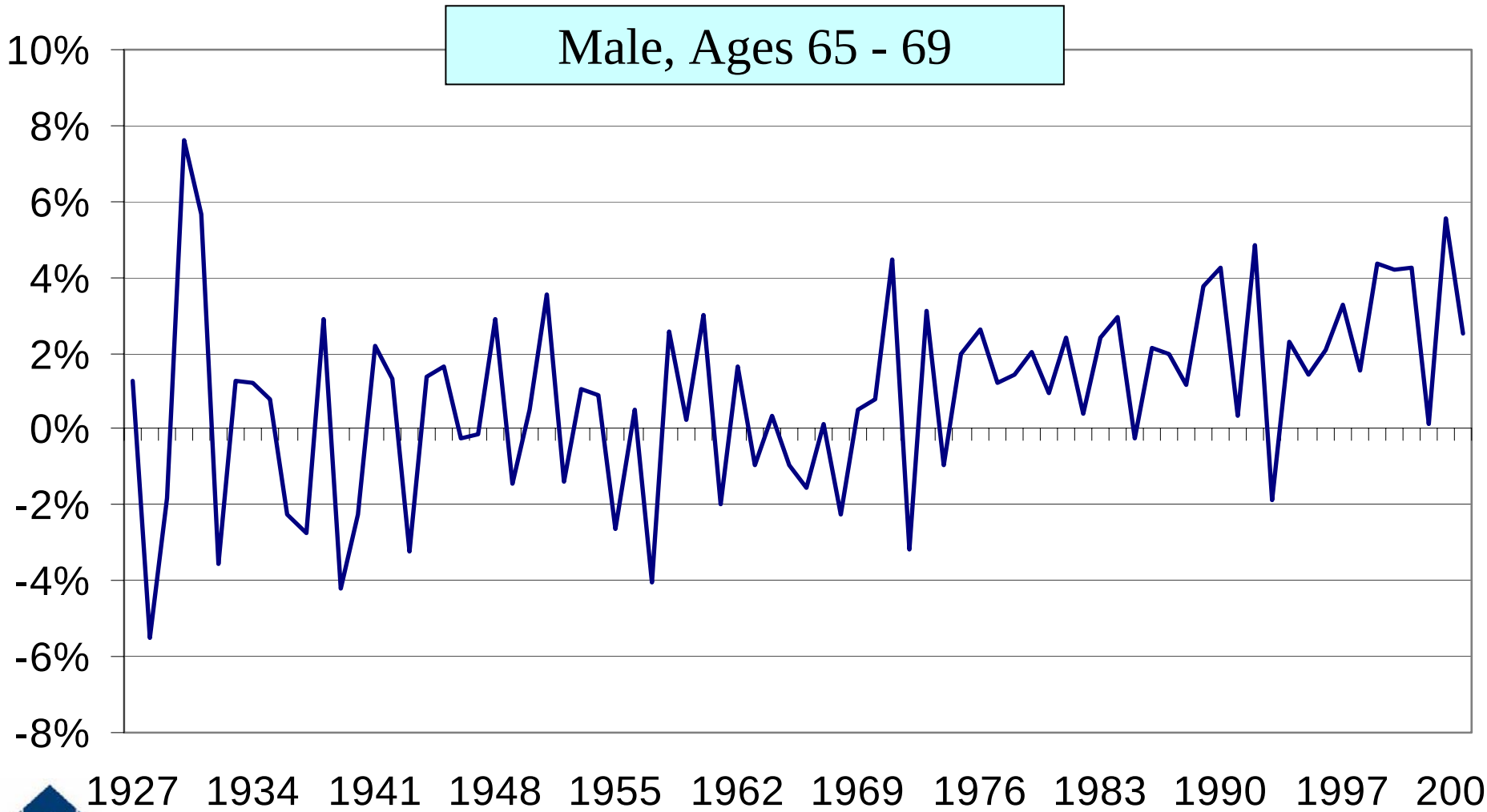
Stochastic Modeling in CPP #23

- Recommendation from review panel
- Unrealistic to make model fully stochastic at this time
- Incorporate stochastic modeling in determination of alternative assumptions for sensitivity analysis
  - Project probability distribution of potential outcomes
  - High cost and low cost assumptions

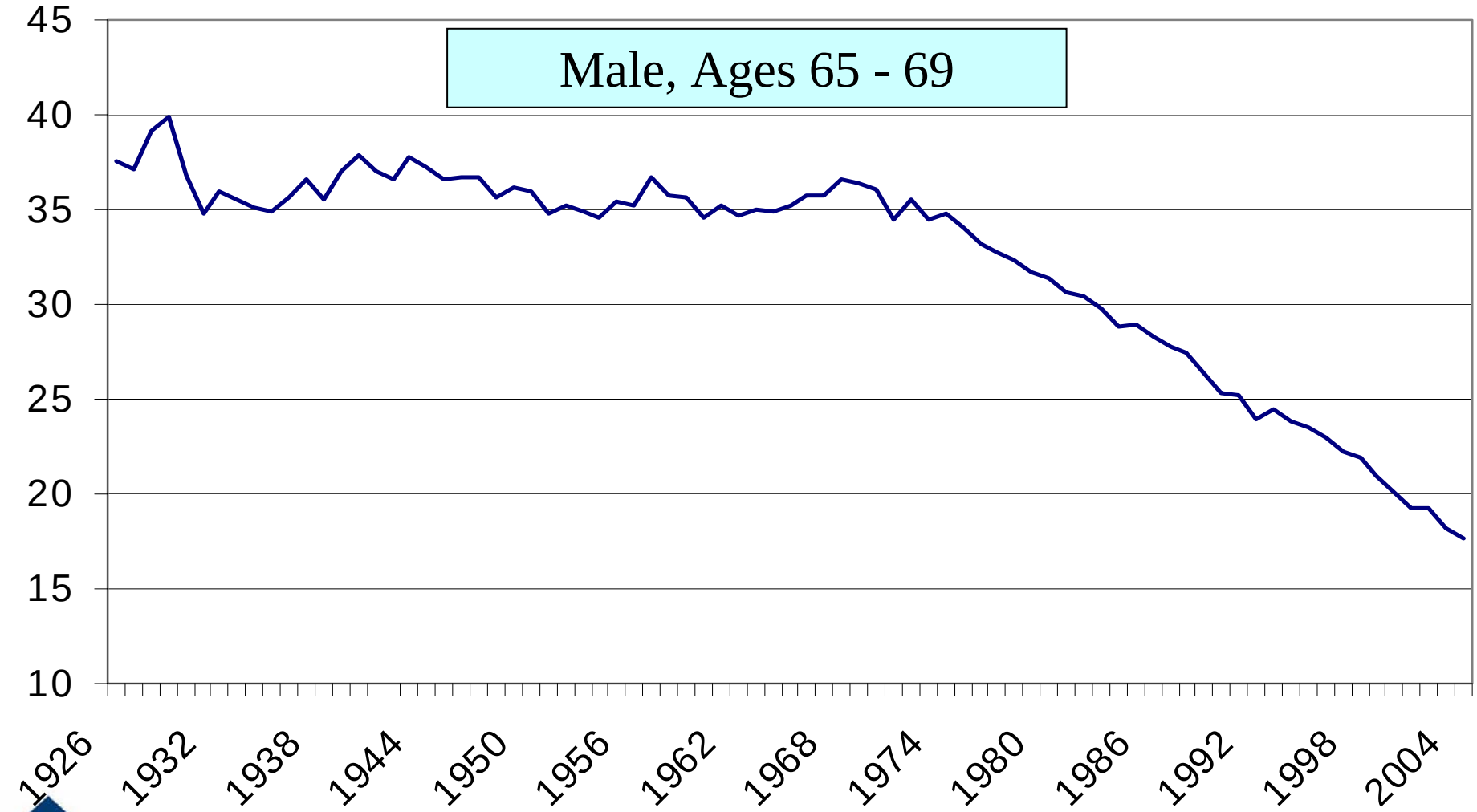
Mortality

- 40 Groups: - Male and Female
  - Under 1, 1-4, 5-9, 10-14,…85-89, 90+
- Focus for model selection: Ages 60-64 & 65-69
- Initially tried to fit Mortality Improvement Rates
  - Poor fit statistics → look at Mortality Rates (deaths per 1,000)
- Model Mortality Rates and convert back to improvements

Mortality Improvement Rates: 1927-2004



Mortality Rates: 1926-2004



Log ARIMA(0,1,0) Model

- **1st difference**: assumes mean is time-varying

- **Log** transformation: allows MR to approach, but not hit, zero

→ Excellent fit statistics: $\mathbf{R^2 > 0.9}$ for all groups (except 90+)

- No AR or MA terms (made little difference to fit)

Time Series Equation

The general form of the equation used is:

$$\ln(Y_{k,t}) = \ln(Y_{k,t-1}) + \mu_k + \varepsilon_{k,t}$$

Thus:

$$Y_{k,t} = Y_{k,t-1}\, e^{\mu_k}\, e^{\varepsilon^{k,t}}$$

where: $Y_{k,t}$ = number of deaths per 1,000 for group k in year t

μ_k = the mean of the transformed series (i.e. logged and differenced series)

$\varepsilon_{k,t}$ = a random error term for group k in year t

Best Estimate

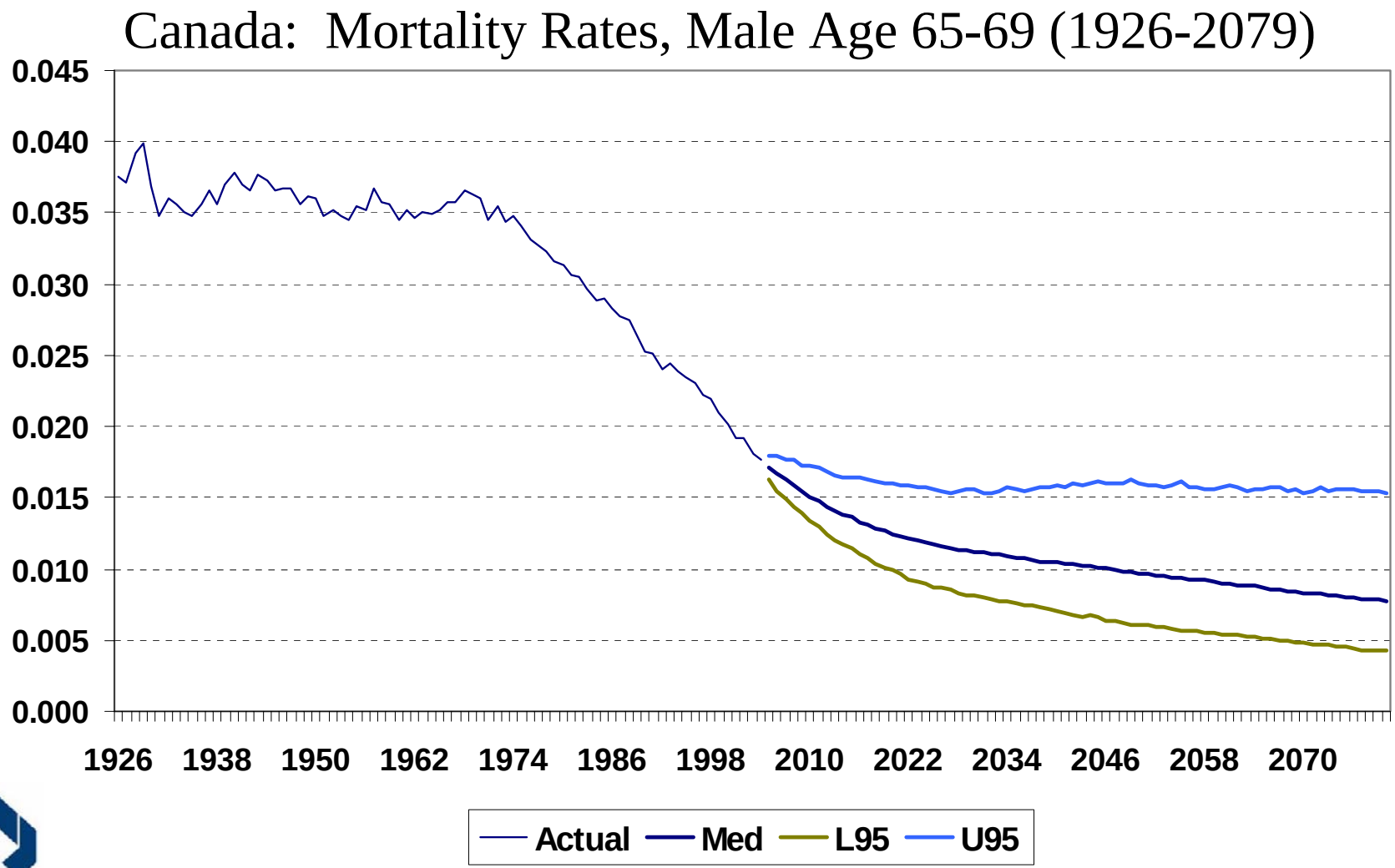
- Mortality model somewhat **deterministic**
  - → Expected value = Best Estimate (2005-2079)
  - → Stochastic scenarios generate CI centered around best estimate

- Removing best estimate gives a new result:
  - Expected value = Median of simulated scenarios
    - → Prediction is based on log ARIMA(0,1,0) model

Stochastic Model

- Log ARIMA(0,1,0) model
- Years 1926-2079 (2005-2079 are projected)
- All 40 age-sex groups correlated using Cholesky decomposition
- 95% confidence intervals and medians for mortality rates, mortality improvement rates and life expectancies at birth and age 65
- Upper boundary for all groups set to 1,000 deaths/1,000

Stochastic Process



Reasons for Incorporating Judgement

- Past experience possibly not reflective of future experience
  - Recent narrowing of gap between male and female mortality rates
- Limitations of the ARIMA model

Annual Mortality Improvement Rates (1974-2004)

	Females		Males	
	1974-1989	**1989-2004**	**1974-1989**	**1989-2004**
0-14	4.9	2.4	4.9	2.8
15-44	2.8	1.4	2.8	2.6
45-64	1.9	1.5	2.6	2.4
65-84	1.6	1.2	1.2	2.0
85-89	1.5	0.4	0.8	0.8
90+	0.1	-0.1	-0.6	0.0
65+	1.3	0.8	1.0	1.6
0-44	3.4	1.7	3.2	2.6
0-64	2.3	1.5	2.8	2.4
0-84	1.8	1.3	1.8	2.2

Note: Similar results obtained using Human Mortality Database and Stochastic approach

Annual Mortality Improvement Rates

- Historically, rates decline with age and are small or even negative for ages 90+
  - Below age 65:
    - marked slowdown observed for both males and females over last 30 years, especially females
  - Ages 65 and over:
    - significant slowdown for females observed over last 30 years, while male improvement rates have increased
    - males are catching up to females (explains the shrinking gap in life expectancy between males and females)

Annual Mortality Improvement Rate Assumptions

- Chosen approach is based on trends over last 30 years and judgement
  - **Initial (2005-2009):** Annual mortality improvement rates based on actual experience over last 15 years (1989-2004) by age and sex
  - **Ultimate (2029+):** Based on the projected historical trends in female improvement rates by age over the last 30 years. Improvement rates are currently higher for males than females but are assumed to be the same for years 2029+.
  - **2010-2028:** Linear interpolation between rates for 2009 and 2029

Life Expectancy
(without future improvements)

	For a newborn			
	Stochastic Process		CPP #23	
	2007	2050	2007	2050
Male	78.2	82.5	78.5	83.0
Female	82.6	85.6	82.9	86.1

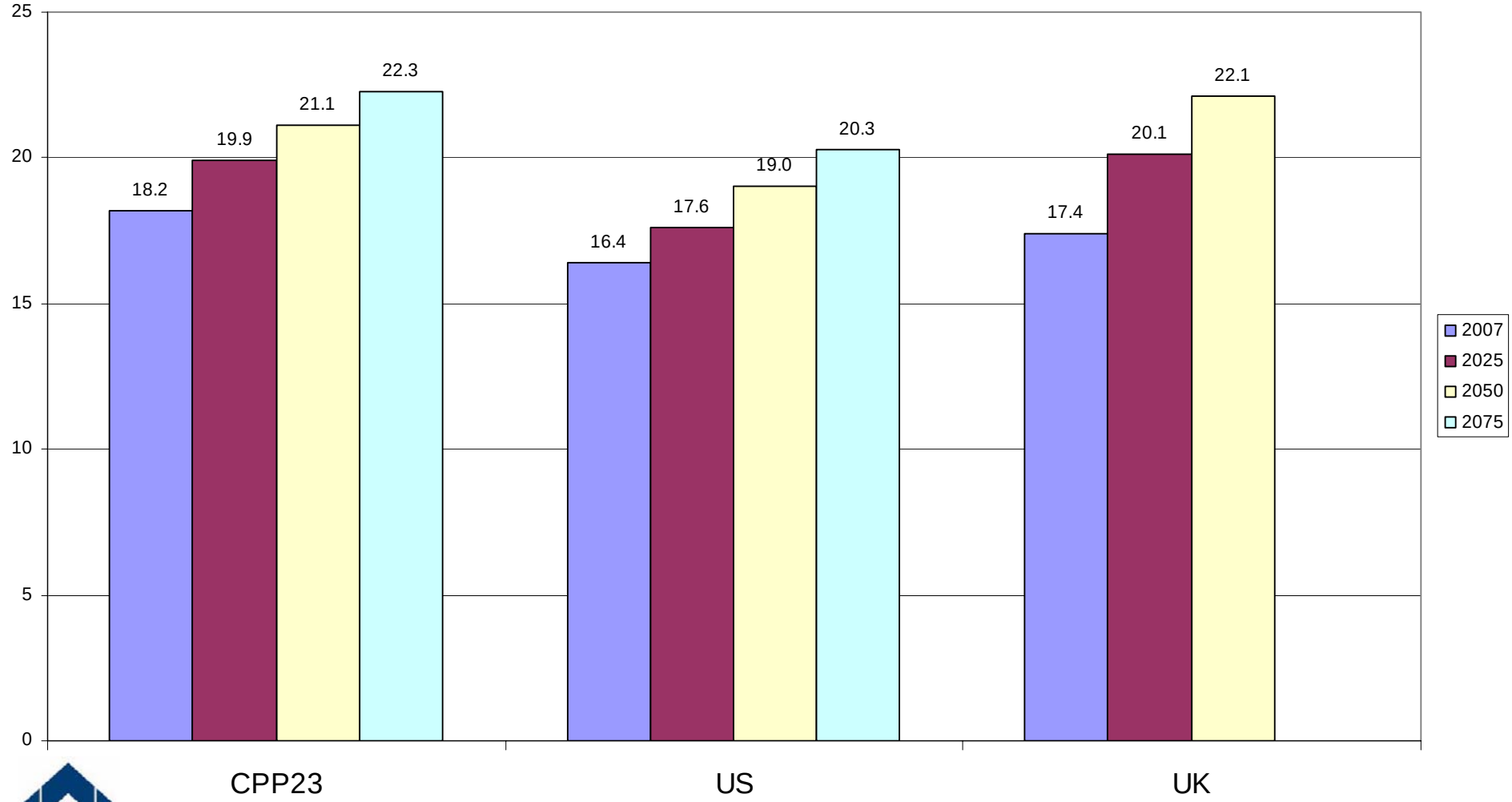
	For a person age 65			
	Stochastic Process		CPP #23	
	2007	2050	2007	2050
Male	18.0	21.0	18.2	21.1
Female	21.1	23.4	21.2	23.4

Life Expectancy
(with future improvements)

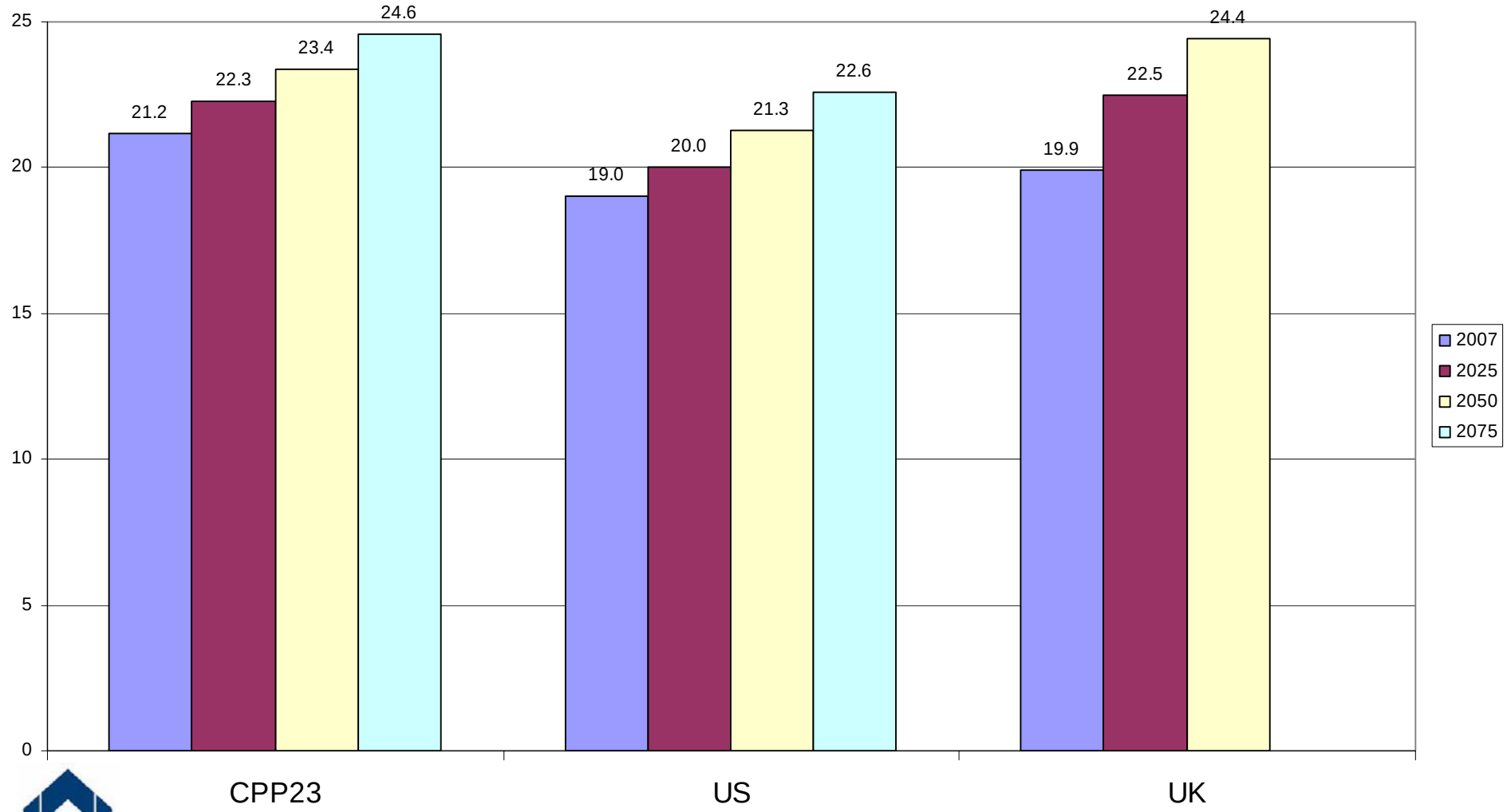
	For a newborn			
	Stochastic Process		CPP #23	
	2007	2050	2007	2050
Male	83.9	86.5	84.5	87.4
Female	87.1	89.1	87.7	90.2

	For a person age 65			
	Stochastic Process		CPP #23	
	2007	2050	2007	2050
Male	19.2	21.6	19.3	21.9
Female	21.9	24.1	22.0	24.2

Comparison of Male Life Expectancy at Age 65
(without future improvements)



Comparison of Female Life Expectancy at Age 65
(without future improvements)

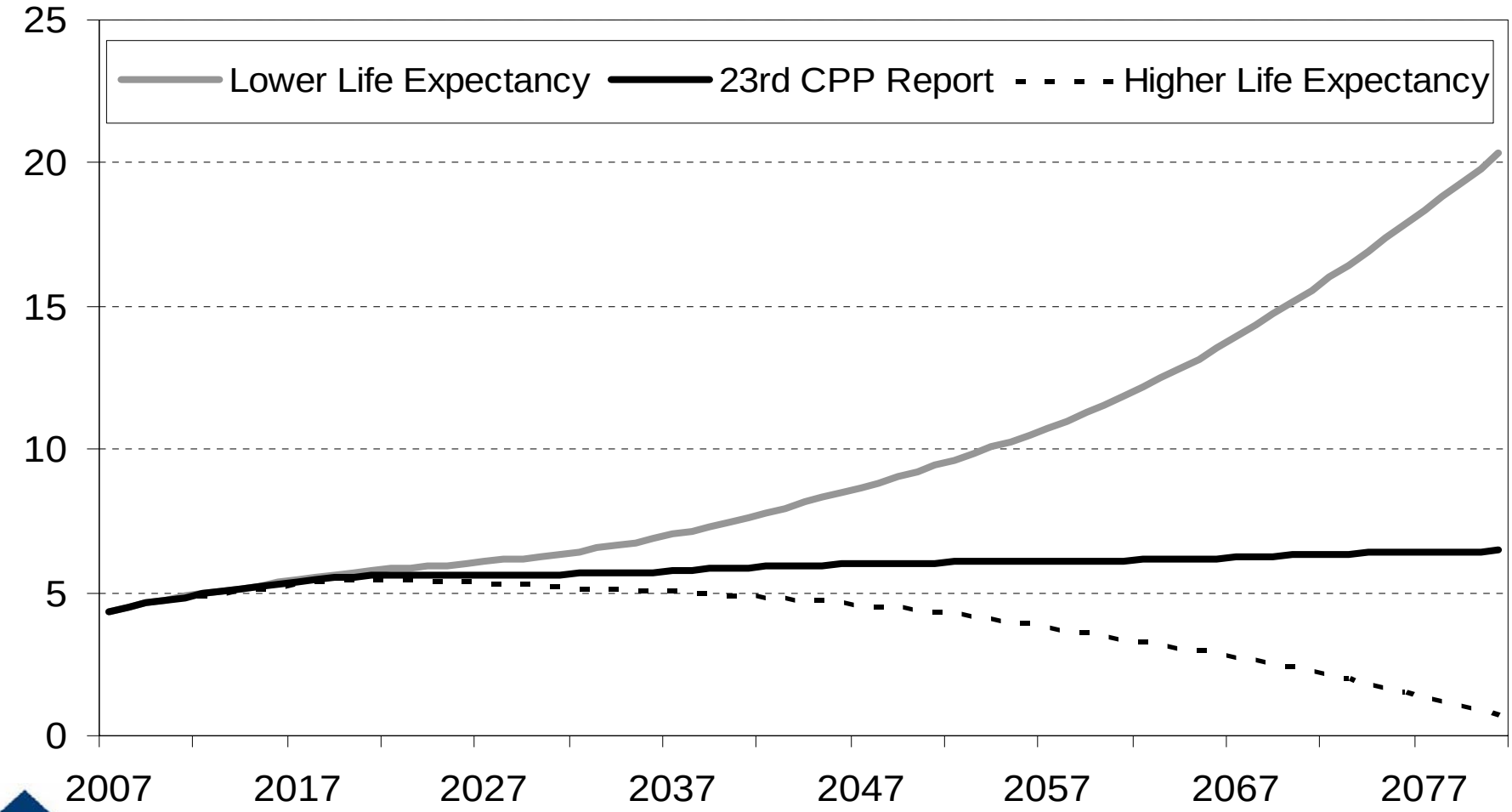


Sensitivity test using stochastic process

Canadian Life Expectancies, with improvements after the year shown

At birth		Actuarial Report	Lower 95% CI	Upper 95% CI
Males	2007	84.5	79.1	88.4
	2025	85.8	80.0	89.8
	2050	87.4	80.8	91.3
Females	2007	87.7	80.6	92.0
	2025	88.8	81.1	93.1
	2050	90.2	81.9	94.6
At 65				
Males	2007	19.3	17.6	20.7
	2025	20.6	17.7	22.9
	2050	21.9	17.8	25.1
Females	2007	22.0	19.5	24.0
	2025	23.0	18.9	25.9
	2050	24.2	18.6	27.9

Evolution of Asset/Expenditure Ratio (9.9% Contribution Rate)



The minimum contribution rate falls between 9.2% and 10.2%

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Thank you

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