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Mortality Improvement for Canadian Pensioners: Proposed Projection Scales
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Outline
1. Introduction
2. Phases of Study
3. Methodology & Results, Phase II
4. Mortality Improvement Rate: Formulas
5. Projection Scales: Proposal
6. Conclusion

1. Introduction

Acknowledgements:
– Financial support from Canadian Institute of Actuaries, and formerly from Chaire d’actuariat, Université Laval and SOA
– Data and support:
  • Office of the Chief Actuary (CPP)
  • Régie des rentes du Québec (QPP)
– CIA CCPME: Committee on Canadian Pensioners Mortality Experience
– and many reviewers, colleagues, students

CCPME
• Created in 2008 by CIA
• Commissioned two studies in 2009
• Data collected in 2010
• Data analysis and review 2010 and 2011
• Reports drafted and reviewed:
  – Registered Pension Plan Study in 2012
    – CPM Study in 2011 and 2012
• CIA Annual Meeting: June 2012 Presentation
CPM

- Canadian Pensioners Mortality = CPM
- Pensioner data only, from CPP and QPP administrators
  - Separate and combined results
  - Data comprehensive and high quality
  - Data segmented by pension income level
  - Almost 8 million exposed lives (86.9 M life-years exposure from 1967 to 2008)
  - pensions payable since 1967

Messages, CIA June 2012 Session

1. It is time to change the Canadian standard for mortality tables for pension plans: Canadian evidence for this
2. Income is important for pensioner mortality (with time, gender, age, source)
3. Mortality trend: Higher improvements rates observed in recent past = troubling news
4. Impact might be material for many plans

2. CPM Study Phases

1: Get high quality data: CPP + QPP = CAN
2: Measure qx at recent point in time:
   - 2005-2007, centered in 2006
   - Phase II Report: May 31st, 2012
3: Measure mortality trends: projection scales
   - With recent experience over 15 years for short term scale: 1992-2007 → 2006 to 2021
   - Long term scale based on C/QPP Actuarial Reports
   - Phase III Report: Draft July 17th, 2012

3. Methodology & Results, Phase II

- Deaths & Exposure measured
- 5 variables: source, gender, age, income, year
- Exact age, constant force of mortality for fractional ages
- Exact age compares to “Nearest Birthday”
- Provides point estimate and confidence intervals
- Graduation: Gompertz, modified at extreme ages, values within bounds of 1 std dev.
Income

- 5 income classes
- Split in % of C/QPP Maximum Pension
  - 1: <35%, 2: 35%-94%, 3: >95%
- Remove lower pensions (Class 1) to get proxy for mortality of pension plans members
  - **Class 4** = **Class 2** (mid) + **Class 3** (high)
  - Class 5 = All income

Results shown here

- Ratios of q(x) : CPM-CAN/ UP-94 @ 2006 +
- 2006: No projection for CPM-CAN
- 2012: 6-Year Projection with short term scale
- UP-94: Scale AA, static proj. to 2006 or 2012

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**CPM vs UP-94 in 2006: ratios q(x) Male**

- [Graph showing ratios q(x) for different income classes]

**CPM vs UP-94 in 2012: ratios q(x) Male**

- [Graph showing ratios q(x) for different income classes]
CPM vs UP-94: 2006 and beyond

- Male: depends on income class, but lower than UP-94 in 2012 until age 84
  - Class 4 ages 74-77: under 102%;
  - Wide gap between income classes,
- For Female: CPM mortality is lower (age<87)
- Projected to 2015, 2020: lower ratios
- Next Charts: compare Classes 2, 3 & 4 only
- Also: compare Sources CPP, QPP, CAN

CPM-CAN 2005-2007 Male: Classes 2, 3 & 4

- Class 2 low
- Class 2 high
- Class 2 grad
- Class 3 low
- Class 3 high
- Class 3 grad
- Class 4 low
- Class 4 high
- Class 4 grad
4. Mortality Improvement Rate, Formulas

Next Slide show formulas for reference

Charts follow and illustrate trends

Excerpts from Phase III Draft Report 
(2012-07)

Formulas: force, prob., weights

Deaths and exposure (exact):  \( \hat{\mu}_x = \frac{D_x}{E_x} \)

Probability of death, from force: \( \hat{q}_x = 1 - e^{\hat{\mu}_x} \)

Variance of force, and of prob.:

\[
\text{Var} (\hat{\mu}_x) = \frac{\sigma^2}{E_x} = \frac{D_x}{E_x} \\
\text{Var} (\hat{q}_x) = \left( e^{-\hat{\mu}_x} \right)^2 \times \text{Var} (\hat{\mu}_x)
\]

Weight:

\[
w_i = \frac{1}{\text{Var} (\hat{q}_x)} = \frac{(E_x)^2}{(1-\hat{q}_x)^2 \times D_x}
\]

Formulas: Regression

Improvement rate: \( q^{\text{init-year+1}}_x = q^{\text{init-year}}_x \times (1 - IR_x) \)

Regression on ln(qx): linear form

\[
\ln (q^{\text{init-year+1}}_x) = \ln (q^{\text{init-year}}_x) + t \times \ln (1 - IR_x)
\]

\[
y_i = \beta_0 + \beta_1 \times x_i
\]

Weighted Linear Regression (Min W, find slope):

\[
W = \sum_{i=1}^{n} w_i \times (y_i - \beta_0 - \beta_1 \times x_i)^2
\]
Formulas: slope, $IR_x$

Slope factor, weighted linear regression:

$$\hat{\beta}_{(w)} = \frac{\sum w_i \times x_i \times y_i - \left(\sum w_i \times x_i\right) \times \left(\sum w_i \times y_i\right)}{\sum w_i^2 - \left(\sum w_i \times x_i\right)^2}$$

Improvement rate:

$$IR_x = 1 - e^{\hat{\beta}_1}$$

Formulas: bounds, $R^2$

Confidence interval: upper and lower bounds

$$LB = \hat{\beta}_{(w)} - t_{\alpha/2,n-2} \times s_{\hat{\beta}}$$
$$UB = \hat{\beta}_{(w)} + t_{\alpha/2,n-2} \times s_{\hat{\beta}}$$

$$rate(LB) = 1 - e^{LB}$$
$$rate(UB) = 1 - e^{UB}$$

Worth of regression: $R^2$

$$R^2 = \frac{\sum w_i \times (y_i - \bar{y})^2}{\sum w_i}$$

15-Year Regression Ending in 2007, CAN-4-M, Age 70

CAN-4-M, Age 70, Prob. of Death $q_{70}$

Weighted Linear Regression, 15-Year Ending in 2007

$q(70,1992+t) = q(70,1992) \times (1-IR70)^t$

$IR=2.78\%, \ 95\% \ C.I.= 2.46\%-3.11\%, \ R^2=96.0\%$

15-Year Regression Ending in 1992, CAN-4-M, Age 70

CAN-4-M, Age 70, Prob. of Death $q_{70}$

Weighted Linear Regression, 15-Year Ending in 1992

$q(70,1977+t) = q(70,1977) \times (1-IR70)^t$

$IR=1.0747\%, \ 95\% \ C.I.= 0.736\%-1.412\%, \ R^2=76.7\%$
15-Year Regression Ending in 2007, CAN-4-M, Age 95

Weighted Linear Regression, 15-Year Ending in 2007

\[ q_{95, 1992+t} = q_{95, 1992} \times (1 - IR_{95})^t \]

IR = -0.14%, 95% C.I. = -0.74% - 0.46%, R² = 1.6%

CAN-4-M: 15 years in 2007

Results vary by length of regression

CAN-4-M Mortality Improvement Rate

Various Lengths of Regression Period Ending in 2007
Results of Last 30 Years (Males)

CAN-4-M Mortality Improvement Rate

Improvement by Classes, CAN-M:2,3,4,5

CAN-M Mortality Improvement Rate
by Income Classes
15-year Regression Period Ending in 2007

Arcadian Research Conference, Winnipeg, Session P4A, Projection Scales 2012-08-03

Improvement by Source, 4-M:CAN, CPP, QPP

4-M Mortality Improvement Rate
by Data Source (CAN, CPP, QPP)
15-year Regression Period Ending in 2007

5. Projection Scales, Proposal

• 15-year: 1992 to 2007 mirrored to 2006-2021
• CPM-CAN Experience
• Income class 4
• Long term: blend of CPP and QPP
  – 2060 assumptions in December 2009 Report
• Mid term: transition from 2021 to 2030
• Based on blended C/QPP 2020 assumptions, adjusted
• Impact: q(x) decreases faster, higher e(x)
  higher $\bar{a}(x)$, higher actuarial liabilities
Proposal: 3 Projection Scales

Short term scale: 2006 to 2021, 15 years

\[ \text{Male } q_{k+1}^{2006} = q_{k+1}^{2006} \times \left(1 - \text{Male }IR_{\text{Short term}}\right)^{\frac{k}{15}} ; 1 \leq k \leq 15 \]

Mid term scale: 2021 to 2030, 9 years

\[ \text{Male } q_{k+1}^{2006} = q_{k+1}^{2006} \times \left(1 - \text{Male }IR_{\text{Mid Term}}\right)^{\frac{k}{15}} \times \left(1 - \text{Male }IR_{\text{Long Term}}\right)^{\frac{k}{9}} ; 16 \leq k \leq 24 \]

Long term scale: 2030 and after

\[ \text{Male } q_{k+1}^{2006} = q_{k+1}^{2006} \times \left(1 - \text{Male }IR_{\text{Short Term}}\right)^{\frac{k}{15}} \times \left(1 - \text{Male }IR_{\text{Mid Term}}\right)^{\frac{k}{24}} ; k \geq 25 \]

Projection Scale: Male

Results

- Charts show impact on a generational basis
- UP-94 G: AA Projection Scale
- CPM-CAN-4 2005-2007: Short/Mid/Long Projection Scales
- Effect on complete life expectancy and PV of life annuity-due \( \dot{c}_x \) & $1,000 \times \ddot{a}_x \)
PV, i=3%, Valuation in 2012: Male

<table>
<thead>
<tr>
<th>Age</th>
<th>UP-94G</th>
<th>CPM-CAN-4-M</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>17,032</td>
<td>17,506</td>
<td>2.78%</td>
</tr>
<tr>
<td>65</td>
<td>14,729</td>
<td>15,097</td>
<td>2.50%</td>
</tr>
<tr>
<td>70</td>
<td>12,434</td>
<td>12,648</td>
<td>1.72%</td>
</tr>
<tr>
<td>75</td>
<td>10,099</td>
<td>10,169</td>
<td>0.68%</td>
</tr>
<tr>
<td>80</td>
<td>7,876</td>
<td>7,811</td>
<td>-0.83%</td>
</tr>
<tr>
<td>85</td>
<td>6,032</td>
<td>5,727</td>
<td>-5.06%</td>
</tr>
</tbody>
</table>

Impact on PV at 3%: Male (generational)

- % Increase in $\hat{a}(x)$
- From UP-94 G to CPM-CAN-4-M
- Generational: with impact of projection scales
- 3 Valuation Years

PV, i=3%, Valuation in 2012: Female

<table>
<thead>
<tr>
<th>Age</th>
<th>UP-94G</th>
<th>CPM-CAN-4-M</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>18,201</td>
<td>18,857</td>
<td>3.61%</td>
</tr>
<tr>
<td>65</td>
<td>16,033</td>
<td>16,572</td>
<td>3.36%</td>
</tr>
<tr>
<td>70</td>
<td>13,812</td>
<td>14,198</td>
<td>2.80%</td>
</tr>
<tr>
<td>75</td>
<td>11,472</td>
<td>11,733</td>
<td>2.27%</td>
</tr>
<tr>
<td>80</td>
<td>9,146</td>
<td>9,255</td>
<td>1.19%</td>
</tr>
<tr>
<td>85</td>
<td>6,983</td>
<td>6,903</td>
<td>-1.14%</td>
</tr>
</tbody>
</table>

Impact on PV at 3%: Female (generational)

- % Increase in $\hat{a}(x)$
- From UP-94 G to CPM-CAN-4-F
- Generational: with impact of projection scales
- 3 Valuation Years
6. Conclusion

- Canadian pattern of mortality known
- Cost of pensions using UP-94 and AA may be underestimated
- Recent trend in mortality
  - faster decrease than thought with previous scales
  - not known when it will trail off
  - No crystal ball: use consensus for long term

Next Steps

- CIA: decision to release Phase II and Phase III reports
- CIA: may provide additional comments
- Discussion at CIA Fall 2012 Pension Seminar
- Actuarial Standards Board (Canada): decide future recommendations for mortality tables for pensions plans purposes

Thank you!
Length of Regression: CAN-4-F in 2007

Improvement by Classes, CAN-F:2,3,4,5

Improvement by Source, 4-F:CAN, CPP, QPP

Impact on Life Expectancy: Male (generational)

- % Increase in complete $e(x)$
- From UP-94 G to CPM-CAN-4-M
- Generational: with impact of projection scales
- 3 Valuation Years
Impact on Life Expectancy: Female (generational)

- % Increase in complete $e(x)$
- From UP-94 G to CPM-CAN-4-F
- Generational: with impact of projection scale
- 3 Valuation Years

Impact:
- % Increase in $e(x)$
- From UP-94 G to CPM-CAN-4-F
- Generational: with impact of projection scale
- 3 Valuation Years

ARC, Winnipeg. Mortality Improvement for Canadian Pensioner Proposed Projection Scale.