Longevity Trends, Past and Future: A Deep Dive into CPP and QPP Mortality

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Plan
- Motivation and background
- National and international mortality
- CPP and QPP socio-economic mortality
- Impact of:
  - pension level
  - evolving plan rules
  - immigration

Motivation
- Pension plans and life insurers
  - Seek to project future mortality
  - Value future liabilities, measure risk and manage risk
- Improved models for making projections using
  - Mortality data for specific socio-economic (or other) subgroups
  - Especially datasets with longer historical runs of data
  - Quantity and understand differences in level and trend
- Mortality rates:
  - Canadian national level
  - Zoom out: International comparisons
  - Zoom in: Canadian sub-populations

How to Process and Interpret Crude Mortality Data?
- How to improve the signal to noise ratio
- Empirical measures: ages standardised mortality rates
- Model-based methods

Historical Death Rates: Canada up to 2011

Age Standardised Mortality Rates (ASMR)
- The ASMR is a weighted average of the crude death rates over a defined age range
- Age range $x_0, ..., x_t$, year $t$

$$ ASMR(t) = \frac{\sum_{x} \hat{m}(t, x) \tilde{E}(x)}{\sum_{x} \tilde{E}(x)} $$

- $\hat{m}(t, x)$ = crude death rate in year $t$ at age $x$
- $\tilde{E}(x)$ = “standard population” exposures
- Use of ASMR facilitates comparison of populations
- Use also reduces the impact of sampling variation
Canada: Improvements Relative to 1981

Recent Improvement Rates: Canadian Males

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<td>30-39</td>
<td>2.0%</td>
<td>0.5%</td>
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<td>50-59</td>
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<td>70-79</td>
<td>2.4%</td>
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Table 1: Annual mortality improvement rates by age group and over different time periods.

- A trend change seems likely
- But was the change in 2010 or 2011 or gradual?
- Makes a big difference when estimating and setting future improvement rates

Zoom Out: International Comparisons

Comparison with Other Countries

- Slowdown in Canada, England £ Wales, USA
- No slowdown in Japan, Sweden, Denmark
- Denmark is in a catch up phase
- Japan and Sweden have amongst the lowest mortality rates
- Hence
  - Will Japan and Sweden also slow down? Or
  - Is the Canadian slowdown temporary?

International Comparison

Zoom In: Socio-Economic Sub-Populations

- Introduction: English data by deprivation
- Canadian data:
  - Canada Pension Plan (CPP)
  - Quebec Pension Plan (QPP)
- Data acquisition facilitated by Canadian Institute of Actuaries project oversight group
Socio-Economic Mortality: England

CPP and QPP data
- Crude death rates for males and females
- Individual calendar years 1968-2015; and ages 65-89
- Subdivided into 11 pension bands
  - Group 1: 0-9% of the cohort maximum pension
  - Group 2: 10-19%
  - ... Group 10: 90-99%
  - Group 11: 100%
- Cohort maximum pension: contributing for at least 40 years with earnings above the Yearly Maximum Pensionable Earnings (YMPE: 2018 – CAD 55,900)

CPP Males and Females: ASMR's
- Initially "good" rankings
- Group 11 stands clear
  - Heterogeneity at top end
  - Conscientiousness (?)
- Middle groups behave well
- Smaller groups more volatile
- Inequality gap widens slightly
- Strange behaviour: Groups 1, 2
  - Supports the healthy immigrant effect

CPP Females: ASMR’s
- Similar spread to males
- Slightly slower improvements
- Group 1 stands clear
  - Large heterogeneous group
- Ordering of groups looks okay until 2006
- Strange behaviour: After 2006 Group 11 worsens significantly relative to other groups
- Reasons for this are not clear, although Group 11 is quite small.

CPP Females: Group 11 Heterogeneity
- Includes beneficiaries who get more than 100%:
  - converted from disability at age 65 or,
  - were already survivors at time of benefit uptake.
- These two groups (higher than average mortality) have gradually increased over time.
- Removing data for these two groups results in a "well behaved" plot.

Source: Office of Chief Actuary calculations, OSFI
QPP Males and Females: ASMR’s

- No obvious anomalies, unlike CPP
- Inequality gap widens more than CPP

 CPP Males: Group 1

- Groups 1 contains a mixture of
  - Low paid workers, long term unemployed, etc. → high mortality
  - People who migrated to Canada in the later part of their working lives → Group is potentially heterogenous
- **The healthy immigrant effect**
  - E.g. Vang et al. (2017)
  - Immigration permitted if:
    - Healthy
    - Fit to work
  - Selection effect diminishes over time
  - But income level does not diminish

Deeper Dive

- To understand better
  - The differences between groups
  - Trends over time
- Helpful to consider
  - How big is each group?
  - How has the calculation of pension benefits evolved over time?
  - How significant is immigration?

CPP Males: Pension Level By Cohort

- E.g. 1990 age 65 retirees:
  - Group 11: 26%
  - Group 10: 36%
  - Group 1: 2%
  - Pre 1977 transition phase
  - Groups 10, 11 largest
  - Lower pension groups very small
  - Gradual decline in numbers attaining high pensions
    - This might artificially push up group-specific improvement rates

CPP Females: Pension Level By Cohort

- Much lower pensions than males
- Likely reasons:
  - Career breaks, part time working; gender pay gap
  - Declining Group 1 later
  - Large Group 1 might explain why Group 1 mortality much worse than Group 2;
    - Heterogeneity within group
Males: Decline in Proportion With High Pensions

- Eligible contribution period 1966 to retirement; max 47 years
- Contributions: % of Earnings capped at Yearly Maximum
- Pensionable Earnings (YMPE)
- Pension based on best 85%
- 2010 age 65 retiree: best 37 out of 1966 to 2009
- Lower earnings early in career mean less likely to attain the maximum

Immigrant Pensions

- Immigrant A:
  - Enters at age 58 in 1983
  - Even if he/she pays maximum contributions:
    - Can’t do better than Group 4
- Immigrant B:
  - Enters at age 58 in 2006
  - Can’t do better than Group 2
- Conclusion:
  - Assuming immigration is stable
  - Group allocations of immigrants will have shifted towards lower groups (stable from 2013)

Immigration: Canada Excluding Québec (CPP)

- E.g. 1990:
  - 75% of retirees (age 65 in 1990) in Canada for at least 40 yrs
  - 5% of retirees arrived after age 55
  - Estimates based on past patterns of net immigration (warning: => NOT reliable)
  - Volatile but also "stable"
- 2015 retirees:
  - Immigration in the last 0-4 years => Group 1 (at 65): ~1.3% of all retirees
  - Potentially 30% of Group 1 are recent healthy immigrants

Immigration: Québec versus Rest of Canada

- Québec
  - Significantly lower immigration
  - So healthy immigrant effect is not easily identified in QPP Group 1
- Both: Females
  - Similar patterns of migration in both regions
  - But for CPP females Group 1 is much bigger
  - So a healthy immigrant effect is not easily identified in Group 1
- CPP Group 1 has a high proportion of late retirees
  - Significant late retirement into mid 70’s
  - (?): Earning and contributing between 65 and late retirement
  - (?): Possibly late retirees are mostly immigrants
  - “Lifetime” Canadians unlikely to benefit

Zoom In Even Closer: CPP Males 2015

- Smoothed mortality curves
- Spread:
  - Wide spread at low ages
  - Convergence at high ages; typical of most socio-economic analyses
- Group 11: well below other groups <80
- Group 1:
  - Age 65: similar to Groups 2-5
  - Older ages: gradual cross over
  - Age 80+: similar to Group 11
- Conclusion: Pattern is consistent with considerable heterogeneity in Group 1
  - A: low-income, lifetime contributors who die off quickly
  - B: vary (!) healthy immigrants
Conclusions

• For forecasting it can be useful to
  – Zoom out – exploit the wider international context
  – Zoom in – understand the detail of your own data
• Healthy immigrant effect – implicit but important
• Evolving accrual rules can impact on pension level
  – Shift towards lower pensions can inflate historical group-level
    improvement rates
• Overall: if forecasting subgroup mortality, it is important to understand the
  nuances in the underlying data
• Some evidence for a widening inequality gap
• So don’t lose sight of what is happening at the national level!

Questions

The views expressed in this presentation are those of the presenter.
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CPP and QPP data

\[ \hat{m}(g,i,t,x) = \frac{D(g,i,t,x)}{E(g,i,t,x)} \]

- \( D(g,i,t,x) \) death counts
- \( E(g,i,t,x) \) exposures
- \( g \) =gender
- \( i \) =pension band (0-9%, 10-19%,…, 90-99%, 100% of \( \text{max} \))
- \( t \) =calendar year
- \( x \) =age last birthday (at date of death)
- Cohort maximum pension: contributing for at least 40 years
  with earnings above the Yearly Maximum Pensionable
  Earnings (YMPE: 2018 – CAD 55,900)
- Years 1968-2015; Ages 65-89
Smoothing and Projecting Mortality

- **Stochastic mortality models**
  - E.g. Lee-Carter, CBD
  - Socio-economic data requires multi-population models
  - Smoothing within calendar years: fitted $m(i, t, x)$
  - Genuine volatility from year to year
  - Many models considered: ‘common age effect’ model best overall

- **Common Age Effect Model:**
  $$\log m(i, t, x) = \alpha(x) + \beta_1(x)i + \beta_2(x)i^2$$
  - $\alpha(x)$: common "base table"
  - $\beta_1(x)$: changes in the level of mortality at all ages
  - $\beta_2(x)$: changes in the slope of the mortality curve

Parameter Estimates: Common Age Effects

Group-Specific Period Effects

- Spread:
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Fitted Period Mortality: E.g. CPP Males 2015