Mortality postponement and compression at older-ages in human cohorts

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Background

- Maximum length of a human lifespan is an age-old question
  - Psalm 90 (<500BC; 80 maximum)
  - Censorinus (248; 100 or 110)
- In the modern era, some debate about whether the human lifespan has reached a limit
  - Olshansky (2016); Dong et al (2016); Kirkwood and Austad (2000) assert we have reached a maximum
  - Oeppen and Vaupel (2002); Vaupel (2010) and Rootzen and Zholud (2017); Zuo et al (2018) assert the opposite

What we do

- Most prior studies use period data (it's easier)
- We use a method of analyzing cohort data that we have developed to estimate the extent to which recent and historical mortality improvements at older ages are due to postponement or compression
- We find that:
  - historically, mortality improvements at older ages were primarily the result of compression, although there have been prior episodes of postponement, BUT
  - cohorts of current elderly appear to be enjoying a historically unprecedented episode of postponement
- We use our results to show why old-age mortality records have been so slow to increase
- If current patterns continue, records will rise by large margins in the coming decades

Prior publications

North American Actuarial Journal

Routledge
Taylor & Francis Group

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An Analysis of Period and Cohort Mortality Shocks in International Data

David McCarthy & Po-Lin Wang

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ORIGINAL ARTICLE

Journal of Risk and Insurance

80 will be the new 70: Old-age mortality postponement in the United States and its likely effect on the finances of the OASI program

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Abstract

Using a Bayesian cohort-based mortality
identify strong evidence of mortality postpo
older ages in the United States. We use the
the model to project mortality rates 75 ye
and show that this will likely raise the U.
dependency ratio to ~55% by 2090 (~30% l
the Social Security Administration [SS
mediate estimates). We estimate how this
the finances of the Old-Age and Survivors
program as modeled by the SSA. In our n
timate, using the SSA's intermediate-cos
tions, mortality postponement will raise
system unfunded liability over a 75-year
around $6.8trn over SSA estimates, wors
actuarial balance of the program by an extr
taxable payroll. Mortality postponement
have significant implications for other g
programs, notably Medicare, and for priv
financial intermediaries, such as pension
insurance companies, as well as private h

KEYWORDS

Bayesian statistics, longevity, public finance

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Pooling mortality risk in Eurozone state pension liabilities: An application of a Bayesian coherent multi-population cohort-based mortality model

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ABSTRACT

We design a coherent cohort-based multi-population mortality model, calibrate it to national mortality rates in the Eurozone using Human Mortality Database data, and use it to project developments in national mortality across the Eurozone. Combining this model with a stylized model of social security pensions in each country allows us to calculate the pension mortality risk in these systems and estimate the benefits of pooling it across the Eurozone. We examine three risk pools, which are all actuarially fair, but differ in how undiversifiable risk is allocated across countries. The first naive approach allocates undiversifiable risk in proportion to GDP, a second according to a CAPM-based measure of the undiversifiable risk each country contributes to the pool and a third ensures that the aggregate benefits of diversification are shared equitably across countries using a measure we adopt. In all cases, the benefits of risk pooling increase over time as mortality uncertainty accumulates, but fall over time as cross-country correlation increases due to the long-term dominance of the mortality trend, which by assumption is shared between countries. The peak benefit occurs around 2050, with an aggregate reduction in the standard deviation of pension expenditures of around 0.11% of GDP, or 3% of pension expenditure at the 99th percentile. We find that allocating undiversifiable risk proportional to GDP does not ensure an efficient allocation of undiversifiable risk across countries, given that different countries have markedly different pension mortality risk due to different pension system generosities as well as different mortality correlation with the Eurozone. Based on our results we propose a contract design that surmounts most of the moral hazard risks created by the pool, and suggest directions for future research.

1. Introduction

Despite recent reforms, European pension systems are, and are scheduled to remain, very costly. As shown in Table 1, the average cost of public pension systems across the Eurozone is currently around 10.8% of GDP per year, and projected to rise by 1.1% of GDP per year by 2040, in response to rapid population ageing.[2] As a consequence, the expected discounted present value of state pension promises already accrued to workers in the Eurozone – a form of public debt – is extremely high. At 258% of GDP in 2015,[3] the last year in which statistics are available, the size of this debt dwarfs both private-sector funded DB pension liabilities (17% of GDP in 2015 in the Eurozone) and standard measures of public debt (90.9% of GDP in 2015).[4] Because state pensions are, by definition, paid only until death, it stands to reason that the amount of longevity risk embedded within these promises is significant.

A great deal of academic work has examined how the mortality risk in private-sector insurance and pension liabilities can be

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[1] The authors would like to thank discussants and participants at Longevity 15 conference in Washington, DC, the World Risk and Insurance Economics Congress (WRIEC 2020), an anonymous referee and the journal editors for useful comments and suggestions. All errors remain our own.

[2] Table 1 also shows the projected development of the Old-Age Dependency Ratio (OADR, the number of people age 65 and over relative to the number between 20 and 64, from the 2019 Eurostat population projections (Eurostat Database, 2019)), and the size of public pension debt as a % of GDP, from the supplementary table on pensions, Eurostat. Projected pension expenditures are from reports of the Ageing Working Group (AWG) of the European Commission (2018).

[3] This value and the value of private pension debt comes from the supplementary table on pensions prepared by Eurostat.

[4] This is the value of government consolidated gross debt for general government, from Eurostat.

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This paper

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RESEARCH ARTICLE

Mortality postponement and compression at older ages in human cohorts

David McCarthy, Po-Lin Wang

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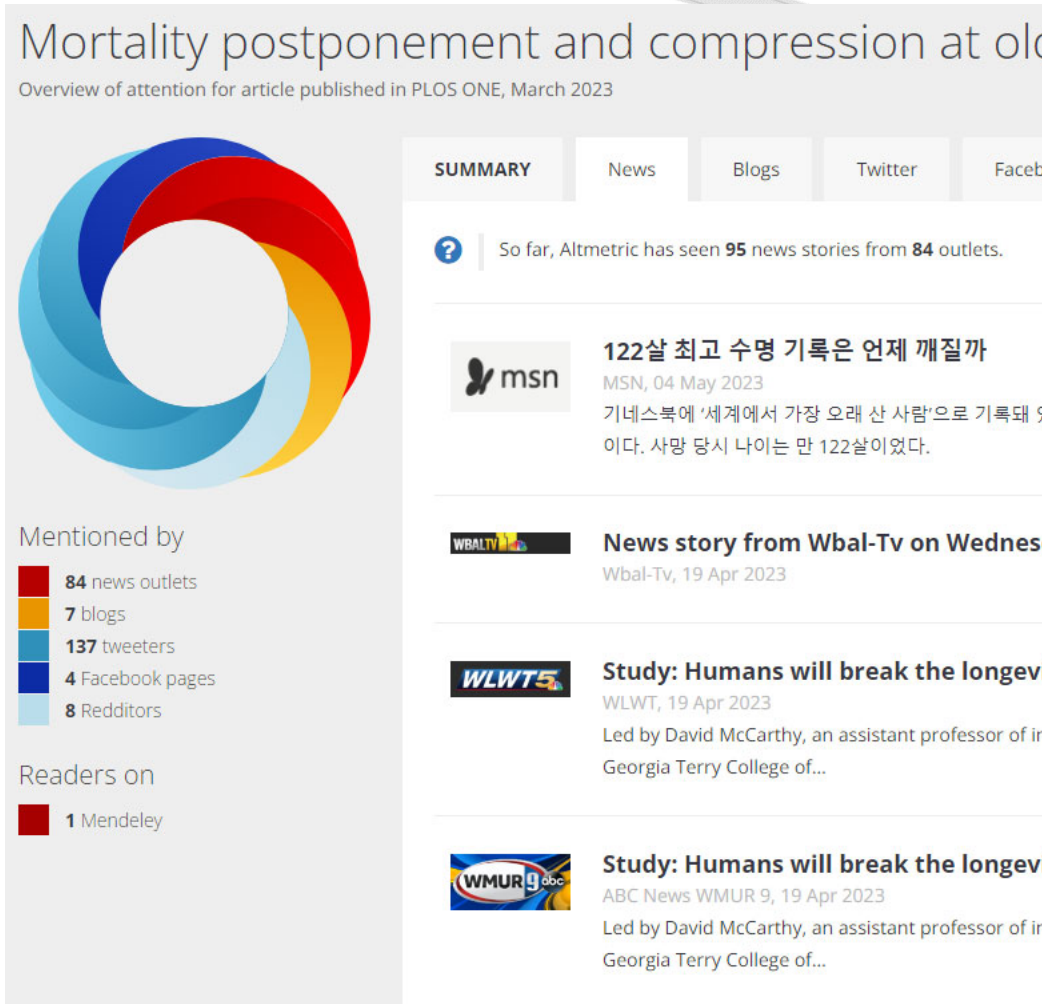
Article | Authors | Metrics | Comments | Media Coverage

Abstract
Introduction
Materials and methods
Results
Discussion
Supporting information
References
Reader Comments
Figures

Abstract

A key but unresolved issue in the study of human mortality at older ages is whether mortality is being compressed (which implies that we may be approaching a maximum limit to the length of life) or postponed (which would imply that we are not). We analyze historical and current population mortality data between ages 50 and 100 by birth cohort in 19 currently-industrialized countries, using a Bayesian technique to surmount cohort censoring caused by survival, to show that while the dominant historical pattern has been one of mortality compression, there have been occasional episodes of mortality postponement. The pattern of postponement and compression across different birth cohorts explain why longevity records have been slow to increase in recent years: we find that cohorts born between around 1900 and 1950 are experiencing historically unprecedented mortality postponement, but are still too young to break longevity records. As these cohorts attain advanced ages in coming decades, longevity records may therefore increase significantly. Our results confirm prior work suggesting that if there is a maximum limit to the human lifespan, we are not yet approaching it.



Mortality postponement and compression at old

Overview of attention for article published in PLOS ONE, March 2023

Mentioned by
84 news outlets
7 blogs
137 tweeters
4 Facebook pages
8 Redditors

Readers on
1 Mendeley

SUMMARY | News | Blogs | Twitter | Faceb

So far, Altmetric has seen 95 news stories from 84 outlets.

msn
122살 최고 수명 기록은 언제 깨질까
MSN, 04 May 2023
기네스북에 '세계에서 가장 오래 산 사람'으로 기록돼 있다. 사망 당시 나이는 만 122살이었다.

WBALTV
News story from Wbal-Tv on Wednes
Wbal-Tv, 19 Apr 2023

WLWT5
Study: Humans will break the longev
WLWT, 19 Apr 2023
Led by David McCarthy, an assistant professor of ir Georgia Terry College of...

WMUR 9 abc
Study: Humans will break the longev
ABC News WMUR 9, 19 Apr 2023
Led by David McCarthy, an assistant professor of ir Georgia Terry College of...

- Substantial media coverage
- Simpler than the others (no allowance for changing smoking habits, and no curvature, so pure Gompertz)

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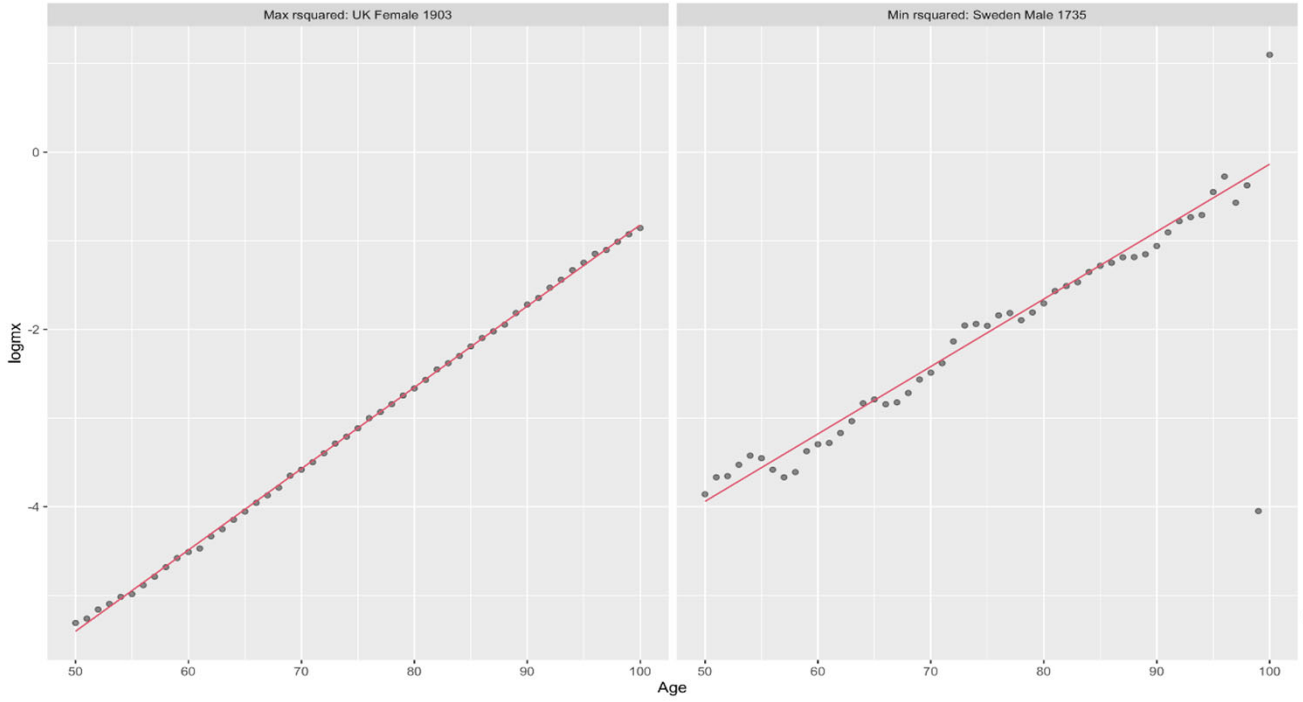
Basic method

- Fit a mortality model to all extinct cohorts individually (can use a variety of models, but Gompertz fits very well in recent cohorts) to summarize the mortality experience of each cohort using a small number of parameters
- Use these results to obtain a (set of) Bayesian prior(s) for how these parameters change over adjacent cohorts
- Combine the prior(s) with the data from all cohorts (extinct and surviving) to obtain a joint posterior estimate of the entire set of parameters of all cohorts
- Use MCMC methods to obtain the statistical distribution of this joint posterior estimate
- Interpret and analyse results

Gompertz law

$$\log(\mu_{x.c}) = \lambda_{50.c} + \delta_c(x - 50), \qquad 50 \le x \le 100$$

- Cohort parameters determined at age 50 and set base mortality; period effects cause mortality to fluctuate around that level
- But Gompertz fits recently extinct cohorts extremely well



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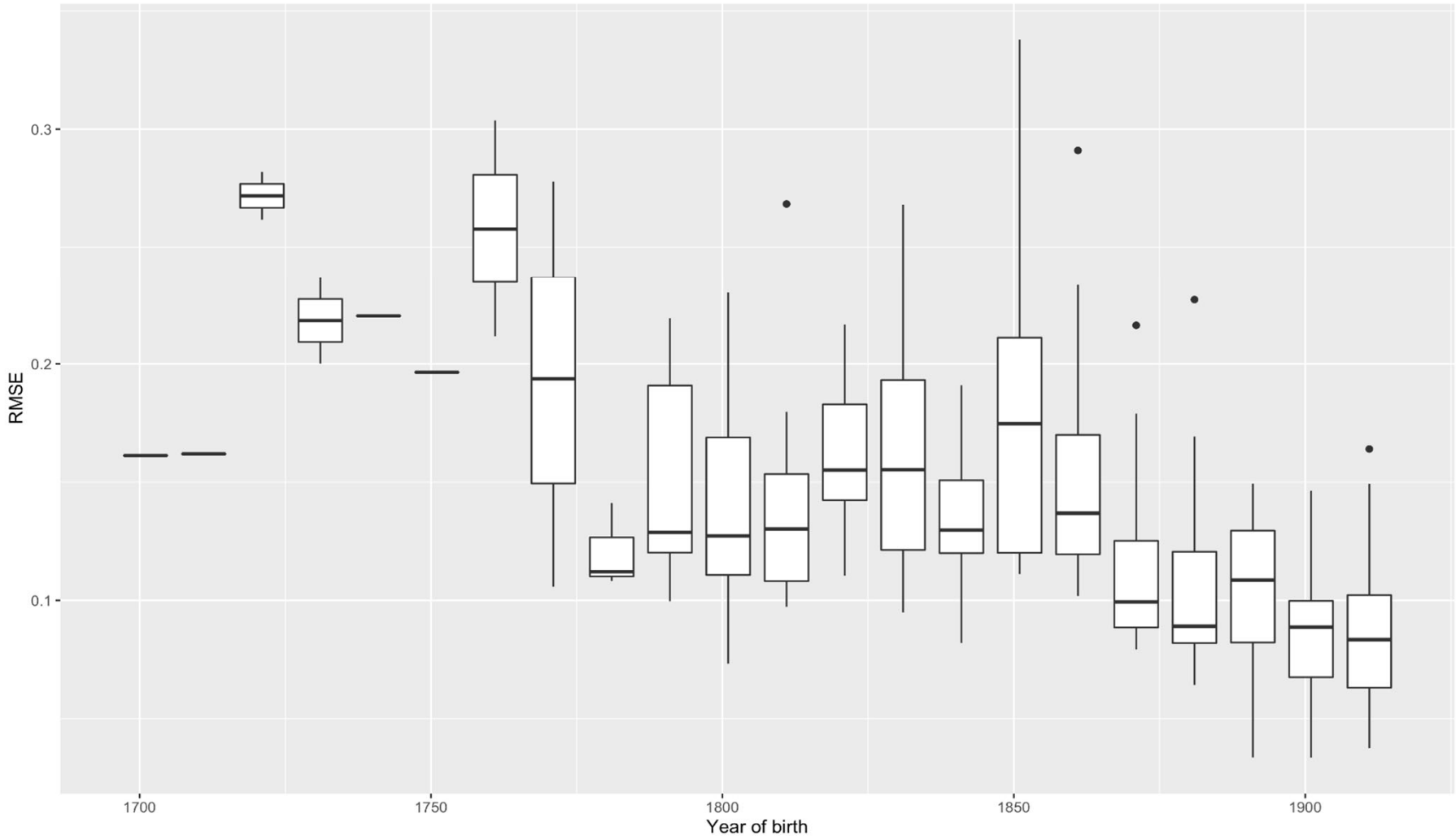
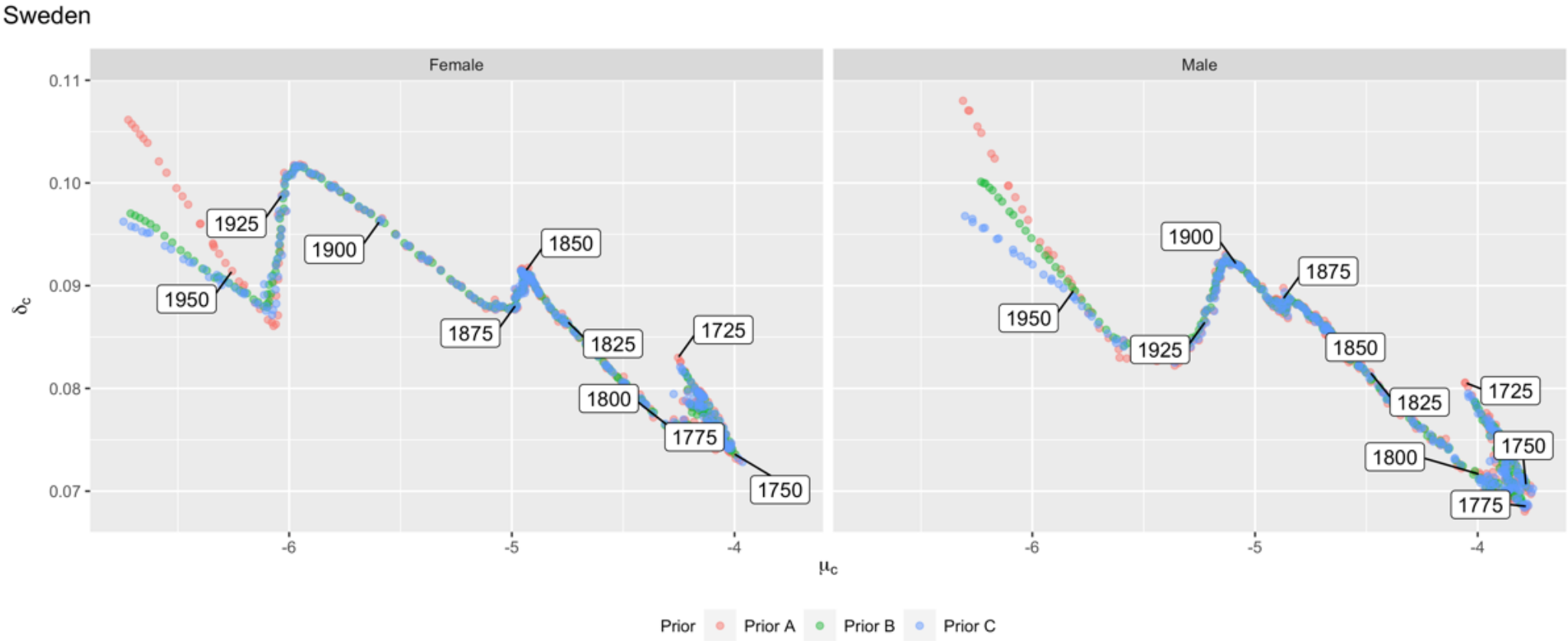
Gompertz law fits extinct cohorts really well

- Distribution of root mean-square error by year of birth



Gompertz parameters: Sweden

- General drift of parameters upwards and to the left
  - Consistent with compression?
  - But how much?



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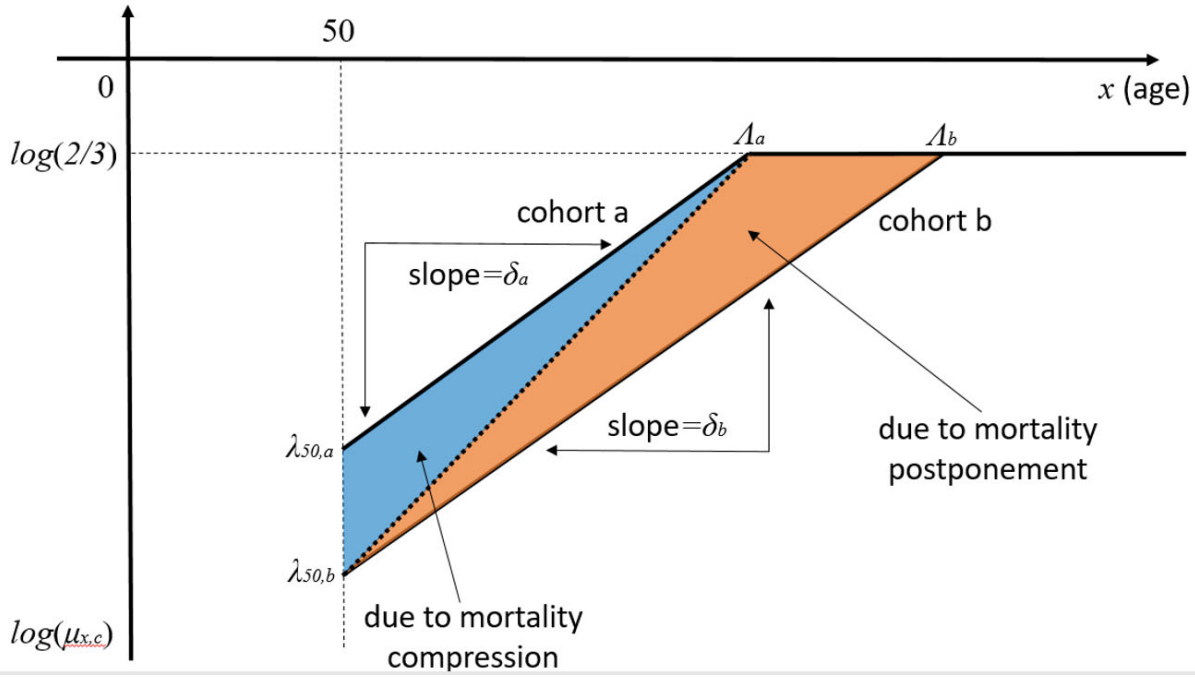
Compression vs postponement

- Posit existence of Gompertzian maximum age at which mortality hazard first hits 2/3 (Barbi et al, 2018; Alvarez et al, 2021)
- Changes in slope needed to preserve GMA we ascribe to compression; changes in GMA to postponement
- Split changes in remaining life expectancy at 50 across cohorts into that due to compression and postponement



Changes in remaining life expectancy at 50 due to compression and postponement: Sweden

- Before 1860: largely compression; 1860-1900: some postponement; 1910-1940: large postponement
- Pattern broadly replicated in other countries

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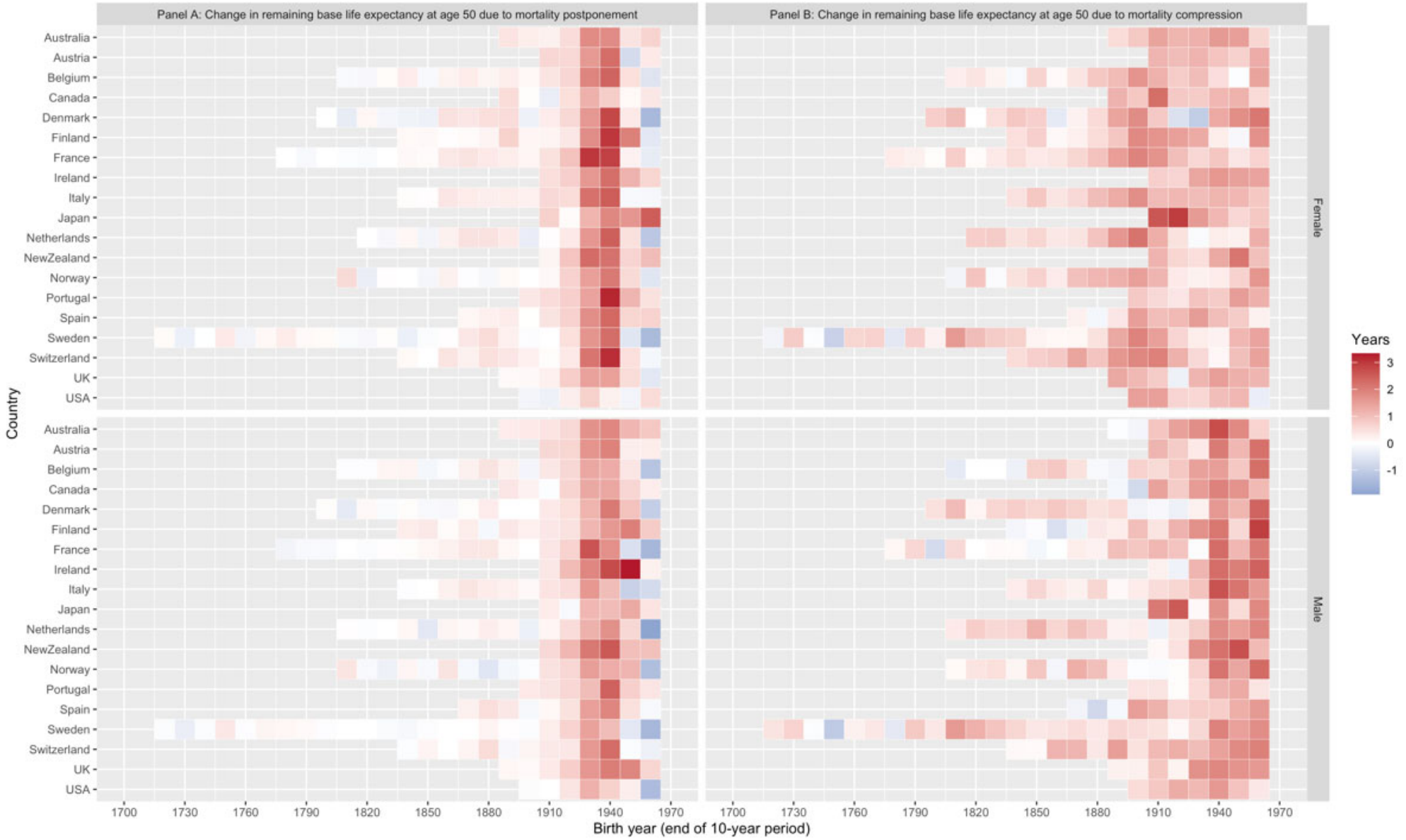
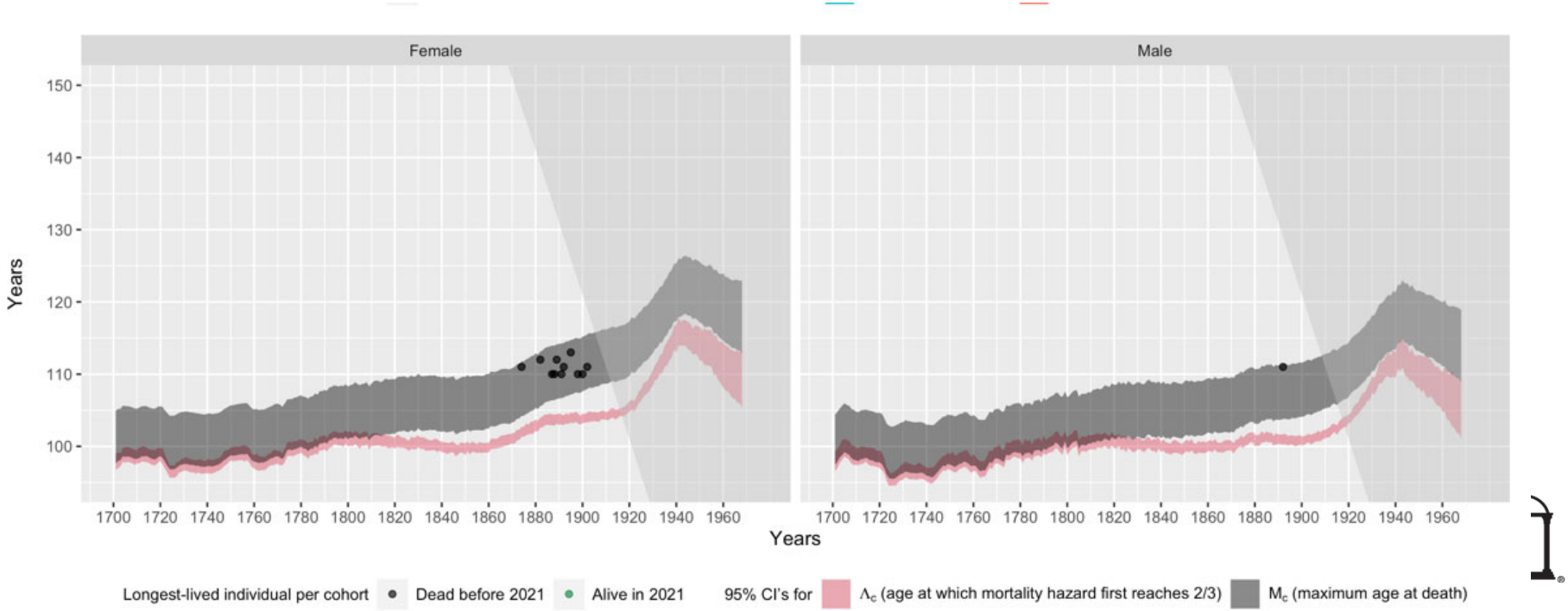
Postponement narrowly concentrated in two episodes; compression broader



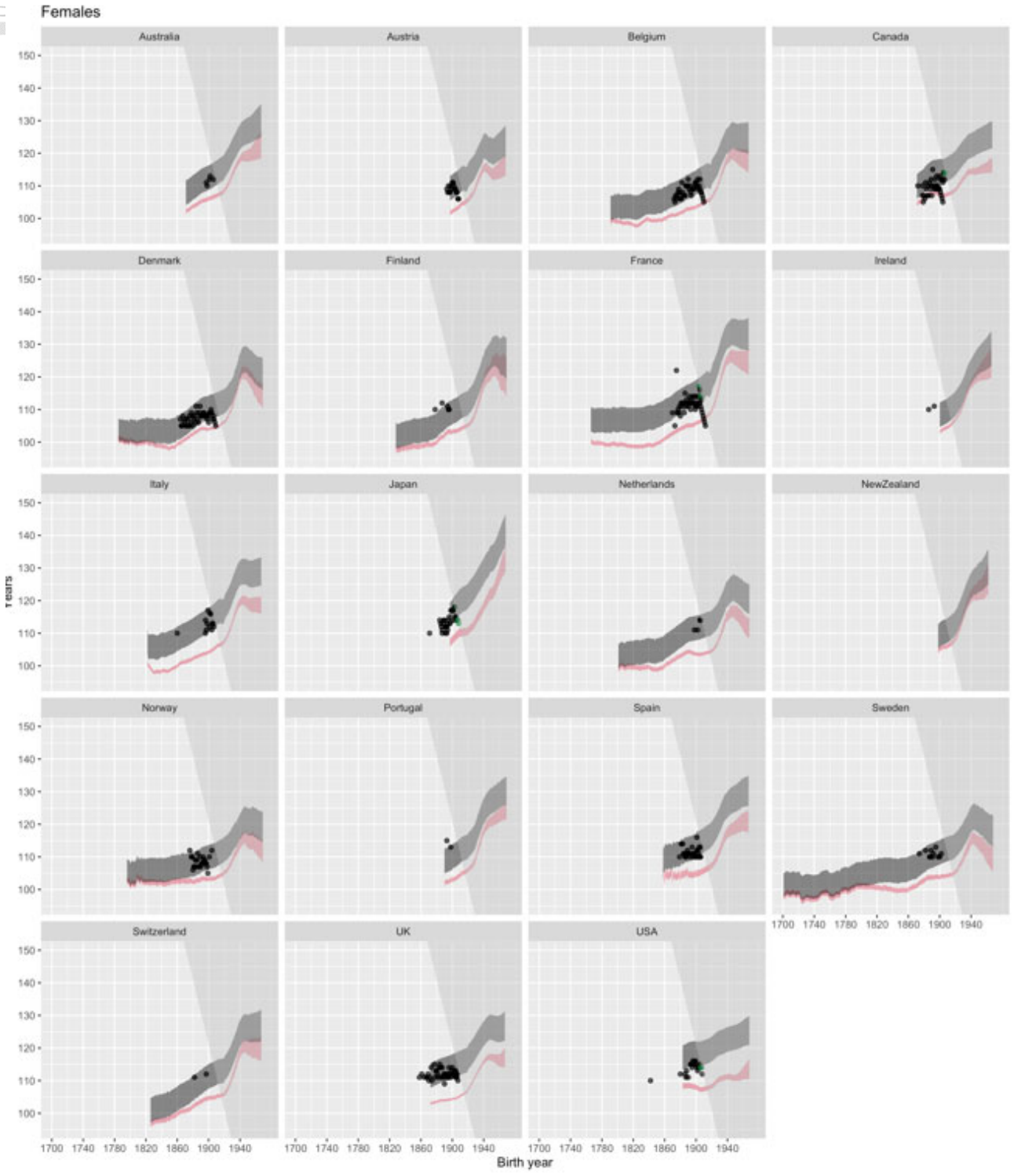
Age at death of longest-lived person in each birth cohort

- Our methodology allows us to estimate the distribution of maximum age at death (Gumbel) and the GMA in each birth cohort; we compare these with databases of super-centenarians maintained by the GRG and the ILD (really a test of GMA assumption)
- GMA is constant over long periods but not over all of our data



All countries

- Model fits most countries extremely well: 2/3 assumption looks accurate!
- Longevity records haven't increased because cohorts reaching advanced ages did not experience postponement
- Postponement seems to be a cohort-based phenomenon



Overall

- Bayesian methodology allows estimates to be obtained for incomplete cohorts
  - Requires strong assumptions about cohort mortality parameters and period shocks
  - Requires a prior to be chosen
- But produces a posterior estimate with confidence intervals
- Results show that:
  - GMA constant over long periods, but there have been prior episodes of postponement
  - Observed patterns of mortality postponement in recent cohorts are extremely unlikely to have arisen by statistical error; pattern is similar in males and females and across countries
- Explain why mortality records have been slow to fall despite postponement

Implications

- Biological – our historical analysis suggests that assuming that patterns of old-age mortality are set at younger ages (before age 50) works well. Is there a biologival basis for this?
- Financial – while the chance that any one individual will live to these extreme ages is low, our results confirm prior work suggesting that individuals currently at retirement age should lengthen their planning horizons
- Economic – proportion of elderly in populations may rise beyond current projections
- Social – if true, our conclusions indicates that younger cohorts in some countries (e.g. the US) may have lower life expectancy when they reach extreme ages