The Uncertainty of Human Life Expectancy and its Impact on the Insurance Industry

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- Managing partner of the Institut für Finanz- und Aktuarwissenschaften (ifa), an actuarial consulting firm based in Ulm, Germany

- Further positions and occupations:
  - adjunct professor for actuarial science at Ulm University
  - serves on several advisory boards
  - associate editor of the Asia Pacific Journal of Risk and Insurance and referee for numerous academic journals

- Memberships:
  - German Society for Actuarial and Financial Mathematics
  - American Risk and Insurance Association

- Research awards:
  - Australia (1997 and 2000)
  - Singapore (1998)
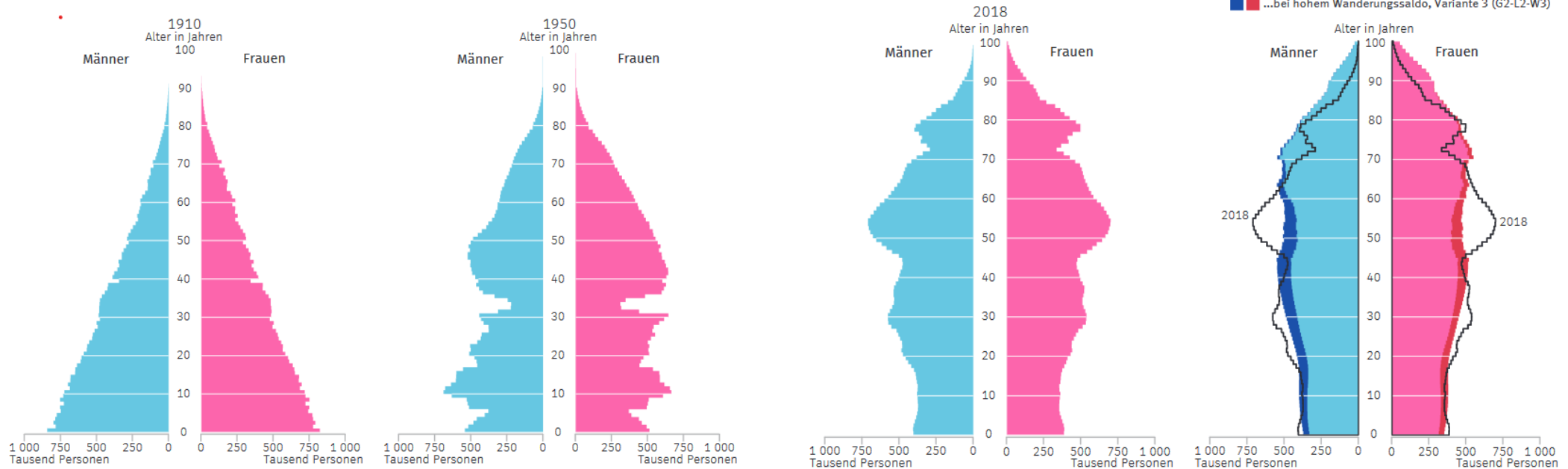 - Germany (1999, 2000, 2004, 2006, 2009, 2016, 2018)

Introduction

Demographic Change and impact on Pay As You Go Pension Systems

Source of Chart:
Statistisches Bundesamt,
14. koordinierte Bevölkerungsvorausberechnung

Some stuff we all know…

The structure of the population will change dramatically.

- Main Reasons: Increasing life expectancy and low birth rates.
- Massive challenge for Pay As You Go Pension Systems
- Increasing importance of private and occupational systems; increasing rates of annuitization expected → Increasing amount of **longevity risk** on balance sheets.
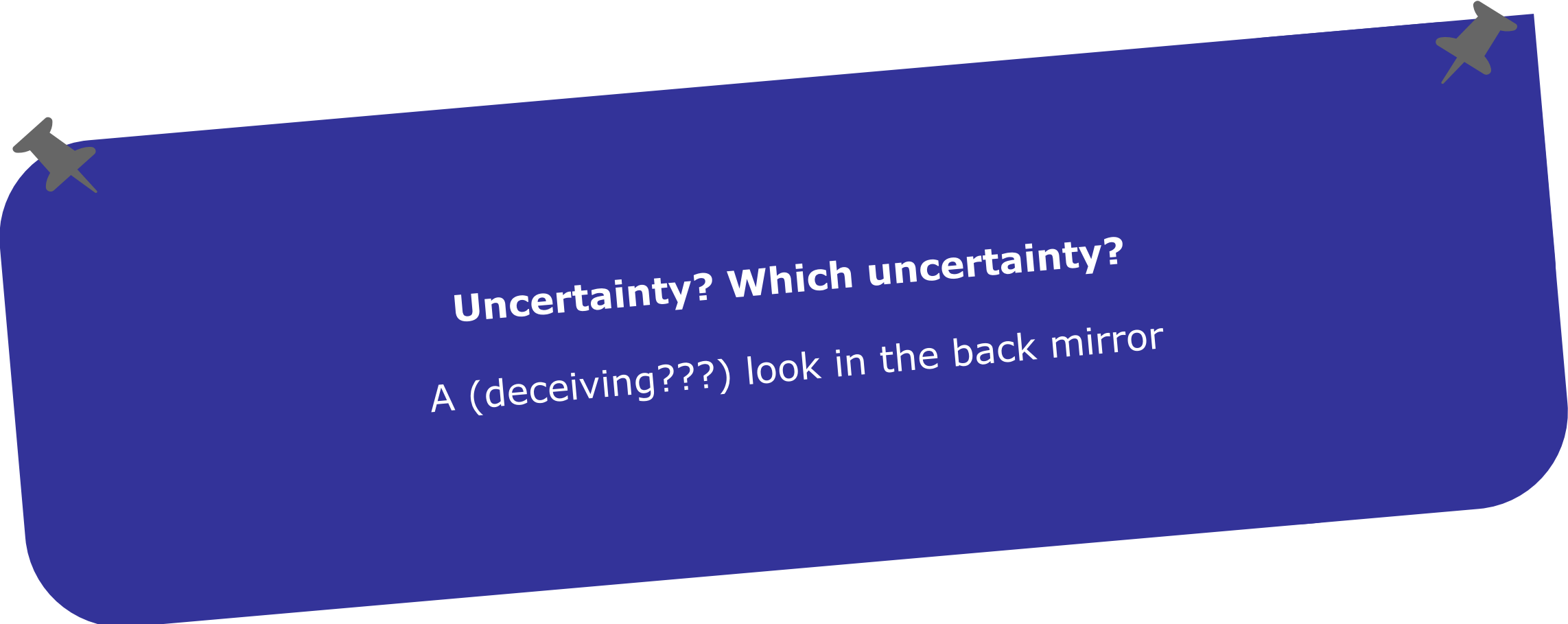
Some more stuff we all know...

Unsystematic longevity risk

- Uncertainty of individual person's lifetime
  - May die before or live longer than life expectancy
- Financial consequences of this risk can be insured by buying an annuity
 - Risk diversifies in a pool of insureds

Systematic longevity risk

- The risk that the insureds live (on average) longer than expected.
- Not diversifiable
- (Understanding), modelling, measuring and managing this risk becomes more and more important.
- **My thesis: The uncertainty of the future development of human life expectancy is currently particularly high!**

Uncertainty? Which uncertainty?

A (deceiving???) look in the back mirror

Source of picture: Oeppen J, Vaupel JW. Demography. Broken limits to life expectancy. Science. 2002 May 10;296(5570):1029-31.
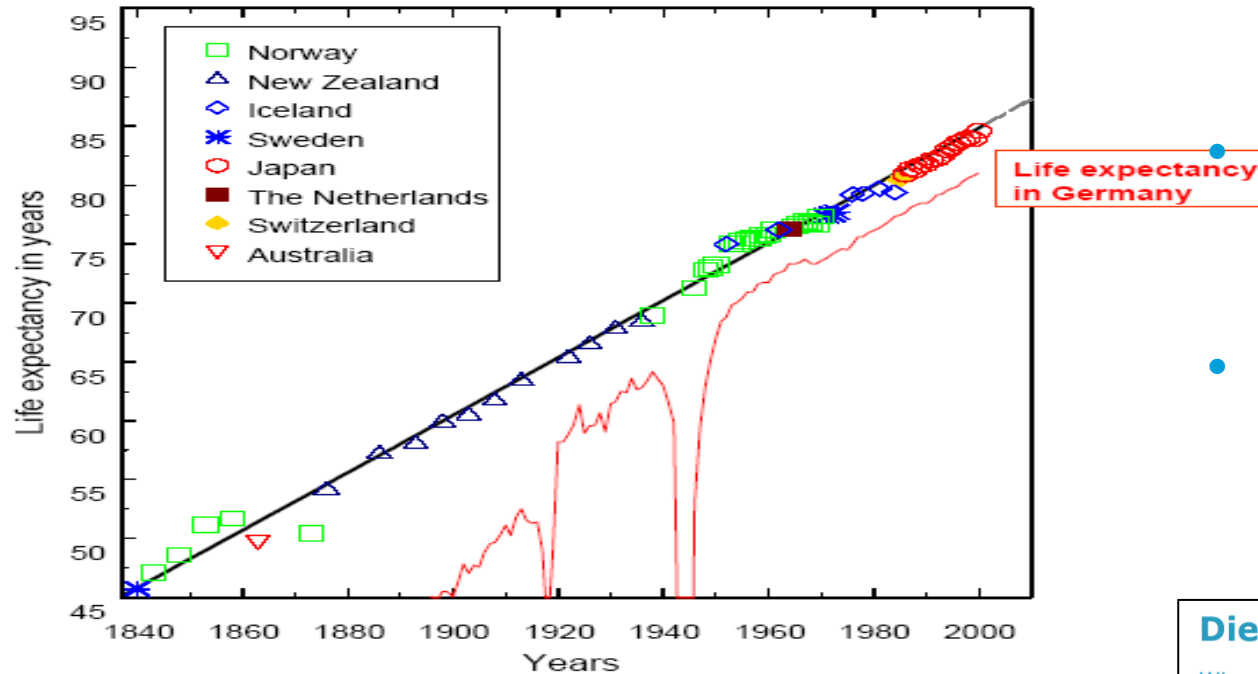
The so-called record life expectancy (life expectancy in the "healthiest" country in the world) has been rising linearly for a long time. Speed: approx. 2.5 years per decade

Will this go on forever?

- A review of the past suggests that human life expectancy is likely to continue increasing steadily and predictably in the future.
- **However:** The uncertainty regarding the future development of life expectancy has probably never been as high as it is today. Insurance provides protection against uncertainty.
- For further information on the uncertainty surrounding human life expectancy, please refer to my talk from April 2023, available at www.ifa-ulm.de/Lebenserwartung.pdf*

Die Zukunft der Lebenserwartung

Wissen wir eigentlich, wie wenig wir wissen?

- Jochen Ruß
- April 2023

* Similar presentation in English language: https://www.ifa-ulm.de/fileadmin/user_upload/download/vortraege/2023_ifa_Russ_The-future-of-human-life-expectancy-Do-we-know-how-little-we-know_2023-20th-Annual-Fasano-Longevity-Conference.pdf

- The following two segments contain a few excerpts from this talk. You are invited to download the complete presentation slides.

Longevity: The Party is over

Why the increase of life expectancy has to slow down or even stop, if we have the same "type" of medical progress in the future as we did in the past.

Prominent argument, based on seminal work (Olshansky et al, 1990; Olshansky et al, 2001)*:

- future increases in life expectancy at a pace similar to those seen in the past are implausible if not impossible

This follows from a biodemographic effect called *entropy of the life table*:

- As life expectancy increases, mortality is postponed and increasingly compressed at higher ages requiring progressively larger relative reductions in mortality rates to achieve further gains in life expectancy.

Related to what medical experts often refer to as the "whack-a-mole effect":

Percentage reduction in death rates at all ages required to raise life expectancy at birth by one year
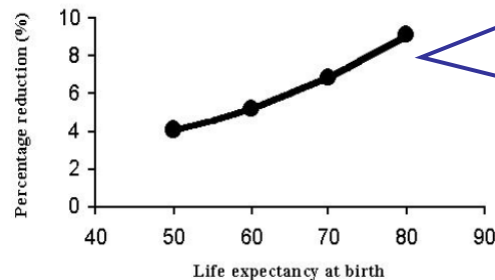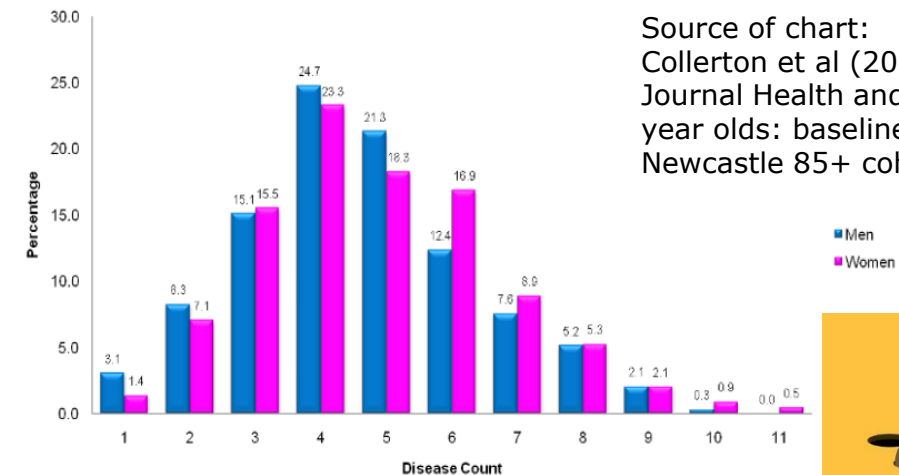
SOURCE: Olshansky, Carnes and Désesquelles, 2001. Prospects for Human Longevity. *Science.*

"when life expectancy at birth is 50, it takes an estimated 4.1% reduction in total mortality at every age to raise life expectancy 1 year […]. By contrast, raising life expectancy from 80 to 81 years requires a 9.1% reduction in total mortality at every age."

Source of chart: Collerton et al (2009) British Medical Journal Health and disease in 85 year olds: baseline findings from the Newcastle 85+ cohort study

* Olshansky, S. J., Carnes B. A., and Cassel C. (1990). In search of Methuselah: estimating the upper limits to human longevity, Science 250(4981), 634–640. Olshansky, S. J., Carnes, B. A., and Désesquelles A. (2001). Prospects for human longevity, Science, 291(5508), 1491–1492.
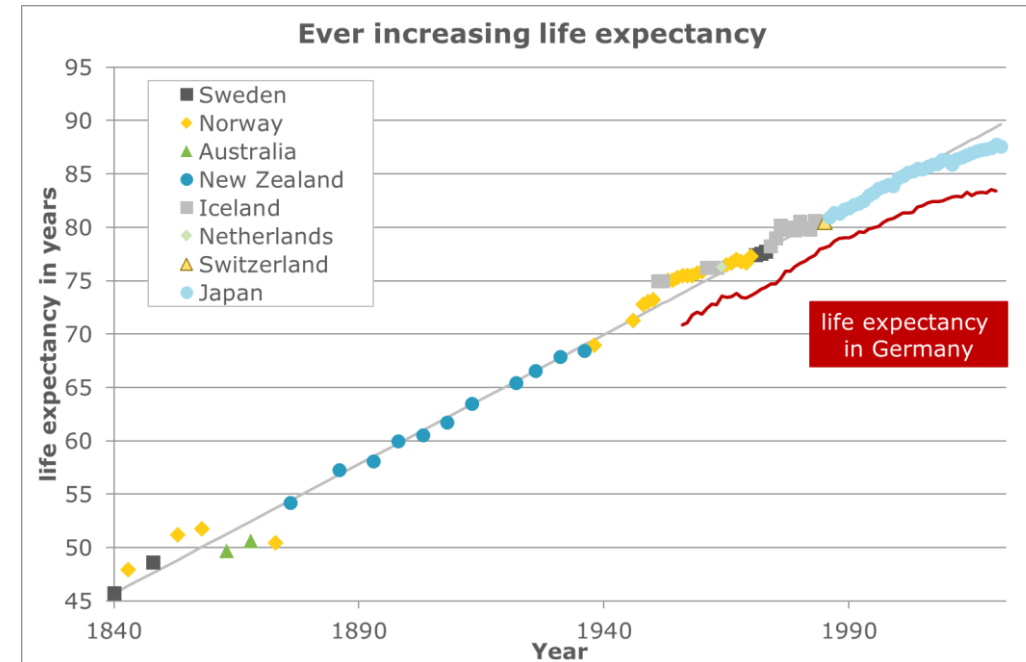
Many other potential causes for a slowdown or even stop of increase of life expectancy (see presentation referenced on slide 7)

All these arguments very strongly indicate that the increase of human life expectancy will necessarily slow down if there is no „new type of medical progress".

- Simplified: Currently we treat people who are already sick.
  - Better diagnosis (detecting earlier) and better treatments
  - Ideally curing but often only prolonging survival with individual diseases

Chart on the right: updated version of the above picture

- Indication that the increase of life expectancy has already slowed down.
- Also, Olshansky et al. (2024)*:
  - for a group of nine countries, the percentage reduction in death rates from all causes at all ages required to raise period life expectancy at birth by 1 year has been increasing relative to the year 1990 following a pattern predicted by their work two decades earlier.

Ever increasing life expectancy

Legend:
- Sweden
- Norway
- Australia
- New Zealand
- Iceland
- Netherlands
- Switzerland
- Japan

life expectancy in Germany

Source: Until 1999: numbers from the chart by Oeppen und Vaupel (2002) (see above); own calculations for the years afterwards.

Longevity: The Party hasn't even started

There are very good arguments suggesting that the increase in life expectancy will accelerate significantly in the near future, since slowing down the biology of human aging seems to be within reach.

Sources (clockwise from top left): 1) Weindruch R, Sohal RS. Caloric intake and aging. N Engl J Med. 1997 Oct 2;337(14):986-94. 2) Gkioni, L., Nespital, T., et al. (2024). A combination of the geroprotectors trametinib and rapamycin is more effective than either drug alone. bioRxiv, 2024-07. 3) Biology of Human Senescence, Talk by Richard Faragher at the „Living to 100 conference" 2023. 4) https://www.jax.org/news-and-insights/2014/may/searching-for-the-secret-ingredients-of-the-fountain-of-youth. 5) Can We Grow Older Without Getting Sicker? TEDMed Talk by Nir Barzilai, MD, AFAR Scientific Director and PI of the TAME Trial. https://youtu.be/MGKB9AdPmwc
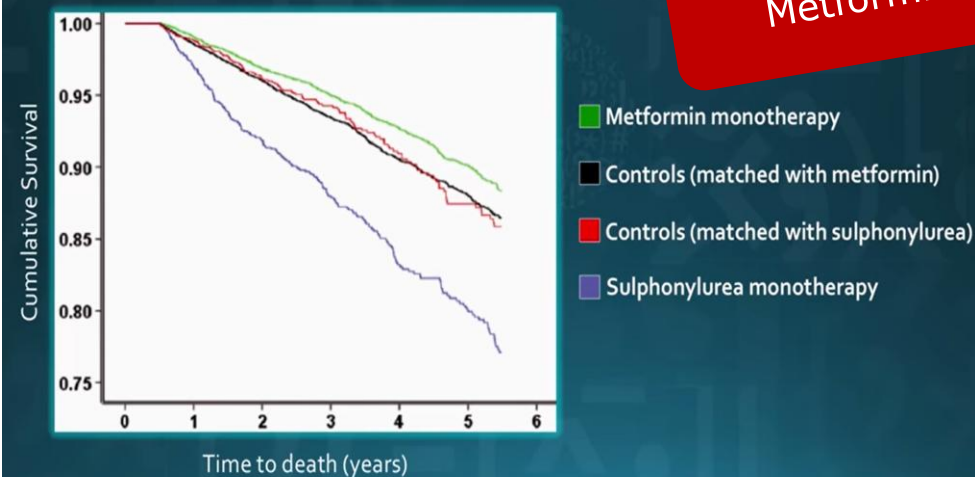
Just a few candidates...
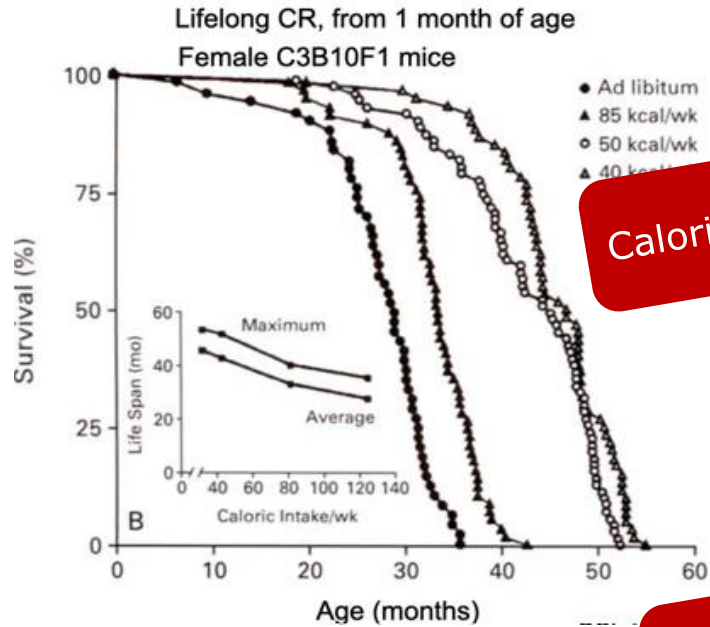
Caloric Restriction
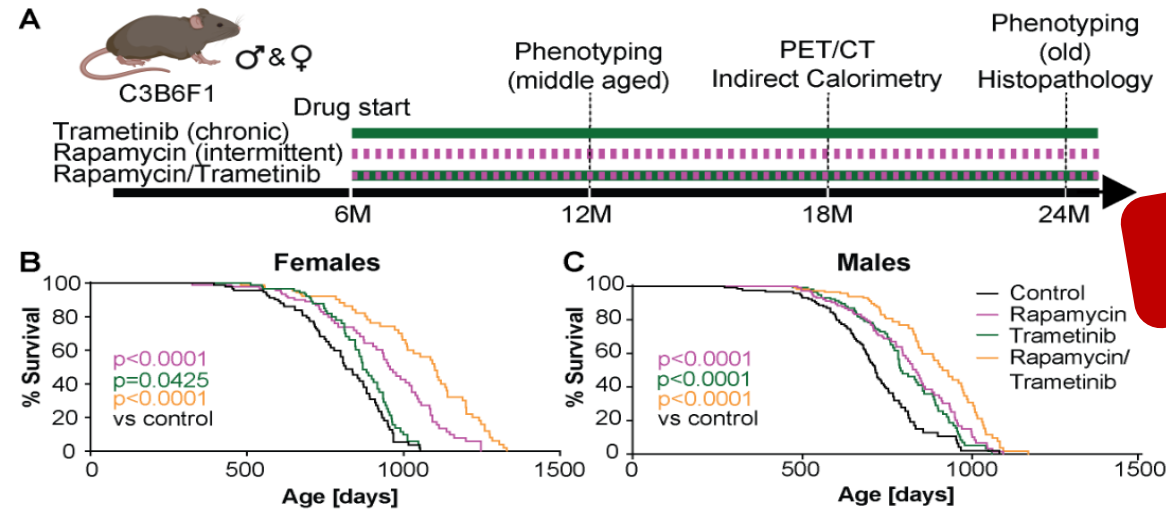
Rapamycin (w/ trametinib)

Metformin

Heterochronic parabiosis

Senolytics

Why is this relevant for the insurance industry?

Some of our research…

… from the time when we did research like typical actuaries ☺
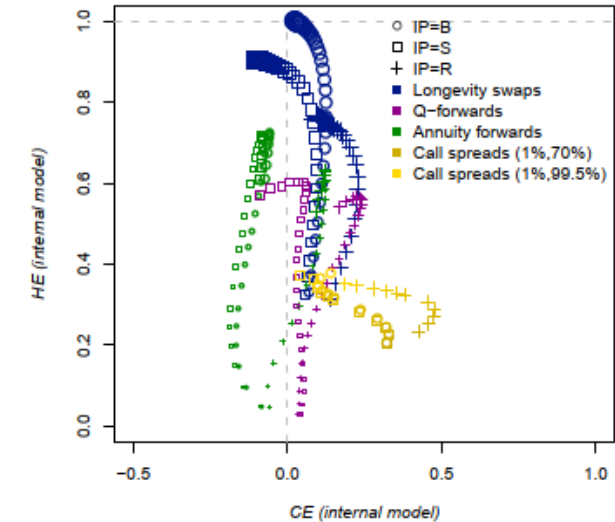

Typical mortality models underestimate long-term uncertainty. „Trend change models" might be better suitable for analyzing long-term risk.
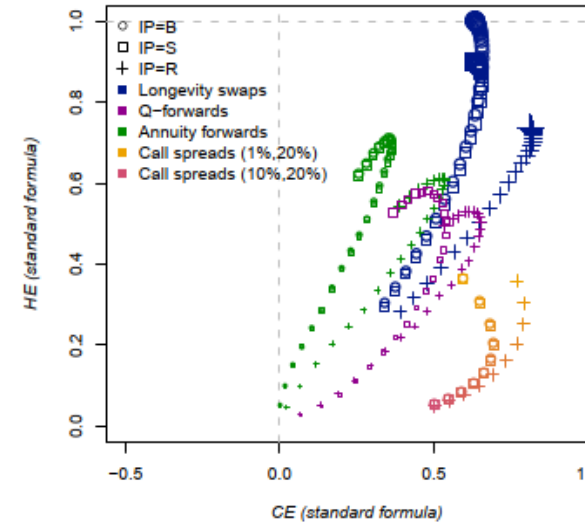
(a) Standard formula

(b) Internal model

Simultaneouls analysis of hecge efectivenes and capital efficiency of different longevity hedges under standard formula and internal model. → Blue print how reinsurers and capital markets should interact efficiently in providing hedging capacity.

... that we did together with leading biogerentologists

**Scanning the horizon: integrating expert knowledge into the calibration of stochastic mortality models**

Richard G. A. Faragher*, Arne Freimann[†] [corresponding author], Jochen Ruß[‡]

This version: 5th of November, 2025

Methuselah Found? Why linear increases in life expectancy do not require ever faster declines in mortality rates

Richard G.A. Faragher*, Arne Freimann[†], Tom Huber[‡],
Linda Partridge[§], Jochen Ruß[**] [corresponding author]

This version: 30th of June, 2025
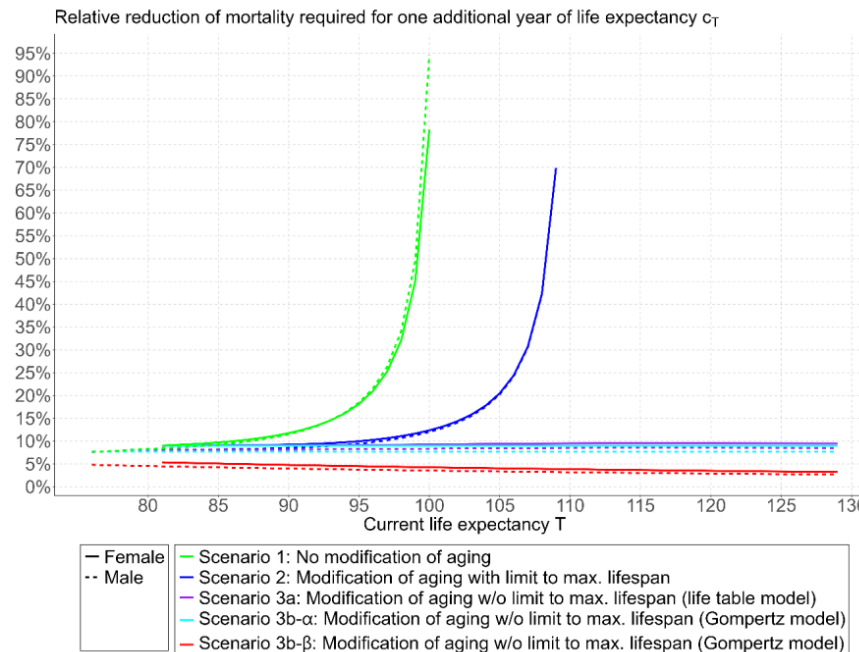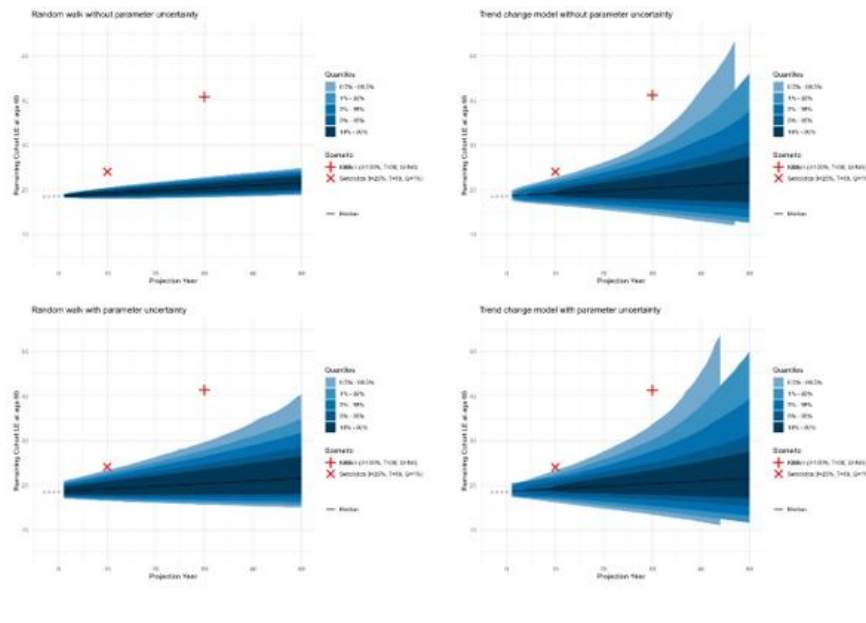
Consequences:

It is possible to use knowledge from other disciplines (here biogerontology) to calibrate stochastic mortality models.

- Here: Events that are considered plausible but unlikely by experts occur at least with some (small) probability in simulations.

If we have a different **type (!)** of medical progress, then the relationship between speed of medical progress and speed of increase in life expectancy will be **structurally** completely different!

A brief conclusion, a thesis and potential alternative approaches to manage systematic longevity risk

Conclusion: With regard to the future development of life expectancy, changes are possible in both directions.

- The aspects that argue for a slowdown in the increase in life expectancy are already present. A dampening seems very likely in the near future (and can already be observed in some countries).
- The slowing of the human ageing process could (in a more distant future) lead to a rather large increase in human life expectancy.
  - No one can seriously predict today if and when "something will happen" and how big the impact will be.
  - However, the sheer number of possible therapies, some of which are already very advanced, suggests that something will happen in the next few decades with a probability that is clearly > 0 (but not 100%!!!).
  - That's uncertainty!
- In particular: This can become relevant before a typical insured person buying a deferred annuity today will have died.

Thesis: The insurance industry must pay more attention to this topic in the future than in the past.

- **Individual view:** Uncertainty of individual life span (which is usually even more uncertain than life expectancy) is much larger than most people think.
  - Managing this uncertainty through lifelong income (buying an annuity) is becoming increasingly important.
- **Collective view:** The so-called systematic longevity risk on insurers' books may be greater than assumed. Typical stochastic models might underestimate this risk.
  - More innovative risk management measures could gain importance (reinsurance, "longevity derivatives", alternative product design (e.g. tontines),...).

Understand risk	Model risk	Measure risk	Manage risk

Degree of interdisciplinarity required

Degree of individuality by company

![european actuarial academy logo - 20 YEARS]

The European knowledge centre for actuaries

Thank you!

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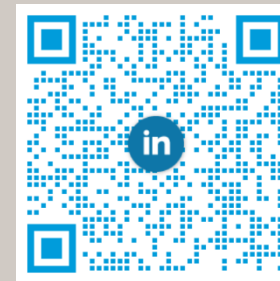
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