

Heriot-Watt University, Edinburgh

Survival models in modern business

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1. About the speaker

1. About the speaker

- Graduated twice from Heriot-Watt: 1990 (BSc) and 2012 (PhD).
- Consultant on longevity risk since 2005.
- Founded longevity-related analytics businesses in 2006:



- Joint venture with Heriot-Watt in 2009:



2. Why care about longevity risk?

2. Why care about longevity risk?

“By providing financial protection against the major 18th- and 19th-century risk of dying too soon, life insurance became the biggest financial industry of that century [...] Providing financial protection against the new risk of not dying soon enough may well become the next century’s major and most profitable financial industry.”

Peter Drucker (1999)

2. Why care about longevity risk?

- Managing longevity risk is a major challenge for the next decades.
- It will play a large role in your career!

3. A spot of time travel

3. 1909

- First UK state pension paid from age 70.
- Probability of a male aged 20 surviving to 70 was 34.8%.
- Life expectancy for a male aged 70 was 8.0 years.

Source: Richards (2013). Period survival probability and period life expectancy calculated according to ELT 6 Construction A in King (1909). No allowance for mortality improvements.

3. 2009

- UK state pension paid from age 67 (for the speaker anyway).
- Probability of a male aged 20 surviving to 67 is 83.6%.
- Life expectancy for a male aged 67 is 16.3 years.

Source: Richards (2013). Period survival probability and period life expectancy calculated according to the Interim Life Table for the UK for 2008–2010. No allowance for mortality improvements.

3. Pop quiz

Q. What would the state pension age have to be to restore the eight-year life expectancy at retirement of the original Old-Age Pension Act of 1908?

3. Pop quiz

Q. What would the state pension age have to be to restore the eight-year life expectancy at retirement of the original Old-Age Pension Act of 1908?

A. 80 years.

Source: Richards (2013). Period survival probability and period life expectancy calculated according to the Interim Life Table for the UK for 2008–2010. No allowance for mortality improvements.

4. Who owns UK plc?

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- Legally, companies are owned by their shareholders.
- However, are shareholders seeing any profits?
- Some FTSE-100 companies appear to be run primarily to fund their pension scheme...

4. Who owns UK plc?

Company	Employer pension contributions (£ millions)	Dividends paid to shareholders (£ millions)
Lloyds Banking Group	667	56
BT	2,179	590
Royal Bank of Scotland	977	301

Source: Figure are for 2012, sourced from LCP's "[Accounting for pensions 2013](#)" report.

4. Who owns UK plc?

- This state of affairs was predicted by Peter Drucker (yes, him again).
- He called it “pension-fund socialism” (Drucker, 1976).
- Even large companies can be dwarfed by their pension schemes...

4. Tail wags dog

Company	Liability (£ billions)	Market cap. (£ billions)	Ratio L/M
International Airlines Group	18.52	3.43	540%
BT	40.99	17.51	234%
BAE Systems	25.16	10.93	230%
Royal Bank of Scotland	30.11	19.52	154%
RSA Insurance	6.43	4.51	143%
Babcock	3.04	2.86	106%

Source: Figure are 2012 pension-scheme liabilities sourced from LCP's "Accounting for pensions 2013" report.

4. Who owns UK plc?

Sometimes the pension scheme even consumes the company:

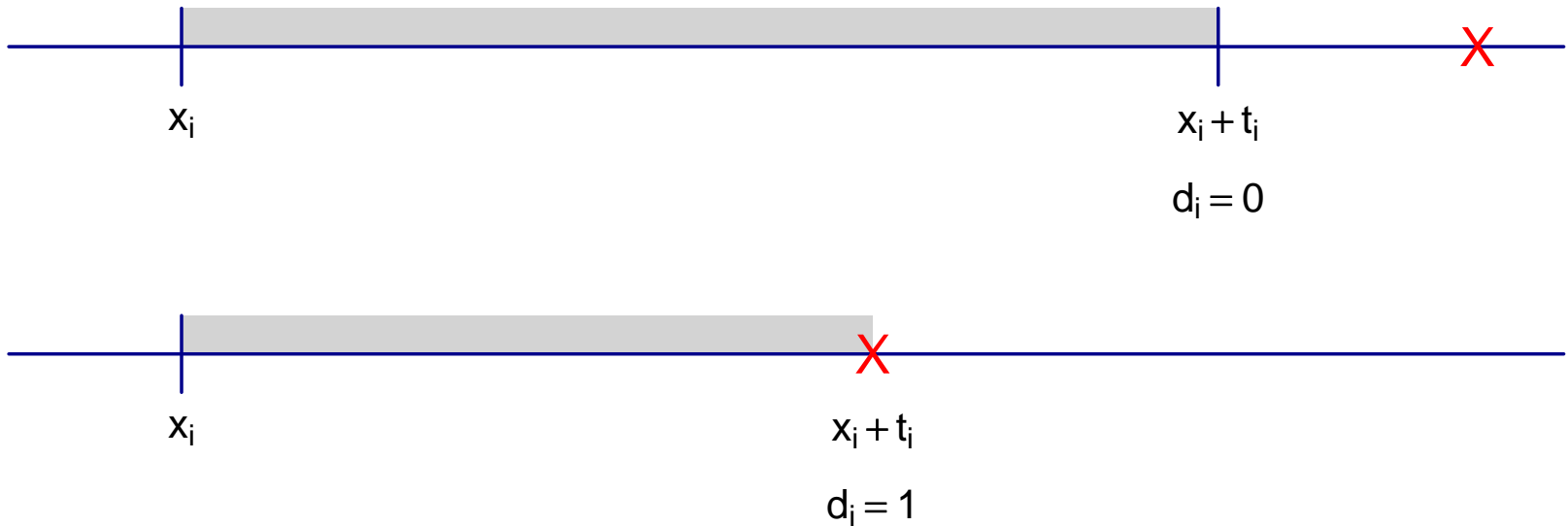
“Under the terms of the restructuring [...] the Uniq Pension Scheme Trustee agreed to release the Company from its pension debt in exchange for a 90.2 per cent. shareholding in the Company and a cash payment to the Pension Scheme.”

Source: Uniq plc (2011). Uniq plc is now part of Greencore.

5. Survival models

5. Survival models

Simple observational structure as longitudinal study:



Time observed, t_i , is shown in grey, while deaths are marked \times .

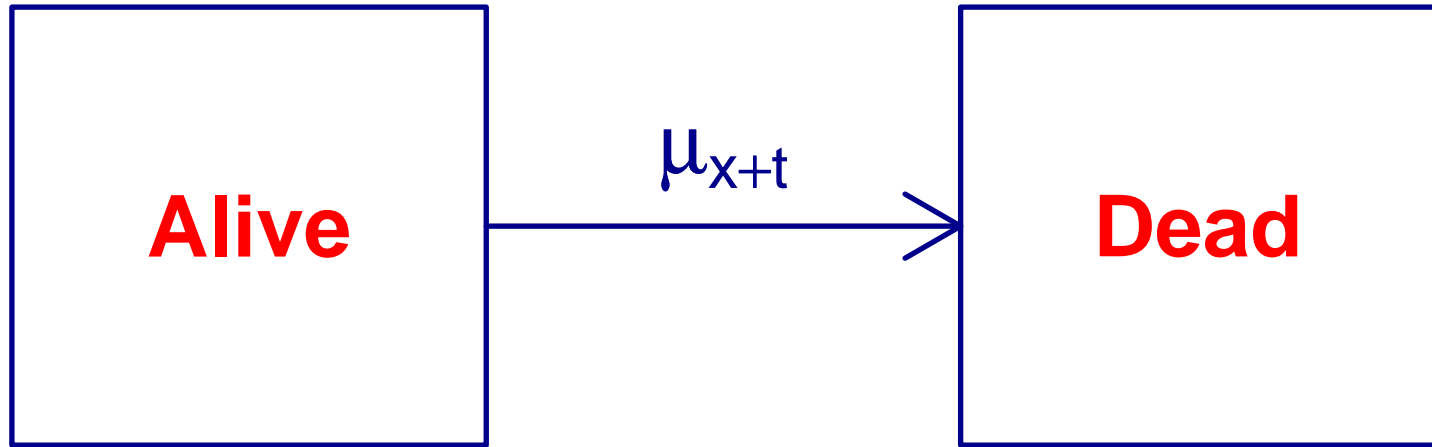
5. Survival models

- Time observed, t_i , is *waiting time* (*central exposed-to-risk* to actuaries).
- d_i is the event indicator.
- t_i and d_i not independent, so considered as a pair $\{t_i, d_i\}$.
- Not all lives are dead, so survival times are *right-censored*.
- Lives enter at age $x_i > 0$, so data is also *left-truncated*.

5. Survival models

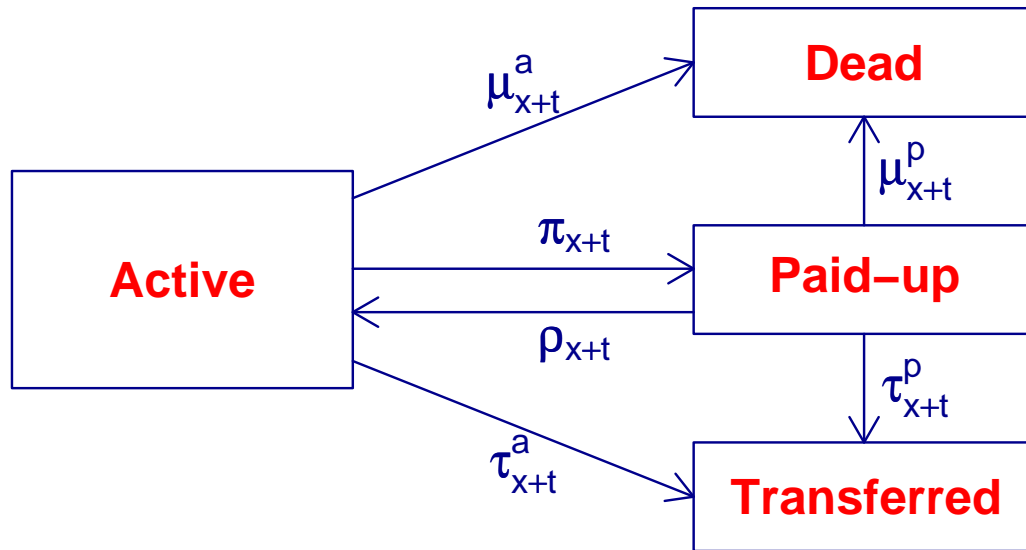
- Survival models are ideal for actuarial work — Richards (2008, 2012).
- A portfolio of risks is like a medical study with continuous recruitment.
- Rapid uptake in survival-modelling techniques in actuarial work.
- Foundation of our main business line!

5. Mortality model for annuities



Source: Longevity Ltd.

5. Persistency model for personal pensions



Source: Longevity Ltd.

6. Actuarial exceptionalism — data

6. Actuarial exceptionalism — data

- Actuaries have specific modelling requirements...
- ...which are not always shared with other users of survival models.
- Two main differences lie with data preparation and model structure.

6. Data preparation for non-actuaries

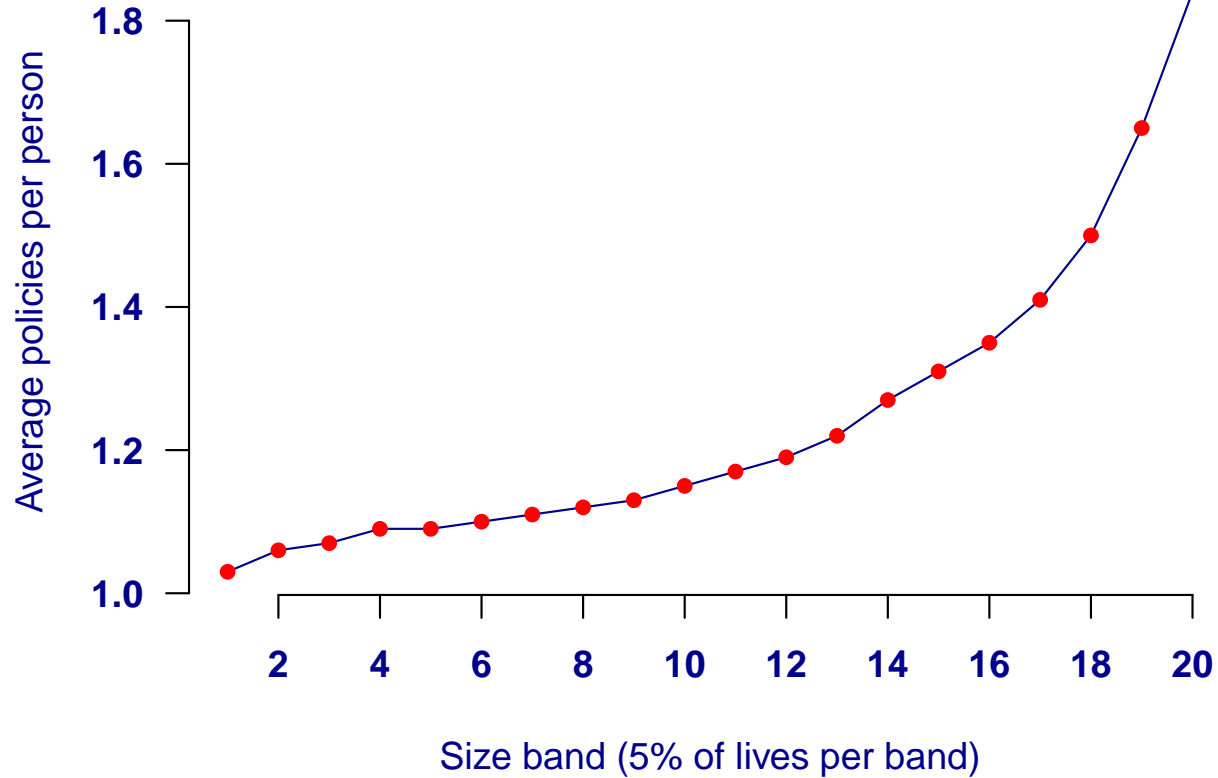
- Data is usually collected on lives.
- Can often model straight after validation.

6. Data preparation for actuaries

- Data is *policy-oriented*.
- People have multiple policies.
- Need to ensure independence assumption.
- Need to find n independent lives behind p dependent policies ($p \geq n$).
- Process of *deduplication*.

More details on deduplication can be found at www.longevity.co.uk.

6. Wealth and duplicates



Source: Richards and Currie (2009).

6. Deduplication challenges

Problem: client identifier not always reliable or unique.

Solution: use combination key made up from reliable fields, e.g.

- Date of birth
- Gender
- Surname
- First initial
- Postcode

6. What's in a name?

Problem: teleserviced data contains mis-spellings of same surname, e.g.

- Ritchie
- Richie
- Richey

Solution: use metaphone encoding of names.

6. What's in a name?

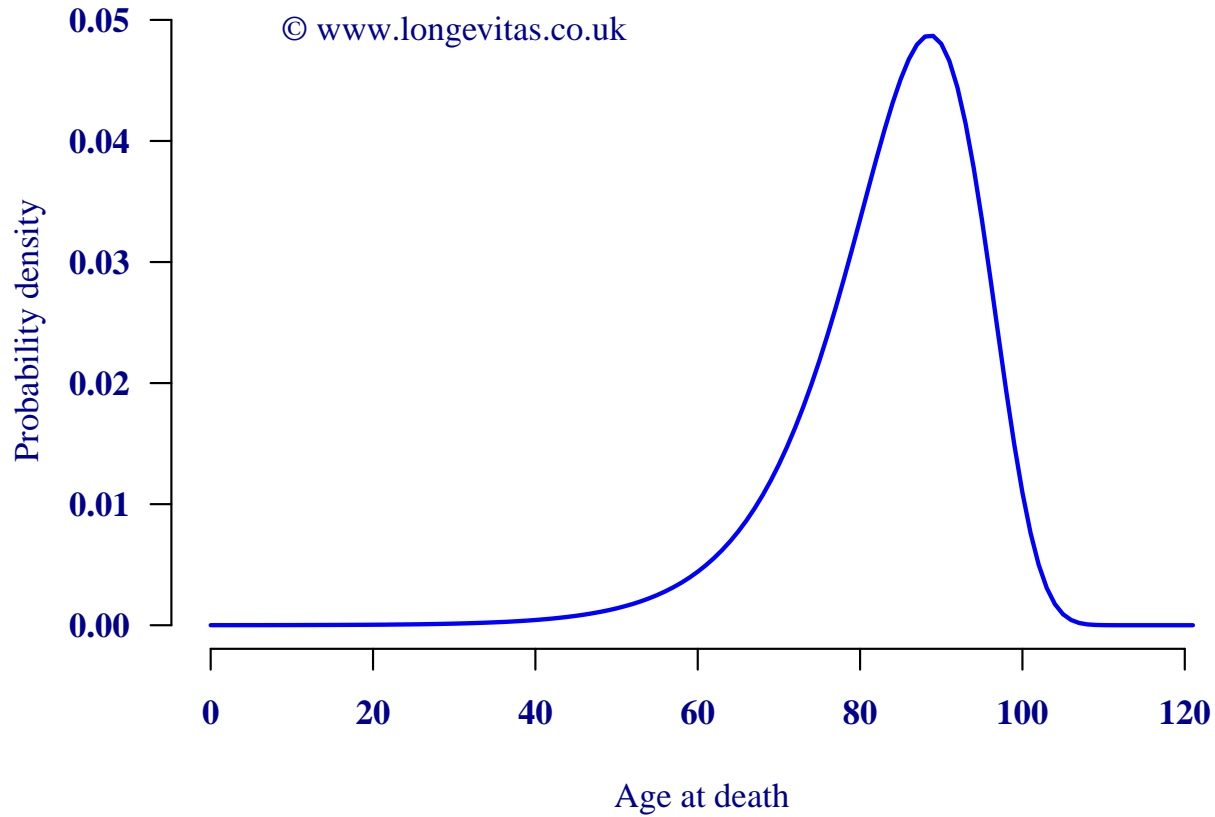
Problem: metaphone structured for Anglo-Saxon names. What about:

- Muhammed
- Muhammad
- Mohammed?

Solution: use double metaphone encoding of Philips (1990).

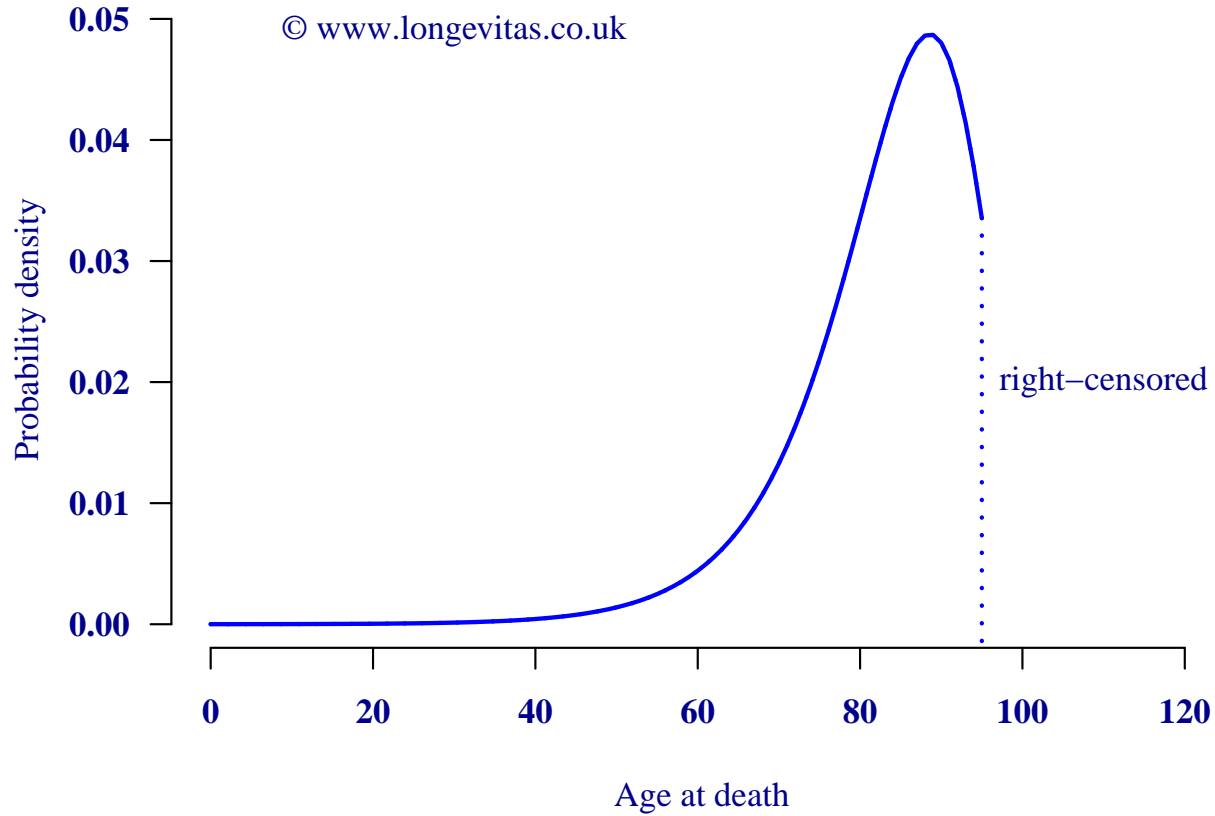
7. Actuarial exceptionalism — models

7. Lifetime distribution



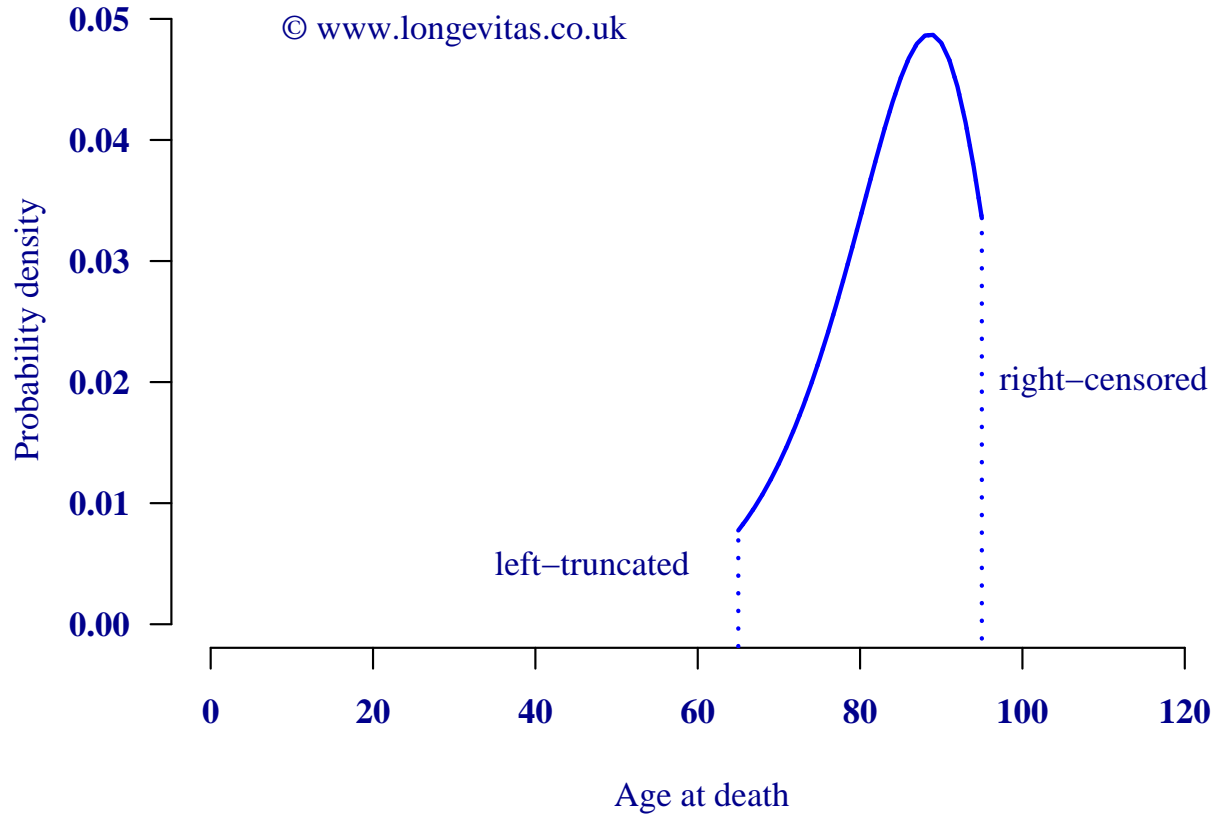
Source: Longevity Ltd.

7. Lifetime distribution



Source: Longevity Ltd.

7. Lifetime distribution



Source: Longevity Ltd.

7. Model structure for non-actuaries

- Survival models in medical trials usually deal with observation times.
- Left-truncation is a relatively uncommon problem for non-actuaries.
- Standard software has few options for left-truncated data.

7. Model structure for actuaries

- In contrast, policyholders enter well into their adult life.
- Actuarial data is therefore almost always left-truncated.
- Often need purpose-built software for this.

8. Conclusions

8. Conclusions

- Survival models are a natural fit to life-office or pension-scheme data.
- Portfolios are like medical trials with continuous recruitment.
- Actuarial data has specific requirements not common elsewhere.
- Bespoke software is typically needed for actuarial work.



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