Scottish Independent Actuaries, Edinburgh

Seasonal mortality

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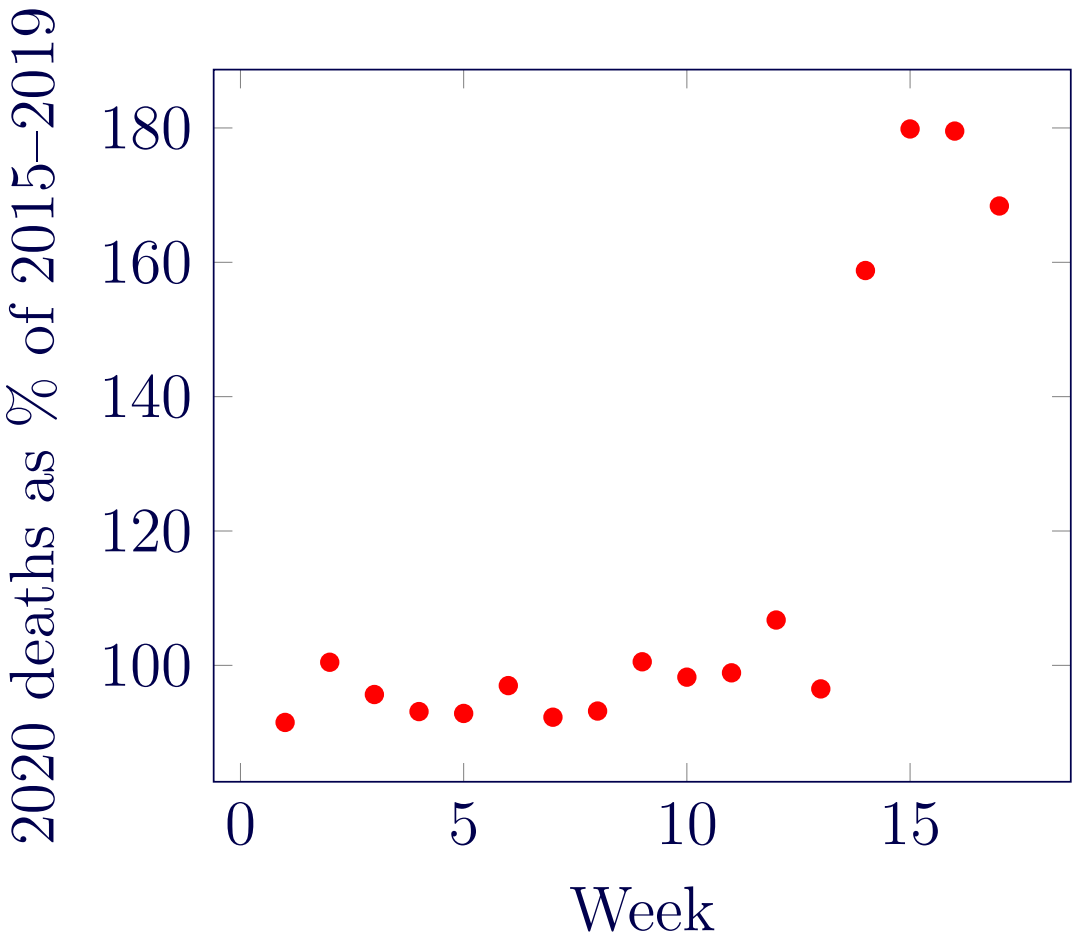
Overview

LONGEVITAS

1. COVID-19
2. Seasonal mortality
3. Modelling seasonal mortality
4. Seasonality and age
5. Shape of seasonal patterns
6. Seasonality by subgroup
7. Conclusions
8. About Longevitas

1 COVID-19

Deaths in Scotland in 2020 as percentage of average in 2015–2019.

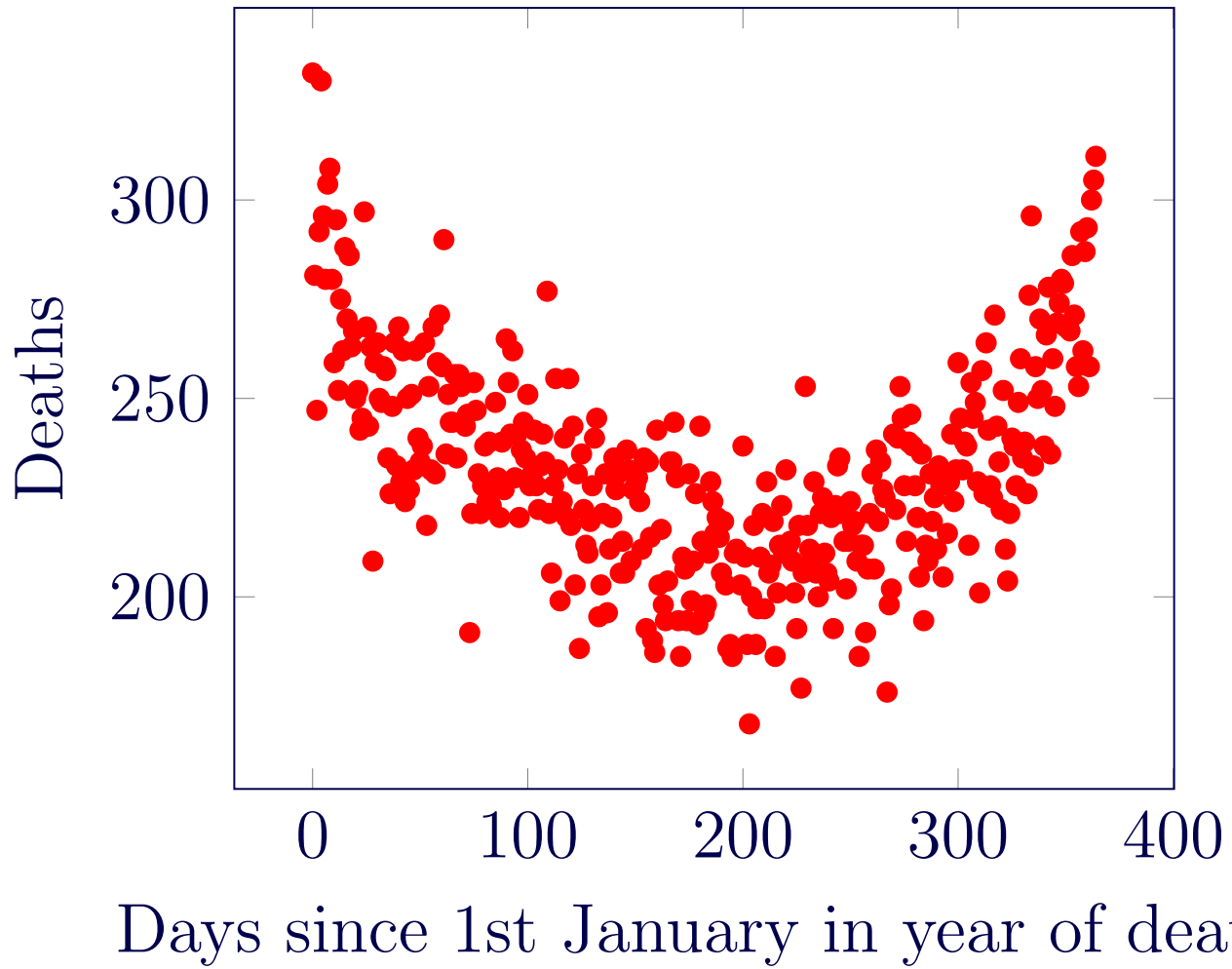


Source: Own calculations using data from General Registrar; accessed 29th April 2020.

2 Seasonal mortality

2 Mortality peaks in winter

Seasonality of date of death in six UK pension schemes.



Source: Richards et al. [2020]. The vertical scale excludes an outlier caused by leap years.

2 Mortality peaks in winter

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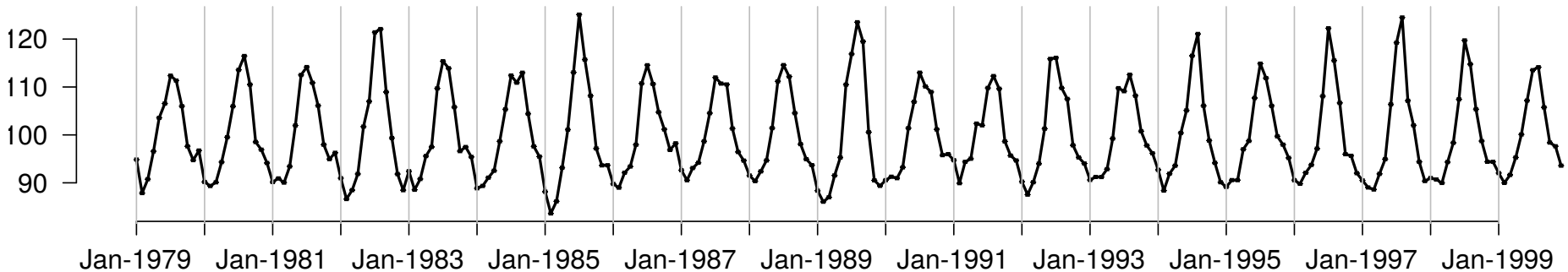
- ONS defines winter as December-March in UK.
- Winter is different in southern hemisphere...

2 Seasonal mortality in Oz

Percentage of average daily number of deaths in Australia, all causes, 1979–1999.



Source: de Looper [2002].

2 Season and cause of death

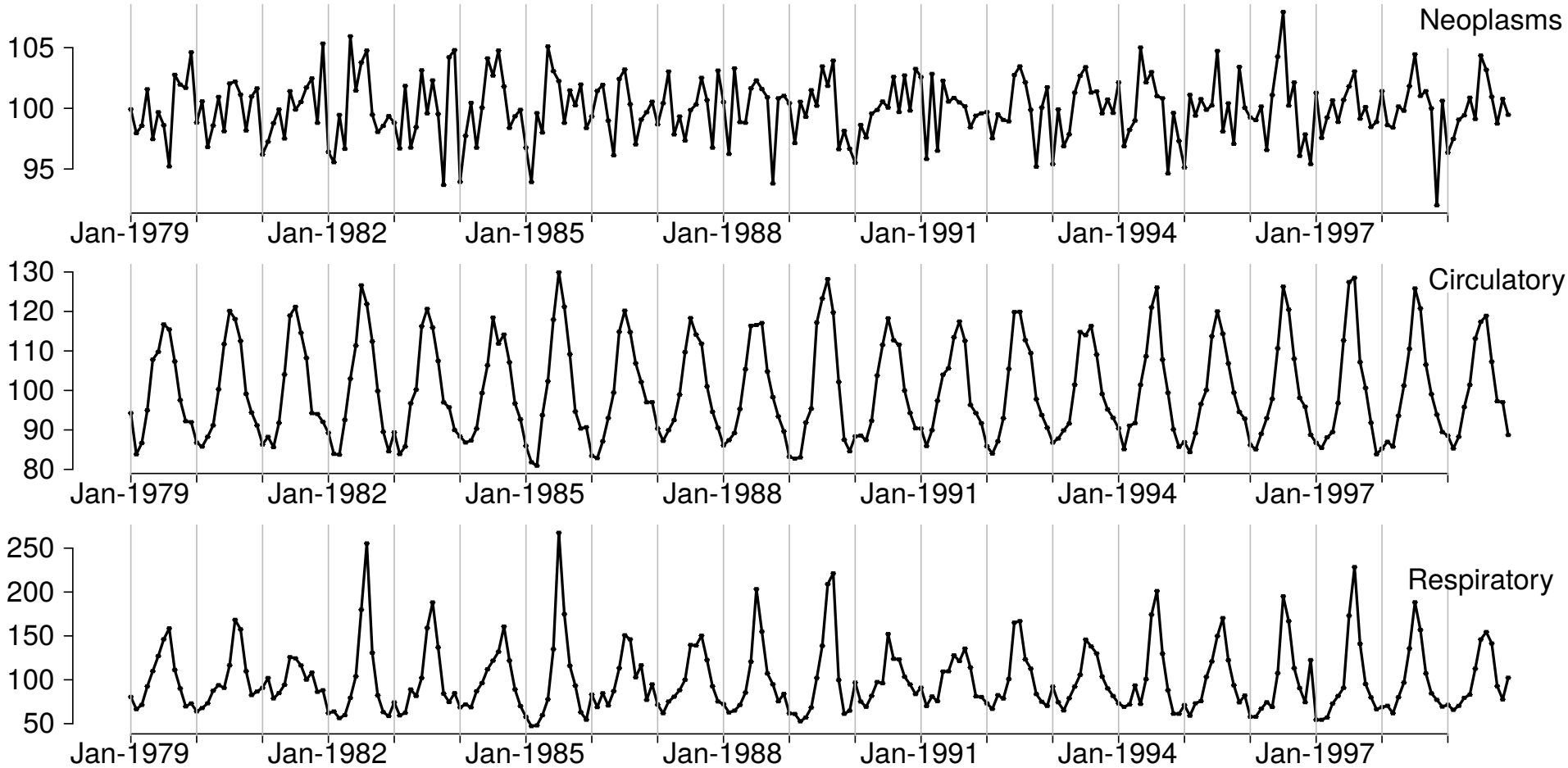
LONGEVITAS

- Seasonal mortality is a reliably recurring phenomenon.
- Previous slides show all-cause mortality.
- Picture is more interesting by cause of death...

2 Season and cause of death

LONGEVITAS

Percentage of average daily number of deaths for selected causes in Australia, 1979–1999.



Source: de Looper [2002].

2 Season and cause of death

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- Cancer has no strong seasonal pattern.
- Circulatory and respiratory causes have clear winter spikes.

3 Modelling seasonal mortality

3 Modelling seasonal mortality

- Past research done using grouped data.
- Using individual records is more powerful [Macdonald et al., 2018].
- What can be done with pension schemes and annuity portfolios?

3 Modelling seasonal mortality

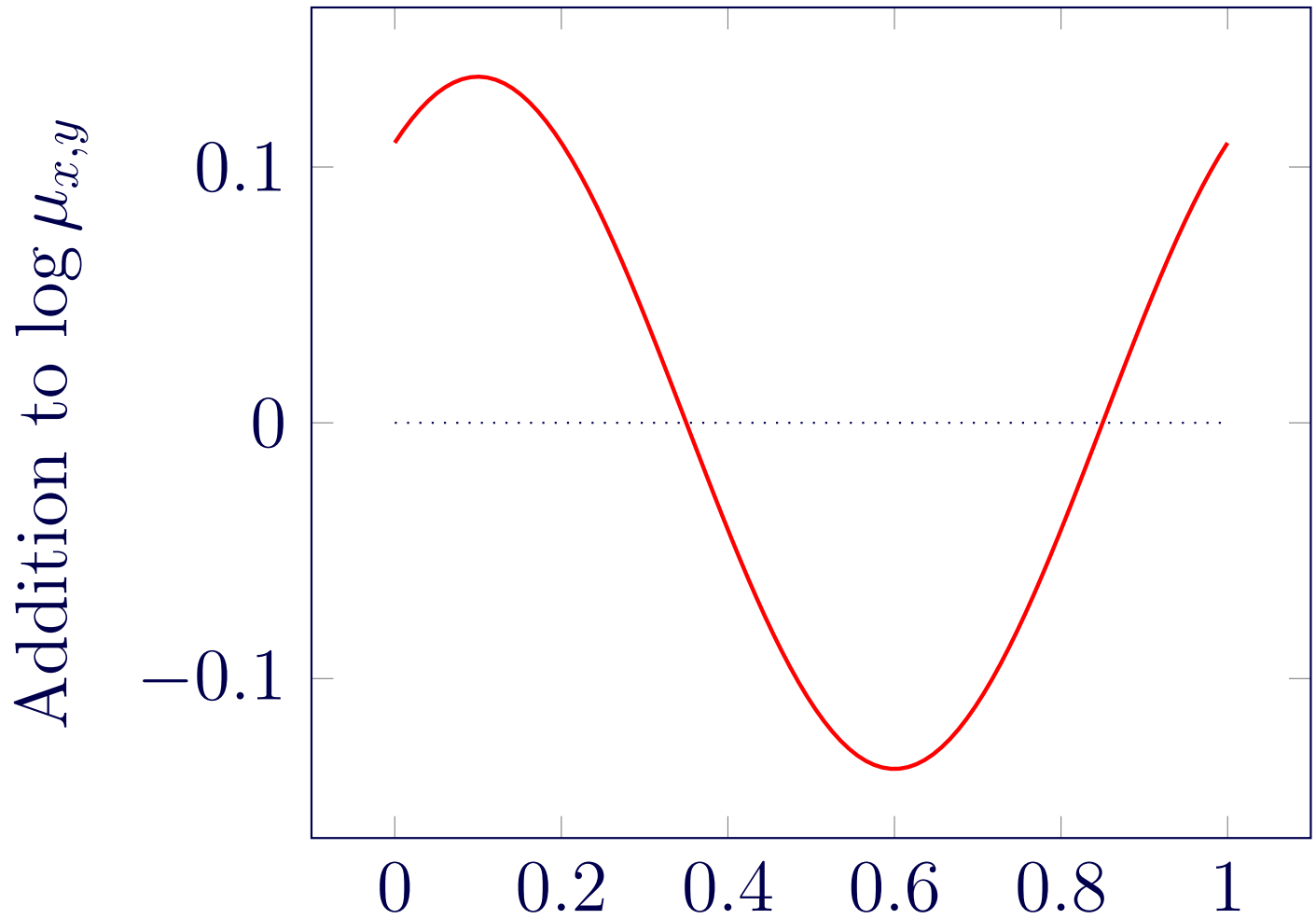
$$\log \mu^*_{x,y} = \log \mu_{x,y} + e^{\zeta} \cos\left(2\pi(y - \tau)\right) \tag{1}$$

- $\mu_{x,y}$ is force of mortality at age x at time y.
- τ is fraction of year after 1st January when mortality peaks.
- e^{ζ} is the amplitude of the mortality peak (log scale).

Source: Richards et al. [2020].

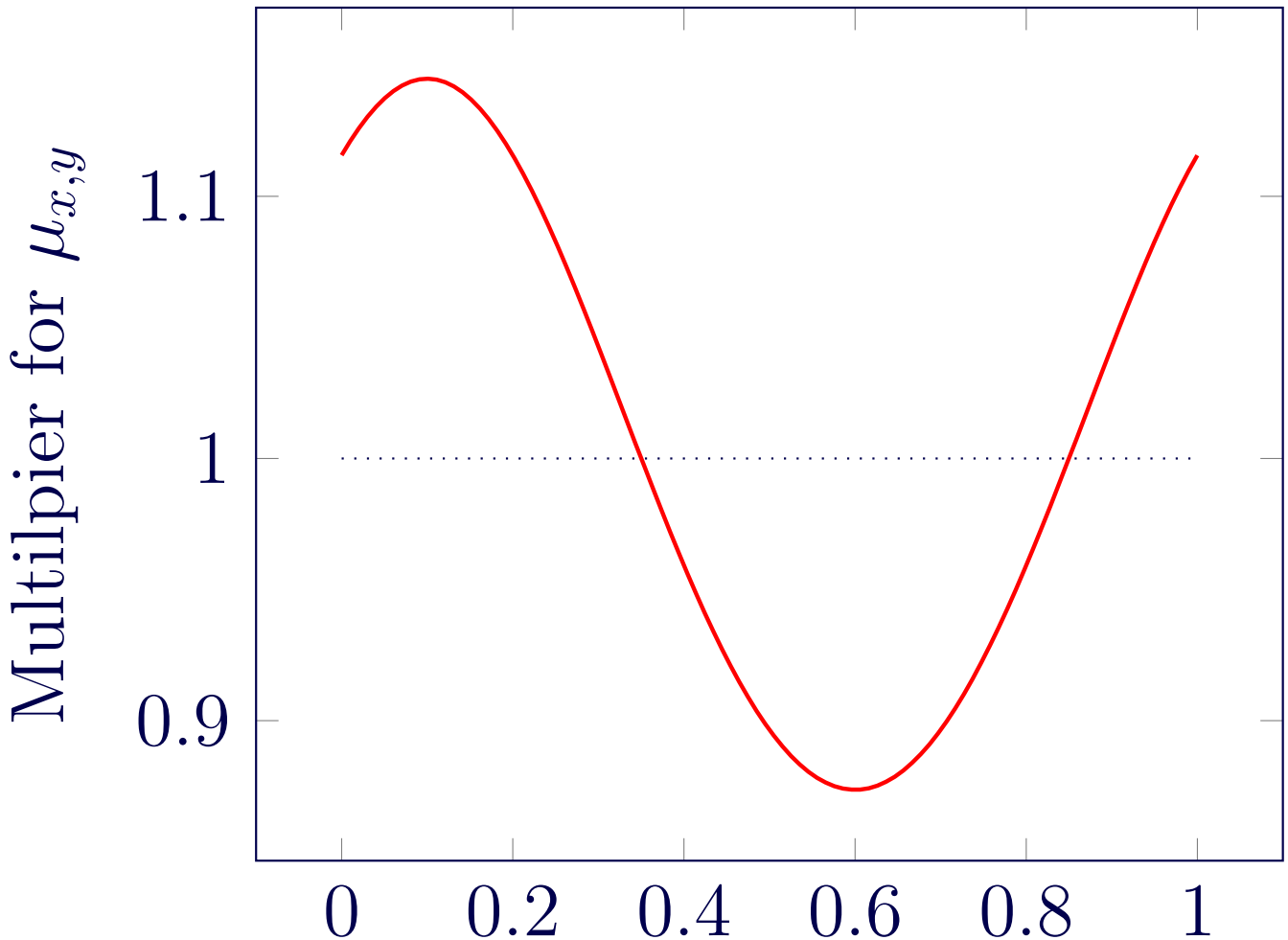
3 Cosine seasonal effect

Example addition to $\log \mu_{x,y}$ with $\tau = 0.1$ and $\zeta = -2$



3 Cosine seasonal effect

Example multiplier for $\mu_{x,y}$ with $\tau = 0.1$ and $\zeta = -2$



3 Peaks around the world

LONGEVITAS

Portfolio	Seasonal Excess $\hat{\zeta}$	Seasonal Peak $\hat{\tau}$	Peak mortality: (i) as % of mean	(ii) time of year
Canada	-2.34	0.0749	110%	27th Jan
England	-2.02	0.0708	114%	26th Jan
France	-2.42	0.0660	109%	25th Jan
Kuwait	-2.36	0.0178	110%	7th Jan
Netherlands	-2.25	0.0524	111%	20th Jan
Scotland	-1.88	0.0815	117%	30th Jan
Spain	-2.89	0.1494	106%	24th Feb
USA	-2.52	0.1420	108%	21st Feb

Source: Richards et al. [2020].

3 Seasonal mortality

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- Consistent pattern across northern hemisphere.
- Peak mortality in late January/early February.
- Scottish portfolio has highest winter peak.

3 Seasonal mortality

- Picture different in southern hemisphere.
- Peak mortality in July...

3 Peaks around the world

Portfolio	Seasonal Excess $\hat{\zeta}$	Seasonal Peak $\hat{\tau}$	Peak mortality: (i) as % of mean	Peak mortality: (ii) time of year
Chile	-2.25	0.5560	111%	22nd July

Source: Richards et al. [2020].

4 Seasonality and age

4 Seasonal mortality by age

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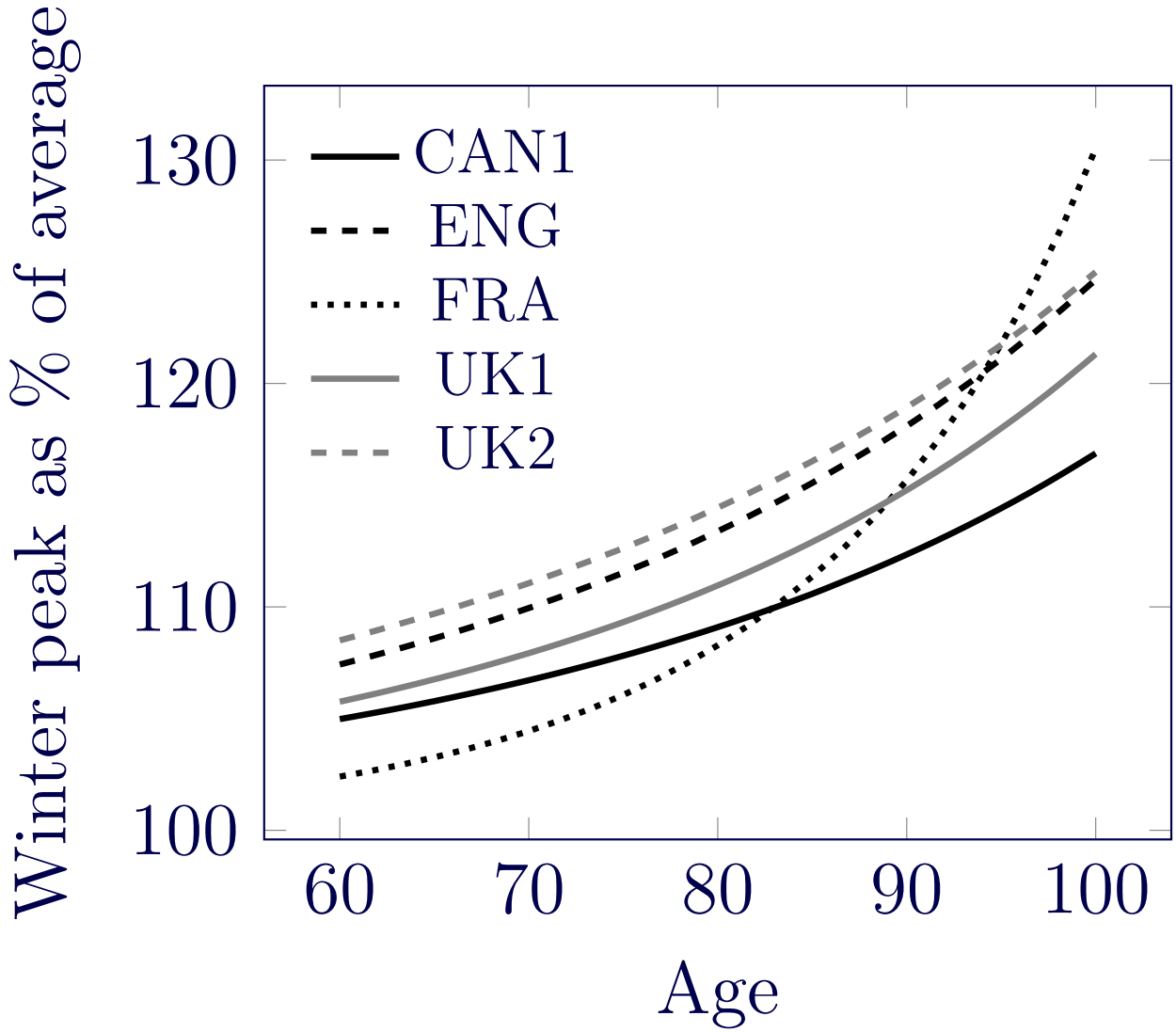
$$\log \mu^*_{x,y} = \log \mu_{x,y} + e^{\zeta + \xi(x-o)/10} \cos\left(2\pi(y-\tau)\right) \qquad (2)$$

- ξ measures increasing amplitude with age.
- o is a normalizing constant ($o = 70$ here).

Source: Richards et al. [2020].

4 Peak mortality by age



Source: Richards et al. [2020].

4 Seasonal mortality by age

For large pensioner and annuity portfolios we can measure the increasing seasonal variation by age.

5 Shape of seasonal patterns

5 Modelling the peak shape

LONGEVITAS

- Cosine function has same curvature for winter and summer.
- However, the winter peak is sharper than the summer trough.
- Replace $\cos t$ with $s(\psi, t)$:
- Choose $s(\psi, t)$ so that $s(0, t) \approx \cos t$.

5 Modelling the peak shape

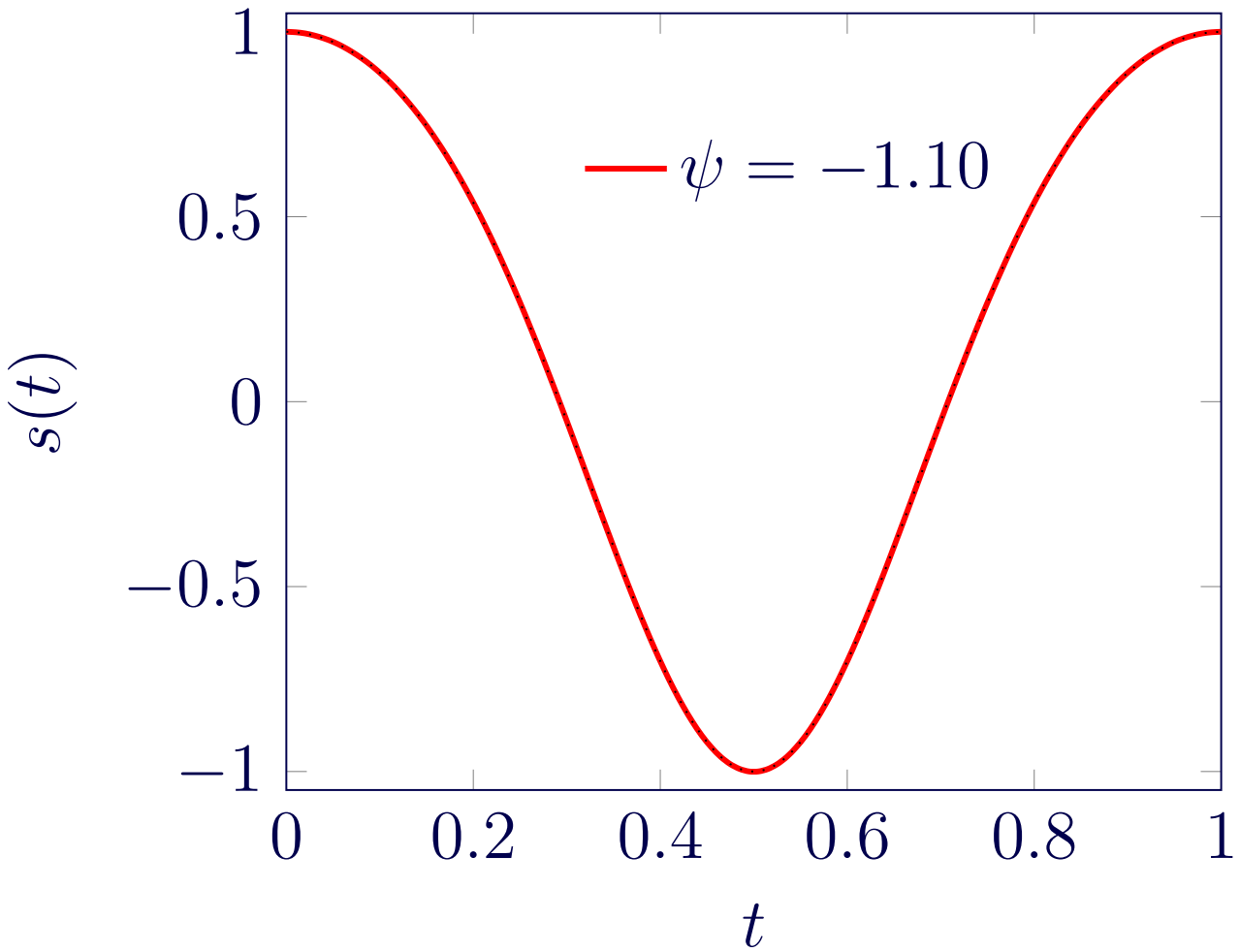
LONGEVITAS

$$\log \mu^*_{x,y} = \log \mu_{x,y} + e^{\zeta} s(\psi, y - \tau) \tag{3}$$

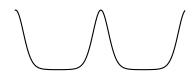
$$s(\psi, t) = \begin{cases} \psi \neq 0 & : 2 \left[\dfrac{e^{\frac{\psi}{2}(1+\cos t)} - 1}{e^{\psi} - 1} \right] - 1 \\ \psi = 0 & : \cos t \end{cases} \tag{4}$$

Source: Richards et al. [2020].

5 Modelling the peak shape



5 Modelling the peak shape

Portfolio	Seasonal Excess $\hat{\zeta}$	Seasonal Peak $\hat{\tau}$	Seasonal Shape: $\hat{\psi}$	
CAN1	-2.31	0.0719	2.11	
CHL	-2.23	0.5464	1.93	
ENG	-2.00	0.0573	2.41	
FRA	-2.38	0.0662	2.28	
KUW	-2.16	0.0105	6.02	
UK1	-2.26	0.0638	2.37	

Source: Richards et al. [2020].

5 Modelling the peak shape

LONGEVITAS

- All portfolios have $\hat{\psi}$ significantly different from zero.

  $\rightarrow$ Can use pension-scheme data to quantify sharpness of winter peak in single statistic.

6 Seasonality by subgroup

6 Sub-groups

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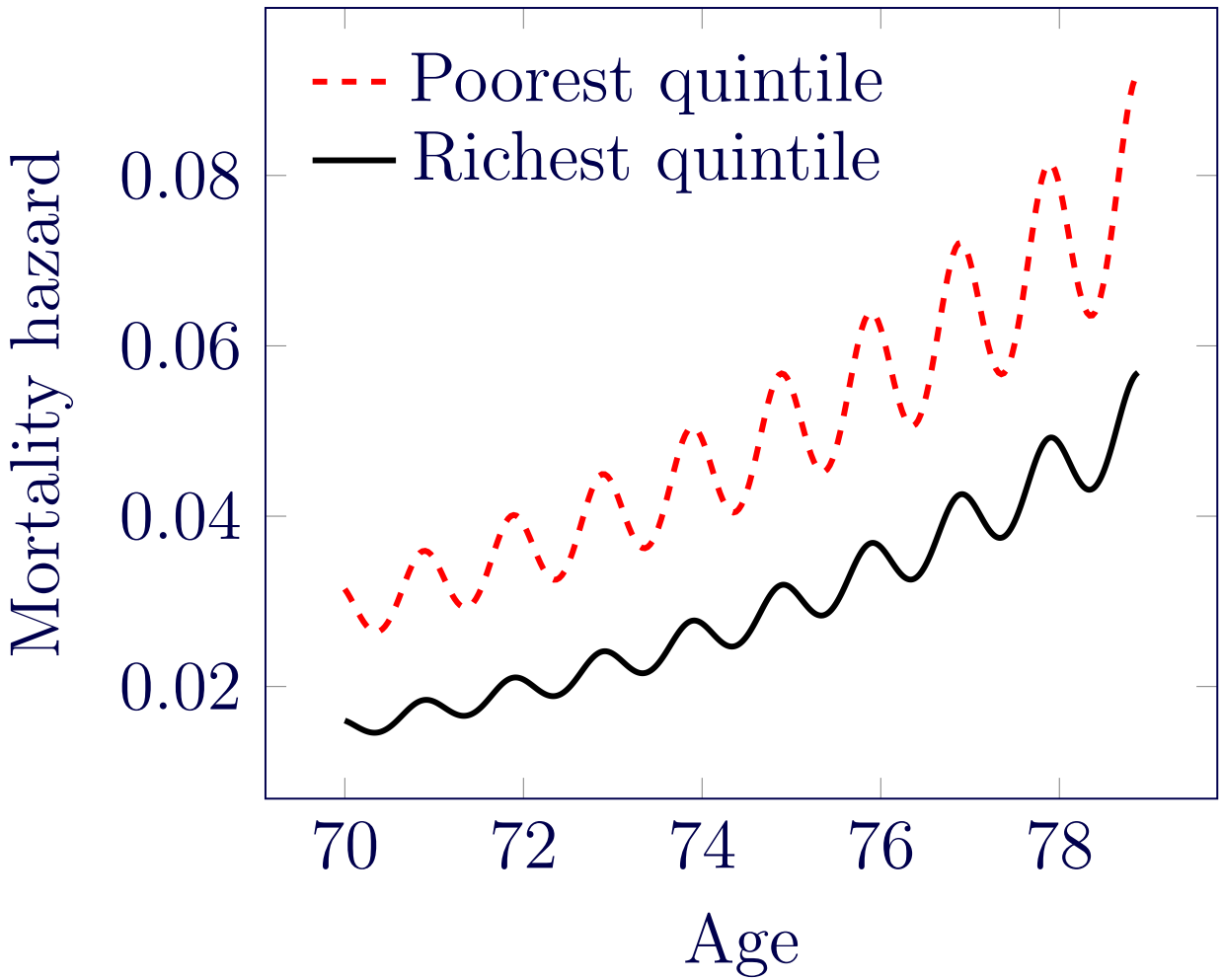
- No signficant difference between males and females.
- However, low-income UK pensioners experience greater seasonal swings...

6 Rich v. poor



Source: Richards et al. [2020].

7 Conclusions

7 Conclusions — I

LONGEVITAS

- Mortality increases in winter.
- Phenomenon recurs reliably from year to year. . .

  . . .and is present in every country.
- Winter spike caused by circulatory and respiratory deaths.

7 Conclusions — II

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- Survival models can detect seasonality in pension schemes...

  ... and the sharpness of the winter peak...

  ... and the increasing seasonality with age.
- No obvious link to gender...

  ...but low-income pensioners more vulnerable.

References I

M. de Looper. *Seasonality of death*, volume Bulletin No. 3. Australian Institute of Health and Welfare, 2002. ISBN 978–1–74024–209–7.

A. S. Macdonald, S. J. Richards, and I. D. Currie. *Modelling Mortality with Actuarial Applications*. Cambridge University Press, 2018. ISBN 978-1-107-04541-5.

S. J. Richards, S. J. Ramonat, G. Vesper, and T. Kleinow. Modelling seasonal mortality with individual data. *Longevitas Ltd*, 2020.

More on longevity risk at ▸ www.longevitas.co.uk

8 Legal matters

Longevitas is a registered trademark for Longevitas Ltd:

- in the UK (registration number 2434941),
- throughout the European Union (registration number 5854518), and
- in the USA (Trade Mark Registration No. 3707314).

9 About Longevitas

9 Longevitas

- Founded 2006.
- Based in Edinburgh, Scotland.
- Provides tools to analyse, price and manage longevity risk.
- Research partnership with Heriot-Watt University.

9 Longevitas software

- Used in UK, USA, Canada and Switzerland.
- Used by insurers, reinsurers and consultancies.