Webinar for Longevitas clients

Mortality shocks in annuity portfolios

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Overview

1. Covid-19
2. Annuity portfolios
3. Non-parametric approach
4. Reporting delays
5. Parametric approach
6. Conclusions

1 Covid-19

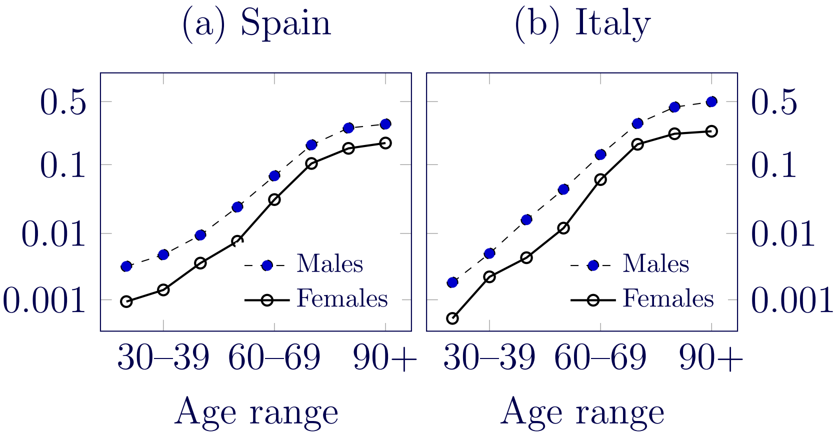
1 Covid-19

- Covid-19 is the disease caused by the novel SARS-CoV-2 virus[†].
- Covid-19 can be fatal…

[†]The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team [2020].

1 Covid-19

Mortality rate by age for confirmed covid-19 infection‡. Logit scale.



‡Own calculations using data from CCAES [2020] and ISS [2020].

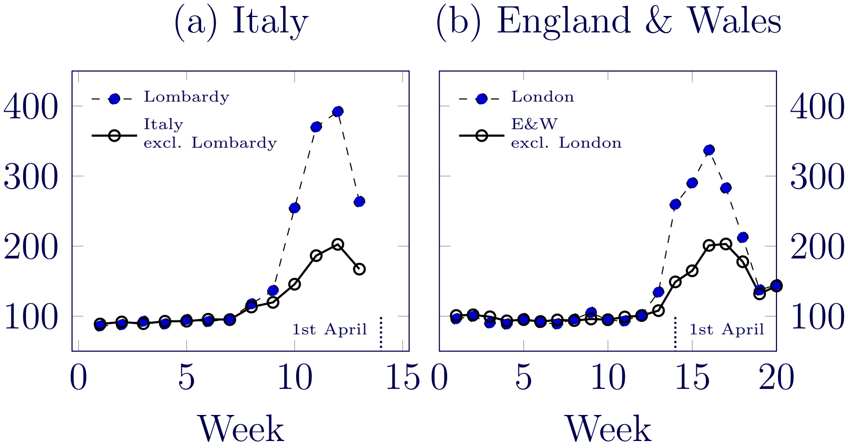
1 Covid-19

- Covid-19 is the disease caused by the novel SARS-CoV-2 virus†.
- Covid-19 can be fatal...

  ...and its arrival was obvious in national mortality statistics...

†The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team [2020].

Deaths in early 2020 as percentage of average in 2015–2019♣.



♣ Source: own calculations using data from Istat [2020] and ONS [2020].

1 Covid-19

Covid-19 mortality shock was:

- Intense.
- Short-term (measured in weeks).
- Very localised.

How might it impact annuity portfolios?

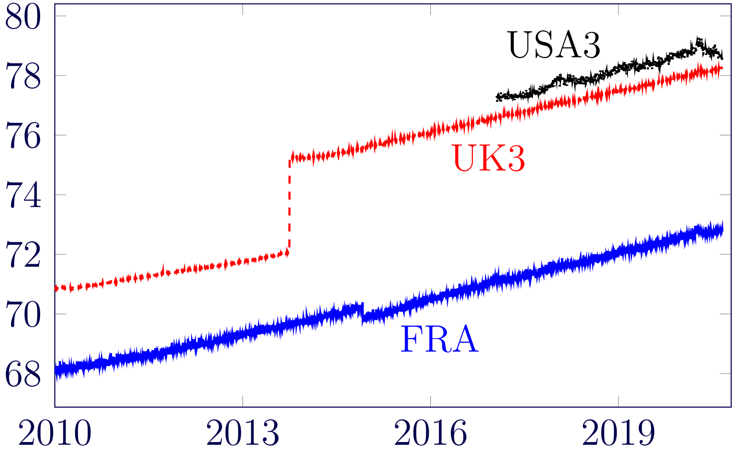
2 Annuity portfolios

2 Annuitant experience data

Portfolio	Cumulative deaths	In-force 1st April 2020
FRA	47,026	251,330
UK3	109,878	146,269
USA3	145,153	723,762

Data extracted in September 2020. Source: Richards [2021].

Average age of in-force annuitants.



Source: Richards [2021].

3 Non-parametric approach

3 Definitions

- μ_x is the mortality hazard at age x.
- $\Lambda_x(t) = \int_0^t \mu_{x+s} ds$ is the integrated hazard.
- Normally the above are defined with respect to age, x.
- What if we define things with respect to time, y?

3 Definitions

- $\{y + t_i\}$ is the set of distinct dates of death,
- d_{y+t_i} is the number of deaths at date $y + t_i$, and
- $l_{y+t_i^-}$ is the number of lives immediately before $y + t_i$.

3 Nelson-Aalen estimator

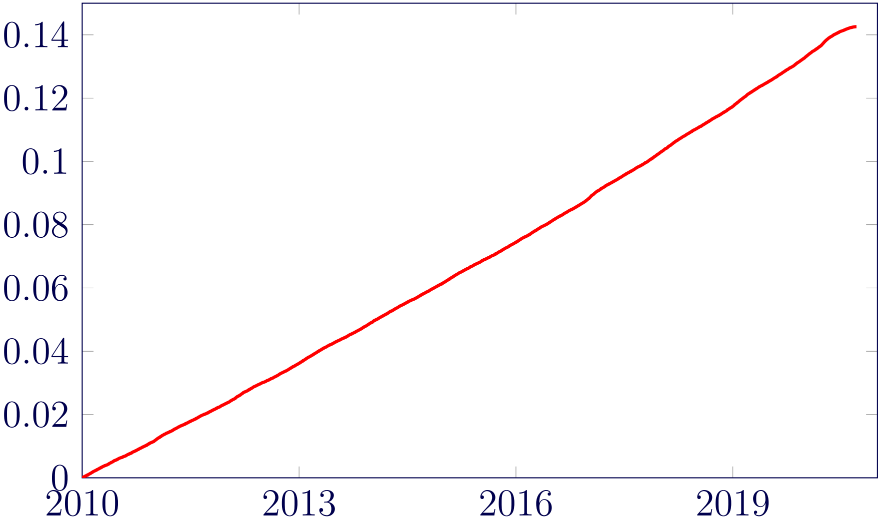
$$\hat{\Lambda}_{y,t} = \sum_{t_i \leq t} \frac{d_{y+t_i}}{l_{y+t_i^-}} \quad (1)$$

$\hat{\Lambda}_{y,t}$ estimates the integrated hazard.

See

https://www.longevitas.co.uk/site/informationmatrix/visualisingcovid19inexperiencedata.html.

3 FRA portfolio, $\hat{\Lambda}_{2010,t}$



3 Non-parametric estimator

- $\hat{\Lambda}_y$ is near-linear (and rather dull).
- What about taking first differences?

3 Non-parametric estimator

First central difference around $\hat{\Lambda}_{y,t}$:

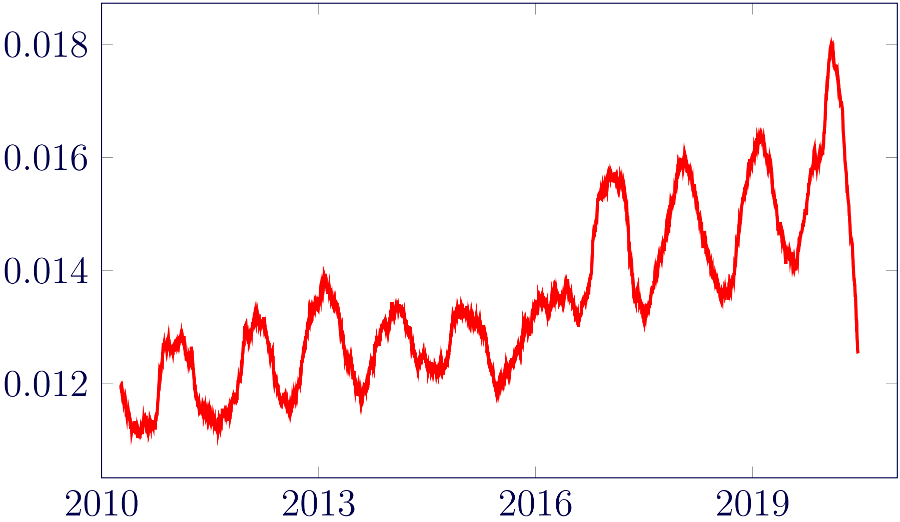
$$\hat{\mu}_{y+t} = \frac{\hat{\Lambda}_{y,t+c/2} - \hat{\Lambda}_{y,t-c/2}}{c} \tag{2}$$

where $c > 0$ is the bandwidth parameter.

See

https://www.longevitas.co.uk/site/informationmatrix/visualisingcovid19inexperiencedata.html.

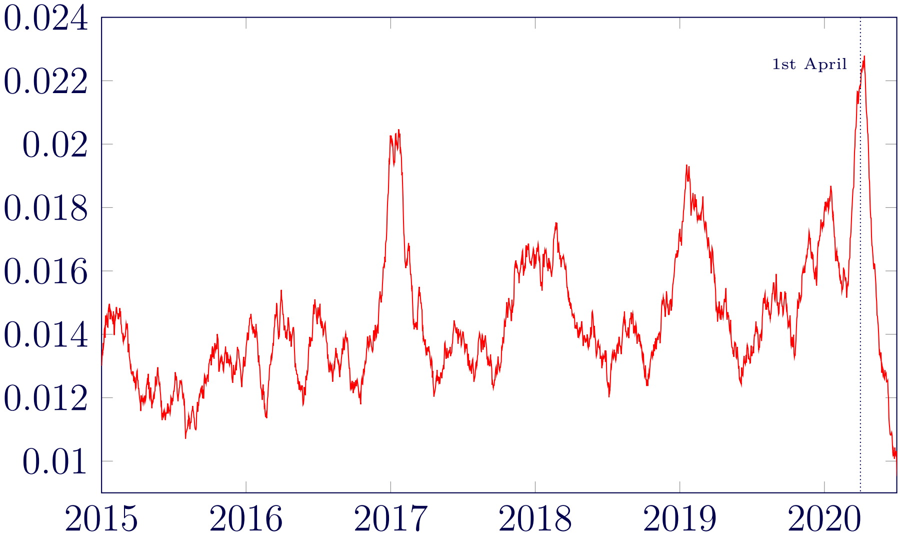
3 FRA, $\hat{\mu}_{2010,t}$, $c = 0.5$



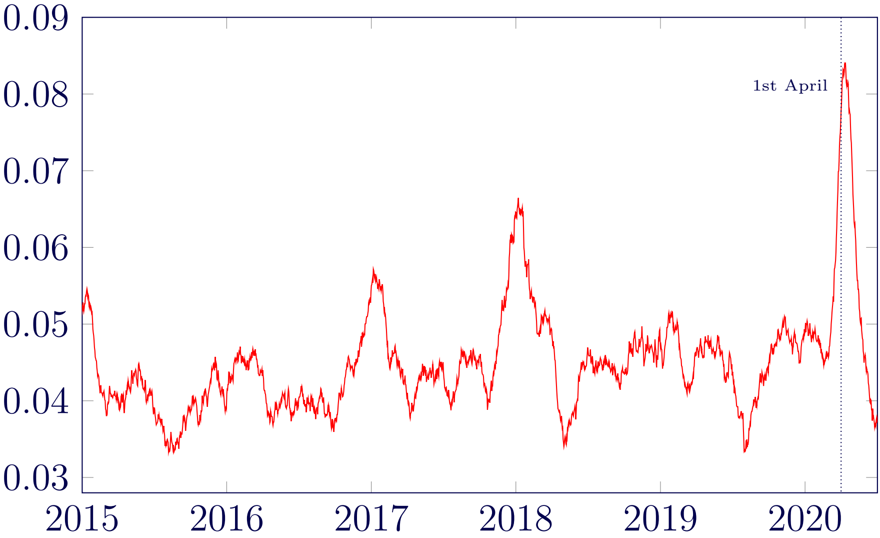
3 Non-parametric estimator

- $\hat{\Lambda}_y$ is near-linear (and rather dull).
- However, $\hat{\mu}_y$ reveals rich detail of seasonal patterns.
- Can $\hat{\mu}_y$ reveal the covid-19 shock?

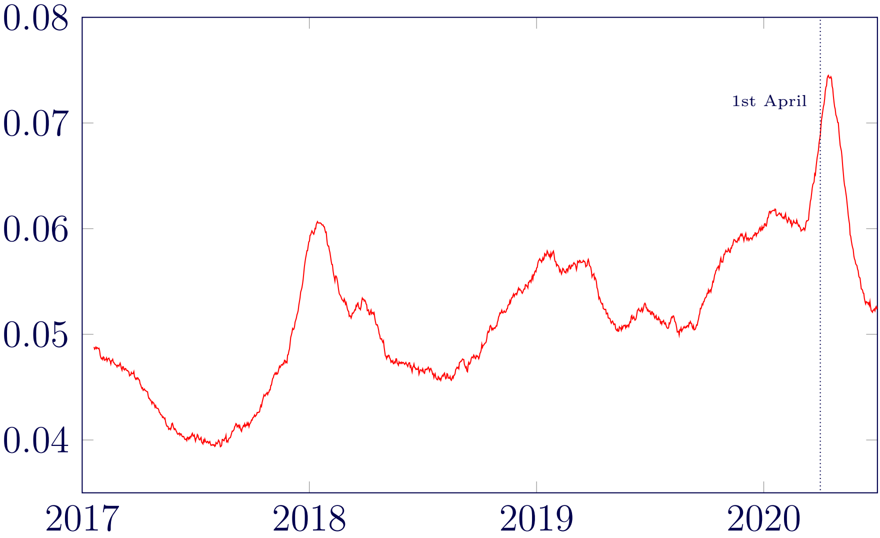
3 FRA $\hat{\mu}_{2015+t}$, $c = 0.2$



3 UK3 $\hat{\mu}_{2015+t}$, $c = 0.2$



3 USA3 $\hat{\mu}_{2017+t}$, $c = 0.2$



3 Non-parametric estimator

Covid-19 shock hit French, UK and US annuity portfolios at the same time, peaking in April 2020.

3 Data privacy

- Only need:
  - Date of annuity commencement,
  - Date of annuity cessation, and
  - Nature of cessation (death, withdrawal etc).
- No personal data required.
- GDPR, CCPA and PIPEDA do not apply!

3 Non-parametric estimator

Advantages:

- Reveals seasonal variation.
- Reveals mortality shocks.
- Requires no personal data (GDPR-, CCPA- and PIPEDA-safe).

3 Non-parametric estimator

Drawbacks:

- Smoothing understates shock.
- Can't separate shock from seasonal effect.
- Doesn't allow for key risk factors like age.
- Not defined for most recent $c/2$ years.
- Affected by reporting delays.

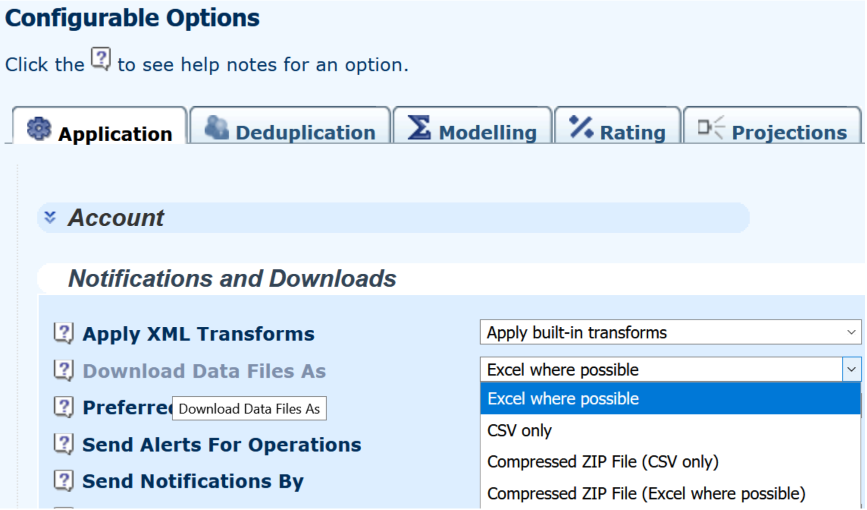
3 Non-parametric estimator

Generating $\hat{\Lambda}_y$ and $\hat{\mu}_y$ in Longevitas:

- Run a data audit.
- Set **Download Data Files As** to "Excel".
- Click on 

 icon.

3 Set downloads to Excel



3 Click Time for spreadsheet

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View Reports

To view a report for this operation, click on the report name.

Report Created	Report Name	Report Type
2020-12-12 14:47:35	Data Audit	TEXT

Name	Text
Data Audit	(Audit)
Decrement: DEATH	Data Audit · Input · Time · XML · Pulse

Non-parametric time estimator(41030) - 360.6 KB

Download: CSV PDF

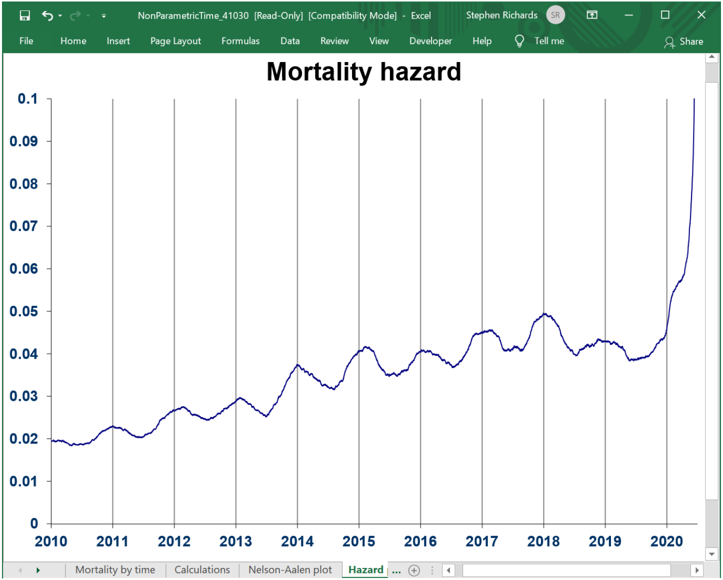
3 $y + t_i$, $l_{y+t_i^-}$ and d_{y+t_i}

	A	B	C
1	All		
2	Time	Lives	Deaths
3	1944.746	1	0
4	1975.301	1117	1
5	1975.523	1166	1
6	1975.929	1271	1
7	1975.978	1284	1
8	1976.268	1438	1
9	1976.331	1465	1
10	1976.617	1582	1
11	1977.052	1744	1
12	1977.137	1769	1
13	1977.164	1780	1
14	1977.203	1787	1
15	1977.855	2041	1
16	1977.868	2045	1
17	1978.101	2133	1

Mortality by time

3 Graph of $\hat{\Lambda}_{y+t_i}$

3 Graph of $\hat{\mu}_{y+t_i}$



4 Reporting delays

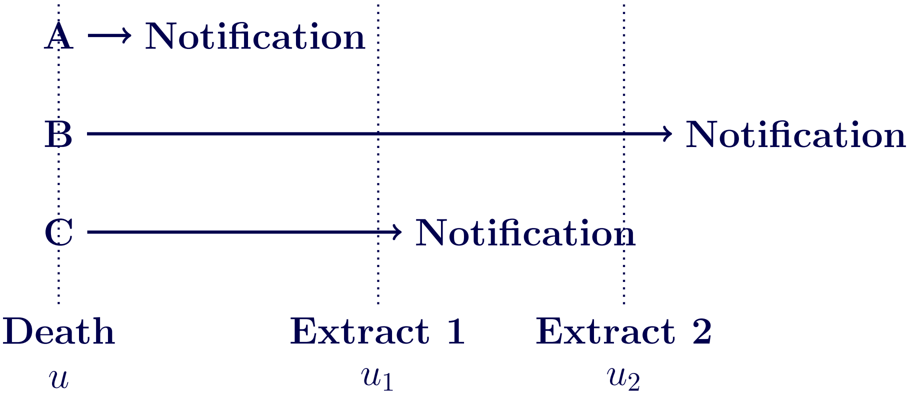
Consider same week for UK3 using two extracts:

	June 2020 extract:		Sept. 2020 extract:	
Date	In-force	Deaths	In-force	Deaths
2020-06-11	145,166	6	144,934	18
2020-06-12	145,163	3	144,920	16
2020-06-13	145,168	9	144,918	14
2020-06-14	145,159	1	144,909	7
2020-06-15	145,162	3	144,906	15
2020-06-16	n/a	n/a	144,898	8
2020-06-17	145,168	3	144,902	29

4 Reporting delays

- Assume we have two extracts at time u_1 and u_2 ($u_1 < u_2$).
- Assume a death occurs at time $u < u_1$.
- There are three possible reporting types...

4 Reporting delays



4 Reporting delays

- Type A deaths reported by time of first extract.
- Type B deaths reported after second extract. Unknown to us!
- Type C deaths reported between extracts.

4 Reporting delays

- Types B and C are occurred-but-not-reported (OBNR).
- Similar term IBNR (incurred-but-not-reported) refers to general insurance claims.
- The distinction was made by Lawless [1994].

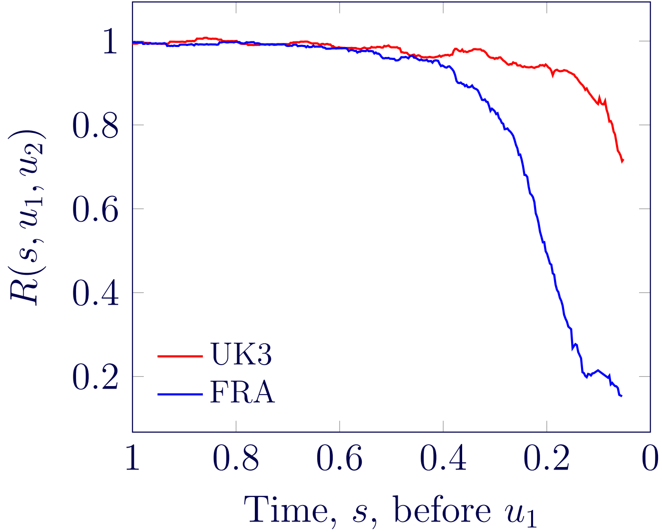
4 Reporting delays

Calculate ratio of $\hat{\mu}_y$ estimates using two extracts:

$$R(s, u_1, u_2) = \frac{\hat{\mu}_{u_1-s} \text{ using extract at time } u_1}{\hat{\mu}_{u_1-s} \text{ using extract at time } u_2} \qquad (3)$$

OBNR impact negligible when R is close to 1.

4 Impact of reporting delays



4 Reporting delays (OBNR)

- OBNR affects most recent mortality estimates.
- Most impact within 0.25 years of extract.
- Minimal impact 0.75 or more years before extract.

See https://www.longevitas.co.uk/site/informationmatrix/reportingdelays.html.

5 Parametric approach

Look again at the ratio measuring the impact of OBNR:

$$R(s, u_1, u_2) = \frac{\hat{\mu}_{u_1-s} \text{ using extract at time } u_1}{\hat{\mu}_{u_1-s} \text{ using extract at time } u_2} \qquad (4)$$

We can re-word this as follows:

$$\rho = \frac{\text{OBNR} - \text{affected } \hat{\mu}_y}{\text{Underlying } \hat{\mu}_y} \tag{5}$$

We can re-arrange as follows:

$$\text{OBNR-affected } \hat{\mu}_y = \text{Underlying } \hat{\mu}_y \times \rho$$

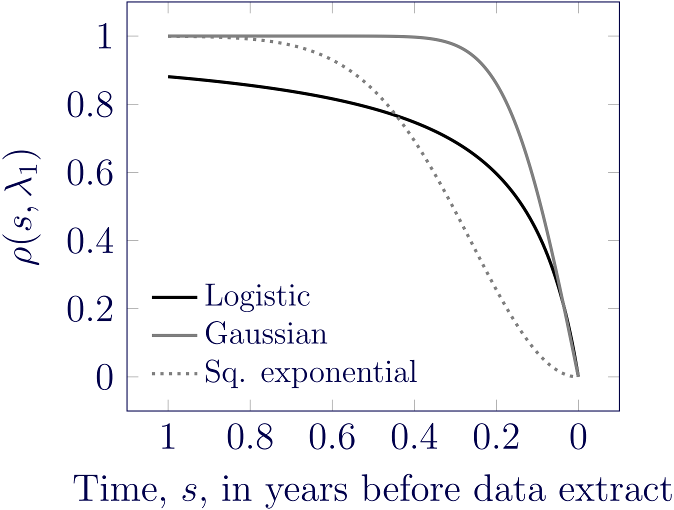
5 Parametric approach

Model for OBNR-affected mortality, $\mu_{x,y}^{OBNR}$:

$$\mu_{x,y}^{OBNR} = \mu_{x,y}^{*}\rho(u_1 - y, \lambda_1) \tag{6}$$

- $\mu_{x,y}^{OBNR}$ is reported mortality,
- $\mu_{x,y}^{*}$ is actual mortality experienced,
- $\rho(s, \lambda_1)$ is scaling factor for OBNR, and
- λ_1 is the OBNR decay parameter.

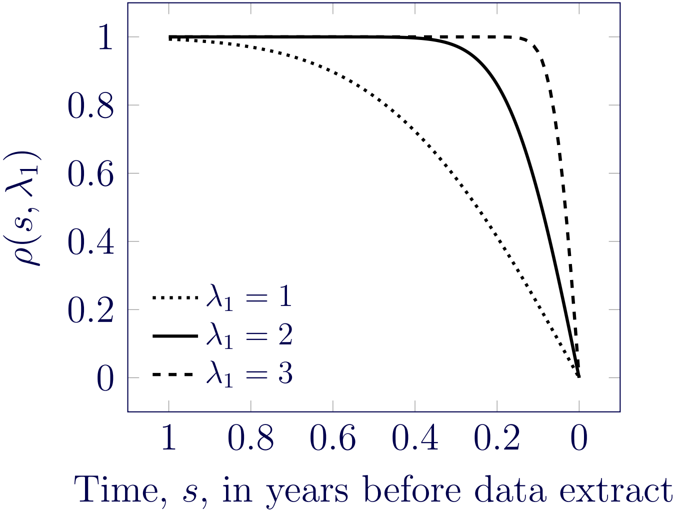
5 Options for $\rho(s, \lambda_1 = 2)$



Details of these and other functions in Richards [2021].

5 Role of λ_1

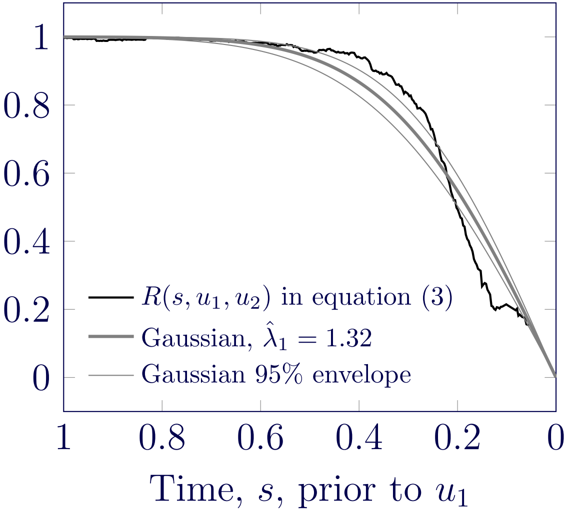
Gaussian OBNR function:



5 Forecasting

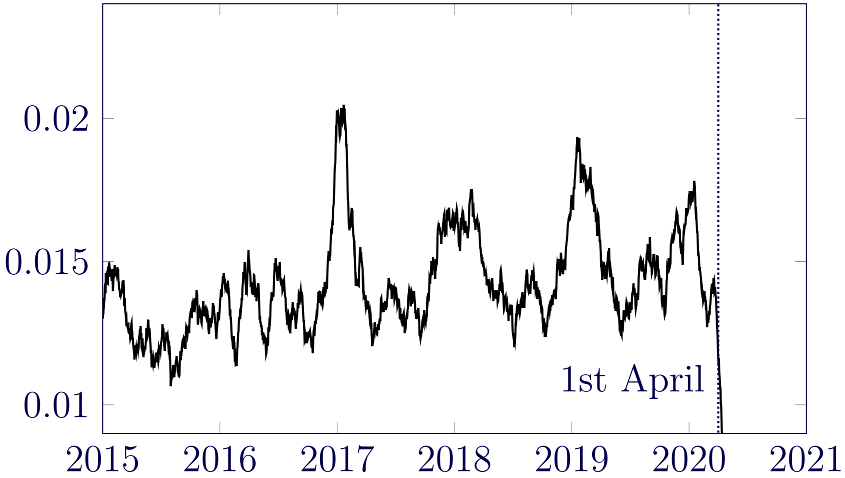
- Can we use a model at time u_1 to predict the unreported deaths by time u_2?
- Can we use the OBNR function to adjust for unreported deaths?

5 Forecasting OBNR



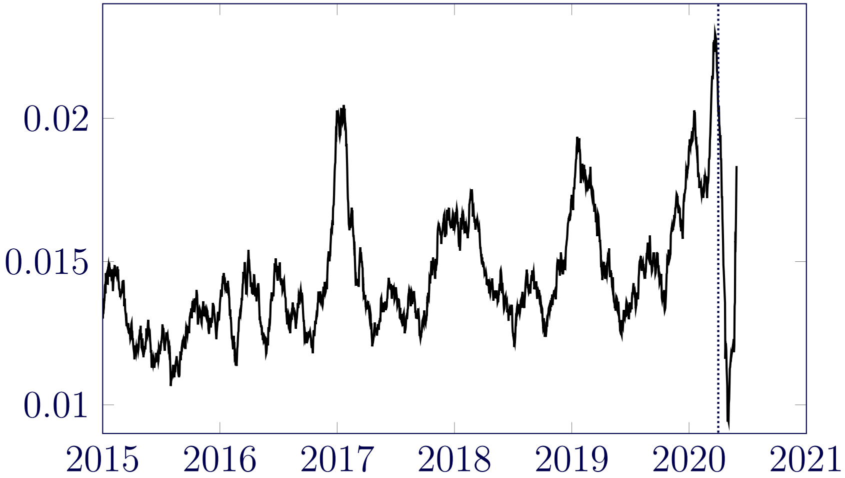
5 Adjusting for OBNR

FRA, June extract:



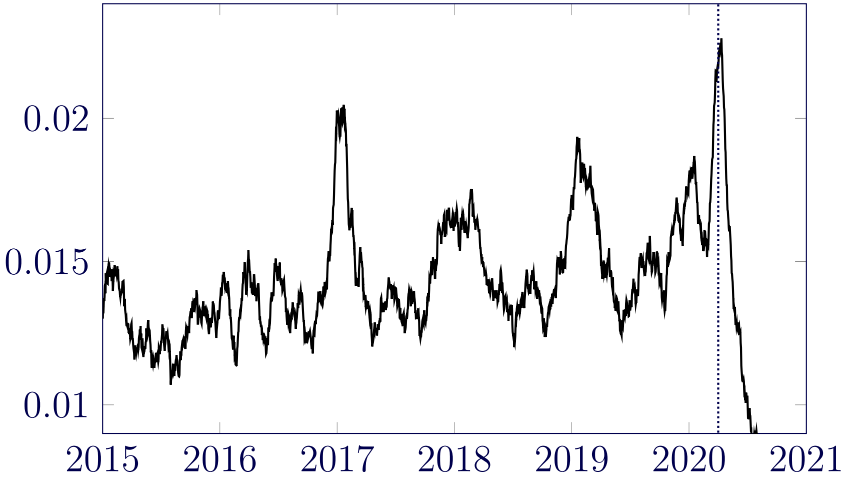
5 Adjusting for OBNR

FRA, June extract with Gaussian OBNR adjustment:



5 Adjusting for OBNR

FRA, September extract:

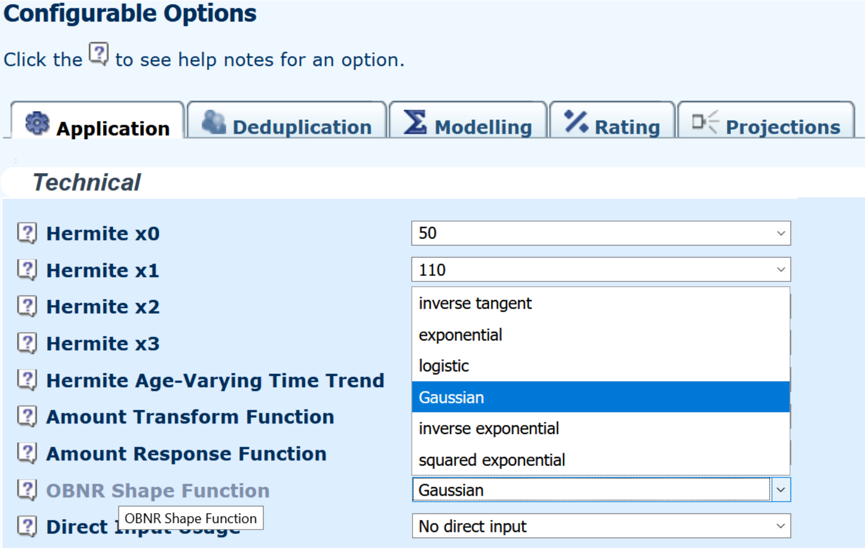


5 OBNR modelling

Fitting OBNR models in Longevitas:

- Set OBNR shape function.
- Select Hermite model.
- Tick OBNR term in model specification.

5 Set OBNR shape function



5 Tick OBNR model term

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Term Groups To Include

	Term Group	Fixed Terms	Optional Terms
Include	☐ Selection	SelectionInitial SelectionTerm	☐ SelectionGradient
	☑ Season	SeasonalExcess SeasonalPeak	☐ SeasonalAge
	☐ Amount	AmountTransformParameter AmountUltimate	☐ AmountGradientInitial ☐ AmountGradientUltimate
	☑ OBNR	OBNRdecay	

Continue | Back | Cancel

6 Conclusions

6 Conclusions — I

- Covid-19 shock detectable in annuity portfolios.
- Shock peaked in April 2020 in France, UK and USA.
- Non-parametric methods are privacy-safe.

6 Conclusions — II

- Reporting delays affect most recent experience.
- However, parametric models can allow for delays…

  … and provide forecasts of unreported deaths.

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CCAES. Actualización no. 120. Enfermedad por el coronavirus (COVID-19). 29.05.2020. Technical Report 120, Centro de Coordinación de Alertas y Emergencias Sanitarias, May 2020.

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References II

J. F. Lawless. Adjustments for reporting delays and the prediction of occurred but not reported events. *Canadian Journal of Statistics*, 22(1):15–31, 1994. doi: https://doi.org/10.2307/3315826.n1.

ONS. Deaths registered weekly in England & Wales. Technical report, 2020. URL `https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/weeklyprovisionalfiguresondeathsregisteredinen`

S. J. Richards. Mortality shocks and reporting delays in portfolio data. *Longevitas Ltd*, 2021.

References III

The Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) — China, 2020. *China CDC Weekly*, 2:113, 2020. ISSN 2096-7071. URL `http://weekly.chinacdc.cn//article/id/e53946e2-c6c4-41e9-9a9b-fea8db1a8f51`.

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

7 Legal matters

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