

IFoA webinar series on Covid-19

Mortality shocks in annuity portfolios

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

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].

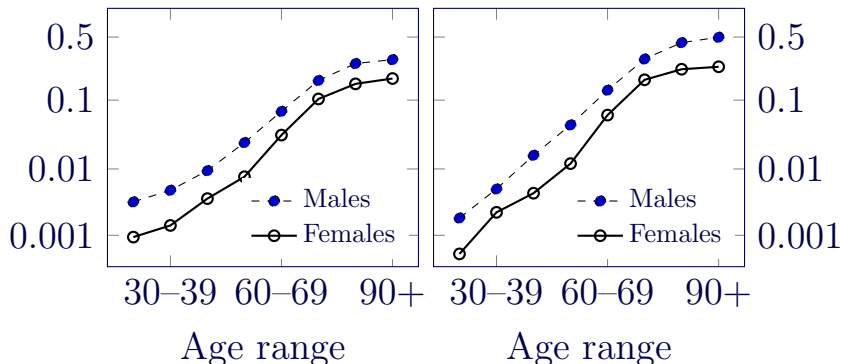
1 Covid-19



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

(a) Spain

(b) Italy



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

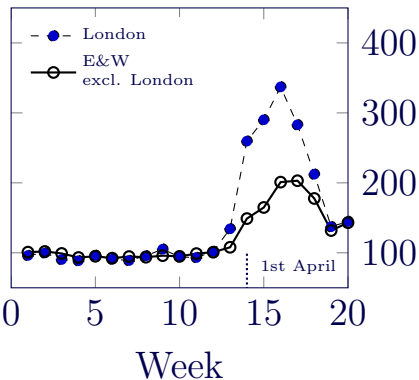
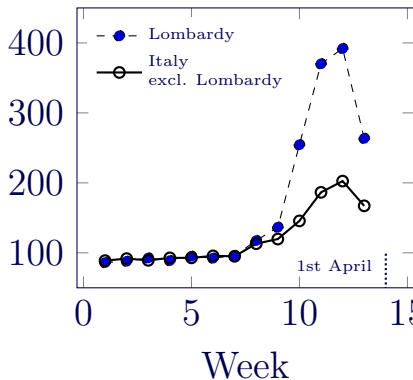
- Covid-19 is the disease caused by the novel SARS-CoV-2 virus[†].
- Covid-19 can be fatal...
...and its arrival was obvious in national mortality statistics...

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

Deaths in early 2020 as percentage of average in 2015–2019[†].

(a) Italy

(b) England & Wales



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

Covid-19 mortality shock was:

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

How might it impact annuity portfolios?

2 Annuity portfolios



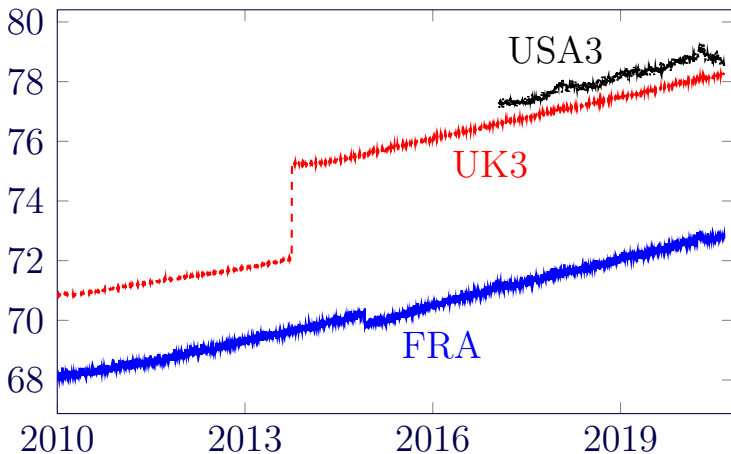
2 Annuitant experience data



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



- 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 ?

- $\{y + t_i\}$ 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 $y + t_i$.

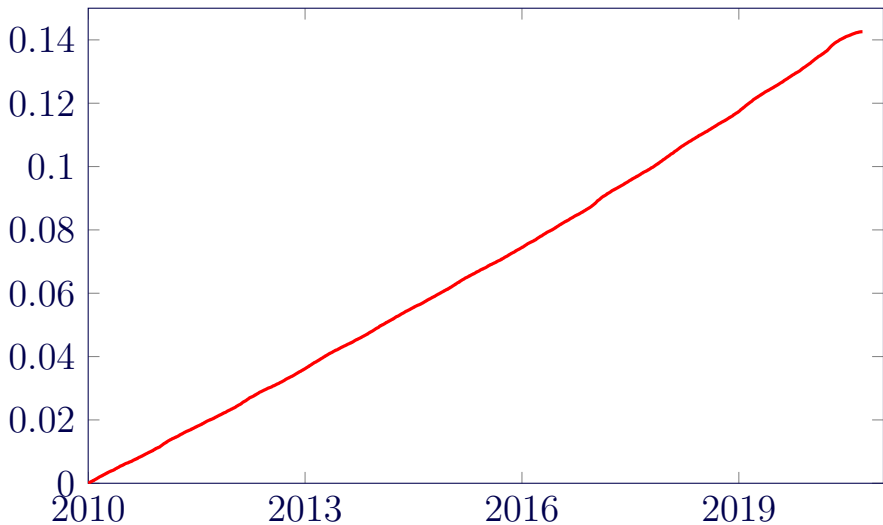
$$\hat{\Lambda}_{y,t} = \sum_{t_i \leq t} \frac{d_{y+t_i}}{l_{y+t_i}^-} \quad (1)$$

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

See

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

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



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

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

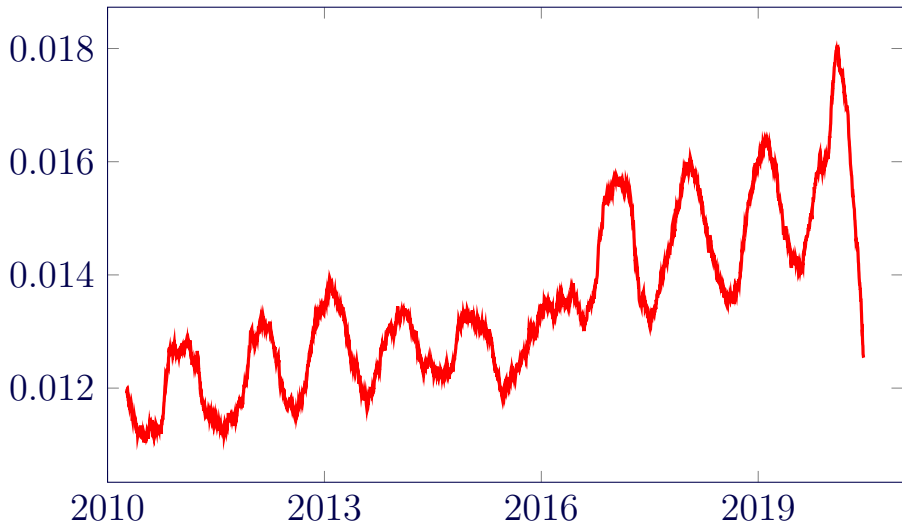
$$\hat{\mu}_{y+t} = \frac{\hat{\Lambda}_{y,t+c/2} - \hat{\Lambda}_{y,t-c/2}}{c} \quad (2)$$

where $c > 0$ is the bandwidth parameter.

See

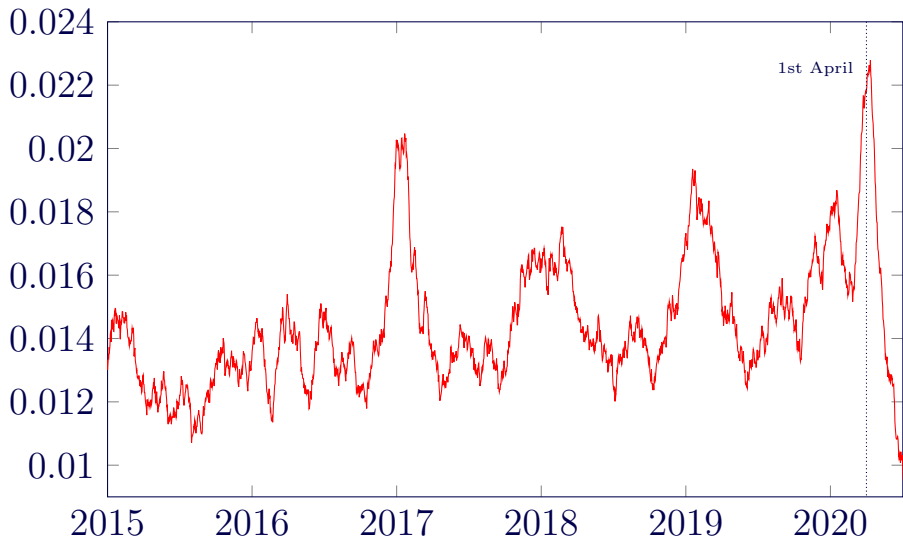
<https://www.longevity.co.uk/site/informationmatrix/visualisingcovid19inexperiencedata.html>.

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

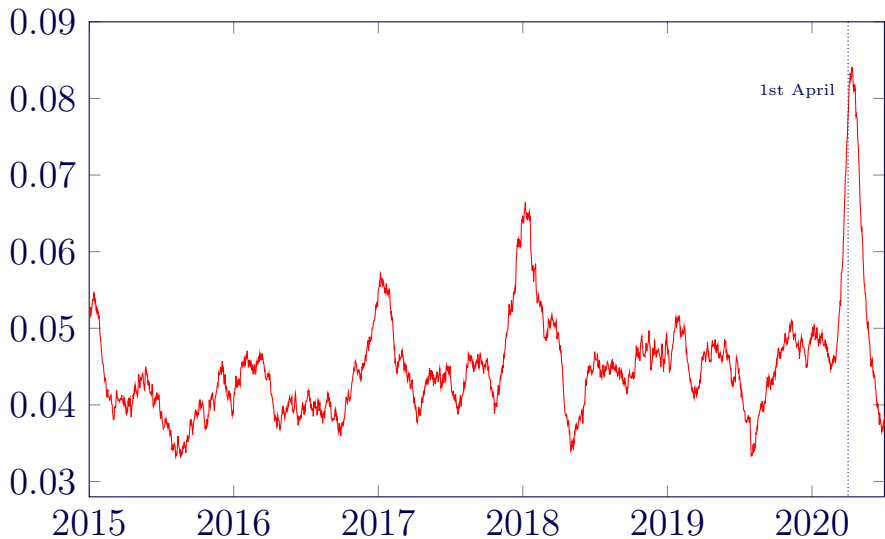


- $\hat{\Lambda}_y$ is near-linear (and rather dull).
- However, $\hat{\mu}_y$ reveals rich detail of seasonal patterns.
- Can $\hat{\mu}_y$ reveal the covid-19 shock?

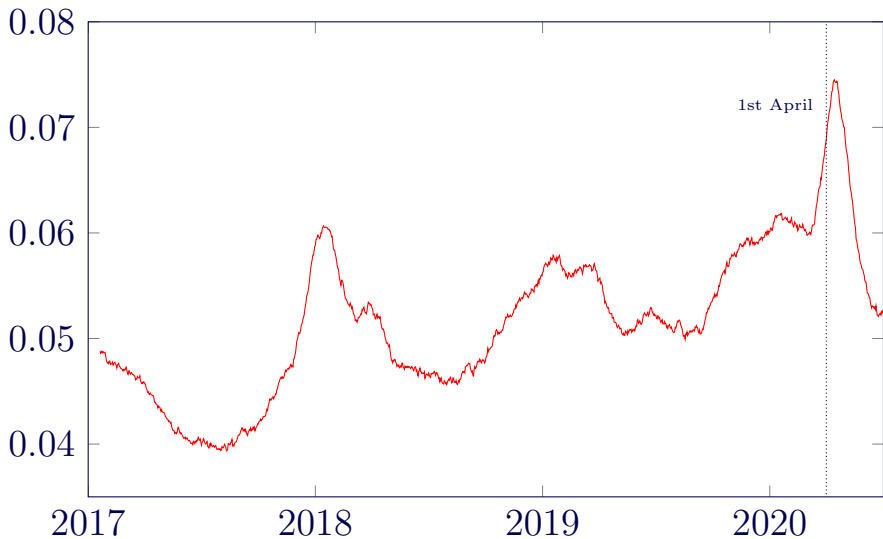
3 FRA $\hat{\mu}_{2015+t}, c = 0.2$



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



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



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

- 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!

Advantages:

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

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.

4 Reporting delays



4 Reporting delays

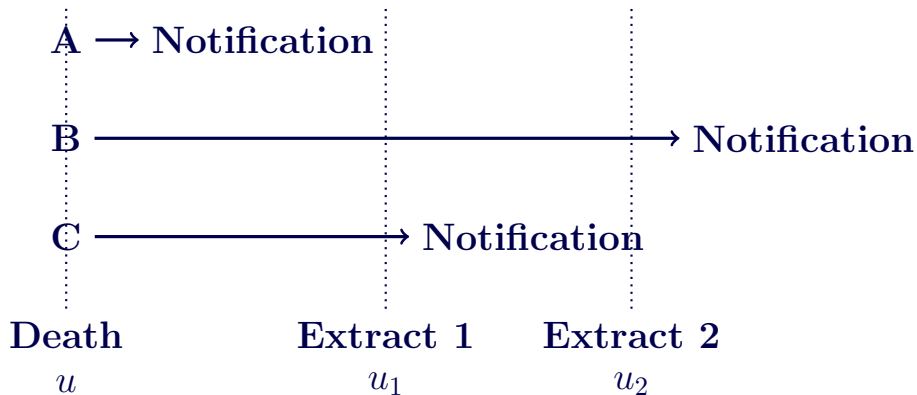


Consider same week for UK3 using two extracts:

Date	June 2020 extract:		Sept. 2020 extract:	
	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

- 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



- 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.

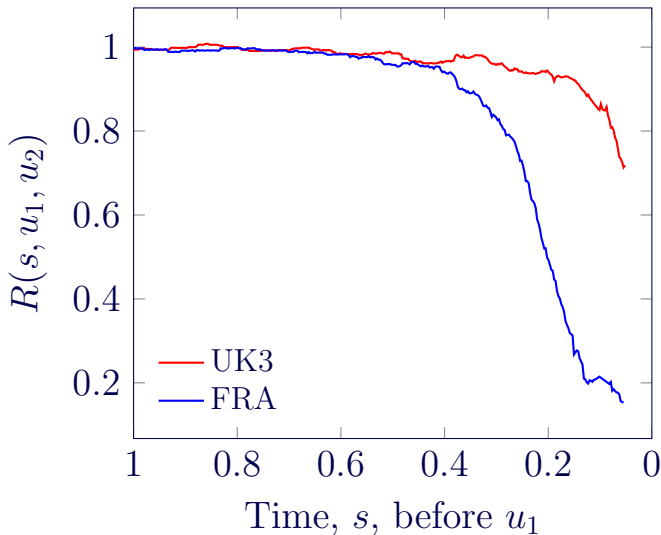
- Types B and C are occurred-but-not-reported (OBNR).
- Similar term IBNR (incurred-but-not-reported) refers to general insurance claims.
- The distinction was made by Lawless [1994].

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

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

OBNR impact negligible when R is close to 1.

4 Impact of reporting delays



- 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.longevity.co.uk/site/informationmatrix/reportingdelays.html>.

5 Parametric approach



Look again at the ratio measuring the impact of OBNR:

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

We can re-word this as follows:

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

We can re-arrange as follows:

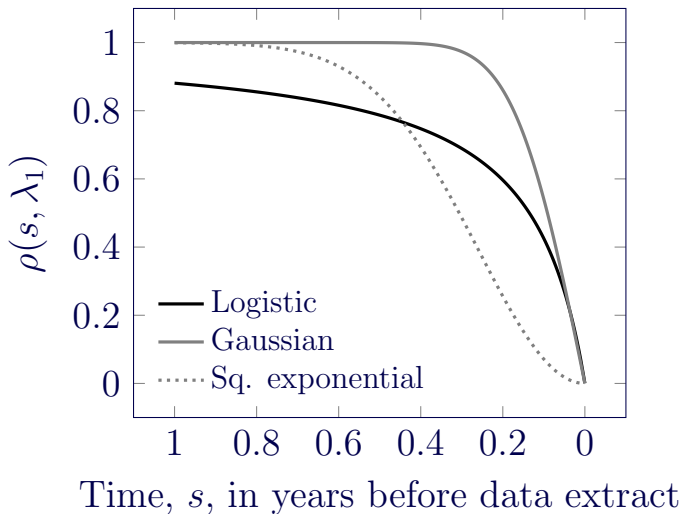
$$\text{OBNR-affected } \hat{\mu}_y = \text{Underlying } \hat{\mu}_y \times \rho$$

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

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

- $\mu_{x,y}^{OBNR}$ 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 $\rho(s, \lambda_1 = 2)$

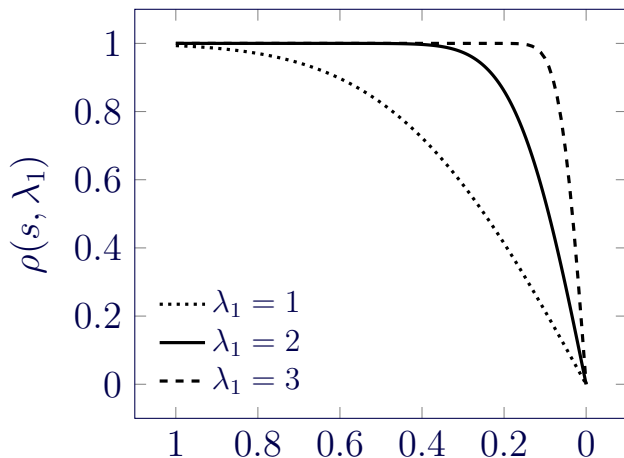


Details of these and other functions in Richards [2021].

5 Role of λ_1



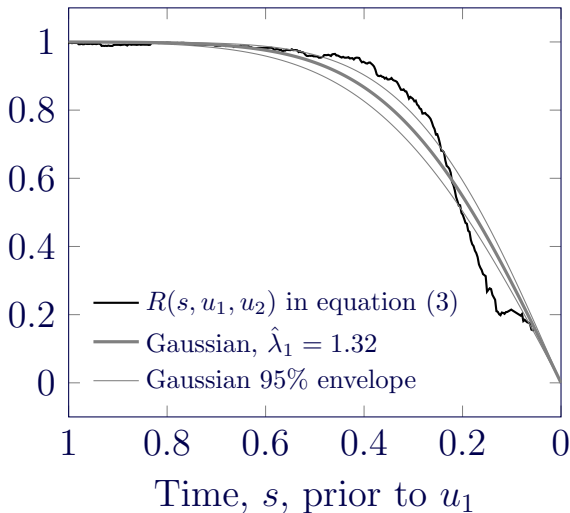
Gaussian OBNR function:



Time, s , in years before data extract

- 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?

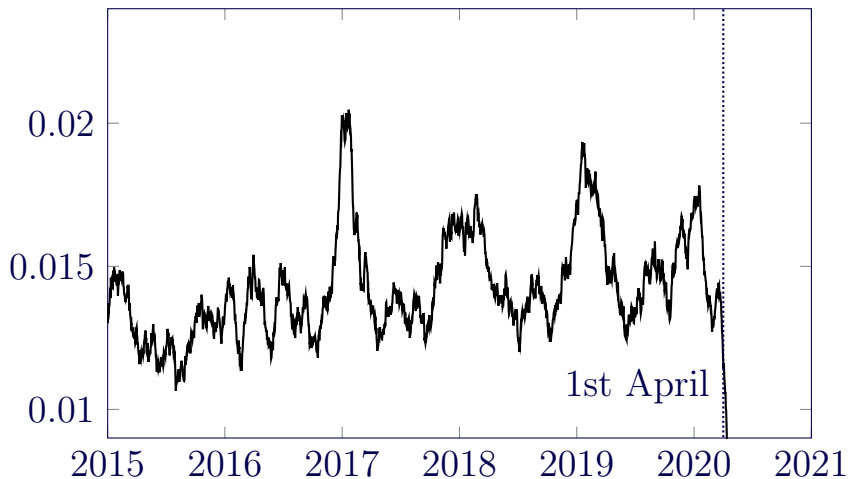
5 Forecasting OBNR



5 Adjusting for OBNR



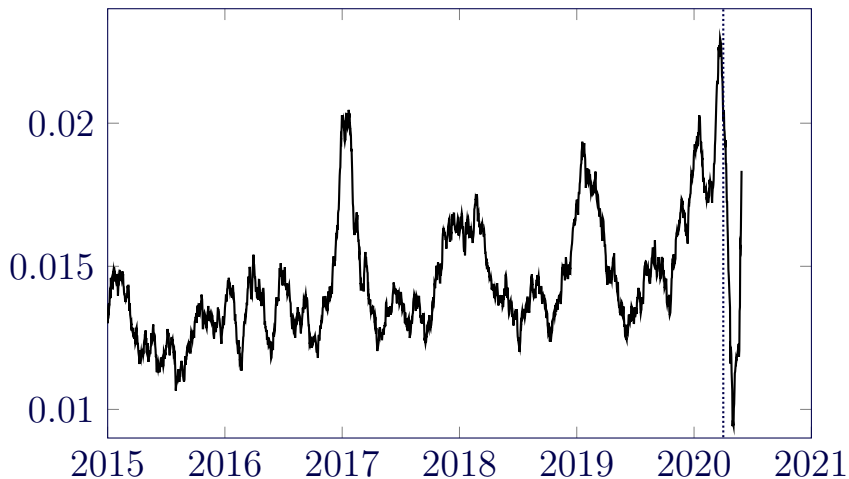
FRA, June extract:



5 Adjusting for OBNR



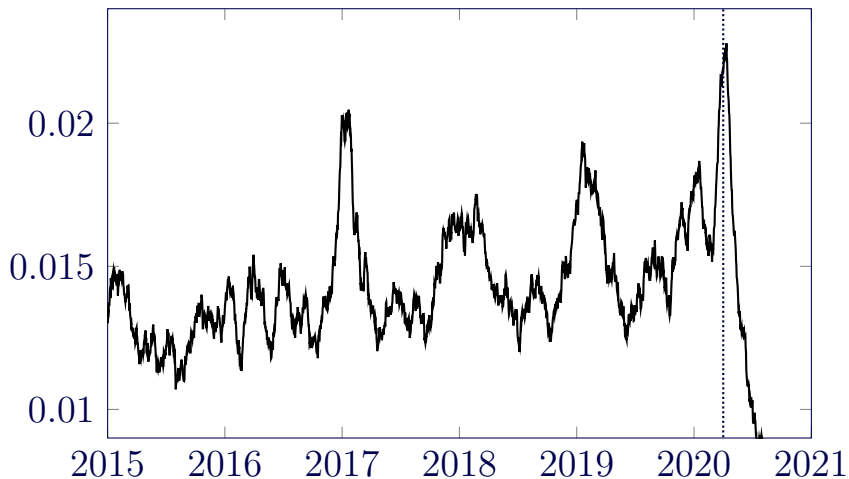
FRA, June extract with Gaussian OBNR adjustment:



5 Adjusting for OBNR



FRA, September extract:



6 Conclusions



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



- Reporting delays affect most recent experience.
- However, parametric models can allow for delays...
... and provide forecasts of unreported deaths.

- 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.
- ISS. Epidemia COVID-19 Aggiornamento nazionale 16 giugno 2020 — ore 11:00. Technical report, Istituto Superiore de Sanità, 2020.
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J. F. Lawless. Adjustments for reporting delays and the prediction of occurred but not reported events.

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[birthsdeathsandmarriages/](https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/weeklyprovisionalfiguresondeathsregisteredinen)

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