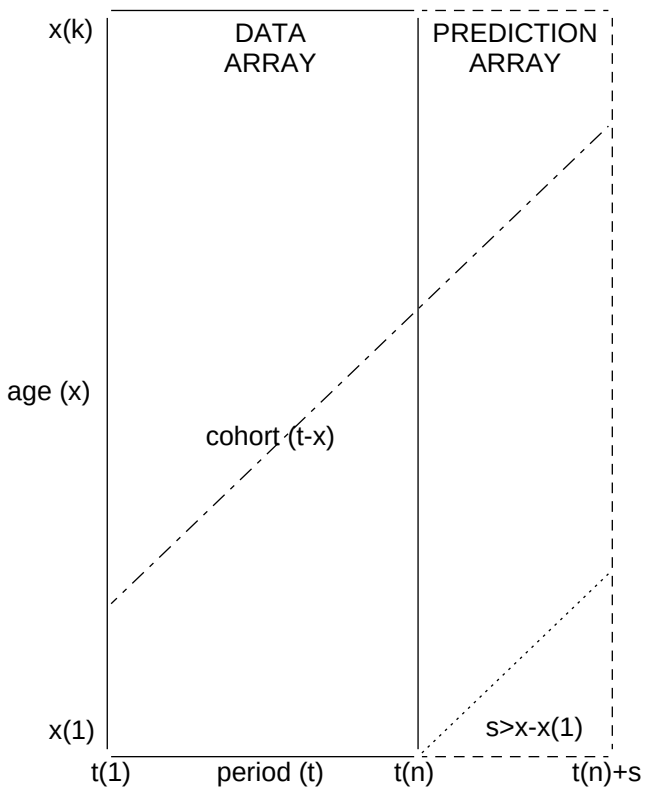


structure (or sub-structure) to crude mortality rates. (ii) Predicting future mortality rates by projecting the fitted structure. (iii) Using future mortality rates to predict statistics of interest: viz. life expectancy, fixed rate annuity, and simulating their prediction intervals. Two sources of error: (i) Structure fitting error. (ii) Time series forecast (prediction) error. Emphasis on simulating prediction intervals. Two case studies:- Figs 1-10: male pensioner 1983-2004/2003 experience; Figs 11-15: E+W male mortality experience 1961-2003.

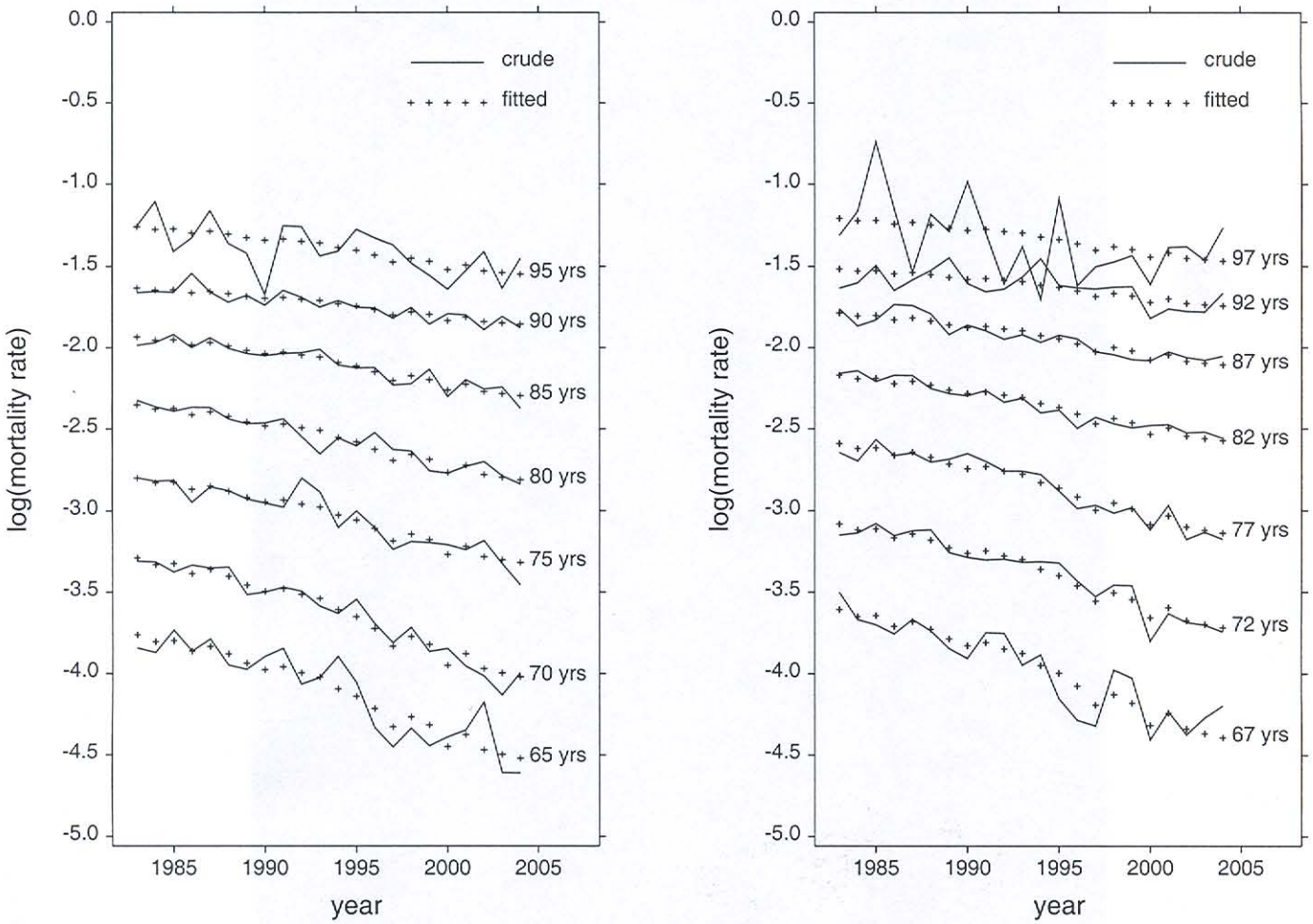


Fig 1. UK 1983-2004 male pensioner mortality experience (ages 51-100).
Plot: crude & fitted log(mortality rates) vs. year (various ages).
Ages 65, 70, ..., 95 left frame, ages 67, 72, ..., 97 right frame.
Poisson LC: age-period (log-bilinear) fitted parametric structure.

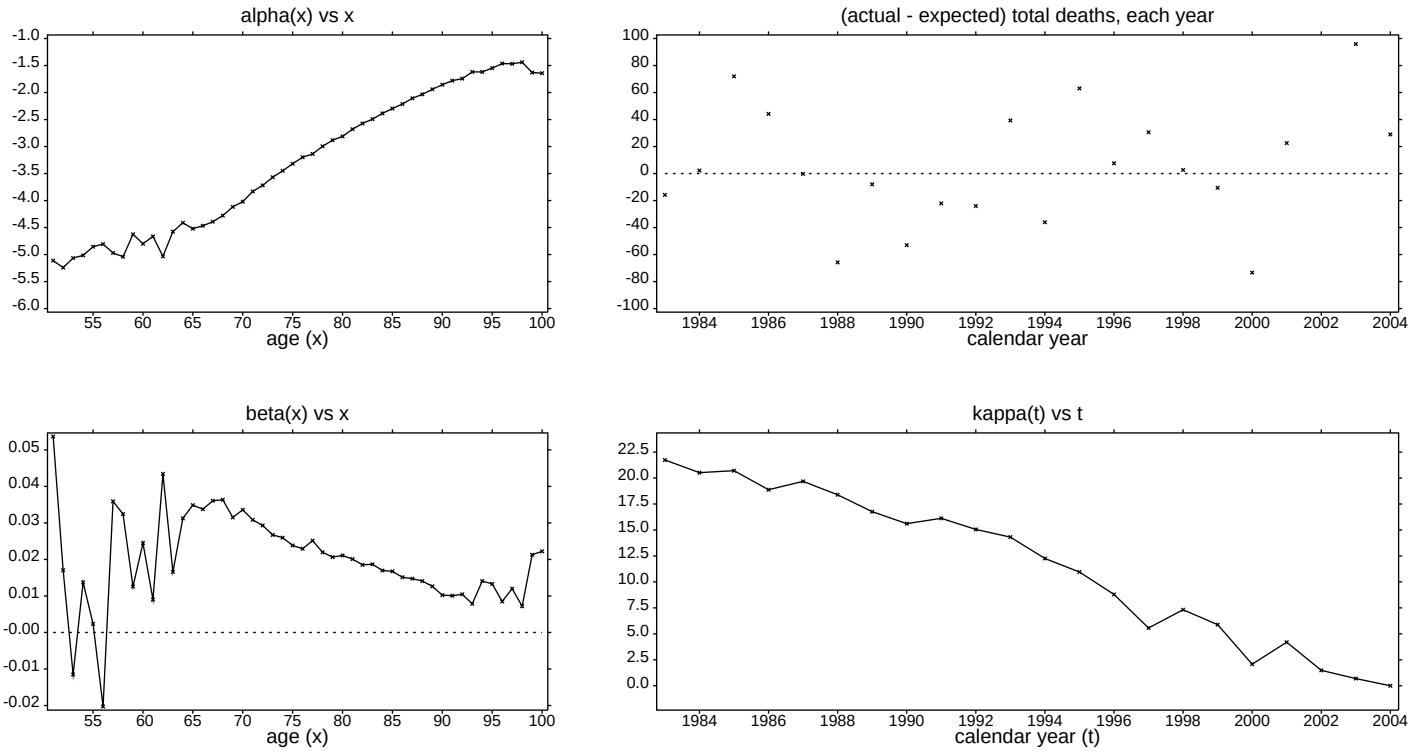
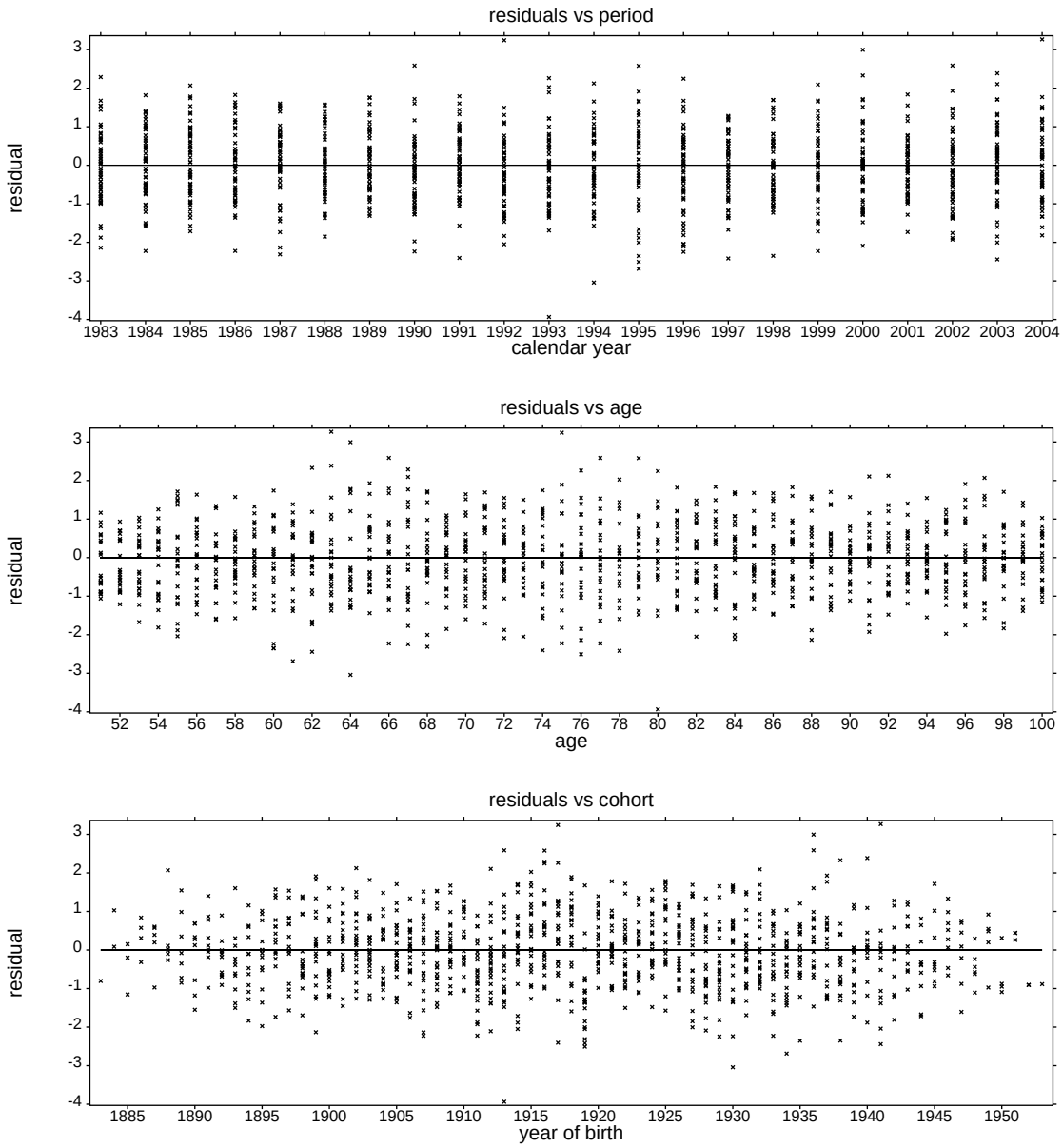
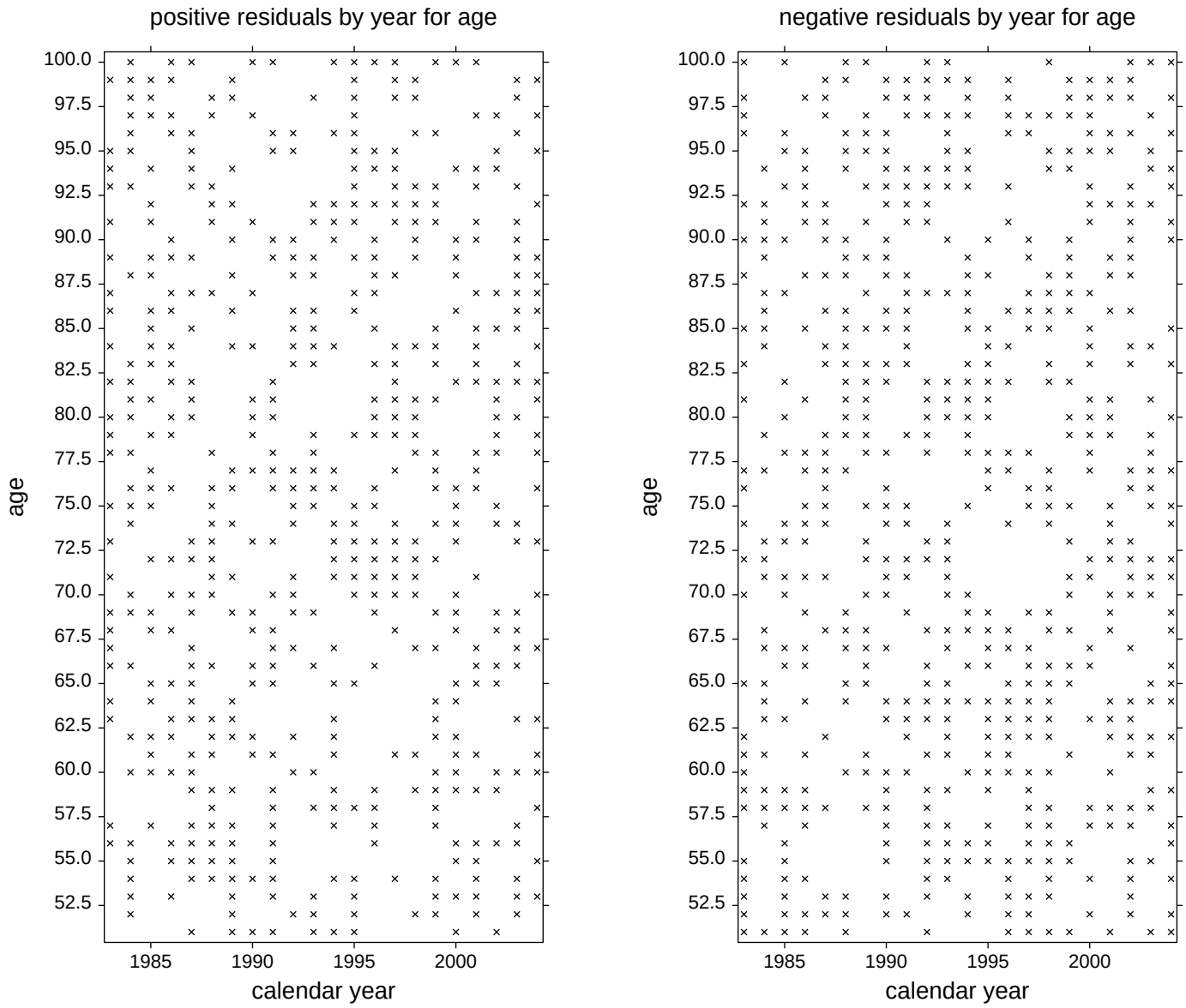


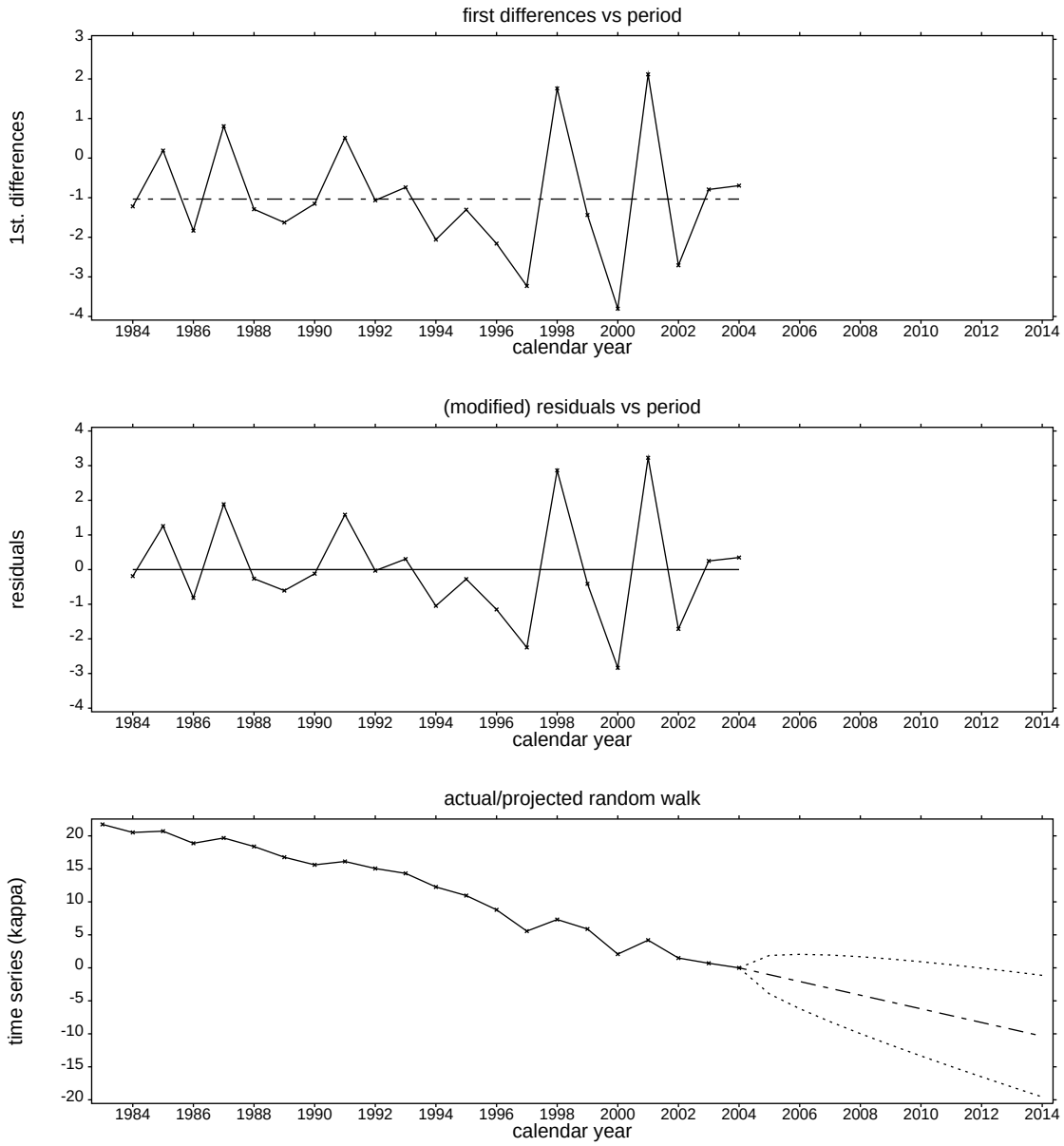
Fig 2. UK 1983-2004 male pensioner mortality experience (ages 51-100).
Poisson LC: age-period (log-bilinear) fitted parametric structure.
Parameter estimates: (a) main age effects, (c) multiplicative
period adjustment factors,(d) main period effects.
Diagnostic: (b) marginal age differences.



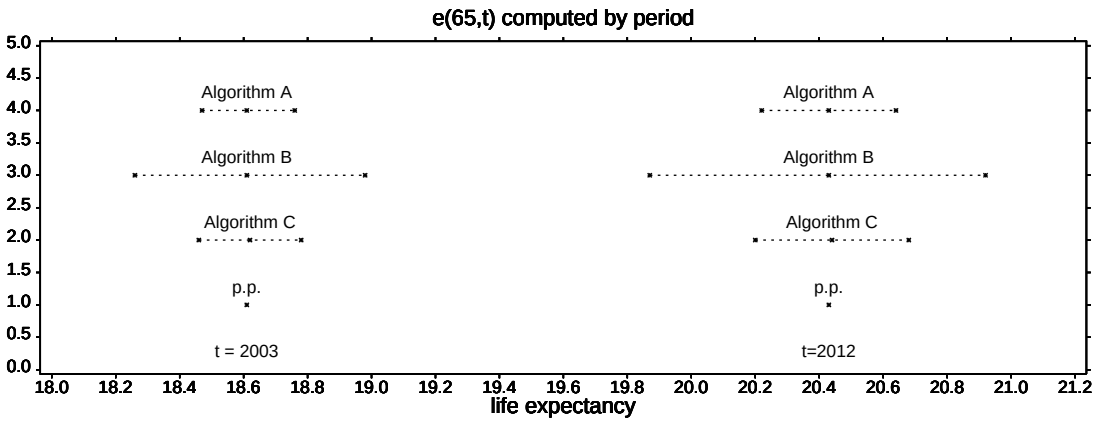
Deviance residual plots against- period, age, cohort, respectively.



Deviance residual plots: left frame- positives; right frame- negatives.



Lower: Restored random walk with forecast and 95% prediction interval.



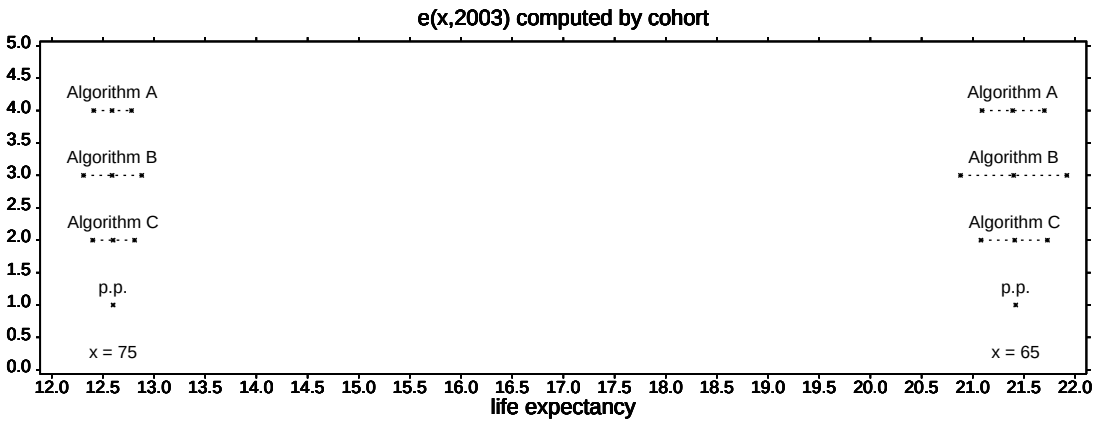
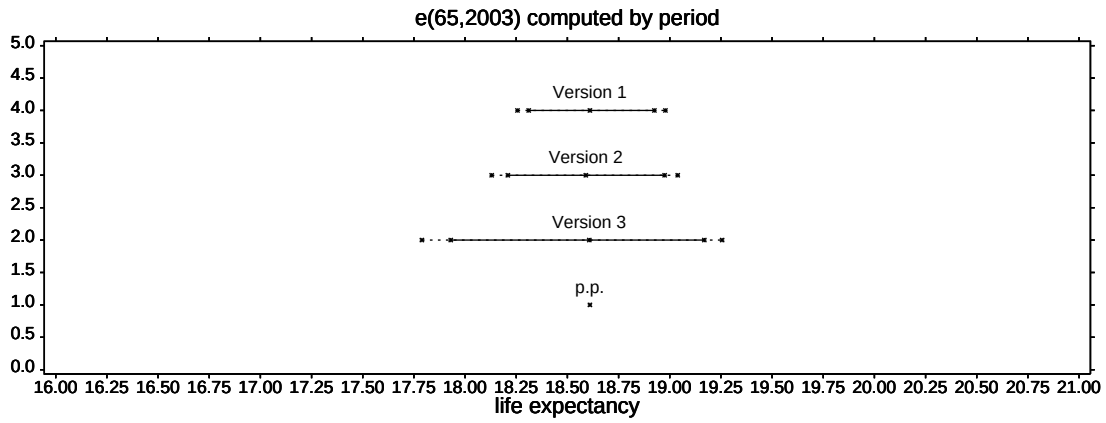


Fig 5. UK 1983-2003 male pensioner mortality experience (ages 51-104).
Poisson LC: age-period (log-bilinear) fitted parametric structure.
Life expectancy: comparison of 2.5, 50, 97.5 precentile based PIs
using three different simulation algorithms, with point predictor (p.p.).



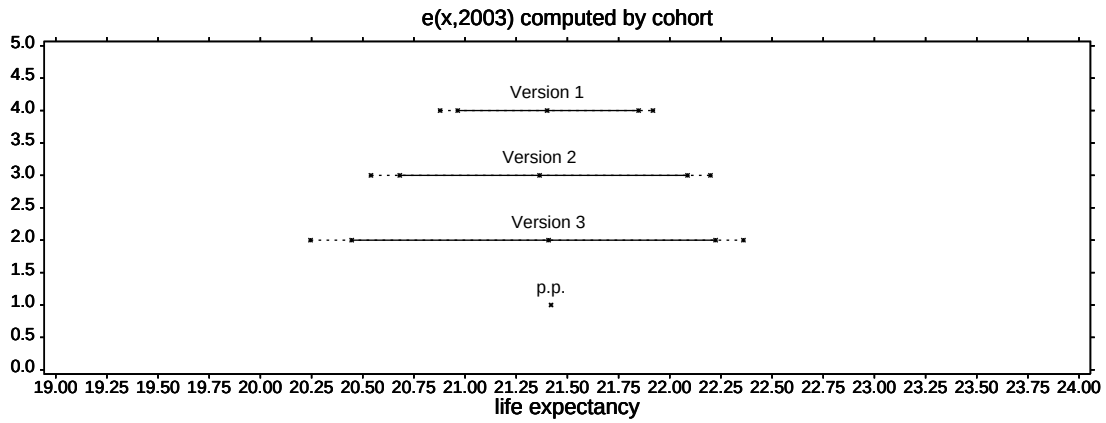
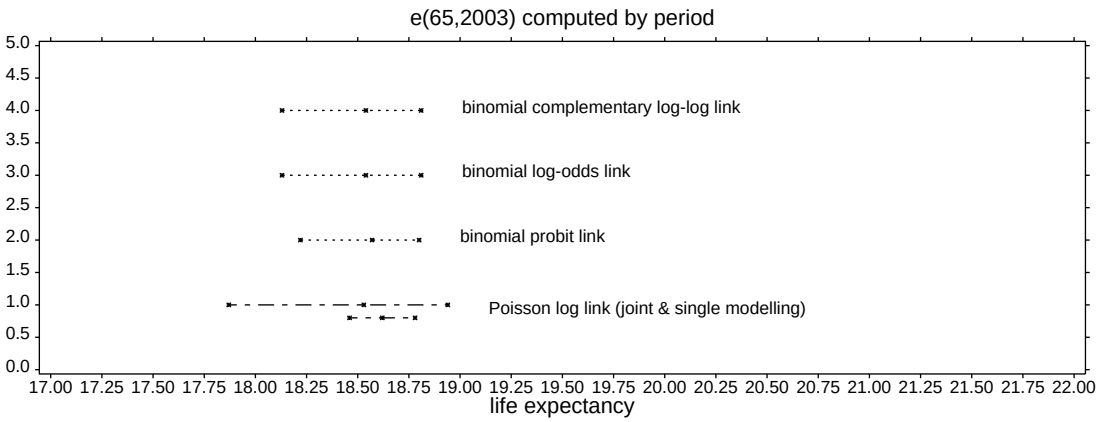


Fig 6. UK 1983-2003 male pensioner mortality experience (ages 51-104). Poisson LC: age-period (log-bilinear) fitted parametric structure, with and without the inclusion of a free-standing (constant) scale parameter. Life expectancy: comparison of 2.5, 50, 97.5 precentile based PIs using different versions of simulation Algorithm B, with point predictor (p.p.).



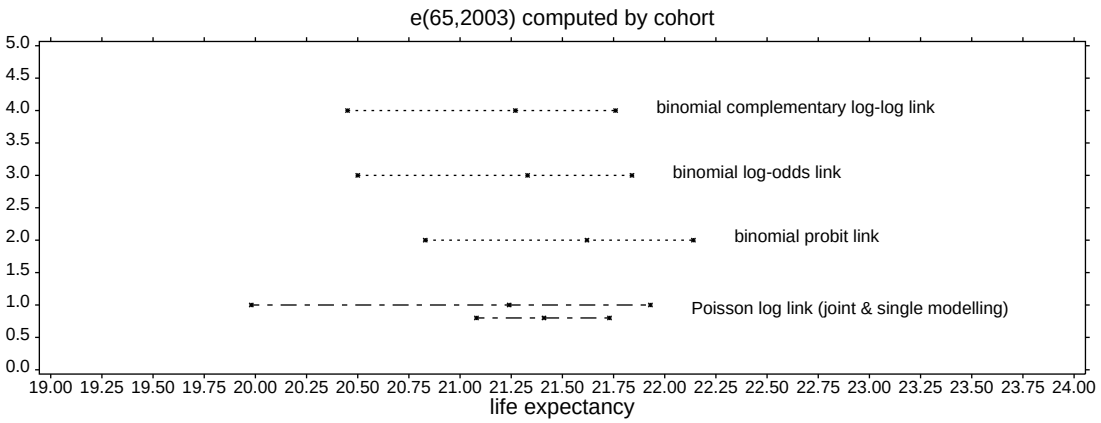
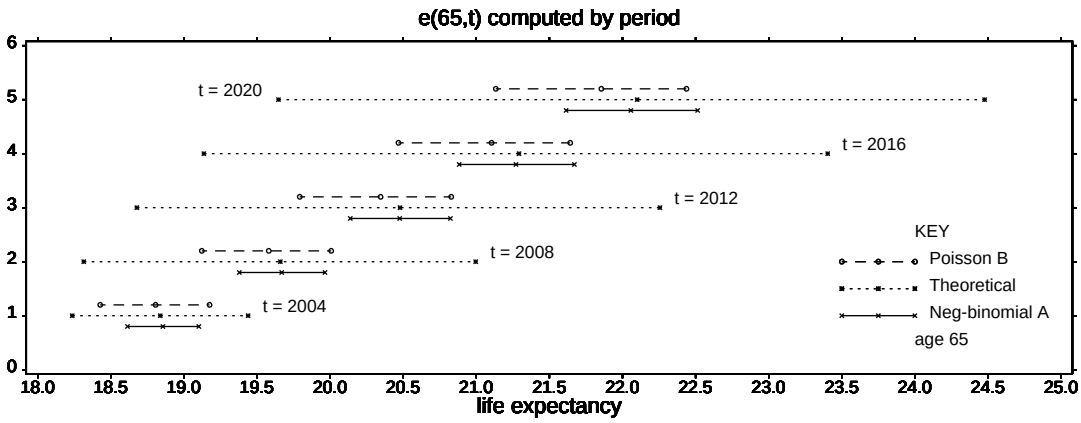


Fig 7. UK 1983-2003 male pensioner mortality experience (ages 51-104). Binomial and Poisson joint modelling, with age effects in the scale parameter. Also Poisson (single) modelling, no scale parameter (Fig 5). LC: age-period (bilinear) parametric predictor structure, various links. Life expectancy: comparison of 2.5, 50, 97.5 precentile based PIs using simulation Algorithm C.



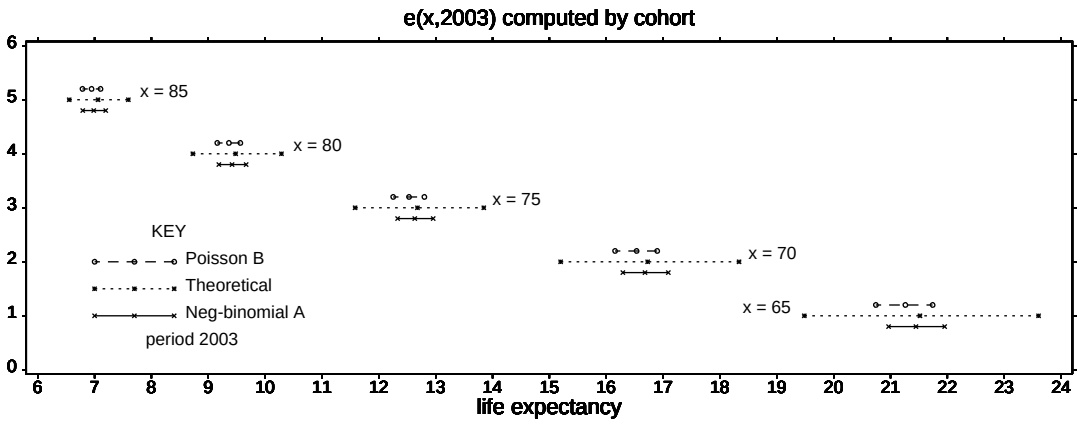
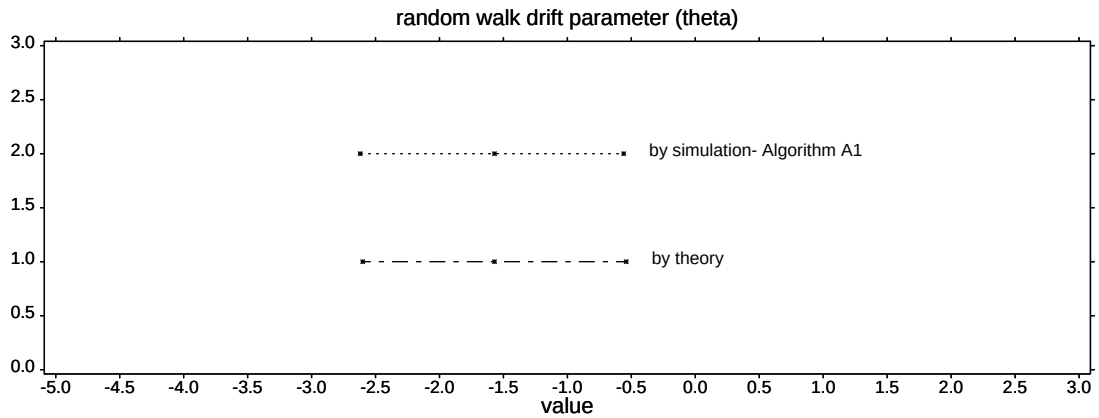


Fig 8. UK 1983-2003 male pensioner mortality experience (ages 51-104). LC: age-period (bilinear) structure in combination with random walk. Life expectancy: comparison 2.5, 50, 97.5 precentile based PIs using (i) Algorithm B, Poisson (version 1). (ii) By theory (Denuit (2007)) (iii) Algorithm A, negative binomial.



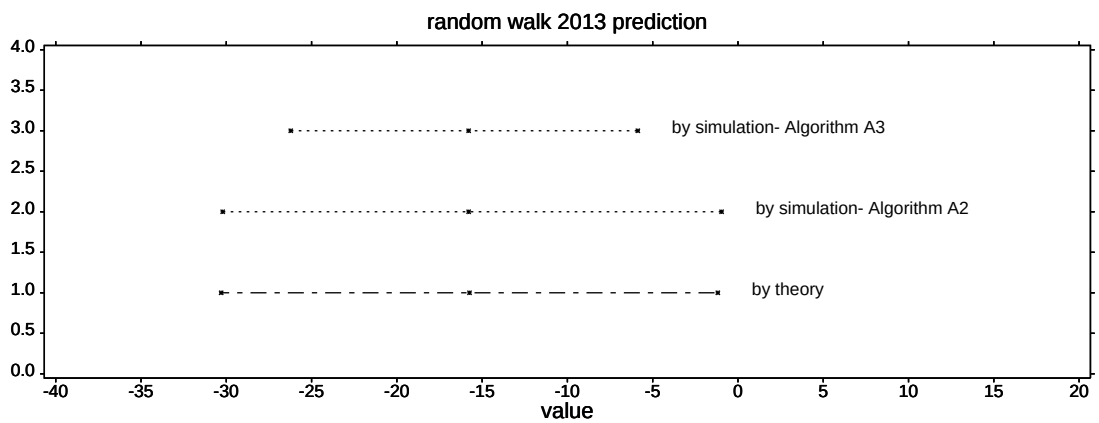
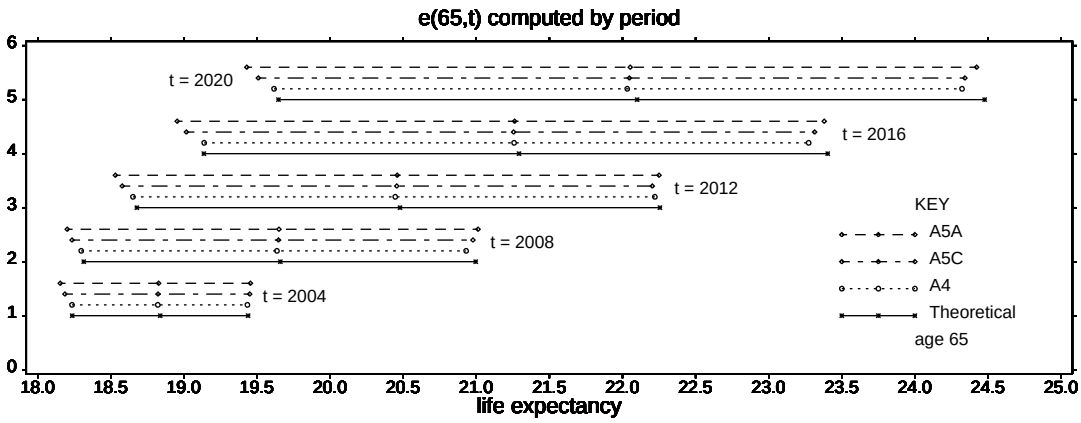


Fig 9. UK 1983-2003 male pensioner mortality experience (ages 51-104). LC: age-period (bilinear) structure in combination with random walk. Simulation intervals are the resulting 2.5, 50, 97.5 percentiles.



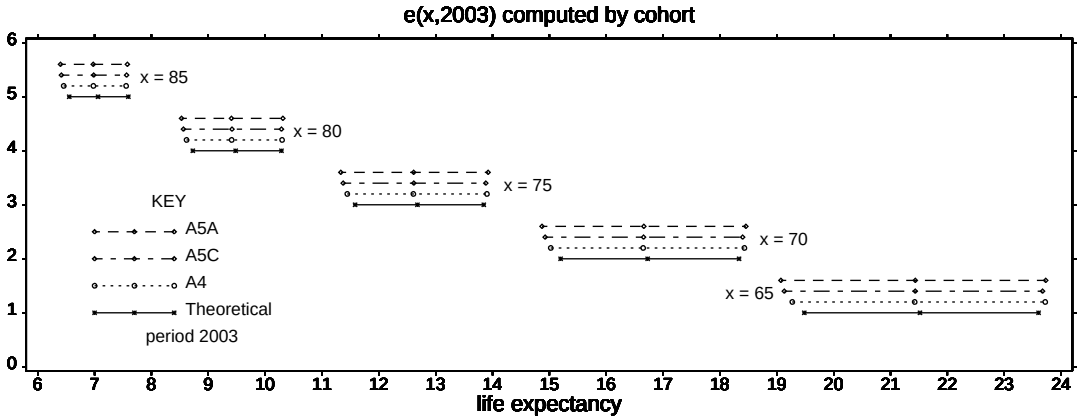
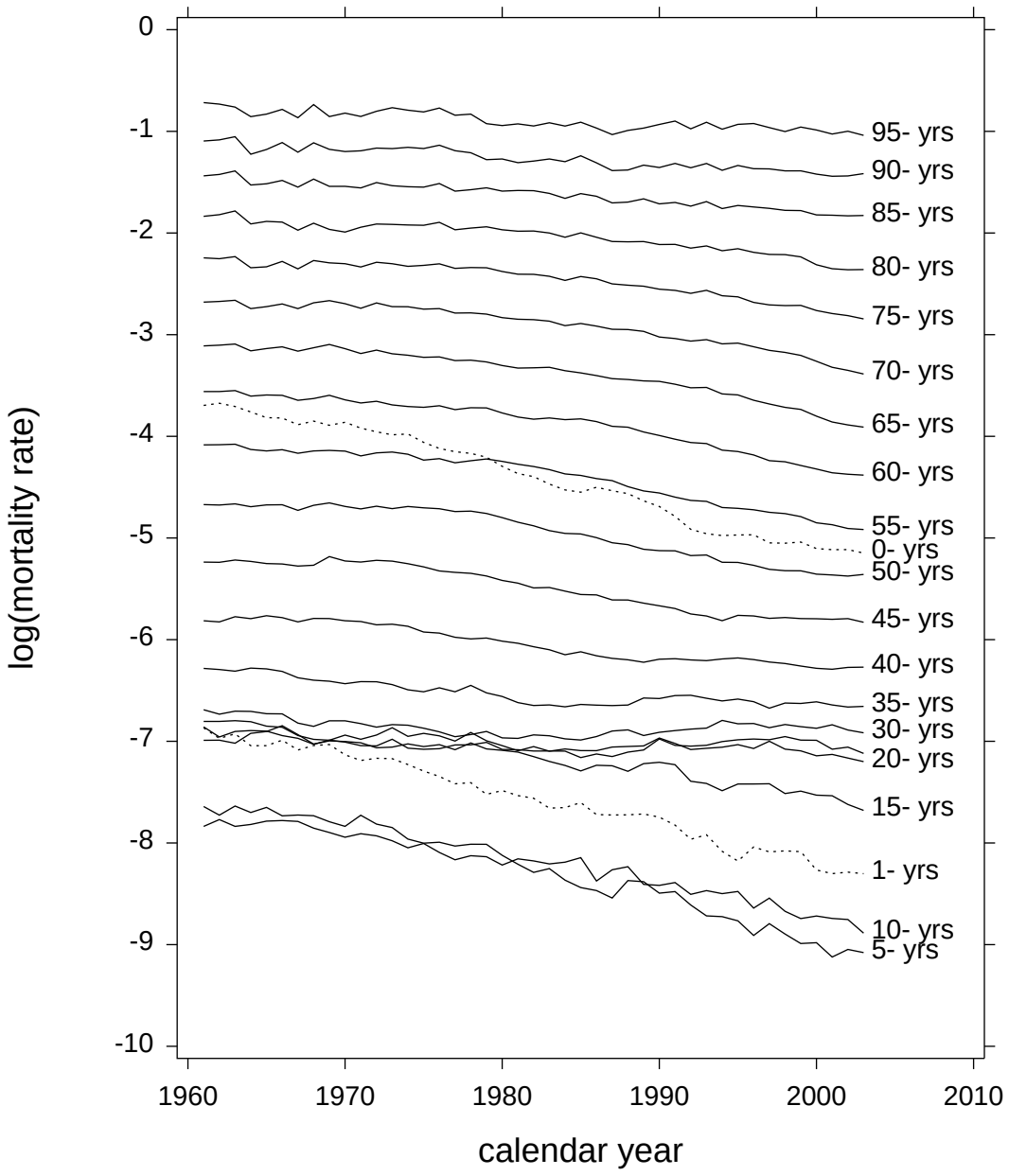
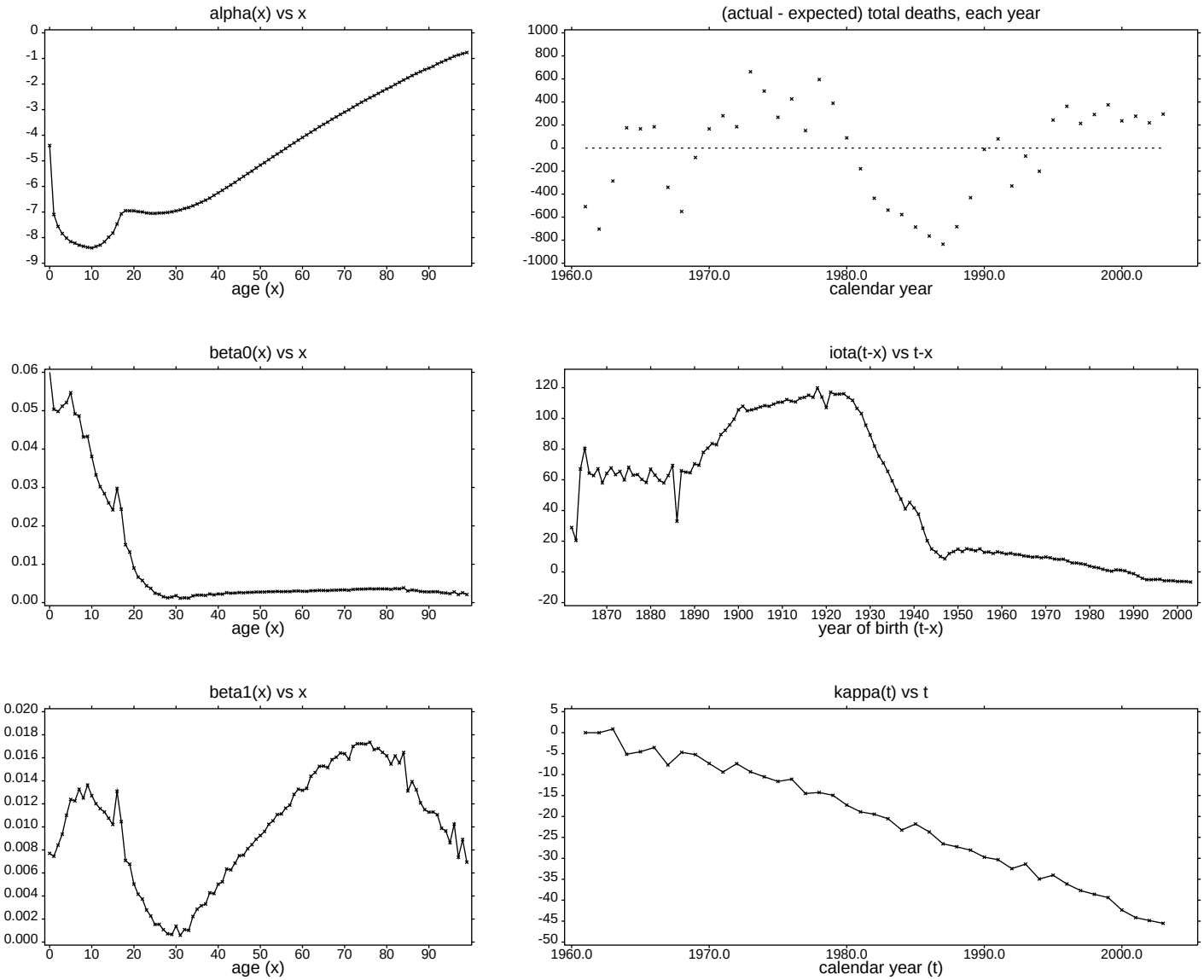


Fig 10. UK 1983-2003 male pensioner mortality experience (ages 51-104). Poisson LC: age-period (log- bilinear) structure, with period random walk. Comparison of life expectancy predictions (various age-period start points) based on 2.5, 50, 97.5 percentiles: (i) By theory. (ii) By bootstrapping the prediction error in the period component time series (Algorithm A5). (iii) By bootstrapping the time series prediction error and including model fitting simulated error (Algorithms A5A or A5C).


0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
log(mortality rate)
1960
1970
1980
1990
2000
2010
calendar year
95- yrs
90- yrs
85- yrs
80- yrs
75- yrs
70- yrs
65- yrs
60- yrs
55- yrs
0- yrs
50- yrs
45- yrs
40- yrs
35- yrs
30- yrs
20- yrs
15- yrs
1- yrs
10- yrs
5- yrs



(e) (f)

Fig 12. E+W 1961-2003 male mortality experience (ages 0-100). Poisson: age-period-cohort parametric structure. Parameter estimates: (a) age effect (as offset), (c) cohort adjustment term, (d) cohort effect, (e) period adjustment term, (f) period effect. Diagnostic: (b) marginal age differences.

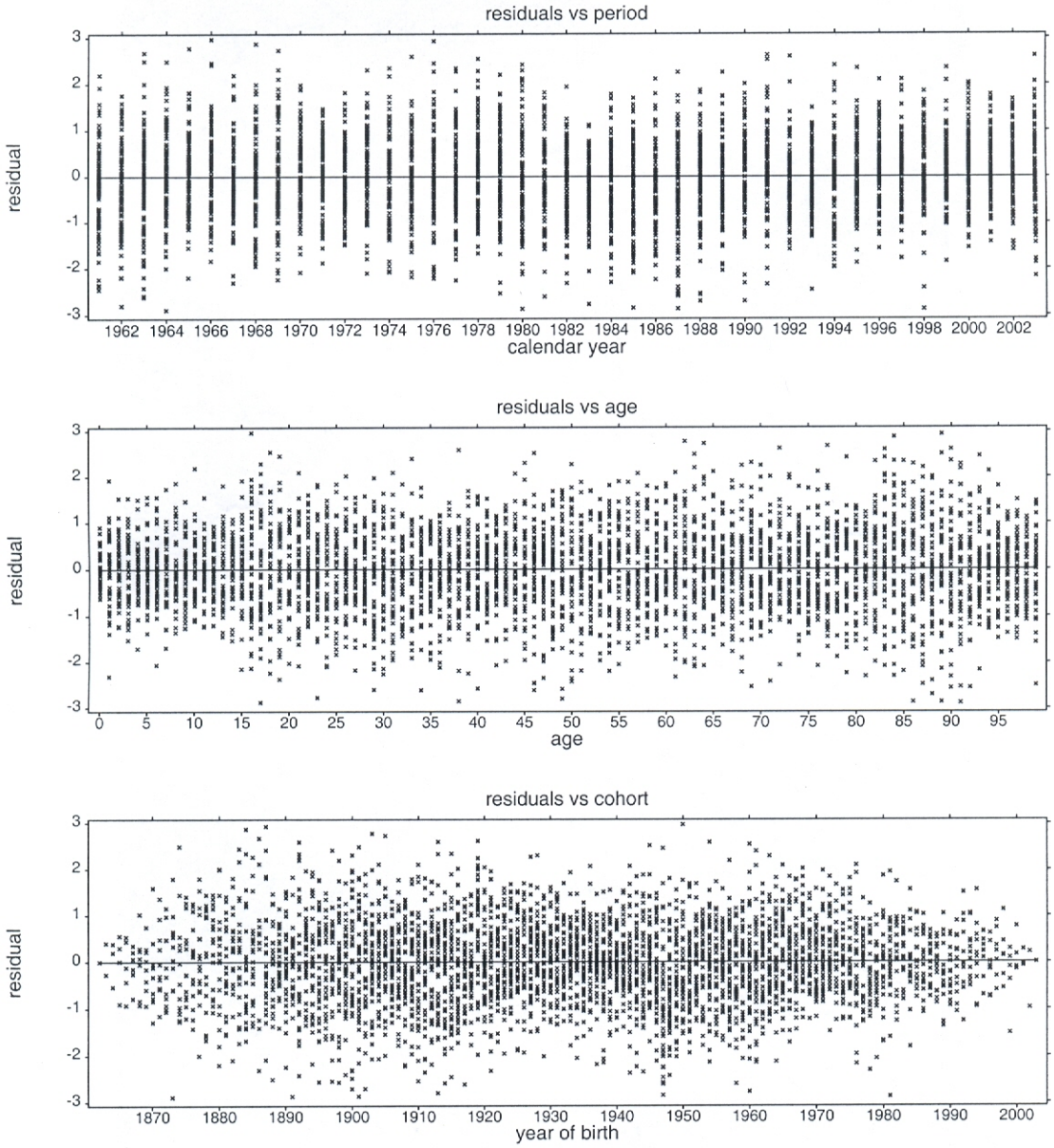
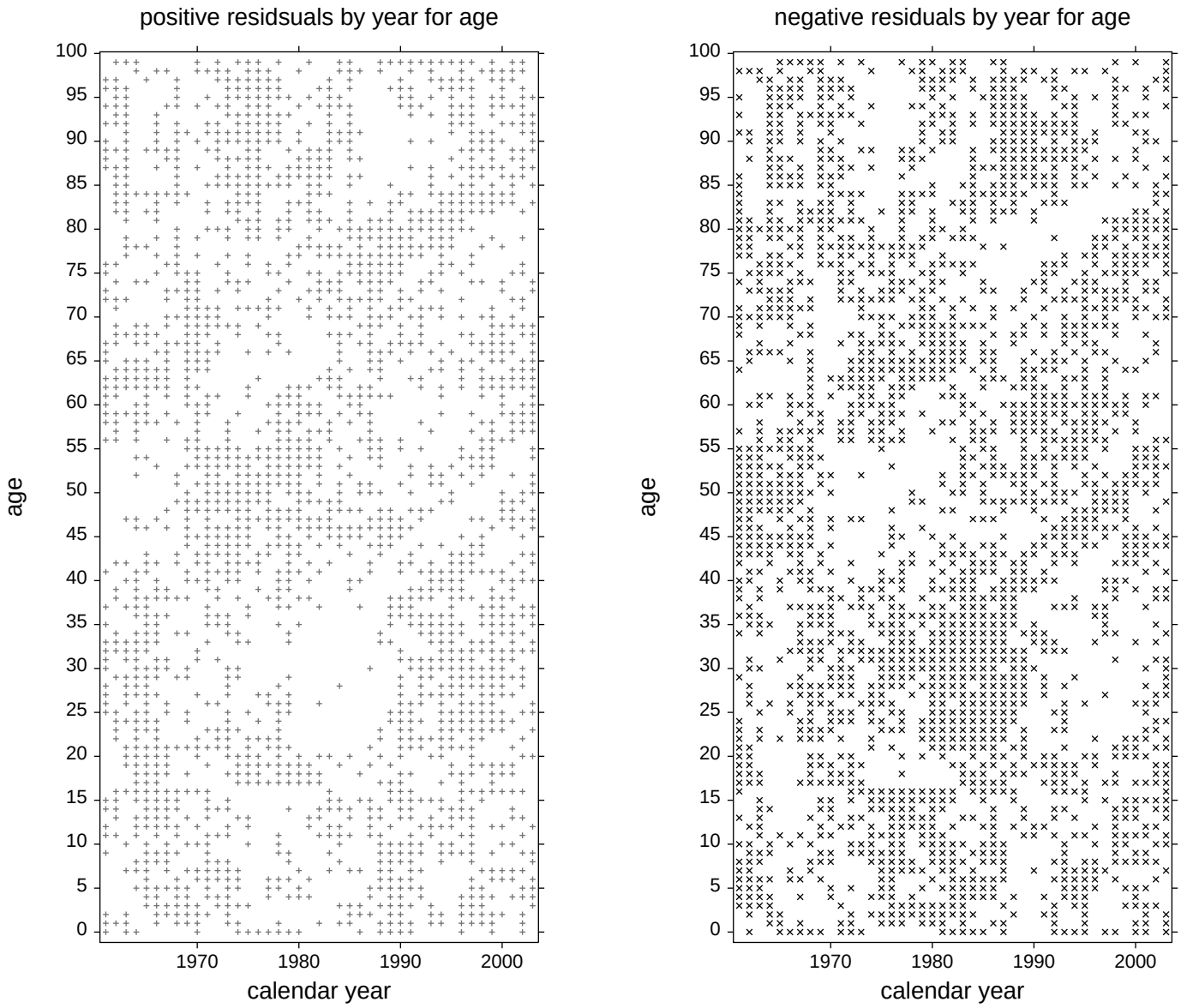
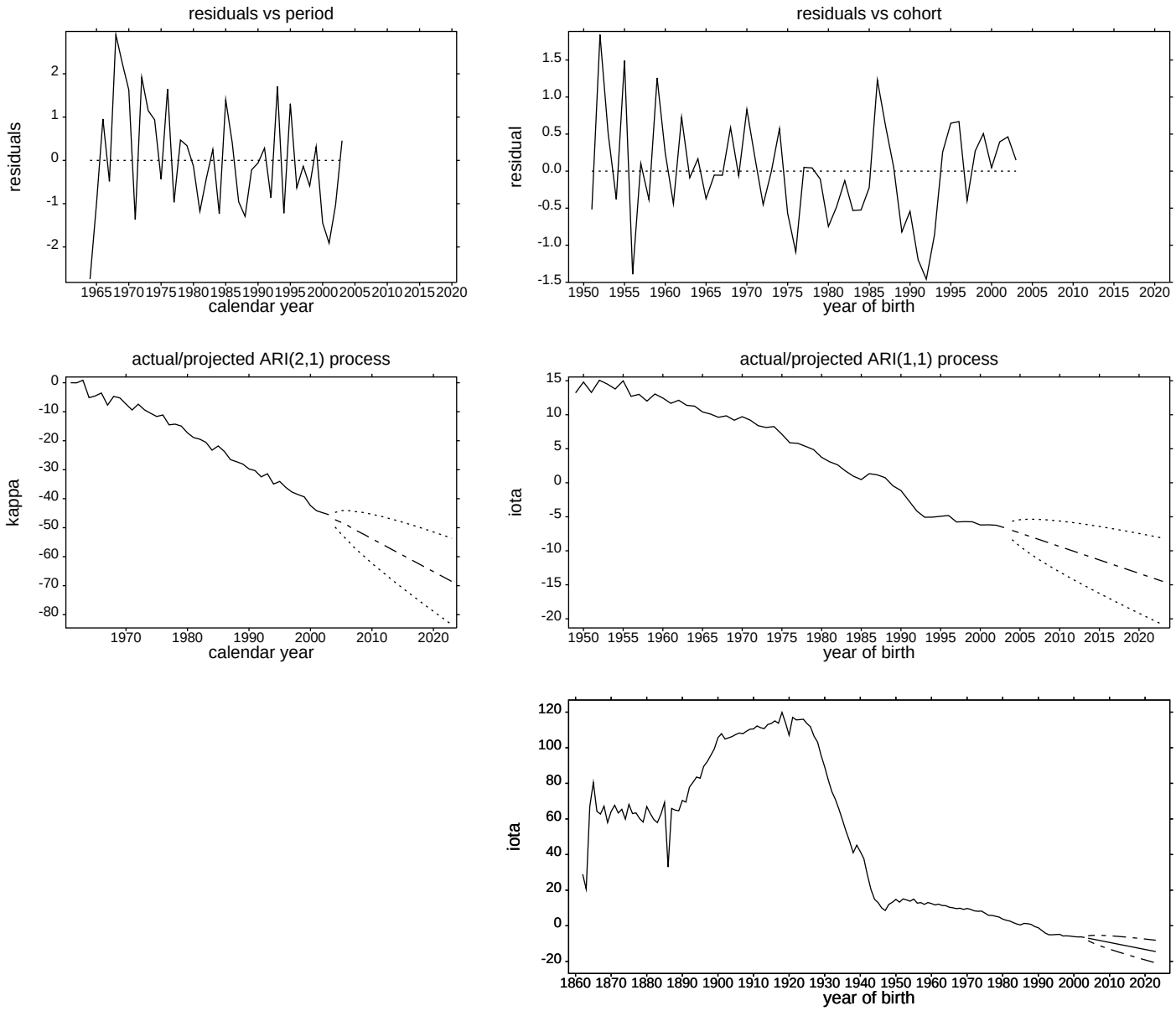


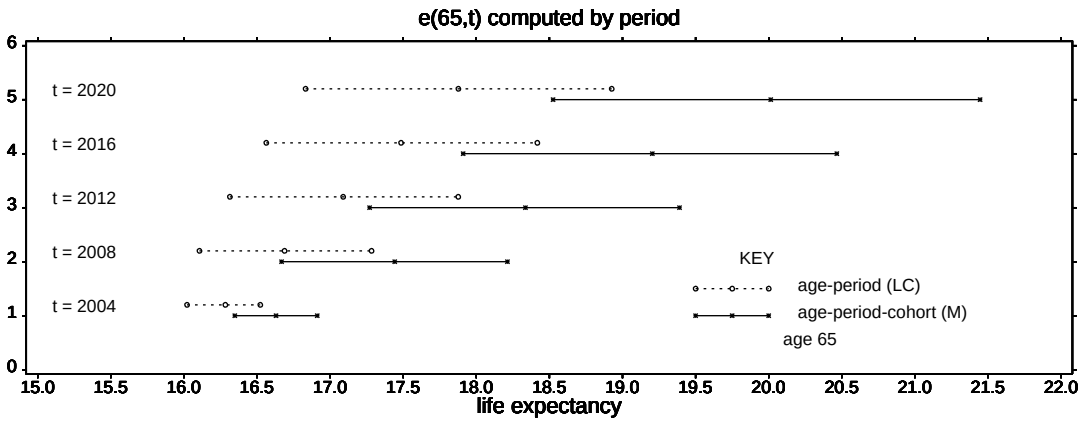
Fig 13a. E+W 1961-2003 male mortality experience (ages 0-100).
Poisson: age-period-cohort fitted parametric structure.
Deviance residual plots against (a) period, (b) age, (c) cohort.



Deviance residual plots: left frame- positives; right frame- negatives.



time series, and then restored.



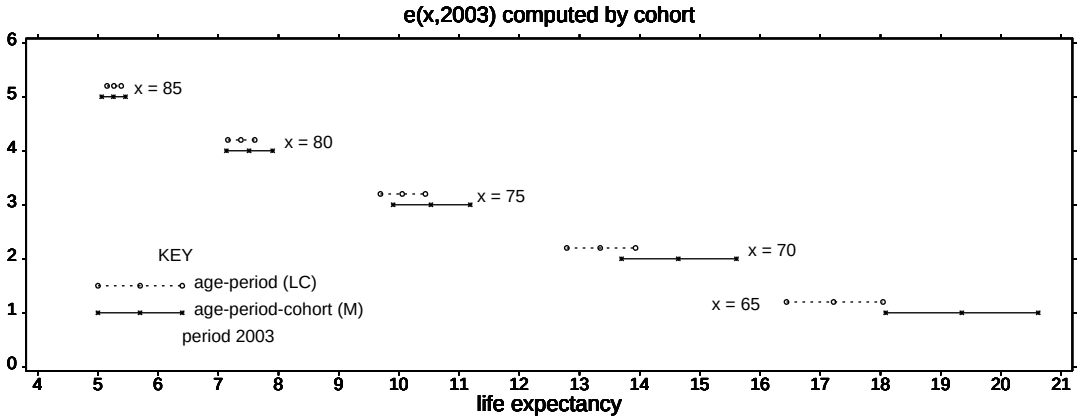
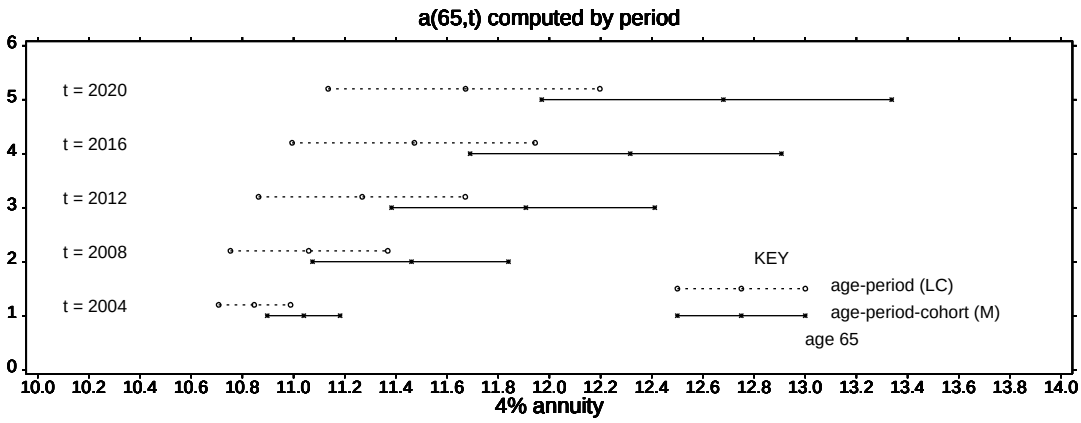


Fig 15a. E+W male mortality: comparison life expectancy predictions using (i) age-period-cohort and (ii) age-period Poisson structures. Predictions with intervals by bootstrapping the time series prediction error in the period (and cohort) components, and selecting the resulting 2.5, 50, 97.5 percentiles.



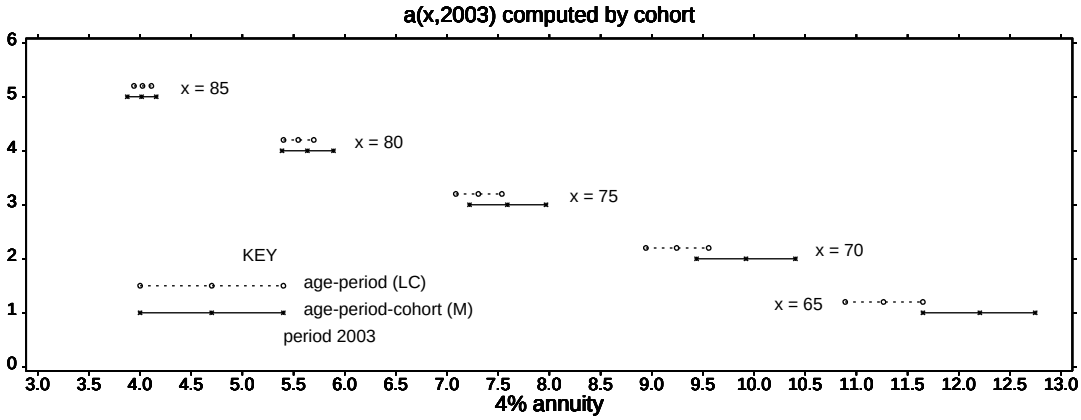


Fig 15b. E+W male mortality: comparison 4% fixed rate annuity predictions using (i) age-period-cohort and (ii) age-period Poisson structures. Predictions with intervals by bootstrapping the time series prediction error in the period (and cohort) components, and selecting the resulting 2.5, 50, 97.5 percentiles.