Adjusting for IBNR in Life Settlements Mortality using Cure Rate Models

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Overview

- A transaction in which a life policy is sold to a 3rd party
- Annual face value traded:
  - Secondary market: \$2-3 B.
  - Tertiary market: $\approx$ \$10 B
- Increasing academic interest in this area: Braun et al. (2015), RMI Review; Xu (2020), NAAJ
  - Practical issues arising out of life settlement underwriting
    - Certain aspects of current methodology are still evolving
    - Bauer et al. (2018); Lim and Shyamalkumar (2020)
    - IBNR deaths

Background of life settlements

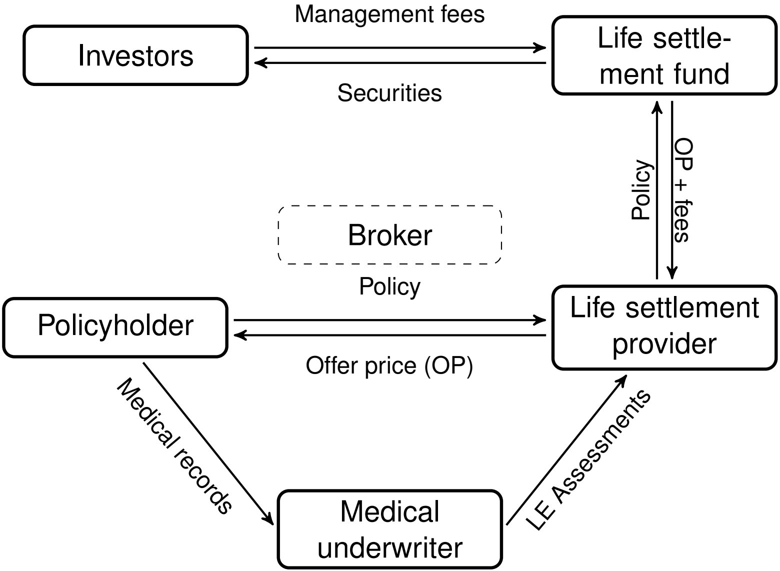
Legality: Grigsby v. Russell (1911)

- Life policy sold to Dr. Grigsby
- Challenged on grounds of insurable interest
- Eventual court ruling:
  - Insurable interest need not exist for assignment
  - To recognize a life policy as an asset requires allowing it to be sold

Senior life settlements

- Roots in 1980s market focusing on AIDS patients
- Cash surrender value tied to health at issue
    - Liquidity for those with deteriorated health
- Returns not tied to financial markets
- Industry focused on marketing

Participants in the life settlement market



Data issue for medical underwriters

- Underwriters need to mortality-track insureds for self assessment
- As a third party, generally lack access to insurer's or fund manager's data
- Primarily rely on public data (Behan, 2012)

Social Security Administration Death Master File

001010230HUNNEYMAN	GEORGE		1200197506121887
001010235LAMPRON	EDWARD	N	0517199012301906
001010236ROY	ANTHONY		0100197411201904
001010237GUIMOND	LEO	W	0409199601241915
001010239RITCHIE	HARRY		1100197304221895
001010240GUIMOND	ALBERT	J	V0913199609161913
001010243ERIAN	JENNIE		1000198505101903
001010244JOSEPHSON	ARTHUR		0200197709111908
001010246PIPER	HERBERT		1200195904241894
001010247APOSTAL	THEMIA		0900198312261907
001010248FOY	EDGAR	J	0618199406281899
001010250BAILEY	MELISSA	A	V0908200711171912
001010252SWEENEY	AGNES	E	V0329200010251902
001010258TAYLOR	JOSEPH		0500196705021877
001010262MURRAY	LILLIAN		0509199303231905
001010263GILBERT	VICTOR		0400196905061886
001010264STRAW	FRANK		0500196304281872
001010265STRAW	LUTHER		0500197306111912
001010268BACHELDER	CLARENCE		0700196702101879
001010269NICHOLS	STEPHEN		1200197912271894
001010271ELLIOTT	ERNEST		0400198002121894
001010273ANDERSON	EMIL		0100197707301896
001010276CRAIK	WILLIS		0100196903181903

Can we ignore IBNR?

Issues caused by ignoring IBNR

- Consider an age-80 cohort with 5000 insureds
  - IBNR of 10%, force of mortality double that of VBT 2015

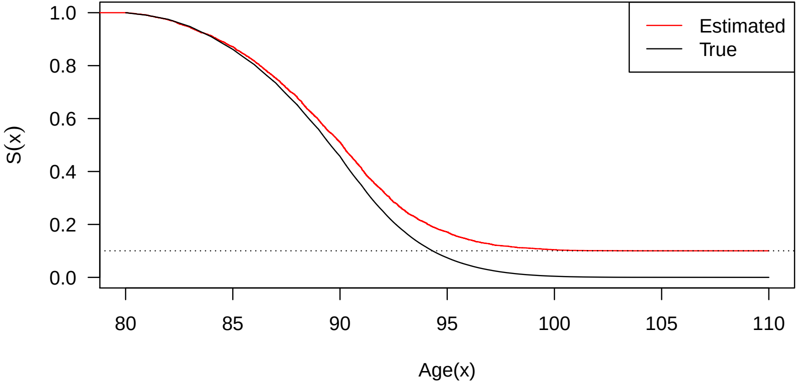


Figure: Estimated and true survival curves.

Annual death probabilities with IBNR

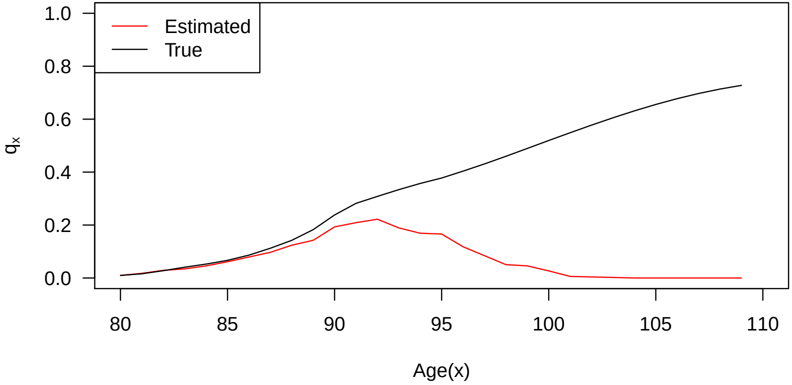


Figure: Estimated and true q_x's.

The crossover effect

- Cohort 2: IBNR 10%, follows VBT 2015

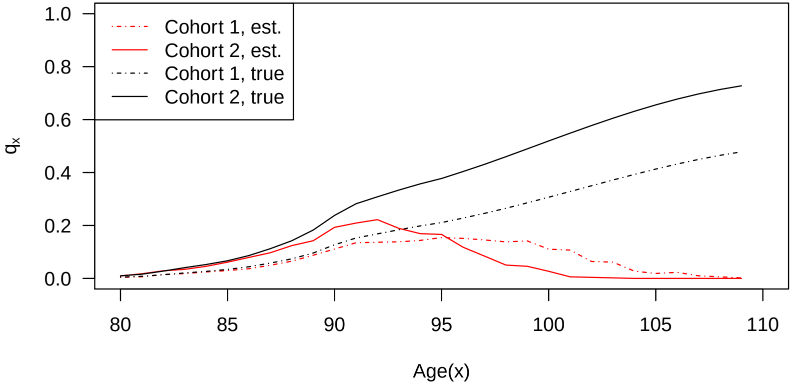


Figure: q_x's from the two cohorts.

Handling IBNR in practice

Extinct cohort method

- Data-driven approach
- Usable when it is reasonable that everyone has died by the end of the study period
- Number of people alive at given age is inferred from only those who have died

Survival curves: extinct cohort method

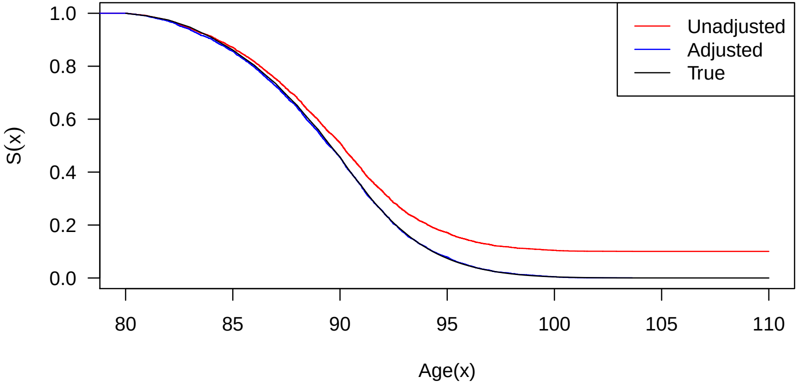


Figure: Estimated and true survival curves.

Annual death probabilities: extinct cohort method

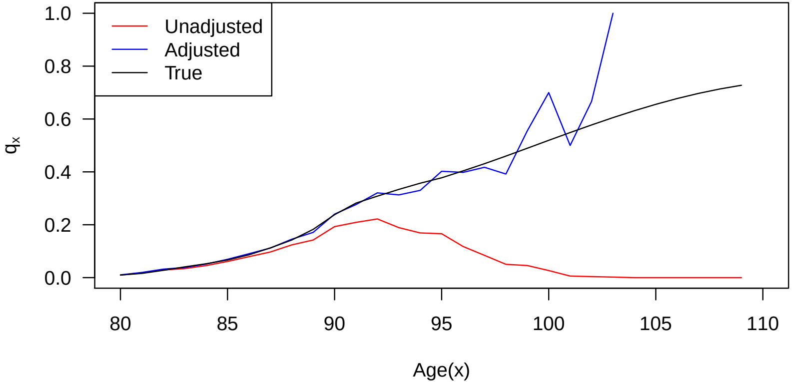


Figure: Estimated and true q_x's.

Extinct cohort method resolves crossover effect

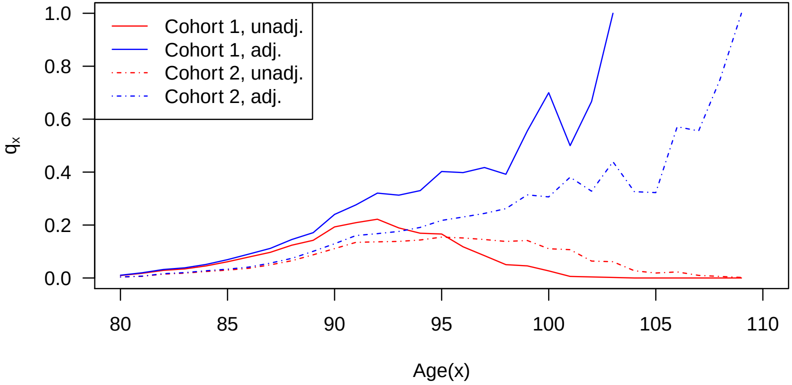


Figure: q_x's for the two cohorts.

Shortfalls of commonly used adjustments

- Actuarial judgement cannot account for emerging trends in data
- IBNR varies over the cohort
  - Risk level of insured (Behan, 2012)
  - Medical underwriter (Fasano, 2010)
- Mortality in life settlements tend to be heterogeneous
  - Extinct cohort methods (and its extensions) requires cohorts be similar in mortality
- Inherently problematic for self-assessments to be subjective

Our proposal

Pertinence of the Cox proportional hazards model

- Medical underwriters use a mortality multiplier λ to adjust a base reference table
- Cox model assumes, for some β and μ_0,

$$\mu_{\mathbf{z}}(x) = \underbrace{\exp(\mathbf{z}'\beta)}_{\lambda}\,\mu_0(x)$$

- Estimation of β does not require knowledge of μ_0
    - Utilized in Lim and Shyamalkumar (2020) to estimate life expectancies under limited information about λ
- Cumulative force of mortality is estimated through a Nelson-Aalen type estimator

IBNR model

- True time until death follows proportional hazards model
- Let u_i be the indicator that insured i's death is reported
  - If $u_i = 0$, insured apparently never dies
- Censoring based on apparent time until death
  - If uncensored, we can infer $u_i = 1$
- $\pi_i := Pr(u_i = 1|\mathbf{w}_i) = g^{-1}(\mathbf{w}_i'\gamma)$, where g is a link function

Our proposal

- Sy and Taylor (2000) and Peng and Dear (2000) propose the use of the EM algorithm to estimate this model in the absence of left-truncation
    - Our contribution: adapt their algorithm to our left-truncated setting
    - Focus of this talk is on aggregate setting
        - Easily extendable to select-and-ultimate

EM algorithm

- Expectation-maximization (EM) algorithm: an iterative procedure to obtain model estimates when
  - The original likelihood function is difficult to maximize
  - When augmented with some unobserved component the likelihood simplifies
- If u_i's were observed, the likelihood function is product of binary (e.g. logistic) regression and Cox regression likelihood

Intuition behind our methodology

- Recall extinct cohort method
  - Disregards information from censored observations
- Partial information is available from censored observations
  - $w_i = Pr(u_i = 1 | censoring\ time, \mathbf{z}_i, \mathbf{w}_i, parameters)$
- EM algorithm: estimate w_i and parameters alternately

Simulation study: survival component

- $n = 5000$ insureds.
- Mortality multipliers: $\lambda_i \sim Unif(1.5, 4.5)$.
- Baseline table: 2015 VBT ultimate.
- Ages at entry: $N(80, 5^2)$, truncated to $(70, 90)$.
- Censoring times: $Unif(0, 25)$.

Recall true death times follow $\mu_i = \lambda_i \cdot \mu^{VBT \cdot Ult}$.
Note $\beta = 1$: $\lambda_i = \exp(1 \cdot \log \lambda_i)$.

Simulation study: IBNR component

- $\pi_i = invlogit(\mathbf{w}_i'\gamma)$.
  - $\mathbf{w}_i = (1, \log\lambda_i, w_{2,i}, w_{3,i})$
  - $w_{2,i} \sim Categorical(0.4, 0.4, 0.2)$.
  - $w_{3,i} \sim Unif(0, 3)$.
  - $\gamma_0 = \gamma_1 = \gamma_3 = 1$
  - $\gamma_2^{(2)} = 0.5; \gamma_2^{(3)} = -0.5$
- Average IBNR $\approx 6\%$.

Simulation results

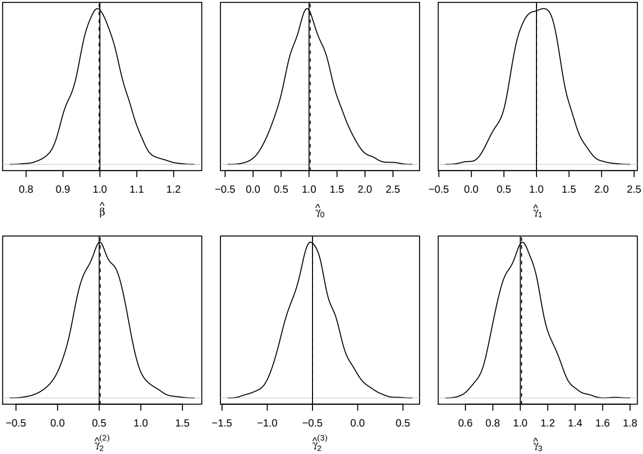


Figure: Simulation results based on 1000 replicates.

Estimated q_x's

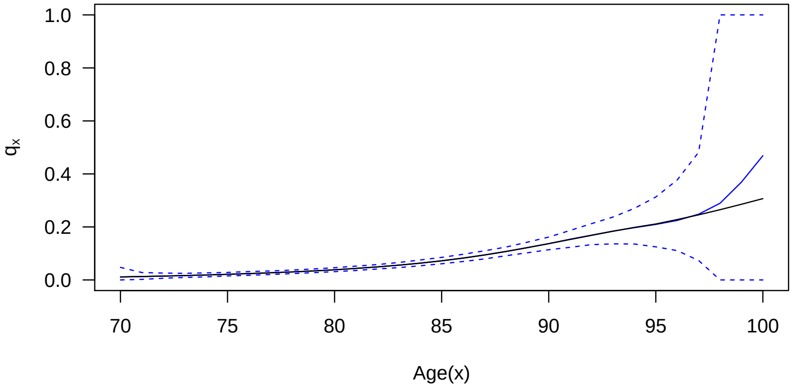


Figure: Mean estimated q_x's along with pointwise 2.5% and 97.5% quantiles; true values in black.

Concluding remarks

- Successfully adapted cure rate models to the actuarial setting
- To investigate more complex models based on real data
- To investigate models where IBNR rate changes over time
  - da Graca et al. (2013): Changes to DMF result in increase in IBNR rate post-2011


Thank you!

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