Life Insurance Mathematics: Home Assignment 3

Academic Year 2021-2022

UNIVERSITEIT VAN AMSTERDAM

Instructions for the Assignments

You should provide answers in Dutch or in English. You must use `R` for your calculations and graphics. You must use `R markdown` for reporting, see http://rmarkdown.rstudio.com/.

Deliverables for the Assignments

Please hand in on or before October 3, 2021 via `Canvas`:

1. An `R markdown` script that you have used for all your calculations. Your script should be well-organized and easy to read. Your text should be brief and guide the reader through your calculations. An example of an `R markdown` script is available on `Canvas`.
2. An `html` or `pdf` file that is the compiled version of your `R` markdown script. Relevant results should be printed in the `html` or `pdf` file.

Please mention the names and student numbers of your team members. You should work in teams (with two students minimum, and four students maximum); it suffices to submit one solution per team.

Motivation of the Assignment

In the lectures we covered the valuation principles for simple life insurance and annuity products. Now you will implement these valuation formulas in R and explore the sensitivity of the valuation of such products with respect to age and interest rate.

Assignment Questions

(1) You start with the DataCamp Chapters on Life Insurances and Life Annuities, see https://www.datacamp.com/courses/valuation-of-life-insurance-products-in-r.

- (Week 3) You watch the following videos (in this order) (from Chapter 4 on Life Insurances) 'The basics', 'The whole, temporary and deferred life insurance', and solve the exercises; (from Chapter 3 on Life Annuities) 'The basics', 'The whole, temporary and deferred life annuity' and 'Guaranteed payments'.
- (Week 4) You watch the following videos (in this order) (from Chapter 3 on Life Annuities) 'On premium payments and retirement plans' and (from Chapter 4 on Life Insurances) 'Combined benefits' and solve the exercises.

This is an individual assignment question, to be completed by each student.

(2) **(Makeham's mortality law)** Makeham's mortality law with $A = 0.00022$, $B = 2.7 \cdot 10^{-6}$, $c = 1.124$ implies

$$\begin{aligned} \mu_x &= A + Bc^x \qquad x \geq 0; \\ {}_tp_x &= \exp\left(-\int_0^t \mu_{x+r} dr\right) \\ &= s^t \cdot g^{c^x(c^t-1)}, \end{aligned}$$

where $s = e^{-A}$ and $g = \exp\left(-B/\log\left(c\right)\right)$.

(a) Verify the expression for ${}_tp_x$.

(b) Visualize the survival function $S_x(t) = {}_tp_x$ versus t for a set of ages x (of your choice).

(c) Create a life table using the q_x obtained from this mortality law.

To solve the following questions you will use Makeham's mortality law, as specified in DHW (Section 4.3 and the expressions for ${}_tp_x$ derived in Example 2.3 on page 41 in the 3rd edition of DHW).

(3) You design two different life insurance products (e.g. whole life insurance, term insurance, endowment insurance). You then calculate for each product the expected present value (EPV) of the product when sold to a life (x). Illustrate how the EPV changes with respect to age of the policyholder. Illustrate the sensitivity of the EPV with respect to the chosen interest rate. Discuss your findings.

(4) You design two different life annuity products. You then calculate for each product the expected present value (EPV) of the product when sold to a life (x). Illustrate how the EPV changes with respect to age of the policyholder. Illustrate the sensitivity of the EPV with respect to the chosen interest rate. Discuss your findings.

Katrien Antonio
Version September 2021.