

Life Insurance Mathematics: Home Assignment 4

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 17, 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.
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 discussed policy values as an essential in the risk management of an insurance company. Now you will implement a strategy to calculate these policy values in R for two standard life insurance products with annual cash flows, the term insurance and the endowment insurance.

Assignment Questions

- (1) **(Makeham's mortality law)** Similar to assignment 3, you will use Makeham's mortality law with $A = 0.00022$, $B = 2.7 \cdot 10^{-6}$, $c = 1.124$ implies

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

where $s = e^{-A}$ and $g = \exp(-B/\log(c))$. Create a life table using the q_x obtained from this mortality law. This is the Standard Ultimate Survival Model used in the DHW book (Appendix D). We will not incorporate selection effects.

Assume an interest rate of 5%, as in the DHW book.

- (2) Consider a 20-year term insurance purchased by a life aged 50. The sum insured, 500 000 EUR, is payable at the end of the year of death, if death occurs within the term of the contract.
- (2.1) Calculate the single premium for this policy.
- (2.2) With level premiums payable annually throughout the term of the policy, calculate the annual premium.

You will now illustrate how the insurer is able to build up assets during the course of the policy, as explained in the DHW book.

- (2.3) Calculate the excess of the annual premium over the EPV of the benefit payable at the end of the year for each year of this policy. Visualize your results as done in Figure 7.2 in the DHW book.

As a final step, you calculate the policy values ${}_tV$ for $t = 0, 1, \dots, 20$ for this policy.

- (2.4) Write down an expression for the policy values ${}_tV$ of the term insurance policy with annual level premiums. Calculate and visualize these values as done in Figure 7.4 in the DHW book.
- (2.5) Repeat question (2.4), for the single premium endowment policy. Plot ${}_tV$ versus t for single and level annual level premium on the same graph.