Health-linked life annuites: combining protection and retirement income

Ermanno Pitacco

University of Trieste

and

MIB Trieste School of Management

ermanno.pitacco@deams.units.it

CEPAR

27th Colloquiun on Pensions and Retirement Research

2-3 December 2019 - UNSW Sydney

Agenda

1. Introduction & motivation
2. Life annuity design on the move
3. Health-linked life annuities: a general framework
4. Actuarial issues
5. Concluding remarks

1 INTRODUCTION & MOTIVATION

In current scenarios, many “traditional” products in the field of life & health insurance:

- do not fit the individual needs
- imply severe risks for insurance companies (and pension funds)

Significant individual needs:

- ▷ post-retirement income (individual longevity risk)
- ▷ health-related protection, in particular at old and very old ages (expense risk and individual longevity risk)

Risks borne by the insurer:

- individual and aggregate longevity risk
- pricing and reserving risks due to
    - ▷ uncertainty in future mortality trends
    - ▷ poor statistical experience, in particular regarding high ages

Looking at recent trends and proposals

1. Life annuities:
   (a) from "investment" to longevity insurance $\Rightarrow$ *old-age life annuities*
   (b) extension of the rating principles $\Rightarrow$ *special-rate*, or *underwritten life annuities*
   (c) linking annuity benefits to aggregate longevity experience $\Rightarrow$ *longevity-linked life annuities*
2. Long-term Care Insurance (LTCI): from stand-alone to *combo products*, e.g. including lifetime-related benefits

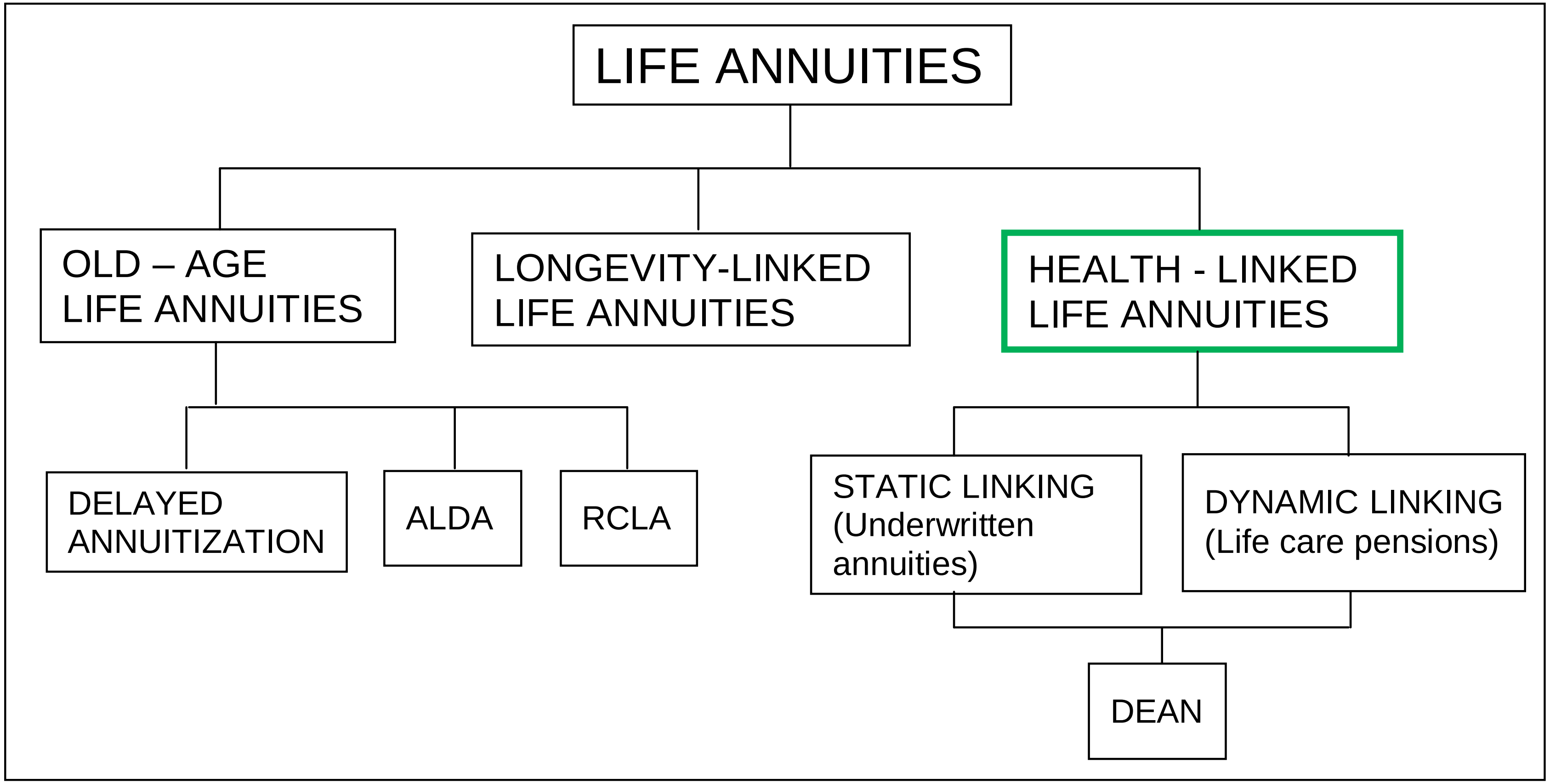
Note that:

- Approach 1(a) $\Rightarrow$ restriction of the coverage (time frame)
- Approach 1(c) $\Rightarrow$ possible reduction of the coverage (amount)
- Approach (2) $\Rightarrow$ extension of the coverage (more needs)
- Approaches 1(b) and (2) $\Rightarrow$ possible implementation via *health-linked life annuities*

All the above trends and proposals should carefully be analyzed, also to capture new opportunities in product design

Main aim of this presentation: to provide a general framework, hopefully useful in exploring the broad (and evolving) range of recent or innovative products

2 LIFE ANNUITY DESIGN ON THE MOVE



How to design more attractive life annuities

Old-age life annuities

From life annuity as an investment to longevity insurance (with a "deductible")

- delayed annuitization
  - ▷ initial retirement period: drawdown from a fund
  - ▷ life annuity as insurance on the tail of the lifetime distribution
- ALDA (Advanced Life Delayed Annuity), proposed by Milevsky [2005]
- RCLA (Ruin Contingent LIfe Annuity), proposed by Huang et al. [2009]

Longevity-linked life annuities

Annual benefit linked to longevity experience (e.g., in a reference population)

Longevity risk sharing between annuity provider and annuitant
$\Rightarrow$ lower safety loading $\Rightarrow$ better premium rates

A number of linking models proposed in the actuarial literature: see Olivieri and Pitacco [2019] and references therein

Remark

For a survey on technical aspects in life annuity products, see for example: Pitacco [2016a, 2017], and references therein

Among the earliest proposals of innovation in life annuity design, see for example: Wadsworth et al. [2001]

Health-linked life annuities

In the area of life & health insurance products

- immediate standard life annuities, and
- stand-alone long-term care insurance (LTCI) products

implement two "extreme" product designs, both with significant difficulties, from the client's as well as the insurer's perspective:

- ▷ life annuities: the "annuity puzzle" !
- ▷ stand alone LTCI: high premium for a "pure protection" product

Health-linked life annuities constitute "hybrid" (or "combo") products which can mitigate risks and disadvantages

3 HEALTH-LINKED LIFE ANNUITIES: A GENERAL FRAMEWORK

Our target:

- to recognize existing products and analyze their relevant features
- to provide hints for (possible) new products

Basic feature of a health-linked life annuity: for a given (single) premium Π, the benefit amount $B(t)$ (either constant or varying throughout the policy duration) depends on the annuitant's health status (either at policy issue or throughout his/her lifetime)

In formal terms, the annuitant's health status can be represented by a stochastic process

$$\{H(t); t \geq 0\}$$

to be defined in terms of:

▷ values (e.g., in LTCI via ADL's or IADL's scoring)

▷ probabilistic structure (e.g., Markov or semi-Markov)

Examples of annuity products in the following

STANDARD LIFE ANNUITY (FLAT PROFILE)

$$B(t) = B = \frac{\Pi}{\ddot{a}_x} = f(\Pi);\;\; t = 1, 2, \ldots$$

where Π = single premium

Health status not explicitly considered, but assumed very good
($\Rightarrow$ annuitants' self-selection)

ANNUITIES WITH STATIC HEALTH-LINKING

$$B(t) = B = \phi(\mathit{\Pi}, H(0)); \;\; t = 1, 2, \dots$$

Underwritten ("special-rate") life annuity (flat profile)

The health status at policy issue is accounted for via underwriting

Purpose:

$$\phi(\mathit{\Pi}, H(0)) > f(\mathit{\Pi})$$

$\Rightarrow$ better annuity rate, in case of non-optimal health conditions

Classification (according to increasing severity):

- Enhanced life annuities
- Impaired-life annuities
- Care annuities

ANNUITIES WITH DYNAMIC HEALTH-LINKING

$$B(t) = \psi(\mathit{\Pi}, H(t)); \;\; t = 1, 2, \ldots$$

Several examples, with related definitions of the health status, in particular:

- LTC annuities
  - ▷ stand-alone and combo products
- Disability annuities (e.g. Income Protection)
  - ▷ possibly degree-related

Focus on LTC annuities

Stand-alone LTC degree-related annuity

$$B(t) = \begin{cases} 0 & \text{if } H(t) = \text{good} \\ b^{(1)} & \text{if } H(t) = \text{bad} \\ b^{(2)} & \text{if } H(t) = \text{very bad} \end{cases}$$

Health status expressed in terms of ADL's or IADL's

Problem: high sensitivity of actuarial values (premiums and reserves) w.r.t. biometric assumptions (disablement, possible recovery, mortality of disabled people)

Enhanced pension (or life care pension)

$$B(t) = \begin{cases} b' & \text{if } H(t) = \text{good} \\ b'' & \text{if } H(t) = \text{bad} \end{cases}$$

The uplift $b'' - b'$ can be financed by a reduction w.r.t. the basic pension

Advantage: lower sensitivity w.r.t. biometric assumptions

LTC annuity combined with old-age life annuity

$$B(t) = \begin{cases} b & \text{if } H(t) = \text{good} \wedge (t \geq t^*) \\ b' & \text{if } H(t) = \text{bad} \end{cases}$$

e.g., $t^* = 80$

An example of combo product, providing longevity insurance $\Rightarrow$ LTCI combined with ALDA

The disability state is assumed permanent $\Rightarrow$ the two benefits are mutually exclusive

A death benefit can be added ($\Rightarrow$ bequest motivation)

A NEW PROPOSAL

Combining *static linking* and *dynamic linking* can suggest interesting product designs

Doubly enhanced annuity

Formally, benefit given by:

$$B(t) = \Phi\big(\mathit{\Pi}, H(0), H(t)\big); \;\; t = 1, 2, \dots$$

Proposed by Ramsey and Oguledo [2019]

4 ACTUARIAL ISSUES

OUTLINE

Assume that an insurer is willing:

- to enlarge its life annuity portfolio by selling underwritten annuities (static health-linking)
  - ▷ higher heterogeneity, partially observable via proxies provided by underwriting results
  - ▷ larger portfolio size $\Rightarrow$ better diversification via pooling (as regards idiosyncratic risk)
  - ▷ what about the “balance” ?
- to sell LTCI products (dynamic health-linking)
  - ▷ uncertainty in biometric bases
  - ▷ what is the impact of “wrong” biometric bases on actuarial values (premiums and reserves), according to the product design ?
  - ▷ sensitivity analysis to assess the impact

IMPACT OF UNDERWRITTEN LIFE ANNUITIES ON THE PORTFOLIO RISK PROFILE

Risk classification based on a frailty model

A (potential) heterogeneous population split into classes (groups) of individuals with similar risk profile $\Rightarrow$ each class with reduced heterogeneity (w.r.t. heterogeneity in the population)

Biometric assumption: constant multiplicative frailty model in terms of the force of mortality

$$\mu_x(z) = z\,\mu_x$$

For each individual i the frailty is a random variable $Z_x^{(i)}$

Assess approximately the individual frailty via medical examination (step of the underwriting process)

Define the group j, $j = 1, 2, \ldots, J$, as follows:

$$G_j = \{i : z_{j-1} < Z_x^{(i)} \leq z_j\}$$

The probability distribution of the frailty in any given group can be assessed as a conditional distribution of the frailty for the whole population

Given the frailty distribution in group G_j and the survival function in the population, the survival function in group G_j can be derived
$\Rightarrow$ calculation of relevant actuarial values

Note: residual unobservable heterogeneity inside each group because of frailty

Numerical investigation

Group	Frailty interval $(z_{j-1}, z_j]$	Relative size at age 65 of group G_j in the general population $\rho_{j;65}$	Expected value of the frailty $\mathbb{E}[Z_{65}\|G_j]$	Coefficient of variation $\mathbb{CV}[Z_{65}\|G_j]$	Expected lifetime $\mathbb{E}[T_{65}\|G_j]$
G_1	$(0, 1.038741]$	60.121%	0.845593	15.243%	22.81
G_2	$(1.038741, 1.307144]$	30.111%	1.152338	6.479%	20.36
G_3	$(1.307144, \infty)$	9.769%	1.445866	8.736%	18.71
Population	$(0, \infty)$	100%	0.996594	23.308%	21.67

Groups (= Risk classes)

We consider six alternative portfolios (see Table):

- portfolios A - E differ for the size of groups G_2 and G_3, and possibly the total portfolio size
- portfolio F has the same size of A, but a different composition

Groups	**Portfolio**					
	A	**B**	**C**	**D**	**E**	**F**
G_1	1 000	1 000	1 000	1 000	1 000	500
G_2	0	200	250	200	501	500
G_3	0	0	0	50	162	0
All	1 000	1 200	1 250	1 250	1 663	1 000

Size and composition of alternative portfolios

Results presented in terms of present value of future benefits PV_t paid by the annuity provider, and in particular, to assess the risk profile in terms of:

- ▷ probability distribution (via stochastic simulation)
- ▷ coefficient of variation (risk index)

$$\mathbb{CV}[PV_t] = \frac{\sqrt{\mathbb{V}\mathrm{ar}[PV_t]}}{\mathbb{E}[PV_t]}$$

Time t	Portfolio A	Portfolio B	Portfolio C	Portfolio D	Portfolio E	Portfolio F
0	1.30%	1.20%	1.17%	1.18%	1.04%	1.87%
5	1.48%	1.37%	1.34%	1.35%	1.19%	1.55%
10	1.75%	1.62%	1.60%	1.60%	1.39%	1.80%
15	2.10%	1.96%	1.91%	1.93%	1.70%	2.19%
20	2.64%	2.45%	2.41%	2.43%	2.17%	2.80%
25	3.55%	3.34%	3.31%	3.31%	3.04%	3.97%
30	5.62%	5.38%	5.32%	5.35%	4.96%	6.54%
35	11.10%	10.78%	10.78%	10.73%	10.28%	13.82%
40	32.19%	32.19%	32.19%	32.19%	31.40%	44.42%
45	136.25%	136.25%	136.25%	136.25%	136.25%	

Coefficient of variation of the present value of future benefits: $\mathbb{CV}[PV_t]$

Main findings and related interpretations

- Portfolio F: the highest riskiness
- Comparing F to A: same size, but in F more heterogeneity (groups G_1 and G_2) not counterbalanced by larger size $\Rightarrow$ higher riskiness
- Portfolio E: high heterogeneity (groups G_1, G_2 and G_3) counterbalanced by the largest size $\Rightarrow$ lowest riskiness, even lower than portfolio A, thanks to larger size

▷ Higher degrees of heterogeneity $\Rightarrow$ higher risk profile

▷ If matched by larger total portfolio size, risk profile can benefit from portfolio diversification (pooling effect)

For details, see: Olivieri and Pitacco [2016]

LTCI: A SENSITIVITY ANALYSIS

Uncertainty in technical bases, in particular biometric assumptions:

- probability of disablement, i.e. prob. of entering LTC state
- mortality of disabled people, i.e. mortality in LTC state

The following products addressed in the sensitivity analysis (see: Pitacco [2016b])

Stand-alone LTCI

(Product P1)

LTCI benefit: a lifelong annuity with predefined annual amount, from the LTC claim on

LTCI as an acceleration benefit in a whole-life assurance

(Product P2(s))

Annual LTC benefit = $\dfrac{\text{sum assured}}{s}$, paid for s years at most

Package including LTC benefits and lifetime-related benefits

(Products P3a($x+n$) and P3b($x+n$))

Benefits:

(I) a lifelong LTC annuity, from the LTC claim on

(II) a deferred life annuity from age $x+n$ (e.g. $x+n=80$), while the insured is not in LTC disability state

(III) a lump sum benefit on death, alternatively given by

- (IIIa) a fixed amount, stated in the policy
- (IIIb) the difference (if positive) between a fixed amount and the total amount paid as benefit 1 and/or benefit 2

Benefits (I) and (II) are mutually exclusive

Enhanced pension (Life care pension)

(Product P4(b', b''))

LTC annuity benefit defined as an uplift with respect to the basic pension b

Uplift financed by a reduction (with respect to the basic pension b) of the benefit paid while the policyholder is healthy

- ▷ reduced benefit b' paid as long as the retiree is healthy
- ▷ uplifted lifelong benefit b'' paid in the case of LTC claim

Of course, $b' < b < b''$

Remark

For details on LTCI products, see for example: Pitacco [2014], and references therein

Biometric functions (needed)

Three-state model, one LTC state, no recovery

For an active (healthy) individual age x:

$q_x^{aa} =$ prob. of dying before age $x+1$

$w_x =$ prob. of becoming invalid (disablement, i.e. LTC claim) before age $x+1$

For an invalid (in LTC state) age x:

$q_x^{i} =$ prob. of dying before age $x+1$

Remark

No dependence on time elapsed since disability inception is allowed for

$\Rightarrow$ a Markov chain model is then adopted

Assumptions

q_x^{aa}: life table (first Heligman-Pollard law)

w_x: a specific parametric law

$q_x^i = q_x^{aa} +$ extra-mortality (i.e. additive extra-mortality model)

Life table

First Heligman-Pollard law:

$$\frac{q_x^{aa}}{1 - q_x^{aa}} = a^{(x+b)^c} + d\,\mathrm{e}^{-e\,(\ln x - \ln f)^2} + g\,h^x$$

In practice the following approximation can be used:

$$q_x^{aa} \approx \frac{g\,h^x}{1 + g\,h^x}$$

a	b	c	d	e	f	g	h
0.00054	0.01700	0.10100	0.00014	10.72	18.67	$2.00532\,\mathrm{E}{-06}$	1.13025

The first Heligman-Pollard law: parameters

$\mathring{e}_0$	$\mathring{e}_{40}$	$\mathring{e}_{65}$	Lexis	q_0^{aa}	q_{40}^{aa}	q_{80}^{aa}
85.128	46.133	22.350	90	0.00682	0.00029	0.03475

The first Heligman-Pollard law: some markers

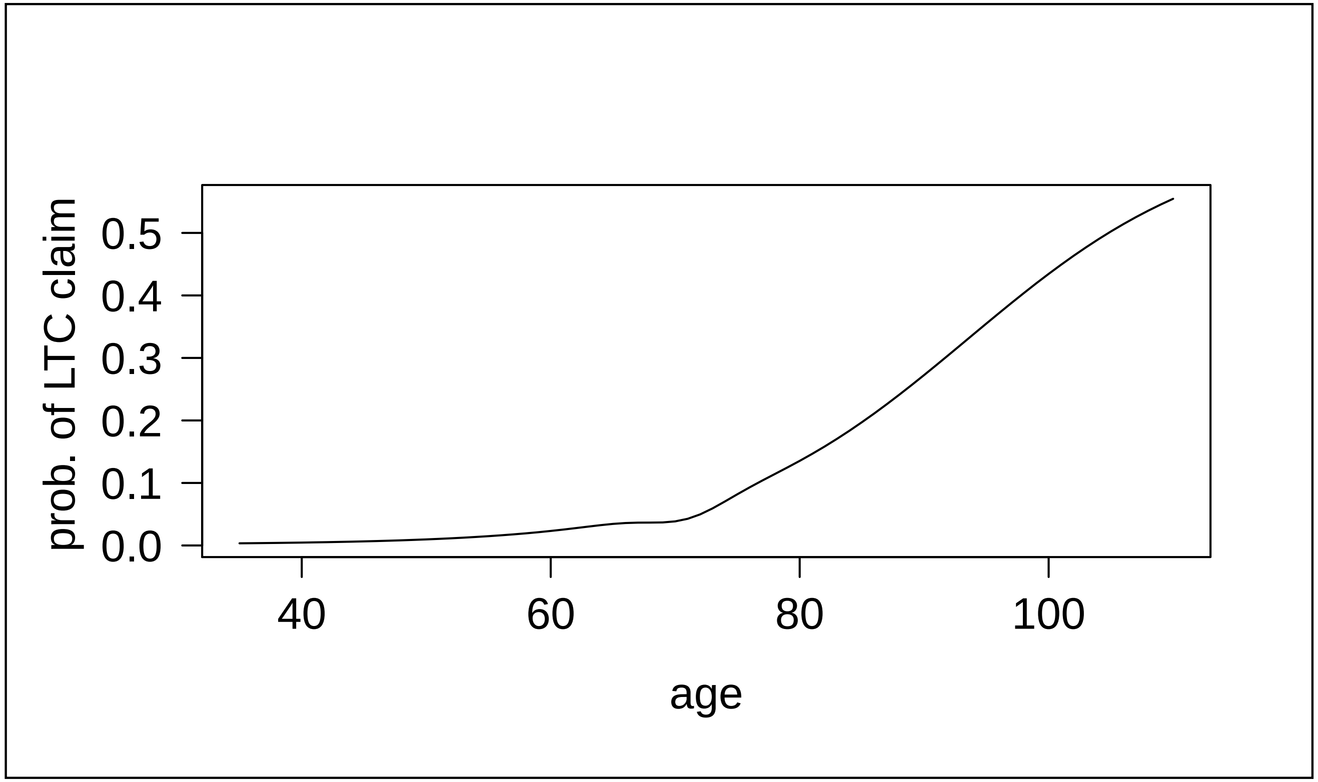
Disablement (LTC claim)

Assumption by Rickayzen and Walsh [2002]:

$$w_x = \begin{cases} A + \dfrac{D-A}{1+B^{C-x}} & \text{for females} \\[2ex] \left(A + \dfrac{D-A}{1+B^{C-x}}\right)\left(1 - \dfrac{1}{3}\exp\left(-\left(\dfrac{x-E}{4}\right)^2\right)\right) & \text{for males} \end{cases}$$

Parameter	Females	Males
A	0.0017	0.0017
B	1.0934	1.1063
C	103.6000	93.5111
D	0.9567	0.6591
E	n.a.	70.3002

Parameters Rickayzen-Walsh



Probability of disablement (Males)

Extra-mortality

Assumption by Rickayzen and Walsh [2002]:

$$q_x^{i^{(k)}} = q_x^{[\mathrm{standard}]} + \Delta(x, \alpha, k)$$

with:

$$\Delta(x, \alpha, k) = \frac{\alpha}{1 + 1.1^{50-x}} \, \frac{\max\{k-5, 0\}}{5}$$

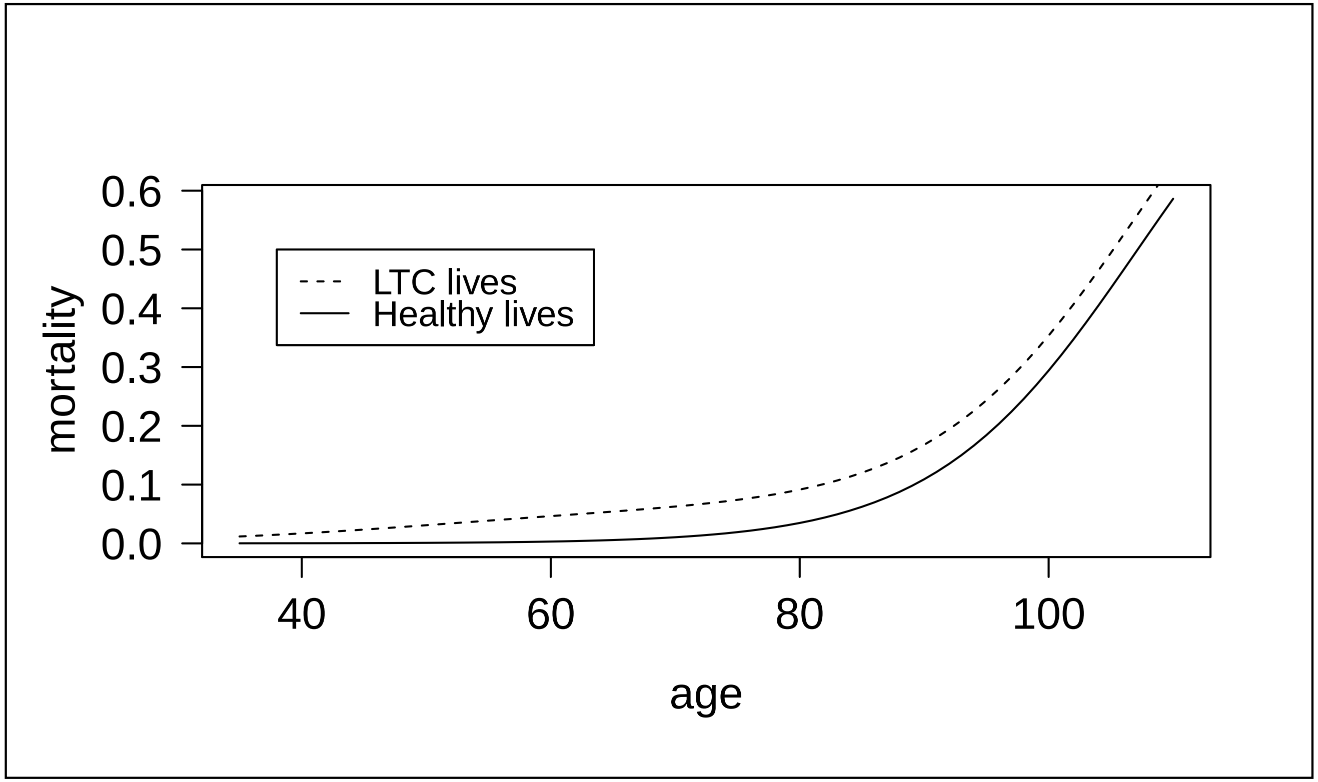
where:

- parameter k expresses LTC severity category
  - ▷ $0 \leq k \leq 5 \;\Rightarrow$ less severe $\Rightarrow$ no impact on mortality
  - ▷ $6 \leq k \leq 10 \;\Rightarrow$ more severe $\Rightarrow$ extra-mortality
- parameter α (assumption by Rickayzen [2007])

$\alpha = 0.10$ if $q_x^{[\mathrm{standard}]} = q_x^{aa}$ (mortality of insured healthy people)

Our (base) choice: $\alpha = 0.10$, $k = 8$; hence:

$$q_x^i = q_x^{aa} + \Delta(x, 0.10, 8) = q_x^{aa} + \frac{0.06}{1 + 1.1^{50-x}}$$



Mortality assumptions (Males)

Sensitivity analysis concerning:

- probability of disablement, i.e. entering into LTC state
- extra-mortality of insureds in LTC state

Notation:

$\Pi_x^{[\mathrm{PX}]}(\delta, \lambda)$ = actuarial value (single premium) of product PX, according to the following assumptions:

- $\delta \;\Rightarrow\;$ disablement

$$\bar{w}_x(\delta) = \delta\, w_x$$

  where w_x is given by the previous Eq. (assumption by Rickayzen and Walsh [2002])

- $\lambda \;\Rightarrow\;$ extra-mortality

$$\bar{\Delta}(x;\lambda) = \lambda\, \Delta(x, \alpha, k) = \Delta(x, \lambda\, 0.10, 8)$$

  and hence:

$$q_x^i(\lambda) = q_x^{aa} + \bar{\Delta}(x;\lambda)$$

For products P1, P2, P3, normalize and define the ratio:

$$\rho_x^{[\mathrm{PX}]}(\delta, \lambda) = \frac{\mathit{\Pi}_x^{[\mathrm{PX}]}(\delta, \lambda)}{\mathit{\Pi}_x^{[\mathrm{PX}]}(1, 1)}$$

For product P4, with given b and b'', normalize and define the ratio:

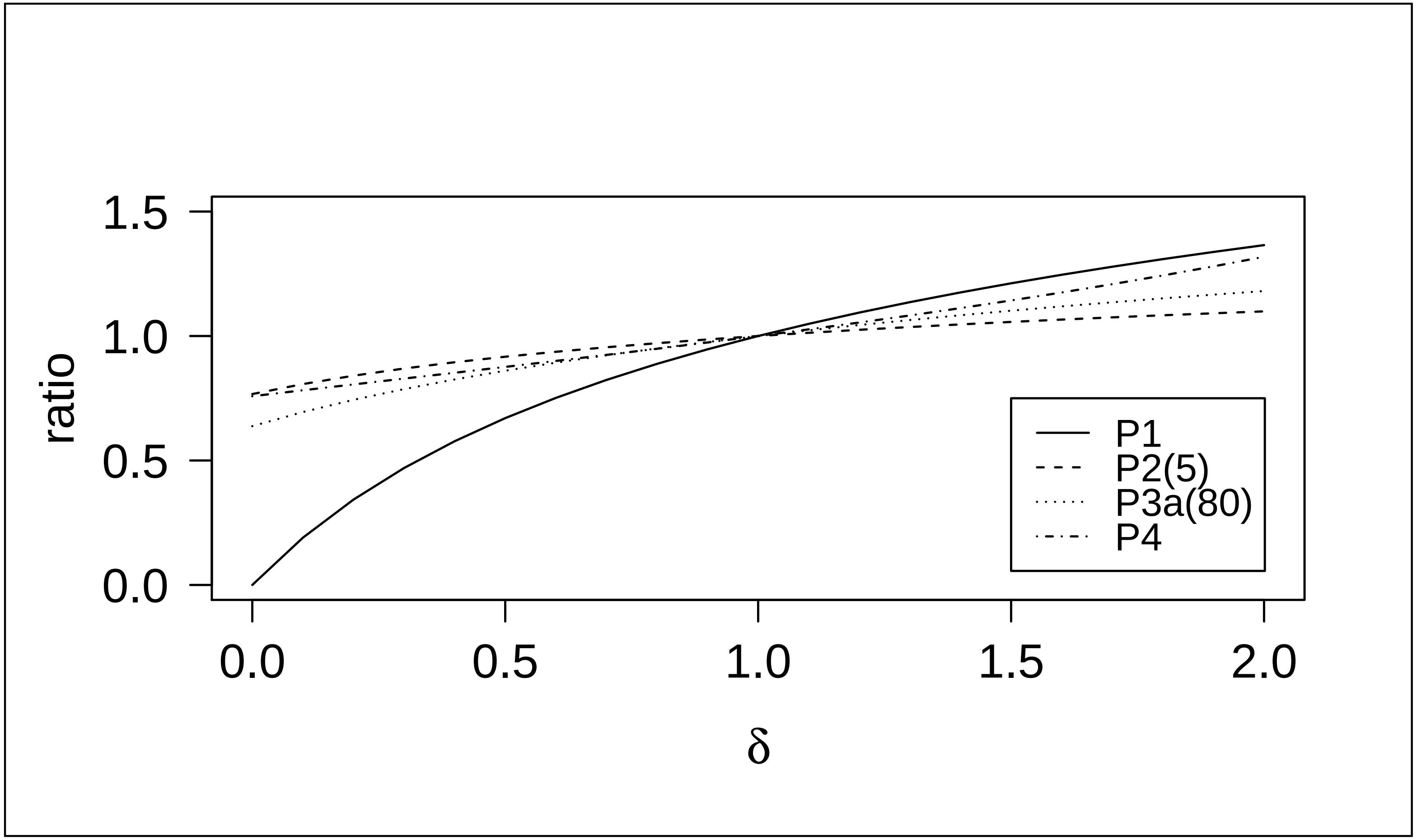
$$\rho_x^{[\mathrm{P4}]}(\delta, \lambda) = \frac{b'(1, 1)}{b'(\delta, \lambda)}$$

For all the products, we first perform *marginal* analysis, i.e. tabulating the functions:

$\mathit{\Pi}_x^{[\mathrm{PX}]}(\delta, 1)$ for P1, P2, P3, $b'(\delta, 1)$ for P4; $\rho_x^{[\mathrm{PX}]}(\delta, 1)$ for P1, P2, P3, P4

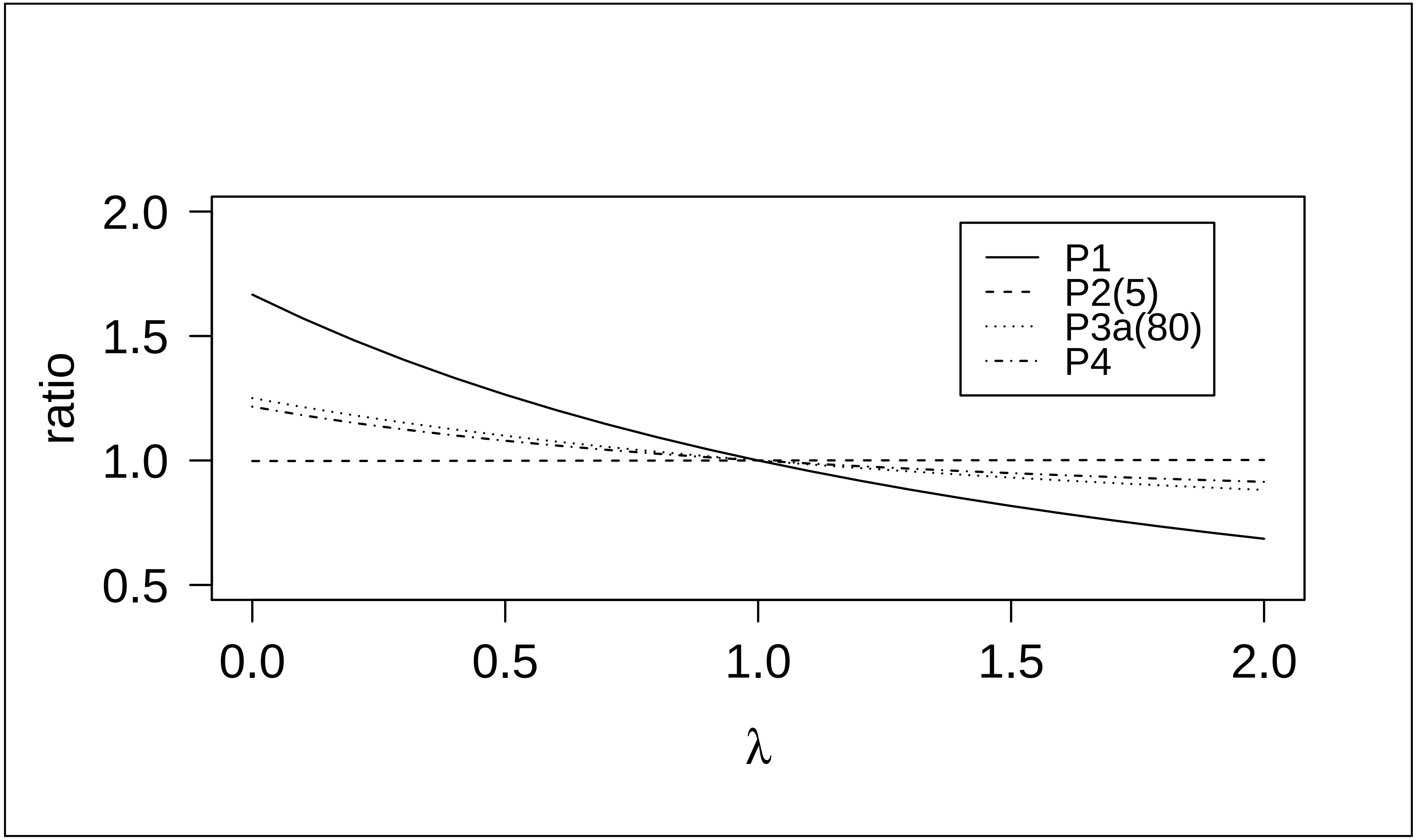
$\mathit{\Pi}_x^{[\mathrm{PX}]}(1, \lambda)$ for P1, P2, P3, $b'(1, \lambda)$ for P4; $\rho_x^{[\mathrm{PX}]}(1, \lambda)$ for P1, P2, P3, P4

Sensitivity analysis: disablement assumption (parameter δ)



Ratios $\rho_x^{[\mathrm{PX}]}(\delta, 1)$

Sensitivity analysis: extra-mortality assumption (parameter λ)



Ratios $\rho_x^{[\mathrm{PX}]}(1, \lambda)$

Joint sensitivity analysis (parameters δ, λ)

Example 1

For the generic product PX, and a given age x, analyze the function:

$$z = \Pi_x^{[\mathrm{PX}]}(\delta, \lambda)$$

Example 2

For the generic product PX, and a given age x, find (δ, λ) such that:

$$\rho_x^{[\mathrm{PX}]}(\delta, \lambda) = \rho_x^{[\mathrm{PX}]}(1, 1) = 1 \qquad (^*)$$

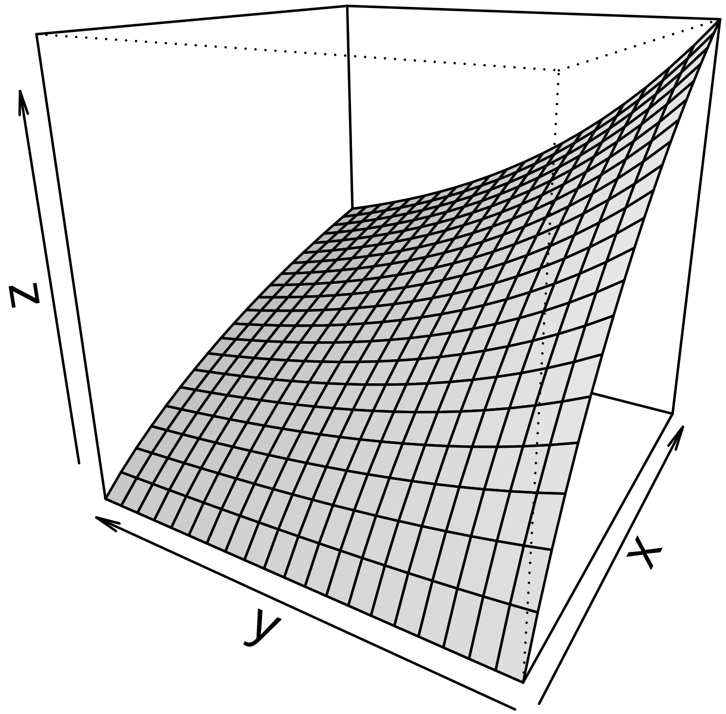
Eq. $(^*)$ implies

- for products P1, P2, P3:

$$\Pi_x^{[\mathrm{PX}]}(\delta, \lambda) = \Pi_x^{[\mathrm{PX}]}(1, 1)$$

- for product P4:

$$b'(\delta, \lambda) = b'(1, 1)$$

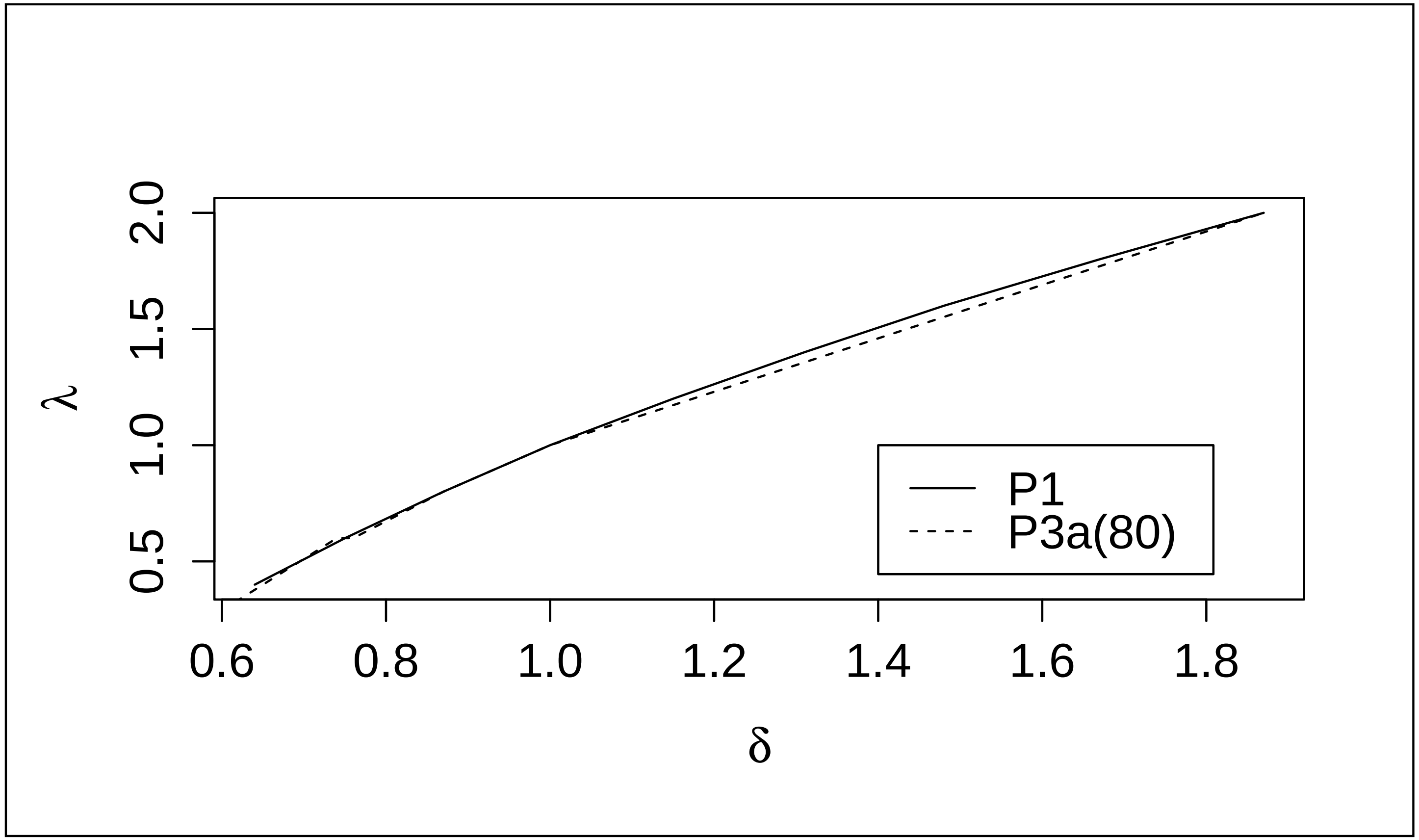


Function $z = \Pi_{50}^{[\mathrm{P3a}(80)]}$

x = δ $\Rightarrow$ *disablement*

y = λ $\Rightarrow$ *extra-mortality*

z = Π $\Rightarrow$ *premium*



Offset effect: isopremium lines

6 CONCLUDING REMARKS

When developing a new product:

- What benefit structure, e.g. what time profile of the health-linked benefits
- What rating model, in particular what information about the applicants should be taken into account ($\Rightarrow$ rating classes)
- What probabilistic model
- What data

Starting from the bottom:

- Data are (almost) always a problem $\Rightarrow$ sensitivity analysis can suggest adjustments in the product design

- Probabilistic model
  - ▷ does not constitute a problem by itself: Markov and semi-Markov multistate models capture whatever benefit structure
  - ▷ its implementation can constitute a problem because of lack of data $\Rightarrow$ approximations frequently needed
- Appropriate rating models can be suggested by recent proposals in the context of underwritten life annuities: a large variety of products, sharing the purpose of "tailoring" the premium rate
- Various benefit structures can be conceived, aiming at a higher flexibility of the benefit amount, in line with the annuitant's needs
  - ▷ suggestions e.g. from Income Protection policies, with reduction of benefit in case of partial recovery
  - ▷ complex claim settlement and monitoring then required

References

Where links are provided, they were active as of the time this presentation was completed but may have been updated since then

H. Huang, M. A. Milevsky, and T.S. Salisbury. A different perspective on retirement income sustainability: The blueprint for a ruin contingent life annuity (RCLA). *Journal of Wealth Management*, 11(4):89–96, 2009

M. A. Milevsky. Real longevity insurance with a deductible: Introduction to advanced-life delayed annuities (ALDA). *North American Actuarial Journal*, 9:109–122, 2005

A. Olivieri and E. Pitacco. Frailty and risk classification for life annuity portfolios. *Risks*, 4 (4):39, 2016. Available at: `http://www.mdpi.com/2227-9091/4/4/39`

A. Olivieri and E. Pitacco. Linking annuity benefits to the longevity experience: A general framework. Working Paper. Submitted, 2019. Available at: `https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3326672`

E. Pitacco. *Health Insurance. Basic actuarial models*. EAA Series. Springer, 2014

E. Pitacco. Guarantee structures in life annuities: A comparative analysis. *The Geneva Papers on Risk and Insurance - Issues and Practice*, 41(1):78–97, 2016a

E. Pitacco. Premiums for long-term care insurance packages: Sensitivity with respect to biometric assumptions. *Risks*, 4(1), 2016b. Available at: http://www.mdpi.com/2227-9091/4/1/3

E. Pitacco. Life Annuities. Products, guarantees, basic actuarial models. CEPAR Working Paper 2017/6, 2017. Available at: http://cepar.edu.au/sites/default/files/Life_Annuities_Products_Guarantees_Basic_Actuarial_Models_Revised.pdf

C. Ramsey and V. Oguledo. Doubly enhanced annuities (DEANs) and the impact of quality of long-term care under a multi-state model of activities of daily living (ADL). *North American Actuarial Journal*, pages 1–43, 10 2019. doi: 10.1080/10920277.2019.1598270

B. D. Rickayzen. An analysis of disability-linked annuities. Faculty of Actuarial Science and Insurance, Cass Business School, City University, London. Actuarial Research Paper No. 180, 2007. Available at: http://www.cass.city.ac.uk/__data/assets/pdf_file/0018/37170/180ARP.pdf

B. D. Rickayzen and D. E. P. Walsh. A multi-state model of disability for the United Kingdom: Implications for future need for Long-Term Care for the elderly. *British Actuarial Journal*, 8:341–393, 2002

M. Wadsworth, A. Findlater, and T. Boardman. Reinventing annuities. Working Paper. Presented to the Staple Inn Actuarial Society, 2001. Available at: `http://www.sias.org.uk/siaspapers/listofpapers/view_paper?id=ReinventingAnnuities`

Many thanks

for your kind attention !