Actuarial values for Long-term Care insurance products. A sensitivity analysis

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Agenda

- Motivation
- LTCI products
- The actuarial model
- Technical bases
- Sensitivity analysis
- Concluding remarks

Paper available at:

`http://www.cepar.edu.au/working-papers/working-papers-2015.aspx`

MOTIVATION

Long-term care insurance (LTCI) products deserve special attention

- LTCI provides benefits of remarkable interest in the current demographic and social scenario
- LTCI covers are “difficult” products

In particular:

- ▷ in many countries, shares of elderly population are rapidly growing because of increasing life expectancy and low fertility rates
- ▷ household size progressively reducing $\Rightarrow$ lack of assistance and care services provided to old members of the family inside the family itself
- ▷ LTCI products are rather recent $\Rightarrow$ senescent disability data are scanty $\Rightarrow$ pricing difficulties arise
- ▷ high premiums (in particular, because of a significant safety loading) $\Rightarrow$ obstacle to the diffusion of these products (especially stand-alone LTC covers only providing “protection”)

Uncertainty in technical bases, in particular biometric assumptions:

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

Need for:

- ▷ accurate sensitivity analysis
- ▷ focus on product design $\Rightarrow$ products whose premiums (and reserves) are not too heavily affected by the choice of the biometric assumptions

LTCI PRODUCTS

A classification

Long-Term Care insurance provides the insured with financial support, while he/she needs nursing and/or medical care because of chronic (or long-lasting) conditions or ailments ($\Rightarrow$ disability implying dependence)

Severity of disability measured according to various scales (ADL, IADL)   See for example: Pitacco [2014] and references therein

Types of LTC benefit:

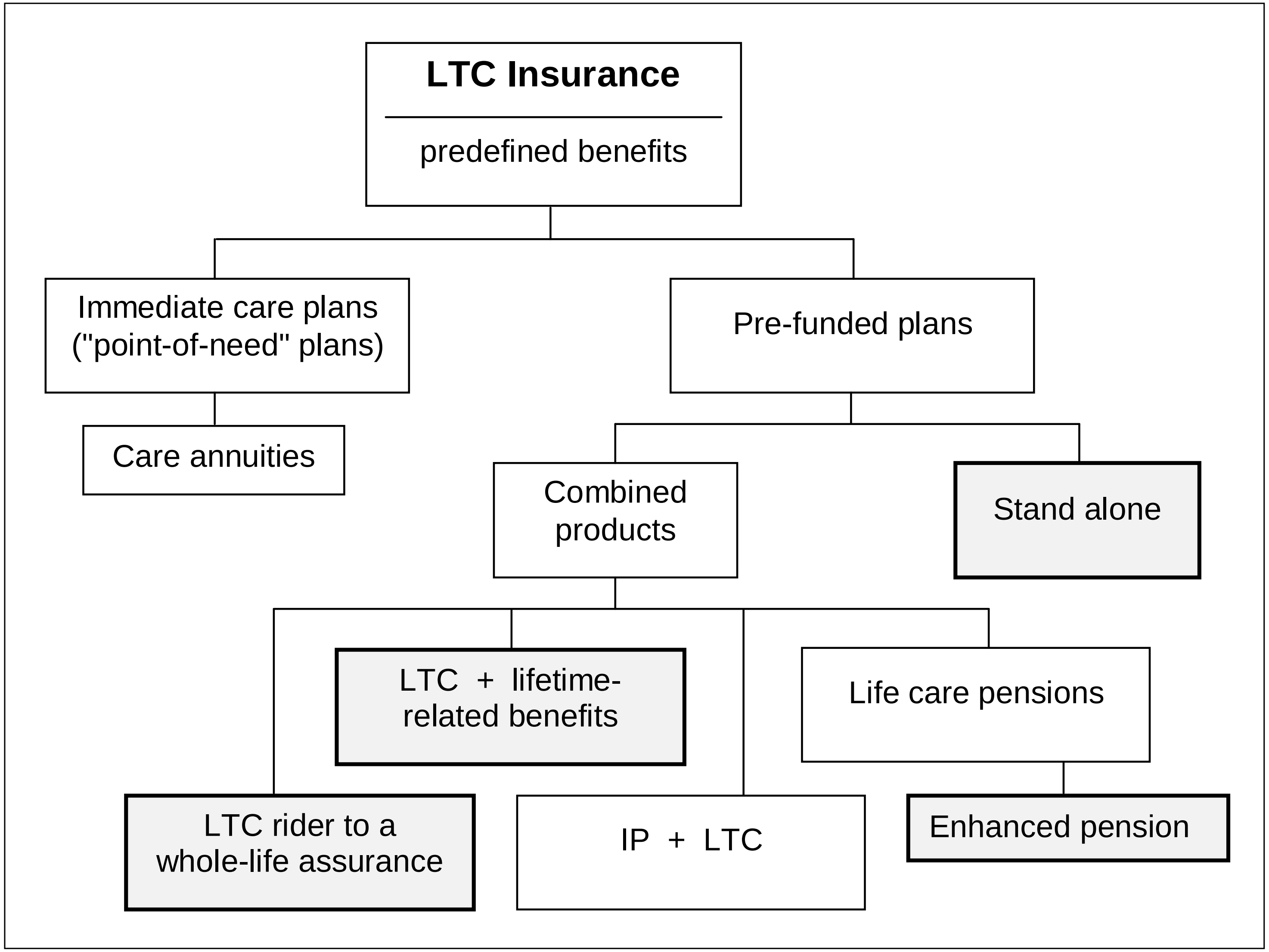
- benefits with *predefined amount* (usually, lifelong annuities)
  - ▷ *fixed-amount* benefits
  - ▷ *degree-related* (or *graded*) benefits, i.e. amount graded according to the degree of dependence (e.g. according to ADL)
- reimbursement (usually partial) of nursery and medical expenses, i.e. *expense-related* benefits
- *care service* benefits (for example provided by the Continuing Care Retirement Communities, CCRCs)

Classification of LTCI products which pay out benefits with predefined amount (see following Figure)

- *immediate care plans* relate to individuals already affected by disability
- *pre-funded plans*, i.e. relying on an accumulation phase
  - ▷ stand-alone
  - ▷ combined products

Several examples of insurance packages in which health-related benefits are combined with lifetime-related benefits

In the following, we focus on LTCI pre-funded plans



LTCI products with predefined benefits: a classification

We consider the following LTCI products:

- Stand-alone LTCI
- LTCI as an acceleration benefit in a whole-life assurance
- Package including LTC benefits and lifetime-related benefits
- Enhanced pension

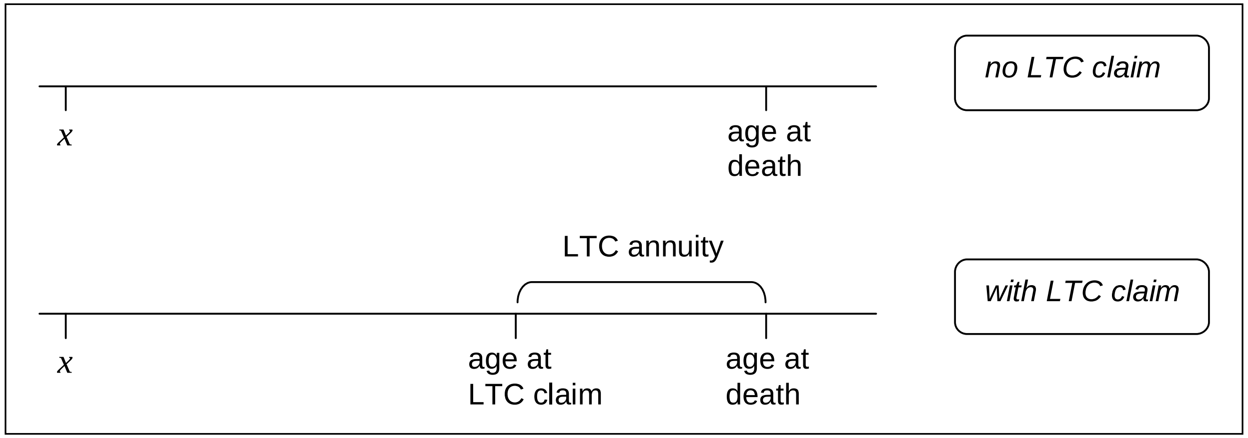
For more information, see Pitacco [2014] and references therein

In what follows: x = age at policy issue

Stand-alone LTCI

(Product P1)

LTCI benefit: a lifelong annuity with predefined annual amount, possibly graded according to the severity of LTC status



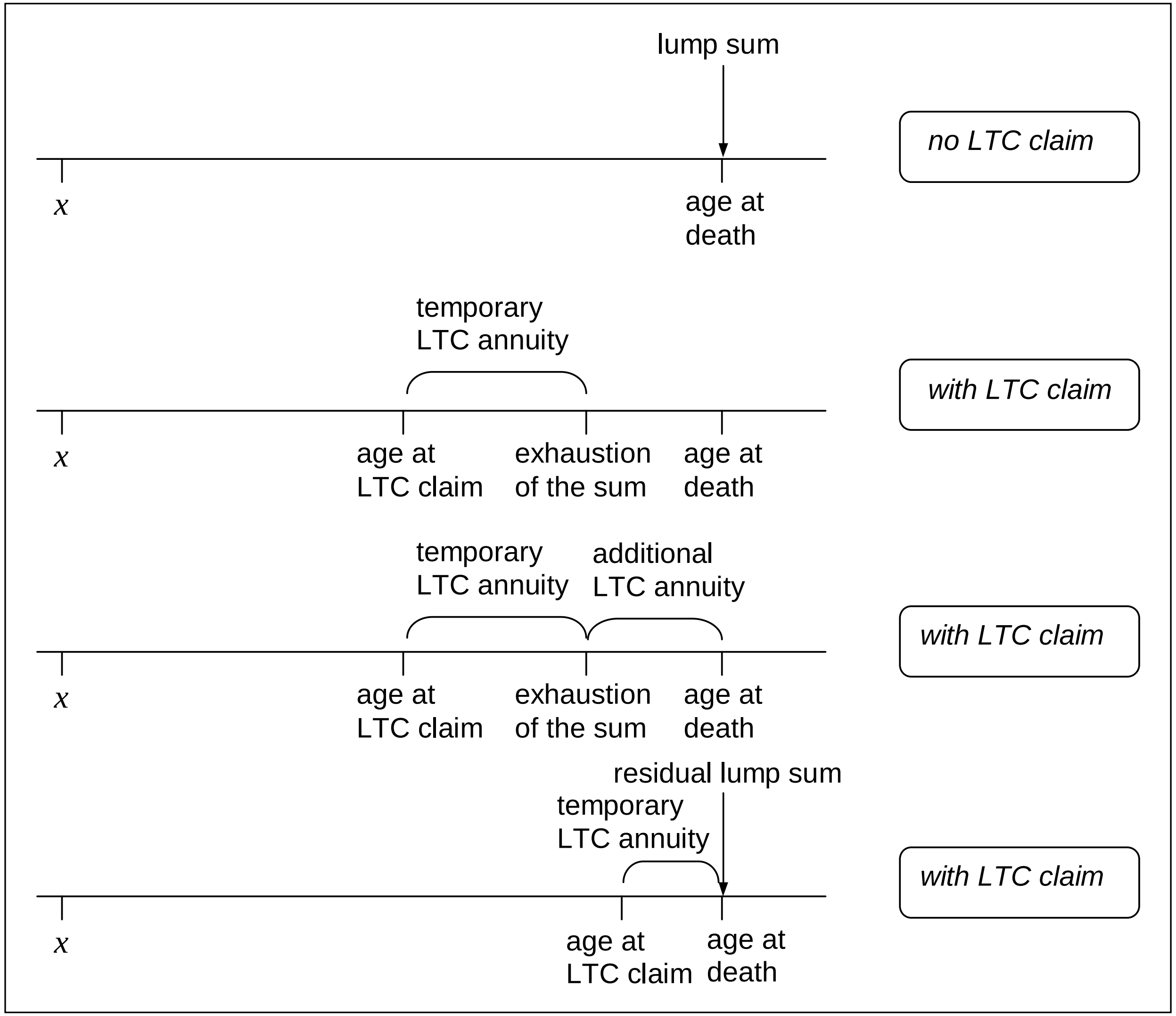
LTCI as an acceleration benefit in a whole-life assurance

(Product P2(s))

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

Possibly complemented by a (deferred) lifelong LTC annuity in the case of sum exhaustion

LTCI products *(cont'd)*



Package including LTC benefits and lifetime-related benefits

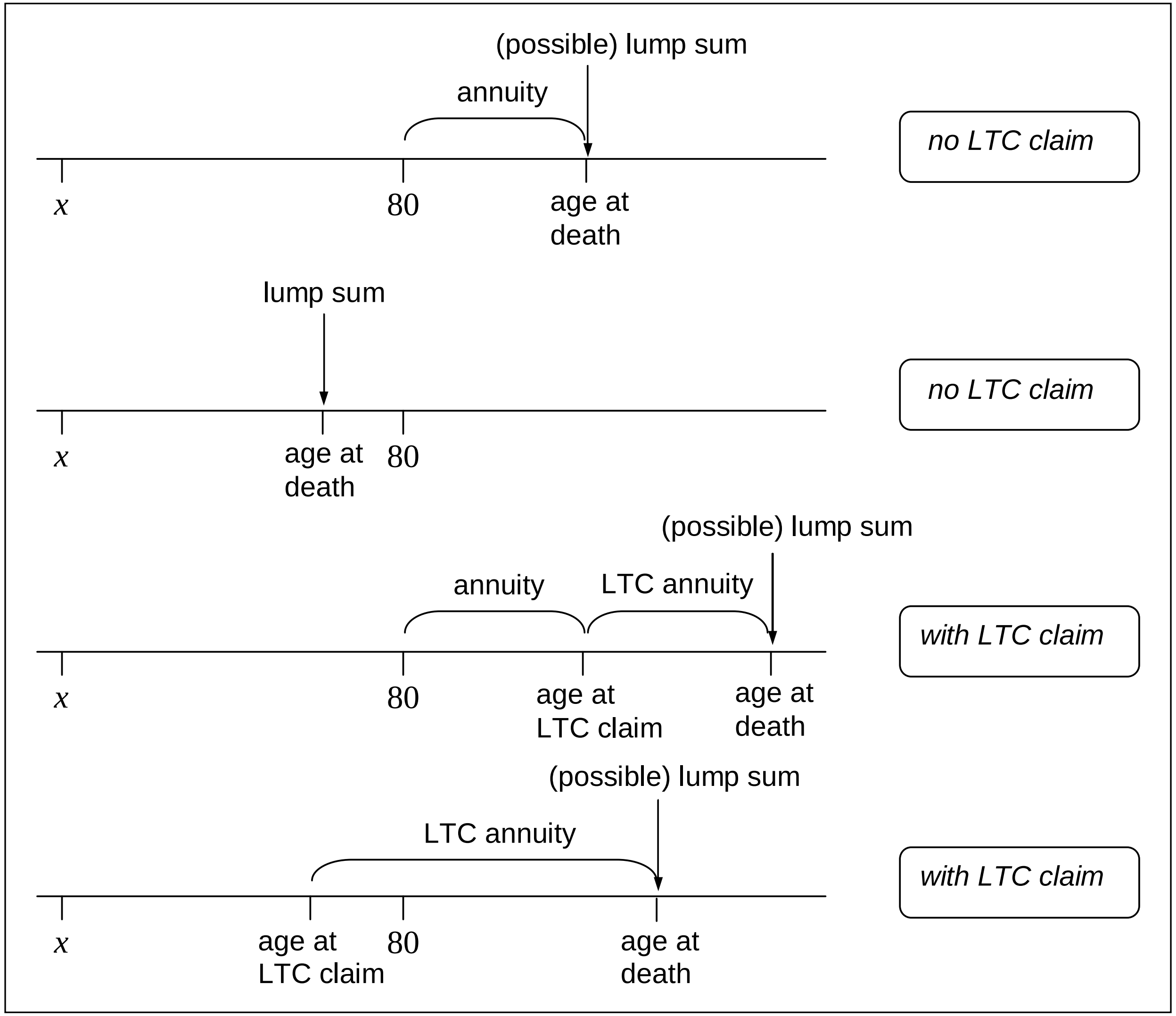
(Products P3a($x+n$) and P3b($x+n$))

Benefits:

1. a lifelong LTC annuity (from the LTC claim on)
2. a deferred life annuity from age $x+n$ (e.g. $x+n=80$), while the insured is not in LTC disability state
3. a lump sum benefit on death, alternatively given by
   - 3a. a fixed amount, stated in the policy
   - 3b. the difference (if positive) between a fixed amount and the total amount paid as benefit 1 and/or benefit 2

Benefits 1 and 2 are mutually exclusive

LTCI products *(cont'd)*



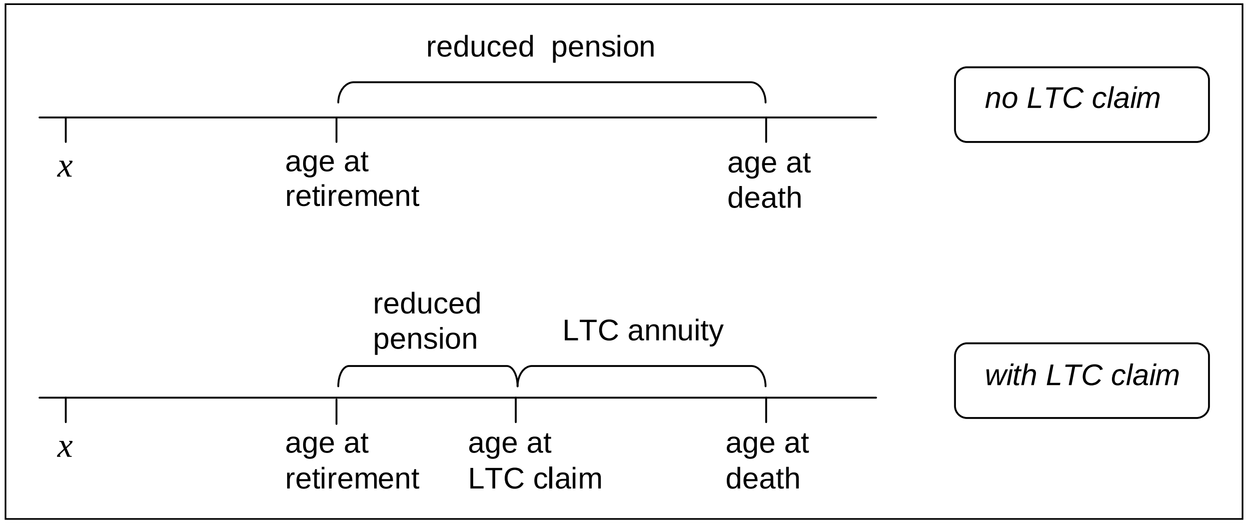
Enhanced pension (Life care pension)

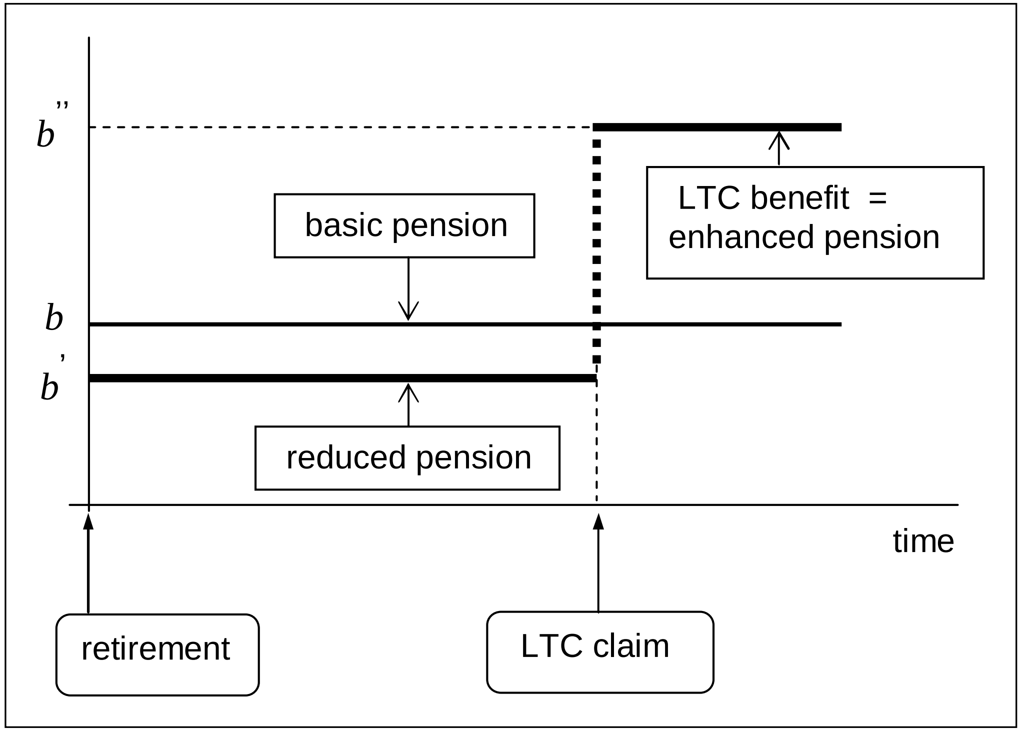
(Product P4(b', b''))

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, $b' < b < b''$)


reduced pension
no LTC claim
x
age at
retirement
age at
death
reduced
pension
LTC annuity
with LTC claim
x
age at
retirement
age at
LTC claim
age at
death


b''
b
b'
basic pension
LTC benefit =
enhanced pension
reduced pension
time
retirement
LTC claim

THE ACTUARIAL MODEL

Multistate models for LTCI

States:

$a =$ active = healthy

$i =$ invalid = in LTC state

$d =$ died

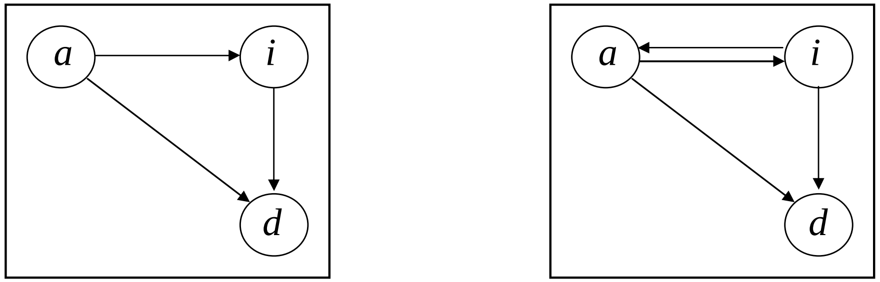
$i' =$ in low-severity LTC state

$i'' =$ in high-severity LTC state

For more information on time-discrete models see Pitacco [2014],

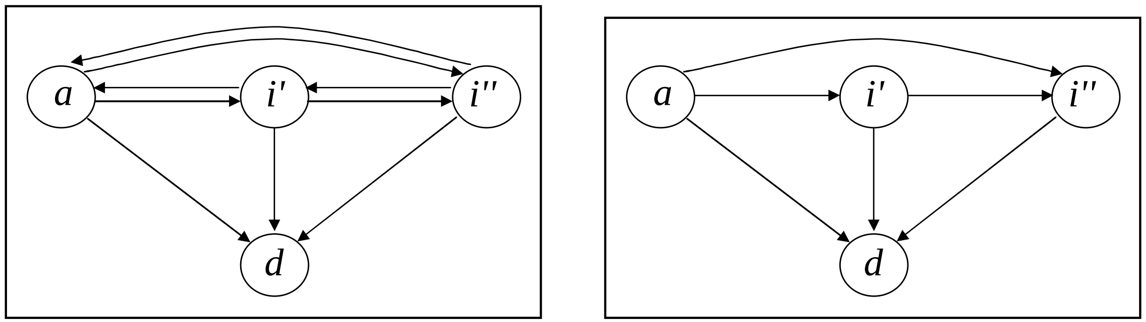
and on time discrete and time-continuous models see Haberman and Pitacco [1999]

The actuarial model *(cont'd)*



(a) (b)

Three-state models



(a) (b)

Four-state models

In what follows we adopt the three-state model (a), in a time-discrete context

Biometric functions (needed)

Refer to three-state model (a)

For an active age x:

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

$w_x =$ prob. of becoming invalid (disablement) before $x + 1$

For an invalid age x:

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

TECHNICAL BASES

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:

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

a	b	c	d	e	f	g	h
0.00054	0.01700	0.10100	0.00014	10.72	18.67	2.00532 E−06	1.13025

The first Heligman-Pollard law: parameters

$\overset{\circ}{e}_0$	$\overset{\circ}{e}_{40}$	$\overset{\circ}{e}_{65}$	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

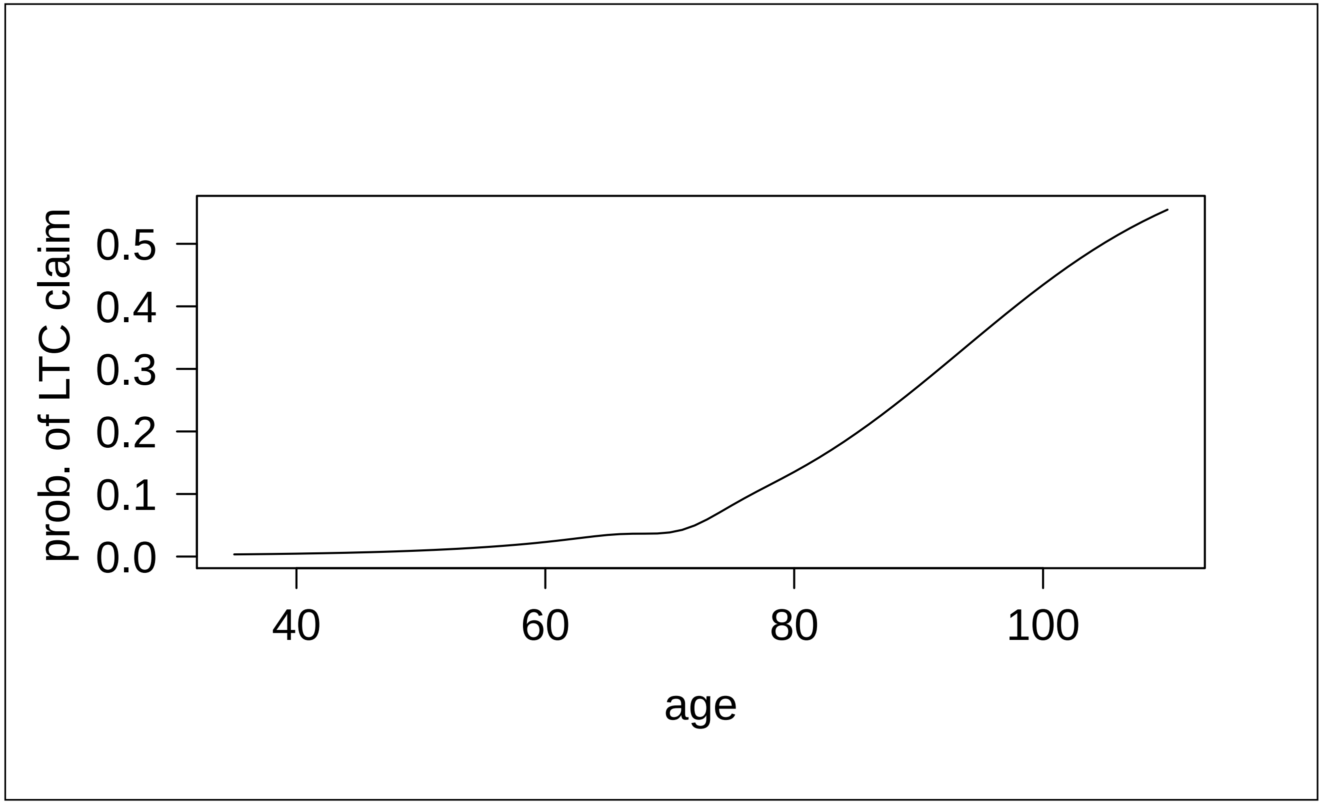
Disablement (LTC claim)

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]

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

with:

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

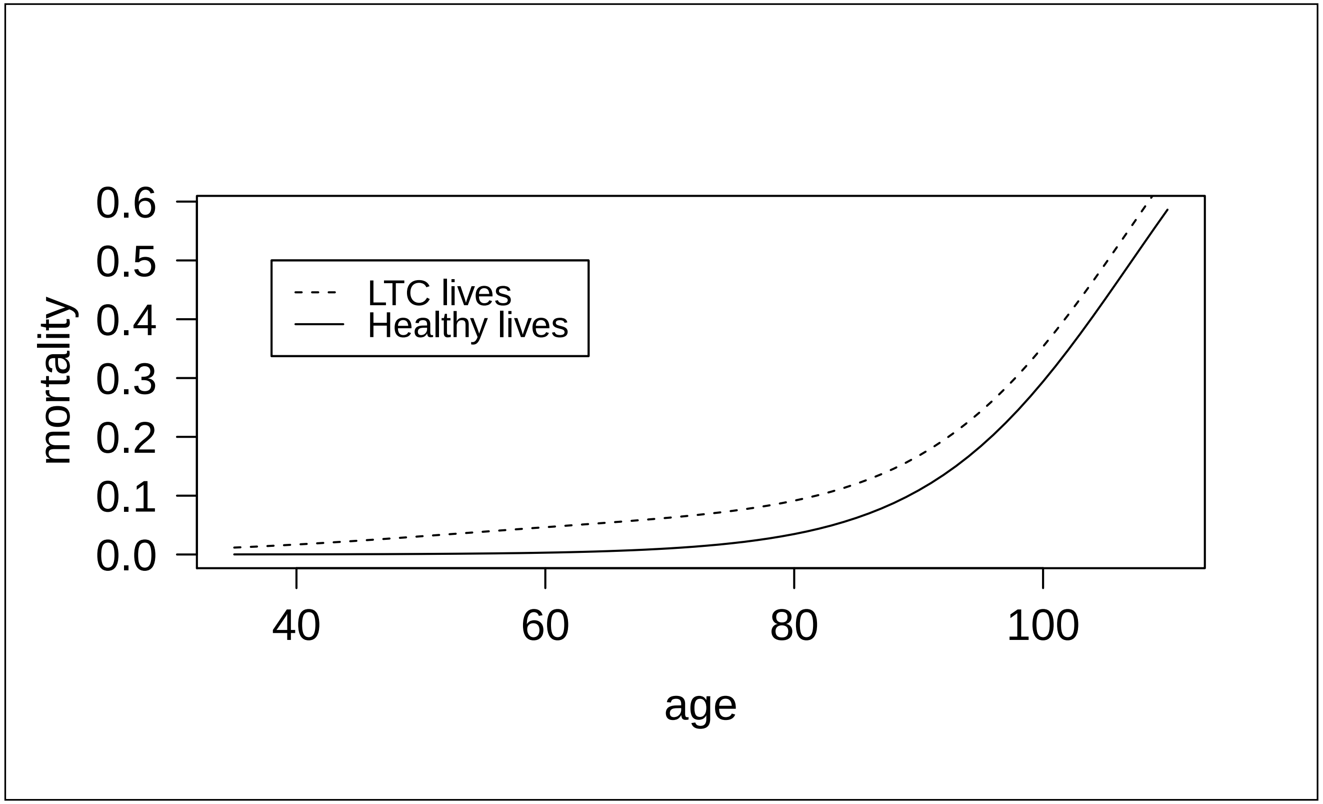
where:

- 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 $q_x^{[\text{standard}]} = q_x^{aa}$ (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

Sensitivity analysis concerning:

- ▷ probability of disablement (i.e. entering into LTC state)
- ▷ extra-mortality of lives in LTC state

Notation:

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

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

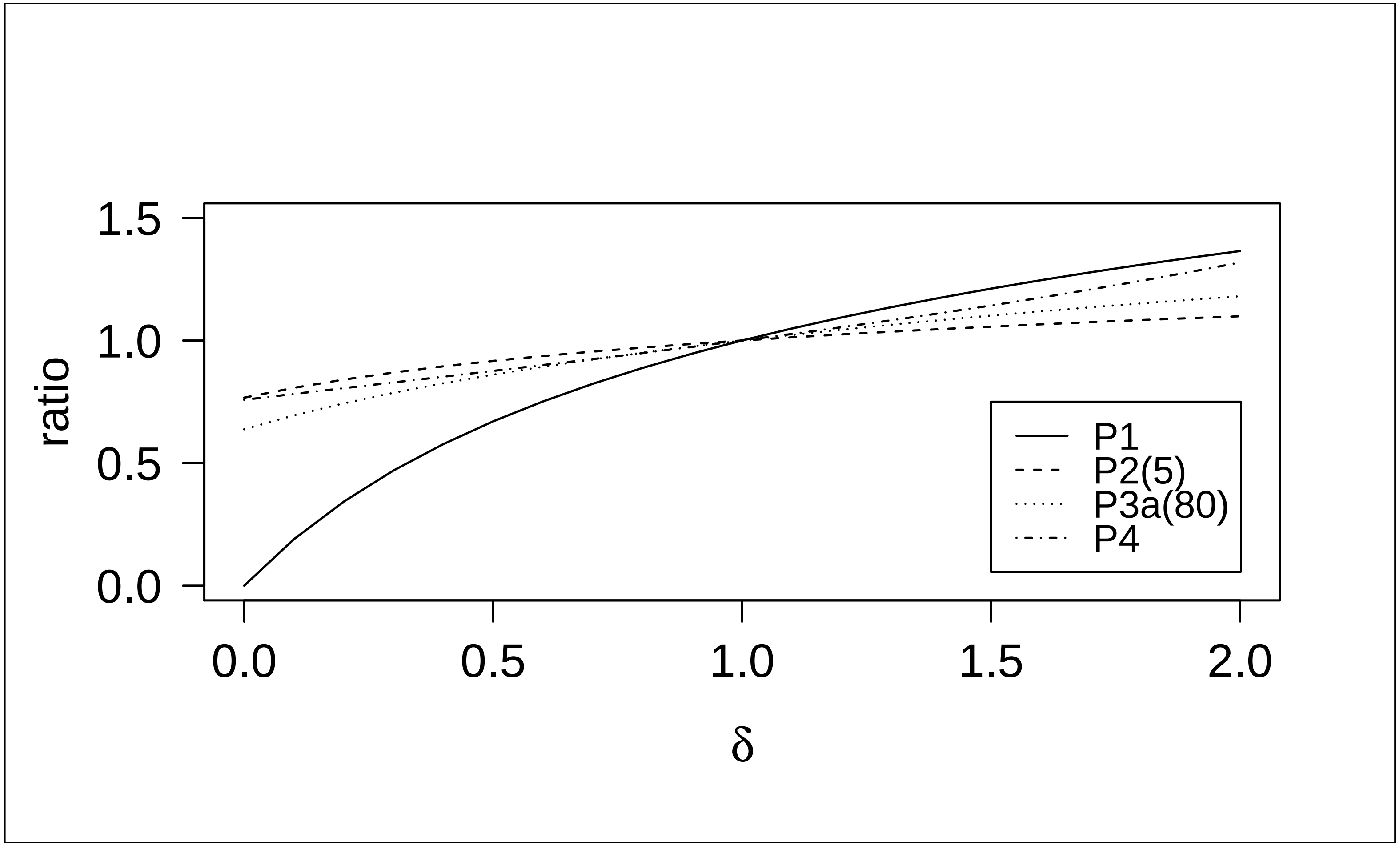
For product P4, with given b and b'', normalize and define the ratio:

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

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

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

Sensitivity analysis: disablement assumption (parameter δ)



Sensitivity analysis *(cont'd)*

δ	$\Pi_{50}^{[\mathrm{P1}]}(\delta, 1)$	$\rho_{50}^{[\mathrm{P1}]}(\delta, 1)$
0.0	0.00000	0.0000000
0.1	97.44457	0.1897494
0.2	176.07799	0.3428686
0.3	241.25240	0.4697798
0.4	296.47515	0.5773125
0.5	344.12555	0.6700999
0.6	385.86840	0.7513839
0.7	422.90118	0.8234961
0.8	456.10675	0.8881558
0.9	486.15044	0.9466585
1.0	513.54361	1.0000000
1.1	538.68628	1.0489592
1.2	561.89632	1.0941550
1.3	583.42997	1.1360865
1.4	603.49644	1.1751610
1.5	622.26854	1.2117151
1.6	639.89052	1.2460296
1.7	656.48397	1.2783412
1.8	672.15229	1.3088514
1.9	686.98406	1.3377327
2.0	701.05581	1.3651339

Product P1 (Stand-alone); $x = 50, b = 100$

δ	$\Pi_{50}^{[P2(1)]}(\delta,1)$	$\rho_{50}^{[P2(1)]}(\delta,1)$	$\Pi_{50}^{[P2(5)]}(\delta,1)$	$\rho_{50}^{[P2(5)]}(\delta,1)$
0.0	492.1453	0.7446436	492.1453	0.7668209
0.1	522.4302	0.7904664	517.9195	0.8069802
0.2	547.3508	0.8281727	539.5114	0.8406230
0.3	568.3981	0.8600184	558.0108	0.8694472
0.4	586.5416	0.8874705	574.1426	0.8945825
0.5	602.4415	0.9115280	588.4118	0.9168156
0.6	616.5641	0.9328964	601.1825	0.9367139
0.7	629.2483	0.9520882	612.7241	0.9546971
0.8	640.7467	0.9694859	623.2411	0.9710837
0.9	651.2520	0.9853810	632.8914	0.9861200
1.0	660.9139	1.0000000	641.7995	1.0000000
1.1	669.8509	1.0135223	650.0652	1.0128789
1.2	678.1584	1.0260919	657.7693	1.0248828
1.3	685.9139	1.0378264	664.9783	1.0361152
1.4	693.1814	1.0488226	671.7475	1.0466625
1.5	700.0145	1.0591615	678.1234	1.0565969
1.6	706.4581	1.0689111	684.1455	1.0659801
1.7	712.5507	1.0781294	689.8475	1.0748645
1.8	718.3251	1.0868664	695.2586	1.0832956
1.9	723.8097	1.0951649	700.4040	1.0913127
2.0	729.0293	1.1030626	705.3059	1.0989504

Product P2 (Acceleration benefit); $x = 50, C = 1\,000$

δ	$\Pi_{50}^{[\text{P3a(80)}]}(\delta,1)$	$\rho_{50}^{[\text{P3a(80)}]}(\delta,1)$	$\Pi_{50}^{[\text{P3b(80)}]}(\delta,1)$	$\rho_{50}^{[\text{P3b(80)}]}(\delta,1)$
0.0	700.5211	0.6379255	524.3054	0.6681005
0.1	762.7792	0.6946205	564.2116	0.7189513
0.2	816.5343	0.7435723	598.8261	0.7630591
0.3	863.9507	0.7867518	629.5434	0.8022009
0.4	906.4564	0.8254594	657.2615	0.8375209
0.5	945.0332	0.8605891	682.5844	0.8697888
0.6	980.3808	0.8927781	705.9351	0.8995436
0.7	1 013.0142	0.9224956	727.6214	0.9271776
0.8	1 043.3239	0.9500969	747.8754	0.9529864
0.9	1 071.6132	0.9758584	766.8772	0.9771996
1.0	1 098.1236	1.0000000	784.7703	1.0000000
1.1	1 123.0514	1.0227003	801.6718	1.0215369
1.2	1 146.5586	1.0441071	817.6790	1.0419342
1.3	1 168.7817	1.0643443	832.8740	1.0612966
1.4	1 189.8365	1.0835178	847.3271	1.0797136
1.5	1 209.8231	1.1017185	861.0993	1.0972629
1.6	1 228.8288	1.1190259	874.2436	1.1140122
1.7	1 246.9299	1.1355096	886.8072	1.1300214
1.8	1 264.1943	1.1512313	898.8317	1.1453438
1.9	1 280.6825	1.1662462	910.3545	1.1600268
2.0	1 296.4487	1.1806036	921.4091	1.1741132

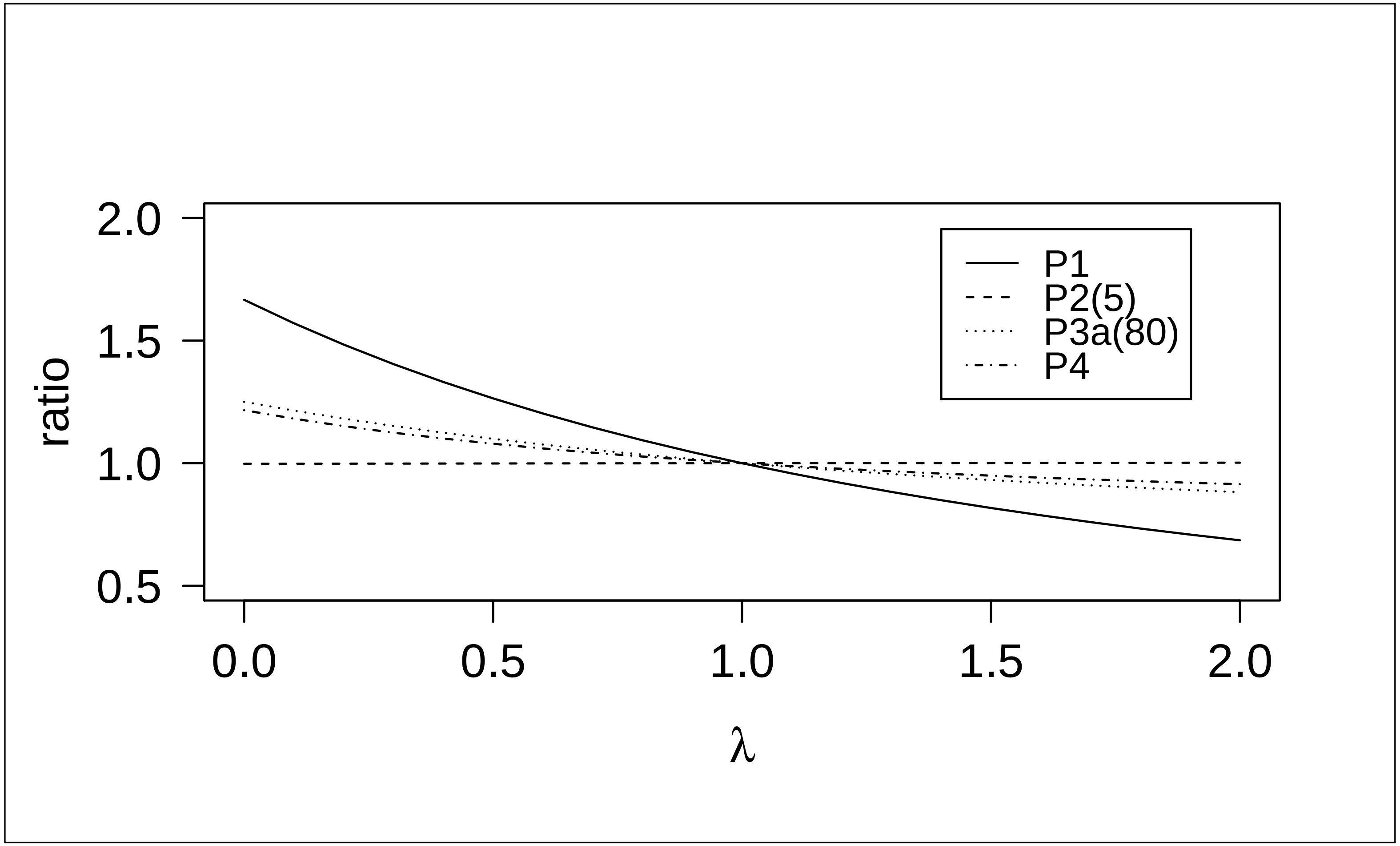
Products P3a and P3b (Insurance packages); $x = 50, C = 1\,000, b' = 50, b'' = 150$

Sensitivity analysis *(cont'd)*

δ	$b'(\delta, 1)$	$\rho_x^{[P4]}(\delta, 1)$
0.0	100.00000	0.7582433
0.1	96.96404	0.7819840
0.2	94.13166	0.8055136
0.3	91.47026	0.8289506
0.4	88.95221	0.8524165
0.5	86.55461	0.8760288
0.6	84.25873	0.8998988
0.7	82.04926	0.9241317
0.8	79.91365	0.9488283
0.9	77.84153	0.9740858
1.0	75.82433	1.0000000
1.1	73.85486	1.0266668
1.2	71.92708	1.0541833
1.3	70.03587	1.0826500
1.4	68.17685	1.1121713
1.5	66.34626	1.1428576
1.6	64.54086	1.1748267
1.7	62.75783	1.2082052
1.8	60.99468	1.2431301
1.9	59.24927	1.2797513
2.0	57.51967	1.3182330

Product P4 (Enhanced pension); $x = 65$, $b = 100$, $b'' = 150$

Sensitivity analysis: extra-mortality assumption (parameter λ)



Sensitivity analysis *(cont'd)*

λ	$\Pi_{50}^{[P1]}(1,\lambda)$	$\rho_{50}^{[P1]}(1,\lambda)$
0.0	855.7094	1.6662838
0.1	806.6737	1.5707987
0.2	761.9567	1.4837234
0.3	721.0856	1.4041370
0.4	683.6467	1.3312339
0.5	649.2769	1.2643073
0.6	617.6576	1.2027364
0.7	588.5080	1.1459748
0.8	561.5807	1.0935405
0.9	536.6571	1.0450079
1.0	513.5436	1.0000000
1.1	492.0686	0.9581828
1.2	472.0797	0.9192592
1.3	453.4411	0.8829652
1.4	436.0319	0.8490650
1.5	419.7439	0.8173482
1.6	404.4804	0.7876263
1.7	390.1547	0.7597305
1.8	376.6889	0.7335090
1.9	364.0128	0.7088255
2.0	352.0634	0.6855570

Product P1 (Stand-alone); $x = 50, b = 100$

Sensitivity analysis *(cont'd)*

λ	$\Pi_{50}^{[\mathrm{P2(1)}]}(1,\lambda)$	$\rho_{50}^{[\mathrm{P2(1)}]}(1,\lambda)$	$\Pi_{50}^{[\mathrm{P2(5)}]}(1,\lambda)$	$\rho_{50}^{[\mathrm{P2(5)}]}(1,\lambda)$
0.0	660.9139	1	640.3371	0.9977214
0.1	660.9139	1	640.4879	0.9979563
0.2	660.9139	1	640.6376	0.9981896
0.3	660.9139	1	640.7863	0.9984213
0.4	660.9139	1	640.9341	0.9986515
0.5	660.9139	1	641.0808	0.9988801
0.6	660.9139	1	641.2265	0.9991071
0.7	660.9139	1	641.3712	0.9993326
0.8	660.9139	1	641.5150	0.9995566
0.9	660.9139	1	641.6577	0.9997791
1.0	660.9139	1	641.7995	1.0000000
1.1	660.9139	1	641.9404	1.0002194
1.2	660.9139	1	642.0802	1.0004374
1.3	660.9139	1	642.2191	1.0006538
1.4	660.9139	1	642.3571	1.0008688
1.5	660.9139	1	642.4941	1.0010822
1.6	660.9139	1	642.6302	1.0012943
1.7	660.9139	1	642.7653	1.0015048
1.8	660.9139	1	642.8995	1.0017140
1.9	660.9139	1	643.0328	1.0019216
2.0	660.9139	1	643.1652	1.0021279

Product P2 (Acceleration benefit); $x = 50, C = 1\,000$

Sensitivity analysis *(cont'd)*

λ	$\Pi_{50}^{[\mathrm{P3a(80)}]}(1,\lambda)$	$\rho_{50}^{[\mathrm{P3a(80)}]}(1,\lambda)$	$\Pi_{50}^{[\mathrm{P3b(80)}]}(1,\lambda)$	$\rho_{50}^{[\mathrm{P3b(80)}]}(1,\lambda)$
0.0	1 373.1426	1.2504444	1 030.1514	1.3126789
0.1	1 333.7360	1.2145591	992.0364	1.2641106
0.2	1 297.7979	1.1818323	957.9426	1.2206663
0.3	1 264.9490	1.1519186	927.4057	1.1817544
0.4	1 234.8573	1.1245157	900.0200	1.1468579
0.5	1 207.2314	1.0993584	875.4306	1.1155246
0.6	1 181.8156	1.0762136	853.3264	1.0873583
0.7	1 158.3843	1.0548760	833.4345	1.0620108
0.8	1 136.7389	1.0351648	815.5147	1.0391763
0.9	1 116.7039	1.0169200	799.3555	1.0185853
1.0	1 098.1236	1.0000000	784.7703	1.0000000
1.1	1 080.8603	0.9842793	771.5943	0.9832104
1.2	1 064.7915	0.9696463	759.6816	0.9680305
1.3	1 049.8081	0.9560017	748.9029	0.9542957
1.4	1 035.8128	0.9432570	739.1434	0.9418596
1.5	1 022.7189	0.9313331	730.3010	0.9305921
1.6	1 010.4485	0.9201591	722.2849	0.9203775
1.7	998.9319	0.9096716	715.0140	0.9111125
1.8	988.1065	0.8998136	708.4160	0.9027050
1.9	977.9161	0.8905337	702.4263	0.8950725
2.0	968.3098	0.8817858	696.9867	0.8881411

Products P3a and P3b (Insurance packages); $x = 50, C = 1\,000, b' = 50, b'' = 150$

Sensitivity analysis *(cont'd)*

λ	$b'(1,\lambda)$	$\rho_x^{[\mathrm{P4}]}(1,\lambda)$
0.0	62.34898	1.2161277
0.1	64.17119	1.1815946
0.2	65.86125	1.1512738
0.3	67.43103	1.1244723
0.4	68.89119	1.1006390
0.5	70.25128	1.0793302
0.6	71.51992	1.0601847
0.7	72.70488	1.0429056
0.8	73.81315	1.0272469
0.9	74.85106	1.0130027
1.0	75.82433	1.0000000
1.1	76.73813	0.9880920
1.2	77.59716	0.9771534
1.3	78.40567	0.9670771
1.4	79.16755	0.9577704
1.5	79.88630	0.9491531
1.6	80.56513	0.9411556
1.7	81.20698	0.9337169
1.8	81.81451	0.9267834
1.9	82.39015	0.9203081
2.0	82.93615	0.9142494

Product P4 (Enhanced pension); $x = 65$, $b = 100$, $b'' = 150$

Joint sensitivity analysis (parameters δ, λ)

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

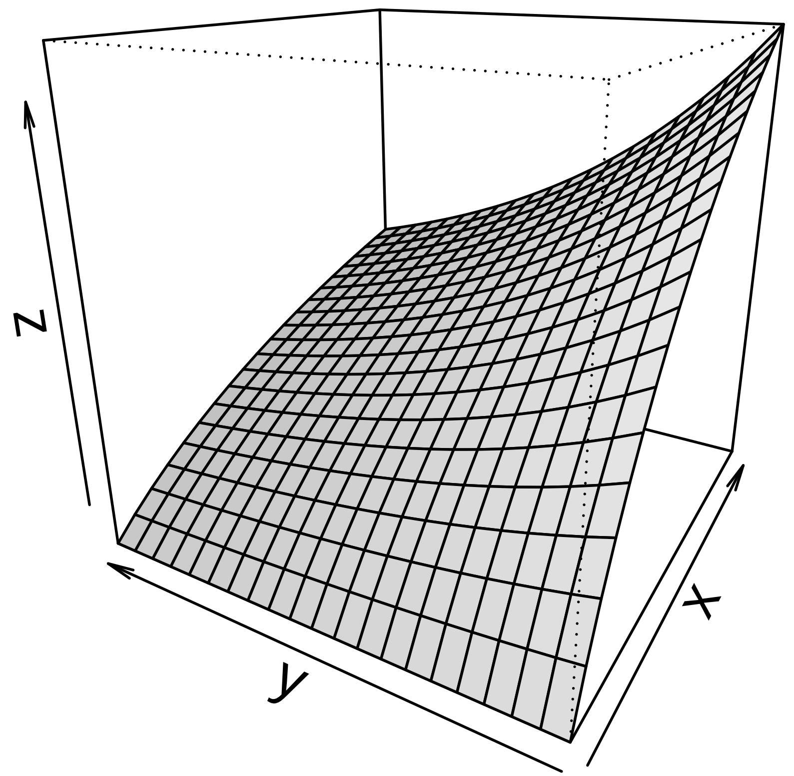
- for products P1, P2, P3:

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

- for product P4:

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

Sensitivity analysis *(cont'd)*

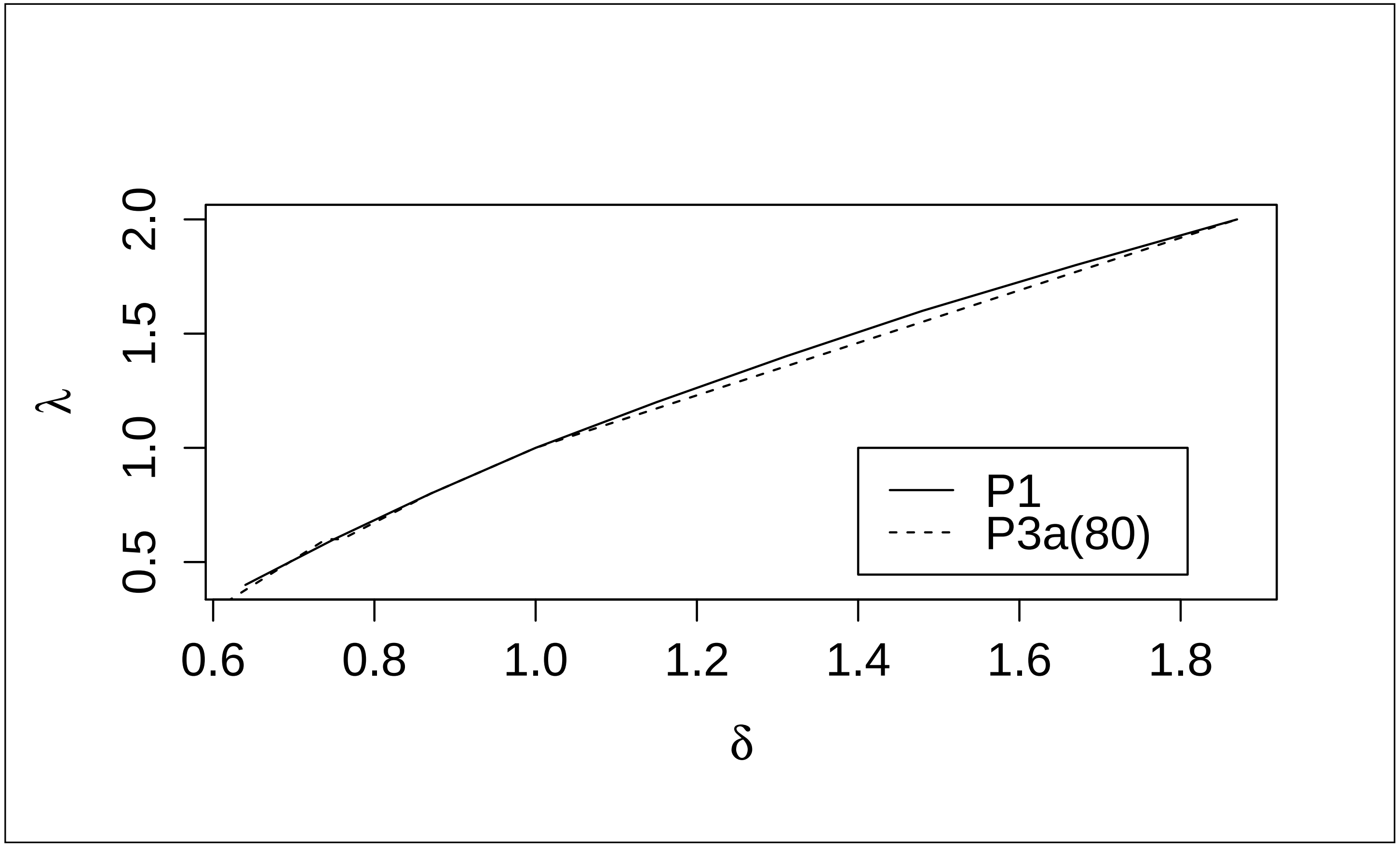


Product P3a(80)

X = δ $\Rightarrow$ *disablement*

Y = λ $\Rightarrow$ *extra-mortality*

Z = Π $\Rightarrow$ *premium*



Offset effect: isopremium lines

CONCLUDING REMARKS

Combined LTCI products: mainly aiming at reducing the relative weight of the risk component by introducing a “saving” component, or by adding the LTC benefits to an insurance product with an important saving component

Combined insurance products in the area of health insurance:

- Insurer’s perspective
  - ▷ a combined product can result profitable even if one of its components is not profitable
  - ▷ a combined product can be less risky than one of its components (less exposed to impact of uncertainty risk related to the choice of technical bases)
- Client’s perspective $\Rightarrow$ purchasing a combined product can be less expensive than separately purchasing all the single components (in particular: reduction of acquisition costs charged to the policyholder)

In particular

- LTC covers as riders to life insurance; see:
  - ▷ acceleration benefit in whole life assurance
  - ▷ LTC annuity in enhanced pension
- LTC covers in insurance packages; see:
  - ▷ packages including old-age deferred life annuity and death benefit

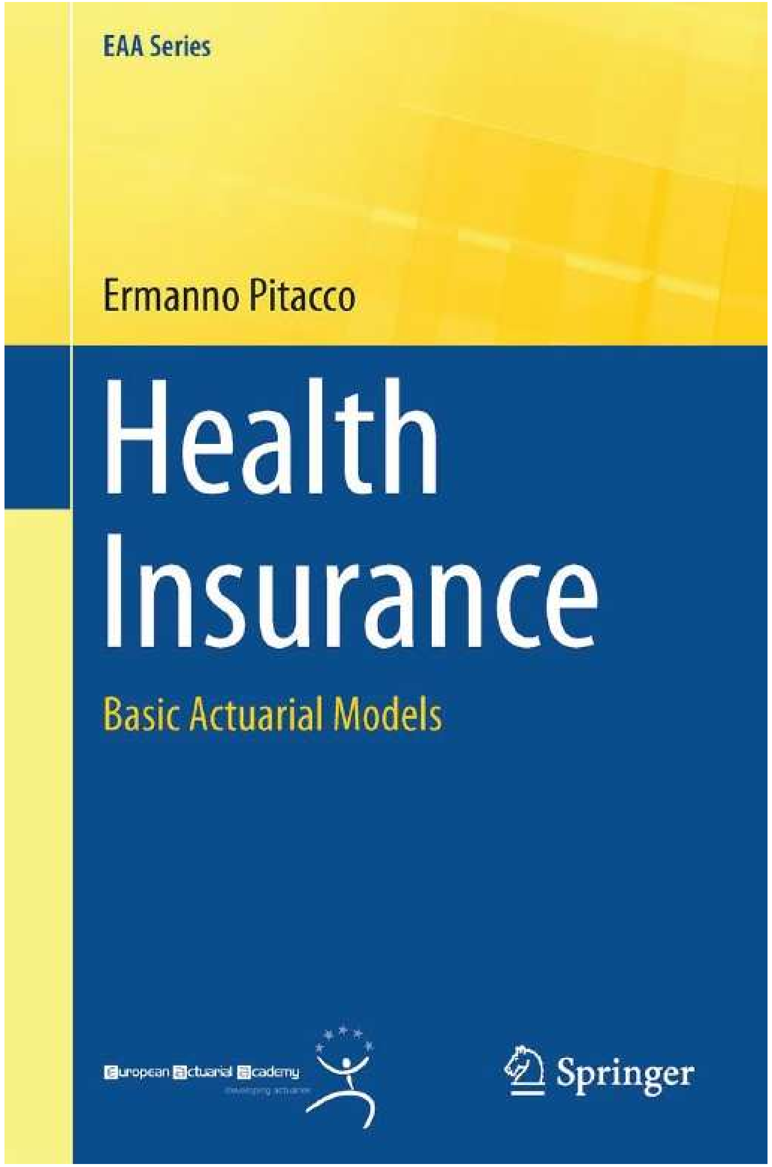
References

S. Haberman and E. Pitacco. *Actuarial Models for Disability Insurance*. Chapman & Hall/CRC, Boca Raton, USA, 1999

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

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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Many thanks

for your kind attention !