

# Longevity Risk Products

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# Longevity risk

## From the perspective of the individual

Risk of outliving his own resources ⇒ Focus: Post-retirement income

Possible individual targets:

- Lifelong payment ⇒ Longevity guarantee
- Fixed or minimum annual amount ⇒ Financial guarantee

## From the perspective of the provider of a longevity guarantee

The “insurer” has to pay lifelong benefits, whatever

- The individual lifetime ⇒ Individual (or Idiosyncratic) longevity risk
- And the average lifetime of the population ⇒ (Aggregate) Longevity risk

✎ Longevity risk affected also by the benefit amount

# Life annuities

## Traditional guarantees

- Lifelong payment
- Fixed annual amount or annual revaluation (participating, with-profit or inflation-linked annuities)

## The longevity guarantee (& the financial guarantee) are embedded

- In the annuity rate  $AR = \frac{1}{a_x}$  (at age  $x$ )
- As well as in the participating rule (to the investment return or inflation rate)); For example:  $b_t = b_{t-1} \cdot \left( 1 + \max \left\{ \frac{\eta_t g_t - i_{(0)}}{1 + i_{(0)}}, 0 \right\} \right)$

## To avoid high loadings $\Rightarrow$ Innovations in product design

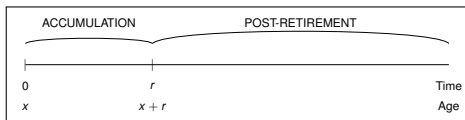
Possibly aimed at:

- Reducing the size of the longevity guarantee
- Delaying the longevity guarantee

# Setting the longevity guarantee

In the following, with reference to an individual:

$x$	Initial age, at time 0	$[0, r]$	"Accumulation" period
$r$	Retirement time	$[r, \infty]$	Post-retirement period
$x + r$	Age at retirement		



The annuity rate can be set:

- At retirement time
- Before retirement time
- After retirement time

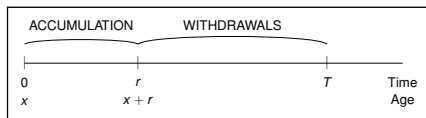
⇒ Impact on the time-profile of the longevity guarantee, and the location of the longevity risk

# Post-retirement income products/arrangements

- Income drawdown
- Traditional life annuities, immediate or deferred
- Late life annuities: Advanced Life Delayed Annuity (ALDA), Ruin Contingent Life Annuity (RCLA)  
...
- Variable annuities  
...
- Group Self-Annuity (GSA), Tontine annuities, other pooled annuities
- Mortality/longevity-linked life annuities

# Income drawdown (Withdrawal plan)

Given the amount  $S$  available at retirement time  $r$ , the individual cashes a post-retirement income so long as money is available, choosing the annual amount, the investment profile, and so on

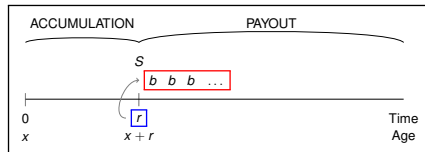


- $T$  is random, depending on the investment performance, lifetime of the individual and annual amounts
- ☞ Longevity risk fully retained by the individual

# CAR immediate life annuity

CAR: Current Annuity Rate, set at time  $r$

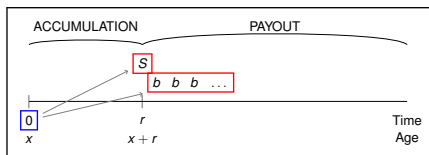
- Fixed benefit or asset-linked benefit



- Longevity risk on the provider in the time-interval  $[r, \infty)$ , impacting on:
  - Annual payout
  - Technical provision
  - Required capital

# GAR deferred life annuity – I

GAR: Guaranteed Annuity Rate, set before time  $r$



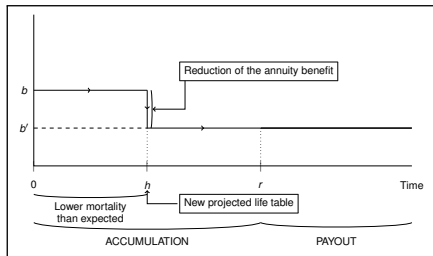
- ☞ Longevity risk on the provider in the time-interval  $[0, \infty)$ , impacting on:
  - The technical provision and the required capital for the whole period
  - The annual payout starting from time  $r$



# GAR deferred life annuity – II

## Conditional GAR

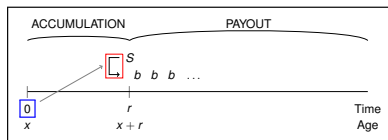
- GAR set at time 0
- In case of unanticipated mortality reduction, after time 0 but before time  $r$  the GAR is updated  $\Rightarrow$  The benefit amount is decreased



- A form of risk sharing
- Possible constraints: measure of the mortality reduction; frequency of updates; maximum total benefit reduction; payments to which the update is applied

# GAO deferred life annuity – I

## GAO: Guaranteed Annuitization Option



Deferred life annuity, providing the following options at retirement:

- Lump sum
- Annuitization at CAR
- Annuitization at GAR

Thus:

$$b = S \cdot \max \left\{ \frac{1}{a_{x+r}^{[CAR]}}, \frac{1}{a_{x+r}^{[GAR]}} \right\} \quad \text{In case of annuitization}$$

# GAO deferred life annuity – II

Value of the option affected by:

- Individual preferences (lump sum vs annuity)
  - Mortality rates
  - Interest rates
- 
- ✎ Longevity risk on the provider in the time-interval  $[0, \infty)$ , impacting on:
    - The reserve and the required capital in  $[0, r]$  and in case of annuitization in  $[r, \infty)$
    - The annual payments starting from time  $r$ , in case of annuitization

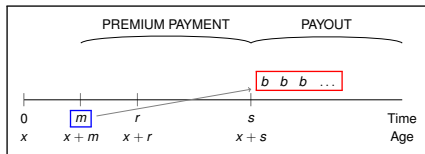
For the valuation of the option, addressing stochastic mortality, see:

[Ballotta and Haberman, 2006], [Biffis and Millosovich, 2006], [Kling et al., 2014b]

# ALDA deferred life annuity – I

## ALDA: Advanced Life Delayed Annuity

- The payout period starts after retirement time (age 80 or 85, say), at time  $s > r$  ( $\rightsquigarrow$  Late life annuities)
- In the period  $[r, s]$ : Income drawdown
- A GAR is set, at time  $m$ ,  $0 < m < s$



- The premium payment may go beyond retirement time

# ALDA deferred life annuity – II

- Longevity guarantees are provided, starting from time  $m$ , for deferred payments
- In comparison to traditional products, guarantees are postponed to older ages  
⇒ The actuarial value of the annuity is reduced

See:

[Milevsky, 2005b], [Gong and Webb, 2010]

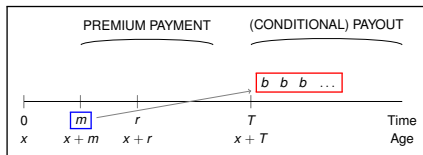
# RCLA deferred life annuity – I

## RCLA: Ruin Contingent Life Annuity

- The payment of the annuity is contingent on the realization of an adverse (financial and longevity) scenario
- Appropriate index for defining the scenario ( $\leadsto$  critical choice)
- Assumed correlation between the scenario and the individual position
- In the meantime (for a random duration): Income drawdown

# RCLA deferred life annuity – II

- Starting from time  $T$  (random), a life annuity is paid conditional on the occurrence of the adverse scenario



- Given the presence of the trigger, the cost of the life annuity is reduced

See:

[Huang et al., 2014]

# Suggestions

For a general description ...

... of the evolving structures of the longevity guarantees in life annuities, and for further references, see: [Pitacco, 2016]

Basic topics to investigate

- Premium loadings
  - Risk margins in technical provisions and required capital
- ⇒ Stochastic mortality model
- Individual preferences
  - ...



# Annuity strategies – I

Common design in the ALDA and RCLA:  
Income drawdown + Annuity at older ages

## A similar design in individual strategies for the post-retirement income

- Optimal annuitization time, partial annuitization, delayed annuitization, staggered annuitization, phased withdrawal, ...
- Problem: When and how much to annuitize
  - If annuitization is postponed: Some mortality credit is lost, but individual funds are retained, and invested with higher flexibility
  - Staggered (or progressive) annuitization: Progressive annuitization of the individual funds
- Balance between the (lost) mortality credit and the (higher) return on investments  
⇒ Optimal asset allocation

# Annuity strategies – II

See:

[Milevsky and Robinson, 2000], [Milevsky, 2001], [Milevsky, 2005a], [Milevsky and Young, 2007a], [Milevsky and Young, 2007b], [Gerrard et al., 2012], [Brown, 2001] [Davidoff et al., 2005] [Dus et al., 2005] [Schmeiser and Post, 2005] [Milevsky and Young, 2007a] [Milevsky and Young, 2007b] [Horneff et al., 2008] [Bayraktar and Young, 2009] [Horneff et al., 2010] [Bruhn and Steffensen, 2011] [Hanewald et al., 2013] [Maurer et al., 2013] [Kling et al., 2014a] [Maurer et al., 2016] [DeLong and Chen, 2017]

# Variable annuities

## GMIB: Guaranteed Minimum Income Benefit

- Lifelong post-retirement income
  - Guarantee on the amount at retirement time, annuitized at the CAR
  - GAO possibly included

## GMWB: Guaranteed Minimum Withdrawal Benefit

- Income drawdown, with a guaranteed duration
  - Fixed duration
  - Fixed duration, provided that the retiree is alive
  - Lifelong duration (logical structure of the RCLA)
- ☞ Longevity risk: In some respect, similar to life annuities, but for a shorter duration (unless a lifelong duration is guaranteed)

See:

Presentation by Jonathan Ziveyi

# Combining death with annuity benefits – I

## From the point of view of the insurer:

- A (natural) hedging effect can be gained
- In particular:
  - In case of a long lifetime, life annuity costs increase while death benefit costs decrease (and vice versa)
  - Combining life annuity with death benefits should reduce the longevity risk
  - Reason: Less mutuality is required
- ☞ Clearly, if less mutuality is required  $\Rightarrow$  The mutuality credits are lower  $\Rightarrow$  Less favourable annuity rates for the annuitant

## From the point of view of the individual

- Bequest needs

# Combining death with annuity benefits – II

## Life annuity with a guarantee period

Temporary annuity-certain + Deferred life annuity

Again, a design similar to RCLA and ALDA

## Value-protected life annuity *or* Life annuity with capital protection *or* Money-back annuities

In case of death of the annuitant prior to a given age:

Unused capital is returned to the beneficiaries

Unused capital = Difference, if positive, between the initial capital  $S$  and the total amount of benefits

## In both cases

The death benefit is provided in a range of ages in which the mortality level is low  $\Rightarrow$  The hedging effect is poor

# Combining death with annuity benefits – III

For a general description, and further references, see: [Pitacco, 2016]

# Combining LTC with annuity benefits

See:

Presentation by Ermanno Pitacco

# Special rates (or underwritten) annuities

Annuity rates are differentiated in relation to the individual health condition (at policy issue)

## Types

- Lifestyle annuities
- Enhanced annuities
- Impaired annuities
- Care annuities (LTC)

With assumed decreasing life expectancy

For more details, and references, see:

Presentation by Ermanno Pitacco



# Sharing the longevity risk

## Idea

To remove or reduce the longevity guarantee concerning

- The benefit amount
- *Or* the mortality credit assigned to the individual account value

⇒ The longevity risk after retirement is (partially) retained by the individual

⇒ Lower loadings/fees

## Two approaches: Based on a given mortality experience

- The benefit amount is updated (either increased or decreased)
- The mortality credit assigned to the individual funds corresponds to the individual funds actually released by the deceased

# Insured or self-insured arrangements

## Self-insured arrangements

- Based on pooling arguments
  - The longevity risk is offset thanks to the pool size
  - However: Only the idiosyncratic longevity risk
- No guarantee  $\Rightarrow$  Lower fees
- Participation both to losses and profits
- Examples: Group Self-Annuitization (GSA), Pooled Annuity Funds (PAF), Annuity Overlay Funds (AOF), tontine investments

## Insured arrangements

- Partial longevity guarantee
- Possible participation to profits
- Examples: tontine annuities, longevity-linked annuities (or similar labels)

# Group Self-Annuityization (GSA), Pooled Annuity Funds (PAF), Annuity Overlay Funds (AOF)

- Self-insured arrangements
- GSA: the benefit amount is updated, based on the ratio between the available assets and the required reserve
- PAF and AOF: the funds released by the deceased are distributed (as a random mortality credit) to the survivors (recorded either at the end or the beginning of the year). Annual benefits (as well as the investment profiles) are (in principle . . . ) chosen by the individual
- Critical issue: fairness and solidarity, especially when the population is heterogeneous

See:

- GSA: [Piggott et al., 2005], [Valdez et al., 2006], [Bravo et al., 2009], [Qiao and Sherris, 2012], [Boyle et al., 2015]
- PAF and AOF: [Stamos, 2008], [Donnelly et al., 2013], [Donnelly et al., 2014], [Donnelly, 2015]

# Tontine arrangements and annuities

- Originally designed as an investment, in which survivors are credited the funds of the deceased participants (or the nominees)
- The funds released upon death can be reinvested or paid as a dividend
- The dividends can be paid on top of an annuity
- Guarantees can be included, or not

See:

[McKeever, 2009], [Baker and Peter Siegelman, 2010], [Sabin, 2010], [Milevsky, 2014], [Milevsky and Salisbury, 2015], [Milevsky and Salisbury, 2016], [Weinert and Gruendl, 2016], [Chen et al., 2018]

# Longevity-linked annuities

- Participating structure
- The benefit amount is allowed to fluctuate, depending on a given longevity experience
- Guarantees can be underwritten (for example: a minimum benefit amount)
- Several labels suggested in the literature: Adaptive algorithmic annuities, Longevity-indexed life annuities, Longevity-contingent life annuities, Mortality-linked annuities, . . .

## See

[Lüthy et al., 2001], [de Melo, 2008], [Denuit et al., 2011], [Richter and Weber, 2011], [Maurer et al., 2013], [Denuit et al., 2015], [Weale and van de Ven, 2016], [Bravo and de Freitas, 2018]

# Interesting topics to investigate

- Risk/return trade-off for the individual and the provider
- Premium loading and size of the longevity guarantee. Pricing of the embedded options
- Benefit volatility and smoothing tricks
- Value based assessment for the provider. Risk margins in technical provisions, required capital
- Longevity index
- Impact of the heterogeneity of the population on sharing arrangements, in particular in the self-insured solutions
- ...

*Many thanks for your kind attention!*

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