Modern life-care tontines

Peter Hieber, **HEC Lausanne, Switzerland**,

DGVFM Weiterbildung “Health and Life Insurance”,
Köln, 01.10.2025.

Co-authors and funding

Some of this is joint work with:

- **Prof. An Chen**, University of Ulm.
- **Dr. Jakob Klein**, Actuary, Allianz Life.
- **Dr. Nathalie Lucas**, Insurance Supervisor, National Bank of Belgium.
- **Dr. Sascha Günther**, ETH Zürich.

IAA grant “Modern survivor funds”

Agenda

Motivation: (Collective) defined contribution pensions

“Pooled” modern pension products

Long-term care rider

Discussion and extensions

In general: Insurance, risk sharing

- **Insurance** works by pooling risks, diversification *(law of large numbers)*.
- Some risks cannot be pooled (example: **longevity risk**).
- There may (**or may not**) be a third party that covers such risk for a cost (pension fund, insurance company).

Pensions

The extremes:

(Collective) defined contribution

A pool shares risks.

No third party (insurer).

No solvency capital.

Policyholder takes all risks.
pooled annuity, group annuitization, tontine, "Zielrente". . .

Defined benefit

Fixed retirement pension.

Third party covers all risks.

Solvency capital needed.

Third party takes all risks.
standard (deferred) annuity,. . .
Many first pillar pensions,. . .

This talk: Left hand side (+ combinations).

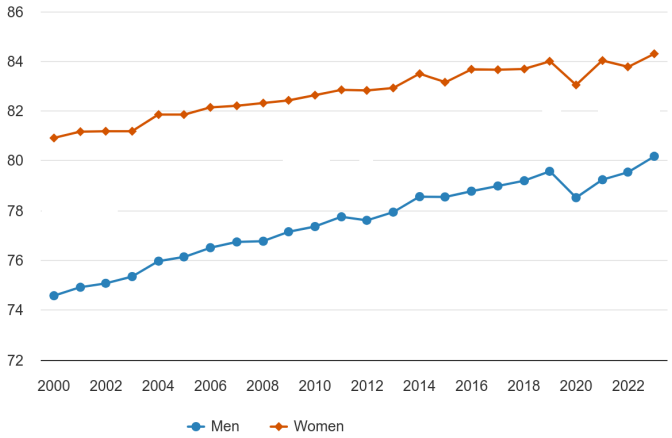
Collective defined contribution schemes

The idea:

- Each year, we compare funds (assets) and promises (rents).
- We compute reserves of rents (assumption on discount factor and mortality!).
- This gives a funding rate (assets / reserves).
- **If far different from 100%, we take action**. . .

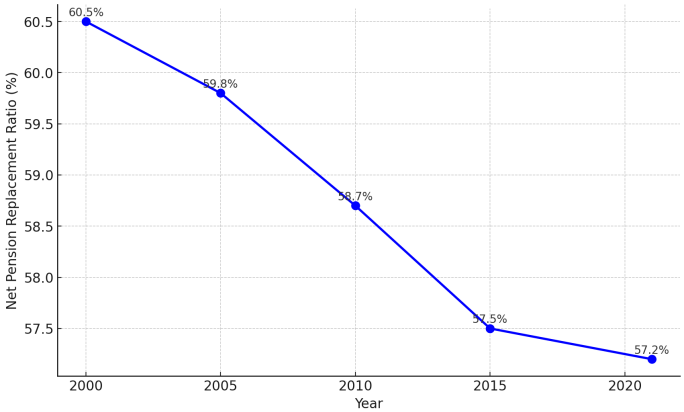
(Similar names in the literature: Pooled annuities, survivor funds, tontines).

Trends 1: Life exepctancy rises!



(OECD Data Explorer, https://www.oecd.org/en/data/)

Trends 2: State pensions decline! (net pension replacement ratio, Belgium)



(OECD Data Explorer, https://www.oecd.org/en/data/)

Trends 3: Long-term care expenses rise!

The New York Times

THE NEW OLD AGE

Many Americans Will Need Long-Term Care. Most Won't be Able to Afford It.

A decade from now, most middle-income seniors will not be able to pay the rising costs of independent or assisted living.

(NYT 2018)

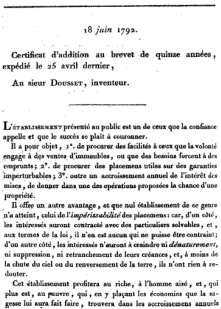
- Belgium: LTC spending (in terms of GDP) increased from **1.7% in 2000** to **2.3% in 2018** (source: Eurostat).
- United Nations projections: The number of **elderly people**, i.e. older than 65, is projected **to triple from 2020 to 2080** to reach 2.2 billion. The global **share of the elderly population** is expected to **rise from 9.4% in 2020 to 20.6% in 2080**.

History: The **old tontines**. . .

- **Mutual insurance** = Risks are shared within a pool.

  Tontines, pooled annuities, survivor funds, *group self annuitization* (used as synonyms).

- **Dominant insurance** several hundred years ago.



18 *juin* 1792.

Certificat d'addition au brevet de quinze années, expédié le 26 avril dernier,

Au sieur Dousset, inventeur.

L'établissement présenté au public est un de ceux que la confiance appelle et que le succès se plaît à couronner.

Il a pour objet, 1°. de procurer des facilités à ceux que la volonté engage à des ventes d'immeubles, ou que des besoins forcent à des emprunts; 2°. de procurer des placemens utiles sur des garanties imperturbables; 3°. outre un accroissement annuel de l'intérêt des mises, de donner dans une des opérations proposées la chance d'une propriété.

Il offre un autre avantage, et que nul établissement de ce genre n'a atteint, celui de l'*imprescriptibilité* des placemens: car, d'un côté, les intéressés auront contracté avec des particuliers solvables, et, aux termes de la loi, il n'en est aucun qui ne puisse être contraint; d'un autre côté, les intéressés n'auront à craindre ni *détournemens*, ni suppression, ni retranchement de leurs créances, et, à moins de la chute du ciel ou du renversement de la terre, ils n'ont rien à redouter.

Cet établissement profitera au riche, à l'homme aisé, et, qui plus est, au pauvre, qui, en y plaçant les économies que la sagesse lui aura fait faire, trouvera dans les accroissemens annuels

- Li, Y., & Rothschild, C. (2020). Selection and redistribution in the Irish tontines of 1773, 1775, and 1777. **Journal of Risk and Insurance**, 87(3), 719-750.
- Milevsky, M. A. (2015). King William's tontine: Why the retirement annuity of the future should resemble its past. Cambridge University Press.

. . . start a revival today as **modern tontines**

The New York Times

When Others Die, Tontine Investors Win

By Tom Verde
March 24, 2017

Living a long life is its own reward. But when you invest in a tontine, there's an added benefit: You collect money that would have gone to people who have died.

That is part of the macabre appeal of the tontine, a 350-year-old investment vehicle that fell into disfavor more than a century ago but is now getting fresh consideration as a way to help people receive steady income in retirement.

Mutual insurance, pooled annuities, tontines, . . .

- Pension payments are shared within an (anonymous) pool of policyholders.
- Pensions are reduced (increased) if life expectancy increases (decreases).
- Germany: Target pension (“Zielrente”). Payments are adapted annually according to the **funding ratio** of the portfolio.
- **No traditional insurance guarantee**. Thus: less **administration** and **risk management charges**, transparent, cost-efficient.

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Private insurance: Example “Le conservateur”, France

- Similar to a fund investment, 20 year product.
- But: Upon death, money is distributed among survivors (“**mortality credits**”).
- Survivors get fund return + mortality credit.
- `http://www.conservateur.fr`

Private insurance: Example Xianghubao

Xianghubao mutual aid amount.

Age group	Mild critical illness	Severe critical illness
30 days to 39-year-old	50,000 yuan	300,000 yuan
40- to 59-year-old	50,000 yuan	100,000 yuan

- **Disability insurance** in China, based on an app, founded 2018.
- Payments are shared in a pool, **no traditional insurer**.
- After 1 year, **100 million users**. Closed 2022 after regulatory concerns.

See also:

- Abdikerimova, S., & Feng, R. (2022). Peer-to-Peer multi-risk insurance and mutual aid. **European Journal of Operational Research**, 299(2), 735-749.

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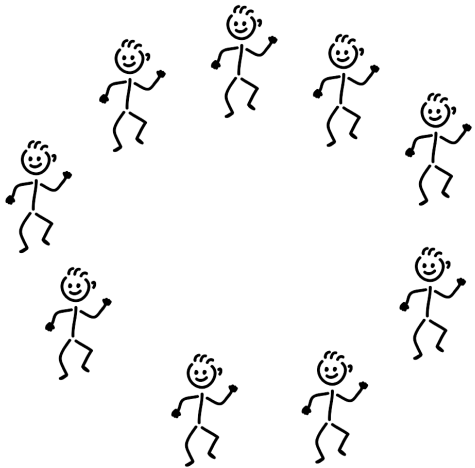
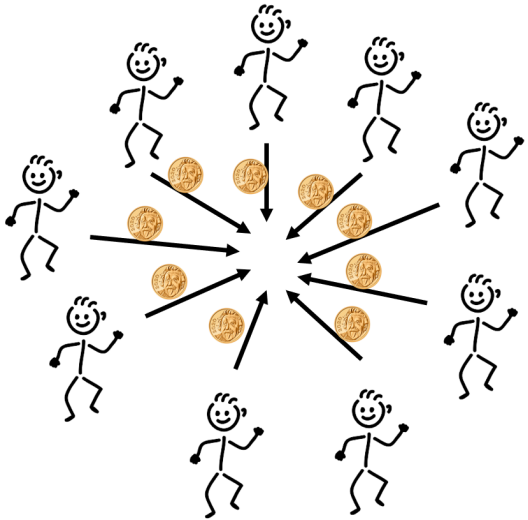
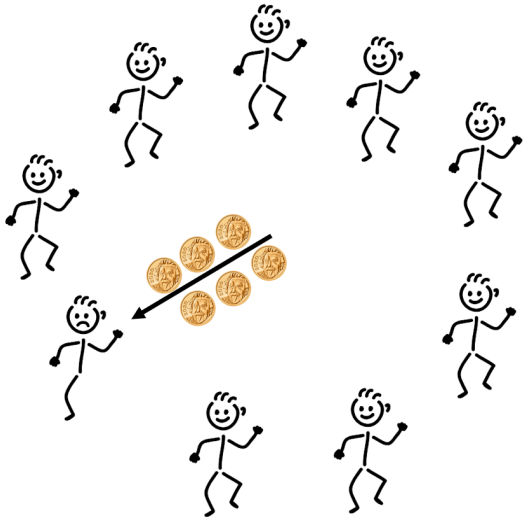
Illustrative: Premium payments



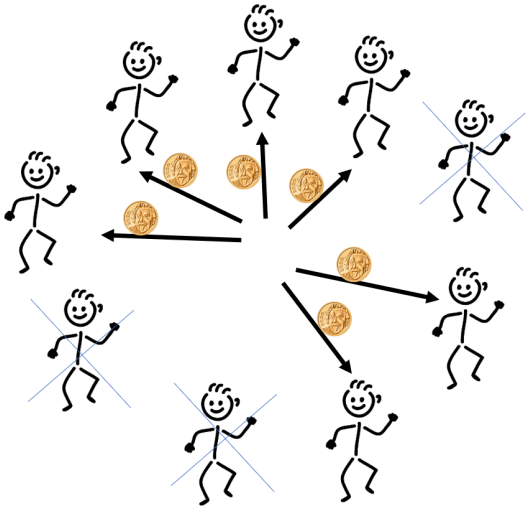
Illustrative: Premium payments



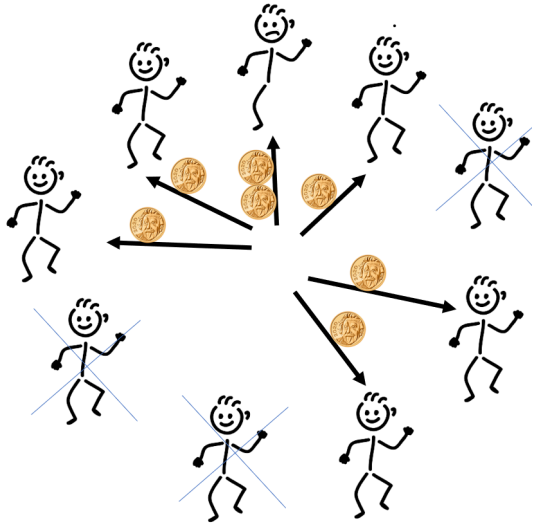
Illustrative: Disability benefit



Illustrative: Pension payments



Illustrative: Modern Life-Care tontine



Qsuper in Australia: Marketing prospectus

Product features

Income for life

Tax-free, fortnightly payments for life – no matter how long you live.

See pages 22 – 29.

Spouse protection option

If chosen, your spouse will continue to receive tax-free, fortnightly payments for life if they live longer than you.

See page 23.

Potential Age Pension benefits

Potentially receive a higher Age Pension than you may otherwise have qualified for, if you are eligible.

See page 24.

How your money is invested

Your funds are pooled with the money of other Lifetime Pension members and invested in the same Balanced investment option as the QSuper Income account. This means that you don't have an individual account balance.

See page 7 (Part B of this PDS).

Payments are adjusted each year

When you purchase a Lifetime Pension, your payment amount will be adjusted each year and may go up or down depending on investment returns, fees and costs and mortality experience. However, the product is designed to increase your payments over time.

See page 28.

Money-back protection

The Lifetime Pension is designed so that you receive your purchase price back in fortnightly payments, or the remainder goes to your beneficiaries once you pass away.

See page 32.

Important to consider

No withdrawals

You have a six-month cooling-off period to decide if it's right for you. After this time, the Lifetime Pension will be a permanent purchase, with no ability to make withdrawals.

See page 25.

Qsuper in Australia: Tax benefits + financial investment

Tax benefits

The investment returns on TTR Income accounts are generally taxed at the concessional tax rate of up to 15%. If you are 60 or older, the payments from your super will be tax-free, and even before age 60 you could still benefit from a tax offset.

If you earn more than $45,000 a year, it could benefit you to salary sacrifice more of your before-tax salary into your super and supplement your income with payments from a TTR Income account.

Salary sacrifice contributions are taxed at a rate of 15%[1] when they are received by a super fund. As the extra payments are taken out of your salary before you've paid income tax, you only pay 15% tax instead of your marginal tax rate (which could be as high as 45% plus the Medicare Levy of 2%). For example, you could save tax by making salary sacrifice contributions to an Accumulation account and taking payments from a TTR Income account.

3 Set an investment strategy

Your investment options

If you start a TTR Income account and do not make an investment choice, your money will be invested in our default investment option, Balanced.

If you want more personalised control over your investments, we also offer the following options:

Diversified options: Pre-mixed investment options offering diversification across asset classes

- Moderate
- Aggressive
- Socially Responsible.

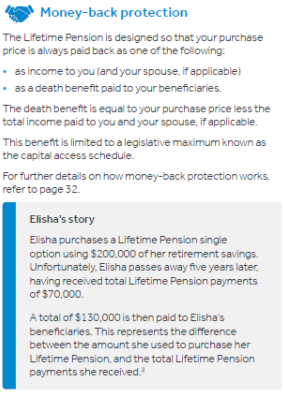
Single Sector options: Invest in individual asset classes

- Cash
- Diversified Bonds
- International Shares
- Australian Shares.

You can select one or more options that align to your goals, and you can change them as often as you like. For more information about the investment options available to you, read Part B of this PDS.

Note: The Self Invest option is not available with a TTR Income account. If you would like to use monies held in Self Invest to start a TTR, you will first need to transfer these monies to other QSuper investment option/s before you commence your TTR.

Qsuper in Australia: Premium refund



Money-back protection

The Lifetime Pension is designed so that your purchase price is always paid back as one of the following:

- as income to you (and your spouse, if applicable)
- as a death benefit paid to your beneficiaries.

The death benefit is equal to your purchase price less the total income paid to you and your spouse, if applicable.

This benefit is limited to a legislative maximum known as the capital access schedule.

For further details on how money-back protection works, refer to page 32.

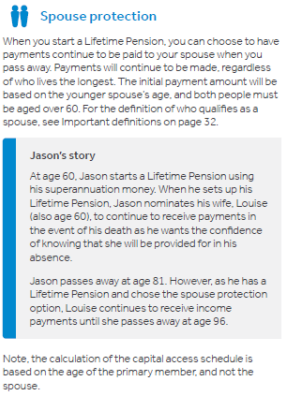
Elisha's story

Elisha purchases a Lifetime Pension single option using $200,000 of her retirement savings. Unfortunately, Elisha passes away five years later, having received total Lifetime Pension payments of $70,000.

A total of $130,000 is then paid to Elisha's beneficiaries. This represents the difference between the amount she used to purchase her Lifetime Pension, and the total Lifetime Pension payments she received.[2]

Joint work with Sascha Günther (ETH Zürich).

Qsuper in Australia: Spouse protection



Spouse protection

When you start a Lifetime Pension, you can choose to have payments continue to be paid to your spouse when you pass away. Payments will continue to be made, regardless of who lives the longest. The initial payment amount will be based on the younger spouse's age, and both people must be aged over 60. For the definition of who qualifies as a spouse, see Important definitions on page 32.

Jason's story

At age 60, Jason starts a Lifetime Pension using his superannuation money. When he sets up his Lifetime Pension, Jason nominates his wife, Louise (also age 60), to continue to receive payments in the event of his death as he wants the confidence of knowing that she will be provided for in his absence.

Jason passes away at age 81. However, as he has a Lifetime Pension and chose the spouse protection option, Louise continues to receive income payments until she passes away at age 96.

Note, the calculation of the capital access schedule is based on the age of the primary member, and not the spouse.

PhD project of Marie-Fleur Borac (University of Lausanne).

Qsuper in Australia: Mortality credits

How Lifetime Pension payments are adjusted

Your Lifetime Pension payments will be adjusted effective 1 July each year based on the pool's financial results during the previous year. The adjustment for the next financial year will apply to your previous year's annual payment amount. The pool is invested in QSuper's Balanced option for Income accounts.

Your Lifetime Pension is designed to generally increase over time to assist with rising costs of living. However, just like an Income account, fluctuations in financial results will mean that payments may go up or down.

Your first annual adjustment will be pro-rated based on the pool financial results from your start date.

Pool financial results

The pool's annual financial results will determine the annual income adjustment in the following year. These results include investment returns, the mortality experience of the pool, timing, and all fees and costs.

Net investment returns

The pool is invested in the QSuper Income account Balanced investment option. Investment returns are calculated net of fees, costs and taxes. All fees and costs are deducted directly or indirectly from the pool and are not attributable to individual members with a Lifetime Pension.

Mortality experience

Mortality experience affects the Lifetime Pension pool in the following ways:

- The pool is debited for insurance costs (see page 32).
- The pool retains credits when members die and their income payments cease.

QSuper makes assumptions regarding the level of these credits and debits and the net variance to these assumptions (which could be positive or negative) will impact the overall adjustment amount.

These variations are not attributable to individual members with a Lifetime Pension and apply to the Lifetime Pension pool.

Similar elements in many products. . .

- **Superannuation** fund: Australian retirement trust (QSuper).
- **Variable payment life annuities** (VPLAs) in Canada.
- **State pension fund** in Iceland.
- **Tontine Trust** in US.
- . . .

Obligatory insurance: Idea of "(collective) defined contribution" is part of many pension / retirement reforms (second/third pillar).

Private insurance: (Still) small market, regulatory concerns, scepticism.

Literature

MODERN LIFE-CARE TONTINES

BY

PETER HIEBER AND NATHALIE LUCAS

ABSTRACT

The tendency of insurance providers to refrain from offering long-term guarantees on investment or mortality risk has shifted attention to mutual risk pooling schemes like (modern) tontines, pooled annuities or group self annuitization schemes. While the literature has focused on mortality risk pooling schemes, this paper builds on the advantage of pooling mortality and morbidity risks, and their inherent natural hedge. We introduce a modern "life-care tontine", which in addition to retirement income targets the needs of long-term care (LTC) coverage for an ageing population. In contrast to a classical life-care annuity, both mortality and LTC risks are shared within the policyholder pool by mortality and morbidity credits, respectively. Technically, we rely on a backward iteration to deduce the smoothed cashflows pattern and the sepa-

Agenda

Motivation: (Collective) defined contribution pensions

“Pooled” modern pension products

Long-term care rider

Discussion and extensions

Very active area of research. . . research directions:

- **Risk sharing** for heterogeneous pools: Denuit, Robert (2019-25), Jiao, et al. (2022),
- **Actuarial fairness** of heterogeneous pools: Milevsky, Salisbury (2016), Dhaene, Milevsky (2024), Dhaene, Milevsky (2024), Bernard et al. (2024).
- **Long-term care** + pensions: Hieber, Lucas (2022), Chen et al. (2022), Kabuche et al. (2024), Zhou, Dhaene (2024).
- **Mixed products**: Chen, Rach (2019), Chen et al. (2020), Weinert, Gründl (2021), Chen, Hanbali, Hieber (2025).
- Towards the **design of products**: Weinert, Gründl (2021), Winter, Planchet (2022).

Fullmer, R. K. Tontines: A practitioner’s guide to mortality-pooled investments. CFA Institute Research Foundation, 2019.

Recent literature overview:

Annals of Actuarial Science (2024), 1–5
doi:10.1017/S174849952400023X

Institute and Faculty of Actuaries

EDITORIAL

Decentralized insurance: On the popularity of tontines and peer-to-peer (P2P) insurance schemes

Michel Denuit[1], Jan Dhaene[2], Runhuan Feng[3], Peter Hieber[4] and Christian Robert[5]

[1]Institute of Statistics, Biostatistics and Actuarial Science (ISBA) Louvain Institute of Data Analysis and Modeling (LIDAM), UCLouvain, Louvain-la-Neuve, Belgium; [2]AFI, Faculty of Business and Economics, KU Leuven, Leuven, Belgium; [3]School of Economics and Management, Tsinghua University, Beijing, China; [4]Department of Actuarial Science, University of Lausanne (HEC Lausanne), Bâtiment Extranef, Lausanne, Switzerland; and [5]Institut de Science Financière et d'Assurances (ISFA), Université Claude-Bernard Lyon 1, Université de Lyon, Lyon, France

Keywords: decentralized insurance; peer-to-peer insurance; tontines; pooled annuities; risk sharing

Designing mutual insurance schemes

We want to:

- Design single-premium mutual insurance schemes that pay **1 for life**.
- Pool members are **heterogeneous** (by age, health).
- This is a **multi-period scheme**.
- (For now), we **ignore financial risk**.
- Work in progress: Add a premium refund guarantee *(joint with Sascha Günther (ETH Zürich)).*

IAA AAI IAALS Life & Annuities

Designing mutual insurance schemes

There are three (similar but different) approaches:

(a) **Share common cash-flow in a survivor pool**
special case: "**natural tontine**" (Milevsky, Salisbury [2015])

(b) **Combine actuarially fair individual tontine accounts** (see, e.g., Sabin, Fullmer [2010, 2018], Donnelly, Guillén, Nielsen [2013, 2014], Denuit [2019], Hieber, Lucas [2022], Denuit, Hieber, Robert [2022] and many more).

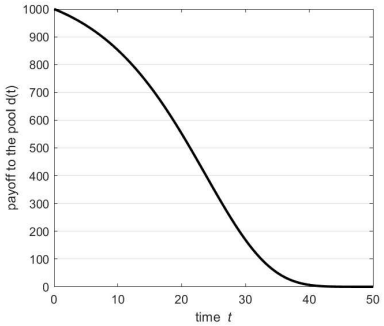
(c) **Adjust realized vs. projected mortality**
(see, e.g. Piggott, Valdez, Detzel [2005], Qiao, Sherris [2013]).

(a) Share common cash-flow

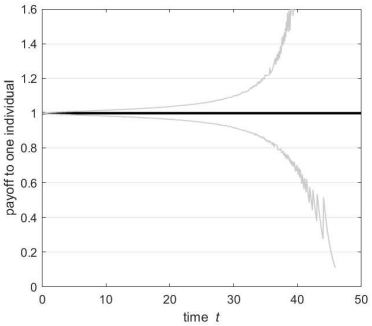
Introduce “**natural tontine**: homogeneous pool of n receives ($n = 1\,000$, $x = 65$)

$$d(t) = n \cdot {}_tp_x\,. \qquad (\textbf{pool payoff})$$

pool



individual



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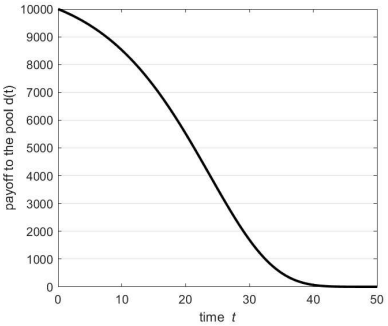
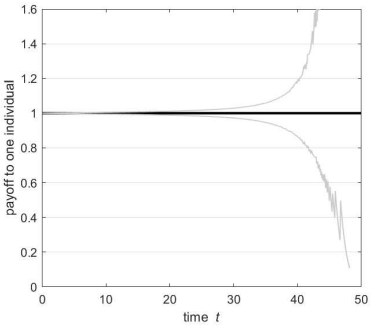


individual



(b) “Pooled” modern pensions

Individual account $c_j(t)$ (“at risk”)

- Lost upon death.
- Entitled to **mortality credits**.

(b) "Pooled" modern pensions

- The financial market is deterministic at an annual return δ_t.
- Each year $t = 1, 2, \ldots$, individual withdraws $s_j(t)$ from its individual account $c_j(t)$:

$$\boxed{c_j(t) = e^{\int_{t-1}^{t} \delta_s \mathrm{d}s} c_j(t-1) - s_j(t)}.$$

- We sum over the accounts of deceased in $(t-1, t]$ (**mortality credits**):

$$X(t) = \sum_{j \text{ died in } (t-1,t]} e^{\int_{t-1}^{t} \delta_s \mathrm{d}s} c_j(t-1).$$

- We find a distribution rule $\beta_j(X(t))$ that assigns mortality credits to j.

(b) Combine actuarially fair individual accounts

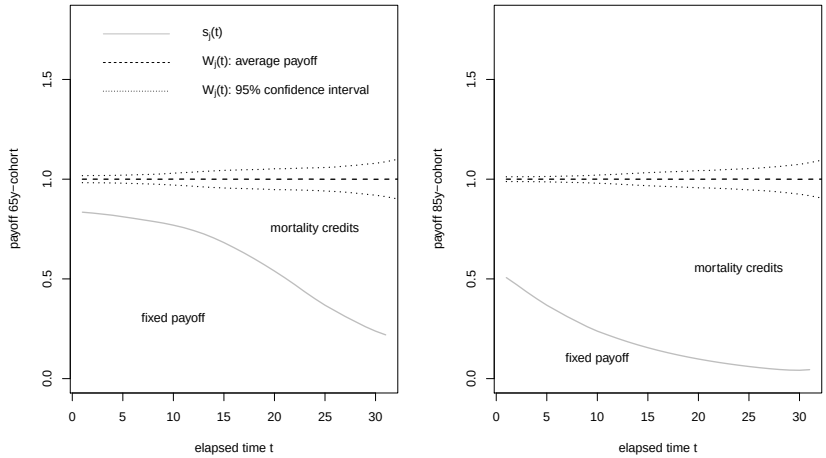
We sum over the accounts of deceased in $(t-1, t]$ (**mortality credits**):

$$X(t) = \sum_{j \in \mathcal{D}_t} e^{\int_{t-1}^{t} \delta_s \mathrm{d}s} c_j(t-1)\,.$$

A survivor $j \in \mathcal{L}_t$ receives in t: $\boxed{W_j(t) = s_j(t) + \beta_j(X(t))}$, where:

- $s_j(t)$: individual, fixed withdrawal amount,
- $\beta_j(X(t))$: collective part of the benefits, i.e. the mortality credits.

Numerical example, two groups/cohorts



“Pooled” pensions: Fairness

- **Self-sufficiency property**: $\sum_{j \text{ alive}} \beta_j(X(t)) = X(t)$.
- **Actuarial fairness property**:

$$\mathbb{E}_{t-1}\left[\beta_j(X(t))\right] = \underbrace{q_{x_j+t-1}}_{\text{probability to die in } (t-1,\,t]} \cdot \underbrace{e^{\int_{t-1}^{t} \delta_s \mathrm{d}s} c_j(t-1)}_{\text{amount at risk at time } t}. \tag{1}$$

Denuit, M. (2020). Investing in your own and peers’ risks: The simple analytics of P2P insurance. ***European Actuarial Journal****, 10(2), 335-359.*

Hieber, P., & Lucas, N. (2022). Modern life-care tontines. ***ASTIN Bulletin****, 52(2), 563.*

Actuarial fairness: Insurer's view

For each $t = 0, 1, \ldots$, the premium equivalence holds: (pool view)

$$\underbrace{\sum_{j=1}^{n} c_j(t)}_{\text{total account values}} = \sum_{j=1}^{n} \underbrace{\sum_{s=t+1}^{\omega - x_j} e^{-\int_t^s \delta_u \mathrm{d}u} W_j(s)}_{\text{discounted future benefits individual } j} . \tag{2}$$

- Right hand side: **random** (big letter!)
- Left hand side: **deterministic**. (this determines mutual insurance!)

“Pooled” pensions: Fairness

- The pension fund is always **fully funded**.
- It is also fair for everyone and any $t = 0, 1, 2, \ldots$:

$$\underbrace{c_j(t)}_{\text{retrospective reserve}} = \underbrace{\mathbb{E}_t\left[\sum_{s=t+1}^{\omega - x_j} e^{-\int_t^s \delta_u \mathrm{d}u} W_j(s)\right]}_{\text{prospective reserve}}. \tag{3}$$

- Longevity risk is shared within the **pool** (**no insurer**).
- Premium refund guarantee can be included. Aim: reduce reservation.
  (important element of QSuper Australian pension fund)

Combining collective pools and guarantees

If one is not willing to fully share longevity risks, combinations are possible. Possibilities:

1. Splitting wealth in collective defined contribution and defined benefit.
2. **Ton**tine-ann**uity**: Share longevity risk in early ages of retirement (tontine) but receive a fixed payment at old ages (annuity).

   Chen, A., Hieber, P., and Klein, J. K. (2019). Tonuity: A novel individual-oriented retirement plan. ***ASTIN Bulletin****, 49(1), 5-30.*

Agenda

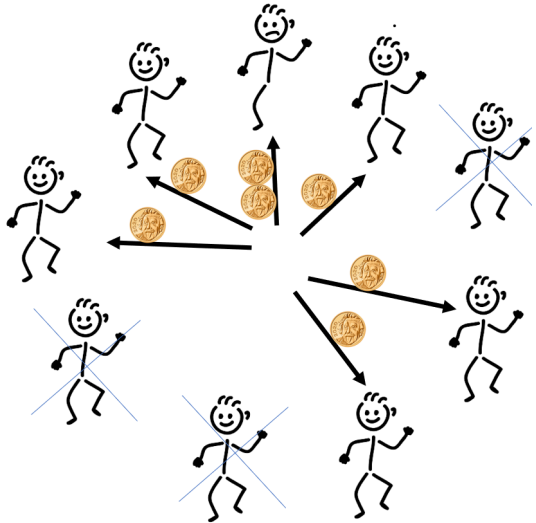
Motivation: (Collective) defined contribution pensions

“Pooled” modern pension products

Long-term care rider

Discussion and extensions

Illustrative: Modern Life-Care tontine



Discussion and extensions

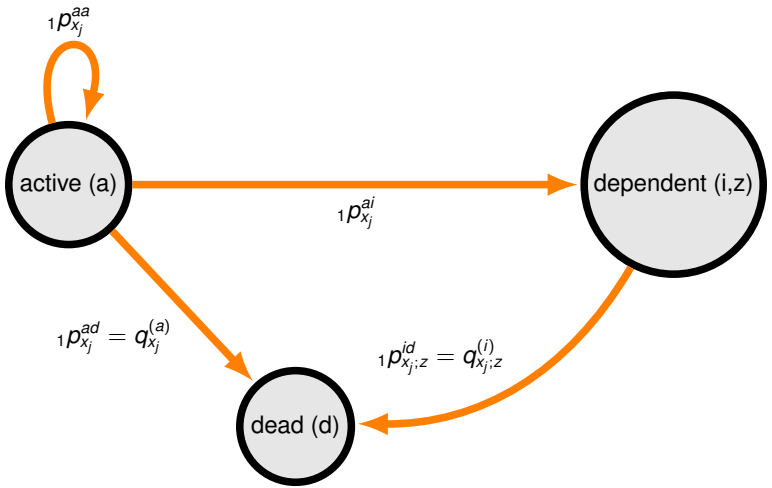
- Include **long-term care benefits**.
- Add **mutual joint-life insurance** (see Donnelly, Zhang [2023]).
- "Pooled" pensions may **supplement** obligatory retirement benefits in many countries (= 2nd, 3rd pillar, e.g. PEPP in Europe).
- Advantage: More transparent, cheaper (less regulation, administration).
- Challenge: Reservation by regulators and traditional insurers.

Modern Life-Care tontine

- An ageing population faces **longevity risk**, **demographic risk** but also **morbidity risks** (long-term care).
- **Idea**: Offer a combined product with higher payments in dependency.
- **Why?**: · Mortality and morbidity risks are *negatively correlated*.
  · Cost reduction due to **reduced adverse selection**!
- **How?**: Mortality rates account for dependency
  $\Longrightarrow$ Higher mortality credits for dependent people.

Hieber, P., & Lucas, N. (2022). Modern life-care tontines. ***ASTIN Bulletin****, 52(2), 563.*

Life-Care Tontine: semi-Markov model



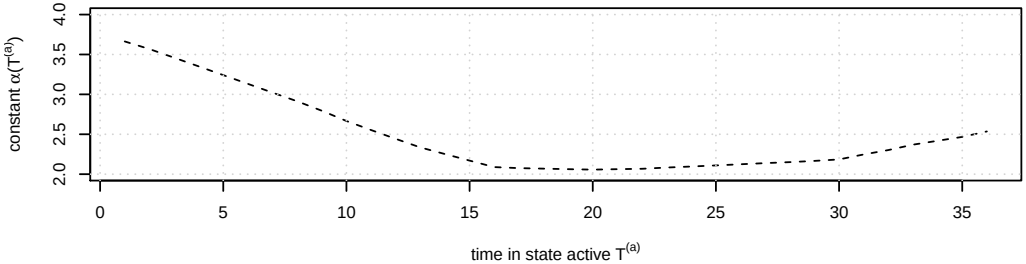
z: time spent in dependency.

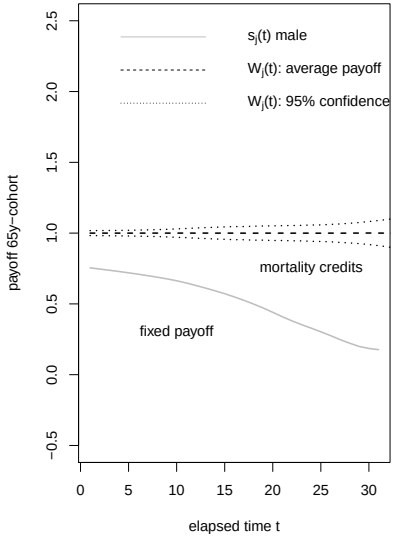
Modern Life-Care Tontine

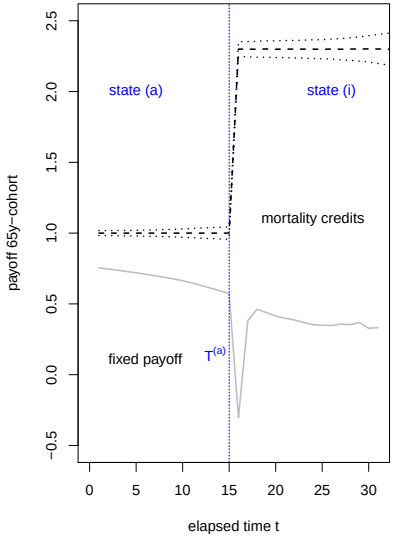
Using real mortality/disability (France), we compute the quotient

$$\alpha(T^{(a)}) = \frac{\ddot{a}_x^{\text{active}}}{\ddot{a}_x^{\text{disabled}}},$$

as a function of the time until disability $T^{(a)}$:




$s_j(t)$ male
$W_j(t)$: average payoff
$W_j(t)$: 95% confidence
mortality credits
fixed payoff
payoff 65y−cohort
elapsed time t
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
0
5
10
15
20
25
30


state (a)
state (i)
mortality credits
fixed payoff
$T^{(a)}$
payoff 65y−cohort
elapsed time t
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
0
5
10
15
20
25
30

Some comments:

- There is need to extend this also to financial risk (random return δ_t). (see Donnelly, Guillén, Nielsen [2014]).
- Actuarial fairness at all times allows people to join later.
- Mortality tables are used to fairly assign mortality credits. If there is agreement, the tables can be updated over time.
- It is possible to design a tontine with premium refund option. This simply reduces risk sharing. *(important element of QSuper Australian pension fund)*

Thank you!

(b) individual accounts, (a) shared cash-flow

(b) Hieber, P., Lucas, N. (2022). Modern life-care tontines. **ASTIN Bulletin**, 52(2), 563.

(b) Denuit, M., Hieber, P., and Robert, C. Y. (2022). Mortality credits within large survivor funds. **ASTIN Bulletin**, 52(3), 813-834.

(b) Denuit, M. (2019). Size-biased transform and conditional mean risk sharing, with application to P2P insurance and tontines. **ASTIN Bulletin**, 49(3), 591-617.

(b) Donnelly, C., Guillén, M., and Nielsen, J. P. (2014). Bringing cost transparency to the life annuity market. **Insurance: Mathematics and Economics**, 56, 14-27.

(a) Milevsky, M. A., and Salisbury, T. S. (2016). Equitable retirement income tontines: Mixing cohorts without discriminating. **ASTIN Bulletin**, 46(3), 571-604.

(a) Chen, A., Hieber, P., and Klein, J. K. (2019). Tonuity: A novel individual-oriented retirement plan. **ASTIN Bulletin**, 49(1), 5-30.

(a) Chen, A., Hieber, P., & Rach, M. (2021). Optimal retirement products under subjective mortality beliefs. **Insurance: Mathematics and Economics**, 101.

Questions? Comments?