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Modern Pension Design by Refundable Income Annuities

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funding:

Co-authors and funding

Some of this is joint work with:

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- **Dr. Nathalie Lucas**, Insurance supervisor, National Bank Belgium.
- **Dr. Jakob Klein**, Actuary, Allianz Germany.
- **Dr. Sascha Günther**, ETH Zurich, Switzerland.

Project "*Modern Survivor Funds*"

Agenda

Motivation: (Collective) defined contribution pensions

“Pooled” modern pension products

Discussion and extensions

Motivation: A traditional annuity

- In 2026, a 70-year old female buys a lifelong annuity of 1 annually.
- Technical rate 0.9%, DAV2004R mortality table, no charges.
- **Premium refund guarantee** (at least contributions are paid back).

Motivation: A traditional annuity

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- Technical rate 0.9%, DAV2004R mortality table, no charges.
- **Premium refund guarantee** (at least contributions are paid back).

"Fair" premium: $P \approx 26$. Refund guarantee until age 96!

- **Problem 1**: This is hardly an insurance product (26-year safe payment $a_{\overline{26}|} \approx 23$).
- **Problem 2**: Insurance charges may be proportional to P *(ignored here)*.

Conclusions: A traditional annuity

- With low interest rates, charges and a premium refund guarantee, it is **hardly possible to offer an attractive traditional annuity**.

(1) Possible alternative: products with lower charges, higher risks (for example tontines).

(2) Split the product in 2:

- A financial account to fund the guarantee ($a_{\overline{26}|} \approx 23$). No insurance charges!
- An insurance product for the remainder ($26 - 23 \approx 3$).

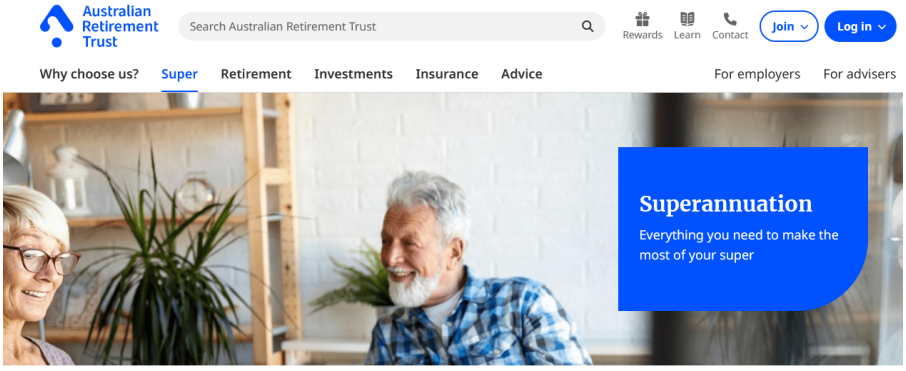
Modern tontines: “Le conservateur”, France

- `http://www.conservateur.fr`
- Probably the first “modern tontine”.
- 20 year product, rolling.
- Upon death, money is distributed among survivors (“**mortality credits**”).

Australia: Retirement Trust (formerly Qsuper)

$230 billion in retirement savings for more than two million members.

Tontine-like product that includes money-back protection.



https://www.australianretirementtrust.com.au/superannuation

Modern tontines: 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**.
- Based on an **app in China**, founded 2018.
- After 1 year, **100 million users**, now stopped by regulator.

Very active academic research:

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

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

Overview of pension designs:

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).

Group-self-annuitization (GSA) schemes

- Simple idea to adjust benefits annually:

$$B_t = B_{t-1} \cdot \underbrace{\frac{\ddot{a}_{x+t}^{\text{old}}}{\ddot{a}_{x+t}^{\text{new}}}}_{CEA_t},$$

using (every year) updated information on mortality and discount rate.

We want a similar scheme, but:

1. **Death benefit guarantee** (ex.: contributions are paid back).

   Advantage: Tax incentives in many countries, reduce scepticism among policyholders.

2. **Modular structure** with individual accounts.

   Advantage: Actuarially fair, allows people to join.

3. **Add widow(er) pension**.

4. **Add long-term care benefit** (higher payoff in dependency).

Advantages and comparison

- “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.

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**.
- Add a premium refund guarantee.

IAALS
Life & Annuities

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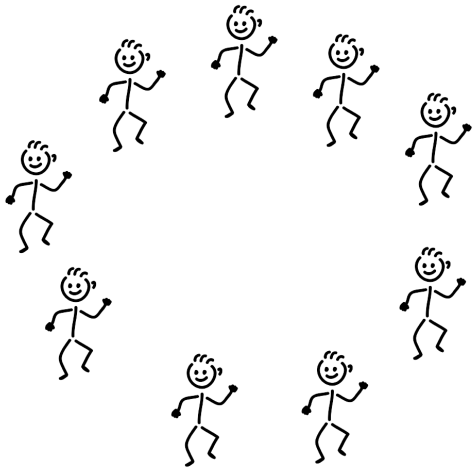
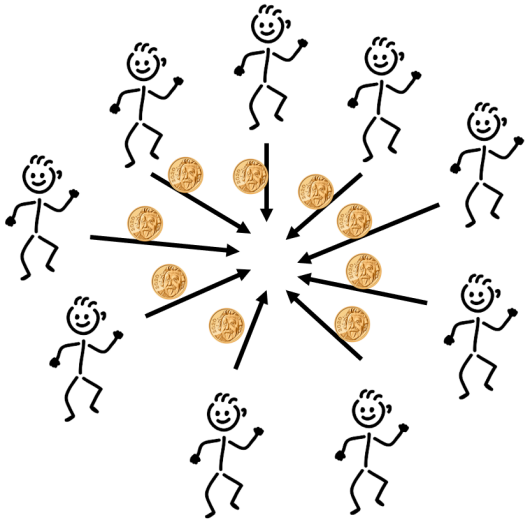
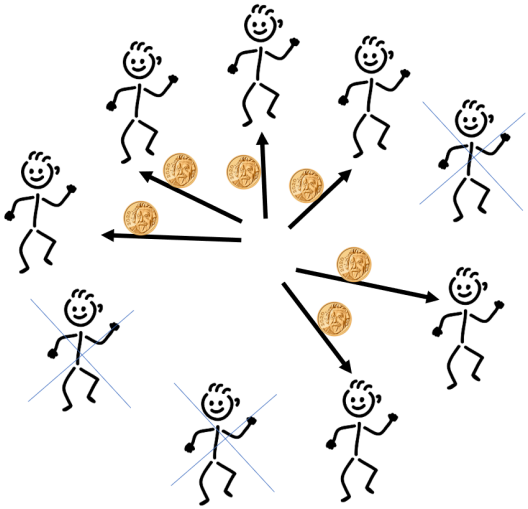
Illustrative: Premium payments



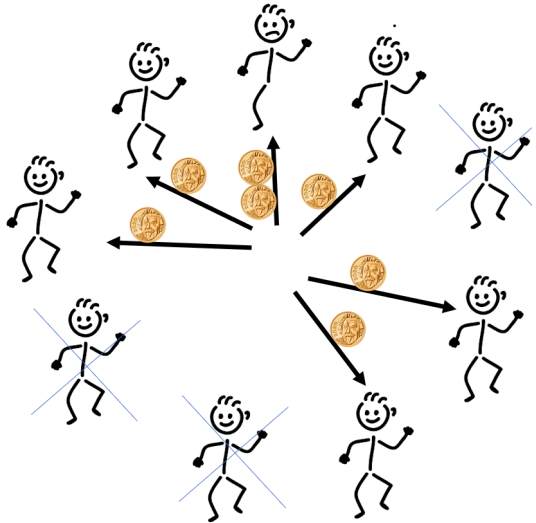
Illustrative: Premium payments



Illustrative: Pension payments



Illustrative: Modern Life-Care tontine



Illustrative: Modern Life-Care tontine

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

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"Pooled" modern pensions

Each individual j has two accounts:

Guarantee account $g_j(t)$

- Fully belongs to j.
- = Premium refund, = Death benefit.
- Used during early retirement.

Individual account $c_j(t)$ ("at risk")

- Lost upon death.
- Entitled to **mortality credits**.
- Used at old ages.

No premium refund $\implies g_j(t) = 0$.

Split $(c_j(t), g_j(t))$ is individual choice (depends on risk aversion, family situation ...).

"Pooled" modern pensions

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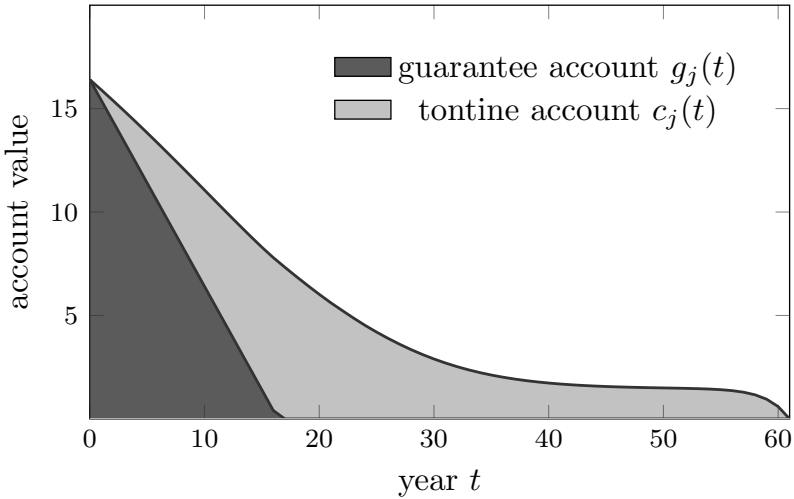
Illustrative: Account values with premium refund guarantee



"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.

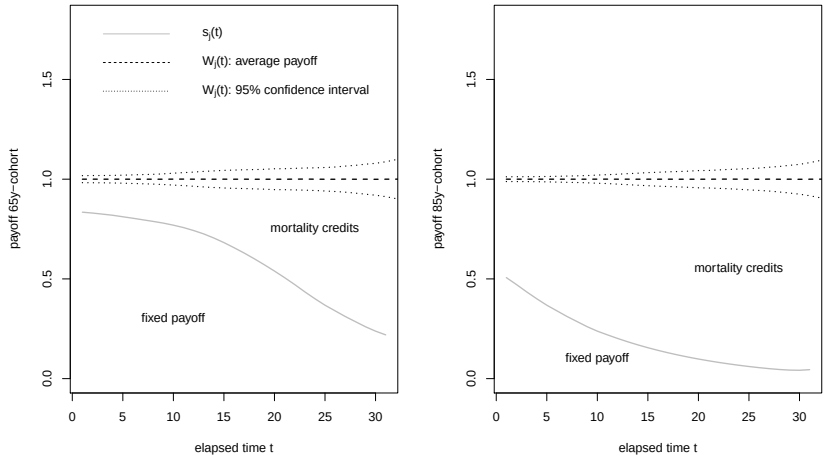
"Pooled" pensions: Fairness

- **You pay what you get**: $\underbrace{\sum_{j \text{ alive}} \beta_j(X(t))}_{\text{credits you distribute}} = \underbrace{X(t)}_{\text{credits earned}}$.
- **Actuarial fairness property**:

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

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

Numerical example, two groups/cohorts



"Pooled" pensions: Fairness

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

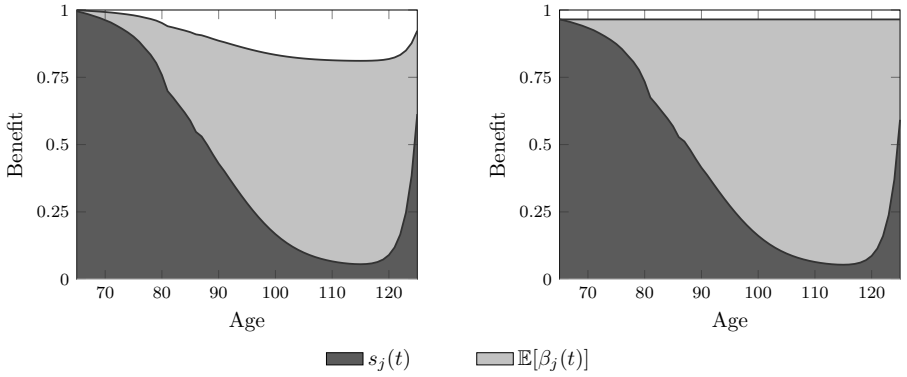
$$\underbrace{c_j(t)}_{\text{retrospective reserve}} = \underbrace{\mathbb{E}_t\left[\sum_{s=t+1}^{\omega - x_j} e^{-\int_t^s \delta_u \mathrm{d}u} W_j(s)\right]}_{\text{prospective reserve}}. \tag{2}$$

- 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)

Adjusting the mortality table

- It may make sense to adjust the mortality table used to redistribute mortality credits regularly.
- **Advantage 1**: Fair conditions for new members.
- **Advantage 2**: Adjustments are more smooth, drops at high ages not that likely.
- **Possibility 1**: We adjust using newly published state mortality tables (DAV in Germany, SAV in Swiss, . . .)
- **Possibility 2**: We adjust by recalibrating a mortality model.

Adjusting the mortality table



Small adjustment at age 65 prevents 20% drop at ages 95-110!

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Discussion and extensions

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) Günther, S., Hieber, P. (2026). Modern pension design by refundable income tontines. Available at SSRN 5022069.

(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.

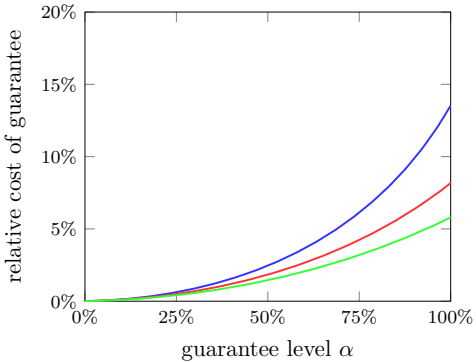
(b) Borac, M. F., Hieber, P. (2026). Couple tontines: Mutual joint-life and last-survivor insurance products. Available at SSRN 6595898.

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

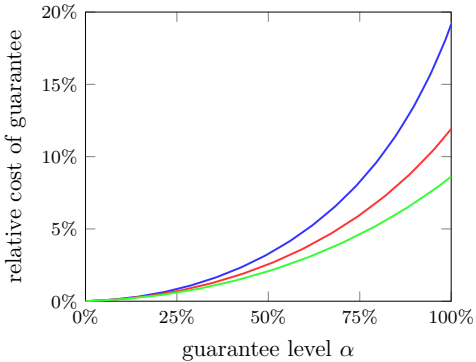
(a) Chen, A., Hieber, P., & Rach, M. (2021). Optimal retirement products under subjective mortality beliefs. **Insurance: Mathematics and Economics**, 101.

Questions? Comments?

How expensive is the guarantee?



(A) starting age 65



(B) starting age 70

$\delta = 2\%$ $\delta = 4\%$ $\delta = 6\%$

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]).