

Actuarial Research Centre

Institute and Faculty of Actuaries

Sharing investment risk or longevity risk, which would you choose and why?

Professor Catherine Donnelly FIA, Principal Investigator, Heriot-Watt University.

C.Donnelly@hw.ac.uk

The 'Minimising Longevity and Investment Risk while Optimising Future Pension Plans' research programme is being funded by the Actuarial Research Centre.

Outline





Actuarial Research Centre

Institute and Faculty of Actuaries

Current situation

- Workplace pension contribution rate now 8% p.a.
- ~20 million workers saving into work-place pension.

• £100bn saved by them to December 2019, since 2012.



Source: DWP estimates derived from the ONS ASHE, GB, 2009 to 2019



22 June 2022



Actuarial Research Centre

Decumulation options





Decumulation options



Increasing investment risk



Actuarial Research Centre

of Actuaries



UK mortality table S1PMA

1.0 0.9 0.8 0.7 0.6 õ 0.5 0.4 0.3 0.2 0.1 0.0 85 95 105 115 65 75 Age x (years) Actuarial **Research Centre** Institute and Faculty of Actuaries ERSITY

Annual probability of death for table S1MPA

Additional expected return due to longevity risk-sharing

Annual expected return due to longevity risk-sharing 1.0 0.9 0.8 0.7 27% 0.6 õ 0.5 11% 0.4 3.5% 0.3 1% 0.2 0.1 0.0 75 85 95 105 115 65 Age x (years) Actuarial **Research Centre** Institute and Faculty of Actuaries

What is a pooled annuity fund?

- Structure to pool longevity risk.
- Everyone becomes the beneficiary of each other.
- Why?
 - To get a higher and life-long income, compared to income drawdown.
 - To get a higher expected income, compared to a life annuity.





Pooled annuity fund implementation

- Collective Defined Contribution (CDC) plan,
 - Under Pension Schemes Act 2021.
 - Post-retirement option.



 Retail fund offered by e.g. insurance company, with suitable regulatory oversight.



Research questions

- Does an open fund improve the pooling of longevity risk?
- Does the distribution of income vary across cohorts in a pooled annuity fund?
- By how much can the income fall?
- How many people are needed to join each year?





Account structure

+ Longevity credits

+ Investment returns

+ Participant's initial account value

- Withdrawals

Total account value







Longevity credit (Qiao and Sherris 2013)

• Longevity credit formula used:

$$LC^{(m)}(n) = F(n_{-}) \times \frac{\frac{F^{(m)}(n_{-})}{p_{n-1}^{(m)}}}{\sum_{i=0}^{n-1} L^{(i)}(n) \frac{F^{(i)}(n_{-})}{p_{n-1}^{(i)}}} - F^{(m)}(n_{-})$$

• $p_{n-1}^{(i)}$ = Probability of surviving one year from time *n*-1, for member of Cohort *i*.

- $F(n_{-}) =$ Total fund value, across all cohorts in the fund,
- $F^{(i)}(n_{-}) =$ Fund value of member of cohort *i*,
- $L^{(i)}(n) =$ Number alive in cohort *i*,

at time n.



Longevity credit decision



Income withdrawn

- Member has fund value F(n) at time n.
- Income withdrawn, if age x at time n, is

 $\frac{F(n)}{\ddot{a}_x(n)}$

• Annuity value projects mortality from time *n*.





Membership and investment

- Everyone joins with £100.
- New members join every year, age 65 when join.
- Constant 2% p.a. investment return...
- Plus longevity credit.
- Income paid out annually, calculated using updated annuity values.
- Use Cairns-Blake-Dowd mortality model include systematic longevity risk but no longevity improvements.





Income sample paths



100 people join every year





Actuarial Research Centre

Research questions

- Does an open fund improve the pooling of longevity risk?
- Does the distribution of income vary across cohorts in a pooled annuity fund?
- By how much can the income fall?
- How many people are needed to join each year?





Research questions

- Does an open fund improve the pooling of longevity risk? YES
- Does the distribution of income vary across cohorts in a pooled annuity fund?
- By how much can the income fall?
- How many people are needed to join each year?





Single cohort – closed fund







Actuarial **Research Centre** Institute and Faculty

Single cohort – closed fund

1 person alone



10,000 people alone

22 June 2022

Income





Actuarial **Research Centre**





of Actuaries





Actuarial Research Centre

of Actuaries





Actuarial Research Centre

of Actuaries



Open fund for 30 years First cohort's income distribution



Open fund for 30 years First cohort's income distribution



Open fund for 30 years First cohort's income distribution



Research questions

- Does an open fund improve the pooling of longevity risk? YES
- Does the distribution of income vary across cohorts in a pooled annuity fund?
- By how much can the income fall?
- How many people are needed to join each year?





Research questions

- Does an open fund improve the pooling of longevity risk? YES
- Does the distribution of income vary across cohorts in a pooled annuity fund? YES
- By how much can the income fall?
- How many people are needed to join each year?





100 people join every year

First cohort 90th perc 90th perc 75th perc 75th perc Median Median 25th perc 25th perc --- 10th perc ·-·- 10th perc 12 . Income ALIONIIE Age Age

Last cohort

Research questions

- Does an open fund improve the pooling of longevity risk? YES
- Does the distribution of income vary across cohorts in a pooled annuity fund? YES
- By how much can the income fall?
- How many people are needed to join each year?











Proportion of samples above lower bound,

Proportion of samples above lower bound,



Proportion of samples above lower bound, alpha=1, 30 years after joining for Cohort 30

Research questions

- Does an open fund improve the pooling of longevity risk? YES
- Does the distribution of income vary across cohorts in a pooled annuity fund? YES
- By how much can the income fall?
- How many people are needed to join each year?





Summary of pooled annuity fund research to date

- Open funds significantly improve the pooling of longevity risk [Qiao & Sherris 2013].
- When a fund closes, the survivors have more volatile income.
- For an open fund, highly unlikely for income to fall by more than 20%, unlikely to fall by more than 10% (but different mortality model will give a different answer).
- Need about 100 people per year to join.





CDC pensions could be 70% higher than DC and 40% more than DB, says WTW

73%





Lecture - 'Can CDC turn base metal into pensions gold?' by

John Ralfe





a Ponzi scheme.

CDC is a game of pass the risk parcel







Research Centre

Actuarial

Turn to the second strand of research

- Now change direction
- What about Collective Defined Contribution (CDC) schemes which include investment risk-sharing?
- Overall question: Is investment risk-sharing beneficial?
- Here: How do scheme design choices contribute to investment risk-sharing?



Collective defined contribution (CDC) plans





Actuarial Research Centre

of Actuaries

CDC plan model

- Modelled a CDC plan with only investment risksharing.
- Everyone contributes annually a constant amount for 30 years, ...
- ... Gets a pension for 20 years,
- ... Then leaves the plan.





Research Centre stitute and Faculty

CDC plan benefit increase

- Investment risk-sharing occurs through a collective benefit increase calculation.
- Benefit increase at time k

Total plan asset value at time *k*

Total discounted value at time kof benefits accrued up to time k - 1

> Actuarial Research Centre

stitute and Facult

Note: It is a one-off increase, not an annual pension increase

Contribution calculation

- Determine CDC plan benefits, e.g. would like members to have annual pension of £100 p.a. when they retire
- Calculate contributions paid by each member...



...Discounted lifetime contributions = Discounted lifetime benefits



Contribution calculation

- Discounted lifetime contributions = Discounted lifetime benefits
- Need an interest rate to discount...
 - ...which will reflect future investment returns ...
 - ...at the time the calculation is done.
- Same contribution paid by all members...
 - ...so all future members are locked into the `Time 0' predictions of investment returns.



How much benefit should be accrued by each contribution?

- Constant benefit accrual means:
 - Younger members get less benefit for same contribution.
 - First contribution made by each generation is too high for the benefit accrued...
 - ...Leads to a large, positive benefit increase for the first generations in the scheme.
 - Inconsistency of "lifetime" basis of constant benefit accrual vs "accrued" basis of benefit increase calcs.





How much benefit should be accrued by each contribution?

- Age-related/compound benefit accrual
 - Younger members accrue more benefit, as further from retirement.
 - Reflects time period for investment returns.
 - Remains an inconsistency: benefits accrued are calculated using returns predictions made at time 0 vs current return predictions used in benefit increase





Actuarial Research Centre

of Actuaries

CDC plan models

Plan	Accrual method	Discount rate based on future investment returns
Unfair CDC scheme	Constant (1/30)	Predicted at time 0
Partially-fair CDC scheme	Age-related/ Decreasing compound	Predicted at time 0
Fair CDC scheme	Age-related/ Decreasing compound	Predicted at time of contribution

Partially-fair' means financially fair on an accruals basis:Contribution amount = PV of benefit accrued by that contribution.

`Fair' means `Partially-fair' + using up-to-date predictions of future returns to discount.



Actuarial

CDC scheme to analyse

- Target benefit of £100 p.a.
- Constant accrual of annual benefit, i.e.
 - 1/30 x £100 annual benefit accrued per contribution paid
- Regular contribution paid for 30 years until retirement.
- Benefit paid out every year for 20 years in retirement
- Financial market model is the Wilkie model, parameterised using 1923 – 2009 data (Wilkie *et al* 2010), with inflation stripped out of stochastic asset returns.
- Discount rate = LT bond yield + 3% p.a. ERP inflation



Benefit attribution

- Analysed the Unfair CDC plan.
- Assume one person joins each year, no existing membership before time 0.
- Of the benefit paid at retirement to the Unfair CDC scheme members, calculated:
 - How much would have got from investing the same contributions in an individual DC scheme, with same investment strategy;
 - How much additionally would have got if had been in the Fair CDC scheme instead; and
 - How much additionally would have got if had been in the Partially-Fair CDC scheme instead.

Benefit attribution key

- Blue line: "Unfair benefits" = Unfair benefit Partially-fair benefit
- Red line: "Unfair predictions" = Partially-fair benefit Fair benefit.
- Green line: "Investment risk-sharing" = Fair benefit Individual DC (IDC) benefit
- Yellow line: IDC benefit
- Black line: Unfair CDC plan benefit = Yellow + Green + Red + Blue lines



Sample paths – difficult to interpret without seeing underlying return sample path



Median of benefit attribution for first year's benefit payment



Benefit payouts are sensitive to the contribution amounts

- If returns are better than implied by contribution calculation, then...
 - First generations are better off in the unfair CDC or partially-fair CDC plan;
 - Last generations are better off in the fair CDC or Individual DC plan.
- Reverse is true.
- Changing numbers of members in each generation can amplify gains/losses.



Median of benefit attribution for first year's benefit payment



Summary of CDC plan results

- Constant benefit accrual:
 - We know it disadvantages younger members who leave the scheme early (not considered here).
 - Gives too high a benefit increase for the first generations, which is paid for by later generations.
- "Gains/Losses" due to poor predictions of returns are borne by later generations,
 - The later the generation, the bigger the impact borne.
 - Membership numbers also have an impact.
 - Can reviewing contributions regularly help?



Future research

- Continuing the study of pooled annuity funds and CDC plans.
- Aim is to understand them better, e.g. where do the risks lie and (Then) how could they be mitigated?



Bibliography – CDC plan + stochastic mortality models

- Barajas-Paz and Donnelly (2022). "An attribution analysis of investment risk-sharing in collective defined contribution schemes". Submitted.
- Cairns (2011). "Modelling and management of longevity risk: Approximations to survivor functions and dynamic hedging". Insurance: Mathematics and Economics, 49, pp438-453
- Cairns, Blake & Dowd (2006). "A two-factor model for stochastic mortality with parameter uncertainty: theory and calibration". The Journal of Risk and Insurance, 73(4), pp687-718.





Research Centre nstitute and Faculty

Bibliography – pooled annuity fund

- Donnelly (2022). "Pooled annuity fund with bequest: a study of a finite, homogeneous population". *Submitted*
- Bernhardt & Donnelly (2021). "Quantifying the trade-off between income stability and the number of members in a pooled annuity fund". ASTIN Bulletin: The Journal of the IAA, 51(1). <u>Preprint.</u>
- Bernhardt & Donnelly (2019). "Modern tontine with bequest: Innovation in pooled annuity funds". *Insurance: Mathematics and Economics*, 86, pp168-188. <u>Preprint.</u>
- Donnelly & Young (2017). "Product options for enhanced retirement income". British Actuarial Journal, 22(3), pp636-656. <u>Open access paper.</u>
- Qiao & Sherris (2013). "Managing systematic mortality risk with group self-pooling and annuitization schemes". *The Journal of Risk and Insurance*, 80(4), pp949-974.







The views expressed in this presentation are those of the presenter.





Actuarial Research Centre

The Actuarial Research Centre (ARC)

A gateway to global actuarial research

The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' (IFoA) network of actuarial researchers around the world.

The ARC seeks to deliver cutting-edge research programmes that address some of the significant, global challenges in actuarial science, through a partnership of the actuarial profession, the academic community and practitioners.

The 'Minimising Longevity and Investment Risk while Optimising Future Pension Plans' research programme is being funded by the ARC.

www.actuaries.org.uk/arc