The implications of mortality heterogeneity on longevity sharing retirement income products

Héloïse Labit Hardy, Michael Sherris, Andrés M. Villegas

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Agenda

- Heterogeneity in mortality
 - Mortality by income in England and Wales
- Longevity risk and annuity puzzle
- Landscape of longevity sharing income products
- Impact of heterogeneity on longevity pooling products
- Conclusions and future work

Heterogeneity in mortality

 Well-documented relationship between mortality and socioeconomic variables: Education, Income, Occupation, Deprivation





Source: OECD (2016). Note: Australia is at age 60.

Mortality by Income in England and Wales

Weekly household income by Middle Layer Super Output Area (MSOA)

ONS Household Income Report



1.00 **Houshold income percentile** 0.75 0.50 0.25 0.00 500 1000 1500 Total weekly income (£)

Household Income distribution by MSOA

Mortality by Income in England and Wales: Males 2015



Mortality by Income in England and Wales: Males 2015



Fit a GAM assuming mortality rate at age x in percentile *i*, $\mu_{x,i}$, is a quadratic function of age with convergence by percentile at older ages:

$$\log \mu_{x,i} = a + s_b(i)(x - x^*) + c(x - x^*)^2$$

Mortality by Income in England and Wales: Males 2015



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Cohort Life Expectancy by Income in England and Wales: Males age 65 in 2016



- Allowance for mortality improvements:
 - ▶ Lee-Carter model with cohort effects: $\log \mu_{xt} = \alpha_x + \beta_x \kappa_t + \gamma_{t-x}$
 - ▶ Fitted to England and Wales Males age 50-89, years 1961-2015
 - Assume same improvement for all percentiles

Survival function by Income in England and Wales: Males age 65 in 2016



Survival function by income percentile

Age at death statistics

Income percentile	10	30	50	70	90	EW
Q1	77.3	79.4	80.5	81.0	82.1	80.0
median	86.7	88.9	90.0	90.5	91.5	89.5
Q3	95.5	97.1	97.8	98.2	98.8	97.6

Implications of heterogeneity in mortality

Important implications on social and financial planning

- Public policy for tackling inequalities
- Social security design
- Annuity reserving and pricing
- Longevity risk management

Our objective: Investigate the impact of of heterogeneity on longevity pooling products

Longevity risk: Types of deviations in mortality

- a) Deviations around expected mortality rates
 - Mortality rates sometimes higher, sometimes lower than expected
 - Random fluctuations, idiosyncratic risk
 - Individual mortality is involved (Usual pooling arguments)
- b) Deviations from expected mortality rates
 - Mortality rates are systematically above or below what is expected
 - Systematic risk
 - Aggregate mortality is involved (pooling arguments do not apply)



Longevity risk: Reluctance to purchase annuities

- For individuals annuities are the only alternative for obtaining full coverage against longevity risk
- Yaari (1965) shows that they are optimal for a risk-averse utility-maximizing individual with no bequest

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Longevity sharing retirement income products landscaspe

Product	Financial	Longevity Risk	
	Risk	Idiosyncratic	Systematic
Life annuity	Provider	Provider	Provider
Systematic Withdrawal	Individual	Individual	Individual
Income Tontine	Provider	Pool	Pool
Group self-annuitisation	Pool	Pool	Pool
Annuity Overlay Fund	Individual	Pool	Pool
Mortality-linked fund	Individual	Provider	Provider
Longevity-linked Annuity	Provider	Provider	Individual

- Recent developments by academics (Valdez, Piggott, and Wang 2006, Donnelly, Guillén, and Nielsen (2014), Milevsky and Salisbury (2015))
- Attention by policy makers: Australian Financial System Enquiry (2014) and Comprehensive Income Products for Retirement (2016)

Traditional Life Annuity

- The insurer takes financial risk, systematic longevity risk, and idyosincratic longevity risk
- ▶ The individual benefits from mutuality
- ▶ For an alive annuitant the reserve is given by

$$F_{t+1} = F_t \underbrace{(1+r)}_{\text{Financial}} \underbrace{(1+\theta_{x+t})}_{\text{Credit}} - \underbrace{b}_{\text{Benefit}}$$
where
$$b = \frac{S}{\ddot{a}_x} \quad \text{and} \quad \theta_{x+t} = \frac{l_{x+t} - l_{x+t+1}}{l_{x+t+1}} = \frac{1}{p_{x+t}} - 1$$

is the mortality drag or extra-yield from mutuality.

Traditional life annuity: Mortality drag

Extra-Yield from Mutuality



Note: Based on England and Wales Male mortality with Lee-Carter + Cohort improvement for a male age 65 in 2016

Income Tontines (Milevsky and Salisbury 2015)

100 retirees aged 65 and each invests S =100 to buy a r = 4% perpetuity



Perpetuity Tontine

x+t	l(x+t)	B(t)	b(t)
65	100	384.62	3.85
75	89	384.62	4.32
85	64	384.62	6.01
100	15	384.62	25.64

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100	15	384.62	25.64

Natural Tontine

x+t	l(x+t)	B(t)	b(t)
65	100	674.22	6.74
75	89	573.62	6.45
85	64	422.43	6.60
100	15	119.39	7.96













Traditional annuity vs. Income Tontine/GSA

	Traditional Annuity	Income tontine / GSA
Financial Risk	Provider	Provider / Pool
Longevity Risk	Provider	Pool
Fund	$F_{t+1}=F_t(1+r)(1+\theta_{x+t})-b$	$F_{t+1} = F_t(1+r)(1+ heta_{x+t}^*) - b_t$
Mortality drag	Based on expected mortality	Based on pool mortality
	$ heta_{x+t} = rac{l_{x+t}-l_{x+t+1}}{l_{x+t+1}}$	$ heta_{x+t}^* = rac{l_{x+t}^* - l_{x+t+1}^*}{l_{x+t+1}^*}$
Benefit	$b=rac{{\sf S}}{{\sf \ddot{a}}_{\sf x}}$	$b_0=rac{{\mathcal S}}{\ddot{{\mathsf a}}_{\scriptscriptstyle X}}$, $b_t=b_0rac{l_{\scriptscriptstyle X+t}}{l_{\scriptscriptstyle X+t}^*}$
	Guaranteed	Variable but fairly stable
	Lower due to	Higher due to
	capital requirement	no capital requirement

Income tontines and group self-annuitisation are promising alternatives for providing longevity risk protection at a lower cost

Pool: 1000 EW males; Initial Investment: 100



Pool: 200 in each percentile; Initial Investment: 100



Pool: 200 in each percentile; Initial Investment: 100 on average



Pool: 1000 percentile 10, 0 percentile 90; Initial Investment: 100



Pool: 800 percentile 10, 200 percentile 90; Initial Investment: 100



Pool: 600 percentile 10, 400 percentile 90; Initial Investment: 100



Pool: 400 percentile 10, 600 percentile 90; Initial Investment: 100



Pool: 200 percentile 10, 800 percentile 90; Initial Investment: 100



Pool: 0 percentile 10, 1000 percentile 90; Initial Investment: 100



Conclusions and work in progress

- Longevity pooling products have attracted recently significant attention
 - Practice, academic literature, policy makers
- ▶ Promising alternative to traditional annuities for covering longevity risk
- ▶ We have highlighted the impact of mortality heterogeneity
 - Important redistribution in favour of the richest
 - Differences in wealth increase the redistribution
- Further steps
 - Impact of financial assumptions
 - Even if inequitable, are pooling products still utility enhancing?
 - Possible solutions to reduce redistribution
 - Change mortality rate assumptions for pricing
 - Group specific prices

Thank you!

a.villegas@unsw.edu.au (Andrés M. Villegas)





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