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Simplifying retirement: Aligning retirement goals and outcomes

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Joint work with William Lim (ANU, Canberra) and Gaurav Khemka (ANU).

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Overview

- Motivation
- Main conclusion
- Set-up
- Investment strategies considered and results
- Summary

Focus on defined contribution (DC) plans

- A lot of people affected, very important!
- Automatic enrolment into a “workplace pension” (DC plan) for most UK employees since Jan 2017.
- 84% of UK staff (9.5m) in workplace pension at March 2018.
- £90bn saved during 2017.
- Estimated 14.5m workers with total savings £682bn by 2035.
- Total minimum contribution rate 8% of salary from April 2019.
- Vast majority of savers are in default DC investment funds (>90%).

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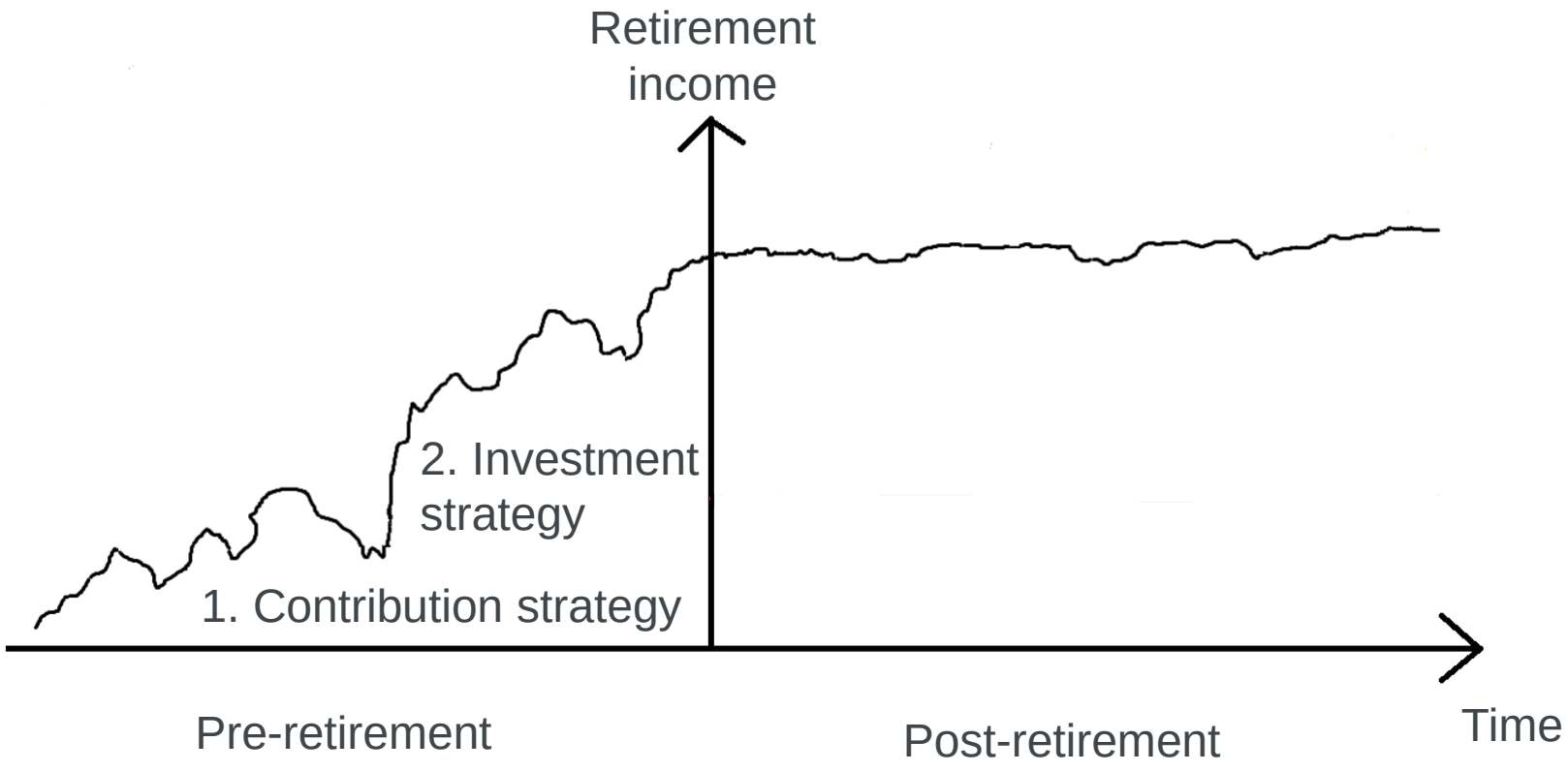
Typical current DC situation



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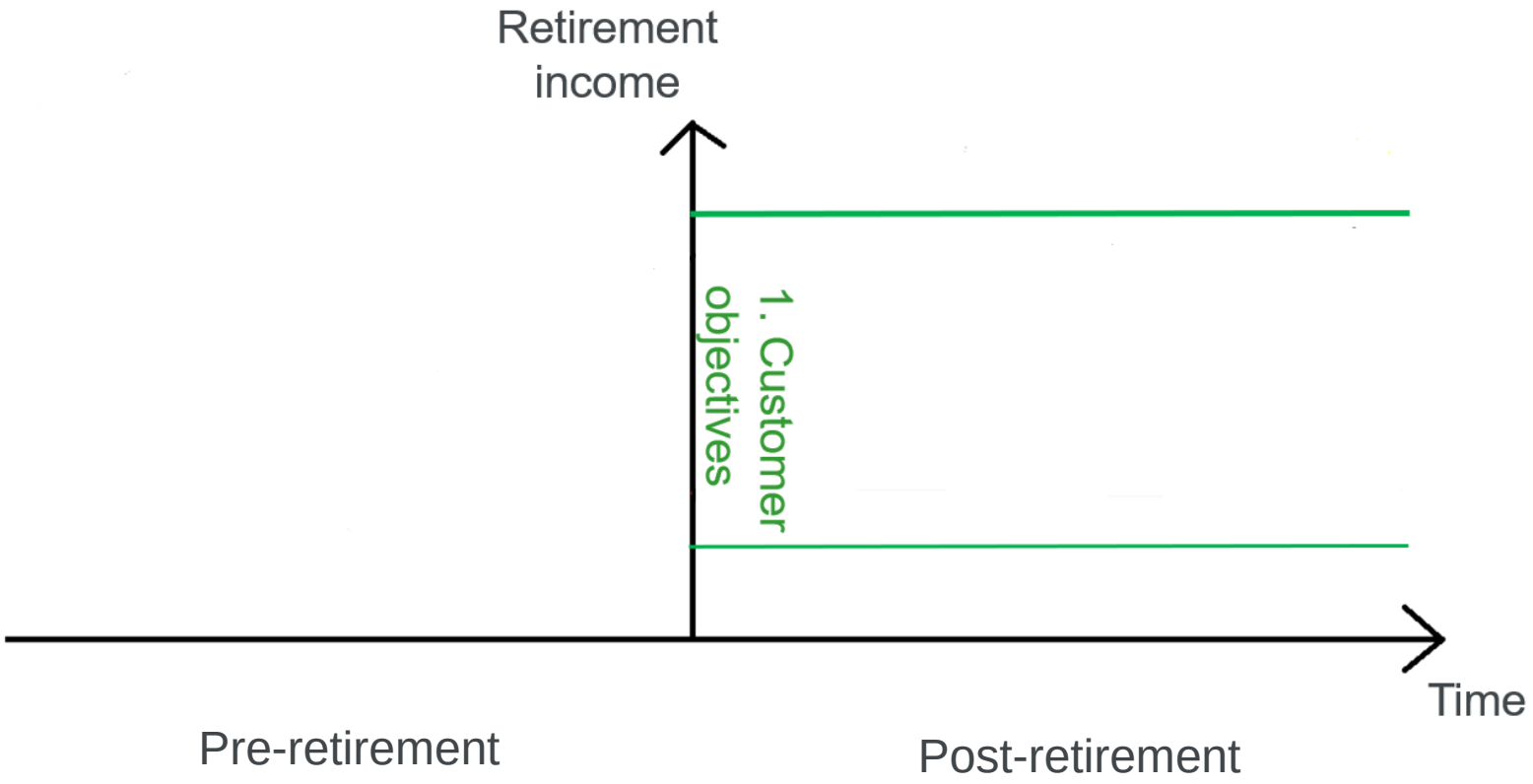
Default DC investment funds

- Typically, lifestyle funds are the default DC fund.
  - e.g. allocate 70% to equities for 20 years,
  - Then e.g. switch to 20% equities gradually over 10 years to retirement, investing released funds in bonds/cash.
- Some Diversified Growth Funds.
  - e.g. lower equity allocation, but
  - Allocation to real estate, commodities, infrastructure, etc.

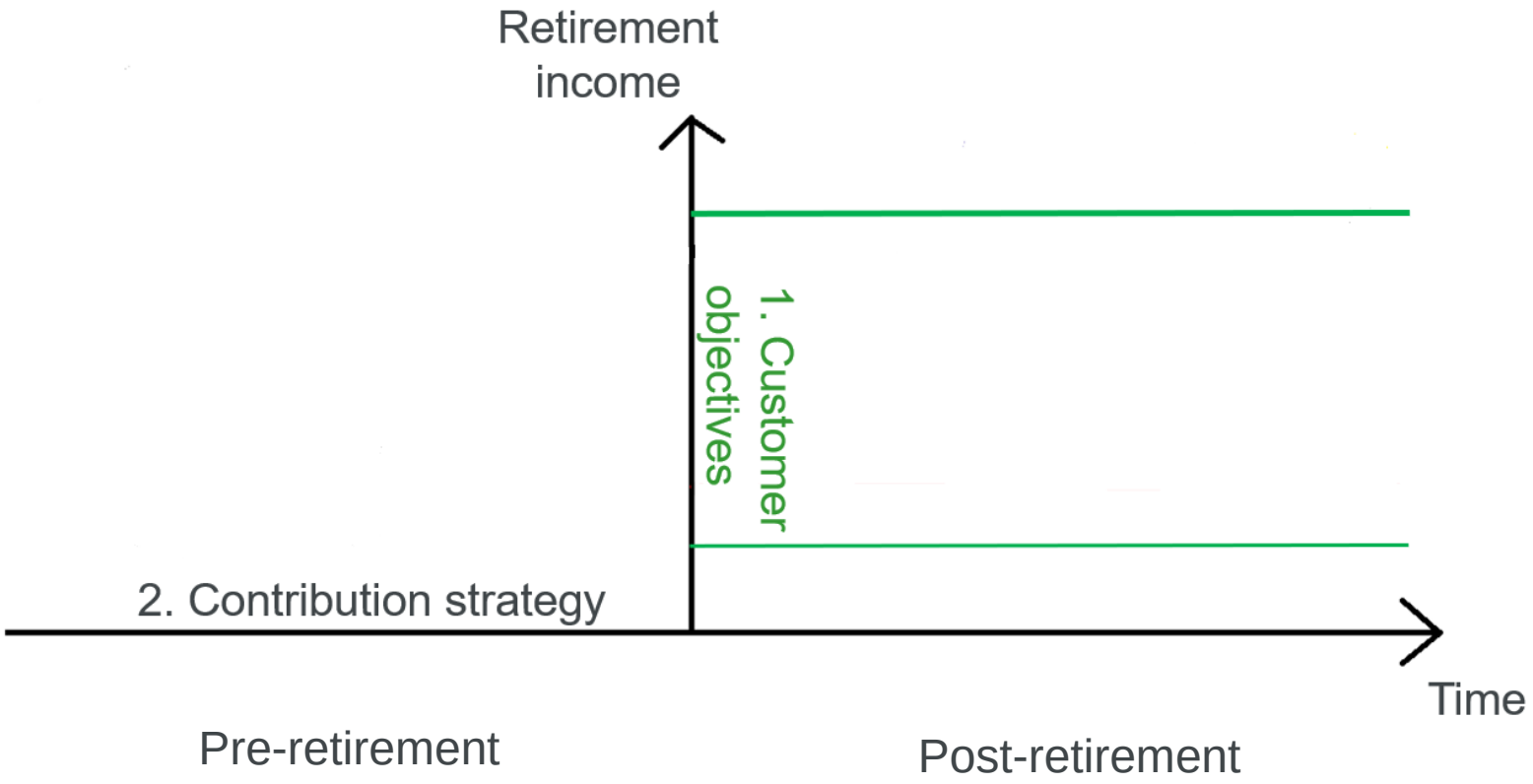
Put retirement objectives at the centre

- Idea: investor sets their retirement goals, and
- Investor gets more certainty about retirement income.
- Motivation from Robert C. Merton (2014) “The Crisis in Retirement Planning”, *Harvard Business Review*.

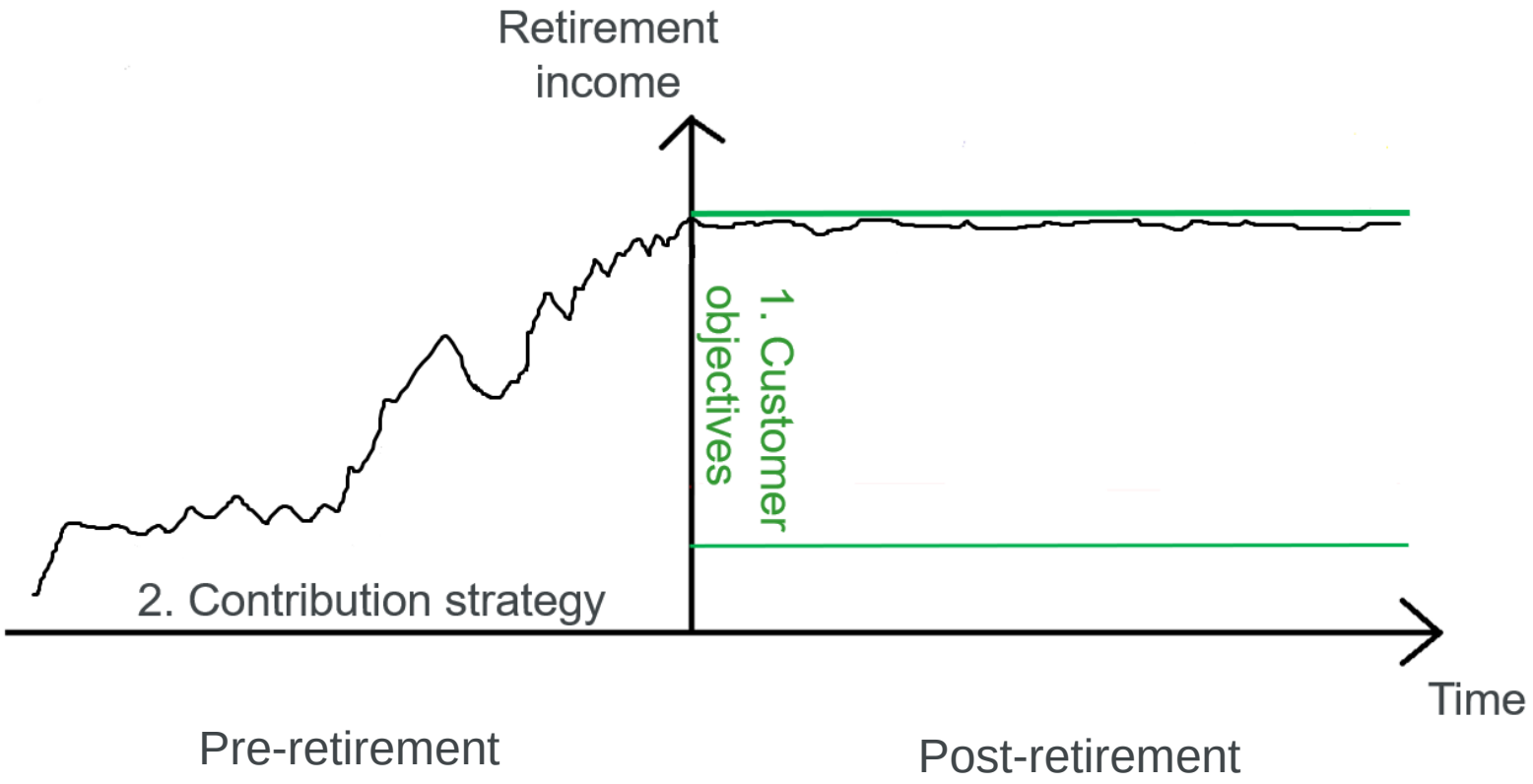
Put customer objectives at the centre



Put customer objectives at the centre



Put customer objectives at the centre



What did we do?

- Aim: give investor more certainty about final retirement outcome.
- Which optimization problem? Should you impose terminal wealth constraints?
- Looked at CRRA (power utility) and loss aversion utility,
- Found: terminal distribution more appealing under loss aversion with no constraints.
- Also looked at a lifestyle strategy, switching from 100% equity to 100% IL bonds over 10 years to retirement.

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What did we do?

- Investor with
  - 40 years until retirement;
  - Investing 18.5% of salary each year;
  - Buys an inflation-indexed life annuity at retirement;
  - No short-selling, annual re-balancing.
- Can invest in FI bonds, IL bonds and equities.
- Replacement ratio at retirement

  = real annuity income/salary in year before retirement.

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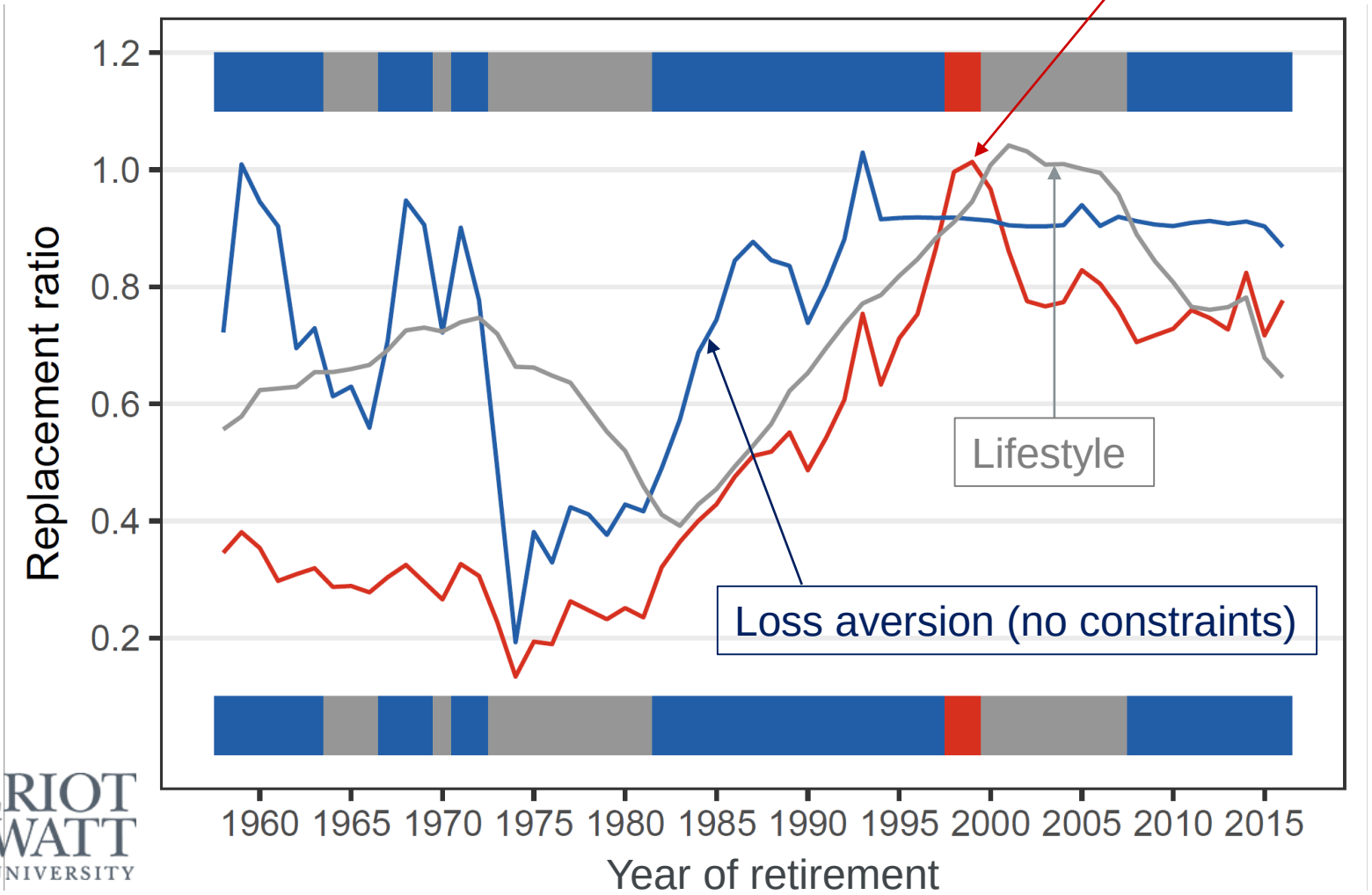
Using UK historical data



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Financial market

Either calibrate to UK data:

- Inflation index $\frac{dI(t)}{I(t)} = \mu_I dt + \sigma_I dW_1(t)$
- Nominal bond (FI) price $\frac{dS_0(t)}{S_0(t)} = r_N dt$
- Inflation-linked bond (ILB) price $\frac{dS_1(\mathrm{t})}{S_1(t)} = r_R dt + \frac{dI(\mathrm{t})}{I(t)}$
- Risky stock price $\frac{dS_2(\mathrm{t})}{S_2(t)} = \mu_2 dt + \sigma_{21} dW_1(t) + \sigma_{22} dW_2(t)$

Or use historical UK real return data
(for ILB: pre-1981, use r_R value from above model).

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1. CRRA utility

- Maximize the expected utility of real wealth at retirement.
- Power utility function, $U(x) = x^{\gamma}/\gamma$.
- Determine investment strategy that maximizes
$$\mathbb{E}U(Real\ wealth\ at\ retirement).$$
- Not the same solution as maximizing nominal wealth, contrary to Zhang (2012) claim (we prove analytical solution).
- But we do a numerical implementation via dynamic programming (indeed, for all our results).

1. CRRA utility

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2. Loss aversion utility background

- Maximize the expected utility of real wealth at retirement.

- Loss aversion approach: people don't like losses.

- Reference point (target), e.g. 100, about which to measure gains/losses.
  - e.g. utility **gain** from obtaining 101 is **2**,
  - But utility **loss** from obtaining 99 is **5**.

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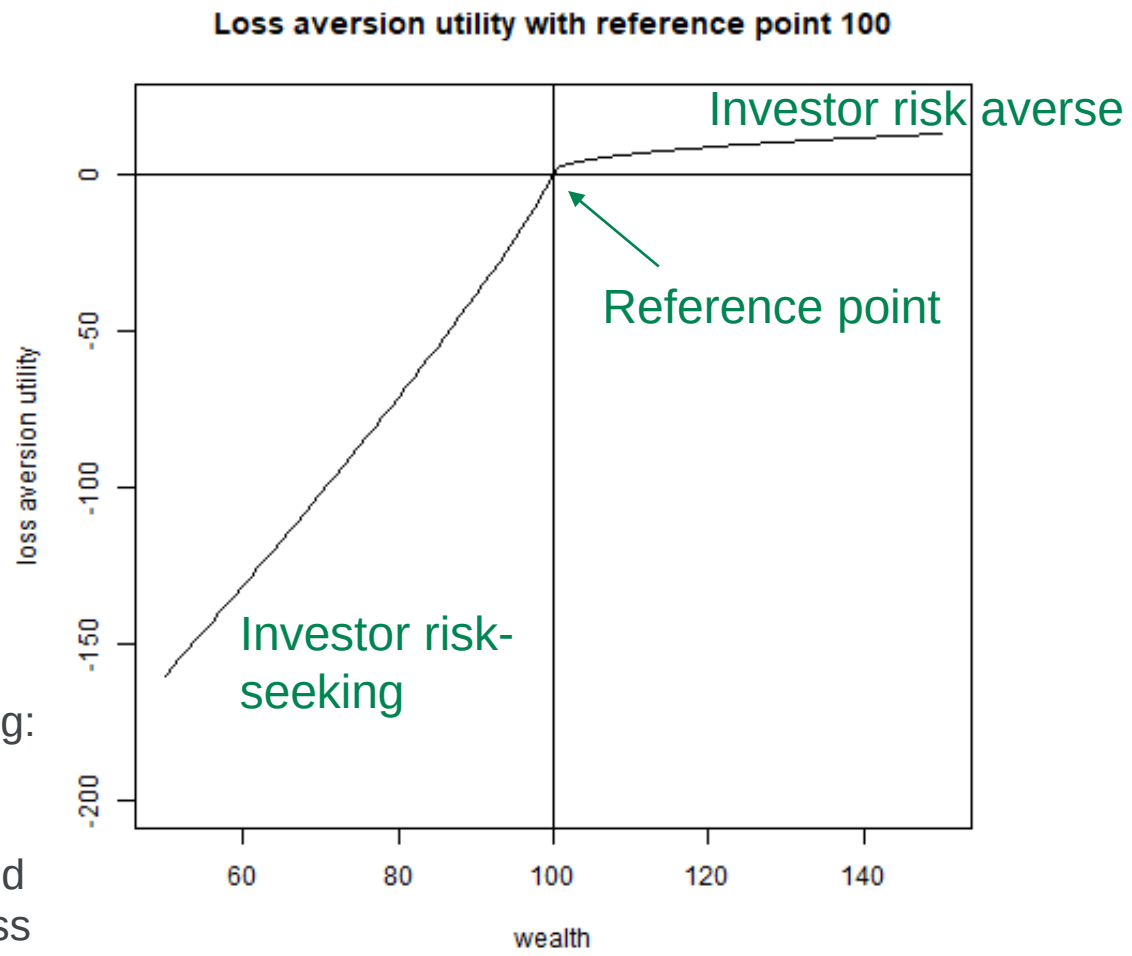
2. Loss aversion utility plot

Risk averse: will not risk a bigger gain when offered a certain gain



Risk-seeking: will risk a bigger loss when offered a certain loss

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2. Loss aversion utility

- Loss aversion utility approach.
- Extension of Blake et al. (2013) – annually updated target-based approach – to include inflation and 3 assets.
- Aiming for 90% replacement ratio.
- Numerical solution.

2. Loss aversion utility

- Annual interim targets + Retirement day target.

$$U_t(F_t) = \begin{cases} \dfrac{(F_t - Target(t))^{0.44}}{0.44} & if\, F_t \geq Target(t) \\ -2.25 \times \dfrac{(Target(t) - F_t)^{0.88}}{0.44} & otherwise \end{cases}$$

- Backward recursion to maximize for one-year buy-and-hold strategies:

$$0.5 \times U_t(F_t) + \beta\, \mathbb{E}_t\left(V_{t+1}(F_{t+1})\right)$$

- β^t is weight applied to utility of year *t* target
- 0.5 applies additionally to utility of interim targets: increase importance of retirement day target's utility.

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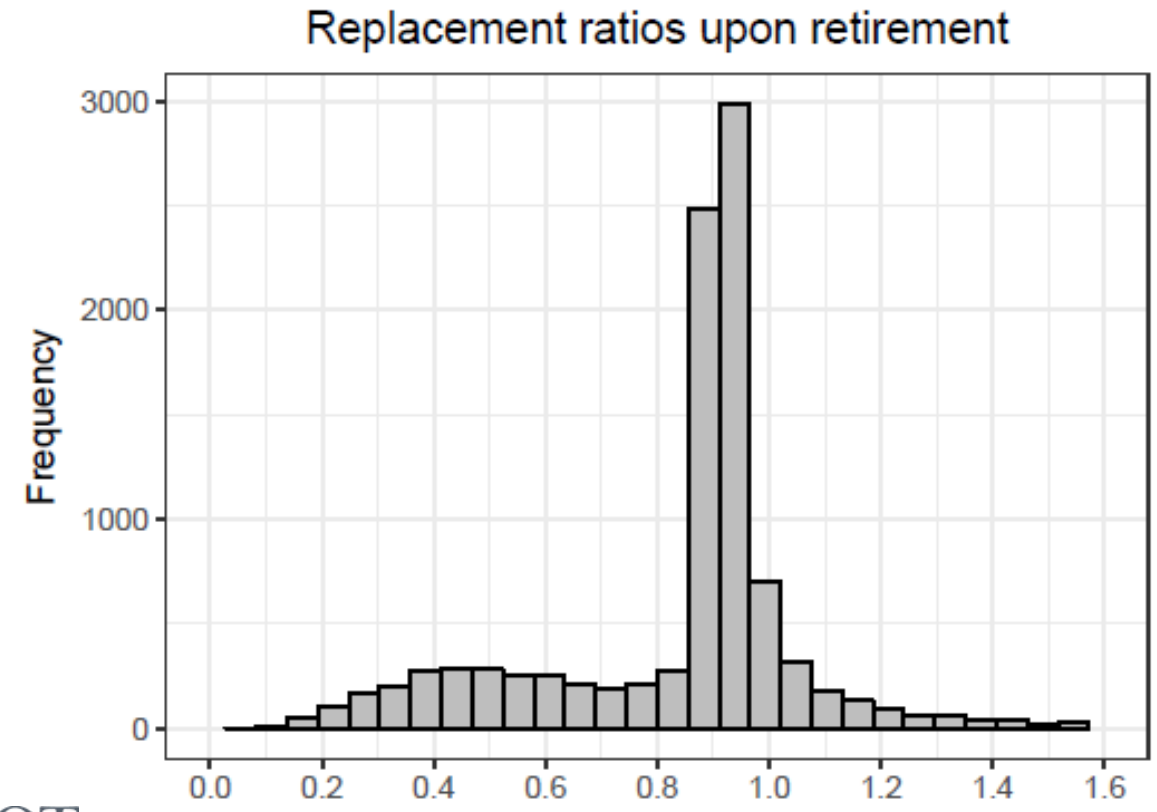
2. Loss aversion utility



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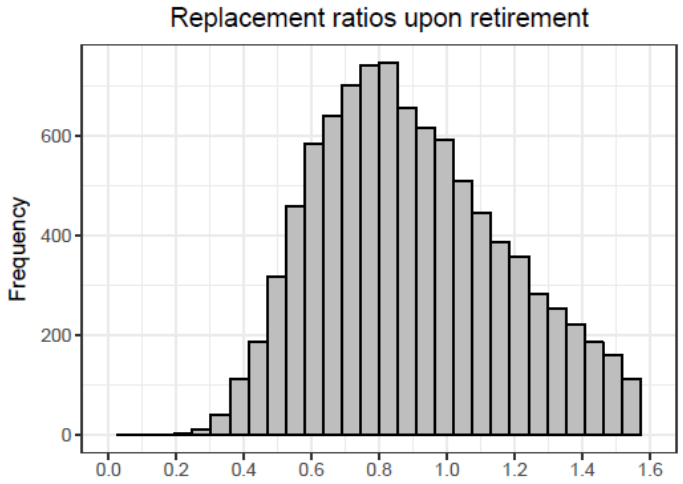
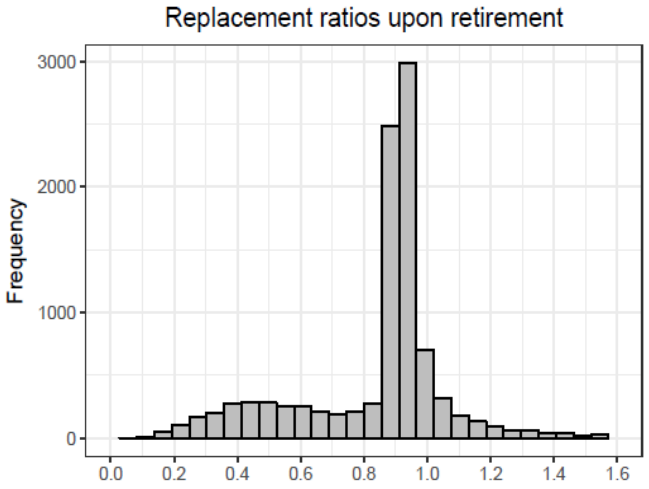
CRRA vs Loss aversion vs Lifestyle

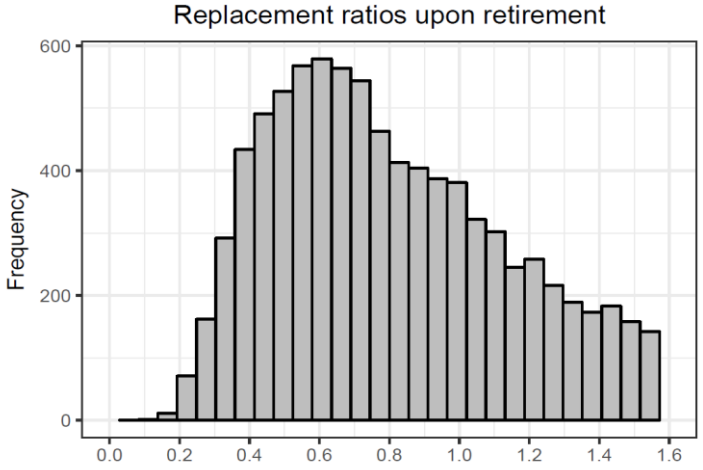


CRRA utility

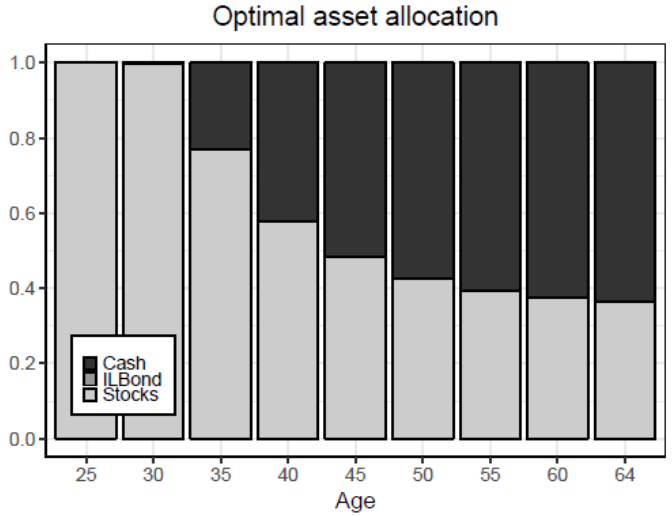


Loss aversion utility

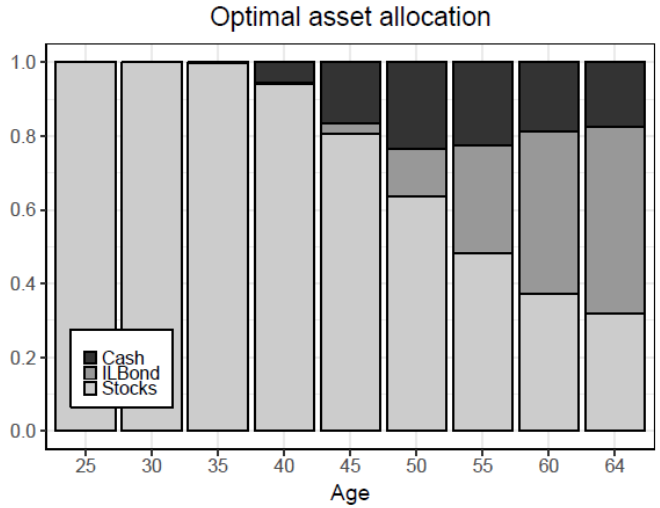
Lifestyle:



CRRA vs Loss aversion mean optimal investment strategy

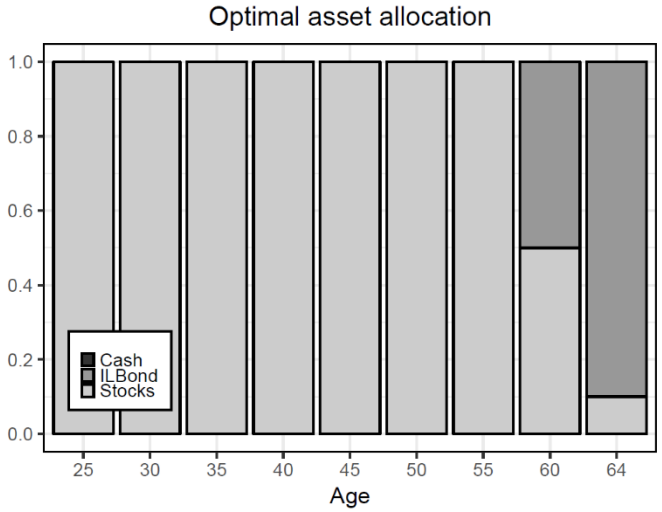


CRRA utility



Loss aversion utility

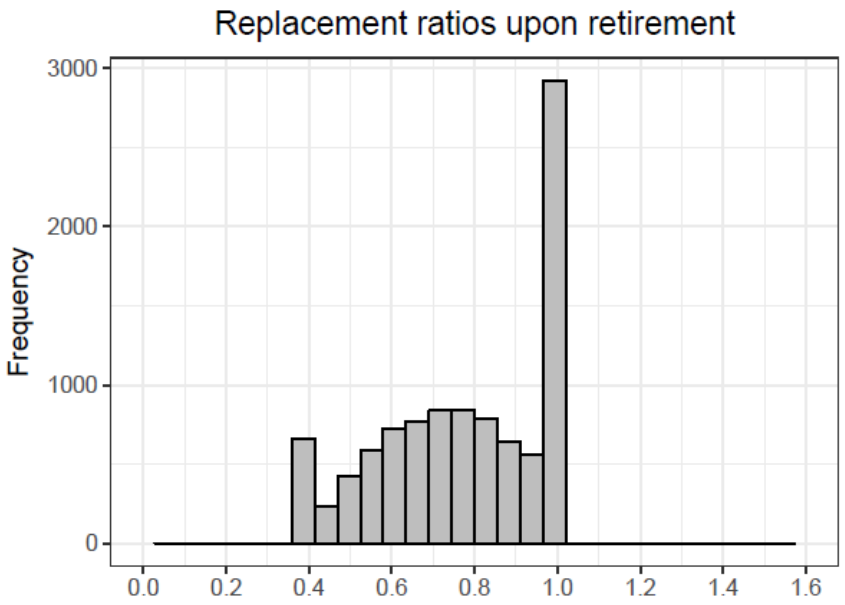
Lifestyle:



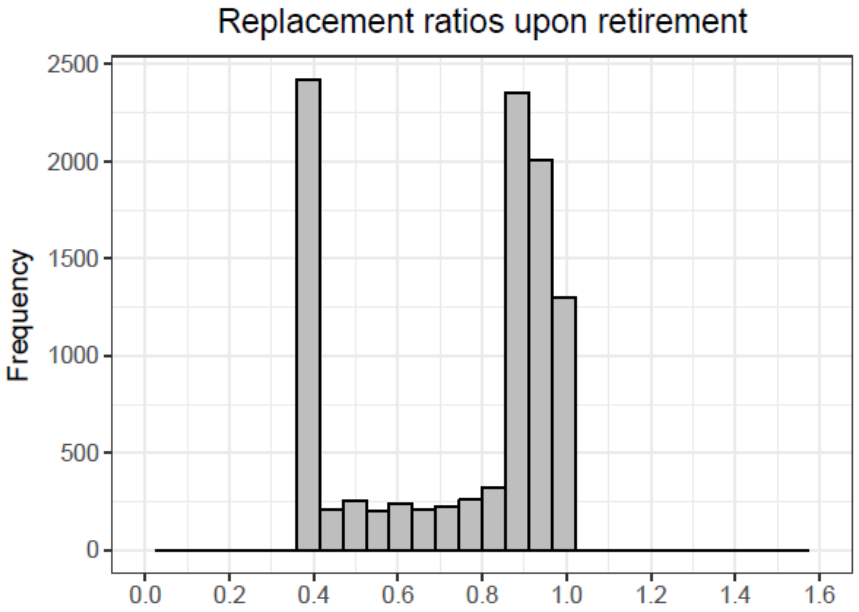
Added in terminal (i.e. retirement day) wealth constraints

- Constrain wealth at retirement to lie between:
  - Lower constraint ≡ 40% replacement ratio,
  - Upper constraint ≡ 100% replacement ratio,
  - For CRRA and loss aversion utility functions
- For CRRA, extension of Donnelly et al (2018) to include inflation and 3 assets.

3. Utility with terminal constraints (synthetic options available)



CRRA utility with terminal constraints



Loss aversion utility with terminal constraints

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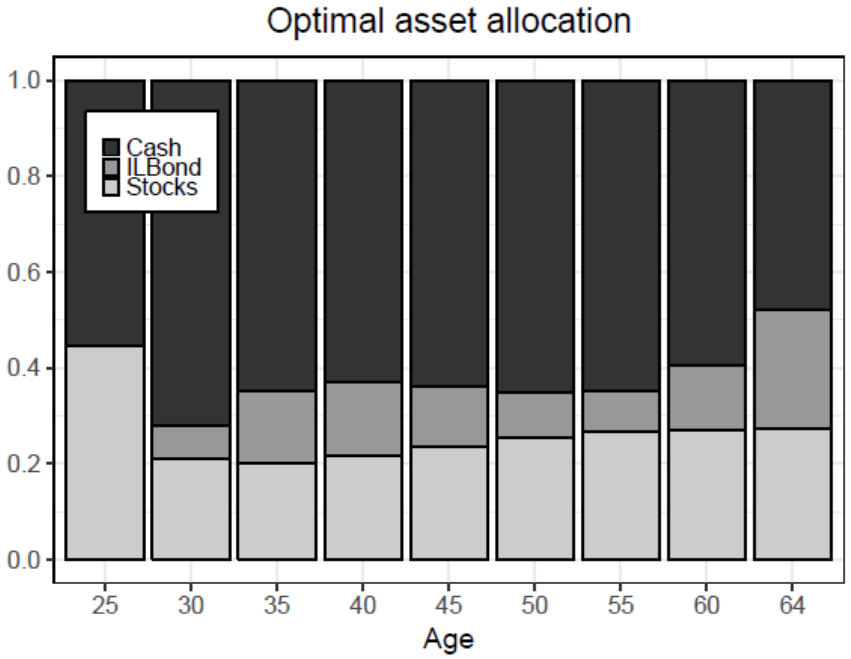
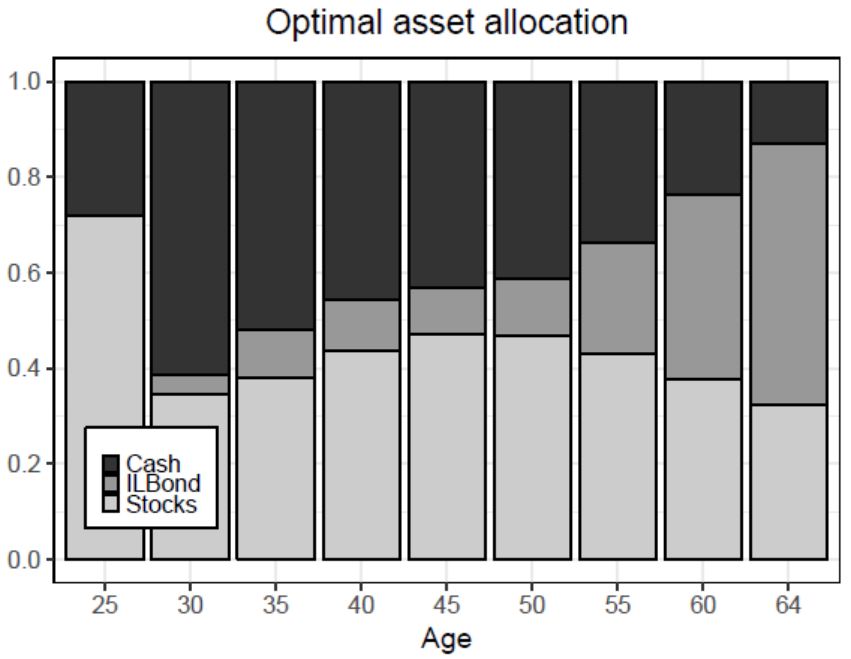
3. Utility with terminal constraints (synthetic options available)



CRRA utility with terminal constraints



Loss aversion utility with terminal constraints

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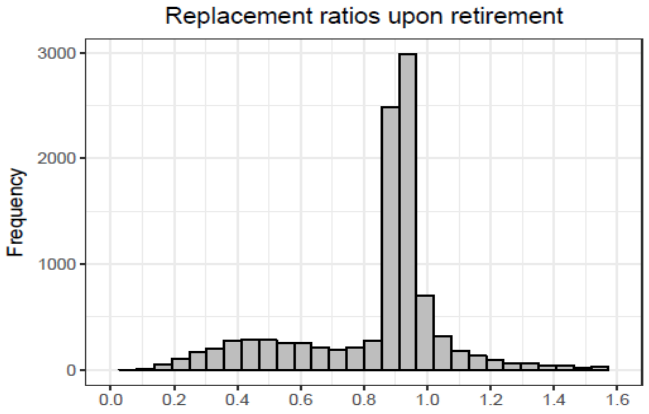
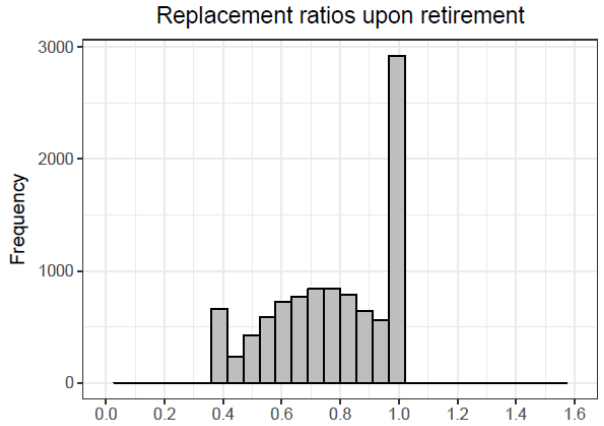
Overall comparison

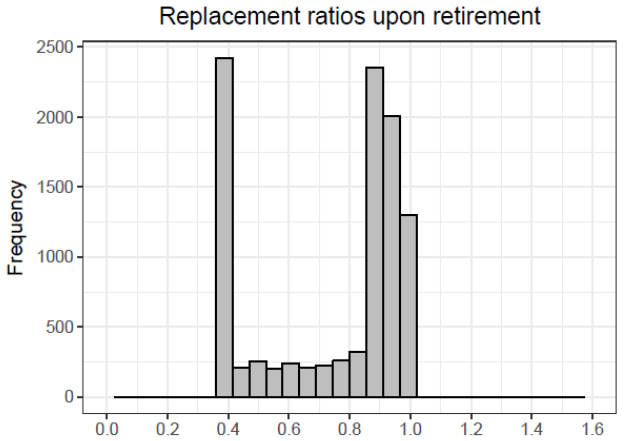
CRRA utility



Loss aversion utility



CRRA utility with terminal constraints



Loss aversion utility with terminal constraints

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Figure 4 (with labels removed) from Blake et al (2013) – bonds and equities only

Loss aversion utility investment strategy at age 64, one year before retirement

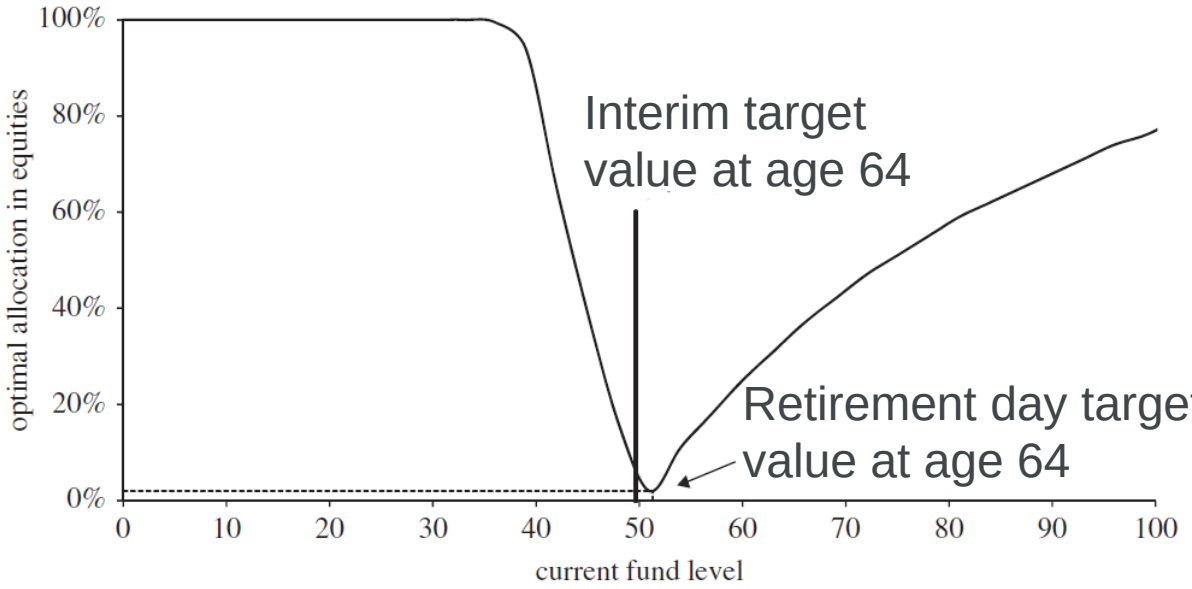

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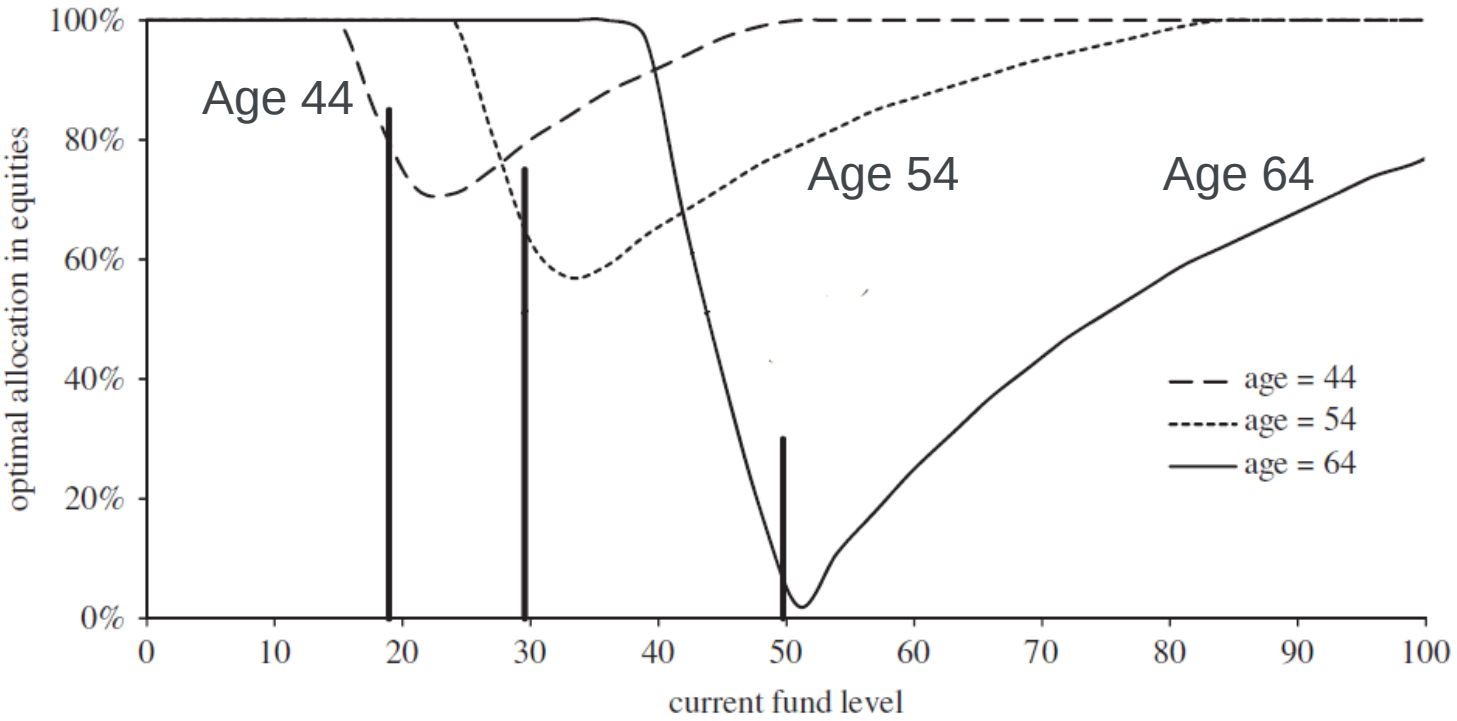
Figure 5 (with labels removed) from Blake et al (2013) – bonds and equities only



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Overall comparison (ranked by 50% quantile of replacement ratio)

Replacement Ratios	Quantiles			
	10%	50%	90%	Mean
Loss aversion unconstrained	45.4%	90.9%	103.3%	85.4%
Loss aversion constrained	40.0%	90.1%	99.8%	74.9%
Lifestyle	56.5%	89.2%	144.7%	96.5%
CRRA unconstrained	41.9%	83.8%	184.3%	103.0%
CRRA constrained	48.4%	79.3%	100.0%	77.7%

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Overall comparison (ranked by Certainty Equivalent Replacement Ratio)

	Certainty equivalent RR	Prob[RR<40%]	Expected[RR| RR<40%]
Loss aversion unconstrained	0.816	7.3%	30.4%
CRRA unconstrained	0.788	1.3%	35.5%
Lifestyle with CERR calculated under loss aversion utility	0.749	8.6%	32.9%
Loss aversion constrained	0.749	0%	N/A
CRRA constrained	0.685	0%	N/A
Lifestyle with CERR calculated under CRRA utility	0.638	8.6%	32.9%

Certainty equivalent RR (CERR) satisfies:
U(CERR x Salary at age 64 x annuity payable from age 65) = EU(Fund value at age 65)).

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Summary

- Extended formulations of Blake et al (2013) and Donnelly et al (2018) to include inflation; 3 assets; with and without terminal wealth constraints.
- Distribution is significantly different under loss aversion compared to power utility (also Blake et al 2013).
- Both loss aversion utility and classical lifestyle do well.
- Terminal wealth constraints don’t add significant benefit.

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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.

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Motivation slides

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CRRA utilit

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Questions

Comments

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

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