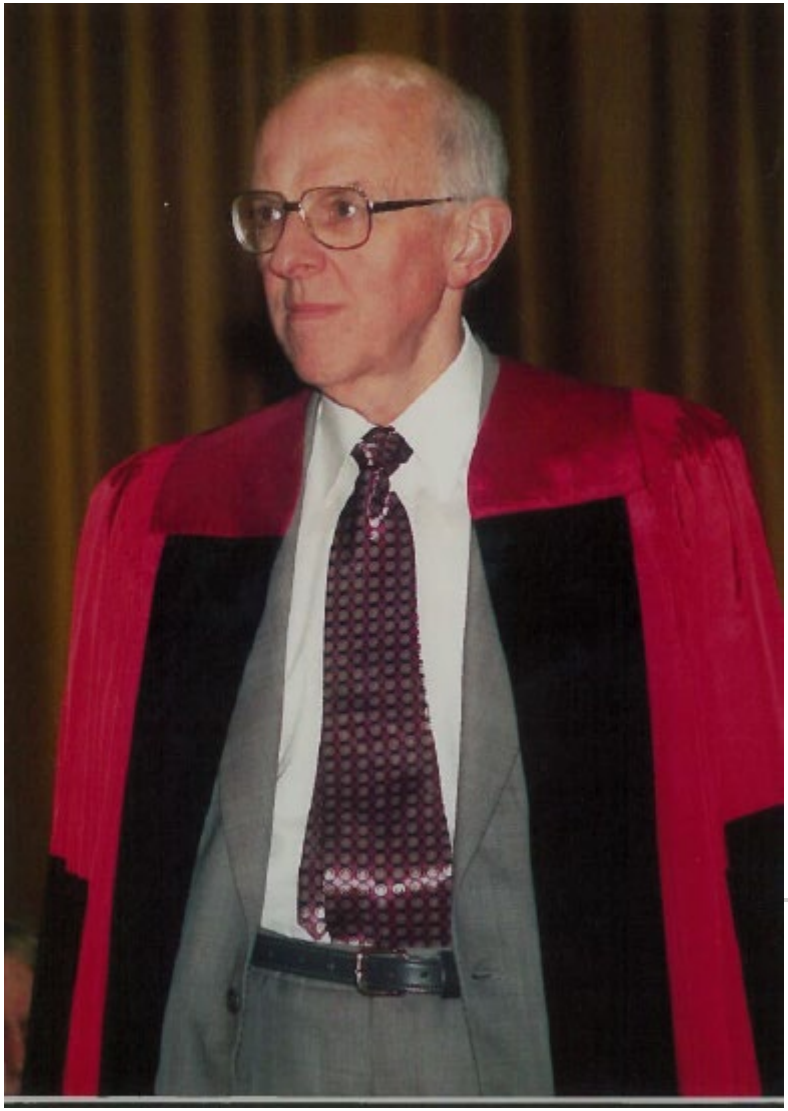

Conference in Celebration of David Wilkie's 90th Birthday

Doctor of Mathematics Honoris Causa
University of Waterloo, June 2002

TARGET BENEFIT PENSION PLANS

Some numerical experiments

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UNIVERSITY OF WATERLOO

Outline

- What's wrong with DB / DC?
- Benefit design criteria
- Model pension plans
- Numerical experiments for DB and Adjustable DB
- Conclusions

Defined Benefit (Traditional)

- Retirement income at retirement is

Accrual Rate x Service x Average Salary

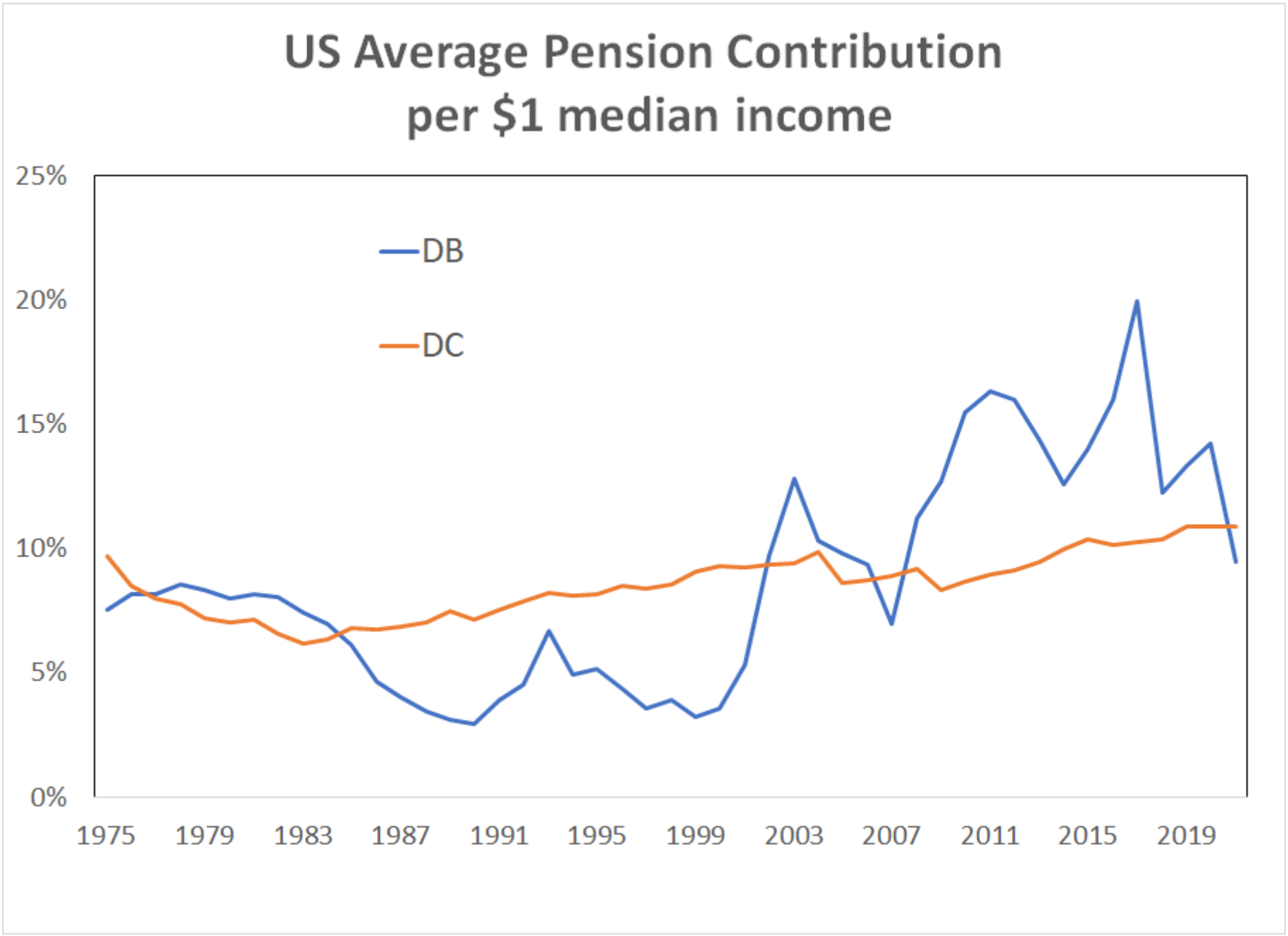
- Typical accrual rates are 1.25%-2.0%
- Contribution rate adjusted to meet cost of benefits
- Default risk -- often ignored

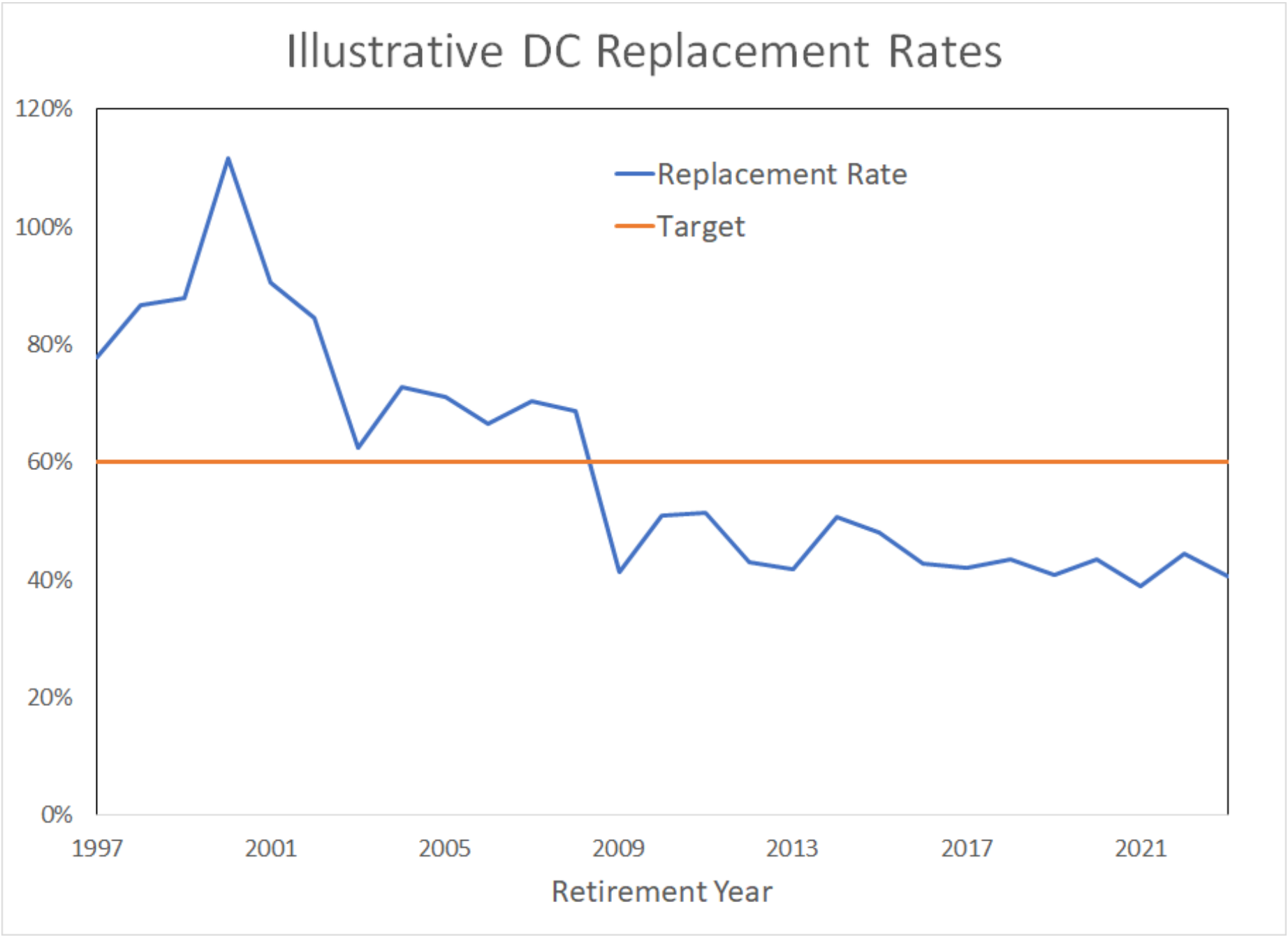
Fixed benefits, variable contributions.

Defined Contribution

- Contributions of, say, c% of salary paid into individual accounts
- Invested at worker's discretion
- Accrued contributions paid out at retirement
  - May be converted to income through annuity purchase

Fixed contributions, variable benefits.


US Average Pension Contribution
per $1 median income
25%
20%
15%
10%
5%
0%
DB
DC
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019


Illustrative DC Replacement Rates
120%
100%
80%
60%
40%
20%
0%
Replacement Rate
Target
1997
2001
2005
2009
2013
2017
2021
Retirement Year

Benefit design criteria

- **Affordable**
  - Limit cost to, eg, 25% of pay
- **Sustainable**
  - Mitigate volatility
- **Efficient**
  - No big surpluses; no windfall benefits
- **Adequate**
  - predictable, inflation/longevity protected, portable
- **Fair**
  - Equal pension for equal work/contribution

Target Benefit plans

- **Collective DC**
  - DC with risk sharing
  - Eg through an Equalization Reserve
- **Adjustable DB**
  - DB, with option to adjust benefits (down)
- Also called Defined Ambition or Intergenerational Risk Sharing (IRS).

NUMERICAL EXPERIMENTS

Traditional DB vs Adjustable DB

Numerical Experiments

- Going concern plan
- Demographics ≈ University of Waterloo
- Assets and inflation ~ Wilkie Model, calibrated to US data (Zhang et al 2018)
- DB vs TB (Adjustable DB)

Model DB Plan

- 1.8% accrual rate; 3-year FAS plan.
- COLA up to 3%, funded;
  - lost on wind-up.
- PUC (partial) funding valuation; TUC solvency
- All contributions from workers' pay
- Invested 60% stocks, 40% long bonds
- Normal Contribution rate ? 18.5%

DB Funding strategy

- Funding A/L > 1.2 → contributions reduced
- Solvency A/L < 1.0 → contributions increased,
- 30% cap on total contribution rates (TCR)
- Wind-up triggered if solvency A/L < 0.5
  - Accrued benefits reduced pro-rata
  - Bulk-buy-out → no further risk

Model TB Plan

- Target benefits, valuations, assets, as for DB
- Same wind-up threshold (Solvency A/L < 0.5)
- No TCR cap
- Funding A/L > 1.2 ⇨ surplus distributed
  - Based on 5-year recovery period
- Solvency A/L < 1.0 ⇨ deficit recouped
  - Based on 10-year recovery period

TB: risk sharing formula

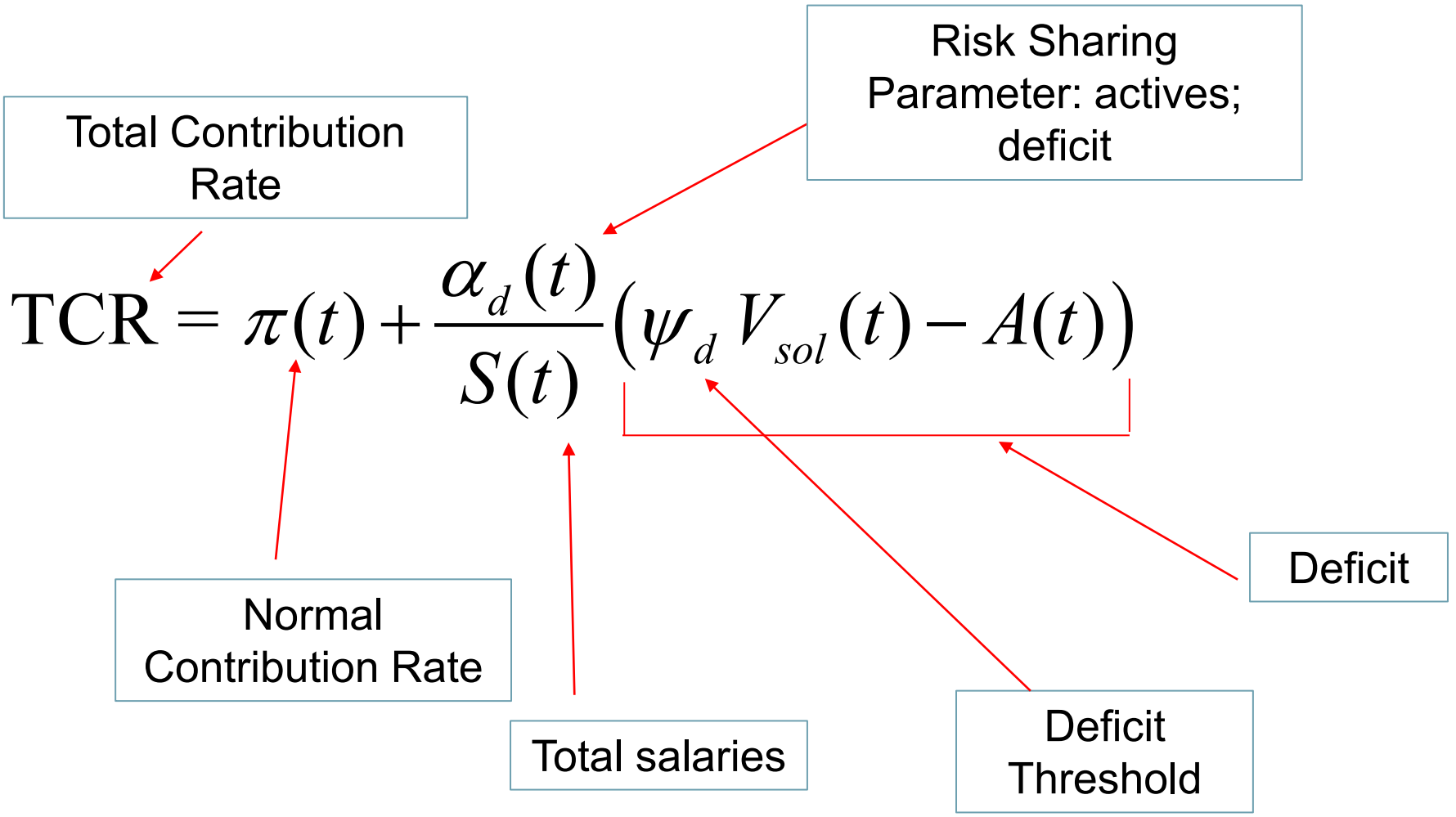
$\alpha_{d/s}(t) + \beta_{d/s}(t)$ is the proportion of deficit/surplus distributed

$\alpha_{d/s}(t)$ is the workers' share of deficit/surplus

$\beta_{d/s}(t)$ is the retiree's share of deficit/surplus

$$\frac{\alpha_s(t)}{\beta_s(t)} = \frac{\alpha_d(t)}{\beta_d(t)} = \frac{\text{Total Salaries at } t}{\text{Total Target Benefits at } t}$$

TB Deficit Sharing: actives



TB Deficit Sharing: Retirees

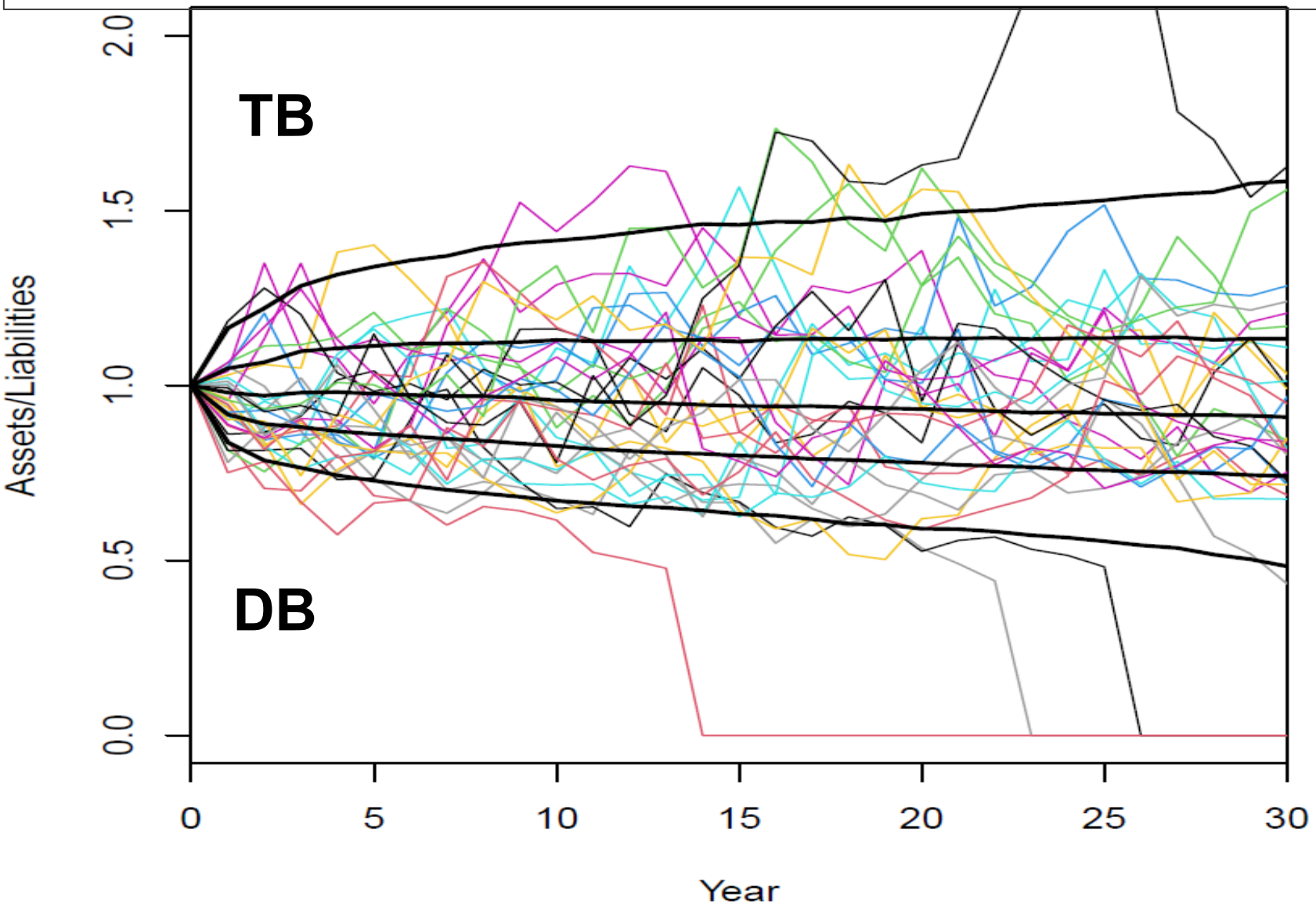
Benefit Adjustment Factor

Risk Sharing Parameter: retirees; deficit

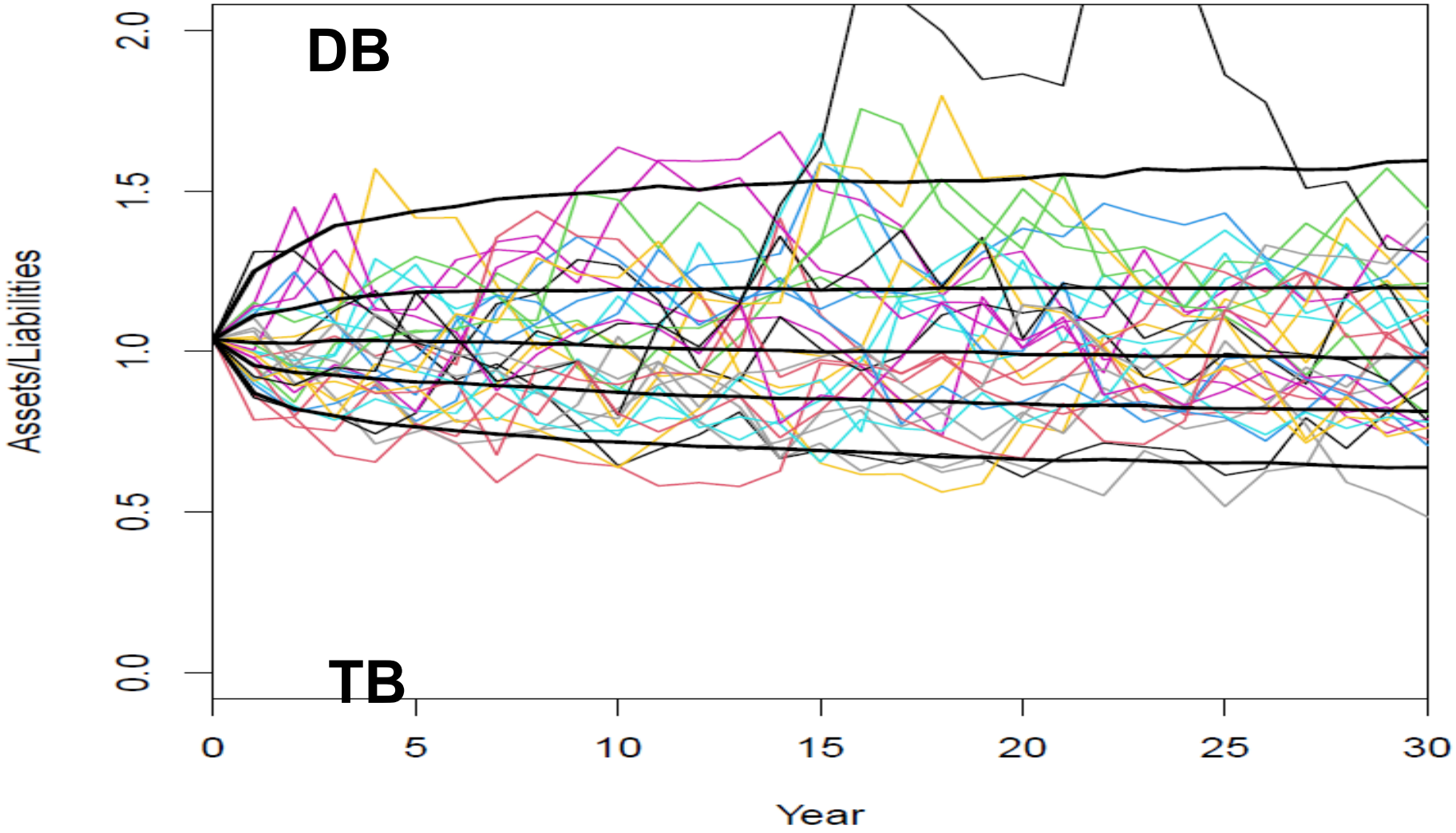
$$\mathrm{BAF} = 1 - \frac{\beta_d(t)}{B(t)}\left(\psi_d V_{sol}(t) - A(t)\right)$$

Total target benefits

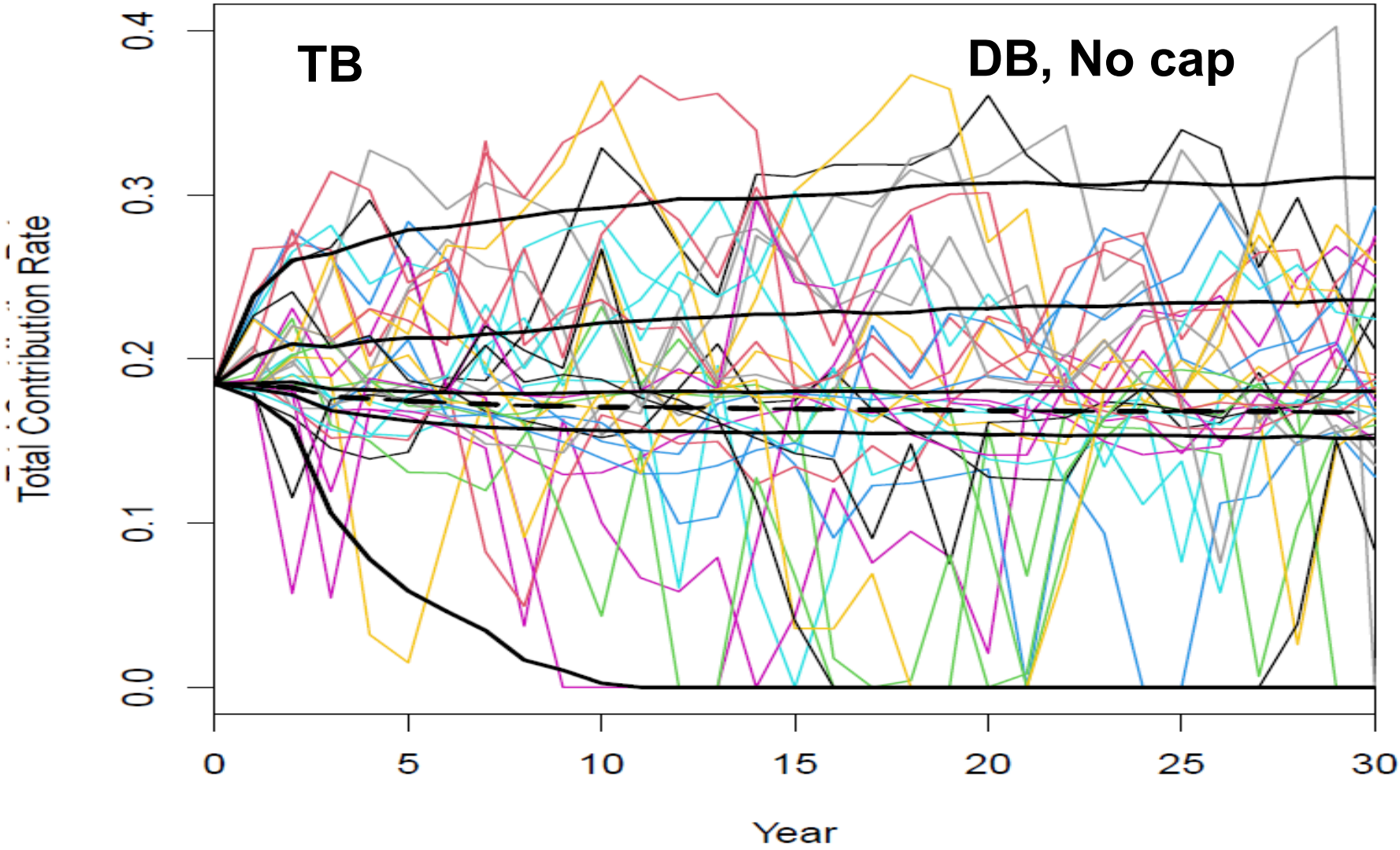
Funding Valuation A/L



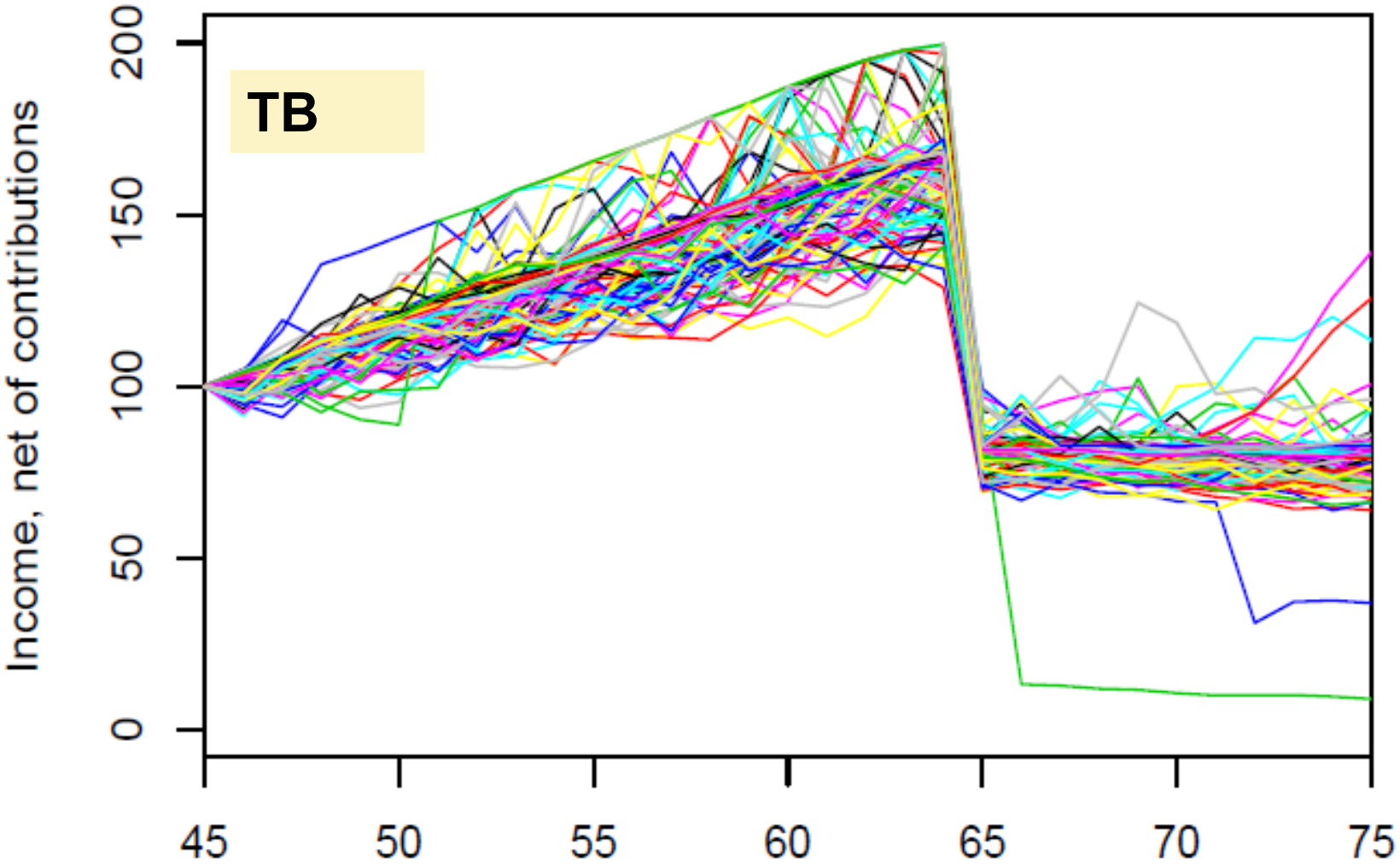
Solvency Valuation A/L



Total Contribution Rate



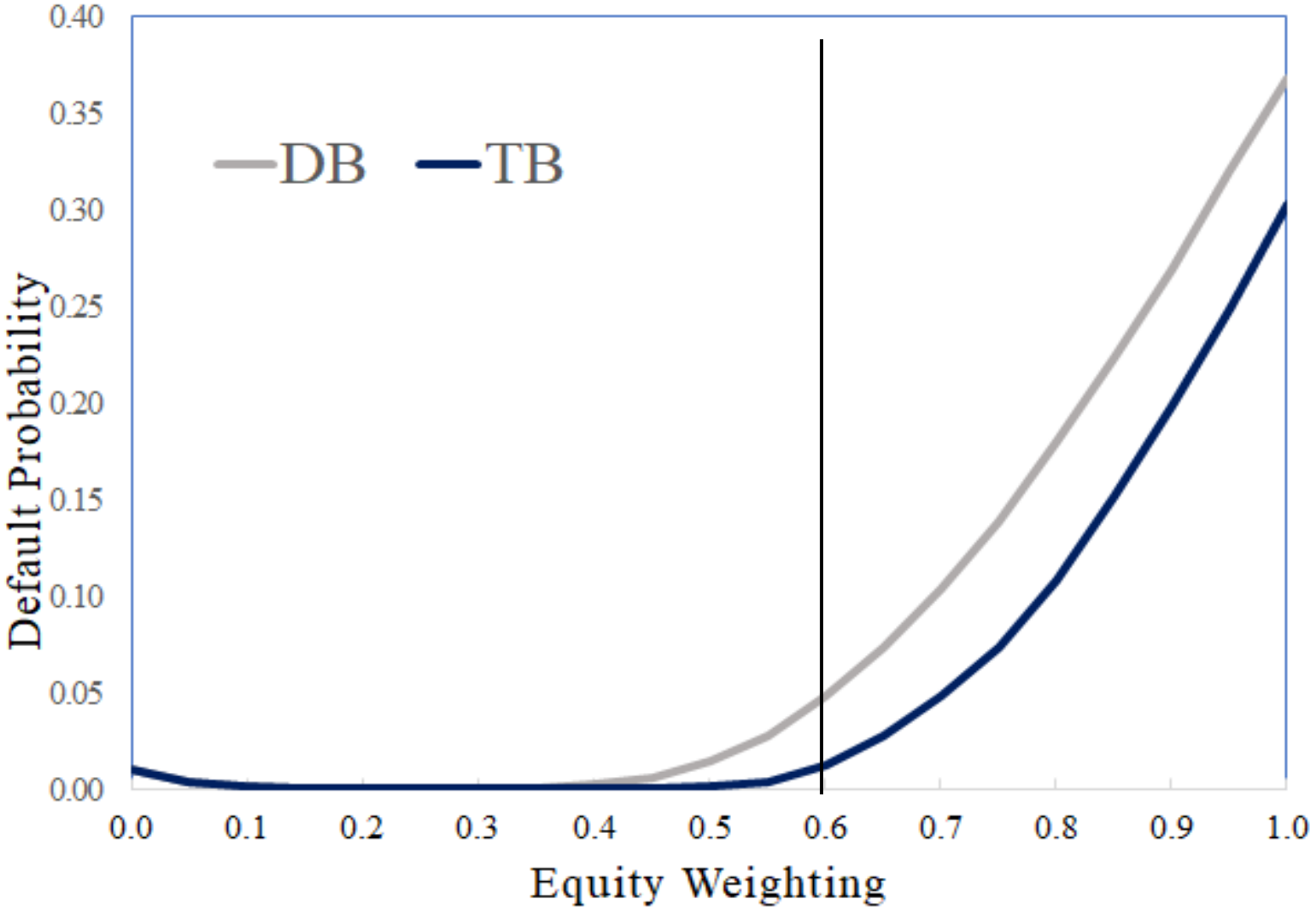
Real Income Paths; age 45



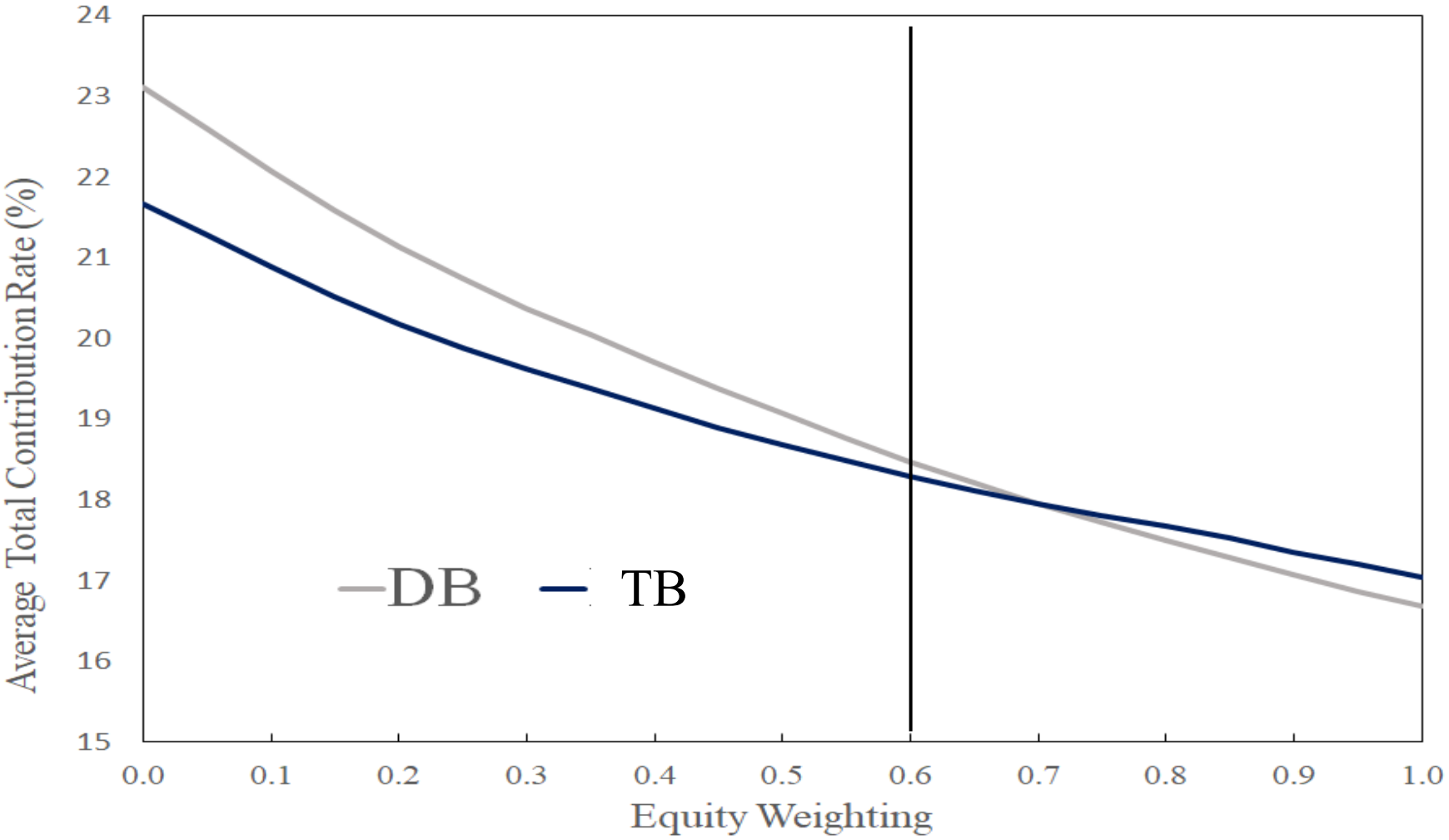
Comparison metrics

- Probability of wind-up
  - Sustainability, adequacy, efficiency, fairness
- Average total contribution rate
  - Affordability
- Income stability – compares actual and target income
  - Adequacy, fairness, efficiency
- Plotted across a range of equity weighting

Wind-up Risk by equity weighting

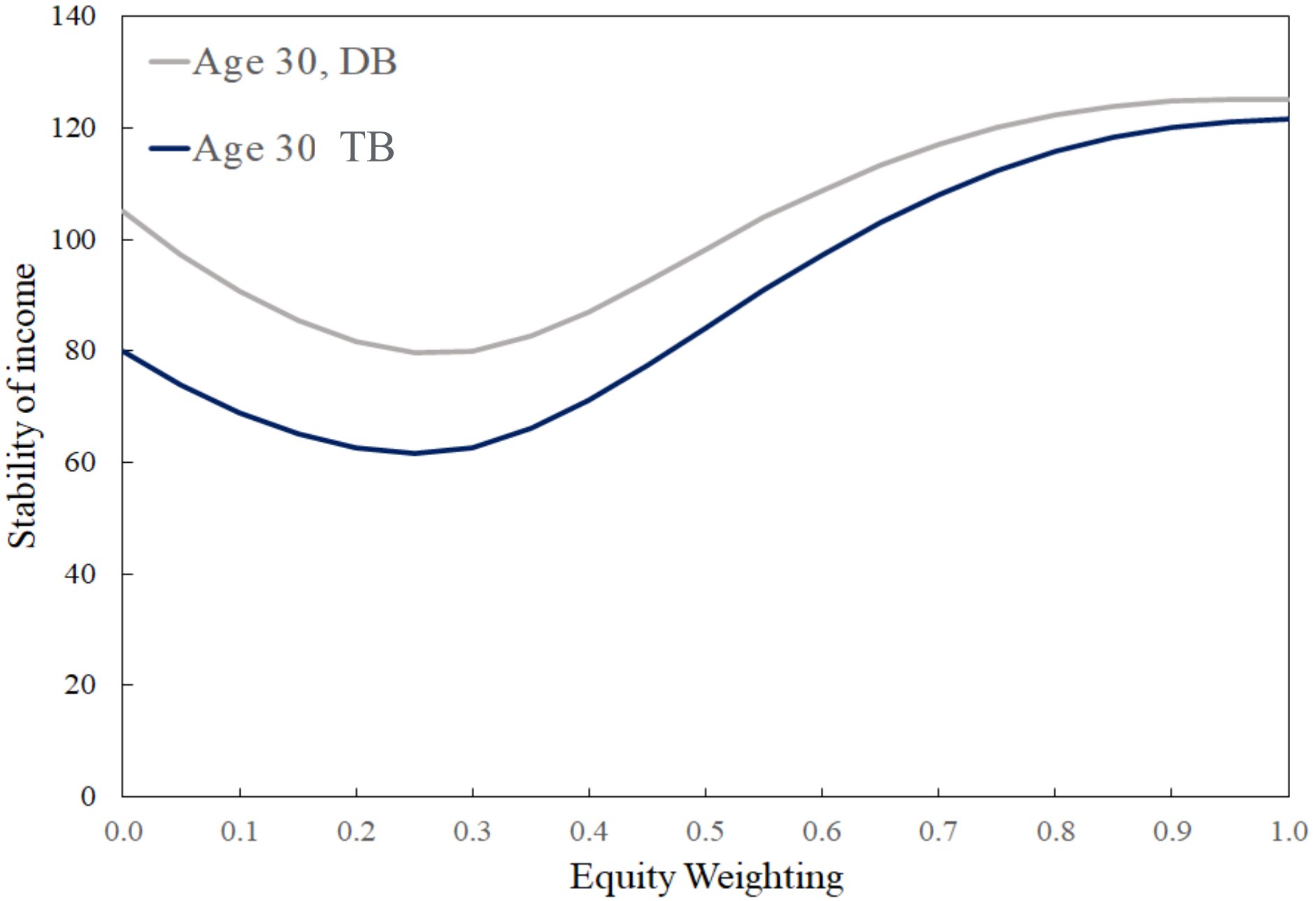


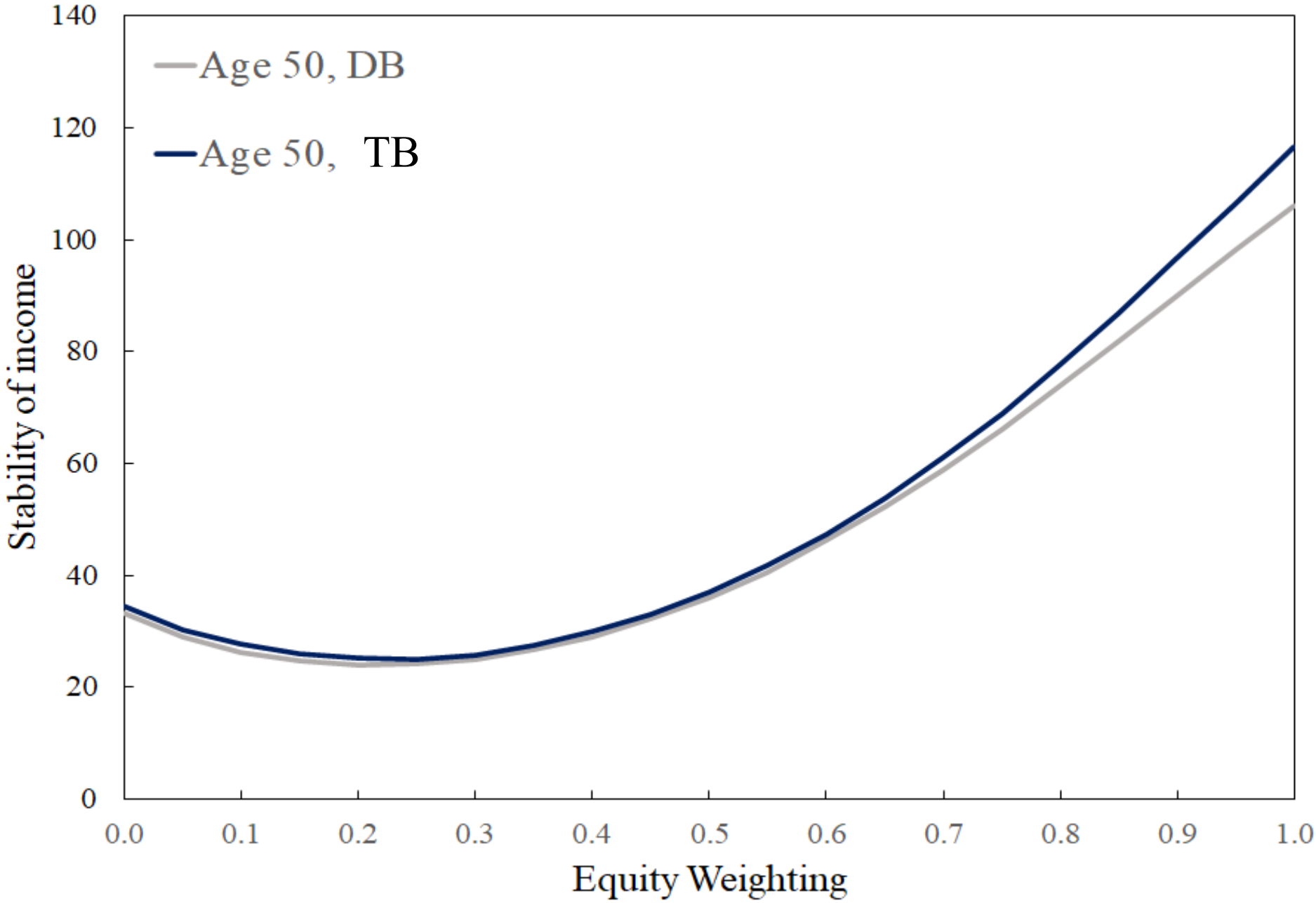
Average TCR by equity weighting

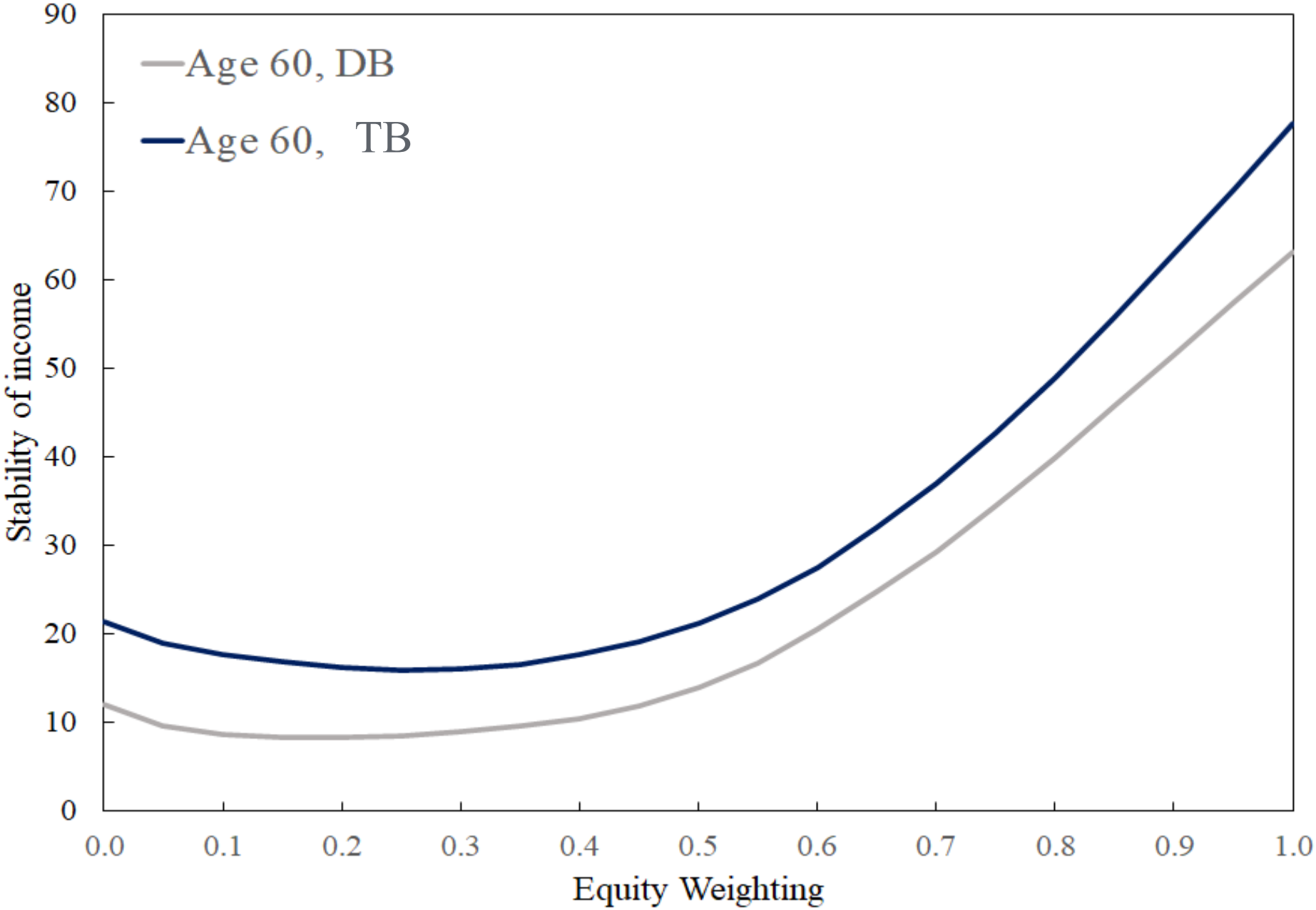


Notes on income stability (IS)

- IS^2 is the average squared disparity of actual and target income.
- Low values are better
- Positive and negative disparities are penalised equally
- Calculated by cohort
- Similar to the objective function used in theory papers


Age 30, DB
Age 30 TB
Stability of income
140
120
100
80
60
40
20
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Equity Weighting


Age 50, DB
Age 50, TB
Stability of income
Equity Weighting
140
120
100
80
60
40
20
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0


Age 60, DB
Age 60, TB
Stability of income
90
80
70
60
50
40
30
20
10
0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Equity Weighting

DB vs TB (Adjustable DB)

- Affordability: TB ? DB
- Sustainability: TB ? DB
- Efficiency: IRS ? DB
- Adequacy: IRS > DB
- Fairness:
  - Blue collar vs white collar

Non-salaried (blue-collar) employees

- Identical demographics
- Flat salary scale from age 30
- Inflationary wage increases only

	Default Rate	Average TCR
DB Salaried	4.9%	18.5%
DB Non-salaried	0.2%	14.4%

	Default Rate	Average TCR
TB Salaried	1.2%	18.3%
TB Non-salaried	0.04%	14.7%

Non-salaried (blue-collar) employees

- Allowing for longevity difference

	Default Rate	Average TCR
DB Salaried	4.9%	18.5%
DB Non-salaried	0.0%	12.6%

	Default Rate	Average TCR
TB Salaried	1.2%	18.3%
TB Non-salaried	0.0%	13.0%

Conclusions (1): usefulness of theory

- Theoretical results pointed to:
  - appropriate risk sharing mechanism
  - parameter constraints and relationships
  - the income stability metric
  - fair transition process

Conclusions(2): TB plan advantages

- TB with linear risk sharing is
  - Transparent,
  - Relatively robust
  - Surprisingly effective
- TB dominates DB on affordability, sustainability, efficiency (based on strong modelling assumptions)
- Allowing for default risk, TB may dominate DB on adequacy

Conclusions (3): More work required

- TB does not much mitigate blue-collar/white collar inequity
- But TB + CARE helps.
- To be further investigated
  - Fairness of discretionary COLA
  - Fairness between stayers and leavers

QUESTIONS?

Selected References

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- Zhu XM, Hardy MR, and Saunders D (2020a). Structure of Intergenerational Risk-Sharing Plans: Optimality and Fairness. Scandinavian Actuarial Journal (forthcoming) .
- Zhu XM, Hardy MR, Saunders D (2020b). Fair transition from a defined benefit to a target benefit pension plan. SSRN (forthcoming).
- Cui J, De Jong F, Ponds E (2011). Intergenerational risk sharing within funded pension schemes. Journal of Pension Economics & Finance, 10(1).
- Gollier C (2008). Intergenerational risk-sharing and risk-taking of a pension fund." Journal of Public Economics, 92(5-6).
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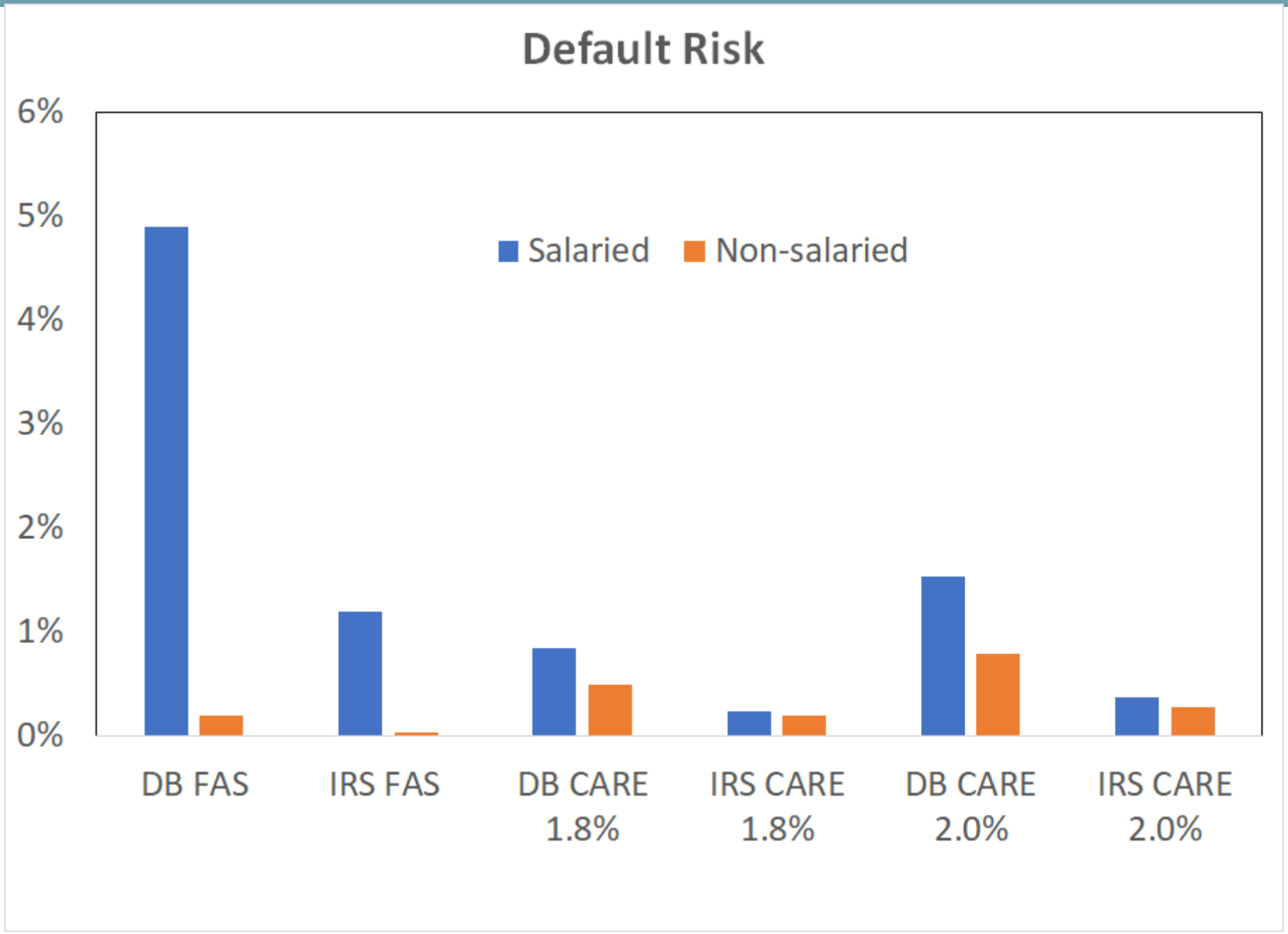
Income stability

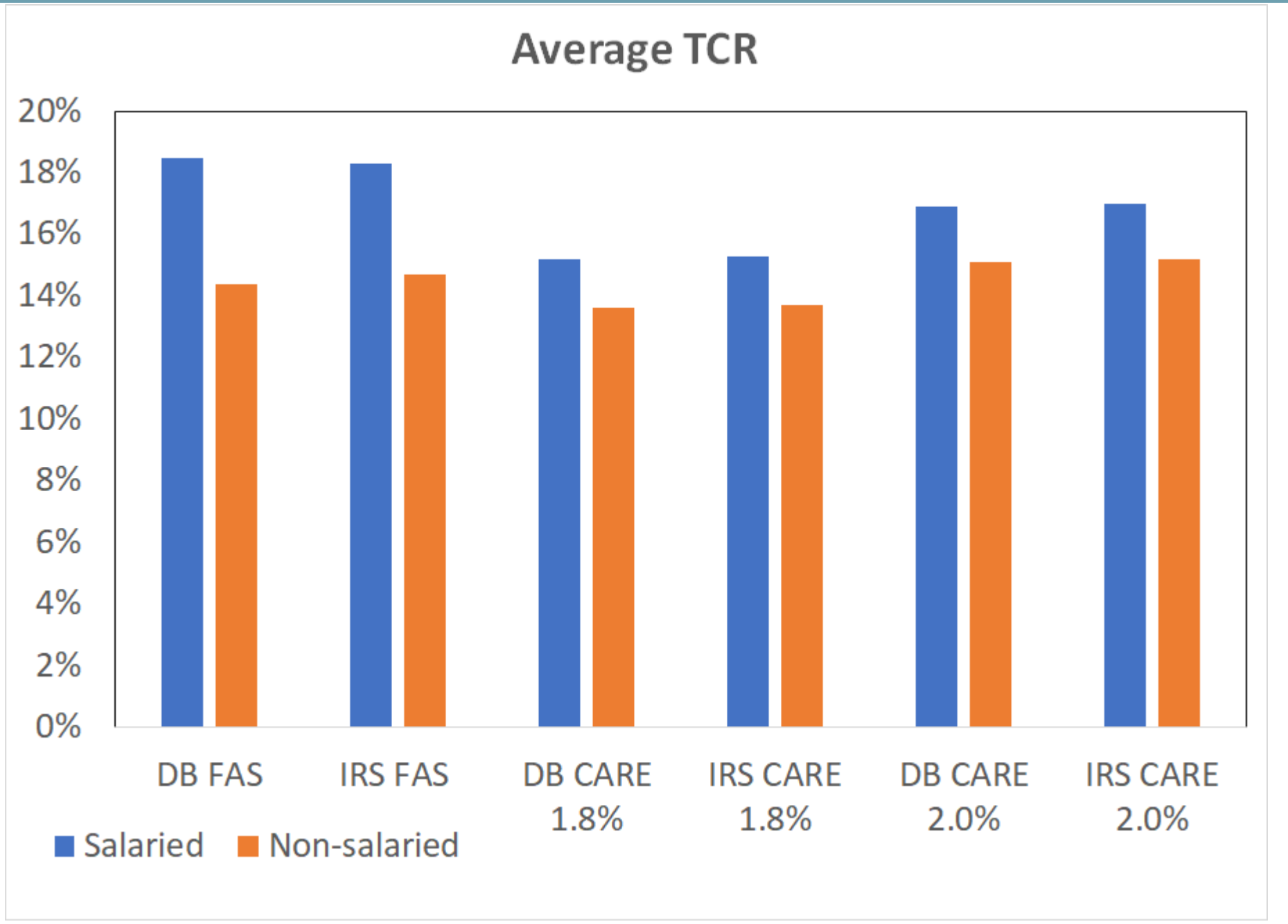
- Let $AI_{y,t}$, $TI_{y,t}$ denote the actual and target income for (y) at time t.
- For lives age x at $t = 0$ we have:

$$IS_x = \begin{cases} \dfrac{100}{S(x,0)} \sqrt{\dfrac{1}{30} \sum_{t=1}^{30} \left(AI_{x+t,t} - TI_{x+t,t} \right)^2} & \text{for } x \le 64 \\ \dfrac{50}{B(x,0)} \sqrt{\dfrac{1}{30} \sum_{t=1}^{30} \left(AI_{x+t,t} - TI_{x+t,t} \right)^2} & \text{for } x \ge 65 \end{cases}$$

Career Average Revalued Earnings

- Ameliorates unfairness problem with FAS plans
- Popular for DB risk reducing in Europe
  - eg, UK university plan
- Modelled with the same assumptions as before
  - Accrued benefit revalued in line with pensions
  - Assume 1.8% and 2.0% accrual
  - Ignore longevity differential


Default Risk
6%
5%
4%
3%
2%
1%
0%
Salaried
Non-salaried
DB FAS
IRS FAS
DB CARE 1.8%
IRS CARE 1.8%
DB CARE 2.0%
IRS CARE 2.0%


Average TCR
20%
18%
16%
14%
12%
10%
8%
6%
4%
2%
0%
DB FAS
IRS FAS
DB CARE 1.8%
IRS CARE 1.8%
DB CARE 2.0%
IRS CARE 2.0%
Salaried
Non-salaried