Pension Funds Performance Evaluation: a Utility Based Approach

Carolina Fugazza   Fabio Bagliano   Giovanna Nicodano
CeRP-Collegio Carlo Alberto and University of Turin

CeRP 10° Anniversary Conference

Motivation

- Performance Evaluation methods associate a higher return per unit of risk with better performance
- But a worker contributes to a pension fund also to stabilize consumption during retirement
- This paper proposes to evaluate the ability of pension funds in performing such function
  - the asset allocation delivered by a life-cycle model - built on Campbell, Cocco, Gomes and Maenhout (2001) - becomes a benchmark
  - a welfare-based metric evaluates ex post the DC fund performance relative to this benchmark

Benchmark asset allocation

- The optimal asset allocation trades off gains from investing in high risk premium assets with the needs to hedge labor income shocks.
- It takes into account
  - asset return distribution
  - risk aversion parameter
  - pension transfer
    - Replacement ratio, indexation, life expectancy
  - labour income distribution

Benchmark asset allocation

- Gains from improvements on asset allocation may be smaller than costs of tailoring portfolios to labor income
  - Simpler portfolio rules may become the benchmark
  - Model indicates when this is likely to be the case
- Two candidates:
- Modified Age Rule (target date retirement funds, Premium Pensions)
  - risky portfolio shares are set at (100-age)%, and equally allocated between stocks and bonds
- 1/3 for the each asset
  - This rule outperforms several portfolio strategies in ex post portfolio experiments (DeMiguel et al (2008))

A Utility-based Performance Metric

- ratio of worker's ex-ante maximum welfare under the benchmark asset allocation to ex ante welfare under the pension fund actual return distribution
  - worse performance may derive from
    - lower return per unit of financial risk
    - worse matching between the pension fund portfolio and its members' labor income and pension risks.

Pension Fund Performance Literature

- Do active p.f. obtain better risk-adjusted performance than passive benchmark?
- Benchmarks: single factor (Ippolito et al, 1987, Lakonishok et al., 1992); multifactor benchmarks and style indices (Coggin et al, 1993; Busse et al. 2008; Bauer and Frehen, 2008); MVE portfolio (Antolin, 2008)
  - Extra-performance deriving from market timing or security selection
  - Short run performance, but in Blake et al (1999)
- Metric: return based (alpha, Sharpe ratio..)

Problems with return based PE

- Is it appropriate also if workers are heterogeneous and there are non-traded assets?
- The benchmark portfolio ought to be the optimal portfolio for hedging fluctuations in the intertemporal marginal rates of substitution (MRS) of any marginal investor. With incomplete markets, the MRS is affected by
    - the variance of the cross- sectional distribution of individual consumption growth (Constantinides and Duffie,1996)
    - the distribution of employed and retired agents across the population (Storesletten et al. 2007)
- But chosen benchmarks usually reflect the state of empirical asset pricing and constraints on available data (Lehmann et al, 2008).

Previous question and ours

- Do active portfolio strategies obtain higher return-to-risk relative to passive efficient benchmarks, assuming investors implement the welfare-maximizing portfolio strategies supporting that benchmark?
- Ours: are pension funds up to the passive welfare maximizing portfolio strategy?

Other welfare-based PE

- Samwick and Skinner (2004) and Poterba et al. (2007) compare life-time expected utility under a DB scheme against a DC scheme
- focus on pension fund design rather than asset allocation
  - their benchmark is the DB plan, as opposed to a benchmark strategic asset allocation

Simple Life-Cycle Model

- **Two** risky assets and one riskless asset
  - calibration uses US stock index, bond index returns and T-Bills
  - any pair of assets can be accomodated, to the extent that their mean returns and (co)variances are precisely estimated
- Return on one risky asset **correlated** with permanent labour income shocks
  - US estimates range from 0 (Cocco et al, 2005) to 0.33 for workers with no high-school education to 0.52 for college graduates (Campbell et al (2001), Campbell and Viceira (2002))

Model Produces

- Mean optimal portfolio shares as a function of age
  - for base-case parameters
  - sensitivity to labour income risk, correlation, risk aversion, replacement ratio..
- Distribution of optimal portfolio shares across agents with the same age
  - this indicates whether pension funds ought to use individual accounts
- Welfare gains relative to simpler portfolio rules
  - these are compared with added management costs to decide whether the optimal policy or the simpler rule is the benchmark

Simple setting

- constant inflation environment
- no changing investment opportunities
  - market timing effects rewards when parameters of the return distributions are known with certainty (Michaelides (2002) and Koijen et al (2008))
  - but negligible ex-post value of market timing (De Miguel et al., 2008) and return predictability in general (Goyal and Welch, 2008; Fugazza et al., 2008) when parameters are uncertain

- Preferences: power utility

$$\frac{C_{it}^{1-\gamma}}{1-\gamma} + E_t\left[\sum_{j=1}^{T} \delta^{j}\left(\prod_{k=0}^{j-1} p_{t+k}\right)\frac{C_{it+j}^{1-\gamma}}{1-\gamma}\right]$$

Budget constraint

$$X_{it+1} = (X_{it} - C_{it})R_{it}^{P} + Y_{it+1}$$

- Labor income

$$\log Y_{it} = f(t, \mathbf{Z}_{it}) + u_{it} + n_{it}$$

Retirement income

$$\log Y_{it} = \log \lambda + f(t_{0-K}, \mathbf{Z}_{it_{0-K}}) + u_{it_{0-K}}$$

Deterministic growth trend

Permanent income shocks

$$u_{it} = u_{it-1} + \eta_{it} \qquad \eta_{it} = \xi_t + \omega_{it} \qquad N(0, \sigma_\eta^2)$$

Temporary income shocks

$$N(0, \sigma_n^2)$$

- Financial assets:
  - two financial assets with risky returns
  - one riskless R^f
  - portfolio return

$$R_t^s - R^f = \mu^s + \varepsilon_t^s$$

$$R_t^b - R^f = \mu^b + \varepsilon_t^b$$

$$R_{it}^P = \alpha_{it}^s R_t^s + \alpha_{it}^b R_t^b + \left(1 - \alpha_{it}^s - \alpha_{it}^b\right)R^f$$

The optimization problem – solution technique

$$\max_{\{C_{it}\}_{t_0}^{T-1}, \{\alpha_{it}^s, \alpha_{it}^b\}_{t_0}^{T-1}} \left(\frac{C_{it}^{1-\gamma}}{1-\gamma} + E_t \left[\sum_{j=1}^{T} \beta^j \left(\prod_{k=0}^{j-1} p_{t+k} \right) \frac{C_{it+j}^{1-\gamma}}{1-\gamma} \right] \right)$$

$$s.t. \quad X_{it+1} = (X_{it} - C_{it}) \left(\alpha_{it}^s R_t^s + \alpha_{it}^b R_t^b + \left(1 - \alpha_{it}^s - \alpha_{it}^b\right) R^f \right) + Y_{it+1}$$

- Bellman equation (recursive form):

$$V_{it}(X_{it}, u_{it}) = \max_{\{C_{it}\}_{t_0}^{T-1}, \{\alpha_{it}^s, \alpha_{it}^b\}_{t_0}^{T-1}} \left(\frac{C_{it}^{1-\gamma}}{1-\gamma} + \beta p_t E_t \left[V_{it+1}(X_{it+1}, u_{it+1}) \right] \right)$$

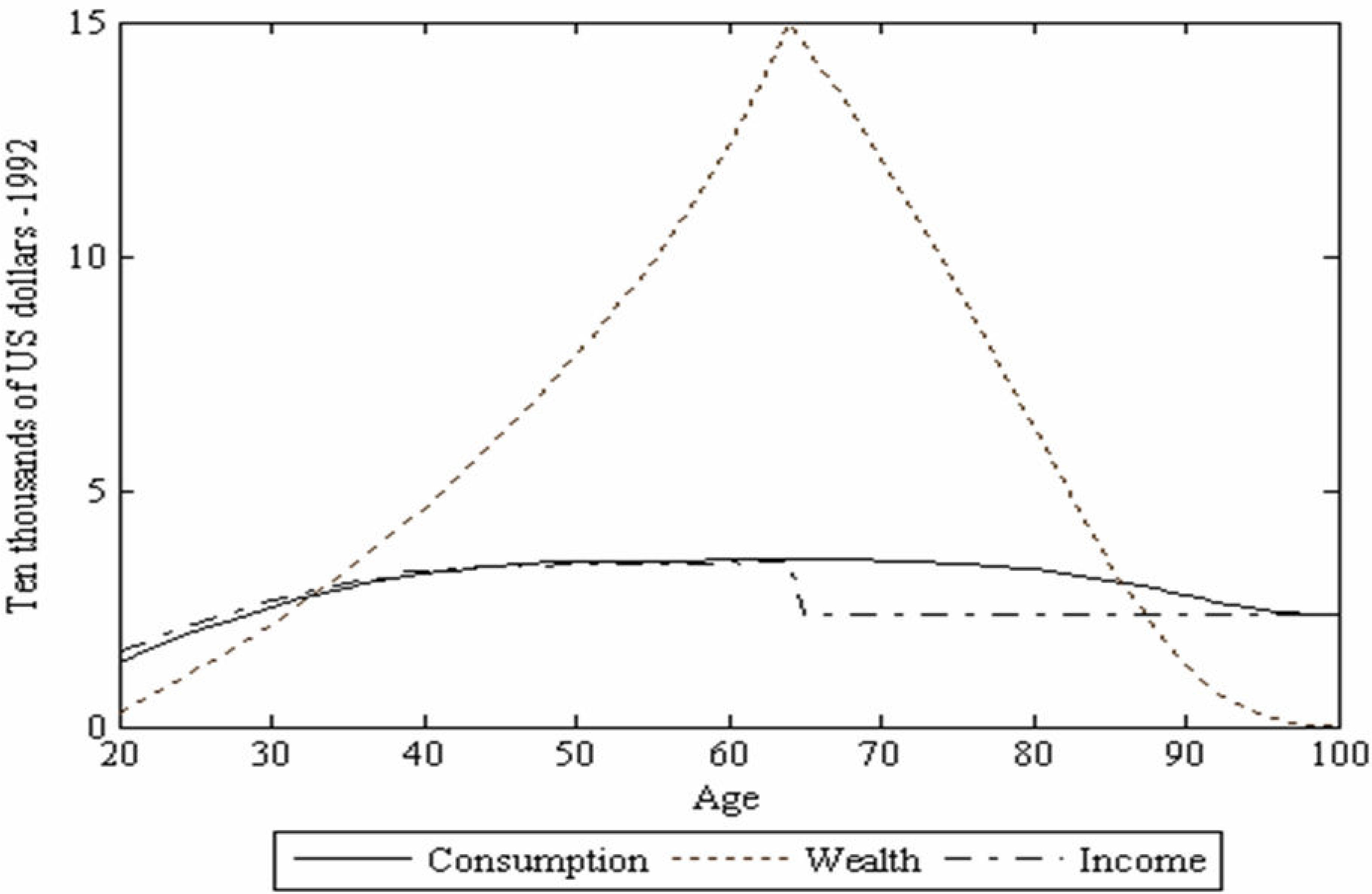
- Solution by backward induction:
  - Last period: the agent consumes all available wealth
  - The value function is used to compute the policy rules for the previous period. The procedure is iterated backwards
- Standard numerical techniques
  - state and decision variables were discretized using equally spaced grids.
  - Gaussian quadrature methods to approximate the density function of asset returns and labor income shocks (Tauchen and Hussey, 1991)
  - Cubic spline interpolation methods to evaluate the value function corresponding to values of cash-on-hand that do not lie in the chosen grid

Calibration

Benchmark parameters

Working life (max)	20 -65
Retirement (max)	65 -100
Discount factor (β)	0.96
Risk aversion (γ)	5
Replacement ratio (λ)	0.68
Variance of permanent shocks to labour income (σ^2_ε)	0.0106
Variance of transitory shocks to labour income (σ^2_n)	0.0738
Riskless rate	2%
Excess returns on stocks (μ^s)	4%
Excess returns on bonds (μ^b)	2%
St. dev. Of stock returns innovations (σ^2_s)	0.025
St. dev. Of stock returns innovations (σ^2_b)	0.006
Stock/bond return correlation (ρ_{sb})	0.2
Stock ret./permanent lab. Income shock correlation (ρ_{sY})	0

The Role of DC Pension Funds in Helping Consumption Smoothing

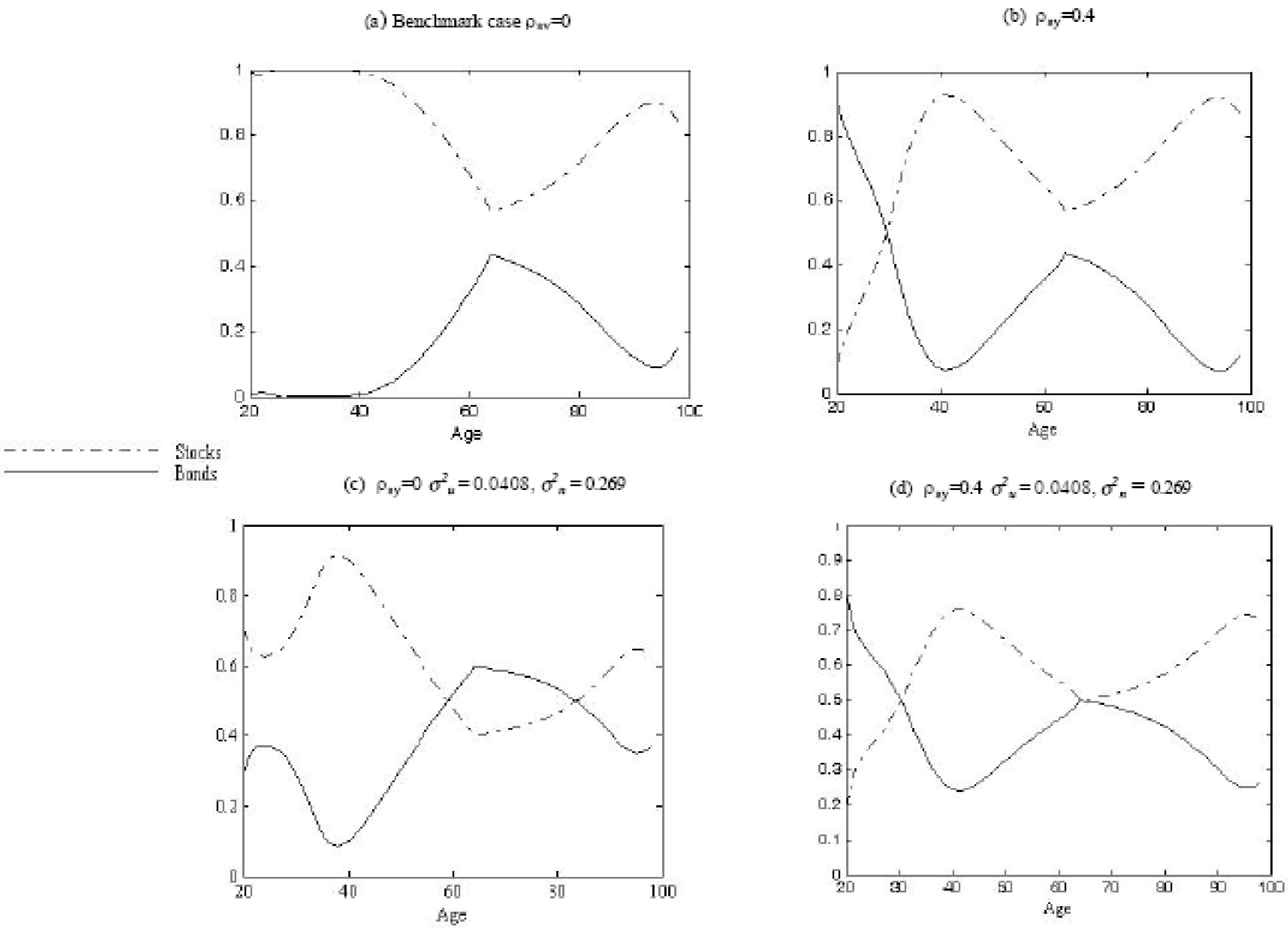


Mean asset allocation, age and labour income risk

- When young the asset allocation is tilted towards riskier assets (stocks) whereas in the two decades before retirement it gradually shifts to safer assets (bonds)
  - As in Bodie et al. (1992), Cocco et al (2005)
- The old invest in stocks as their pension wealth is in the riskless asset and financial wealth is used up
  - As in Cocco et al (2005)
  - Flatter schedule with bequest
- As the variance of labour income shocks increases, the optimal share in stocks at 65 drops to 40% and never exceeds 60% thereafter

Asset Allocation and Age, with Changing Income Risk

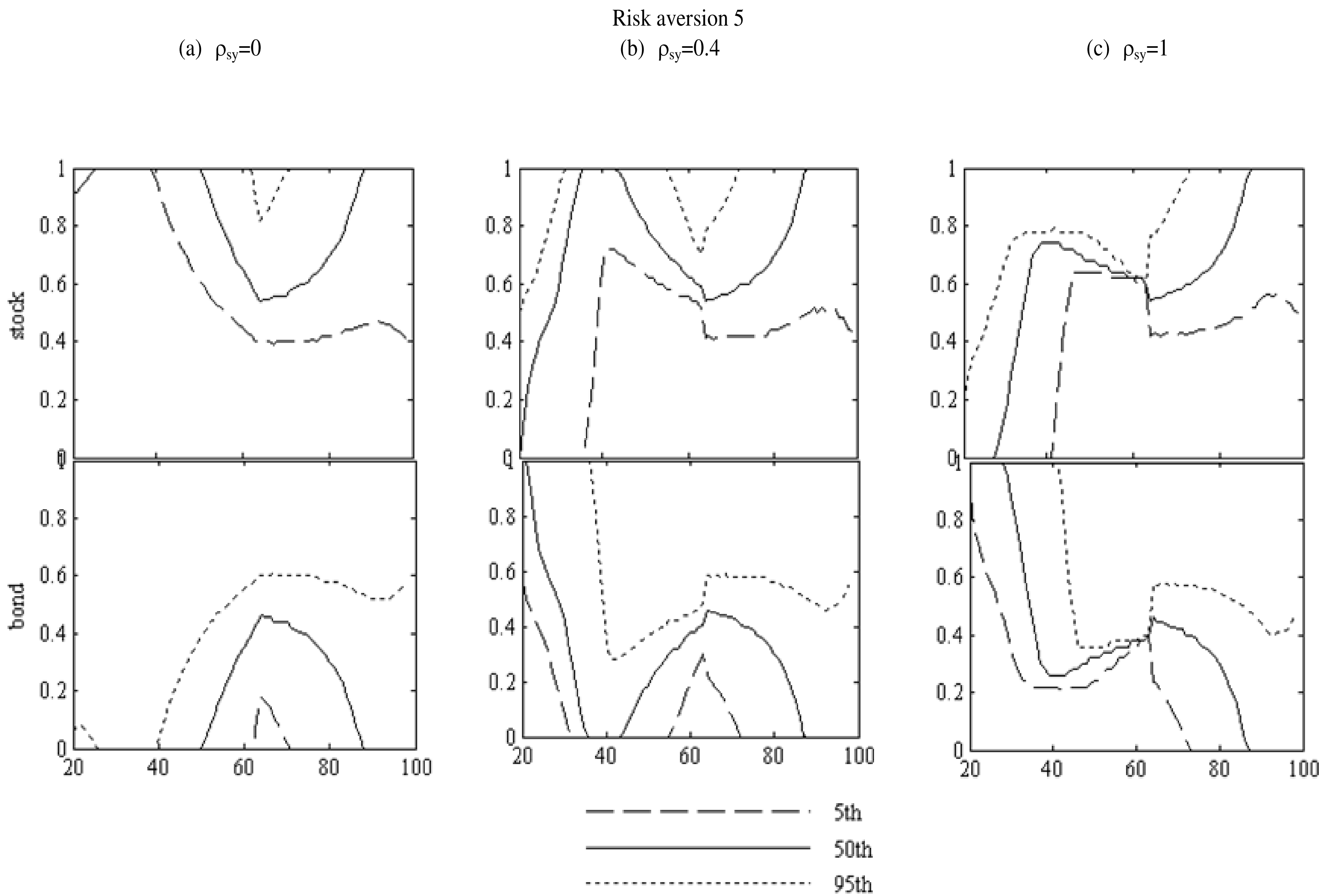
Figure 5
The figure reports mean share profiles, as a function of age, for stocks (dashed –dotted) and bonds (solid). The replacement ratio is equal to 0.68, the correlation between stock and bond returns is set to 0.2 while the one between stocks and labour income varies between 0 and 0.4. The variance of permanent and transitory shocks are 0.0106 and 0.0738, when not specified.



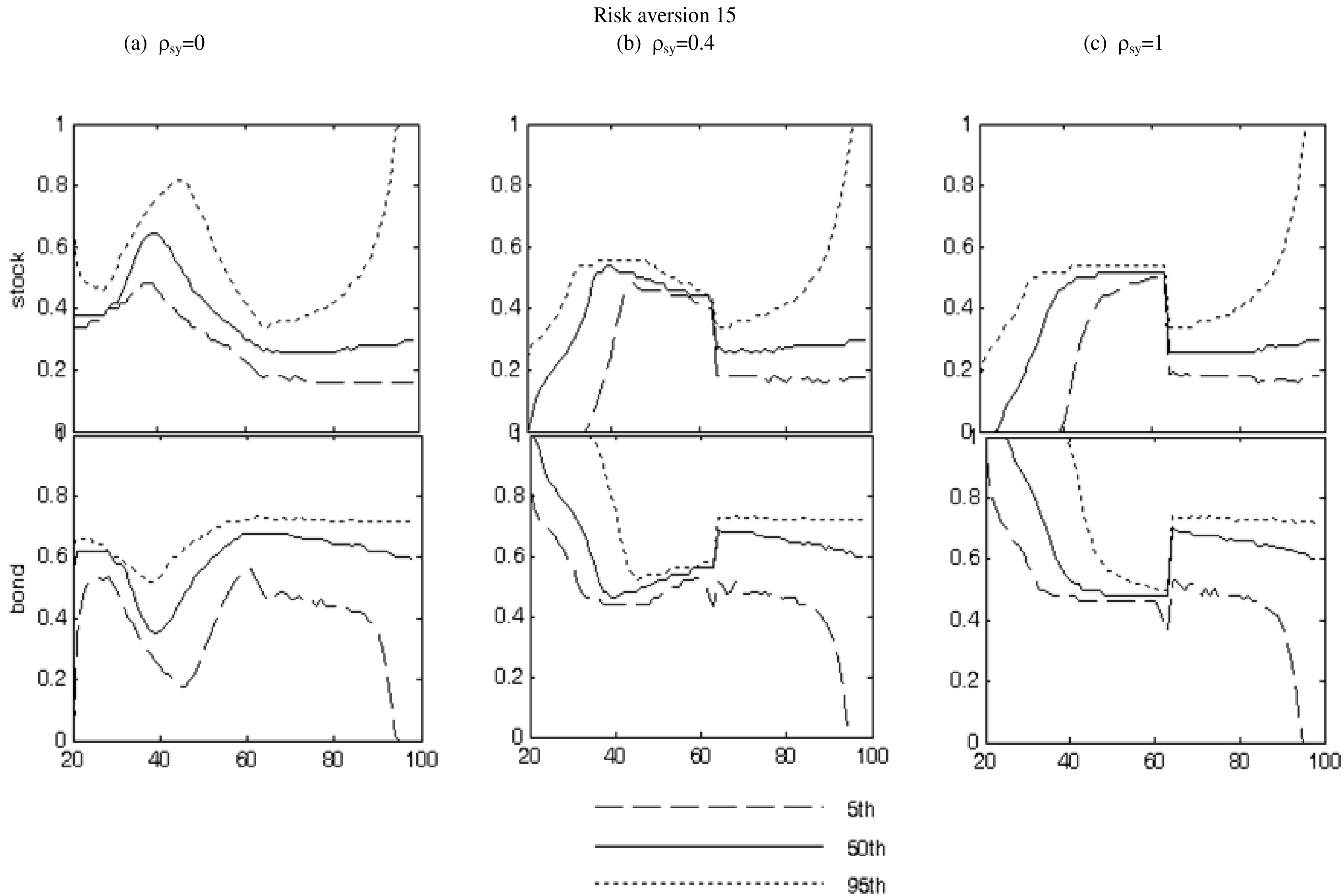
Asset allocation and labor-stock correlation

- asset allocation obtained in base case holds for middle-aged workers and retirees
- younger workers (in the 20-40 age range) accumulate slowly stocks, since labor income is closer to an implicit holding of stocks
- portfolio reallocation at 65: portfolio composition is sensitive to the income-stock return correlation during working life, whereas during retirement this is no longer the case

Asset allocation and labor-stock correlation



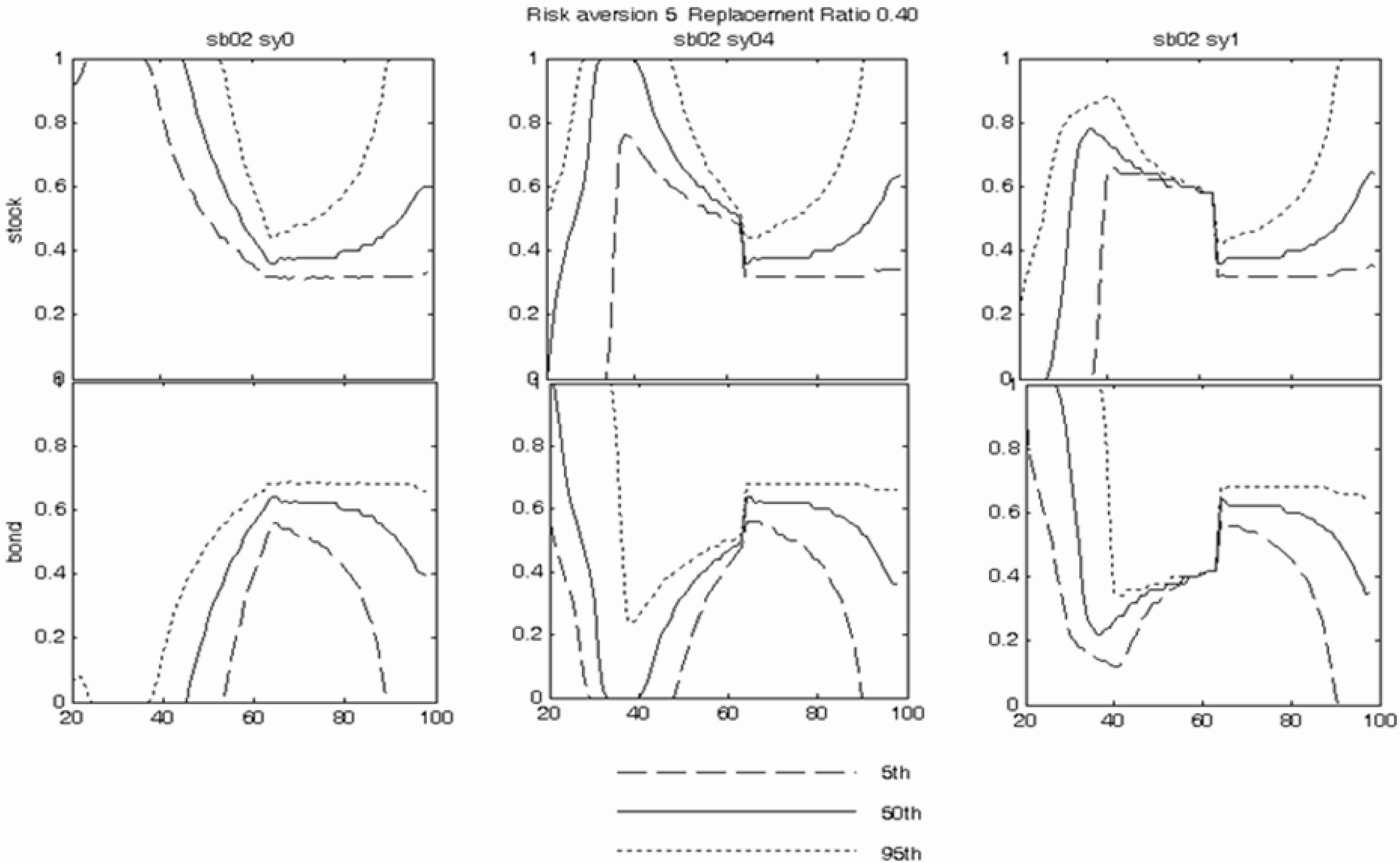
Asset allocation and labor-stock correlation with higher risk aversion



Asset allocation and replacement ratios

- Lower replacement ratios
  - lower riskless pension income H
  - agents save more, thus accumulating a higher level of risky financial wealth W
  - a lower H/W determines a lower optimal share of stocks at all ages - and especially before retirement
- Reduction in inflation indexation or healthcare coverage akin to reduction in replacement ratio - abstracting from precautionary savings

Lower replacement ratio



Distribution of Optimal Portfolios

Heterogeneous portfolios due to individual-specific income shocks require individual accounts.

- But dispersion decreases
- as retirement approaches, the more so the higher is the labor income-stock return correlation
  - The histories of labor incomes converge and so do portfolio choices
- with higher risk aversion and lower replacement ratio
  - They increase savings and financial wealth, which implies lower sensitivity of portfolio shares to human capital.
  - This insensitivity increases the closer is the worker to retirement age, when financial wealth is maximal

Welfare Costs of Simpler Portfolio Rules

- ***1/N*** has lower welfare costs than *(100-age)/2*
- Imagine a 1% yearly fee
  - Benchmark asset allocation is 1/N for high wealth workers and/or medium-to-high replacement ratios countries. Otherwise, management fees exceed welfare gains
  - Optimal asset allocation remains the benchmark for low and medium wealth workers in low replacement ratios countries

Welfare Costs- Base Case

	Risk aversion 5		Risk aversion 15	
		$\rho_{sy}=0$		
	WelfareCosts		***WelfareCosts***	
	(100-age)/2	***1/3***	***(100-age)/2***	***1/3***
Mean	0.021	0.018	0.015	0.013
5th percentile	0.032	0.027	0.043	0.037
50thpercentile	0.024	0.021	0.012	0.0105
95thpercentile	0.004	0.003	0.004	0.004
		$\rho_{sy}=0.4$		
	WelfareCosts		***WelfareCosts***	
	(100-age)/2	***1/3***	***(100-age)/2***	***1/3***
Mean	0.012	0.012	0.012	0.011
5th percentile	0.027	0.022	0.036	0.034
50thpercentile	0.013	0.011	0.006	0.005
95thpercentile	0.0013	0.0013	0.0015	0.0014
		$\rho_{sy}=1$		
	WelfareCosts		***WelfareCosts***	
	(100-age)/2	***1/3***	***(100-age)/2***	***1/3***
Mean	0.012	0.011	0.011	0.010
5th percentile	0.025	0.023	0.032	0.031
50thpercentile	0.012	0.011	0.005	0.005
95thpercentile	0.0016	0.0010	0.0016	0.0017

Welfare Costs – Replacement Ratios

Risk aversion 5					
	Replacement ratio 0.40		**Replacement ratio 0.80**		**Replacement ratio 0.68 Decreasing (implied by a decreasing annuity)**
	WelfareCosts				
	(100-age)/2	***1/3***	***(100-age)/2***	***1/3***	***(100-age)/2***
Mean	0.031	0.026	0.018	0.015	0.027
5th percentile	0.063	0.055	0.023	0.019	0.053
50thpercentile	0.029	0.020	0.020	0.017	0.023
95thpercentile	0.0049	0.0026	0.0022	0.0019	0.0045

Pension Fund Performance Evaluation

- Welfare Ratio captures
  - ability to smooth consumption, hedging labor income, pension income and financial risk
  - Numerator: welfare obtained under the optimal (or 1/N) asset allocation associated with given replacement ratio, members’ labour income process, life expectancy
  - Denominator: welfare under the pf return distribution
    - Obtained by simulation of optimal consumption decisions for pf members, without optimizing for the asset allocation, given the pension fund return distribution
    - mgt fees can be subtracted from portfolio returns when computing workers wealth accumulation

Properties of WR

- comparable across countries
  - pf is evaluated against appropriate benchmark for each country
- numerator-denominator can be computed conditional on restricted asset menu, if there are regulatory constraints

Welfare Ratio: an Example

- Assume pension fund follows age rule
- Age rule has higher Sharpe ratio than optimal asset allocation
  - Standard return based performance would rank age rule higher
- Table reports WR
  - WR ranks optimal asset allocation (before management fees) higher than age rule

Welfare Ratios

	Risk aversion 5		
Replacement ratio	**0.68**	**0.4**	**0.8**
		$\rho_{sy}=0$	
Sharpe ratio			
Optimal	0.260	0.286	0.244
Age rule	0.337	0.337	0.337
Welfare Ratio			
Mean	1.051	1.096	1.044
5th percentile	1.101	1.096	1.048
50thpercentile	1.056	1.074	1.057
95thpercentile	1.014	1.011	1.007

Welfare Ratios

Replacement ratio	0.68	0.4	0.8
		ρ_{sy}=0.4	
Sharpe ratio			
Optimal	0.273	0.310	0.257
Age rule	0.337	0.337	0.337
Welfare Ratio			
Mean	1.033	1.049	1.028
5th percentile	1.049	1.076	1.028
50thpercentile	1.040	1.054	1.032
95thpercentile	1.009	1.012	1.007
		ρ_{sy}=1	
Sharpe ratio			
Optimal	0.296	0.314	0.264
Age rule	0.337	0.337	0.337
Welfare Ratio			
Mean	1.025	1.037	1.020
5th percentile	1.042	1.029	1.032
50thpercentile	1.031	1.043	1.021
95thpercentile	1.002	1.009	1.002

Summary

- Quest for shift in performance evaluation criteria for pension funds: from beating the market to ability in hedging income risk
- Investigation of properties of benchmark
  - requires individual accounts but for certain parametric configurations
  - optimal asset allocation less welfare enhancing for higher income members and higher replacement ratios countries
    - Simpler rule as benchmarks
  - 1/N better than age rule!
- Next: sensitivity to model details (bequest) and asset menus (long term Inflation Indexed Bonds, housing)