Quantification of the Discontinuity Risk of Pension Funds

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Background

- Intern at APG since April till August; Netspar-student.
- For my MSc. Quantitative Finance & Actuarial Science, Netspar; BSc. Econometrics at Tilburg University also.
- Supervisors Thesis:
  - Dr. Samuel Sender (UvT, Netspar);
  - Dr. Michiel van Leuvensteijn (ACM, APG);
  - Jurre de Haan (APG).
- Co-reader Thesis:
  - Prof. Dr. Bertrand Melenberg (UvT, Netspar).

Outline

Definition

- Car-sharing example: discontinuity risk.
- Problem: collective amount has to be divided fairly.
  - Discontinuity due to inter-generational risk sharing.

Definition

Discontinuity risk *The probability that new generations (of 25 years old) — when they enter the labour market — abstain from entering the collective pension contract, and/or the probability that older generations (from 26 till 64 years old) — currently in the collective fund — withdraw from the collective pension contract and enter the individual fund.*

Relevance & Literature

- Not taken into account in current ALM-analysis.
- Current debate: 'hoofdlijnennota' of the cabinet.
- Inter-generational risk-sharing, "solidarity":
  - Welfare enhancing, *if* committed to contract.
- Minimum funding ratios:
  - Indifference point individual DC v.s. collective DB.
- Briefly discontinuity risk:
  - Mainly on new generations, not older generations.

Research Question

I extend on the research of discontinuity risk:

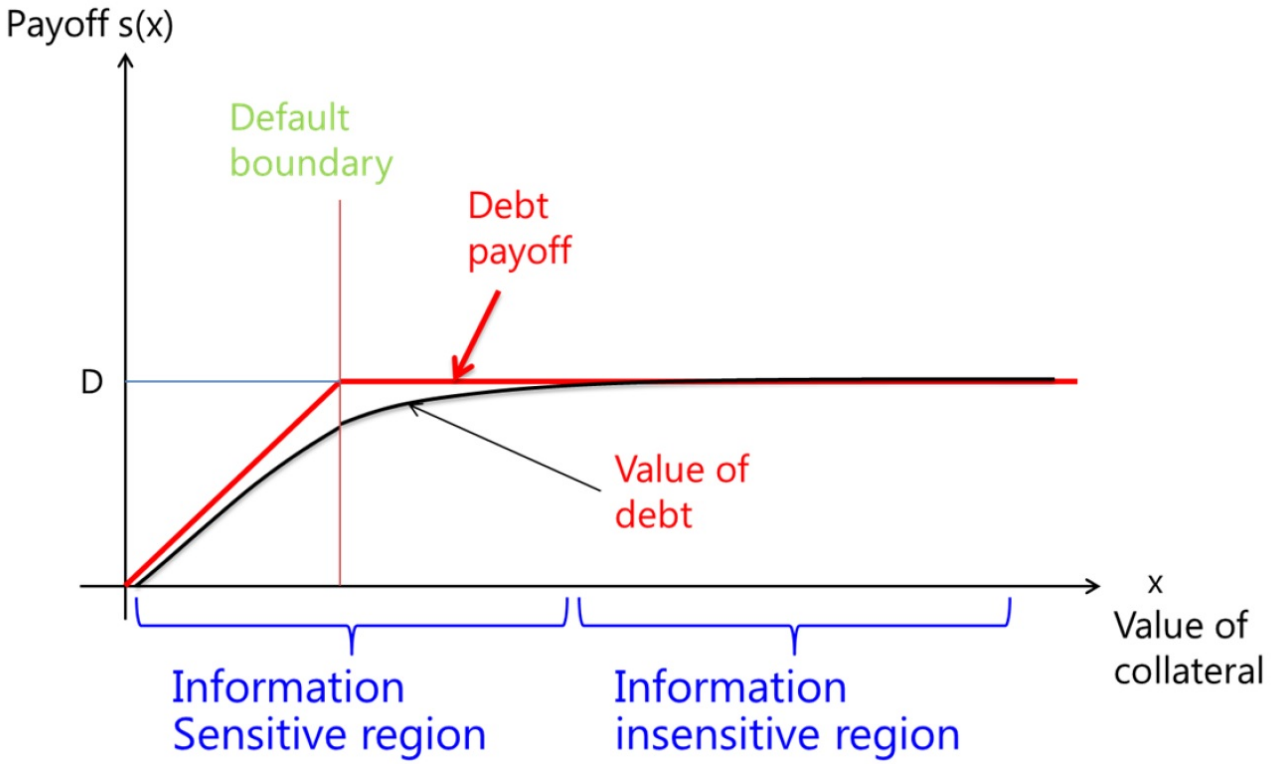
1. How do new entrants and current participants react during a discontinuity event?
2. How affects (endogenous) discontinuity risk the sustainability of the (larger) pension funds in The Netherlands and how large is the discontinuity risk?

Method of analysis: Monte Carlo simulations.

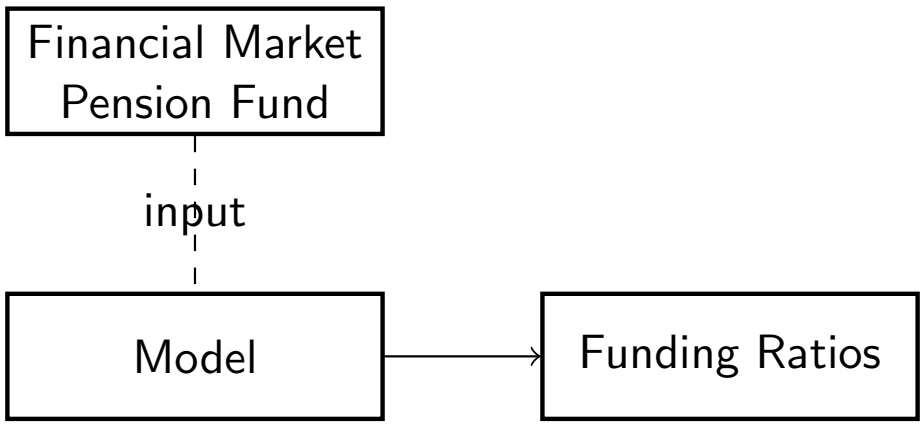
In the News

Philosophy for thesis emerged from Holmstrom (2015).

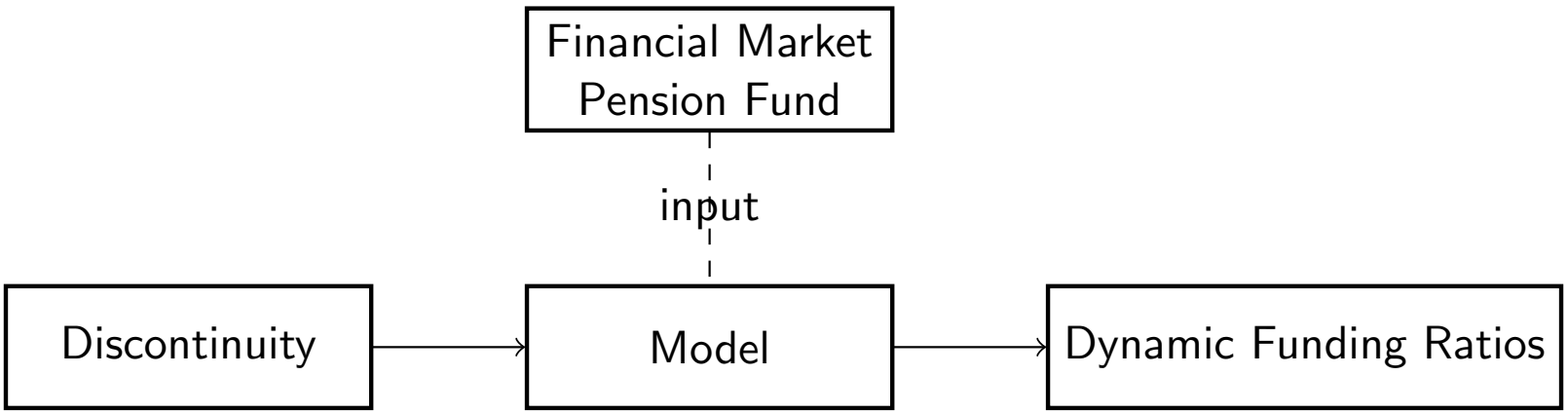
- *Understanding the role of debt in the financial system.*
- Contract-theory: Nobelprize!



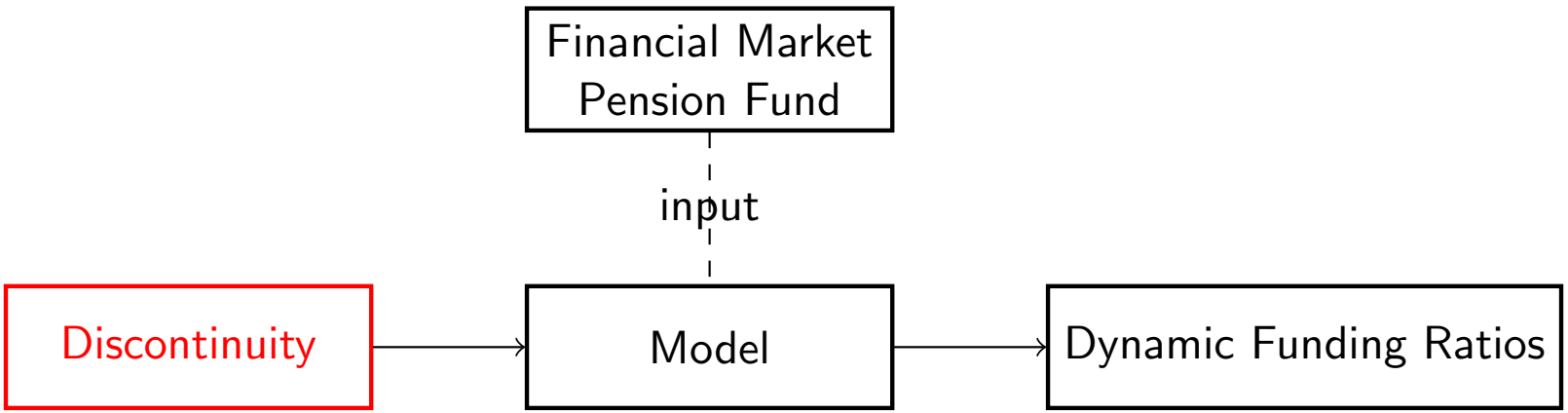
Current Static Approach



New Dynamic Approach



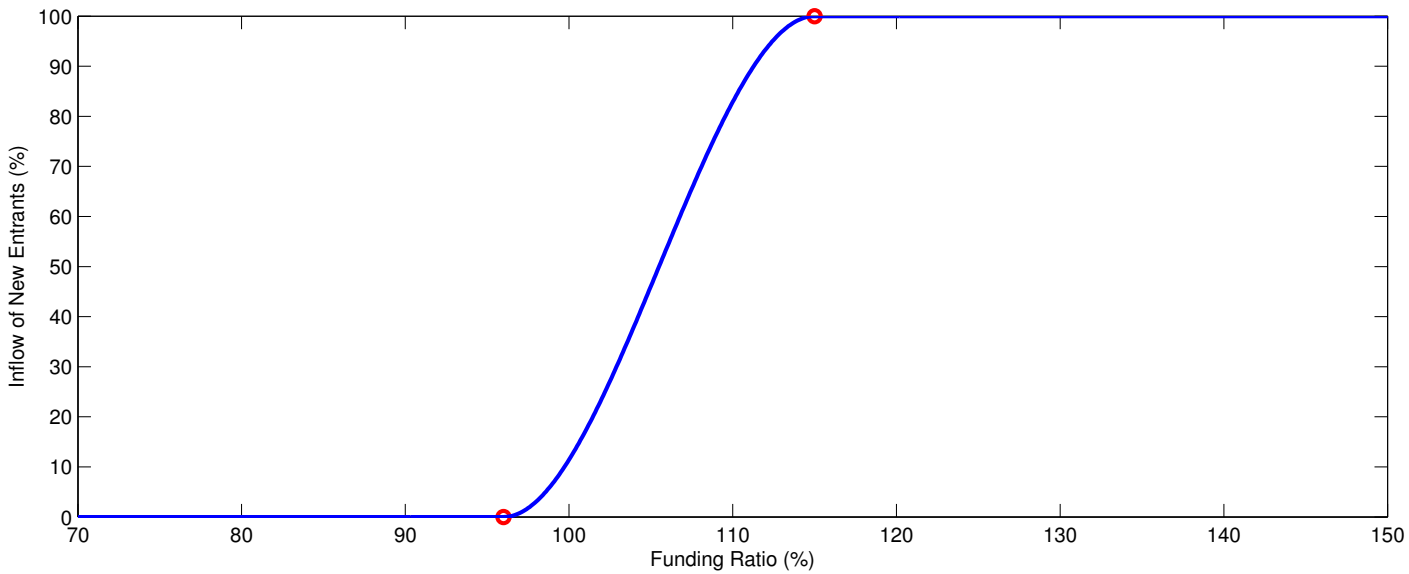
Outline


Financial Market
Pension Fund
input
Discontinuity
Model
Dynamic Funding Ratios

Discontinuity Event

- Evidence-based is difficult, no historic events.
- Who leave the pension fund and what are the costs of if?
  - 25-64 years, transfer values twofold.
- Can participants leave a fund and where do they go to?
  - Collective or individual scheme; options in reality.
- Do they not enter due to the (unsustainable) current situation of the fund, or because other individuals are probably not going to participate?
  - Snowball/bank-run effect a.k.a. information cascade.

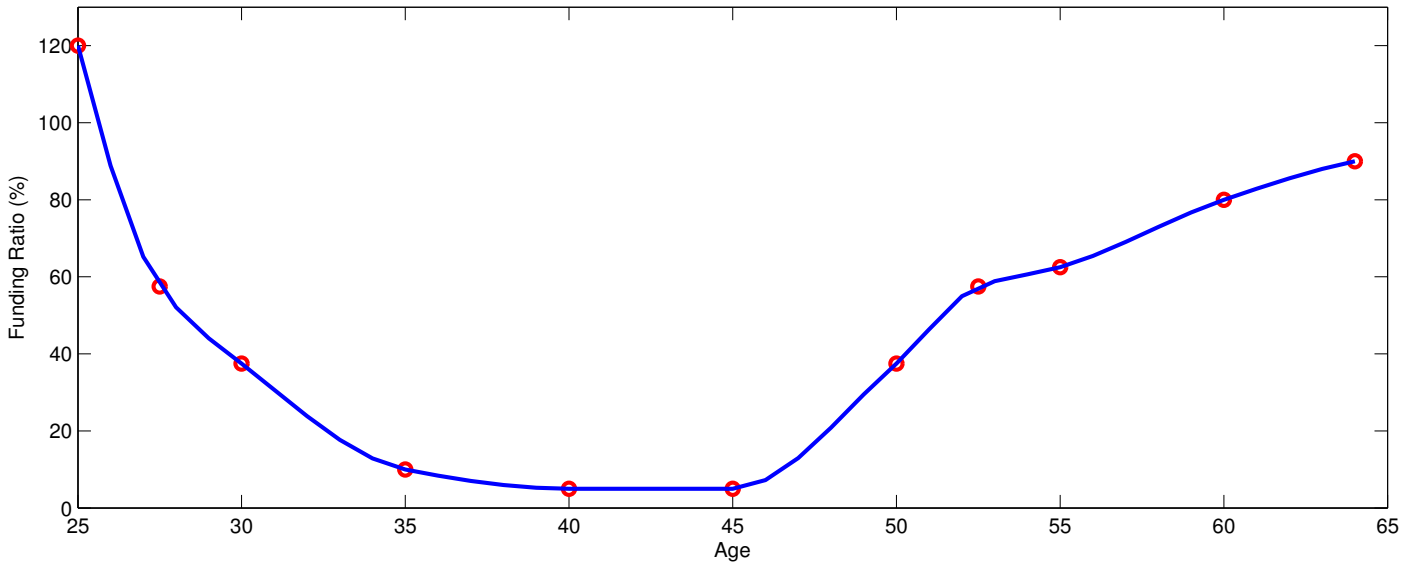
Reaction-function: 25-year-old



Based on literature of Siegmann (2011):

- Minimum funding ratio 25-year-old at 96%.

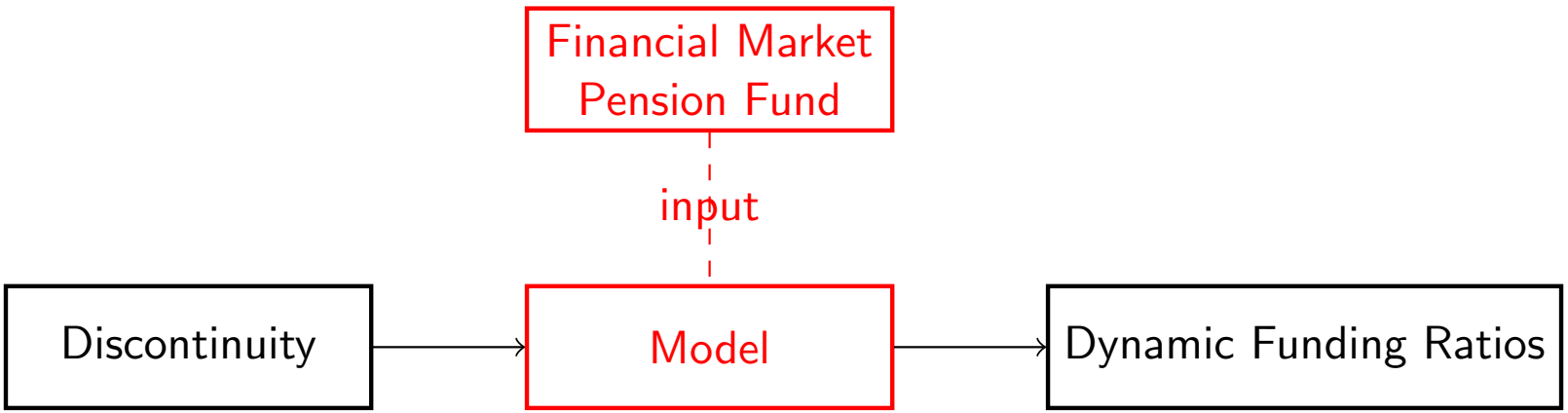
Break-even Funding Ratios: 25-64 year-olds



Based on literature of Molenaar et al. (2011):

- Minimum funding ratio 25-year-old at 120%.

Outline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Financial Market & Pension Fund

Two dominant risks pension fund:

- Stock market;
- Interest rate (mean-reverting), with random inflation.

$\Rightarrow$ Realised in a continuous Black-Scholes-Vasicek model.

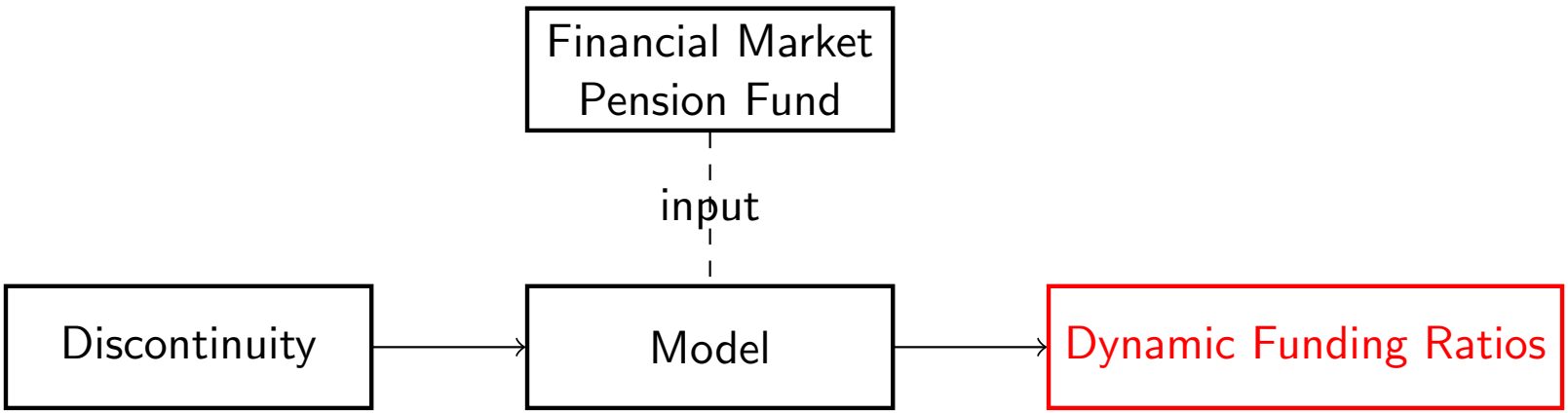
Output:

- Portfolio returns (6% stocks and 3% bonds) and term-structure (2% long-term interest rate).

Pension fund:

- Takes The Netherlands as baseline.
- Initial funding ratio 90%.

Outline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(I) Dynamic Inflow

Entry level 96% (left) and entry level 120% (right):
Buffer-drop due to small grey fund, effect on long-term.

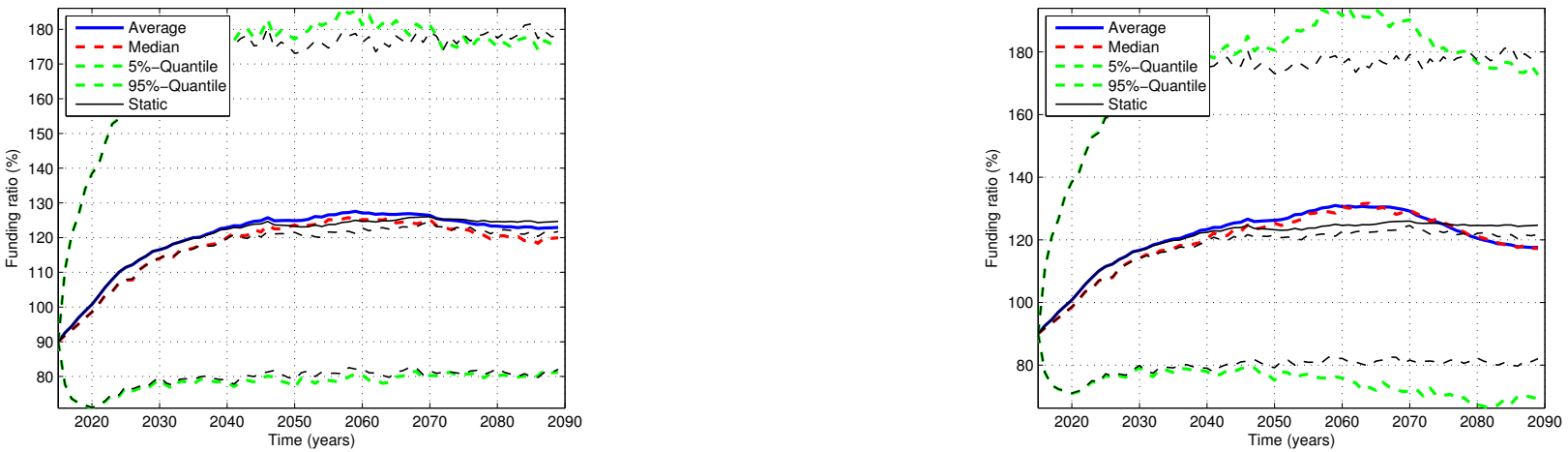


Figure: Funding ratios with dynamic inflow.

(II) Dynamic Inflow and Outflow

Characteristic hump gone due to leaving near-retirees:
Effect on long-term (default), but also on short-term.

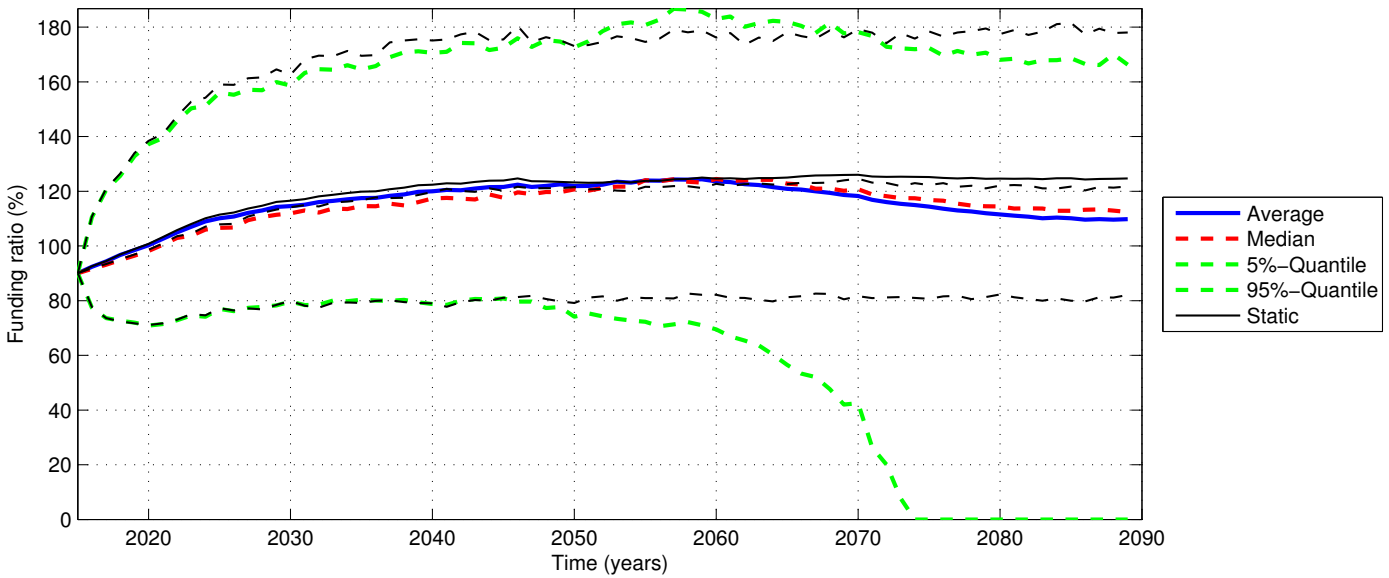


Figure: Funding ratios with dynamic inflow and outflow.

Effect Discontinuity for Participants

Effect of same magnitude as benefit reductions/recovery premia.

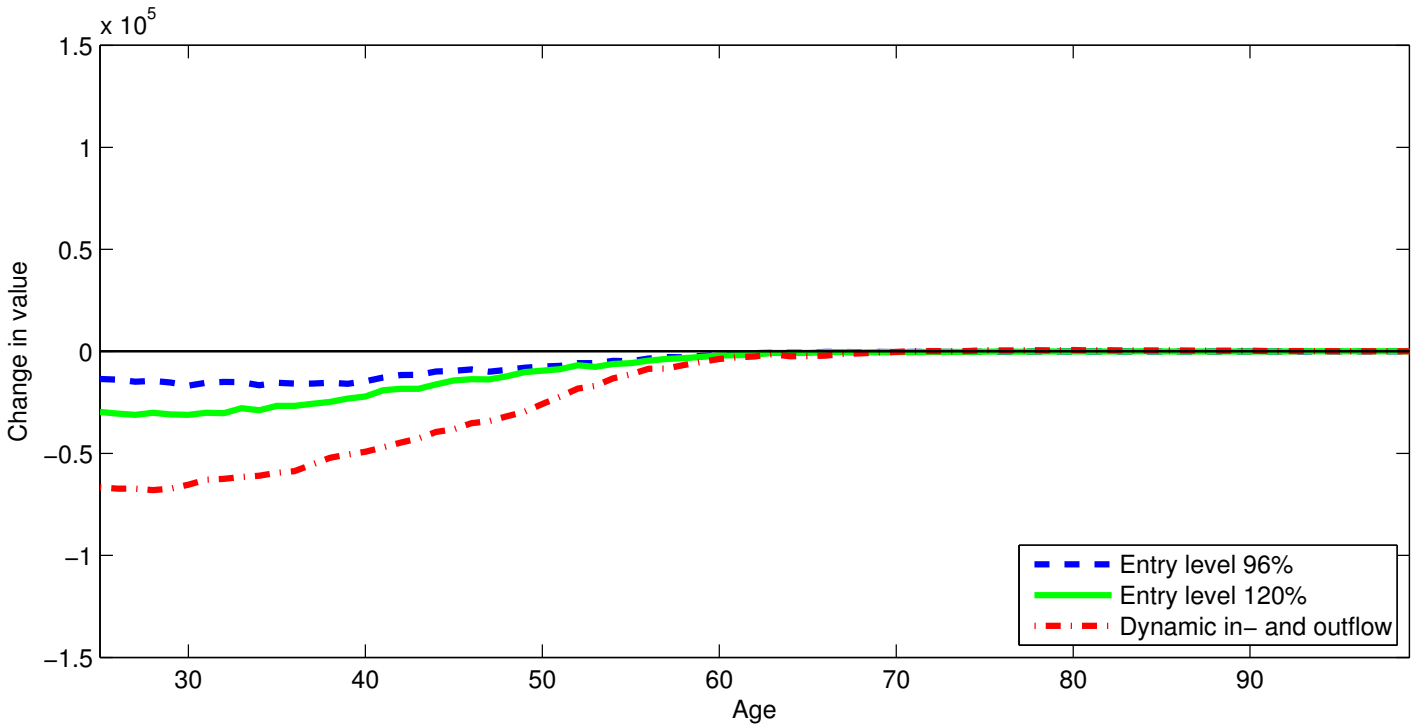


Figure: Change in generational accounts: value-based ALM.

Sensitivity Analysis

- Transfer value 100% of the rights, instead of conditional:
  - Assets deplete quickly (funding rate 41.15% lower).
  - Fund transfers too much w.r.t. their funding level.
  - Fund's population too small to steer.
- Initial funding ratio steady-state 121.8%:
  - Short-term no effect, but Sinking Giant.
  - For too long too few pension income.
  - Funding rates between 33% - 71% lead to certain default.
- Lower interest and inflation rate:
  - More sensitive to shocks and more risky.
  - Higher liabilities, lower return on assets, higher transfer values.

Summary & Conclusion

Results corroborate intuition and expectation.

1^{st} research question:

- Reactions quantified by reaction-function.
- During a discontinuity event an information cascade happens.

2^{nd} research question:

- Funding rates become lower, sensitive and more volatile.
- Fund's population is smaller.
- Effect of discontinuity on long-term.
- Discontinuity risks mainly elderly and entrants: 49.3% - 76.2% .
- Discontinuity has same effect as benefit reductions and recovery premia.

Recommendations & Further Research

- Pension funds should consider financial sustainability and participants' support:
  Trade-off (only funding rate is not sufficient).
- Smoothing periods work sub-optimal:
  Make them conditional on population and funding level.

$\Rightarrow$ What is optimal?

- Reaction-function is used as a benchmark, but research needed: parameters independent, utility functions, indifferent premium levels, CDB v.s. IDC, effect of policy, population size.
- Questions?
- Suggestions?

Appendix 1: Reaction-function

Discontinuity function at time t for age $25 \leq x < 64$:

$$d_{x,t}(FR_t) = \begin{cases} 1 & \text{if } FR_t \leq BFR_x \\ p(FR_t) & \text{for } BFR_x < FR_t < BFR_x + 20\% \\ 0 & FR_t \geq BFR_x + 20\% \end{cases},$$

where BFR_x is the age-specific break-even funding ratio (constant trough time), FR_t is the prevailing nominal published funding ratio and p is the interpolating function.

Number of participants in the dynamic case $M^d_{x,t}$ ($F^d_{x,t}$) for each age x at time t follows from

$$M^d_{x,t} = M_{x,t} \cdot d_{x,t},$$
$$F^d_{x,t} = F_{x,t} \cdot d_{x,t},$$

where $d_{x,t}$ stems from the funding ratio at the start of year t.

Appendix 2: Dynamic In- and Outflow

Evolution of bankruptcy in the 5%-quantile:

(i) Continuous underfunding.

(ii) Nobody enters and many current cohorts of 55-64 years leave.

(iii) Assets deplete due to:
- Low returns;
- No new inflow;
- Transferring of pension rights.

(iv) Liabilities decrease also, but not so fast.

(v) Namely, middle-aged cohorts remain and, thus, small population.

(vi) Steering is almost impossible in combination with suboptimal smoothing.

(vii) If no measures are taken (e.g. government or other policy), funds goes default.

Appendix 3: Leaving a Fund

Options in reality (see BPFbouw for construction workers):

(i) Become self-employed;

(ii) Switch from job or employer to another pension fund provider;

(iii) Work abroad;

(iv) Abstain from working;

(v) Too low z-score allows employer to switch;

(vi) Have at least an equal or better alternative.

These are examples of 'voting with your feet', another possibility is to 'vote with your voice'.

Appendix 4: Term Structure

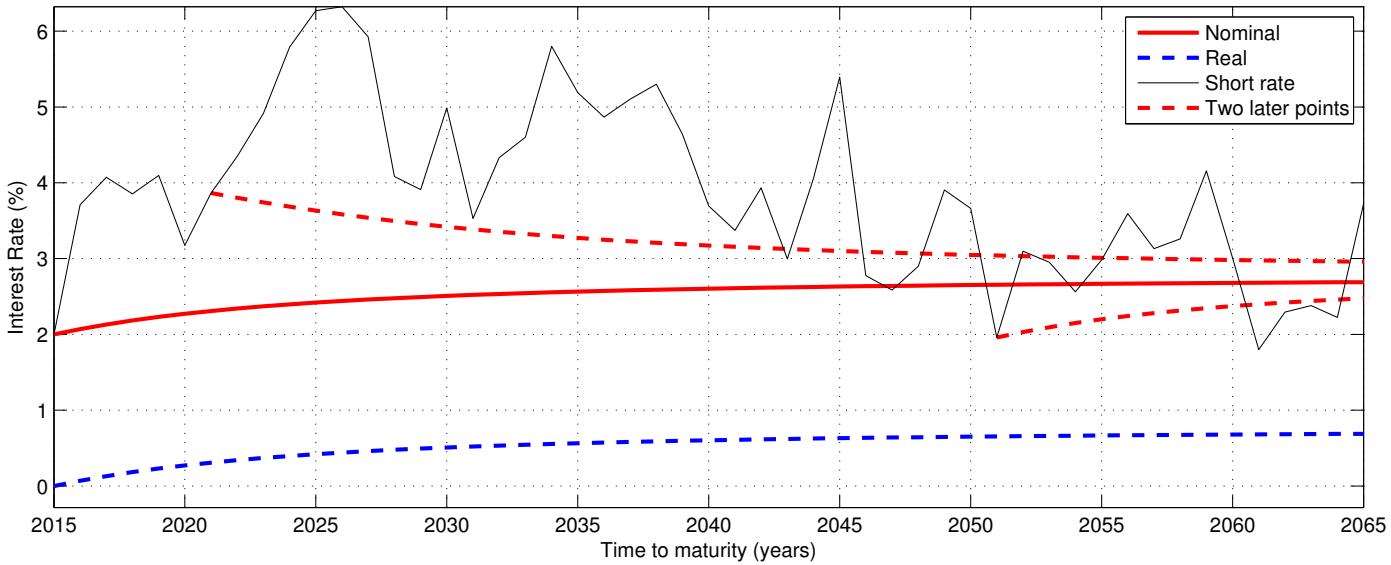


Figure: Term Structure: $\alpha = 0.15, \kappa = 2\%, \sigma_r = 1\%$

Nominal and real term structure in Vasicek model (sensitivity).
Short rate and nominal term structure at two later points.

Appendix 5: Demography Population

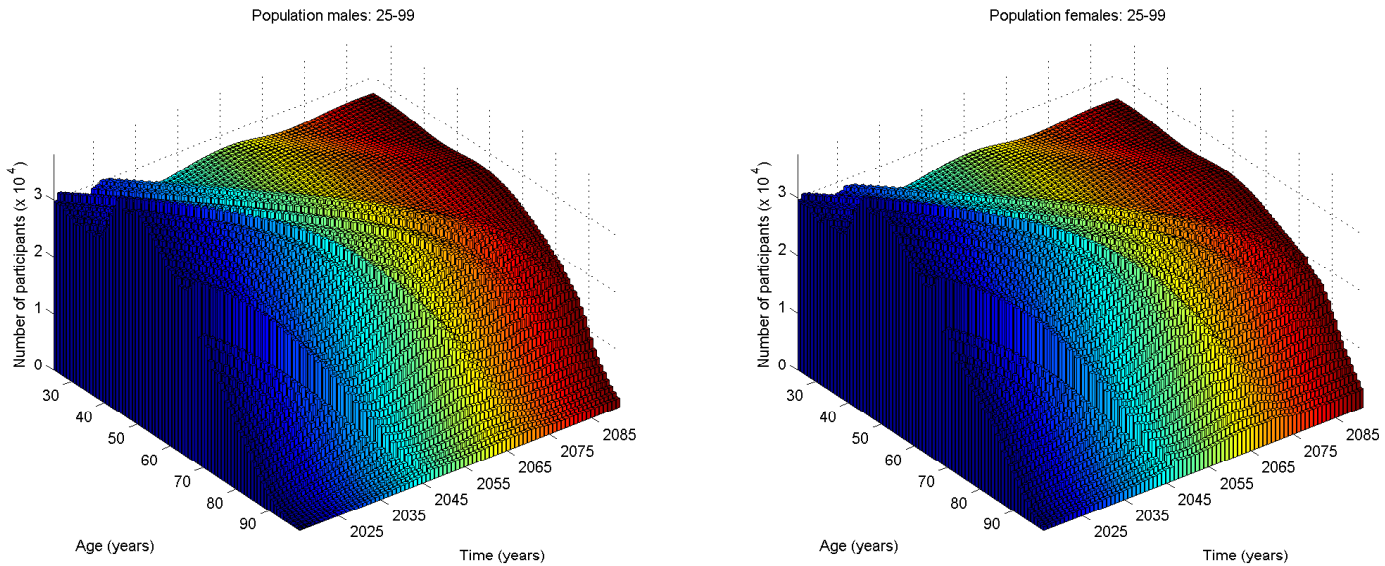


Figure: Evolution number of participants through time and age (males, females).

Appendix 5: Salary

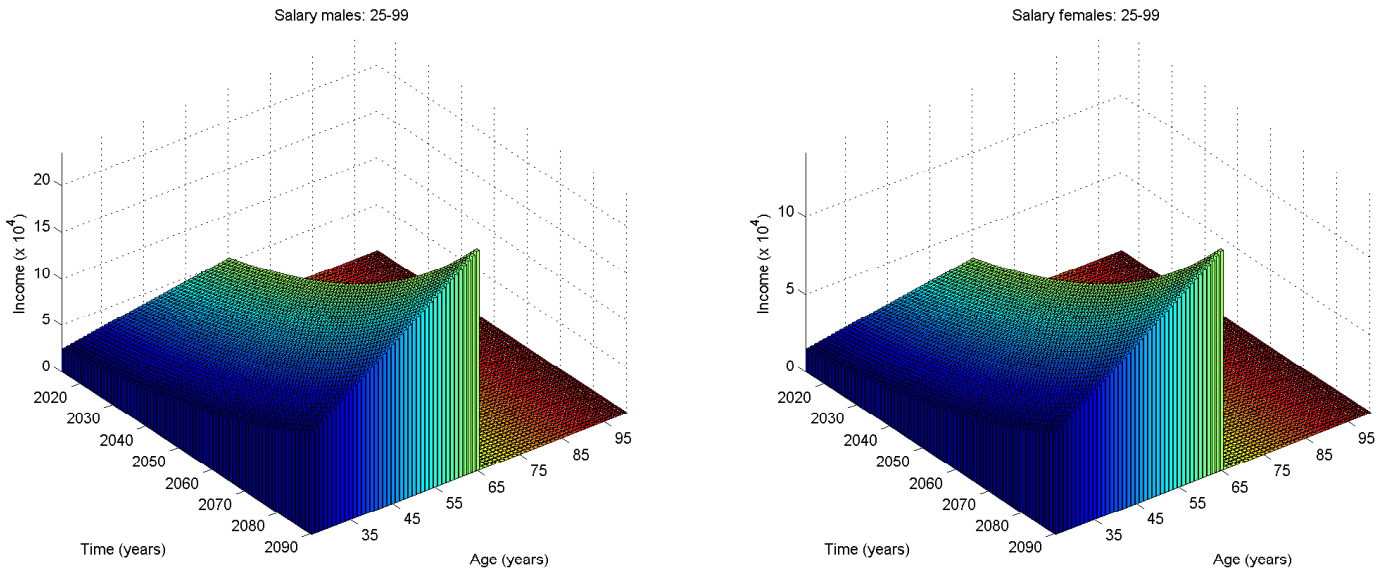


Figure: Evolution (mean) income through time and age (males, females).

Appendix 6: Pension Setting

Variable	*Males*	*Females*	*Total*
Workers (< 65)	1,279,622 (1,087,577)	1,277,190 (1,039,988)	2,556,812 (2,127,565)
Retirees (≥ 65)	400,395 (637,108)	483,236 (704,017)	883,631 (1,341,125)
Accrual rate ϵ (yearly)	1.875%	1.875%	-
Income (average)	€38,848	€23,309	-
Pension at 65	€29,136	€17,482	-
Liabilities ($\times$ bln.)	€318	€219	€537
Funding ratio			90%

Table: Initial Pension Fund Set-up 2015 (in parentheses the population sizes for 2060).

Appendix 7: Policy

140%	Full indexation Lower premium Surplus sharing, smoothing period 5 years
140%	Full indexation Cost-covering premium
130%	Linear indexation Cost-covering premium
110%	No indexation Cost-covering premium
105%	No indexation Cost-covering premium Sustainability cut, smoothing period 10 years
95%	No indexation Recovery premium Sustainability cut, smoothing period 10 years
90%	No indexation Recovery premium Sustainability cut, smoothing period 10 years Recovery plan, smoothing period 10 years

Appendix 8: Static Funding Ratios

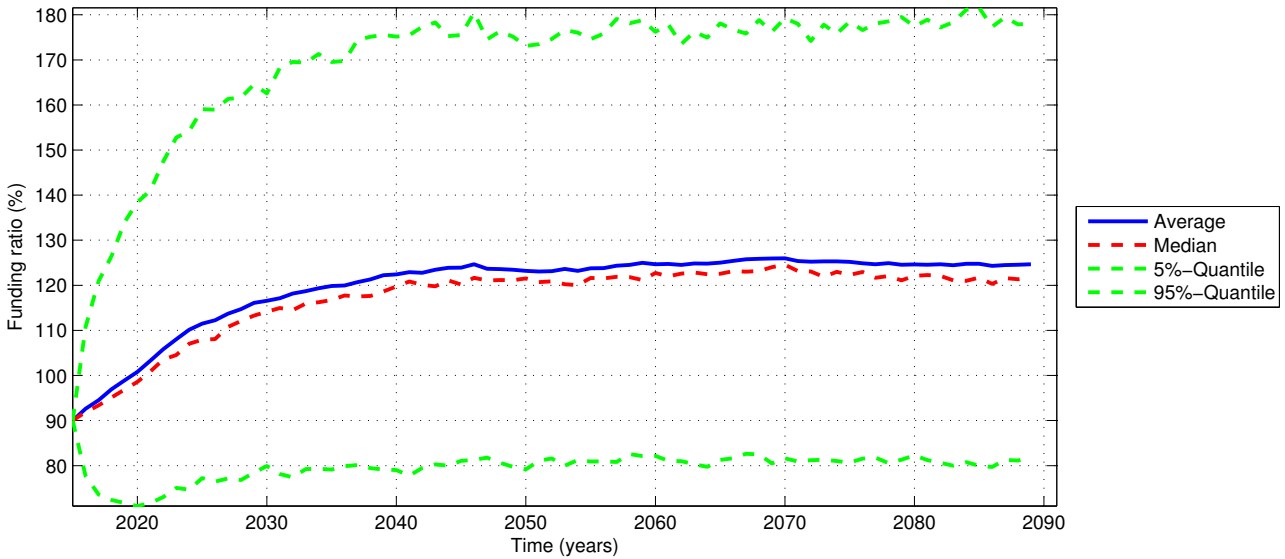


Figure: Funding Ratios: static, nominal, under $\mathbb{P}$.

Cost-covering premium (on average): 18.39%.

Appendix 9: Value-based ALM

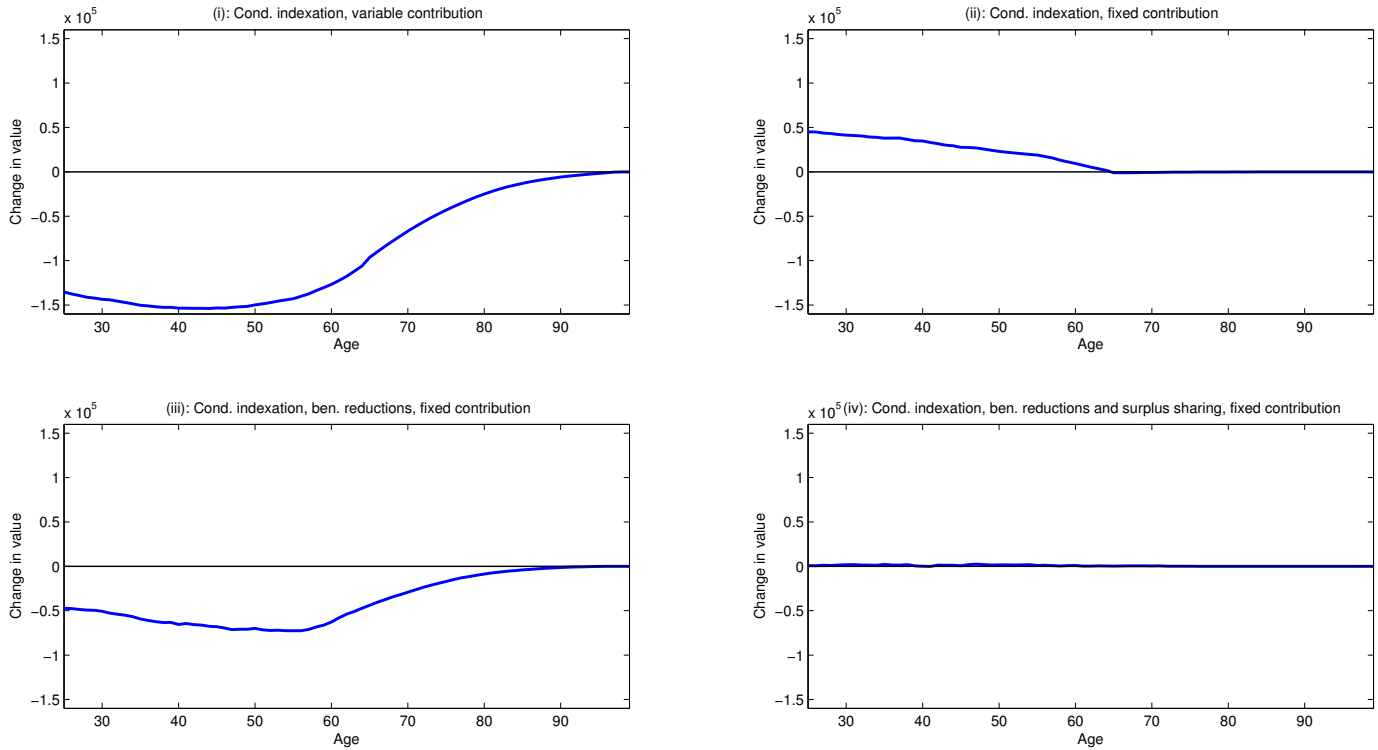


Figure: Effects Policy Instruments: value-based ALM.

Appendix 10: Transfer Value

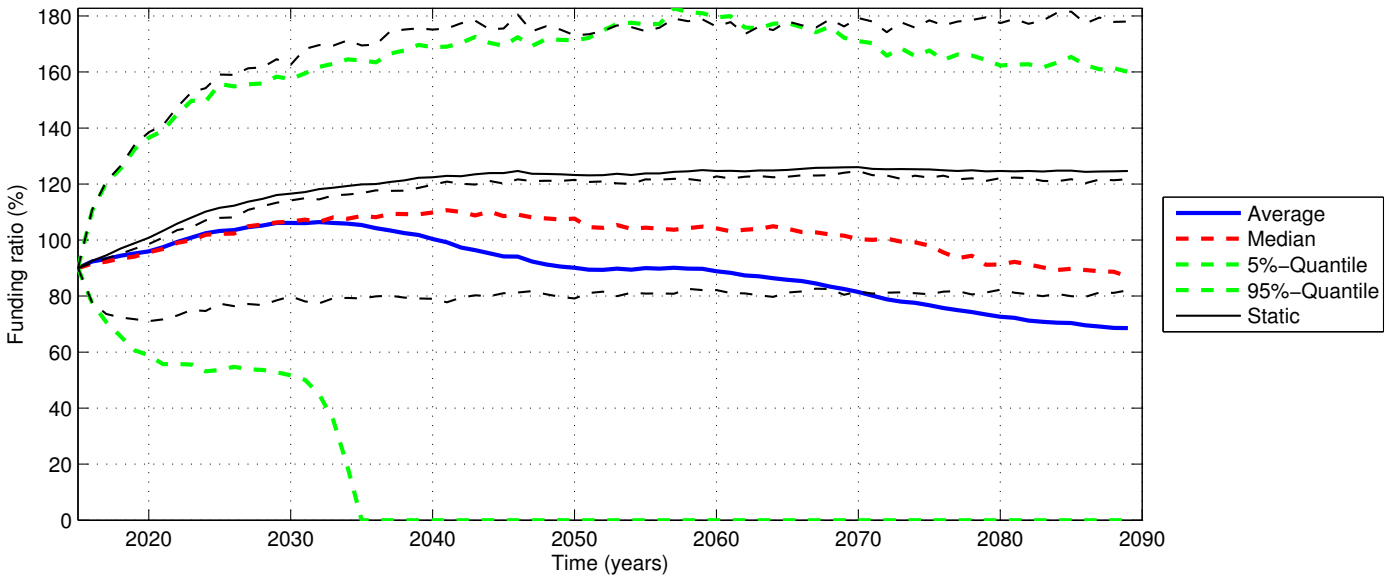


Figure: Transfer value equals 100% of acrrued rights.

Appendix 11: Initial Funding Ratio

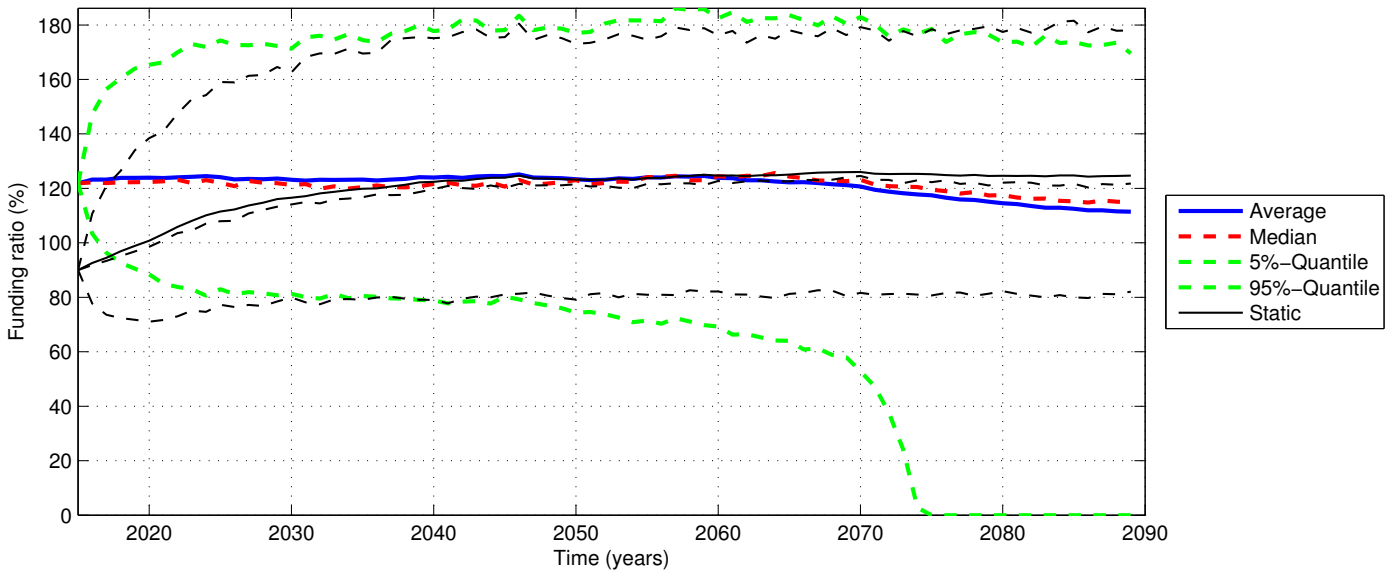


Figure: Initial funding ratio equals steady-state 121.8%.

Appendix 12: Interest Rate

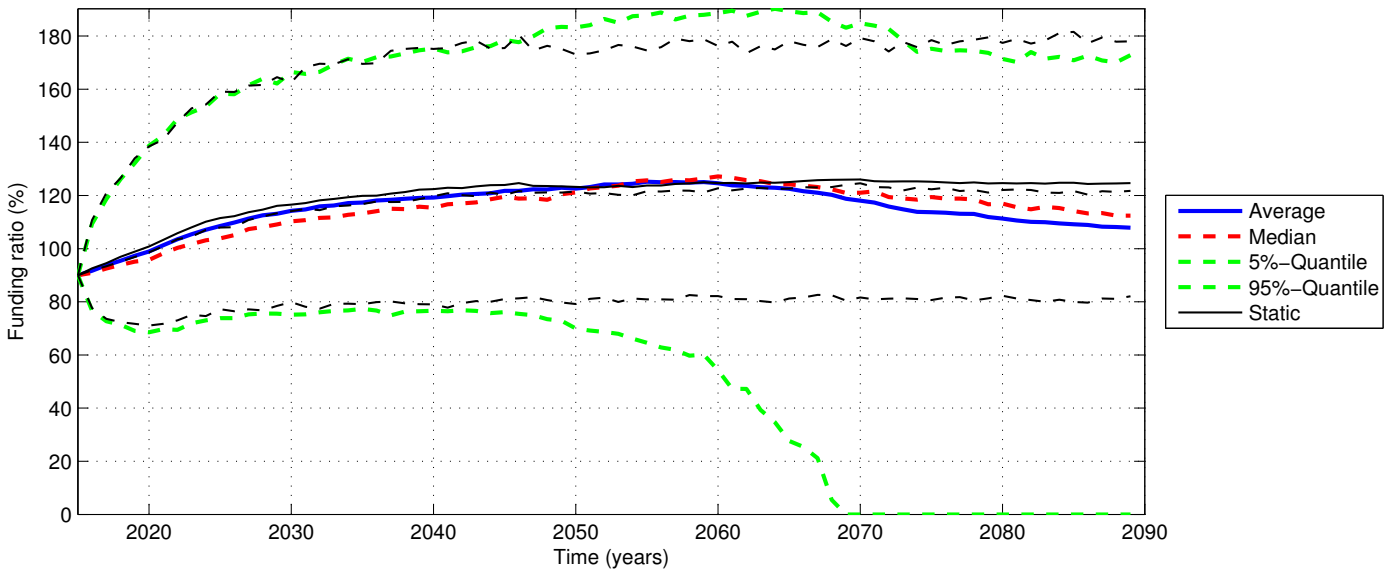
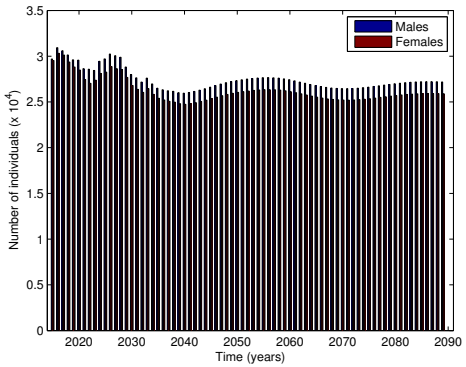


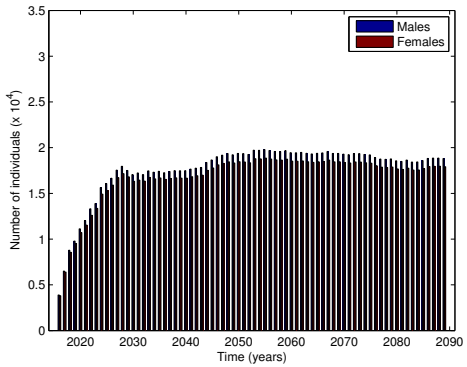
Figure: Long-term interest rate $\kappa = 0\%$, inflation rate $\mu = 0.5\%$.

Appendix 13: Inflow of Cohorts

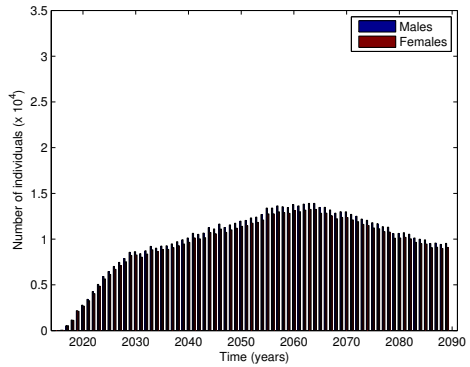
Average inflow of new entrants for static and dynamic inflow:
Less new entrants, fund's population turns grey.



(A) No discontinuity.



(B) $FR = 96\%$.



(C) $FR = 120\%$.