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Voluntary Participation in a Defined Benefit Pension Scheme

An Option Pricing Approach

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October 1, 2015

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- Worldwide examples from mandatory to voluntary pension schemes: **The U.K.** (April 2015): withdraw pension assets at the age of 55 **Canada** (May 2015): Minister of Finance: "*consider allowing additional voluntary contributions to the country's mandatory Canada Pension Plan*"

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- We investigate how stability in terms of participation is affected by:
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  - investment risk
  - risk smoothing
- What is the critical funding rate for which the collective DB pension scheme collapses and what is the probability of such an event?

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- Regulation policy to adjust financial shocks in the funding rate (F):

$$E_t^{\mathbb{Q}}\left(F_{t+s} - \bar{F}\right) = \alpha^s \left(F_t - \bar{F}\right), \ \forall s \geq 0, \ \alpha \in (0,1)$$

Low α: immediate recovery

High α: smoothing risks by allowing funding rate fluctuations

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  - exercise at each date until retirement (*American*)
- Main contribution of this paper is to model participation decisions as an American option to explore stability of the pension scheme

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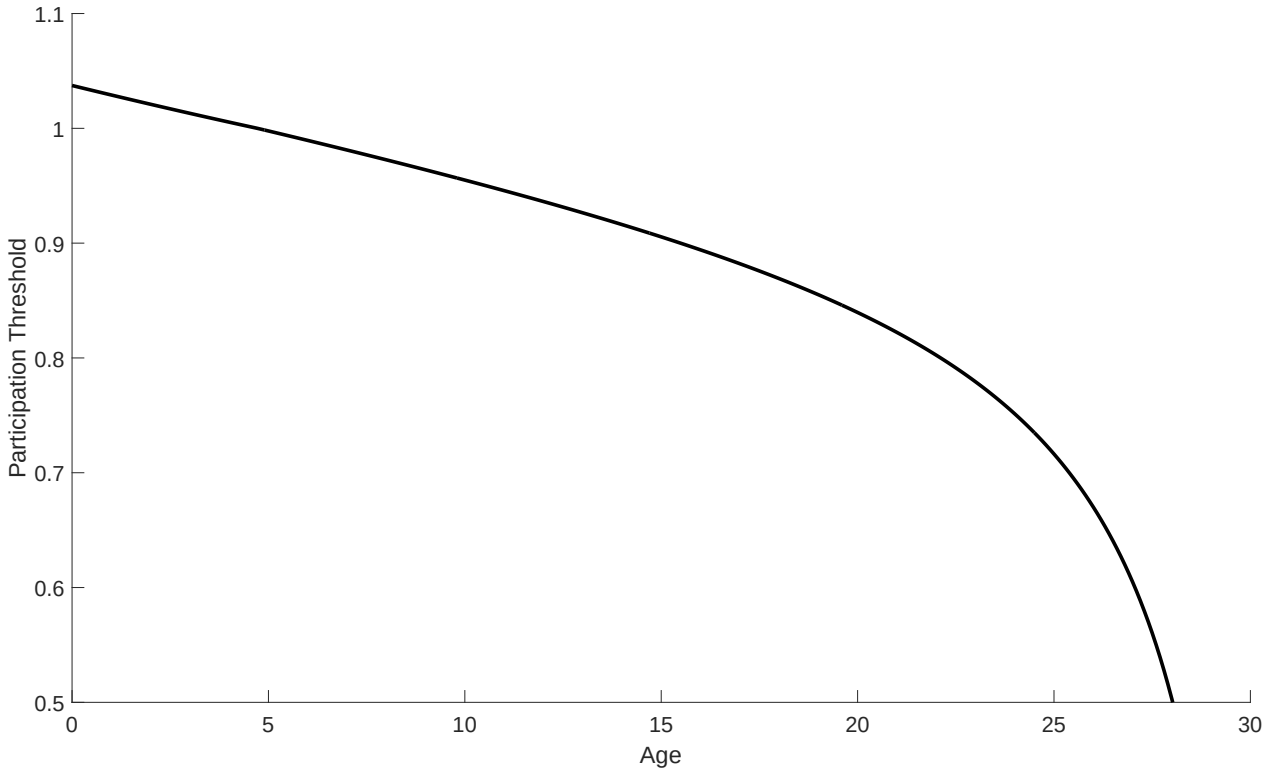
- Elderly are more willing to stay due to the uniform contribution rate ("doorsneesystematiek"), because of the *"PAYG-element"* in it
- Including more exercise dates increases the willingness of the young to participate and, hence, stability of the collective pension scheme increases

Benchmark Parameters

Description	Symbol	Value
Entry age	t_0	0
Retirement age	t_R	40
Age of death	t_D	60
Target funding rate	$\bar{F}$	1
Risk smoothing	α	0.5
Interest rate (risk free)	r	0.02
Portfolio return volatility	σ	0.15
Wage	w	1
Accrual rate	ψ	$70\%/t_R$

European Option

Participation Tresholds



Exercising the option can be beneficial for a young agent when the funding rate is particularly low. An entry generation participates voluntarily for $F_0 \geq 103.7\%$

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- Overview of the funding rate thresholds for an entry generation:
  - European option: threshold $= 103.7\%$
  - Bermudian option: threshold $= 96.3\%$ (shown in the paper)
  - American option: threshold $= 84.4\%$

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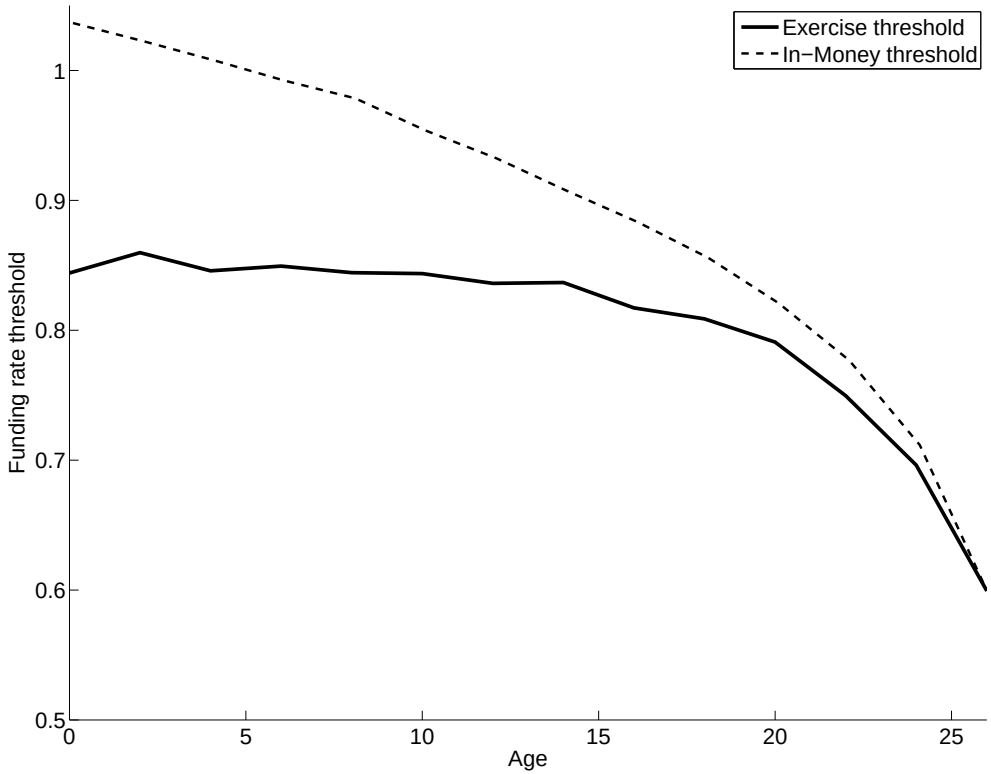
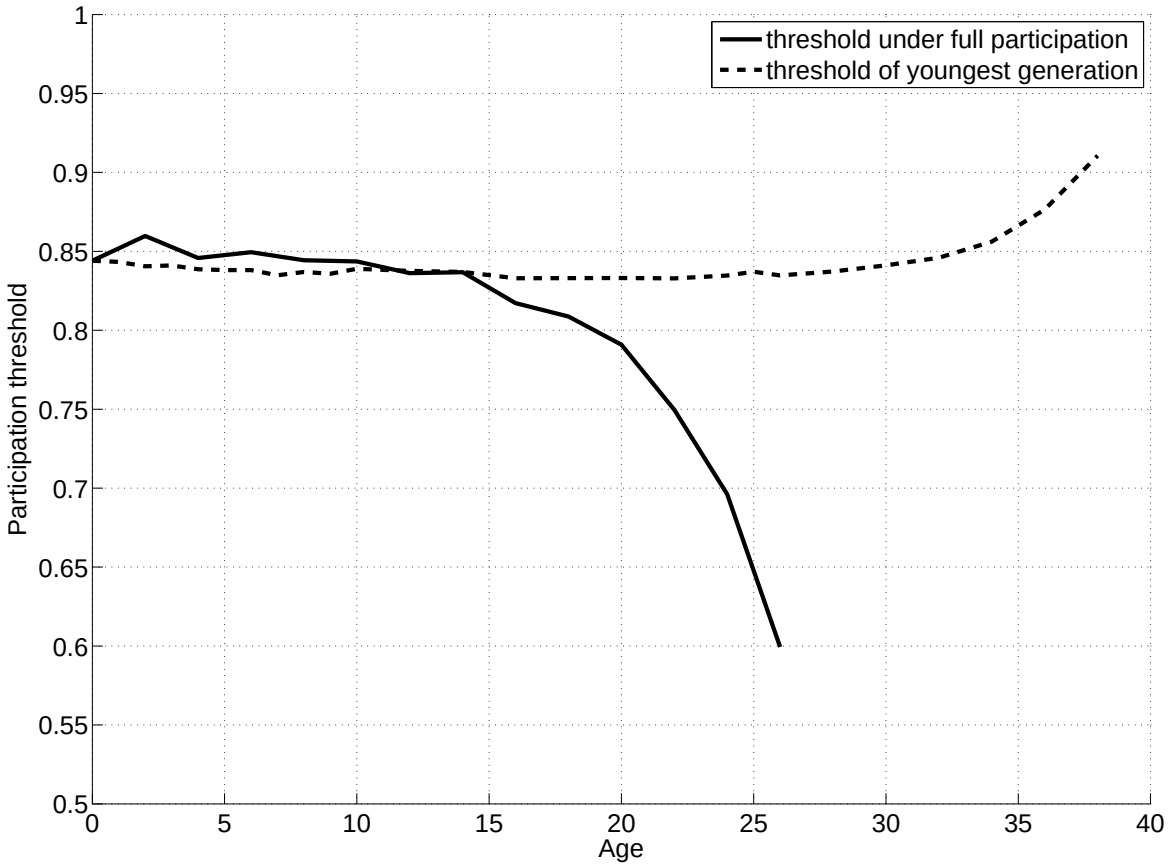
  - Bermudian option: threshold $= 96.3\%$ (shown in the paper)
  - American option: threshold $= 84.4\%$
- Agents are more inclined to stay when there are more exercise dates (i.e. more flexibility), because quitting is possible at a later stage as well under the American option.

Participation Thresholds



Dashed line: European option (103.7% at the age of $t_0 = 0$)
Solid line: American option (84.4% at the age of $t_0 = 0$)

Equilibrium



The graphs cross at a funding rate of 83.8% and age 11.5

Three Scenarios under the American Option

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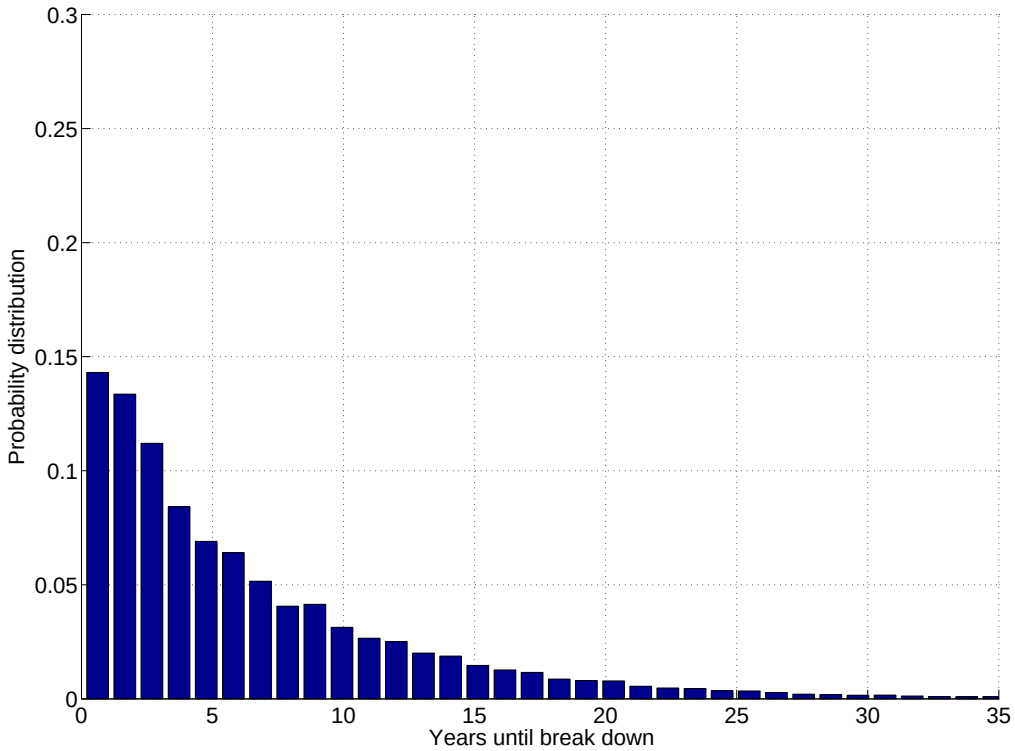
(iii) Funding rate $F_t < 83.8\%$:

- a large group of generations leave the collective pension scheme. As a result, the thresholds of older generations increase and, therefore, they prefer to leave the collective scheme as well. Hence, a chain reaction of cohorts exercising the option occurs and the collective system collapses

Break-Down Distribution



The probability that the pension fund survives at least 20 years (10 years) is about 5% (20%).

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Conclusion

- Participants are more inclined to stay when there are more exercise dates (i.e. more flexibility)
- Particularly young are willing to exit if the funding rate is low
- Risk smoothing and investment risk increases the survival probability of the collective DB pension scheme
- However: the collective pension scheme collapses almost surely after 20 to 40 years depending on the parameter settings
- In the absence of mandatory participation, it is only a matter of time before such a break-down occurs

Additional Slides

Related Literature

- **Benefits from collective funded pension plans**: Teulings and De Vries (2006); Ball and Mankiw (2007); Gollier (2008); Cui et al. (2011); Chen et al. (2014)
- **Conditions on voluntary participation in funded pension schemes**: Hemert (2005); Bommel (2007); Siegmann (2011); Beetsma et al. (2013); Beetsma and Romp (2013)
- **Applying option pricing theory to pensions**: Fung and Chan (1995); Blake (1998); Kocken (2006); Timmermans et al. (2011); Broeders et al. (2013)
- **American option of early retirement**: Friedman and Shen (2002); Chevalier (2006)
- **Least Squares Monte Carlo (LSMC) approach to valuate pension and life insurance products**: Pelsser et al. (2007); Bernard and Lemieux (2008); Cathcart and Morrison (2009); Boyer and Stentoft (2013); Chen (2015)

Tradeoff Mandatory vs. Voluntary Participation

- Arguments that advocate mandatory participation:
  - protection against complex investment decisions and myopia
  - costs reduction
  - facilitate (intergenerational) risk-sharing arrangements

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- Arguments that advocate mandatory participation:
  - protection against complex investment decisions and myopia
  - costs reduction
  - facilitate (intergenerational) risk-sharing arrangements
- Arguments that advocate voluntary participation:
  - lack of trust
  - increasing life expectancy
  - freedom of choice & heterogeneous preferences
  - increasing labor mobility & self employment

Value of Participation

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- Value of participation at age $t_M =$

$$\underbrace{\exp\left[-r\left(t_R - t_M\right)\right]\Pi_{t_R}\left(B_{t_R}\right)}_{\text{Discounted future retirement benefits}}$$

$$- \underbrace{E^{\mathbb{Q}}_{t_M}\left[\int_{t_M}^{t_R} c_s \exp\left[-r\left(s - t_M\right)\right] ds\right]}_{\text{Discounted expected contribution payments}}$$

$$- \underbrace{\min\left(1, F_{t_M}\right)\Pi_{t_M}\left(B_{t_M}\right)}_{\text{Value obtained from exiting}}$$

Participation Decision at Retirement

- Value of participation at the age of t_R, i.e. the retirement age:

$$Participation_{t_R} = \underbrace{\Pi_{t_R}(B_{t_R})}_{\text{PV benefits}} - \underbrace{0}_{\text{Contributions}} - \underbrace{\min(1, F_{t_R})\,\Pi_{t_R}(B_{t_R})}_{\text{Value from exiting}}$$

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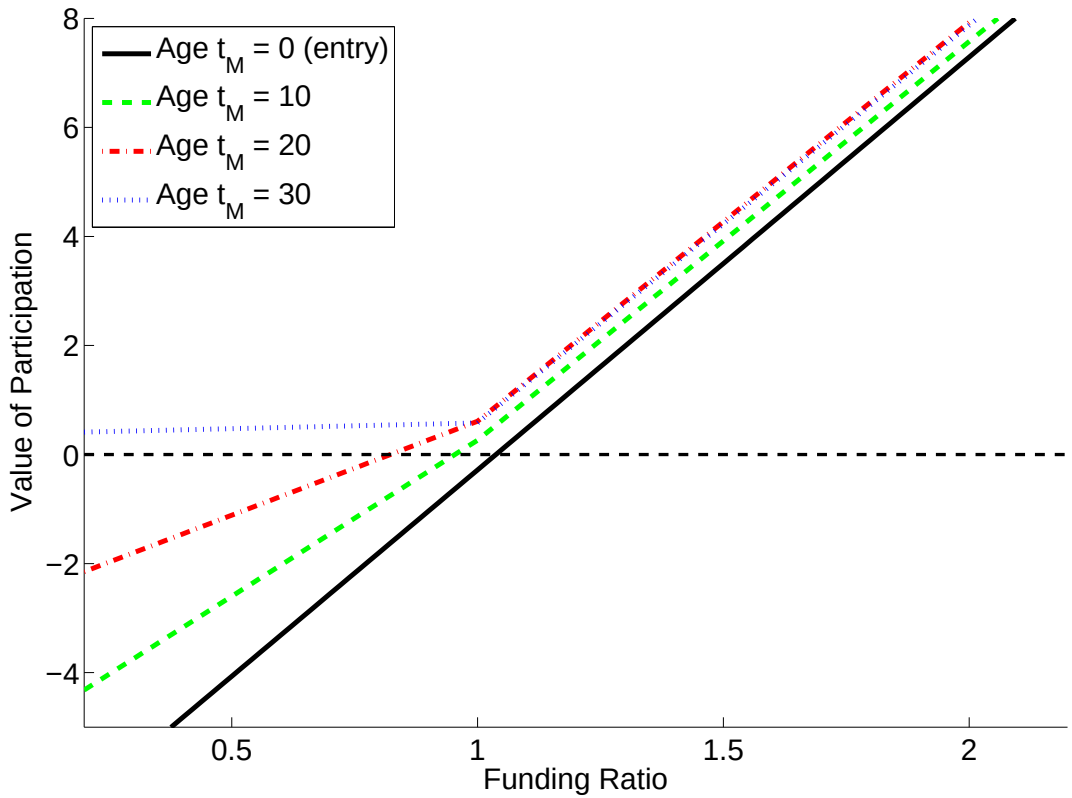
- Overfunding: $Participation_{t_R} = 0$
  Underfunding: $Participation_{t_R} = (1 - F_{t_R})\,\Pi_{t_R}(B_{t_R}) > 0$

Value of Participation at ages 0, 10, 20 and 30



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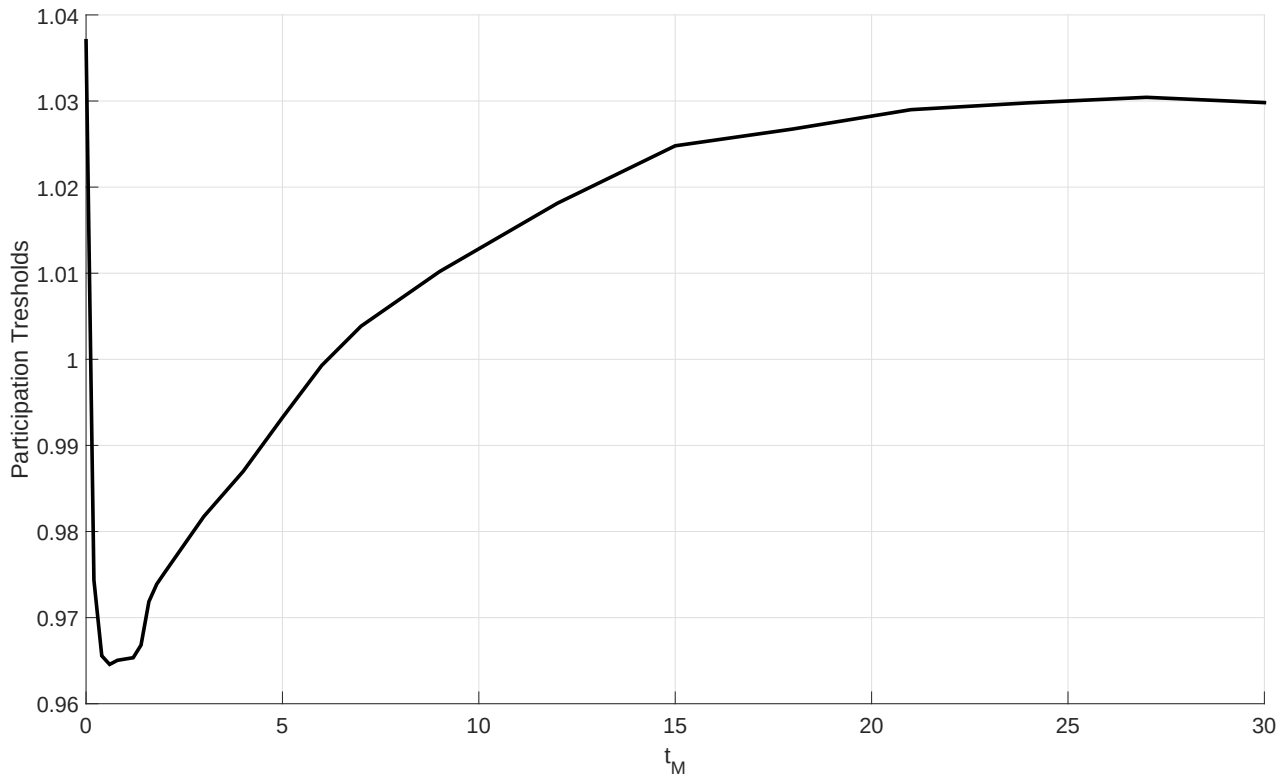
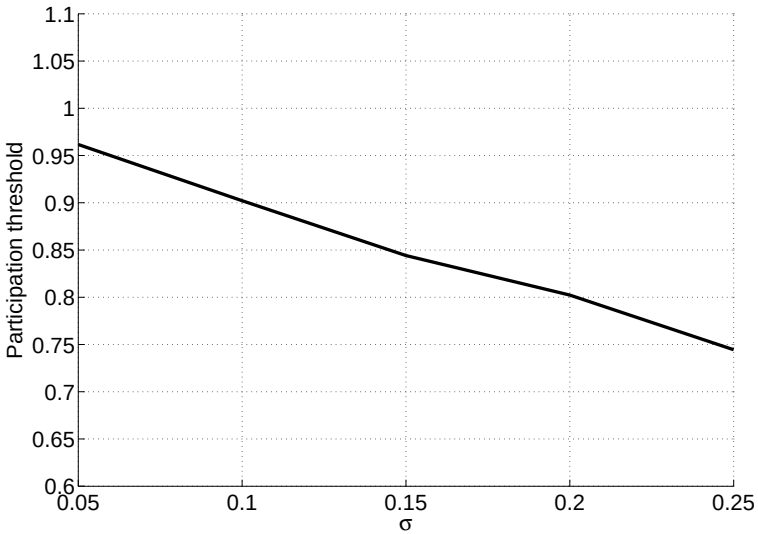
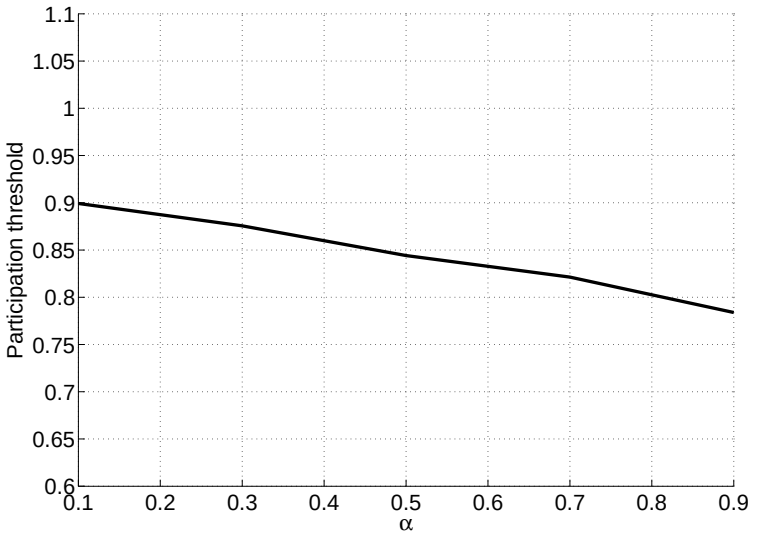
Decision at Entry and Another Arbitrary Age (Bermudian Option)



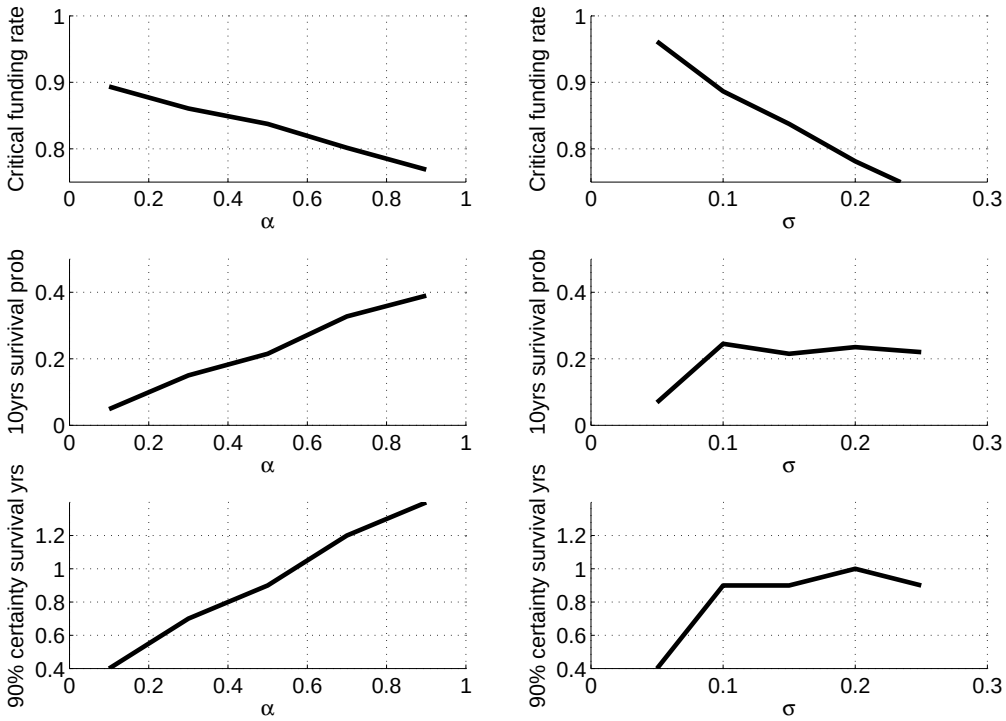
Additional exercise date most valuable at ages $t_M \in [0.5, 5.0]$

Investment Risk and Recovery Smoothing



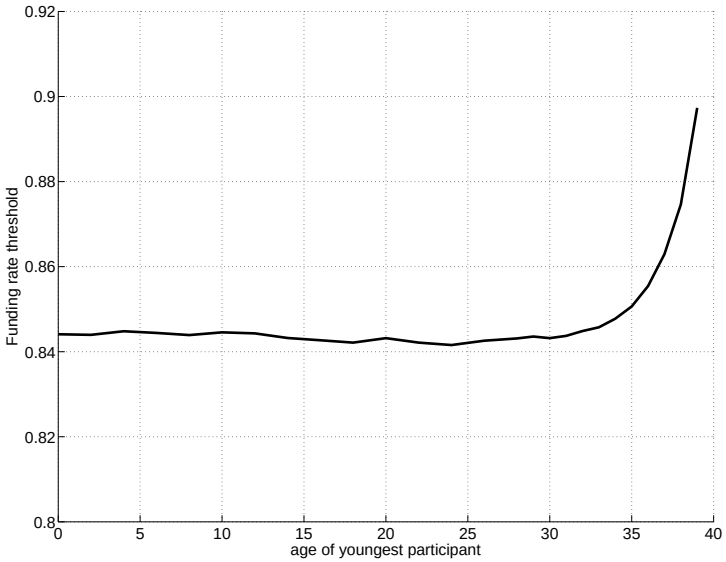


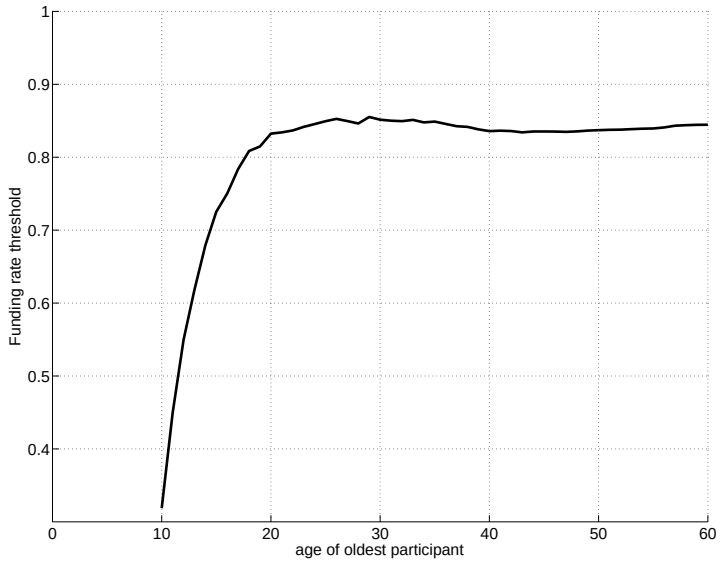
Smoothing and Investment Risk



The critical funding rate decreases for a longer recovery window (α) and for higher investment risk (σ). However, these parameters also raise the funding rate volatility.

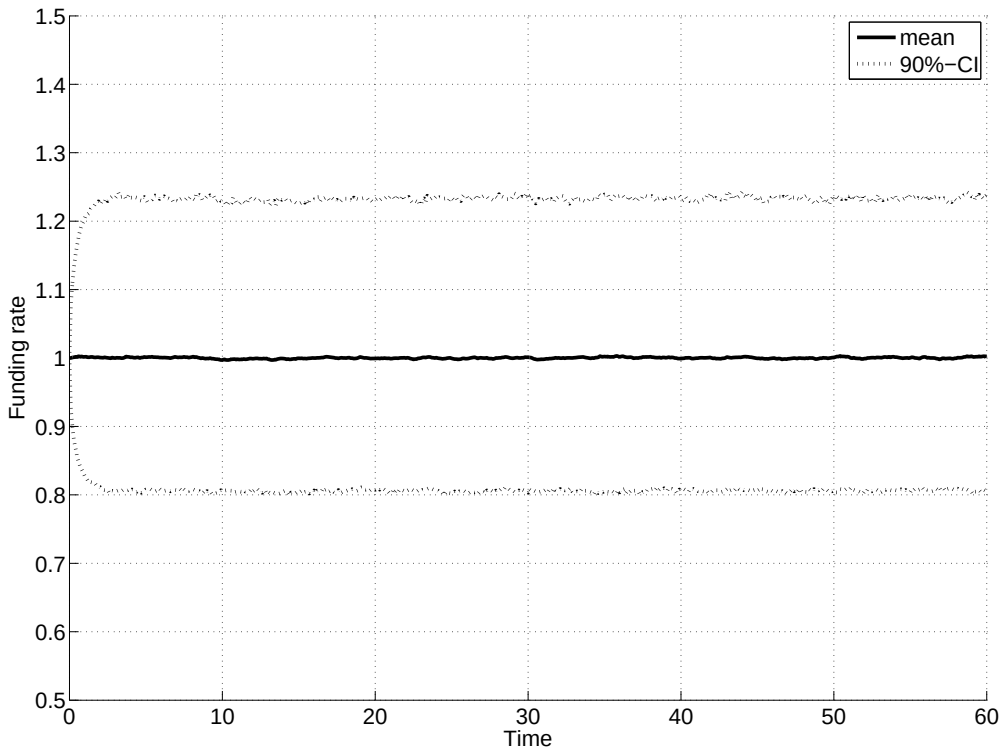
Entry Generations





A relatively old pension scheme is unattractive for entry generations, causing the thresholds to increase (**left**). Vice versa, for a relatively young pension scheme (**right**).

Funding Rate Simulations



At least 5% of the funding rate simulations are below the critical level of 84.4%.

Least Squares Monte Carlo Approximation Method

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5. If the approximated value of continuation exceeds the value of stopping, then update the corresponding elements in the pay-off vector and corresponding exercise dates in the exercise dates vector.

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5. If the approximated value of continuation exceeds the value of stopping, then update the corresponding elements in the pay-off vector and corresponding exercise dates in the exercise dates vector.
6. Repeat steps 3 to 5 until date $t_0 = 0$ is reached.
7. The value of participation at time t is then given by: $Participation_t = \frac{1}{Q} \sum_{i=1}^{Q} (Cont_{t,i} - Stop_{t,i})$

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