AFIR LIFE MUNICH 2009

Understanding the Death Benefit Switch Option in Universal Life Policies

September 7, 2009

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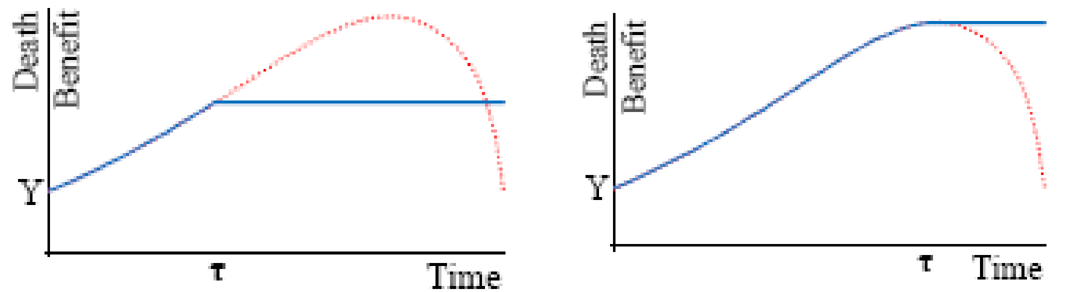
Motivation

- Universal life policies are the most popular insurance contract design in the U.S.
- Lifelong policies with flexible premium payments (frequency, amount) as long as cash value remains positive
- Death benefit either
  - level: fixed face amount, or
  - increasing: pays available cash value in addition to fixed amount
- Embed the option to switch from one death benefit scheme to the other: „death benefit switch option“
  - Switch from increasing to level without costs / evidence of insurability (unlike switch from level to increasing)

Motivation



- Option of no concern for insurers?

- Death benefit is fixed at the current level, does not affect net amount at risk

- But, crucial: dependence on *premium payment behavior* after switch (not prescribed by insurer)

➢ Combination of two options, can be very valuable

➢ Has not been investigated to date

Aim

- Enhance understanding of this feature

- Develop model framework of increasing universal life policies
- Incorporate switch probabilities and stochastic interest rates
- Investigate effects of adverse exercise behavior depending on health status of insureds
  - Consider mortality heterogeneity using a frailty factor
  - Assume different switch probabilities for different health status
- Account for modified premium payment behavior after switch

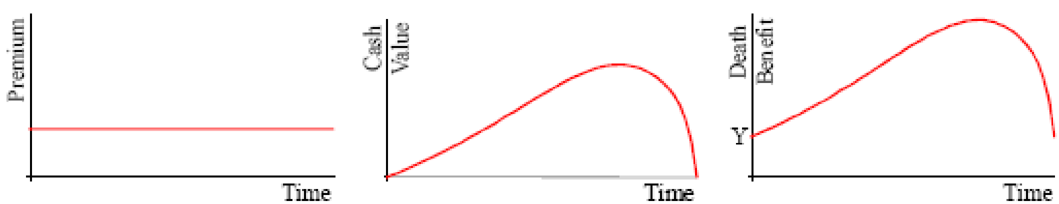
Aim

- Based on this model: quantify net present value of option from the insurer's perspective
- Conduct simulation analysis
- Sensitivity analysis with respect to frailty distribution
- Derive policy recommendations for life insurers

The model of an increasing universal life policy

- Pool of increasing lifelong universal life policies
- Cash value (policy reserve) V_t
- Increasing death benefit $Y_t = Y + V_t, \quad t = 1, \ldots, T$
- One-year table probability of death at age *x+t* $q'_{x+t}, \quad t = 0, \ldots, T-1$
- Constant annual interest rate *i*
- Constant annual premiums *B* (equivalence principle)

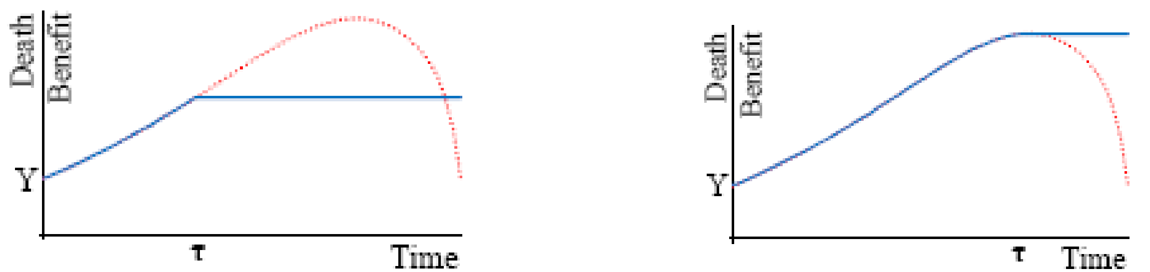
$$B \cdot \sum_{h=0}^{T-1} (1+i)^{t-h} = Y \cdot \sum_{h=0}^{T-1} q'_{x+h} (1+i)^{t-h-1}$$



Death benefit switch option

- Death benefit at time *t* given exercise of the switch option at time τ

$$Y_t^{(\tau)} = \begin{cases} Y_t, & t = 1,\ldots,\tau \\ Y_\tau, & t = \tau+1,\ldots,T \end{cases}$$



- Switch before peak of cash value: original premiums too high, need to be reduced
- Switch near, at, after peak of cash value: higher premiums needed due to higher death benefit

Premium payment scenarios

- Cannot analyze death benefit switch option alone: we need to make assumptions about premium payment
- Consider two viable scenarios after switch:
- Minimum *constant* premium (level premium scenario)
- Minimum *flexible* premium (risk premium scenario)
- Ensure positive cash value throughout the contract term
- Any other constant or flexible premiums need to exceed these premium amounts

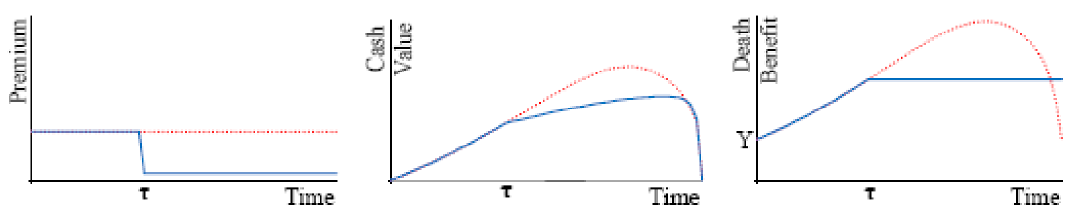
$$B_t^{(\tau)} = \begin{cases} B, & t = 0,\ldots,\tau-1 \\ B^{(\tau)}, & t = \tau,\ldots,T-1 \end{cases}$$

Model framework: Premium scenario

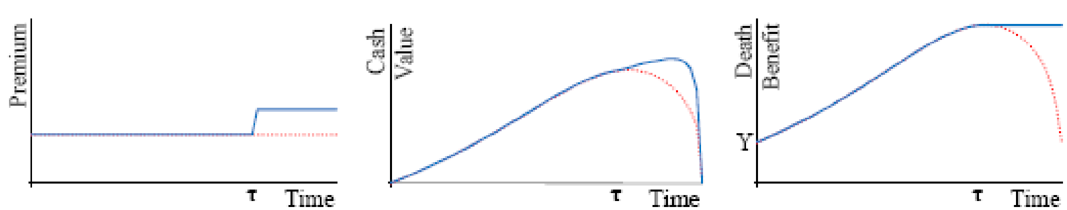
- Minimum constant premium (level premium scenario)

$$B^{(\tau)} \sum_{t=0}^{T-\tau-1} {}_t p'_{x+\tau} \left(1+i\right)^{-t} + V_\tau = Y_\tau \sum_{t=0}^{T-\tau-1} {}_t p'_{x+\tau} q'_{x+\tau+t} \left(1+i\right)^{-(t+1)} \Rightarrow B^{(\tau)} = \max\left\{ \frac{Y_\tau \sum_{t=0}^{T-\tau-1} {}_t p'_{x+\tau} q'_{x+\tau+t} \left(1+i\right)^{-(t+1)} - V_\tau}{\sum_{t=0}^{T-\tau-1} {}_t p'_{x+\tau} \left(1+i\right)^{-t}}, 0 \right\}$$

a) Switch before peak of cash value curve



b) Switch at peak of cash value curve

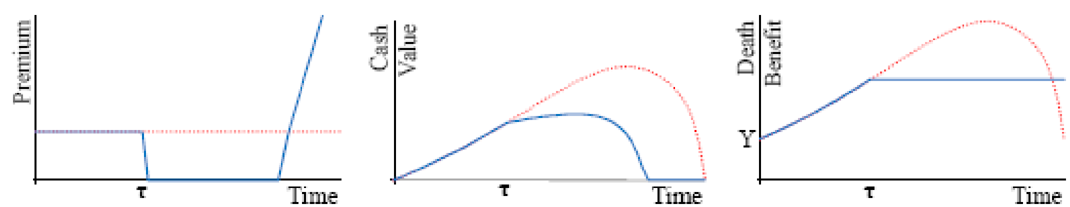


Model framework: Premium scenario

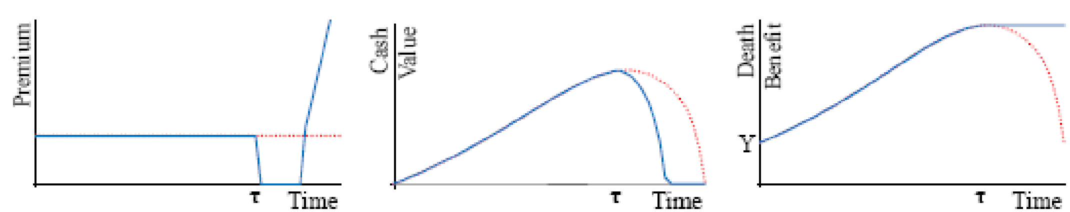
- Minimum flexible premium (risk premium scenario)

$$B_t^{(\tau)} = \begin{cases} B, & t = 0,\ldots,\tau - 1 \\ \max\left\{0, q'_{x+t} Y_{t+1}^{(\tau)} (1+i)^{-1} - V_t^{(\tau)}\right\}, & t = \tau,\ldots,T-1 \end{cases}$$

a) Switch before peak of cash value curve



b) Switch at peak of cash value curve



Contract valuation

- Valuation depends on mortality
- Consider mortality heterogeneous insureds

\- Individual frailty factor *d* specifies individual's state of health

$$q_x = \begin{cases} d \cdot q'_x, & d \cdot q'_x < 1 \\ 1, \quad x = \min\left[\tilde{x} \in \{0,\ldots,\omega\} : d \cdot q'_{\tilde{x}} \geq 1\right] \\ 0, & \text{otherwise} \end{cases} \qquad \text{for } x \in \{0,\ldots,\omega\} \text{ and } q_\omega := 1 \text{ for } d < 1$$

$d \geq 1$ Insureds with average or below-average life expectancy

$d < 1$ Insureds with above-average life expectancy

$$f^{\Gamma}_{(\alpha,\beta,\gamma)}(d) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}}(d-\gamma)^{\alpha-1} e^{-\frac{d-\gamma}{\beta}}, \quad \text{for} \quad d \geq \gamma, \gamma \in \mathbb{R}, \alpha, \beta > 0.$$

Contract valuation

- Switch probabilities *s*(*t*,*d*)

$$F_\tau(k) = \mathrm{P}(\tau \le k) = \sum_{h=1}^{k} s(h) \prod_{\nu=1}^{h-1} \left(1 - s(\nu)\right)$$

- Short-rate process: Vasicek model

$$dr(t) = \kappa\left(\theta - r(t)\right)dt + \sigma dW^{\mathrm{Q}}(t)$$

- Affine term structure, zero bond price formula:

$$P(0,t) = \mathrm{E}^{\mathrm{Q}}\left(e^{-\int_0^t r(u)du}\right) = \exp\left\{\left(\frac{1-e^{-\kappa t}}{\kappa}\right)\left(\theta - \frac{\sigma^2}{2\kappa^2} - r\right) - t\left(\theta - \frac{\sigma^2}{2\kappa^2}\right) - \frac{\sigma^2}{4\kappa^3}\left(1-e^{-\kappa t}\right)^2\right\}$$

Contract valuation

- Net present value (NPV) of the increasing policy

$$NPV(d) = \mathrm{E}^{Q}\left(\sum_{t=0}^{T-1} B \cdot 1_{\{K(x)\geq t\}} \cdot e^{-\int_0^t r(u)du}\right) - \mathrm{E}^{Q}\left(\sum_{t=0}^{T-1} Y_{t+1} \cdot 1_{\{K(x)=t\}} \cdot e^{-\int_0^{t+1} r(u)du}\right)$$
$$= \sum_{t=0}^{T-1} B_{t}\, p_x P(0,t) - \sum_{t=0}^{T-1} Y_{t+1\,t}\, p_x q_{x+t} P(0,t+1).$$

- NPV of the increasing policy with death benefit switch option

$$NPV^{(\tau)}(d) = \mathrm{E}^{Q}\left(\sum_{t=0}^{T-1} B_t^{(\tau)} 1_{\{K(x)\geq t\}} e^{-\int_0^t r(u)du}\right) - \mathrm{E}^{Q}\left(\sum_{t=0}^{T-1} Y_{t+1}^{(\tau)} 1_{\{K(x)=t\}} e^{-\int_0^{t+1} r(u)du}\right)$$
$$= \sum_{t=0}^{T-1}\left(\sum_{k=1}^{T} B_t^{(k)} s(k) \prod_{h=1}^{k-1}(1-s(h))\right)_t p_x P(0,t) - \sum_{t=0}^{T-1}\left(\sum_{k=1}^{T} Y_{t+1}^{(k)} s(k) \prod_{h=1}^{k-1}(1-s(h))\right)_t p_x q_{x+t} P(0,t+1).$$

Contract valuation

- Expectation $$NPV = \mathrm{E}^{\mathbf{Q}}\left(NPV(D)\right)$$
  $$NPV^{(\tau)} = \mathrm{E}^{\mathbf{Q}}\left(NPV^{(\tau)}(D)\right)$$

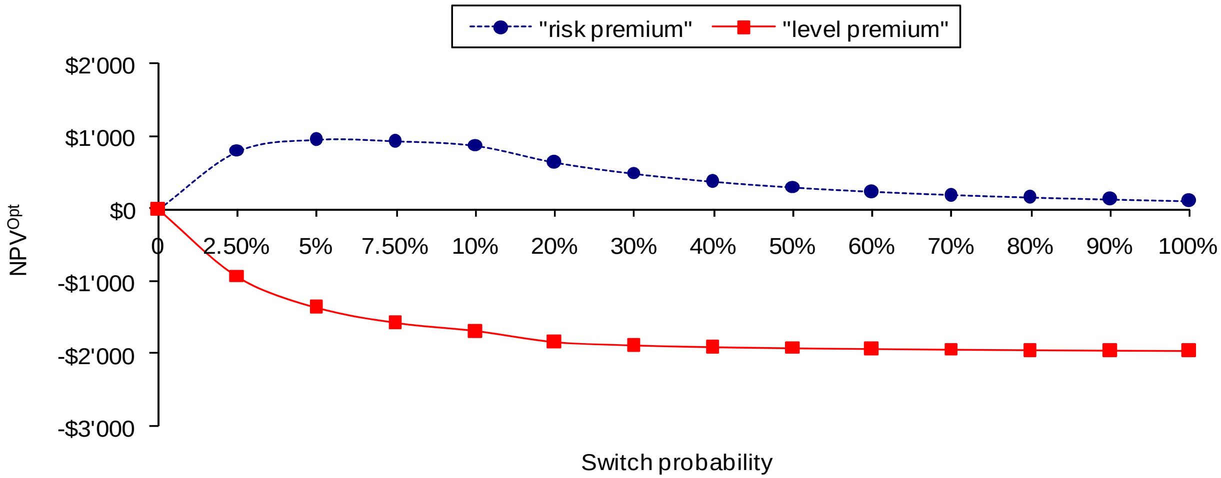
- Value of the death benefit switch option: Difference between value of policy with switch option and value of policy without the switch option

$$NPV^{Opt} = NPV^{(\tau)} - NPV$$

Numerical examples: Input paramters

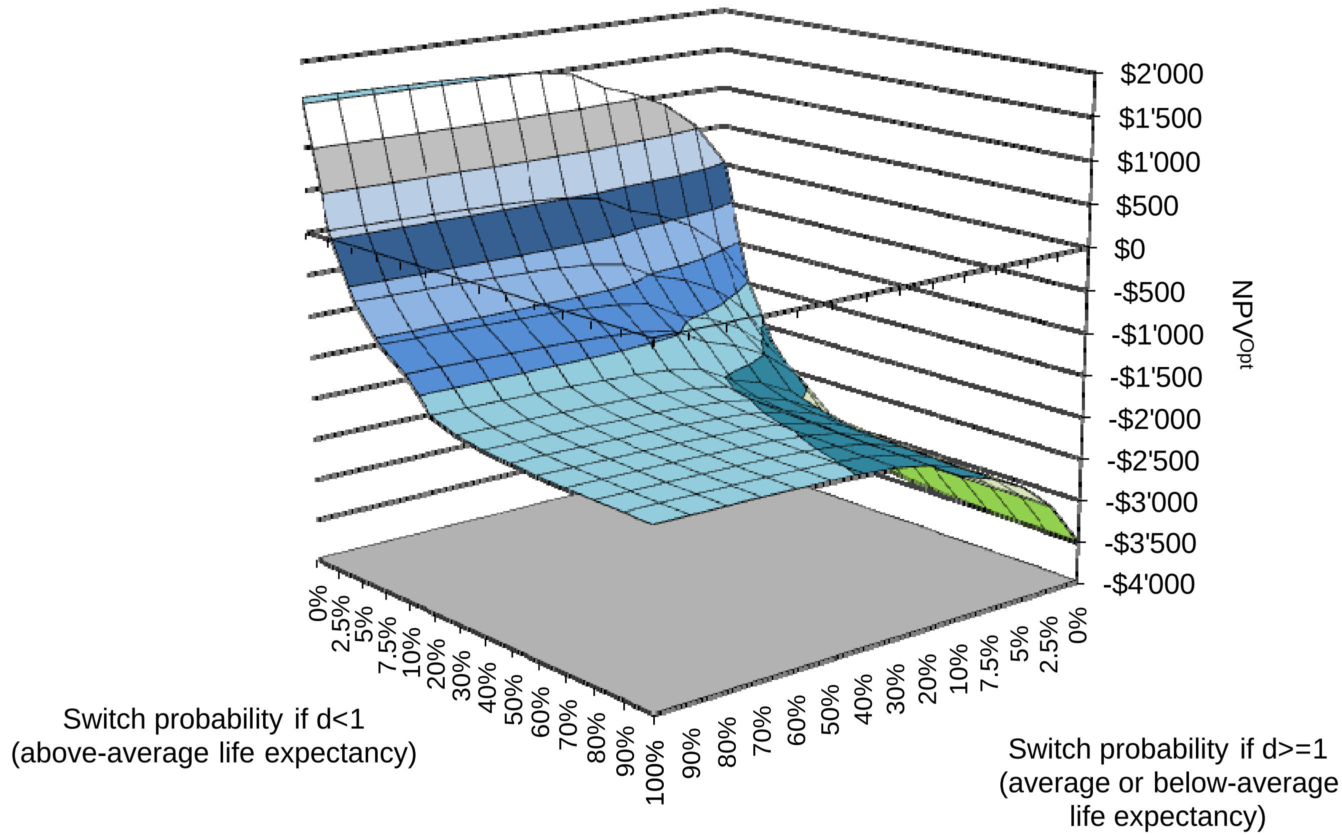
- Policy face value Y = \$100.000
- Age at inception: x = 45 years
- Actuarial minimum interest rate i = 3.5%
- U.S. 1980 CSO male ultimate composite mortality table
- Frailty distribution $D \sim \Gamma(2.0; 0.25; 0.5)$.
- Constant annual premium B = \$5,937 (calibrated)
- NPV for increasing policy (without switch) from the insurer's perspective is NPV = \$2,866

Value of the death benefit switch option by constant switch probability (insurer perspective)

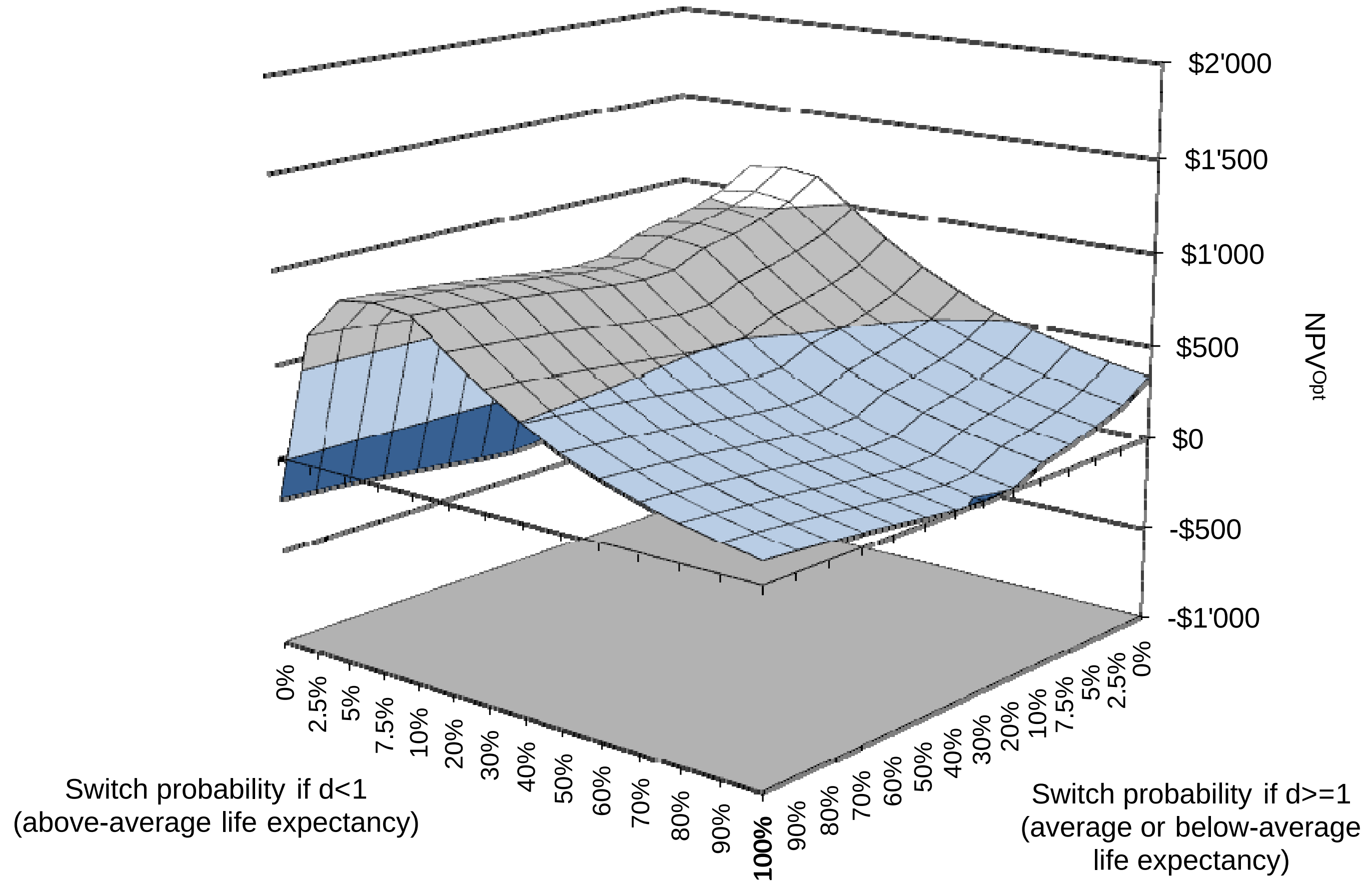


- Negative for “level premium scenario”
- Positive but decreasing for “risk premium scenario”, due to high risk premiums, but: turns negative in case of policy lapse
- High *s* implies more negative values (early switch, long lifetime)

Value of the death benefit switch option by switch probability and health status: Level premium



Value of the death benefit switch option by switch probability and health status: Risk premium



Switch option value for specific exercise scenarios depending on health status

	s=100% at *t*=41 (peak)			*s*=10% *t*=25 to *t*=41			*s*=10% to *s*=100%* (linear) *t*=25 to *t*=41			*s*=10% *t*=5 to *t*=15		
	All	Below LE	Above LE	All	Below LE	Above LE	All	Below LE	Above LE	All	Below LE	Above LE
Level premium	-365	12	-377	-750	194	-945	-1’023	293	-1’315	-1’189	856	-2’045
Risk premium	1’324	-89	1’413	1’332	-108	1’440	1’576	-123	1’700	758	-204	962
Risk premium (lapse)	808	10	799	288	-37	325	229	-42	272	-740	128	-867

$d \geq 1$ Insureds with average or below-average life expectancy

$d < 1$ Insureds with above-average life expectancy

Lapse scenario: lapse as soon as risk premium exceeds 10% of new level death benefit

Results

- Strong adverse effects can be observed depending on premium payment method and health status
- Scenarios that are intuitively rational pose greatest threat to insurers, namely

- If insureds with above-average life expectancy switch early and thus save risk premiums by making level payments

- If impaired insureds set out premium payments after switch, being aware of possibly not surviving until high risk premiums have to be paid

Policy implications for life insurers

- Analysis allowed identification of four key factors of relevance for the switch option value:
  - insureds' life expectancy
  - premium payment method after switch
  - switch probabilities (time of switch)
  - lapsation
  - ➢ Combination of these factors can make switch option either valuable or risky for insurer
- Problem: Option can be valuable when exercised early as well as late during the contract term

Policy implications for life insurers

- Switch as an alternative to surrender
- Impose new evidence of insurability (tradeoff: costs, penalizes healthy insureds)
- Prescription of premium payments after switch, combined with charges for group that causes adverse effects
- Restrict switch exercises to predefined time ranges
- In summary: death benefit switch option can pose a threat to insurers in case of adverse exercise behavior with respect to insureds health status
  - ➢ Careful monitoring is crucial

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Thank you very much for your attention!

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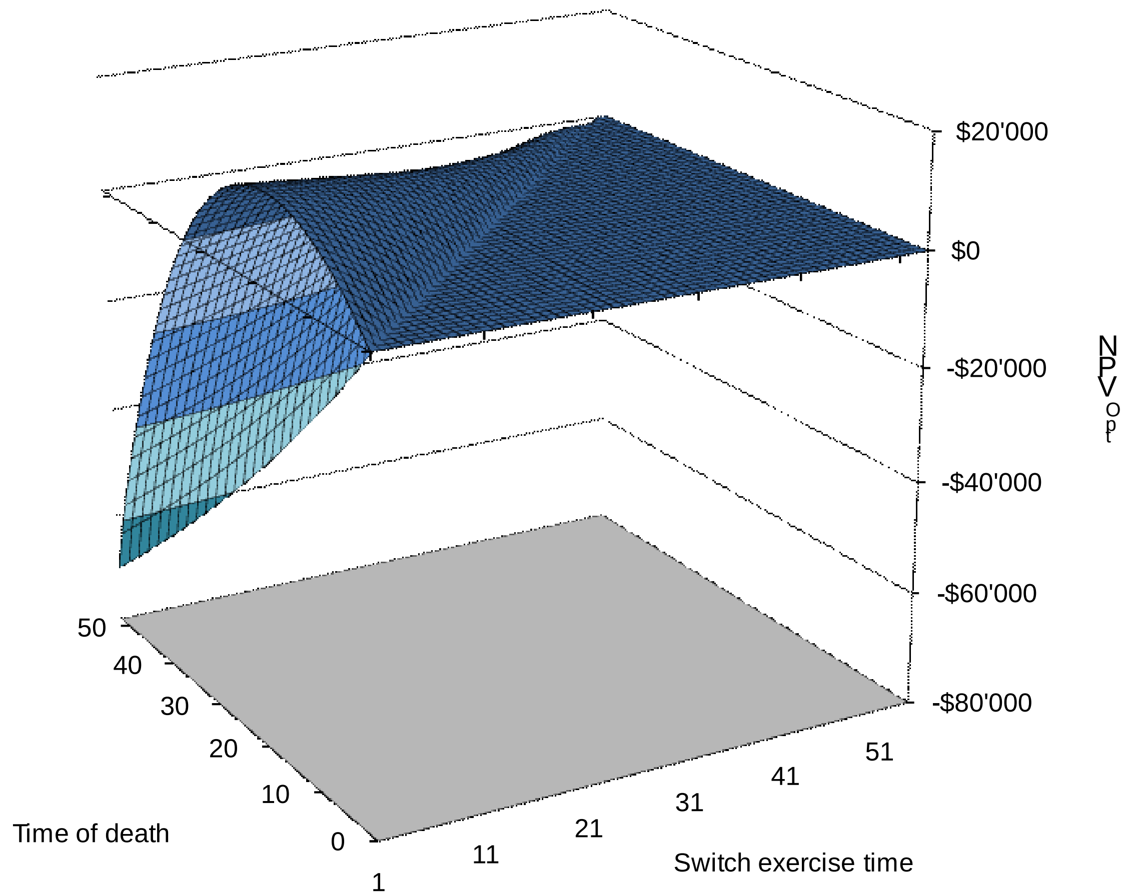
Deterministic results: Level premium



Deterministic results: Risk premium