# Lifecycle Portfolio Choice with Systematic Longevity Risk and Variable Investment-Linked Deferred Annuities

Vasily Kartashov, Raimond Maurer, Olivia S. Mitchell, Ralph Rogalla

Frankfurt, September 2011

# VILDAs –
# Variable Investment-Linked Deferred Annuities

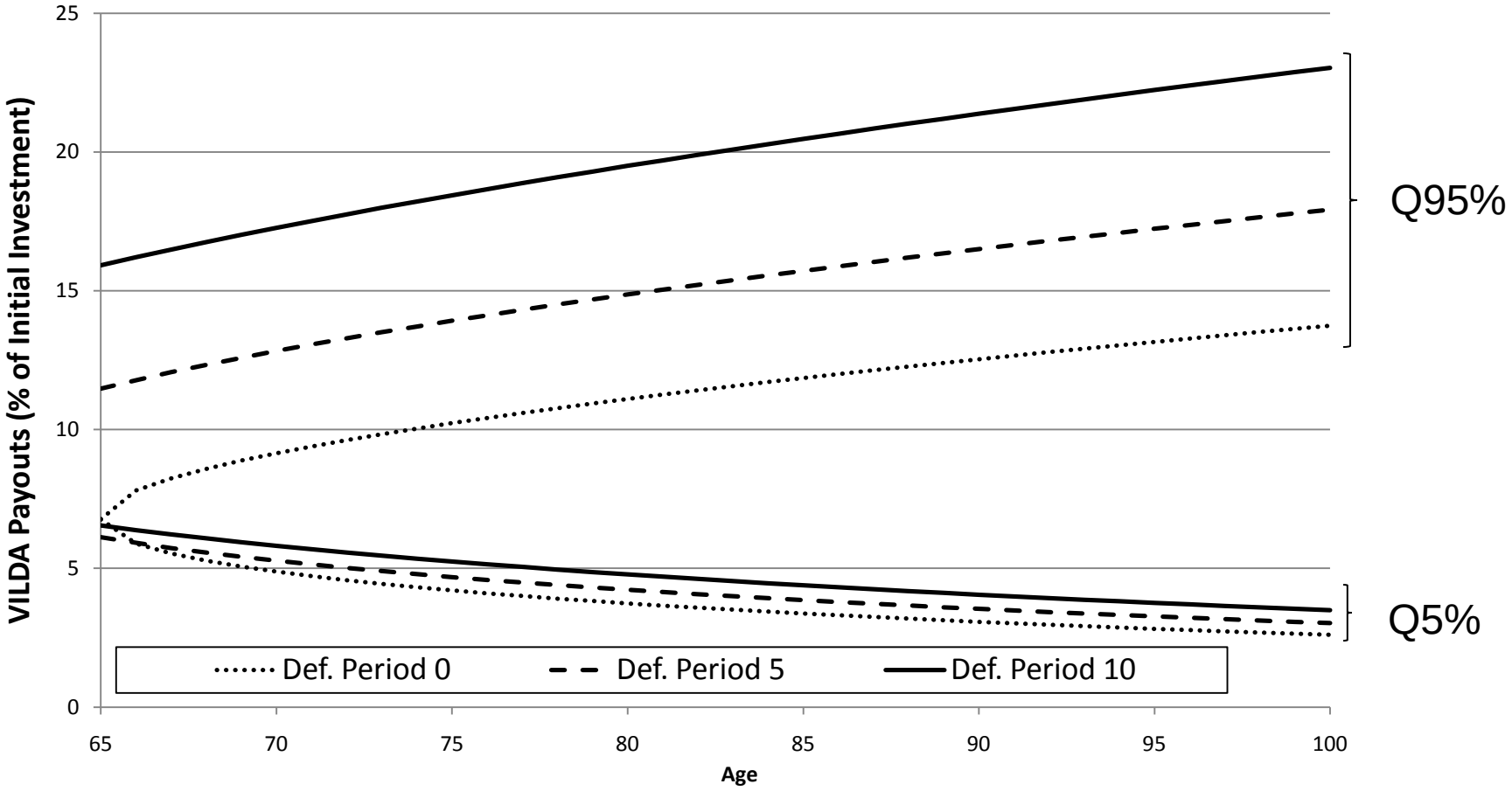
- Premium is paid immediately / benefits start later at pre-specified retirement age (pension product; no bequest; inflexibility; survival credit)
- Retirement-Payments linked to return of underlying portfolio (bonds/stocks)
- Pricing depends on deferral period, loadings, mortality assumptions, and guarantees by annuity provider
- Guarantees by the annuity provider
  - Investment risk: (→ covered by annuitant; portfolio allocation)
  - Individual longevity risk (→ covered by insurance company; creating risk pools)
  - Systematic longevity risk (change of mortality assumptions)
    - Covered by insurance company (→ pricing; internal/external hedging)
    - Covered by annuitant (→ updating rule for benefits)

# Literature & Contributions


- LC-portfolio choice studies with life annuities:
  - ✓ Many studies on immediate life annuities: Milevsky/Yong (2007, 2009), Horneff et al. (2008, 2009, 2010);
  - ✓ Little research on deferred life annuities although they appear to be ubiquitous (SoSe; DB plans): Horneff et al. (2010); Milevsky (2005);
- Models with uncertain mortality rates:
  - ✓ Many empirical work on mortality developments / pricing of life annuities: Lee/Carter 1992, Cairns/Blake/Dowd (2008); Milevsky et al. (2009)
  - ✓ Little research on uncertain mortality rates in LC-portfolio choice: Horneff et al. (2010); Cocco/Gomes (2011 WP)
- We ask:
  - ✓ What role of VILDAs in LC-portfolio choice?
  - ✓ How does stochastic mortality influence individuals optimal behavior?
  - ✓ How results depend on annuity provider's approach to systematic longevity risk?

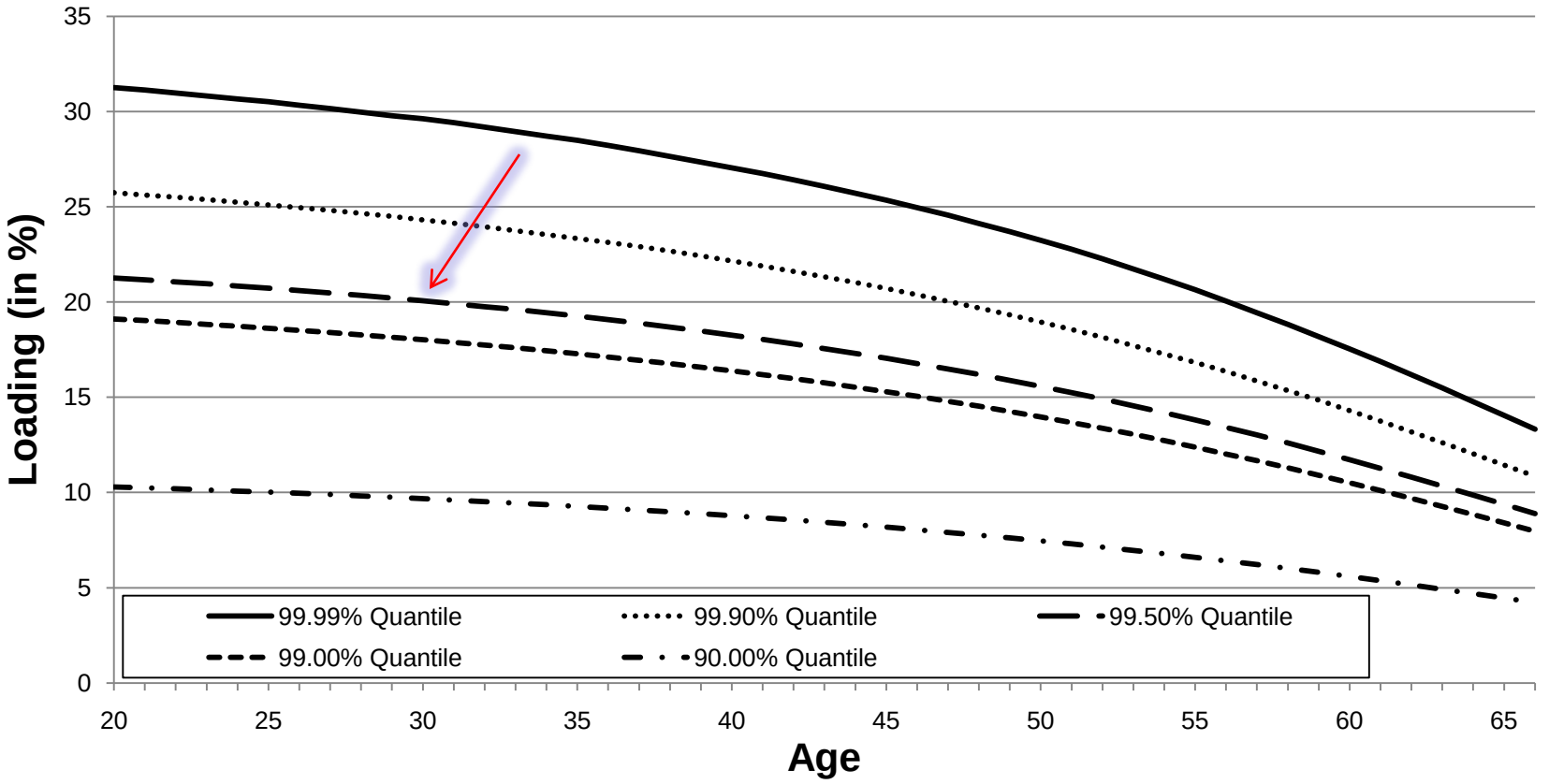
# Impact of Deferring & Investment Risk on Payouts

**(50:50 stock/bond allocation)**



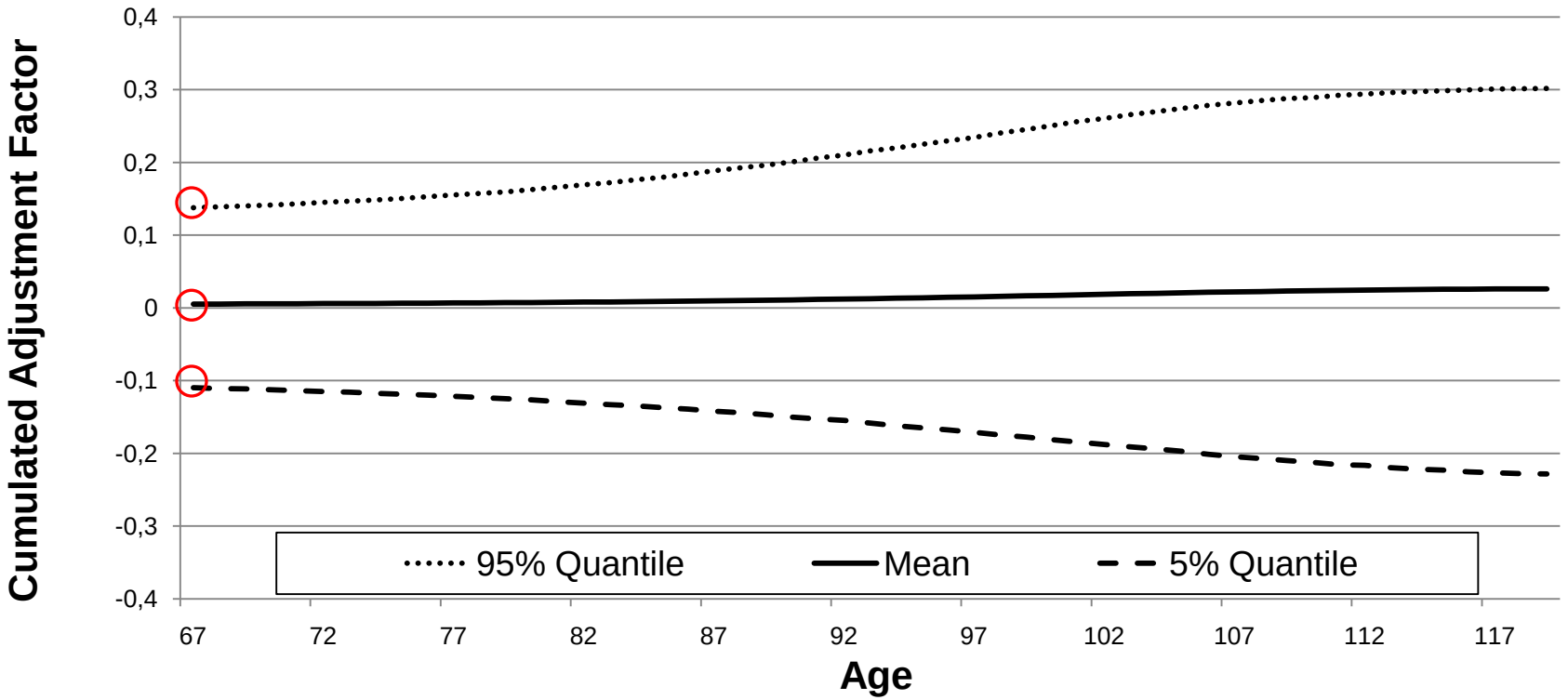

Level (survival credit & investment returns) and range (investment volatility) of payouts increase with deferring period

# Management of Systematic Mortality Risk: Self-Insurance Scheme




Notes: Implied loading relative to actuarial (trend adjusted) fair premium (US females) to self finance VILDA at the specified confidence level. VILDA payments start at age 67; AIR (3%)

# Management of Systematic Mortality Risk: Participation Scheme




Cumulated Adjustment Factors: Difference of benefit payments between participating VILDAs (bought at age 20) and actuarial fair priced non-participating VILDAs (trend adjusted).

# Multi-Period Life-Cycle Model


- Household (dynamic consumption utility optimizer)
  - Decides each year how much to consume / save (stocks/bonds/VILDAs)
  - CRRA utility function (no bequest motive; RRA=5, DF=0.96)
  - Stochastic, unspanned labor income (Cocco et al. 2005 high school profile)
  - Retirement from age 67 on (public pension 40% of last salary)
  - Uncertain time of death between age 20-120
    - Setting 1: given mortality rates
    - Setting 2: stochastic mortality rates by CBD (2008) 2-factor model; fitted US f.rates (1933-2007)

- Incomplete life annuity markets
  - Deferred life-annuity with investment-linked payments from age 67 on
  - No annuity purchases after retirement/deferring age 67
  - Pricing / Risk management of systematic mortality risk by annuity provider
    - Setting 2a: Self-Insurance calculating sufficient premiums (99.99% quantile pricing)
    - Setting 2b: Participating annuities (updating rule)

- Numerical solution by dynamic optimization; MC Sim. 1 Mio. LifeCycles

# Life Cycle Results with Deterministic/Stochastic Mortality: Mean Annuity Purchases & Payments (multiple of first labor income)

| Age | Given Life Table (LT) | Stochastic LT, Participating | Stochastic LT, Non-participating |
|---|---|---|---|
| *Panel A: Annuity Purchases* | | | |
| 30 | 0.00 | 0.00 | 0.00 |
| 40 | 0.27 | 0.10 | 0.00 |
| 50 | 0.50 | 0.55 | 0.89 |
| 60 | 0.51 | 0.54 | 1.07 |
| 67 | 1.06 | 1.20 | 1.39 |
| *Panel B: Annuity Payments* | | | |
| 67 | 1.84 | 1.73 | 1.60 |
| 80 | 2.07 | 1.96 | 1.82 |
| 90 | 2.19 | 2.08 | 1.93 |
| 100 | 2.33 | 2.20 | 2.03 |

# Welfare Analysis - VILDA-related Consumption Increases (mean in %)

| Age | Given Life Table (LT) | Stochastic LT, Participating | Stochastic LT, Non-participating |
|---|---|---|---|
| 20 | 1.52 | 1.31 | 0.99 |
| 40 | 4.35 | 3.58 | 2.49 |
| 60 | 5.44 | 4.11 | 2.31 |
| 80 | 16.36 | 12.53 | 7.18 |
| 100 | 19.03 | 25.53 | 18.41 |

Notes: Mean additional consumption (in %) at specified age that household with access to VILDAs is able to afford compared to household with no access VILDAs

# Demand Side: Break-Even Loadings - VILDA Participation vs. Non-participation

| Age | Wealth level ( x initial labor income) | | | |
|---|---|---|---|---|
| | 2 (%) | 3 (%) | 4 (%) | 5 (%) |
| 40 | 1.52 | 1.19 | 1.02 | 0.69 |
| 50 | 1.37 | 1.20 | 1.46 | 1.72 |
| 60 | 3.84 | 3.63 | 3.68 | 3.57 |
| 65 | 7.70 | 5.99 | 5.23 | 4.79 |

Notes: Loading to actuarial fair premium for non-participating VILDA compared to participating VILDA with no-loadings.

# Sensitivity Analysis (for stochastic mortality): Range of VILDA-related Consumption Increases

| | Participating VILDA | | | Non-participating VILDA | | |
|---|---|---|---|---|---|---|
| Age | 5% Quantile (%) | Mean (%) | 95% Quantile (%) | 5% Quantile (%) | Mean (%) | 95% Quantile (%) |
| 20 | 1.31 | 1.31 | 1.31 | 0.99 | 0.99 | 0.99 |
| 40 | 3.25 | 3.58 | 3.73 | 2.38 | 2.49 | 2.43 |
| 60 | 3.80 | 4.11 | 4.24 | 2.09 | 2.31 | 2.49 |
| 80 | 12.39 | 12.53 | 12.53 | 7.44 | 7.18 | 7.07 |
| 100 | 24.53 | 25.53 | 25.93 | 19.14 | 18.41 | 18.06 |

Excess consumption (in %) at specified age that household with access to VILDAs is able to afford compared to household in non-VILDA world.

# Conclusion

- VILDAs are private (funded) pensions products allowing households to participate survival credit, access to financial markets, low premiums
- Managing of Systematic Mortality Risk:
  - Self-insurance of guaranteed mortality assumptions could be very expensive (unless there is an inexpensive natural hedge available). Efficiency improvement using the mortality instruments?
  - Participation scheme is more attractive to households
- Even with expensive self-insurance VILDAs substantially increase the consumption over the life cycle
- Milevsky (2005: 110): “(…) engaging in irreversible financial transactions - that is annuitization - involving large lump sums will never be appealing to individuals regardless of (whether they grasp) the importance of longevity insurance.”
- VILDAs to overcome the psychological barriers to voluntary annuitization?

# Backup

## Mean VILDA Bond Share (%), for Alternative Mortality Table Assumptions

| Age | Given Life Table (LT) | Stochastic LT, Participating | Stochastic LT, Non-participating |
|---|---|---|---|
| 45 | 0.24 | 0.40 | 0.32 |
| 50 | 0.33 | 0.35 | 0.69 |
| 60 | 0.52 | 0.50 | 0.51 |
| 67 | 0.60 | 0.60 | 0.59 |
| 80 | 0.58 | 0.58 | 0.58 |
| 90 | 0.59 | 0.59 | 0.59 |
| 100 | 0.60 | 0.61 | 0.61 |

# Life Cycle Results with Deterministic Mortality: Annuity Purchases and Payments

| Age | 5% Quantile | Mean | 95% Quantile |
|---|---|---|---|
| **Panel A: Annuity Purchases** | | | |
| 30 | 0.00 | 0.00 | 0.00 |
| 40 | 0.00 | 0.27 | 2.16 |
| 50 | 0.08 | 0.50 | 1.22 |
| 60 | 0.06 | 0.51 | 1.43 |
| 67 | 0.21 | 1.06 | 2.79 |
| **Panel B: Annuity Payments** | | | |
| 67 | 0.59 | 1.84 | 4.08 |
| 80 | 0.59 | 2.07 | 4.81 |
| 90 | 0.58 | 2.19 | 5.26 |
| 100 | 0.57 | 2.33 | 5.71 |

Money (as a multiple of initial labor income) invested in VILDAs at specified age as well as benefits (as a multiple of initial labor income) paid by accumulated VILDAs at specified age.

# Life Cycle Results with Deterministic Mortality: VILDA-related Consumption Increases

| Age | 5% Quantile (%) | Mean (%) | 95% Quantile (%) |
|---|---|---|---|
| 20 | 1.52 | 1.52 | 1.52 |
| 40 | 3.17 | 4.35 | 4.40 |
| 60 | 4.60 | 5.44 | 5.91 |
| 80 | 17.13 | 16.36 | 16.38 |
| 100 | 19.54 | 19.03 | 19.08 |

Excess consumption (in %) at specified age that household with access to VILDAs is able to afford compared to household in non-VILDA world.