COMPARING LIFE INSURER LONGEVITY RISK MANAGEMENT STRATEGIES IN A FIRM VALUE MAXIMIZING FRAMEWORK

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AFIR/ERM IAA FINANCIAL RISKS AND ERM SECTION
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Motivation

- Increased interest in reinsurance and longevity bonds to manage longevity risk for providers of products that guarantee a retirement income (life annuities, pensions)
- Longevity risk management strategies:
  - Capital and product pricing (Nirmalendran *et al.*, 2012)
  - Reinsurance (Olivieri, 2005; Olivieri and Pitacco, 2008; Levantesi and Menzietti, 2008)
  - Securitization (e.g., Cowley and Cummins, 2005; Wills and Sherris, 2010; Biffis and Blake, 2010; Gupta and Wang, 2011)
- Strategies involve differing costs and risks
- Research question: How do longevity risk management decisions impact the firm's value for an insurer issuing life annuities allowing for frictional costs, market premiums and solvency?

Summary of the Model

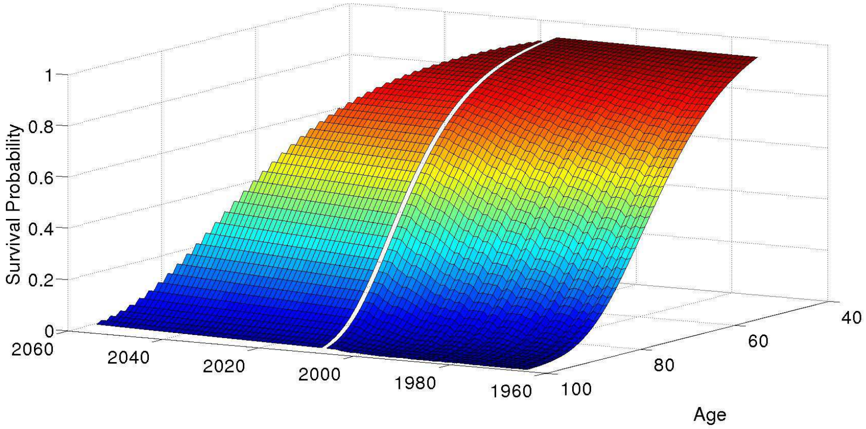
- We refer to a life annuity provider facing longevity risk
- Multi-period setting
- Stochastic mortality model with both systematic and idiosyncratic longevity risk
- Risk Management tools:
  capital, premium loading, longevity swap, longevity bond
  - Frictional costs for the capital invested
  - Costs for transferring risk (reinsurance premium, margin on longevity bond)
  - Policyholders' price-default-demand elasticities
- Valuation approaches:
  Economic Balance Sheet Value
  Market-Consistent Embedded Value (MCEV)

The Stochastic Mortality Model

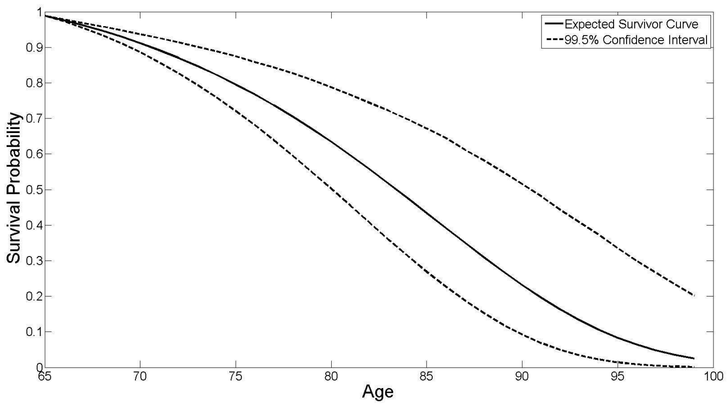
Affine Term Structure Model in Blackburn and Sherris (2012)

2-factor version, calibrated to Australian male population mortality data (ages 50–100, years 1965–2007, source: HMD)

Kalman filter used for forecasting and simulation



ATSM Survival Curve Forecasts

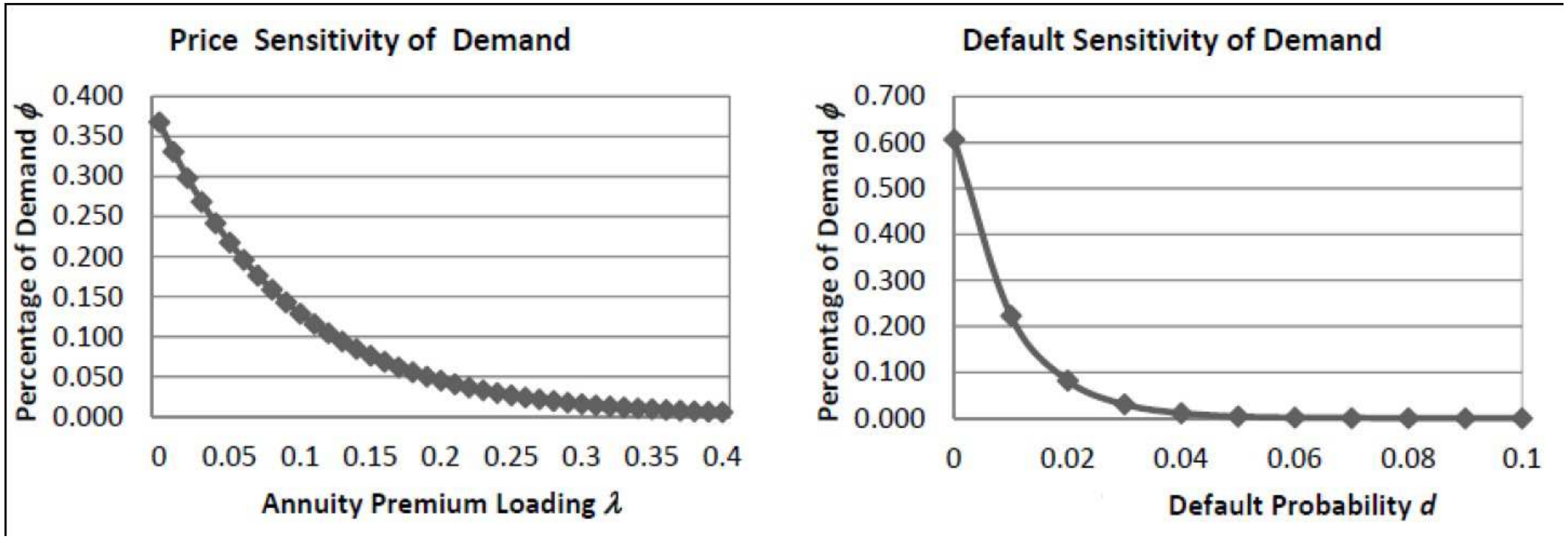


Survival Curve Distribution
(Cohort Age 65 at $t = 0$)

Idiosyncratic risk: binomial distribution for the annual number of deaths

Price-Default Demand Elasticities

Following Nirmalendran *et al.* (2012), we assume an exponential function for the annuity demand, in respect of both the price loading and the probability of default (prior to the run-off of the portfolio)



Percentage (in respect of the maximum potential market size) of individuals willing to buy the annuity: $\phi(\lambda, d) = e^{(\alpha\, d+\beta\, \lambda+\gamma)}$

Capital Management Strategy

The portfolio reserve, $V_t^{[\mathrm{P}]}$, and the minimum required capital, M_t, are assessed according to Solvency 2
(financial risks are fully hedged; the capital is required just in face of longevity risk)

Asset value A_t	Excess capital $X_t = A_t - (V_t^{[\mathrm{P}]} + M_t)$	Capital Management Decision
$A_t \geq V_t^{[\mathrm{P}]} + M_t$	$X_t \geq 0$	Dividend: $D_t = X_t$
$V_t^{[\mathrm{P}]} < A_t \leq V_t^{[\mathrm{P}]} + M_t$	$X_t \leq 0$	Recapitalization: $R_t = -X_t$
$A_t \leq V_t^{[\mathrm{P}]}$	$X_t \leq 0$	Default

Default probability: $d = 1 - \mathbb{P}\left\{\bigwedge_t A_t \geq V_t^{[\mathrm{P}]}\right\}$

Reinsurance vs. Securitization

Similar structure: agreement to exchange (fixed vs random) cash flows in the future

Variable	Longevity Swap	Longevity Bond
Benefits:	$B_t^{[\mathrm{LS}]} = b\,N(t;x)$	$B_t^{[\mathrm{LB}]} = b\,N(t;x)^{[\mathrm{syst}]}$
Premiums:	$\Pi_t^{[\mathrm{LS}]} = b\,(1+\lambda^{[\mathrm{LS}]})\,\mathbb{E}_0[N(t;x)]$	$\Pi_t^{[\mathrm{LB}]} = b\,(1+\lambda^{[\mathrm{LB}]})\,\mathbb{E}_0[N(t;x)^{[\mathrm{syst}]}]$

where

- $N(t;x)$: number of annuitants in the portfolio at time t, initial age x
- $N(t;x)^{[\mathrm{syst}]}$: number of annuitants, net of idiosyncratic effects

Same loadings: $\lambda^{[\mathrm{LS}]} = \lambda^{[\mathrm{LB}]}$

The swap (bond) is issued at time 0, with maturity T (either longlife: $T = \omega - x$, or fixed-maturity: say, $T = 90 - x$)

The reduced risk in the future annuity payments for the insurer is accounted for in the calculation of the reserve

For the required capital, we either assume no relief or 100% relief

Firm Valuation: Economic Balance Sheet Approach

Economic Balance Sheet at time 0

Assets	Liabilities		
A_0	$V_0^{[\mathrm{P}]}$	portfolio reserve	
	$PV_0(FC_t)$	frictional costs	$FC_t = \rho\,(\max\{A_{t-1} - V_{t-1}^{[\mathrm{P}]}, 0\})$
	$PV_0(FC_t^{[\mathrm{R}]})$	frictional costs in case of recapitalization	$FC_t^{[\mathrm{R}]} = \psi\, R_t$
	$PV_0(RM\_Cost_t)$	net cost of the longevity risk transfer	$RM\_Cost_t = \sum_{j=\mathrm{S,B}} w^{[\mathrm{L}j]}\,(\Pi_t^{[\mathrm{L}j]} - B_t^{[\mathrm{L}j]})$ ($w^{[\mathrm{L}j]}$: proportion underwritten of the longevity swap / bond)
	$LLPO_0$	Limited Liability Put Option	$LLPO_t = \sum_h \mathbb{E}_t[\max\{0, V_h^{[\mathrm{P}]} - A_h\}]\,v(t,h)$
	$X_0^{[\mathrm{E}]}$	economic (value of the) equity	

Value at time 0 of cashflows to/from shareholders:

$$NPV_0 = \underbrace{-PV_0(R_t)}_{\text{recapitalization flows}} + \underbrace{PV_0(D_t)}_{\text{dividends}}$$

Firm Valuation: Market-Consistent Embedded Value

Market-Consistent Embedded Value at time 0

$$MCEV_0 = \underbrace{PV_0(PL_t) - PV_0(FC_t) - PV(FC_t^{[\mathrm{R}]}) + LLPO_0}_{\text{Value of the In-Force Business, } VIF_t} + \underbrace{M_0 + X_0}_{\text{equity}}$$

Present Value of Future (Industrial) Profits

Main difference between Economic Balance Sheet and MCEV approach: timing of profits

- Economic Balance Sheet approach: Assets & Liabilities logic
- MCEV: Deferral & Matching logic

In particular, for a cohort of life annuities: $MCEV_0 \leq X_0^{[\mathrm{E}]}$

Further: MCEV also accounts for the volatility of the portfolio reserve

Results: Data

One cohort; initial age: $x = 65$

Mortality model calibrated to Australian population data
Term structure model calibrated to Australian market data

Frictional cost: $\rho = 1\%$ of the equity at time t; $\psi = 3\%$ of the additional capital subscribed at time t

Loading for the longevity swap, and the longevity bond:
$\lambda^{[\mathrm{LS}]} = \lambda^{[\mathrm{LB}]} = 5\%$

No capital relief in face of a risk transfer

Results: No Longevity Risk Transfer

Variable	premium loading 10% (expected) value	premium loading 15% (expected) value
Default probability, d	2.58%	13.50%
Policies issued, N_0	$4\,427$	$1\,594$
Initial capital, $(A_0 - V_0^{[P]})/N_0$	$1\,209.58$	$1\,814.37$
Economic equity, $X_0^{[E]}/N_0$	$1\,050.67$	$1\,655.15$
Cash flows to shareholders, NPV_0/N_0	528.40	$1\,114.38$
Value of In-Force business, VIF_0/N_0	872.19	$1\,458.21$

Results: Longevity Swap – 1

Maturity of the arrangement: $T = 90 - x$ (i.e., up to age 90)

Premium loading: 10%

	no risk transfer	swap
VARIABLE	(expected) value	(expected) value
Default probability, d	2.58%	17.68%
Policies issued, N_0	$4\,427$	$2\,170$
Initial capital, $(A_0 - V_0^{[\mathrm{P}]})/N_0$	$1\,209.58$	$1\,209.58$
Economic equity, $X_0^{[\mathrm{E}]}/N_0$	$1\,050.67$	$1\,062.07$
Cash flows to shareholders, NPV_0/N_0	528.40	-87.13
Value of In-Force business, VIF_0/N_0	872.19	275.46

Results: Longevity Swap – 2

VARIABLE	no risk transfer (expected) value	swap (expected) value
Default probability, d	2.58%	17.68%
Policies issued, N_0	$4\,427$	$2\,170$
Initial capital, $(A_0 - V_0^{[P]})/N_0$	$1\,209.58$	$1\,209.58$
Frictional costs, $PV_0(FC_t)/N_0$	146.55	147.89
Frictional costs recapitalization, $PV_0(FC_t^{[R]})/N_0$	12.37	1.92
Net cost of risk transfer, $PV_0(RM\_Cost_t)/N_0$	0	4.11
Limited Liability Put Option, $LLPO_0/N_0$	0	6.41
Economic equity, $X_0^{[E]}/N_0$	$1\,050.67$	$1\,062.07$
Recapitalization flows, $PV_0(R_t)/N_0$	$1\,031.47$	683.28
Dividends, $PV_0(D_t)/N_0$	$1\,559.87$	596.14
Cash flows to shareholders, NPV_0/N_0	528.40	-87.13
Present Value of Future Profits, $PV_0(PL_t)/N_0$	$1\,031.11$	418.86
MCEV, $MCEV_0/N_0$	872.19	275.46

Summary

Strategies with higher loadings on the annuity premium produce (in relative terms) higher shareholder value and lower volatility

Subscribing shareholder capital reduces insolvency risk, but shareholder value is reduced due to the frictional costs arising on capital invested in the insurance company

Longevity swap (longevity bond): reduces volatility of financial results, but just up to some age (later in time: impact of ageing and reduced portfolio size)

Reinsurance premiums (longevity bond loadings) reduce profitability and may exceed direct financial gains from risk management

Similar findings for longevity swap and longevity bond (due to the same structure and loading coefficient $\Rightarrow$ idiosyncratic longevity risk is not a significant factor)

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