Managed Volatility Strategies for Pooled Annuity Products

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May 21-24, 2019

AFIR ERM 19 Florence

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AFIR-ERM Colloquium
Florence Italy
May 21–24, 2019

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What are Pooled Annuity Products?

- A retirement product to generate income for a pool of annuitants (see Piggott et al. (2005), Donnelly et al. (2014), Milevsky (2015)) to share:
  - Systematic or aggregate mortality risk
  - Idiosyncratic or individual mortality risk (largest mortality risk facing an individual)
  - Investment risk allowing inclusion of equity and other investments consistent with individual risk appetite.
- Reduced capital requirement compared to guarantee products such as traditional life annuities (see Donnelly et al. (2013)).
- Relatively small pool sizes can effectively reduce idiosyncratic longevity risk (see Stamos (2008)).
- Most pooled annuity products use fixed interest investment strategies to replicate life annuity bond interest returns (see Qiao and Sherris (2013)).

Why Managed Volatility Investment Strategy?

Managed-volatility investment strategies (see Doan et al. (2018)):

- Pooled annuity products can include equity investments to improve expected returns.
- The management of equity volatility risk reflects a prescribed level.
- Reduced downside risk by forecasting volatilty, allowing reduced equity exposure when volatility is forecast to increase.
- Potential to enhance returns through the link between forecast volatility and expected returns.
- An unexplored research topic for pooled annuity funds - we are the first to consider these strategies for pooled annuity funds.

Research Approach

- We consider a range of target volatility strategies, the impact on expected annuity cash flows and cash flow risks as well as impact of pool size.
- We focus on group self-annuitization:
  - Annuity payout at time t for the ith individual in the cohort that entered at age $[x]$ and been in the fund for k years is given by:

$$ {}^{k}_{[x]}B^{*}_{i,t} = {}^{k-1}_{[x]}B^{*}_{i,t-1} \times MEA_t \times IRA_t $$

    where MEA_t is the mortality experience adjustment and IRA_t is the investment adjustment for the period from year $t-1$ to t.
- We use a stochastic aggregate mortality model, an Economic Scenario Generator, a term structure model and volatility forecasting model. We use 10,000 mortality scenarios and 1000 economic scenarios.

Mortality Model

- For systematic mortality risk we use a continuous-time two-factor affine mortality model (see Blackburn and Sherris (2013)).
- We use parameters from Ignatieva et al. (2016) fitted to Australian male cohort data from 1964 to 2011 at age 50.
- For idiosyncratic mortality risk we use a Poisson approximation.
- Number of deaths of period from $t-1$ to t is assumed Poisson$(E_x, \mu(t;x))$ where E_x is the exposure at time t, and $\mu(t;x)$ is the force of mortality from the systematic model.

Mortality Model

The simulated force of mortality and survival function

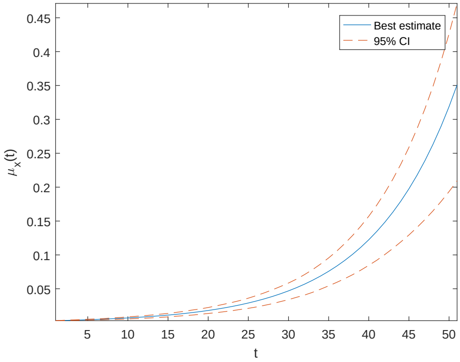


Figure 1: Simulated Force of Mortality From 2014

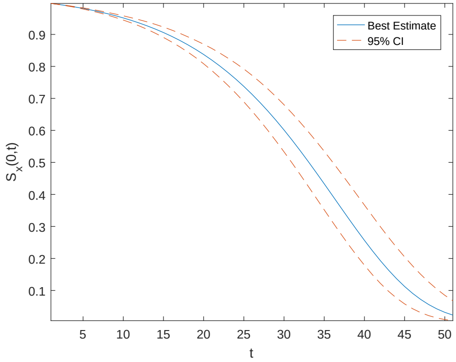


Figure 2: Simulated Survival Function From 2014

Economic Scenario Generator and Yield Curve Model

- We use a multivariate autoregressive (VAR) model as the Economic Scenario Generator (see Wilkie (1984), Sherris and Zhang (2009))
- VAR(1) model

$$y_t = a + A_1 y_{t-1} + \varepsilon_t$$

  where y_t is the vector of first differenced log scale series of CPI, equity index, GDP and short term interest rate.
  a is a vector of constant,
  A_1 is a 4-by-4 matrix of AR coefficients, and
  ε_t is a column vector of conditionally multivariate random errors, with correlation matrix Q.
- Single-factor Cox-Ingersoll-Ross (CIR) model is used to estimate the interest rate term structure.

Equity Volatility Forecast Model and Managed Volatility

- We construct an AR(1) model of 'realized volatility' to predict volatility. The parameters for the fitted AR(1) model are:

Table 1: Realized Volatility AR(1)

Parameter	Value	Std Error	t-Statistic
Constant	0.0028	0.0030	0.9436
AR	0.9627	0.0390	24.6907
Variance	$2.77 * 10^{-5}$	$2.97 * 10^{-6}$	9.3195

- The AR term is significant.
- The weighted w_t invested in the equity market, also referred to as the participation ratio, is given as:

$$w_t = \frac{\textit{target volatility}}{\hat{\sigma}_t}$$

where $\hat{\sigma}_t$ is the volatility forecast for date t.

Risk Measures

- PV and annuity payments at ages 80 and 90 - Mean, 2.5- and 97.5-percentiles for nominal and real values.
- Break even year (BEY) - the minimum number of years that the accumulated annuity payments without interest reach the initial investment amount.
- Coefficient-of-Variation:

$$CV_t = \frac{v_t}{m_t}$$

  where v_t is the volatility of the annuity payment amounts at time t, and m_t is the mean of the annuity payment amounts at time t.

- The CDD at time t defined as:

$$CDD_t = \frac{\sqrt{DD_t}}{m_t}$$

where Downside Deviation at time t is

$$DD_t = \frac{min(B_{it} - m_t, 0)^2}{N_t}$$

Managed Volatility compared to Balanced Allocation

- Managed Volatility 1.25 historical volatility compared to ‘Balanced’ fund: 65% fixed-income, 35% equity

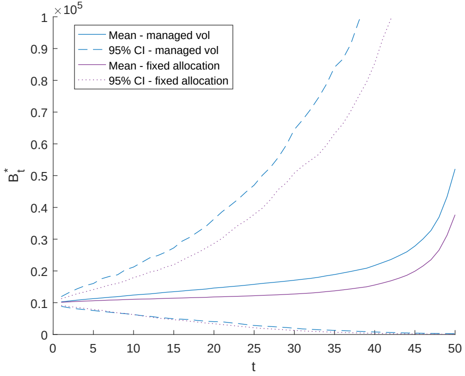


Figure 3: Managed-Volatility Vs Fixed Allocation (65%/35%) - Nominal

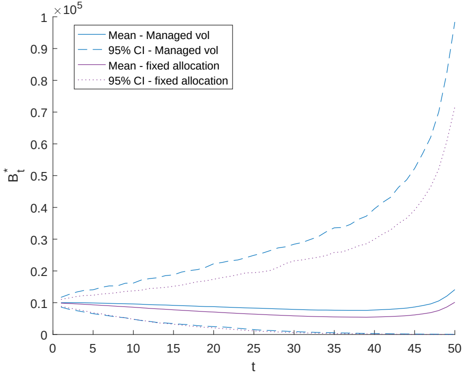


Figure 4: Managed-Volatility Vs Fixed Allocation (65%/35%) - Real

Managed Volatility Risk Measures - Percentiles

Table 2: Base Case: Annuity Payments at Age 80 and 90 - Nominal

	Age 80			Age 90		
Annuity Payment	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
Managed-Volatility	17,076	1,979	64,504	21,732	790	113,346
Fixed Allocation	12,741	1,284	50,797	15,574	364	85,344

Table 3: Base Case: PV Annuity Payments - Nominal Vs Real

	Nominal			Real		
PV Annuity Payments	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
Managed-Volatility	362,034	122,504	1,118,248	213,224	93,966	515,499
Fixed Allocation	295,151	111,769	889,271	180,308	89,340	426,634

Table 4: Base Case: Break Even Year - Nominal

	Nominal		
Break Even Year	Mean	2.5%-tile	97.5%-tile
Managed-Volatility	15	NA	11
Fixed Allocation	17	NA	12

Managed Volatility Risk Measures - CV and CDD

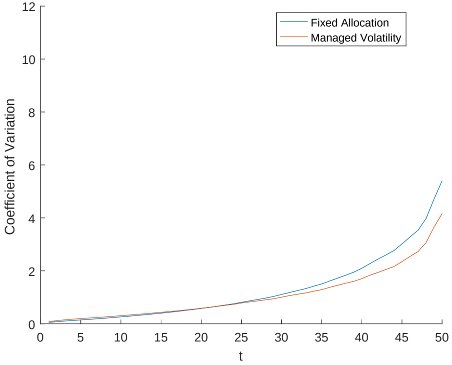


Figure 5: CV: Managed-Volatility vs Fixed Allocation

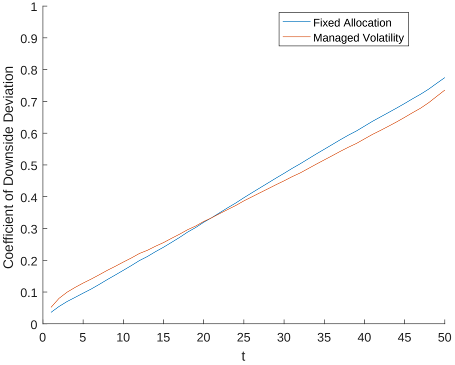


Figure 6: CDD: Managed-Volatility vs Fixed Allocation

Varying Initial Allocations - Impact on Annuity Payments

Table 5: Annuity Payments at Different Initial Allocations at Age 80 and 90

Annuity Payment		Age 80			Age 90		
FI/Equity	Asset Allocation	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
80%/20%	Managed-Volatility	10,596	894	42,687	12,806	199	71,993
	Fixed Allocation	9,045	638	37,899	10,885	121	62,853
65%/35%	Managed-Volatility	17,076	1,979	64,504	21,732	790	113,346
	Fixed Allocation	12,741	1,284	50,797	15,574	364	85,344
50%/50%	Managed-Volatility	28,266	3,822	100,717	40,403	2,692	176,100
	Fixed Allocation	18,244	2,272	66,516	23,501	1,044	120,537

Table 6: PV Annuity Payments at Different Initial Allocations

PV Annuity Payments		Nominal			Real		
FI/Equity	Asset Allocation	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
80%/20%	Managed-volatility	264,253	104,840	774,528	165,073	85,286	376,239
	Fixed Allocation	239,543	100,366	682,581	152,110	82,250	336,479
65%/35%	Managed-volatility	362,034	122,504	1,118,248	213,224	93,966	515,499
	Fixed Allocation	295,151	111,769	889,271	180,308	89,340	426,634
50%/50%	Managed-volatility	535,537	149,816	1,647,287	292,319	105,250	748,161
	Fixed Allocation	377,269	128,044	1,161,115	219,743	96,991	535,033

Varying Target Volatility - Impact on Annuity Payments

Table 7: Annuity Payments at Different Fixed Target Volatilities at Age 80 and 90

	Age 80			Age 90		
	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
Fixed Allocation	12,741	1,284	50,797	15,574	364	85,344
1 historical vol	13,633	1,415	53,270	16,798	422	91,590
1.25 historical vol	17,076	1,979	64,504	21,732	790	113,346
1.5 historical vol	21,520	2,733	77,124	28,697	1,441	138,148

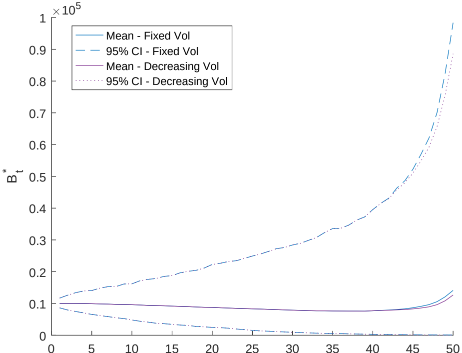
Table 8: PV Annuity Payments at Different Fixed Target Volatilities

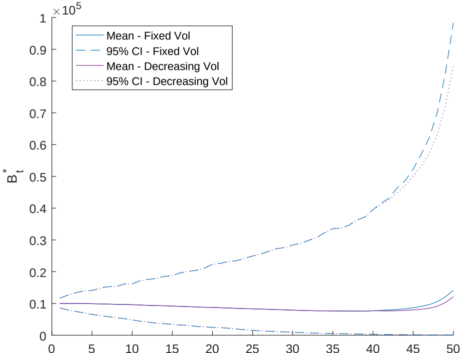
	Nominal			Real		
	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
Fixed Allocation	295,151	111,769	889,271	180,308	89,340	426,634
1 historical vol	310,310	113,091	945,729	188,229	89,956	447,627
1.25 historical vol	362,034	122,504	1,118,248	213,224	93,966	515,499
1.5 historical vol	429,562	133,505	1,319,962	244,708	98,498	604,932

Trending Down in Target Volatility

Table 9: PV Annuity Payments at Different Target Volatilities

	Nominal			Real		
	Mean	2.5%-tile	97.5%-tile	Mean	2.5%-tile	97.5%-tile
Fixed Target Vol	362,034	122,504	1,118,248	213,224	93,966	515,499
Trend Down Vol	358,390	122,142	1,101,347	212,132	93,835	511,014
Step Down Vol	355,997	121,905	1,090,013	211,391	93,731	507,902





Impact of Initial Pool Size

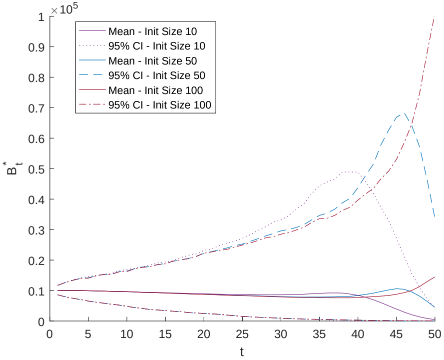


Figure 9: Initial Pool Size Comparison: 10 vs 50 vs 100 - Real

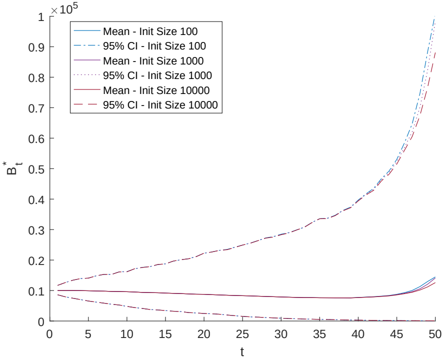


Figure 10: Initial Pool Size Comparison: 100 vs 1k vs 10k - Real

Conclusions

- For the first time, we develop, apply and assess a "managed-volatility framework" for pooled annuity funds.
- We show the impact of including equity investments on pooled annuity payments and the present value of pooled annuity payments.
- We quantify risks in pooled annuity payments from including equity investment and assess how effective target volatility strategies are in enhancing pooled annuity values while controlling downside equity risk.
- We show
  - Target volatility strategies generate higher expected and less risky pooled annuity payments compared to a fixed asset allocation strategy.
  - Relatively small pool sizes of around 100 are sufficient to reduce idiosyncratic mortality risk in the pool when equity investments are included.

Acknowledgements

Recognition of support from:

- Society of Actuaries Center of Actuarial Excellence Research Grant 2017–2020: Longevity Risk: Actuarial and Predictive Models, Retirement Product Innovation, and Risk Management Strategies.
- CEPAR Australian Research Council Centre of Excellence in Population Ageing Research project number CE170100005 for 2018–2024.
- Australian Research Council Discovery Project 2017–2020 DP170102275: Retirement income product innovation.

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