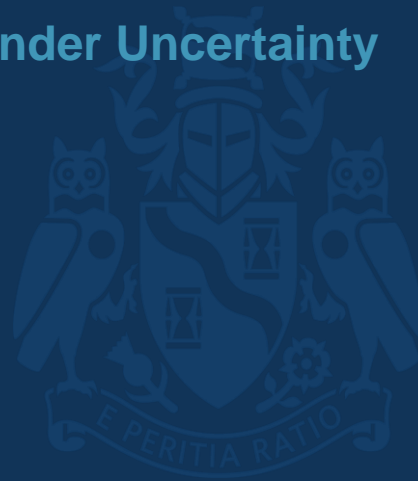




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Business Planning Under Uncertainty

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Business Planning Under Uncertainty

A Bayesian Approach



21 April 2017



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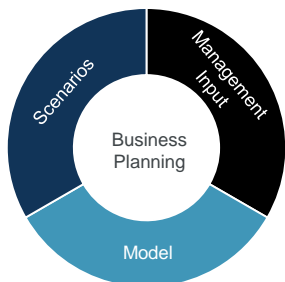
Agenda

- Insurance company business planning
- Our model – a Bayesian approach
- Genetic algorithm
- Observations and conclusions

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Insurance Company Business Planning



Scenarios: economic, regulatory, market
 Management Input: sales, investment, capital

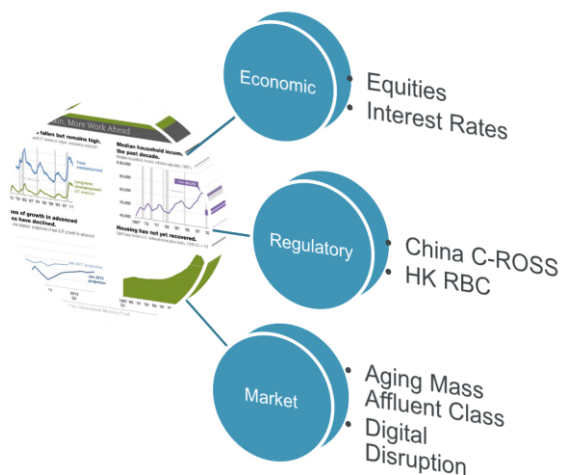


Planning Period :
 2017-2020
 Business Unit :
 Life Insurance
 BE Scenario :
 EV Basis

	YE 2016	YE 2017	YE 2018	YE 2019	YE 2020
Profit					
ROEC					
Cash					
Expense					
EVNBV					

Model – that's what we are talking about today

Scenarios



Our Model – a Bayesian Approach

- Model Objectives (upside risk)

Optimal new business sales volume to maximise the

“defined total profit”* projected over N years

- Model Constraints (downside risk)

Solvency capital ratio (capital risk appetite)

Can be extended to other financial management decision-making process such as ALM/SAA

* Average profit before tax and before solvency consideration

Our Model – a Bayesian Approach

- Economic cycles: boom, recession, and two transitions

Controlling equity and rates behaviours

- A Markov Regime Switching (MRS) process

Hamilton (1990,1991)

Hardy (2001)

- Multivariate optimisation with constraints

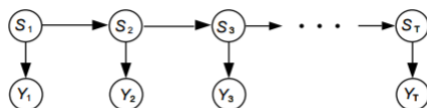
Hamilton (1990) – Quasi Log-likelihood (QL)

Franses • van Dijk (2000) – Expectation Maximisation (EM)

Genetic Algorithm (GA)

Our Model – Hidden Markov Model (HMM)

- A Markov process with unobserved (hidden) states.



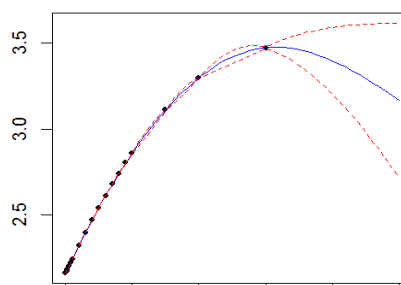
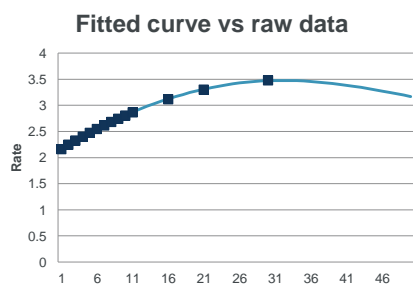
- 4 state HMM
- HMM will reach a stationary distribution for each states

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Our Model – Assets

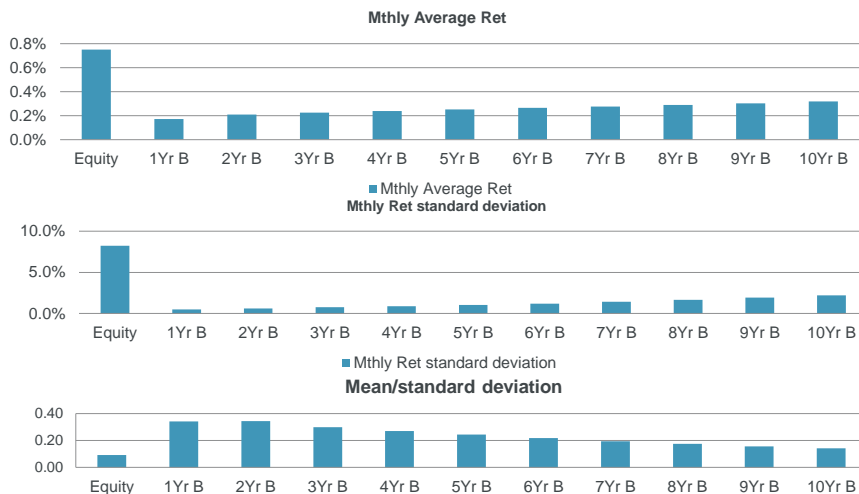
- Equity total return index
- Bond portfolio (1-10 year zero coupon bonds) total return index
- Smoothed monthly yield curve (Gaussian process)



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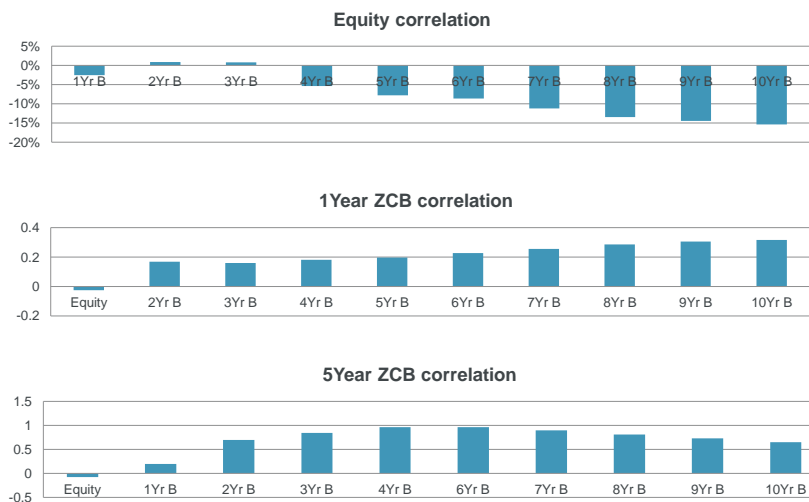
Equity & ZCB Bond returns



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Equity & ZCB Bond return correlations

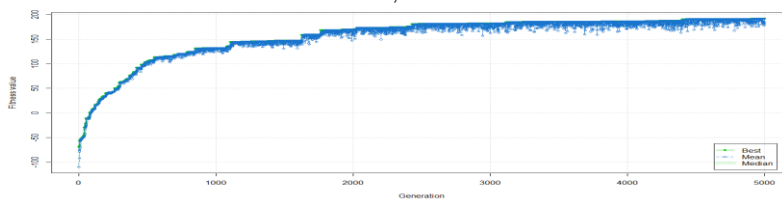


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Genetic Algorithm

- Evolution: mutation and alteration
Candidate individuals, genotype, encoding
- Fittest to survive
Iteration of generations, selection, genome modification
- Target: Equity total return index
Generation maximisation, fitness level



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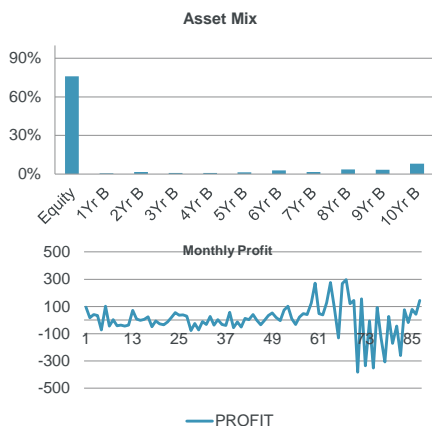
Our Model – Liabilities

- Endowment, Unit Linked and With Profit
- Single premium 10 year maturity
- PVFP pricing
- Ignoring mortality, lapse and expense
- Deterministic discounting

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First Target – Optimise PVFP

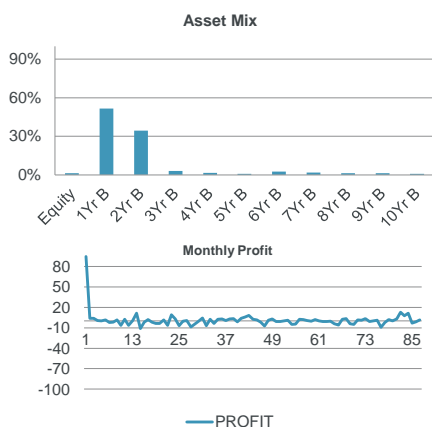


- This target has not considered the fluctuation of profit over different policy year
- Equity return is highest so it is not surprising to see the optimal asset mix is equity
- Smoothed profit preferred

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Second Target – Optimise PCFP with Loss Penalisation

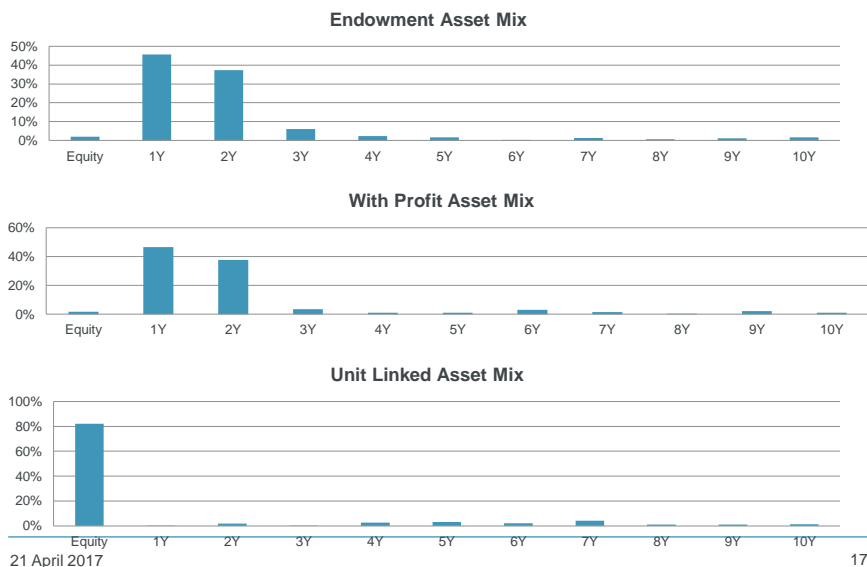


- Exclude large loss in any single month
- Used to optimise the Unit Linked and With Profit product asset mix

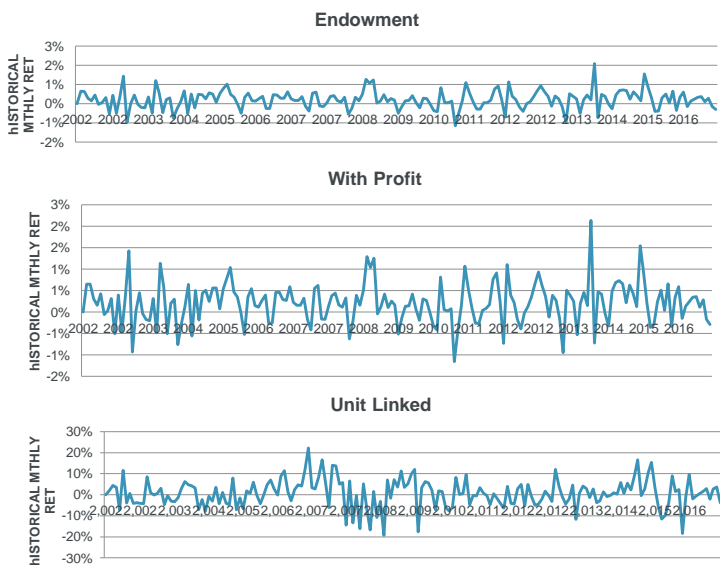
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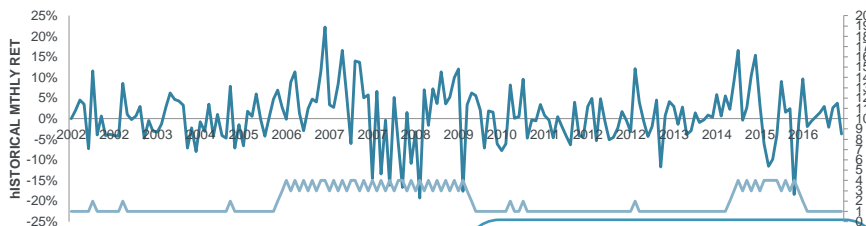
Optimal Asset Mix



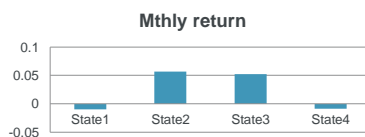
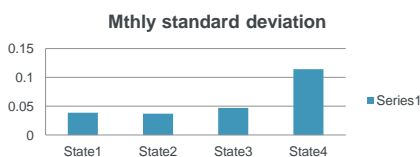
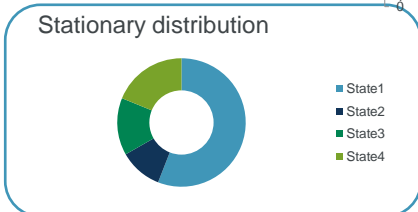
Historical Returns



4 States Hidden Markov Model – Unit Linked



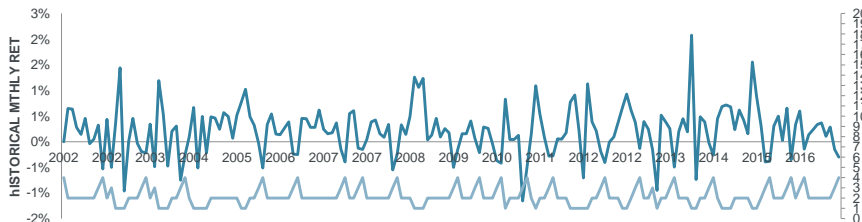
Transition Probability	State1	State2	State3	State4
State1	86%	14%	0%	0%
State2	73%	13%	15%	0%
State3	0%	11%	0%	89%
State4	0%	0%	68%	32%



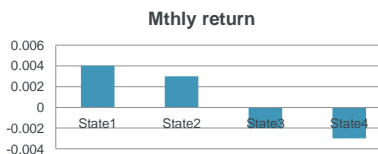
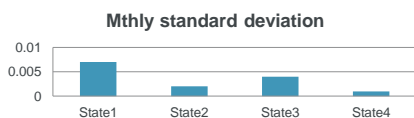
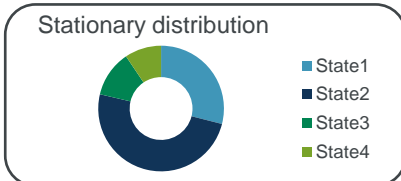
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4 States Hidden Markov Model – Endowment



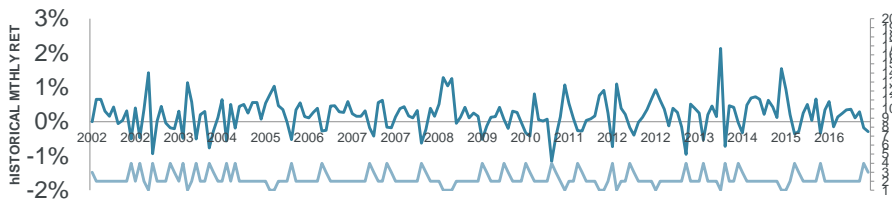
Transition Probability	State1	State2	State3	State4
State1	60%	40%	0%	0%
State2	16%	60%	24%	0%
State3	21%	0%	0%	79%
State4	12%	88%	0%	0%



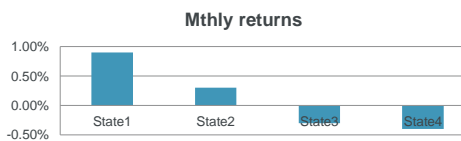
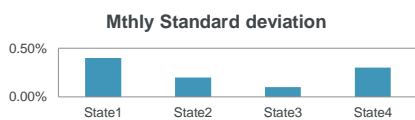
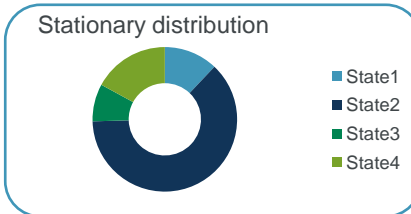
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4 States Hidden Markov Model – With Profit



Transition Probability	State1	State2	State3	State4
State1	59%	41%	0%	0%
State2	12%	62%	26%	0%
State3	33%	0%	0%	67%
State4	11%	89%	0%	0%

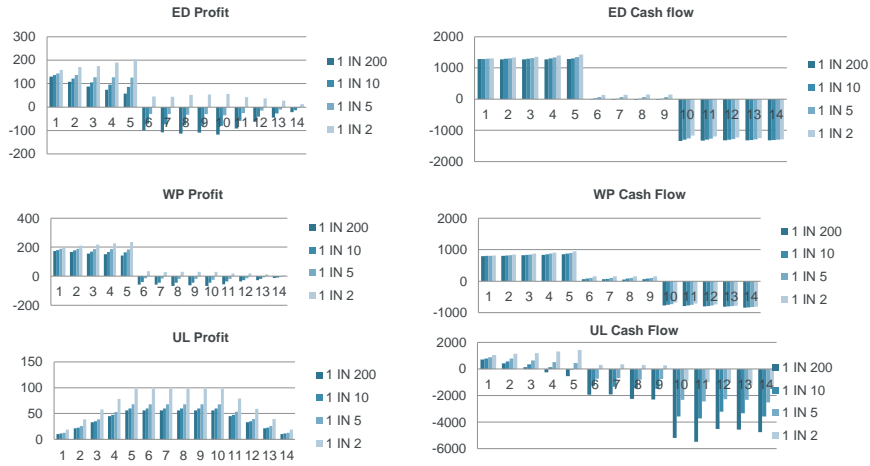


Gaussian Copula to correlate the simulated monthly returns Historical monthly return correlation vs simulated correlation

Historical data	Unit Linked	With Profit	Endowment
Unit Linked	100%	29%	32%
With Profit	29%	100%	100%
Endowment	32%	100%	100%

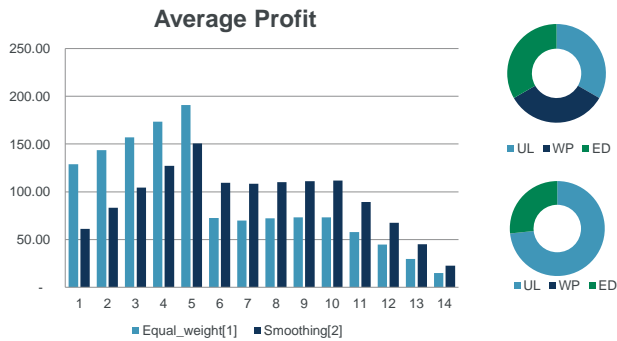
Simulation	Unit Linked	With Profit	Endowment
Unit Linked	100%	24%	27%
With Profit	24%	100%	98%
Endowment	27%	98%	100%

Profit & Cash Flow by Products



Assume 5 year equal new business

Experiment 1: Optimise Product Mix to Smooth Profits



By penalising the variance of average profit over year, we get the smoothed annual profit result with similar average profit

Profit and EV results[1]

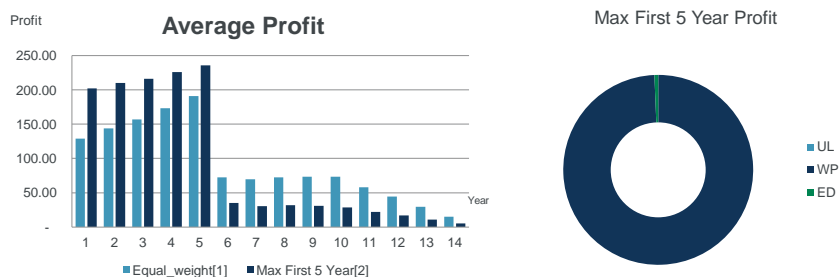
Equal weighted business mix

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	129	144	157	173	191	UL	33%
EVNBV	427	427	427	427	427	WP	33%
EV in force	349	311	273	228	177	ED	33%
Cash Flow	1,066	1,130	1,181	1,253	1,327		

Weights optimised to smooth annual profit

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	61	83	104	127	150	UL	73%
EVNBV	460	460	460	460	460	WP	0%
EV in force	533	476	416	347	271	ED	27%
Cash Flow	1,136	1,242	1,320	1,437	1,558		

Experiment 2: Optimise Product Mix to first 5 year profits



By maximizing the first 5 year profit, the weight changed to WP dominant as its profit emerge more in the beginning 5 year

Profit and EV results[2]

Equal weighted business mix

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	129	144	157	173	191	UL	33%
EVNBV	427	427	427	427	427	WP	33%
EV in force	349	311	273	228	177	ED	33%
Cash Flow	1,066	1,130	1,181	1,253	1,327		

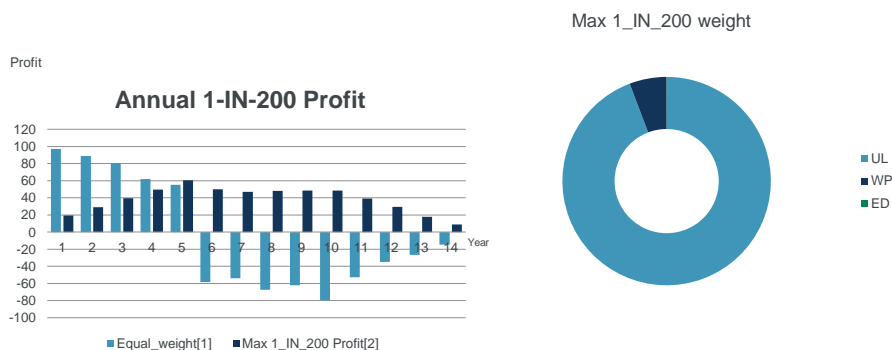
Weights optimised to max first 5 year annual profit

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	202	210	216	226	236	UL	0%
EVNBV	377	377	377	377	377	WP	99%
EV in force	148	128	110	90	68	ED	1%
Cash Flow	818	849	879	913	948		

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Experiment 3: Optimise Product Mix to 1_IN_200 Annual Profits



By maximizing annual 1_IN_200 profit, the weight changed to UL dominant as its profit is most stable

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Profit and EV results[3]

Equal weighted business mix

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	129	144	157	173	191	UL	33%
EVNBV	427	427	427	427	427	WP	33%
EV in force	349	311	273	228	177	ED	33%
Cash Flow	1,066	1,130	1,181	1,253	1,327		

Weights optimised to max 1_IN_200 annual profit

	YE2017	YE2018	YE2019	YE2020	YE2021	Product Type	Product Mix
Profit	36	61	86	111	136	UL	94%
EVNBV	465	465	465	465	465	WP	6%
EV in force	600	535	464	386	300	ED	0%
Cash Flow	1,058	1,186	1,281	1,422	1,567		

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Summary

1. Unit Linked
 - profit from the asset management charge
 - policyholders take the investment risk
 - optimal strategy: more aggressive SAA
 - cash flow more volatile although profits are smoothed
2. With Profit and Endowment
 - investment risk shared between policyholders and shareholders
 - optimal strategy: less aggressive SAA
 - profits less smoothed

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Future improvements

1. Liability model to include dynamic lapse rates, correlated to movement of yield curve
2. Include regular premium products
3. Include expense assumption
4. Develop the solvency capital projection
5. More data (higher frequency)
6. Multi-dimensional optimisation (proper ALM – adjusting sales and SAA at the same time): more powerful PC!
7. More asset classes, e.g. credit



Questions

Comments

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