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# Better ALM and Liquidity with Stochastic Liability Modelling

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13 May 2016

## Topics

- Life Insurance Liability Modelling
- Variability of Portfolio Cash Flows...within the Best Estimate
- ALM, Liquid and Illiquid Assets
- A Stochastic MSM for Equity Release
- ALM: Equity Release and Annuities



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## Motivation and Goals

- This type of modelling happened partly by accident
- In pricing Fin Re for unfamiliar life insurance products, the goals were:
  - To understand what could go wrong and how badly
  - To understand if there was a better way to invest, e.g. for products with heavy surrender exposure, was there a balance of asset types which balanced return and risk aversion (we were reinsuring the tail)
- We were looking at stressed cash flows and a funny thing happened: variability within the Best Estimate projection itself. This became a new focus.



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## Life Insurance Liability Modelling: Probabilistic vs Stochastic



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## Life Insurance Liability Modelling

### Probabilistic Modelling

- Project probabilities of being in each state
- Projected benefits and probabilities are as smooth as the underlying decrements
- The projection of a portfolio of policies in the sum of “model points”, like a population average

### Stochastic Modelling

- Project individual lives through single states
- Projected benefits are not scaled by probabilities, but paid in full, if the life occupies the required state
- The projection of a portfolio contains one simulated life per policy



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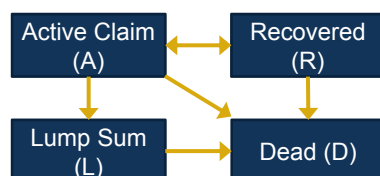
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## Life Insurance Liability Modelling

### Multi-State Decrement Model (MSM)

#### Income Protection

##### Transition Diagram



##### Transition Matrix

From\To	A	R	L	D
A	√	√	√	√
R	√	√	0	√
L	0	0	√	√
D	0	0	0	1



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## Life Insurance Liability Modelling

### Probabilistic Modelling

State \ Period	0	1	2	3	4	5	...
Active Claim (A)	1.000	0.902	0.827	0.744	0.688	0.602	...
Recovered (R)	-	0.030	0.043	0.049	0.052	0.059	...
Lump Sum (L)	-	0.020	0.053	0.073	0.080	0.092	...
Dead (D)	-	0.048	0.077	0.134	0.180	0.247	...

### Stochastic Modelling

State \ Period	0	1	2	3	4	5	...
Simulation 1	A	A	R	R	A	A	...
Simulation 2	A	A	L	L	L	L	...
Simulation 3	A	A	A	A	D	D	...
...							
Simulation $N$	A	R	A	A	A	A	...



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## Variability of Portfolio Cash Flows



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## Variability of Portfolio Cash Flows

- Within a Best Projection, there is inherent variability of cash flows, depending on the probability of payment and inversely proportional to portfolio size
- For simplified portfolios, e.g. identical policies, we can calculate this analytically via the binomial distribution
- For real-life portfolios, this can be evidenced through stochastic liability modelling
- Thinking about some life insurance products—e.g. annuities in payment, whole of life, or income protection—what are their relative levels of variability?

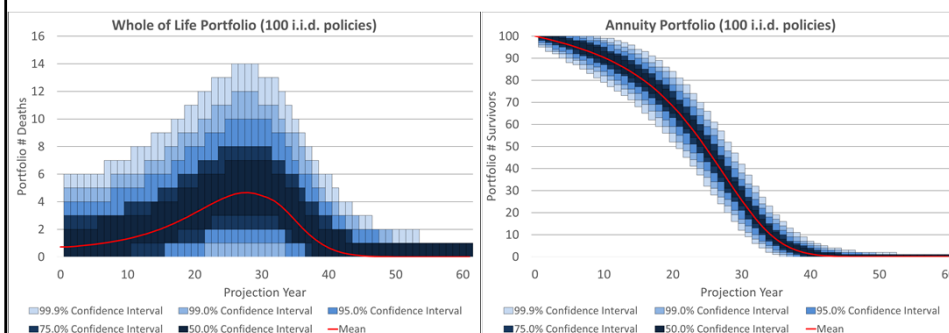


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## Variability of Portfolio Cash Flows

**Analytic variability (binomial) for portfolios of 100 identical whole of life and annuity policies, respectively**

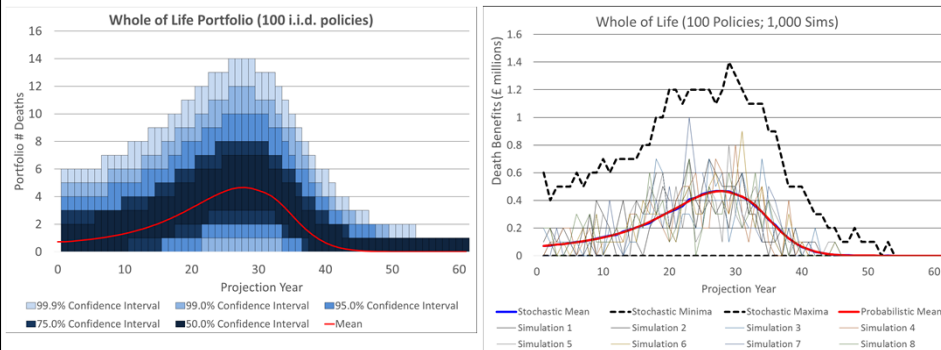


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Whole of Life—100 identical policies

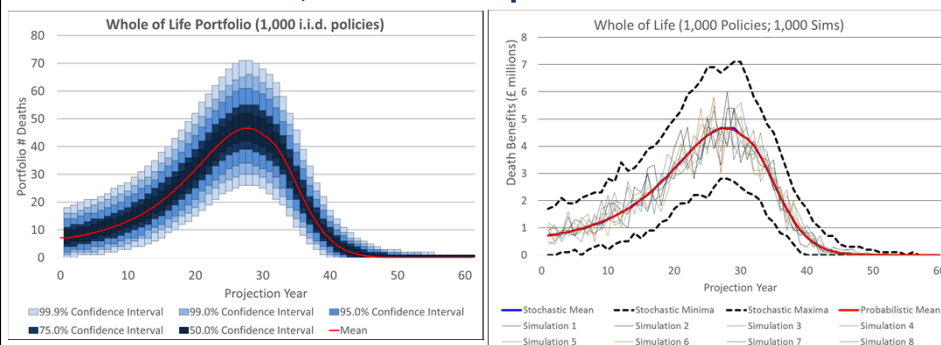


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Whole of Life—1,000 identical policies

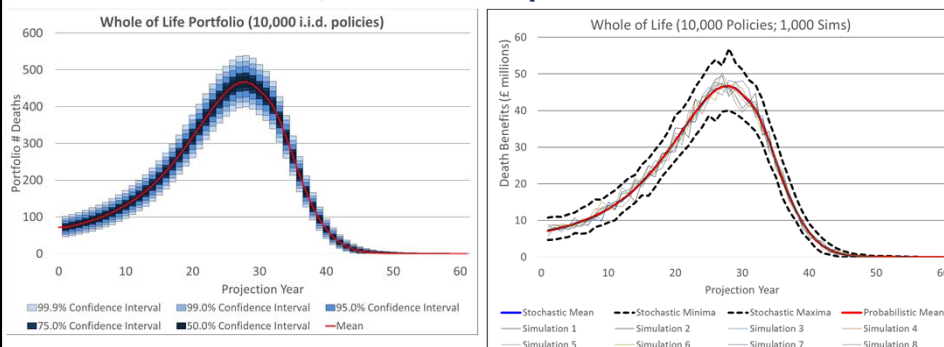


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Whole of Life—10,000 identical policies

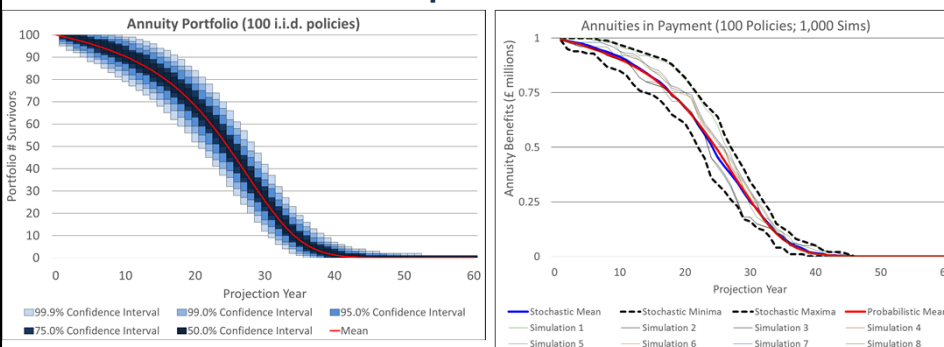


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Annuities—100 identical policies

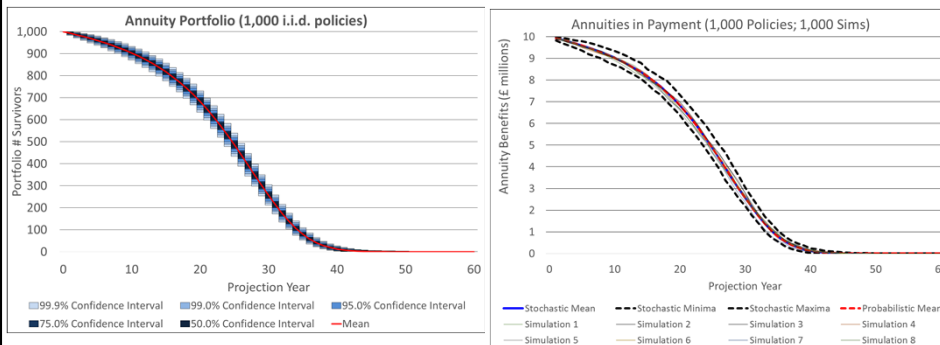


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Annuities—1,000 identical policies

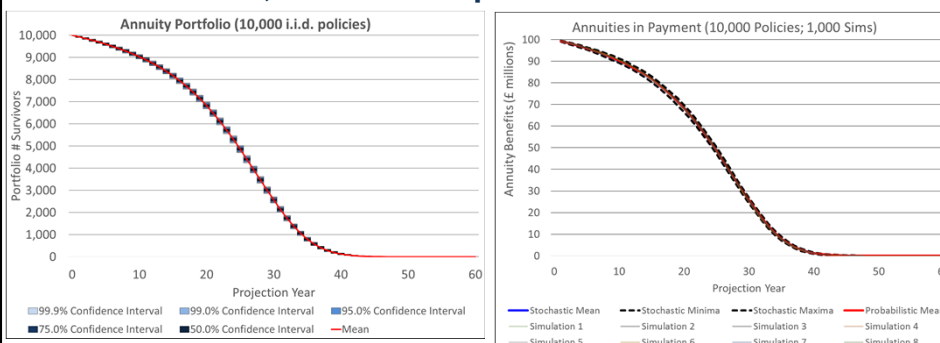


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## Variability of Portfolio Cash Flows

### Binomial distribution vs stochastic simulation Annuities—10,000 identical policies



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## ALM, Liquid and Illiquid Assets

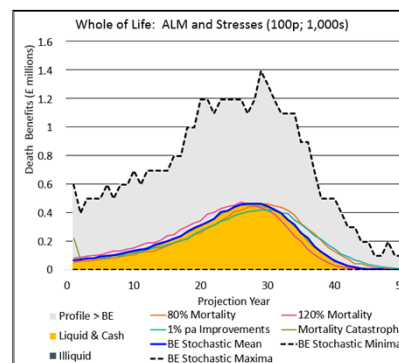
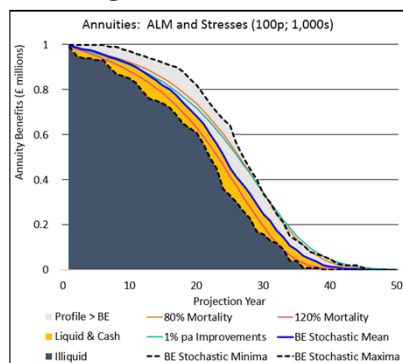


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## ALM, Liquid and Illiquid Assets

### Matching: Small Portfolios of Annuities vs Whole of Life

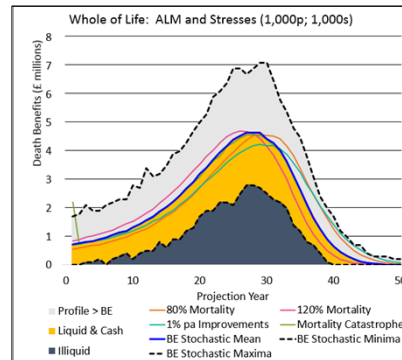
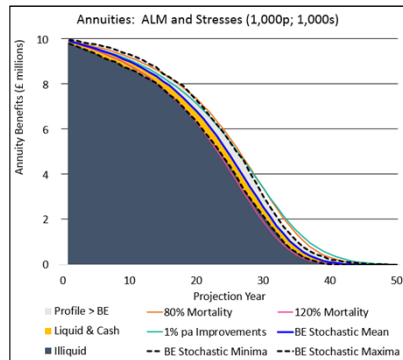


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## ALM, Liquid and Illiquid Assets

### Matching: Medium Portfolios of Annuities vs Whole of Life

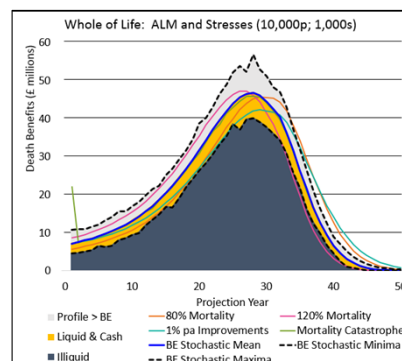
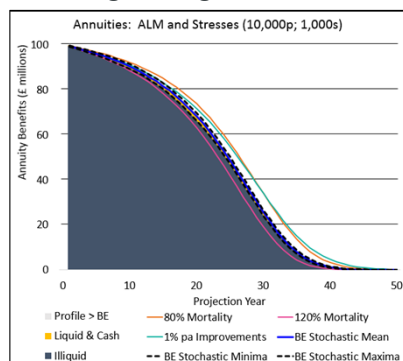


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## ALM, Liquid and Illiquid Assets

### Matching: Large Portfolios of Annuities vs Whole of Life



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## ALM, Liquid and Illiquid Assets

### Stochastic Modelling of Income Protection



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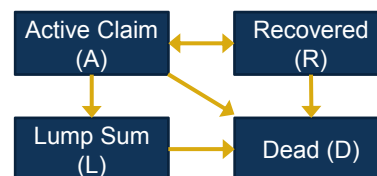
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## ALM, Liquid and Illiquid Assets

### Income Protection Portfolios

- Realistic portfolios of IP
- Ages 20 to 64
- Active claim 1 day to 20 years
- Benefits £25K to £500m p.a.
- Insurer option to pay out lump sums at 80% SII BEL
- Three portfolios: 50, 250, and 1,000 policies

### Transition Diagram

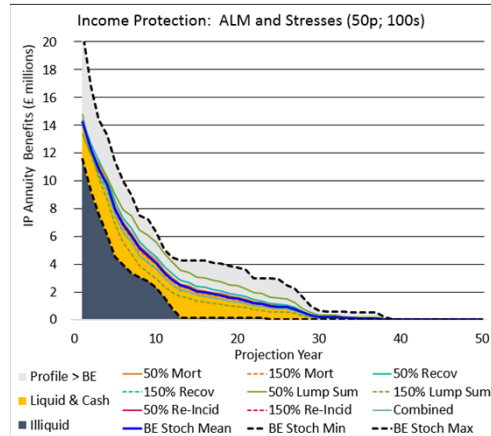


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## ALM, Liquid and Illiquid Assets

### Income Protection Portfolio of 50 Policies

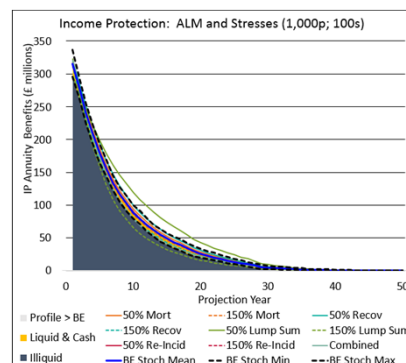
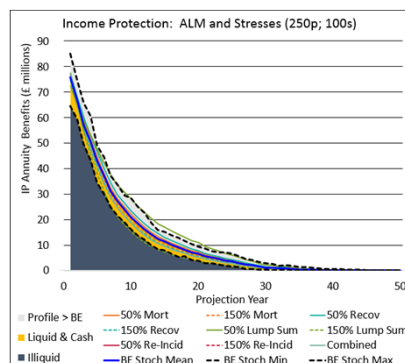


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## ALM, Liquid and Illiquid Assets

### Income Protection Portfolio of 250 and 1,000 Policies



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## ALM, Liquid and Illiquid Assets

### Discussion and Salient Points

- Defining the ideas of an “economic ALM match”, “economic BEL” and “economic risk capital”
- From this economic perspective, let’s consider:
  - Illiquid assets and the BE stochastic projections
  - Illiquid assets and stresses
  - Liquid assets, cash and risk capital
- Bring back to a Solvency II ALM match
- Thoughts? Questions?



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## An Aside: “Simulation Error”

- With a stochastic MSM, you might get modelling error, but not simulation error
- For small portfolios, the stochastic average is bumpy because the population is small
- Within a probabilistic MSM,
  - Using a large-population mortality table artificially smooths the BE cash flow profile,
  - Potentially hiding unnoticed liquidity strains or reinvestment needs **within the best estimate projection itself**
- For the stochastic MSM, “simulation error” might be better described as “finite portfolio variability”



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## Stochastic MSM on the Asset Side

### A Better Model for Equity Release



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## Equity Release: Overview

“ERMs are a type of lifetime mortgage [...] with the following features: they are restricted to older customers, they do not have a fixed term, they generally have a no negative equity guarantee, and there is no obligation to make regular interest payments on the capital.”  
(PRA DP1/16)

A homeowner releases a portion of the equity in their home which is repaid whenever they choose (if able, of course) or ultimately on sale of their property following their death or move into long term care.

The borrower may choose to pay interest on the loan on a regular basis, e.g. monthly, or not to pay interest and let the loan accrue. Interest-paying borrowers may opt to cease paying interest at any time.



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## Equity Release Thought Experiment

- Equity release, enormously simplified, is the sum of:
  - A reverse annuity: interest payments, with the option to cease
  - A reverse whole of life: inflating at the interest rate, with the option to repay early, repayment capped at property value
- Based on results for annuities and whole of life, how variable will a portfolio of  $N$  equity release loans be?
- Equivalently, will the equity release portfolio of  $N$  loans provide the ALM cash flows when needed?



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## Equity Release: Issues & Goals

- Issues:
  - An asset that acts like a life insurance liability
  - Mark-to-Market is a stretch
  - Fundamental question: ALM—will a portfolio of equity release provide the future cash flows needed (cash flow matching)
- Goals:
  - Model equity release in a simple, yet realistic manner
  - Model HPI, decrements and borrower behaviour all stochastically
  - Measure the reliability of equity release cash flows used within an ALM portfolio to match annuities



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## Modelling Equity Release

### Equity Release for backing Annuities

- Modelling ethos:
  - Understand the product in isolation and within a portfolio
  - As simple as possible, as complex as required, as detailed as reliable
- Model:
  - Stochastic HPI, AR time-series model based on UK HPI data
  - Stochastic decrements and borrower decisions (MSM)



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## Modelling Equity Release

### Loan portfolio overview

- 6% interest p.a.
- Expenses of £100/£50 inflating at 3% p.a.
- 400 interest paying loans, 400 interest roll-up loans
- Broadly evenly distributed:
  - Ages 50 to 90 (LTVs from 25% to 45%)
  - Current property values from £100,000 to £5m
  - Initial loan values from £13,000 to £2m

### Generic terms and conditions:

- Option to repay early, subject to a charge
- Repaid on death or earlier move to long term care, with NNEG
- Additional loan increments granted subject to LTVs



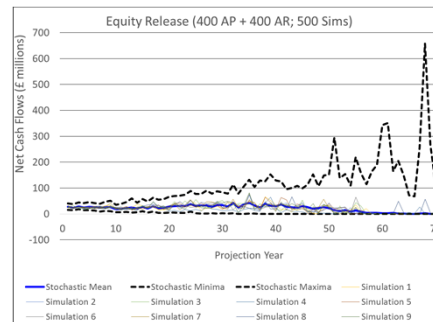
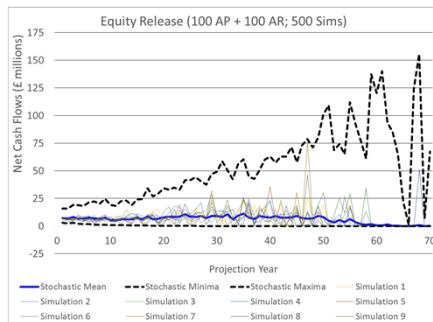
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## Variability of Equity Release Cash Flows

- Portfolio size reduces variability...

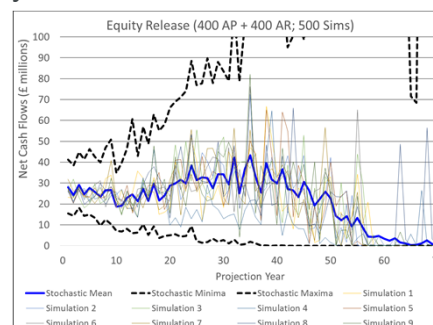
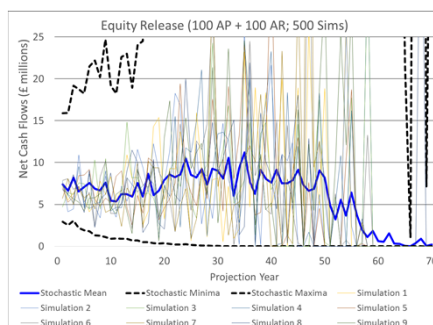


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## Variability of Equity Release Cash Flows

- We're concerned with ALM and the reliability of the cash flows we need to meet annuity liabilities

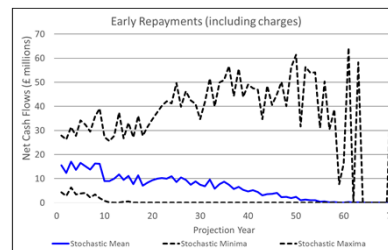
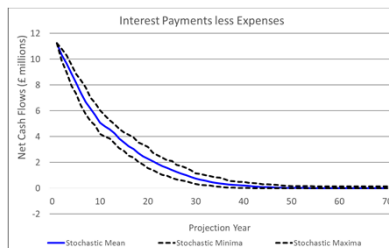
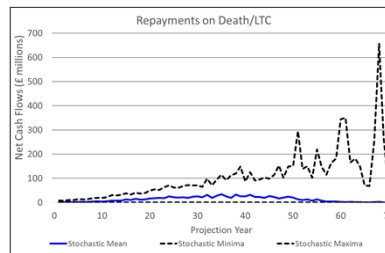


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## Component Cash Flows

- 800 Policies
- 500 Simulations

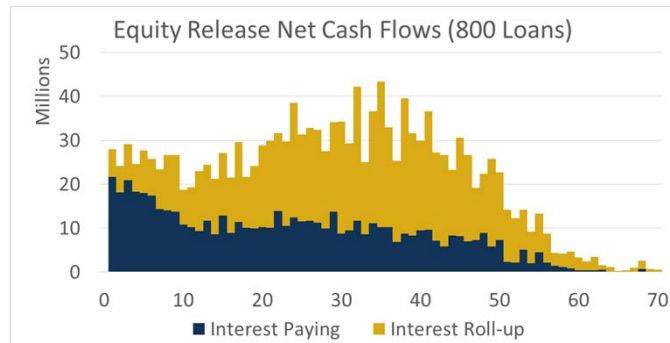


## ALM: Equity Release and Annuities

- Situation
  - Liabilities: annuities in payment
  - Assets: approximately 75% gilts and corporate bonds, 25% equity release and cash as needed
- Process
  - Determine BE profiles for annuities and equity release
  - Determine a “reliable” profile to be met by proceeds from the equity release loans
  - Match the remainder with gilts and corporate bonds
  - Test the reliability of the equity release ALM profile

## ALM: Equity Release and Annuities

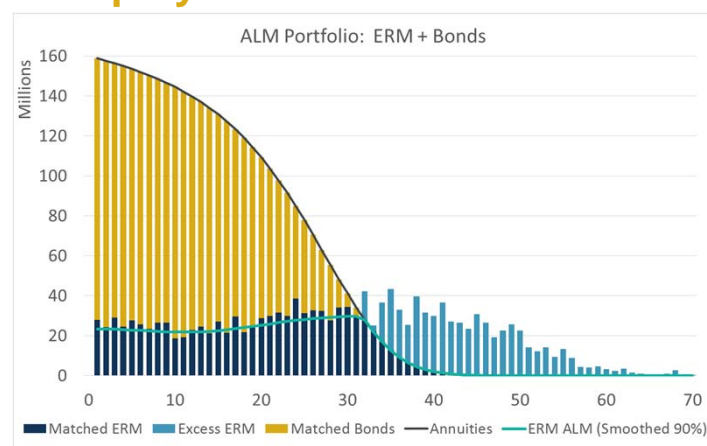
- Best Estimate net cash flows arising from a portfolio of 800 equity release loans, 500 portfolio simulations



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## ALM: Equity Release and Annuities

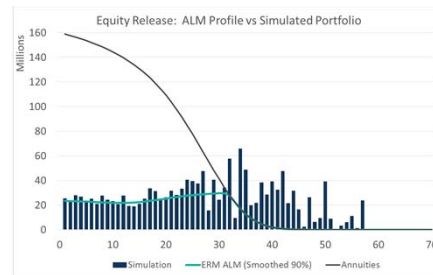
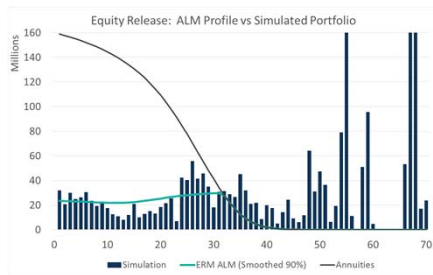


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## ALM: Equity Release and Annuities

- In some simulations (potential versions of reality), the equity release portfolio provides sufficient cash flows as or before they are needed, in others not



- How can we measure this?



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## Equity Release ALM Reliability

- Simple test of reliability of equity release cash flows:
  - Vary the equity release ALM profile: 100%, 90%, 80%, ...
  - Carry forward surpluses (deficits) as cash
  - Count the simulations which require cash *at any point*
  - Calculate the amount of cash to hold at the start to:
    - Ensure no cash is needed in all 500 simulations
    - Ensure no cash is needed in 90% of simulations



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## Equity Release ALM Reliability

- As with whole of life, variability reduces with portfolio size
- There is a balance between using a high proportion of the ERM BE profile as the ERM ALM profile and reliability

Number of Simulations Requiring Cash at Some Point (out of 500)			
ERM Portfolio Size	200 Loans	400 Loans	800 Loans
100%	499	499	497
90%	359	209	79
80%	139	46	10
70%	44	4	1
60%	12	0	0
50%	2	0	0



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## Equity Release ALM Reliability

- It is possible to hold cash to fund future deficits in all simulations
- Is this sufficiently “fixed” to qualify for the SII MA?

Cash to Fill Deficits in all 500 Simulations (% of undiscounted liabilities)			
ERM Portfolio Size	200 Loans	400 Loans	800 Loans
100%	£73m (8%)	£120m (7%)	£194m (5%)
90%	£50m (5%)	£76m (4%)	£109m (3%)
80%	£26m (3%)	£32m (2%)	£41m (1.1%)
70%	£2.8m (0.3%)	£0.8m (0.0%)	£0.5m (0.0%)
60%	£1.5m (0.2%)	N/A	N/A
50%	£0.2m (0.0%)	N/A	N/A



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## Equity Release ALM Reliability

- We need less cash if we aim for 90% of simulations
- Is this sufficiently “fixed” to qualify for the SII MA?
- Where’s the split between BE ALM and risk capital?

Cash to Fill Deficits in 90% of Simulations (% of undiscounted liabilities)			
ERM Portfolio Size	200 Loans	400 Loans	800 Loans
100%	£20m (2%)	£28m (2%)	£41m (1%)
90%	£6m (1%)	£5m (0.3%)	£1.3m (0.0%)
80%	£1m (0.1%)	N/A	N/A
70%	N/A	N/A	N/A
60%	N/A	N/A	N/A
50%	N/A	N/A	N/A



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## Equity Release and ALM...A Work in Progress

Next steps:

- Thinking about BAU: what do you do with greater than expected repayments? When do you start to worry?
- Dealing with basis risk and model risk
- Drawing the line between the Best Estimate and Solvency II Risk Capital
- Calculating realistic risk capital requires a plan!



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## Equity Release and ALM...Reality Check

### Discussion

- Matching, even with bonds, after 30 years? 50?
- SII, MA, ring-fencing: what do you do with the long-term, unmatched equity release cash flows?
- What would you do with this type of equity release model if you had it? How would it fit with existing ALM models? How would they need to be adapted? What else would this ALM suite then be capable of?
- Is this model spurious? Are simpler, deterministic closed-form models good enough? Are they reliable?



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**Questions**

**Comments**

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