



Institute
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Risk-Based Profit and Loss Attribution for Annuities

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Attribution Working Party



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Original motivation (1)

- Existing AoS process for annuity business inadequate to provide required understanding within timescales
- Fundamental redesign of process called for
- Issues reconciling AoS items with stresses from ICA

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Original motivation (2)

- Existing process depended fundamentally on fixed order in which risks were assumed to occur
- Time-consuming
- Practical difficulties verifying that ordering being applied consistently throughout → reliability issues
- Paper to 2012 IAA Life Section Colloquium:
<http://www.actuaries.org/mexico2012/papers/Lockwood.pdf>
- Working Party established to articulate methodology in a way more accessible to practitioners

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Working Party members

- Chair: Oliver Lockwood
- Ravi Dubey
- Margaret Emery
- Kevin Engelbrecht
- Andrew Scott

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Reasons for focus on annuity business

- Simple type of business to use to illustrate concepts
- Liability cash flows do not depend on asset performance
- Historic compulsory annuitisation → financially significant

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Risk factors

- Start from risk factors in internal model

	GBP	EUR	USD
Interest rates	3	3	3
Inflation	3	3	3
Government bond spreads	3	3	3
Supranational bond spreads	1	1	1
Corporate bond spreads	7	7	7
Currency movements relative to sterling	N/A	1	1

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Further detail on risk factors

- Base yield curve = swap yield curve – credit risk adjustment. This is starting point for spreads
- Interest rate, inflation and government bond spread stresses derived by principal component analysis, but with adjustments for smoothing and tapering down to fixed ultimate forward rate
- Government bond spread and inflation stresses are to forward rates. Interest rate stresses are to log forward rates, to avoid negative forward rates
- Level spread movements only
- Corporate bond spread stresses relative to next higher rating rather than risk-free yield curve, to avoid correlations close to 1
- Risk factors are movements in market indices, rather than in specific assets held

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Credit migration risk (1)

- Derive a base and a stressed transition matrix by reference to historic rating agency data
- Assets may transition between rating classes at different rates from those in base transition matrix
- Assets transition between spread curves for different ratings
- Partial offset on liability side if matching adjustment (MA) used

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Credit migration risk (2)

- Stressing future transition matrix increases fundamental spreads
 - More assets default
 - More assets are sold on being downgraded below investment grade
- Only applies when fundamental spreads are above floor of 35% of long-term average spreads

Longevity and expense risks

- Can be brought into same P&L attribution framework as asset risks
- Requires look-through to how liability cash flows are derived
- Expense risk relatively straightforward
- Longevity risk more complex - depends on age, gender and possibly block of business

Value metric in which to perform P&L attribution

- Theoretical framework completely general
- Bottom line value metrics, e.g. own funds, most relevant in a reporting exercise
- Useful for illustrating concepts to consider assets and liabilities separately
- In this example:
 - Assets
 - Own funds without MA = Assets – BEL without MA
 - Own funds with MA = Assets – BEL with MA
 - NB: no risk margin as all risks hedgeable (except credit migration risk, for which a bespoke allowance is made)

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Taylor series expansion

Change in value metric

= Expected closing value – Opening value

+ Actual closing value – Expected closing value

= Expected change

+ f(Expected value of variable 1 + Risk factor 1,

Expected value of variable 2 + Risk factor 2, ...)

- f(Expected value of variable 1, Expected value of variable 2, ...)

= Expected change

+ Sensitivity to risk factor 1 * Risk factor 1

+ Sensitivity to risk factor 2 * Risk factor 2 + ...

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Expected position

- Does not fall out automatically, so needs to be defined
- Needs to be commercially acceptable as a forecast, **but** rigour of P&L attribution process imposes realism
- Definition open to debate subject to meeting these criteria

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Expected position example

- Forward rates or spreads:

Year 1	Year 2	Year 3
0.5%	1.0%	1.5%

- Risk-free yield curve after one year:

Year 1	Year 2
1.0%	1.5%

due to no-arbitrage arguments

- A-rated corporate spreads after one year:

Year 1	Year 2
0.5%	1.0%

possibly more appropriate due to rating transitions

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Deviation terms (1)

- Shape of yield curve movements will not in general be in line with risk factors
- Define: Deviation term = Actual ZCB price – Expected ZCB price
 - Sensitivity of ZCB price to risk factor 1 * Risk factor 1
 - Sensitivity of ZCB price to risk factor 2 * Risk factor 2 – ...
- Add deviation terms into Taylor series expansion
- Could have a deviation term for:
 - Each month (but potential excessive run time)
 - Each calibration point (but complications with expected roll-forward)

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Deviation terms (2)

- Corporate and supranational bond spreads: Similar to yields
- Credit migration experience: Deviation term for each asset and each rating the asset could transition to
- Future credit transitions: Deviation term for each entry of transition matrix
- Inflation experience: Deviation term for each actual emerging RPI figure
 - Need historic RPI figures as well as latest one because of indexation lagging

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Solving for the amounts of the risk factors that have occurred – Assumption changes

- Corporate bond spreads, supranational bond spreads, credit migration experience:
 Σ (deviation terms) = 0 gives a linear equation to be solved
- Inflation:
 - Vector of deviation terms should have zero component in direction of each risk factor
 - Gives 3 simultaneous linear equations
- Interest rates and government bond spreads:
 - Need to solve for both at once
 - Gives 6 simultaneous linear equations

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Solving for the amounts of the risk factors that have occurred – Experience variances

- Bring experience variance deviation terms into same equations as assumption change deviation terms, rather than setting up separate experience variance risk factors
- Maintains consistency of risk categorisation with internal model
- Can still report experience variances separately when required for presentational purposes

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Specimen results – Sterling interest rate risk

	Assets	Own funds without MA	Own funds with MA
Risk factor 1	(58.6)	(1.4)	(1.6)
% of risk factor occurred	47%	44%	45%
Sensitivity to risk factor	(124.7)	(3.2)	(3.6)
Risk factor 2	59.1	(1.2)	(1.2)
% of risk factor occurred	(73)%	(75)%	(76)%
Sensitivity to risk factor	(80.9)	1.6	1.5
...			

- Small own funds sensitivities due to close matching
- Takes account of more assets needing to be held to back BEL when there is no MA
- Risk factor %'s slightly different in each column due to weighting differences

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Specimen results – Sterling inflation risk

	Assets	Own funds without MA	Own funds with MA
Risk factor 1	28.3	0.8	0.8
% of risk factor occurred	65%	62%	64%
Sensitivity to risk factor	43.6	1.3	1.2
Risk factor 2	13.2	(0.4)	(0.4)
% of risk factor occurred	48%	46%	46%
Sensitivity to risk factor	27.4	(0.9)	(0.8)
...			

- Similar sensitivities to sterling interest rate risk, but smaller magnitude of asset stresses because:
 - Inflation stresses only apply to inflation-linked assets and liabilities
 - Lower volatility of risk factors

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Specimen results – Currency risk

	Assets	Own funds without MA	Own funds with MA
EUR currency risk	1.8	1.8	1.8
% appreciation of EUR	9%	9%	9%
Sensitivity to a 1% appreciation	0.2	0.2	0.2
USD currency risk	1.1	1.1	1.1
% appreciation of USD	(11)%	(11)%	(11)%
Sensitivity to a 1% appreciation	(0.1)	(0.1)	(0.1)
...			

- Zero liability sensitivities, as liabilities denominated in sterling in this example
- Small asset sensitivities, in view of hedging
- Similar comments apply to overseas interest rate and inflation risks

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Specimen results – Spread risks

	Assets	Own funds without MA	Own funds with MA
GBP supranational bond spreads	(1.4)	(1.4)	0.1
Spread widening occurred	0.21%	0.21%	0.21%
Sensitivity to a 1% widening	(6.8)	(6.8)	0.4
GBP A-rated corporate bond spreads	9.5	9.5	0.2
Spread widening occurred	(0.32)%	(0.32)%	(0.32)%
Sensitivity to a 1% widening	(29.7)	(29.7)	(0.7)
...			

- NB: material spread risk may remain after MA in some circumstances, because of regulatory restrictions on credit for MA for certain types of asset, e.g. callable bonds

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Specimen results – Credit migration risk

	Assets	Own funds without MA	Own funds with MA
Credit migration risk	(14.4)	(14.4)	(3.6)
% of risk factor occurred	36%	36%	36%
Sensitivity to risk factor	(40.0)	(40.0)	(10.0)

- Only partial offset via MA when migration experience is different from that expected
- May also be changes in future fundamental spread assumptions, affecting MA only
- No changes in future fundamental spreads in this example, as equal to floor

Unexplained

- Only two possible causes:
 1. Data changes not mapped to a risk factor
 2. Higher-order terms in Taylor series
- If unexplained too large, then attempt to rule out 1. before quantifying higher-order terms
 - Data errors
 - Risks not allowed for in internal model
- Consider structure of risk factor definitions to identify which higher-order terms are likely to be significant

Extension to new business risks

- Suggest bringing these into P&L attribution in same way as any other type of risk
- Expected position would use:
 - Sales volumes in line with business planning forecasts
 - Levels of profitability targeted by pricing process
- Independent verification that level of profitability targeted by pricing process is being achieved in practice
- Risk factors for:
 - Variance in sales volumes against those expected
 - Variance in profitability against that expected

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Extension to value metrics that do not vary smoothly

- Examples:
 - Fundamental spreads only vary with credit transition matrix when they are above floor
 - Limited price indexation
- Similar problem in Economic Capital modelling – cannot sensibly fit smooth formulae to quantities that do not vary smoothly
- Can be dealt with by adding indicator variables as additional risk factors

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Extension of remit of Working Party

- SII/Economic Capital modelling generally uses instantaneous stresses
- Only difference is that instantaneous stresses are calculated on an actual balance sheet, P&L attribution coefficients on an expected rolled-forward balance sheet
- Gives means of quantifying instantaneous stresses without a separate model run on each set of stressed assumptions
- Significant opportunity to improve efficiency of SII/Economic Capital reporting processes, including risk margin

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Developing an Excel-based tool

- Import asset data and liability cash flows to provide a P&L attribution and calculate instantaneous sensitivities for any annuity fund
- Not yet released outside Working Party, as limited testing on actual data carried out
- Release publicly once a reasonable amount of testing has been performed
- Wikipedia-like model
- Macro to analyse dependency structure of variables and identify those needed for current application
- Version control process

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Common code for all risk factors

- e.g. Sensitivity of matching adjustment = Sensitivity of asset-based discount rate – Sensitivity of risk-free rate
- Useful to be able to specify this simultaneously for all risk factors and all deviation terms
- Creates flexibility to use alternative risk categorisations
 - Different companies will use different categorisations in internal models and/or be on Standard Formula
 - Internal model categorisations not always most useful categorisations for managing the business, e.g. monitoring investment performance
 - Not all applications require most granular categorisation

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Renaming of Working Party

- Renamed to 'Industrialising Financial Reporting WP'
- Techniques applicable to all forms of financial reporting, and to any type of business
- Opportunity for increased consistency and transparency of reporting practices
- Techniques unlikely to be developed separately by each company, for resourcing reasons

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Questions



Comments

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