Implementing Economic Capital in APAC
1. **Overview of Economic Capital in APAC (review of previous material)**
   - Regulatory environment in APAC
   - What is Economic Capital
   - Approaches to implementing Economic Capital

2. **Beyond regulatory capital**

3. **Making the most of Economic Capital**
Brief Overview of Economic Capital
Regulatory drivers in APAC

**Australia**
- Principle-based approach with standard formula, similar to SII
- ICAAP requirement

**China**
- Economic Capital reporting requirement
- C-ROSS finalised - expected in 2016

**Japan**
- Field Tests of Economic Value-Based Solvency Regime

**Singapore**
- RBC-2 Review
- Own Risk and Solvency Assessment

**Hong Kong**
- Consultation on RBC framework

**International Association of Insurance Supervisors**
- Core Principles
Economic Capital – basic concept

1-year (say) Value-at-Risk of a market consistent balance sheet

- A probability-based risk measure (A view of the future)
- Market-consistent liability valuation (Estimating the fair value)
Why Economic Capital?

» Regulatory Capital
  – Prescriptive – although benefit of less prescriptive approaches recognized – e.g. ORSA
  – May not reflect the economic reality & risks an entity faces.
  – Attempts to ensure business are not under-capitalized

» Economic Capital
  – Based on the *economic* risk that an entity is running, and realistic balance sheet.
  – Potentially more granular – carried out at portfolio/project/exposure level – to facilitate decision making.
  – To run the business!!

Of course we do see overlap.
Measuring probability

Economically coherent stochastic modelling of the paths of a wide array of risk **Marginal distributions**

- Models should capture stylized facts
- What is the likelihood of extreme events for each individual variable?

**Dependence structures**

- Traditional correlation measures of dependency are limited, it doesn’t uniquely specify the dependency structure
- Need a measure which captures the entire dependency structure (Copulas)
- What is the likelihood of extreme events occurring simultaneously?
Consistent modeling framework

Interest rates
- Bonds
- Nominal/real rates

Equity markets
- Sectors
- Broad market indices

Credit

Real estate

Currency

Inflation

Diagram:
- Equity returns
- Property returns
- Alternative asset returns
- Corporate bond returns
- Initial swap and government nominal bonds
- Nominal short rate
- Real short rate
- Inflation expectation
- Realised inflation
- Foreign rates, inflation
- Credit risk model
- GDP and real wages
- Exchange rate
Liability valuation

Life insurance liability valuation cannot be obtained from a data screen…

<table>
<thead>
<tr>
<th>Economic Valuation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aim</strong></td>
<td>Fair Valuation</td>
</tr>
<tr>
<td><strong>Complexity</strong></td>
<td>Long-term path-dependent guarantees</td>
</tr>
<tr>
<td><strong>Valuation methods</strong></td>
<td>Monte Carlo simulation</td>
</tr>
<tr>
<td><strong>Sensitivity to market</strong></td>
<td>High</td>
</tr>
<tr>
<td><strong>Model choice</strong></td>
<td>Consistent with observable market prices as much as possible</td>
</tr>
</tbody>
</table>
A nested stochastic problem
Stress-and-correlate

Identify the 99.5th percentile of each risk factor and the capital charge

Determine diversification and overall capital by a correlation matrix

\[
\text{Total Capital} = \sum_{ij} \text{Corr}_{ij} \times \text{Capital}_i \times \text{Capital}_j
\]
Stress-and-correlate

Simplest method, BUT with big assumptions:
1. Loss is a linear function of the risk factors
2. Risk factors are jointly normally distributed

Bivariate Normal Distribution

Fat Tail, Tail Dependency?
Nested Stochastic

The full nested stochastic approach requires a full set of market consistent scenarios for each 1 year VaR scenario.

This is not practical for life insurer ALM model

### Scenario Budget

<table>
<thead>
<tr>
<th>Scenario Type</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year VaR Scenarios</td>
<td>100,000+</td>
</tr>
<tr>
<td>Market Consistent Scenarios</td>
<td>5,000</td>
</tr>
<tr>
<td>Total Scenarios</td>
<td>500,000,000+</td>
</tr>
</tbody>
</table>
**Curve Fitting**

Fits a polynomial function through a set of chosen points with accurate valuations

Still a constraint to ALM

<table>
<thead>
<tr>
<th>Scenario Budget</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year VaR Scenarios</td>
<td>50</td>
</tr>
<tr>
<td>Market Consistent</td>
<td>5,000</td>
</tr>
<tr>
<td>Scenarios</td>
<td></td>
</tr>
<tr>
<td>Total Scenarios</td>
<td>250,000</td>
</tr>
</tbody>
</table>
Least Squares Monte Carlo

More fitting points with reduced number of market consistent scenarios

Better fit in capturing the overall shape

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year VaR Scenarios</td>
<td>50,000</td>
</tr>
<tr>
<td>Market Consistent Scenarios</td>
<td>2</td>
</tr>
<tr>
<td>Total Scenarios</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Applying LSMC

There are four main steps followed to derive the liability proxy function:

1. **Step 1**
   - Identify risk and generate fitting points

2. **Step 2**
   - Calculate liability PV for each fitting point

3. **Step 3**
   - Run Optimisation to fit PVs

4. **Step 4**
   - Validate proxy function using accurate valuations
Economic Capital Methods

Key criteria for a good method:

- **Accuracy**
  - Tail estimate, joint risk factor dynamics, non-linearity…

- **Measurability of errors**
  - How good is the fit (and how to validate)?

- **Fitting efficiency**
  - Number of simulations needed?

- **Ease of implementation**
  - Fast, automated, easy to communicate, need subjective judgments?

- **Use as a practical management tool**
  - Provide full probability distribution, extendable to multi-year projections?
## A comparison

<table>
<thead>
<tr>
<th></th>
<th>Stress-and-Correlate</th>
<th>Curve Fitting</th>
<th>LSMC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Measurability of errors</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fitting efficiency</td>
<td>○</td>
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<tr>
<td>Ease of Implementation</td>
<td>○</td>
<td>○</td>
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<tr>
<td>Use as a practical management tool</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Applications of Proxy Modeling

- 1-year VaR Capital Calculation
- Multi-year Capital Projection
- Projection of Dynamic Hedging Strategies
- Assessment of Asset Strategies
- Regular Monitoring and Stress Testing
2

ORSA and multi-year projection
Own Risk and Solvency Assessment (ORSA): converging global standards

» ORSA is emerging as a global regulatory standard
  » Pillar II of Solvency II
  » Why ORSA?
  » Can be easily added to an existing regulatory environment
  » The ORSA adds a forward looking measure often lacking in existing frameworks
  » Included in IAIS Insurance Core Principles – so eventually everyone will have to have an ORSA
  » Low regulatory overhead

» ORSA implementation approaches have local differences, but in all cases they require insurance firms to make assessments of their current and future solvency capital requirements
  » Focus here on quantitative, rather than qualitative requirements
Quantitative modelling requirements of ORSA

» Regional variations exist, but broad modelling requirements of ORSA could be considered in three categories:

» Backward-looking
  » Analysis of annual change in regulatory reserves (i.e. MCEV, SII TP)

» Current-looking
  » Real-time monitoring of regulatory capital requirements
  » Own assessment of current solvency capital requirements (compared to e.g. Prescriptive standard formula calcs)

» Forward-looking
  » Multi-time-step forward projection of solvency capital requirements (regulatory capital and / or economic capital)
Projecting the balance sheet

- Forward looking analysis of solvency & capital requirements.
- Potentially complex depending on the nature of assets and liabilities.
- Data and calculation intensive nxN more than the initial solvency calculation.
- Significant expert input – scenarios, calibration, approximation methods etc.
Calculating solvency capital along the path

Multi time-step projection is orders of magnitude more calculation intensive than a capital calculation.

For a number of planning scenarios we need to be able to calculate the required capital in every one of the next 5 years.

» This will allow us to derive a full distribution of future capital.
A simple approach to multi-year LSMC?

One year LSMC

Multi-year LSMC

- Computational demand (roughly) scales with number of years
- In general risk factors at years 2, 3,... need to capture path dependency
- May present practical implementation challenges within cash flow model
‘Local’ vs ‘Global’ fitting

» ‘Local’ fitting

Separately calibrate different proxy functions for each time $t$:

$$\text{Market-consistent value}(t) = f_t(risk\ factors)$$

A potential drawback with this fitting method is that certain coefficients in the polynomial may vary widely over time.

» ‘Global’ fitting

Include time as an additional variable and calibrate once:

$$\text{Market-consistent value}(t) = f_{global}(time, risk\ factors)$$

Equivalent to assuming that the coefficients of the ‘local’ polynomials $f_t$ are themselves polynomials.
Multi-Year Fitting Case Study
Product Example

» Annual return credited to policyholder is calculated as
  – Credited return (t) = max (Fund return (t) – 1.5%, 2%)
  – i.e. Policy Account (t) = Policy Account (t-1) * (1+ credited return (t))
  – Policy Account (0) = Asset Portfolio Value (0)
  – Product pay-out at time 10 is Policy Account (10)

» Asset fund invested in diversified portfolio of investment-grade corporate bonds
  – 70% A-rated
  – 30% BBB-rated
  – Term of 8 years
  – Re-balanced annually

» No allowance for taxes, expenses, lapses, mortality
Market consistent liability valuation

» The policy pay-out is path-dependent, i.e. it is a function of the 10 annual returns, not the 10-year return
  – Market-consistent simulation required to produce time-0 valuation

» Market-consistent liability value at time 0 was calculated to be 119% of the starting fund value in end-2012 market conditions
  – Calculated using market-consistent scenario set for interest rates and corporate bond returns

» How will this market-consistent liability value behave over the 10-year lifetime of the product?
Proxy Function Fitting

» Proxy functions produced using 5 risk factor variables
  – Two risk-free yield curve factors
  – Interest rate volatility factor
  – Credit return factor
  – Policy account value (i.e. roll-up of credited returns)

» Proxy functions produced for valuation at each time-step using the ‘global’ and ‘local’ methods described earlier

» Functions fitted to quadratic term in individual risk factors and cross-terms

» Fitted local functions had around 10 statistically significant parameters

» Global function had 32 statistically significant parameters
Out-of-Sample Validation Results – Year 1

'Local' fit

- Adverse scenarios
- Random scenarios

'Global' fit

- Adverse scenarios
- Random scenarios
Out-of-Sample Validation Results – Year 9

'Local' fit

1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1

Proxy

Actual

Adverse scenarios
Random scenarios

'Global' fit

1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1

Proxy

Actual

Adverse scenarios
Random scenarios
Illustrative Analysis (1): Stochastic Projections

» Market-consistent deficit is *expected* to reduce over time due to risk premium in asset fund

» **In this example we can observe that there is only** c30% probability of the product pay-out being less than final asset portfolio value
Illustrative Analysis: (1) Stochastic Projections

Projected Net Assets in year 5

In this example there is strong exposure to credit spread behaviour

High risk-free rates are also onerous for the shareholder in this example product, but not as significant as credit spreads
Illustrative Analysis: (2) Reverse Stress Testing

Economic scenario path for worst ranking simulation

- Rank year-5 real-world scenarios by market-consistent deficit
- This scenario has the biggest deficit at year-5
- The economic scenario is consistent with previous scatterplots
### ORSA: Example Stress Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Real GDP</th>
<th>Median Home Price</th>
<th>Fed Funds Target</th>
<th>Unemployment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S1</strong> Stronger Recovery</td>
<td>Real growth of 4.4% in 2010, 4.2% in 2011</td>
<td>Peak-to-trough decline of 23%, turnaround at the middle of 2010</td>
<td>The funds rate is expected to end 2010 at 2.1% and 2011 at 3.7%</td>
<td>Peaks at 10.1% in Q4 2009 and ends 2010 at 8.7%</td>
</tr>
<tr>
<td><strong>BL</strong> Great Recession</td>
<td>Real growth of 2.8% in 2010, 3.6% in 2011</td>
<td>Peak-to-trough decline of 34%, turnaround in early 2011</td>
<td>The funds rate is expected to end 2010 at 0.9% and 2011 at 3.0%</td>
<td>Peaks at 10.4% in Q4 2010</td>
</tr>
<tr>
<td><strong>S2</strong> Deeper Recession</td>
<td>Real growth of 1.7% in 2010, 1.4% in 2011</td>
<td>Peak-to-trough decline of 40%, turnaround after mid-2011</td>
<td>The funds rate is expected to end 2010 at 0.2% and 2011 at 1.2%</td>
<td>Peaks at 12.5% in early 2011</td>
</tr>
<tr>
<td><strong>S3</strong> Very Severe Recession</td>
<td>Real growth of 1.2% in 2010, -0.6% in 2011</td>
<td>Peak-to-trough decline of 45%, turnaround at beginning of 2012</td>
<td>Rate remains below 1% until mid-2012</td>
<td>Peaks at 14.1% in mid-2011</td>
</tr>
<tr>
<td><strong>S4</strong> Depression</td>
<td>Real growth of 0.9% in 2010, -1.8% in 2011</td>
<td>Peak-to-trough decline of 49%, turnaround in late 2012</td>
<td>Rate remains below 1% until late 2013, but raises steadily and slowly from the middle of 2011</td>
<td>Peaks at 15.0% in early 2012</td>
</tr>
<tr>
<td><strong>S5</strong> Double Dip</td>
<td>Real growth of 1.4% in 2010, 1.7% in 2011</td>
<td>Peak-to-trough decline of 32%, turnaround in early 2011</td>
<td>The funds rate is expected to end 2010 at 0.1% and 2011 at 1.2%</td>
<td>Peaks at 11.5% in Q1 2011</td>
</tr>
</tbody>
</table>
Illustrative Analysis: (3) Scenario Testing

Apply 7 macro-economic stress tests

- Baseline forecast
- Stronger Near-Term Rebound
- Slower Near-Term Growth
- Double-Dip Recession
- Protracted Slump
- Below-Trend Long-Term Growth
- Oil Price Increase, Dollar Crash Inflation

- 7 macro-economic, multi-year stress tests specified by Moody Analytics ECCA team
- Proxy function used to project liability valuations through these scenarios
- What is happening in the oil price scenario?!
**Illustrative Analysis: (3) Scenario Testing**

- **Very significant yield curve increases in the early years of the product.**
- **Asset fund value falls by 40% after two years**

**Oil Shock Scenario**

- This down-then-up path is very bad for the product (shareholders)
  - Early poor returns clearly hurt due to 2% minimum guarantee
  - Later strong returns also hurt as they are applied to the policy account value, which is much greater than the asset portfolio value

![Graph showing yield curve and asset fund value trends over years]

**This is followed by very strong bond returns in later years**
Comparing Stress Test and Simulation Results

» The Oil Shock stress test produced a year-5 asset-liability deficit which was almost double the deficit in the 99th percentile of the stochastic projection

» Ultimately, insurance firm must judge whether the oil scenario is an example of event risk that is not being well-captured by a stochastic model...

» …or whether the probability of such an 5-year economic path is extremely low

» In general, probabilistic long-term projection inevitably involves significant expert judgement and we can rarely claim to hold the single version of the ‘truth’

» This is why we believe these different techniques are complementary and add insight when considered together
# Stress Testing – Key Challenges for Insurers?

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Scenario Design**    | • Scenario design is at the heart of a stress testing framework.  
                          • Need to be able to define “Narrative” planning scenarios for business planning  
                          • Regulatory & “Narrative” planning scenarios need to be translated into fully articulated scenarios that can be used by insurer’s various projection engines.                                                                 |
| **Projection & Consolidation** | • Multi-year projection of assets, liabilities, revenue items and capital in a robust and consistent way across a complex business is challenging  
                          • Consolidation of projected results across entities/business units (e.g. Life, P&C, Health etc.) and a range of accounting and solvency regimes is not straightforward.                                      |
| **Performance**        | • Being able to assess the impact of different scenarios quickly is challenging across existing infrastructure.  
                          • Stress testing increasingly being used as part of the regulatory toolkit and regulators will expect fast turnaround on requests.                                                                 |
| **What-If Analysis**   | • Business will require what-if capability to support risk-based decision-making.  
                          • Need to support wide range of stakeholders – External (e.g. regulator) and internal.                                                                                                                   |
| **Methodology**        | • A robust projections/stress testing capability will require clearly defined methodologies for complex areas such as path dependent liabilities, asset projections, capital projections, tax etc.                                                                                                   |
| **Integration**        | • Existing infrastructure unlikely to have been designed to meet needs of multi-year stress testing framework in terms of performance.  
                          • Extracting, consolidating and aggregating all the analytical data at the level of granularity required by the business is a major challenge.                                                                 |
3

Economic Capital in Practice
## Economic Capital/Internal Model Elements

**What we have discussed today:**

<table>
<thead>
<tr>
<th>Required Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1-year (multi-year) VaR Risk Scenario</strong></td>
<td>• Projection of market and non-market risks, with an associated dependency structure over a 1 year time horizon using range of models including structural and statistical models.</td>
</tr>
<tr>
<td><strong>Asset &amp; Liability Proxy Functions</strong></td>
<td>• Replicates complex liability (and asset) models using mathematical functions by Least Squares Monte Carlo and curve fitting approaches.</td>
</tr>
</tbody>
</table>

What else do we need?
Economic Capital in practice – aims?

Driven by regulators, rating agencies or an internal desire to manage risks more effectively, the insurance industry is increasingly using risk-based capital as a metric for managing their business.

» Attribution and allocation of capital

» Insurance group risk management

» To meet the needs of the “Use Test”

» What-if Analysis

Coupled with:

» Increase reporting requirements – and tighter deadlines!

» Risk Data and IT system requirements – data integrity
## The Challenge

The Challenge: Implement a robust fast Monte Carlo capability for Internal Model calculations that can support the Use Test.

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk-Based Decision Making</td>
<td>• Internal Models must be able to meet the needs of the “Use Test”. Having What-If capability is critical to supporting the needs of using it in the business.</td>
</tr>
<tr>
<td>Business Analytics</td>
<td>• Most insurers will have to invest in new tools, techniques and technology to provide the range of risk, solvency and capital metrics to support risk management analysis and decision making.</td>
</tr>
<tr>
<td>Aggregation Performance</td>
<td>• Monte Carlo aggregation is challenging from a performance perspective. Running 1+ million scenarios across many risk factors and asset/liability proxy models is not a trivial calculation, requiring an industrial strength aggregation engine and robust data management capabilities.</td>
</tr>
</tbody>
</table>
| Proxy Model Calibration Timescales  | • Asset and liability proxy functions are increasingly been used for Internal Models.  
• Implementing a consistent production ready proxy calibration process is a significant challenge, particularly to meet regulatory requirements such as Solvency II.                                  |
| Risk Factor Modelling               | • Setting the real world stochastic assumptions, calibrating appropriate risk factor models and generating risk factor scenarios lie at the heart of an Internal Model, requiring specialist knowledge, expertise and solutions. |
| Data Management                     | • Extracting, consolidating and aggregating all the data required for Internal Models is a major challenge particularly for insurers with complex entity structures.  
• Data quality, standards and consistency also a significant problem |
Platform overview
Enterprise framework

A controlled enterprise environment to manage business processes in a multi-user/multi-site environment.

**INPUT**

- Assets
- Liabilities
- Finance Data
- Calibration Data
- Market Data
- Stresses
- Assumptions

**CONFIGURE**

- Organisational Structure
- Risk Hierarchy
- Risk Factors
- Modelled Balance Sheet
- Scenario Generation
- Stress Mapping
- Proxy Functions
- Calculation Configuration

**CALCULATE**

- Risk Scenarios
- Balance Sheet
- Aggregated Capital
- Attributed Capital
- Solvency Metrics
- Risk Metrics

**REPORT**

- Regulatory Reporting
- Business Reporting
- Analytics
- Key Risk Indicators

**REFINE**

- Risk Based Decision Making
- Business Planning
- Investment Strategy
- Hedging
- Stress Testing

**DATA MART**

Data Integration, Storage, Security, Audit and Workflow Capabilities
Infrastructure
Capital Attribution – case study
Capital attribution

Insurers are often interested on quantifying how the overall capital can be attributed to:

1. Sub-portfolios (e.g. Business units, geographical locations, product types)
2. Risk factors
Capital Aggregation

1. Organisational Structure
Organisational structure and associated node attributes provides the foundation for the capital calculation.

2. Asset & Liability Modelling
Assets & Liabilities modelled using proxy functions from RiskIntegrity Proxy Generator.

3. Risk Scenarios
Can upload 1 year VaR scenario sets from the Risk Scenario Generator. The scenarios are used in the valuation of the assets and liabilities.

4. Capital Aggregation
Aggregation across Organisational Structure using aggregation rules by scenario.

5. Capital Attribution
Capital attribution of aggregated capital metrics across products.

6. Reporting & Analytics
Standard reports, business analytics & intermediate outputs.
Results
Product Diversification

This chart shows:
The diversification that exists between different products (organisation nodes)
Results
Risk Diversification

This chart shows:
The diversification that exists between the risks affecting a given organisation node, e.g., a product.
Results NAV Distribution

This chart shows:
The distribution of NAV (net asset value) at a given organisation node.
Results
Capital Attribution

This chart shows:
How much of the capital requirement at a given Organisation Node may be attributed to each constituent “product”
Results
Diversification by Product

This chart shows:
How the diversification present at a given Organisation Node may be apportioned between each constituent “product”
Results
Biting Scenario(s)

This chart shows:
The behaviour of the risk factors in the neighbourhood of the biting scenario, for a given organisation node.
Bringing it all together
Business Analytics

Business Intelligence

Ability to leverage underlying data model to create business orientated interactive dashboards

Risk-Based Decision Making

Building capabilities that can facilitate better risk-based decision making.

Implementing Economic Capital in APAC, February 2015
Conclusion

- Risk factor model key to producing realistic distributions
  - Little point of implementing sophisticated techniques if underlying models are wrong!
- Inclusion of complex liabilities adds significant complexity to the problem.
  - Monte-carlo market consistent valuation required
- Stress and Correlate approach a simple solution.
  - But has limitations
- Proxy function approach opens the door to range of useful applications
  - Multi-year projection
  - Fast calculation of “what if” and stress scenarios
  - Timely business analytics (as part of a robust ERM framework)
Questions?
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