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Making Use of Internal Capital Models

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Agenda

1. ***Introduction – Solvency II and market's current state of affairs***
2. ***Risk Appetite in a nutshell***
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   Schematic of IAG Framework
3. ***Benefits of using Capital Models***
4. ***How to construct a good Capital Model***

Conclusions

Introduction – Solvency II and market's current state of affairs

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… Significantly invested to build, develop and refine a Solvency II capital model but yet to use it to add value to your business?… **Is this issue relevant to you?**

Solvency II and insurance industry's current state of affairs

… Significantly invested to build, develop and refine a Solvency II capital model but yet to use it to add value to your business?…

Is this issue relevant to insurance industry?

- Many insurers have invested a significant amount of resources into building, developing and calibrating their Internal Capital Models (ICMs) for the purposes of determining capital requirements and being compliant with Solvency II standards.
- However, very few players across the industry are actively using their ICMs to provide insight into their company and make better informed business decisions.
- Is regulatory compliance the only reason for developing and using the ICM?
- Recent market surveys suggest that two thirds of insurers have reduced their internal model development activity following the announcement of the delay in implementation of Solvency II Directive.
- Integrating ICM into company's enterprise risk processes could actually bring many advantages in addition to model's value in just meeting regulatory requirements.

Solvency II and insurance industry's current state of affairs

Limited scope of ICM build and use – current ICMs are too Solvency II centric

- Using ICM should go well beyond the scope of regulatory compliance and aim at providing greater insight into company's risk profile and assisting management in strategic decision making
- A competitive advantage can be gained by unlocking the potential and making better use of ICM. In particular, ICM could be used as a risk management tool in establishing and supporting Risk Appetite Framework:
  - ***Risk Appetite Framework*** is aimed at identifying management's tolerance of risk and its composite at different levels of company's risk profile and using this information as risk constraints of future risk takings in finding optimal risk and capital structures ensuring efficient capital use and enhanced value of business.
  - ***ICM*** is used as a risk management tool to monitor company's health and how business tracks against the goals and targets set in the Risk Appetite Framework.
  - Inappropriate use of Risk Appetite Framework is costly as it could mislead management in their decision making resulting in
    - departure from the desirable form of company's risk profile tolerated by investors, which in turn could lead to depreciated market value of business; and
    - increased cost of financial distress and insolvency.

Solvency II and insurance industry's current state of affairs

Common shortfalls of ICMs recently developed by insurers. Many those models have been developed under tight time constraints. Also their modelling capabilities are restricted by weaknesses and limitations of DFA modelling platform …

- **Instability and lack of robustness.** Many ICMs are not stable in the tail of company's risk profile, particularly at the 1-in-200 level of capital requirements. They do not properly model low-frequency extreme events and thus are sensitive to sampling error. This issue has been known by modellers as *'The Tail Wagging the Dog'* syndrome.
- **Inefficiency of model run.** Many ICMs were designed without taking into account the perspectives of future 'model use'. As the result the models are often appear to be unwieldy and such that would require days to run. There are two things that often contribute to this issue
  - *Model design is driven by modelling aspirations* rather than business needs and requirements; and
  - *Level of model design intelligence* – model's ability to prevent re-running of the model's parts that are not meant to be run.
- **Model outputs do not often reflect reality.** For example, modelling of risk interaction and risk aggregation.
- **Compromised transparency.** Is it easy to interrogate the model at the scenario level? Does it provide insight into risk composite at different levels of company's risk profile.

Solvency II and insurance industry's current state of affairs

Questions discussed in this presentation

- Raising awareness of the business requirements that drive the needs for and the design of ICM:
  - ***Risk Appetite Framework*** – understanding company's risk utility function and using it in maximising business value under the constraints of external factors, such as regulators, rating agencies, investors, etc.

    This presentation is mainly focusing on the schematic of one specific *Risk Appetite Framework for Insurance Companies* developed by Insurance Australia Group (IAG).
- **Benefits of using ICM** - how ICM can be used to develop and support Risk Appetite Framework
- Points to consider when **building a good ICM**

Risk Appetite in a nutshell

An example of a good Risk Appetite:
Schematic of IAG Framework of Risk Appetite for Insurance Companies

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… The main purpose of risk appetite framework is to support risk management decision making. In essence, it is like a business navigation tool designed to navigate company's management towards more efficient use of capital and enhanced business value.

Overview of Risk and Capital

Capital is required to support risk assumed by an insurer

- By and large insurers, and in particular stock insurers, leverage themselves by issuing 'risky debt' in the form of insurance policies. In turn assumed risk is financed by
  - Shareholders providing equity (free) capital required to support insurer's solvency; and
  - Policyholders supplying risky debt as a part of operating capital required to generate underwriting profit
- An insurer uses free capital as a buffer against variability in its earnings that avoids 'ruin' and enables it to continue operating in a manner consistent with achieving stated financial objectives
- For an insurer, capital takes on a greater level of importance given the extent of insurance liabilities that are held on the promise of future payment
- Both shareholders and policyholders require a reasonable degree of confidence in the viability of the organisation to realise value from their investment or premiums

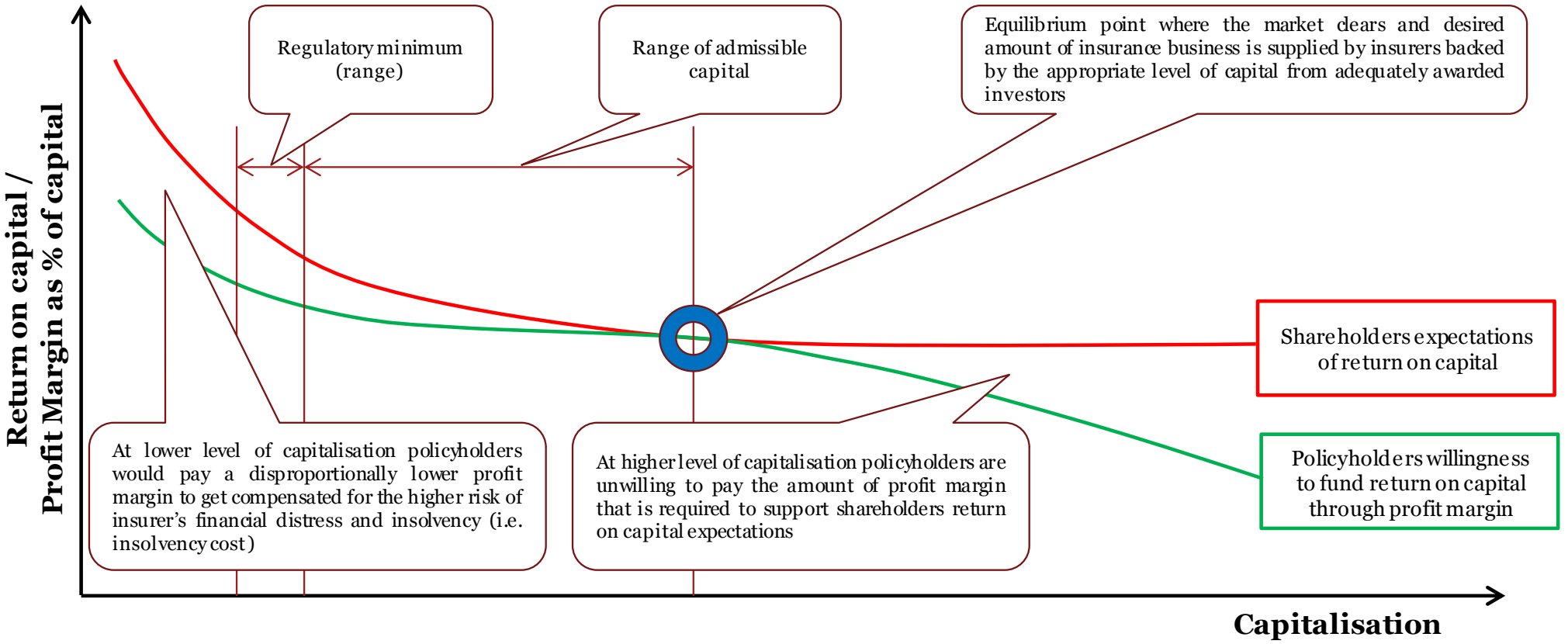
A selection of typical risks faced by the insurer:

- Large catastrophe event (e.g. high category windstorm or high intensity earthquake) striking densely populated and high wealth households areas
- Excessive social (superimposed) inflation in bodily injury classes
- Prolonged and unexpected economic inflation
- Collapse in asset values, particularly equities, as the result of global financial crisis
- Pandemics leading to widespread business interruption
- Collapse in our asset values, particularly equities
- Severe reputational damage leading to loss of confidence or protest actions
- Massive business interruption due to loss of a building
- Loss of reinsurance recovery due to reinsurer's default
- IT systems failure preventing all processing for a prolonged period
- Lack of innovation in insurance products
- Failure of underwriting controls resulting in high risk policies being written
- Large scale fraud, embezzlement
- New products with no data to establish an appropriate price

Overview of Risk and Capital (capital trade-off)

Policyholders would be willing to pay an increasing profit margin for additional security directly associated with insurers capitalisation/solvency level. But this will taper off to a maximum profit margin at some point. When expressed as a percentage of capital, the profit margin has a shape of the curve depicted in green.

Shareholders would progressively require a lower return on an increasing capital base due to decreasing level of risk undertaken by the insurance company. This is represented by the curve depicted in red.



Risk Appetite Framework – general concept

Risk and Capital are linked via company's risk appetite

A typical insurance company usually develops a market proposition and company's strategy after consideration of the exogenous environment and its stakeholders.

This broadly defines the nature of market risk the organisation will absorb and manage in order to deliver enterprise/business value.

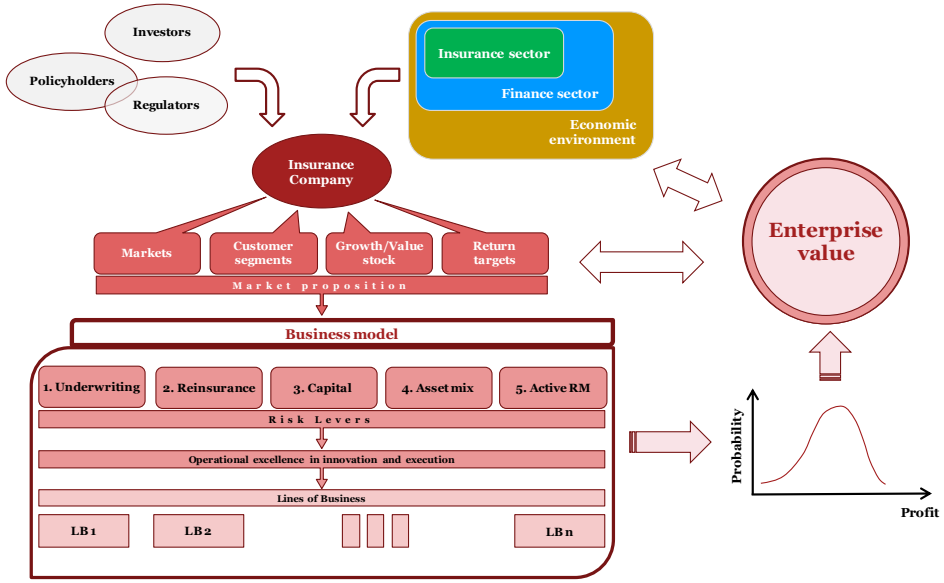
There are five fundamental business risk levers that define the risk appetite in delivering this enterprise value:

1. *Underwriting business;*
2. *Reinsurance;*
3. *Capital adequacy and capital allocation;*
4. *Asset allocation;* and
5. *Active risk management strategies & control environment* (e.g. portfolio mix, dividend policy, contingent capital, credit risk exposure, etc.)

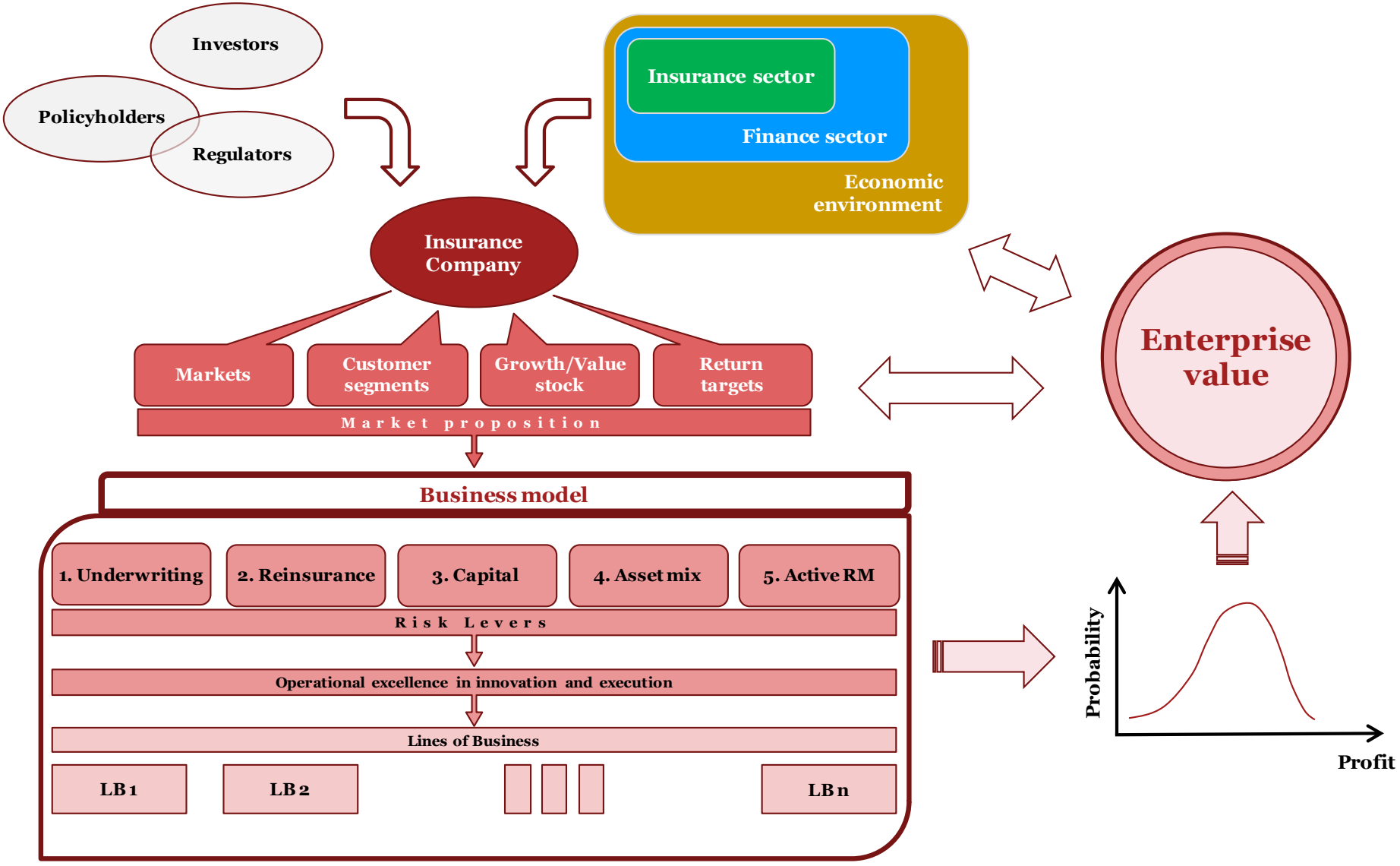
These levers are arranged into a business model that has a focus on alignment, accountability and operational excellence in innovation and execution.

The earnings profile will then be produced that embodies the risk appetite outcomes and drives enterprise value.

Risk appetite is the way in which the fundamental risk levers are applied to produce an earnings profile that supports the overall market proposition and corporate strategy in achieving enterprise value objectives.



Risk Appetite Framework – general concept (zoomed in diagram)



Risk Appetite Framework – key objectives

Provide insightful MI 1

The main purpose of risk appetite statement is to support risk management decision making. In essence, it is like a business navigation tool designed to navigate company's management towards more efficient use of capital and enhanced business value.

Identify 'DNA' of company's risk profile by cascade risk appetite down to a sensible granularity level 2

Being specific about Board's risk attitude helps calibrate parameters of 'business navigation tool'. For example:

- *Maintaining solvency* is not just about gaining insight into risk attribution and related risk exposure limits at the MCR level. It also involves analysing how risks are competing for capital consumption at various points causing financial distress and well before actual regulatory ruin occurs. Put another way, risk attribution of capital consumption for pivotal capital layers helps to understand the evolution path of company's risk profile leading to insolvency. For example, excessive exposure to investment risk or cat risk might not be palatable to existing shareholders/investors as they may see company's main competitive advantage to be in insurance.
- *Stability of earnings growth*. Control of earnings volatility is not always associated with managing 'standard deviation' metric. The aloofness of this risk metric towards up- and down-side potentials should be overcome by considering higher orders of risk profile. Risk managers would, for instance, 'leapfrog' the traditional volatility metric and put more emphasis on the third order of retained risk, i.e. skewness – they might want to know the position of adverse earnings outcomes in the form of insurance margin at say 1-in-4, 10, 20 years level relative to budget central estimate.
- *Strategic view of key risk levers*. Company's long-term view of
  - ***reinsurance purchasing*** – e.g., retention point attaches at 1-in-4 years, vertical cover extends up to 1-in-250 years, horizontal cover is well defined by number of reinstatements and drop-down options;
  - ***strategic asset allocation*** - statement of admissible exposure to investment risk and its composite

Establish risk controls and performance monitoring 3

Putting controls in place and using them to monitor performance against risk appetite statement's targets.

Risk Appetite Framework – key attributes (1)

It begins from defining the fundamental risk of the enterprise 1

It requires understanding risk, defining it from first principles and linking it to risk appetite

The *Enterprise Risk* is generally defined as a possibility of having adverse performance result (insurance, investment, or company's overall result) that results in 'low capital performance' (i.e. a return on capital below the investors' opportunity cost of capital) and/or erosion of current business value (i.e. capital consumptions).

Risk is perceived differently by different stakeholders (policyholders, investors, management, regulators, etc.).

- *Variant 1:* For example, company's management would consider the risk to start materialising when the rate of return on capital falls below the opportunity cost of capital and continues to the point where the capital is eroded to the level of minimum capital requirements (MCR). In the event that capital falls below MCR the regulator would take management control of the company – theoretically the Directors no longer have a direct interest in the company.
- *Variant 2:* From the investors' point of view the risk range is wider, spanning even further down to the point of absolute ruin (full capital erosion). The diagram below illustrates the capital layers supporting the risk range.
- *Variant 3:* On the other hand, policyholders would be mainly concerned with the chance of company going bust and the size of policyholders' deficit at default.

Setting risk appetite is equivalent to determining a 'utility function' of risk averse principal of the company. In practice, company's management (i.e. Board of Directors) act and manage the company on behalf of their principals – investors. Therefore, Variant 1 is the most natural choice of enterprise risk definition. The enterprise risk is thus directly associated with 'capital consumption' to the point where regulatory ruin occurs and management looses control of the company.

Risk Appetite Framework – key attributes (2)

Understanding where the risk is coming from, what carries it and how it 'consumes' capital 2

- Identifying key risk attributors – underwriting, catastrophe, reserving, market, credit, operational
- Defining and modelling their corresponding 'risk carrier' – e.g., operating profit before tax

Using risk carriers to quantify interaction and dependencies between various types of risk 3

- This will determine the methodology of risk attribution and capital allocation
- Attribution of various types of risk to overall capital requirements at the pre-specified level will help establish exposure limits for each risk category.

Specifying strategic key objectives and formalising risk appetite statement 4

- **Examples of strategic key objectives would include:** maintaining solvency, stability of earnings growth, liquidity and adequate access to funding, cherishing enterprise brand and maintaining stakeholder confidence.

Benefits of using Capital Models

3

… Integrating ICM into company's enterprise risk management brings many advantages in addition to ICM's value in just meeting regulatory requirements.

Internal Capital Models

The nature and purpose of ICM:

- The Internal Capital Model (ICM) of an insurer is a financial forecasting system designed to support risk management decision making by placing a probability based statistical distribution around key financial variables such as projected claims, liabilities, asset values.
- This enables the ICM to be used to make predictions, within specified probabilities, of future key performance indicators of the modelled insurer such as profit & loss, return on equity and capital adequacy relative to minimum capital requirements specified by a regulator.
- The ICM is based around the insurer's budget and current balance sheet. It works by placing a statistical distribution based on past experience of key insurance portfolios around the key elements of the budget (premium volumes, loss ratios, investment income etc) so as to produce many equally likely scenarios for future emerging balance sheets and income statements, starting from the current balance sheet position.

ICM addresses questions such as:

- How likely is it that the insurer will be unable to meet policyholder claims as they fall due? (i.e. economic ruin).
- How likely is it that the Economic Capital will fall below the minimum regulatory capital requirements, resulting in regulatory ruin?
- How likely is it that the Economic Capital will fall below a certain threshold, leading to a financial distress and triggering potential intervention by the regulator?
- Which lines of business are the most volatile and/or consume more capital and hence require the most capital? (typical question asked when allocating capital to business classes)
- Which lines of business should be expanded, and which need to be contracted?
- What type of reinsurance should the insurer purchase?
- What is the optimal portfolio of reinsurance counterparties?
- How should the insurer optimally invest its assets?

Benefits of using Internal Capital Models

Reduced capital requirements when used for Solvency II:

- *Pillar 1* - switching from the Standard Formula to ICM approach could lead to reduced minimum capital requirements (i.e. capital savings)
- *Pillar 2* - can be used to demonstrate integrated enterprise risk management and model governance capabilities to the regulator
- *Pillar 3* - provides advanced reporting suite and increased transparency of company's risk profile

Enhanced business value when used to support Risk Appetite Framework in business as usual situation:

- Used to support Risk Appetite Framework in providing informative risk management decision making aimed at enhancing business value. For example, in optimising capital structure via ROE maximisation – involves dealing with various risk levers and optimisation of business strategies
- This would usually happen under the settings of multi-year time horizon to get a longer term view of company's risk profile
  - Financial year balance sheet basis more realistic than run-off measures.
  - One year is insufficient to capture evolving risks such as inflation that impacts both premium and provisioning adequacy. This is particularly relevant for insurers writing long tail classes with material balance sheet provisions.
  - One year is insufficient to allow the impacts of an insurance cycle to emerge.
  - Three -year time horizon seems to be optimal – the ability to predict the exposure growth, business mix and profitability in a dynamic market diminishes beyond three years.
  - Capital modelling does not typically include actions taken to address an ailing solvency position. Three years represents a compromise between allowing risks to emerge and being able to effectively mitigate an adverse position.

Examples of ICM use in business decision making (1)

How do we become more capital efficient?

- *Reinsurance optimisation* – has your company purchased the same reinsurance protection each year with little consideration of the impact on capital? The Internal Capital Model is often capable of assessing the value achieved from the existing programme and investigating the benefits to be gained from changes. Reinsurance is the key risk lever used within Risk Appetite Framework to protect against insolvency, maintain stability of earnings volatility and provide capital relief. It is also used as a form of rented capital to replace more expensive paid-in capital.
- *Underwriting portfolio mix analysis* – do portfolio composition decisions incorporate capital efficiency? There is a competitive advantage to be gained by selecting a portfolio mix which offers both strategic sense and capital efficiency. The Internal Capital Model can be used to determine the optimal portfolio structure and unlock the excess capital.

How can we make more informed business decisions?

- *Intelligent pricing of risk* – few companies are effectively allowing for risk within the pricing process. There is value to be achieved by making informed, risk-based decisions at the pricing stage before the company is bound to the risks. Outputs from the Internal Capital Model can feed into an effective risk-based strategic pricing process.
- *Merger / acquisition assessment* – investors are increasingly looking for greater value from their investments; this is often achieved via the merger or acquisition of a target company or strategic sale of a portion of the portfolio. The Internal Capital Model can be used to evaluate potential options to achieve a capital efficient solution.
- *Run-off portfolio management* – many companies manage the run-off of their portfolios in-house without considering the potential drag on capital. Internal Capital Models can be used to assess the marginal impact of actively running-off the reserves compared with more strategic run-off solutions which may unlock capital and free-up resources.

Examples of ICM use in business decision making (2)

How do we better understand our business?

- *Management information* – is the Internal Capital Model used to provide management with insight into their business? The Internal Capital Model contains a vast array of useful information which can be channelled to allow management to better understand the dynamics of their business and make more informed decisions.
- *Diversification* – diversification is a key area which, if fully understood, can enable the business to unlock potential via capital efficiency, better risk management, and providing investors with greater value.

How do we better manage risk?

- *Monitoring risk and performance* – historically risk appetites have been determined without reference to the Internal Capital Model. Setting the risk appetite, tolerances and limits with aid of the Internal Capital Model enables a more powerful and accurate approach to Enterprise Risk Management. Regular monitoring of the company's compliance with the risk appetite can be performed using the Internal Model. This in particular includes risk attribution at different levels of company's risk profile, capital allocation and performance management.
- *Effective risk management/mitigation strategies* – risk managers often use various risk management strategies like risk pooling, risk hedging and risk transfer, both traditional and alternative, to maximise return on investment. The Internal Capital Model can be used to test and evaluate the optimal risk management solution.
- *Risk and Capital Dashboards* – the ICM can be used as an early warning indicator where management decisions are required to correct the trajectory of the business. It could also be used to make real-time portfolio decisions.

Improved efficiency and intelligence of ICM

- *Model fine-tuning* – in order to achieve the competitive advantages set out above, the client's Internal Capital Model may require optimising to reduce run-time and increase the speed of response and flexibility. This will permit faster business decisions and enable a greater level of information to be presented to management.

Capital modelling challenges and how to build a good Capital Model

4

Building efficient capital models

Criteria for a good efficient model

- **Fit for purpose** – model outputs must reflect what was meant to be modelled
- **Adaptable** - is flexible enough to handle different aspects of risk modelling
  - Follows principles of global settings/coding. For example, using variation of existing reinsurance contract/treaty should not trigger a model change, but rather be accommodated via a combination/switch of existing model functions;
- **Robust** - is stable enough to demonstrate its invariance to re-sampling and resistance to biasness
  - Typical examples of the issue leading to model instability would include large sampling error associated with modelling Cats – we are talking about 10% to 15% of sampling error at 1-in-200 capital requirements.
- **Simple and pragmatic**
  - The methodology/approach used in the model should be simple enough so that the model is auditable and such that can be interrogated at the scenario level when required. Although, it should not be overly simple and the reality should not be sacrificed for elegance or simplicity.
  - The model structure should be lean and optimal (intelligent) so that the model run time is within reasonable boundaries.

Being aware of weaknesses and limitations of model platform

Dealing with modelling challenges

- **Pros**
  - Most modern commercial DFA modelling platforms (e.g. Igloo, MoSes, Remetrica) are specifically designed to cope with large scale linear operations.
  - Risks and their components are usually assumed to be modelled using straight forward (Monte Carlo) sampling from distribution curves. Once all the types of risk are modelled the model could utilise the power of modelling platform to easily process financial accounts at the class level and consolidate them across classes and business divisions.
- **Cons**
  - The big hurdle for DFA modelling platforms here though is to get through the maze of 'non-linear' algorithms of modelling certain types of risk, e.g. modelling of credit risk or superimposed inflation involving regime switching, or implementing reinsurance structures of non-linear nature like excess of loss, or non-traditional contracts like LPT/ADC.
  - Another important weakness/limitation – modelling platforms often assume MC simulation approach and have rigid structures preventing modeller to efficiently implement ‘variance reduction’ techniques.
  - Inability of a particular modelling platform to accommodate efficient implementation of a certain non-linear modelling approach or simulation approach could compromise model robustness and/or lead to increased model run time.

Dealing with modelling challenges – real examples (1)

Modelling of rare/extreme events – cat modelling

- This involves dealing with low-frequency and high-severity event losses.
- In the case of Cat modelling the external models, like RMS, AIR, EQECAT, etc., are used. The external models are not simulation engines – they rather provide a useful statistical information, such as Event Loss Tables (ELT) and PML/OEP curve, that can be further unfold to simulate actual cat events.
- Special care needs to be taken when simulating cat event losses. The following things could contribute to inaccurate modelling of risk in the tail and thus have a tremendous impact on capital requirements:
  - *Straightforward Monte Carlo* - it works against us and thus some form of variance reduction techniques is required. Using direct MC approach to modelling cats makes ICM very sensitive to sampling error – having 10% -15% sampling error at 1-in-200 capital requirements makes it impossible to validate the model.
  - *Poor understanding of external model limitations* – e.g. possible event clustering and dependency leading to over-dispersion of event frequency (i.e. the case of non-Poisson frequency).
  - *Cat model uncertainty and choice of cat model blending approach.*
- Inappropriate approach to modelling infrequent extreme events could lead to model instability.

Dealing with modelling challenges – real examples (2)

Cat modelling – understanding the DNA of cat statistics

RMS ELT

Label	Description
EventID	EventID
Rate	Freq parameter
STDEVI	Parameter of standard deviation of total loss across all the geo locations that are independently impacted by the cat event
STDEVC	Parameter of standard deviation of total loss across all the geo locations that are dependently impacted by the cat event
EXPVALUE	Parameter in respect of the total exposure loss
PERSPVALUE (Size / Expected Loss)	Total expected loss for that particular EventID
Allocation to DFA Class 1	Expected loss allocated to DFA class 1
Allocation to DFA Class 2	Expected loss allocated to DFA class 2
etc	

AIR ELT

Label	Description
EventID	EventID
Rate	Freq parameter
Size / Expected Loss	Total expected loss for that particular EventID
Allocation to DFA Class 1	Expected loss allocated to DFA class 1
Allocation to DFA Class 2	Expected loss allocated to DFA class 2
Allocation to DFA Class 3	Expected loss allocated to DFA class 3
etc	

- ELT – a set of all possible independent events for a given peril, each defined and represented by a statistical distribution of frequency (Poisson) and severity, i.e. system of independent Compound

  Poisson losses $CP_e = \sum_{k=1}^{N_e} X_{ek}$, X_{ek} with $CDF_{X_{ek}}$

- Homogenised peril event severity: $CP = \sum_e CP_e$ with individual severity distribution $CDF_X(x) = \sum_e \frac{\lambda_e}{\lambda} CDF_{X_{ek}}(x)$
- Use of OEP curve - link between individual event severity and PML: $CDF_{PML}(x) = P_N\left(CDF_X(x)\right)$
- Apply variance reduction techniques to model individual event losses from (N, X). **Please do not toss a coin to draw event losses directly from ELT!**

Dealing with modelling challenges – real examples (3)

Other modelling challenges

- **Reinsurance modelling**
  - Modelling reinsurance covers with interactions between layers, perils, contracts, etc.
  - Execution of numerous non-linear transformations in one model run, like excess of loss or stop-loss, could increase the model run time. This could happen when, for example, implementing reinsurance program at the contract level rather than at the treaty level.
- **Credit risk modelling**
  - For example, modelling of reinsurance credit risk would often involve generating very infrequent default events as most reinsurers would be of good credit quality due to limits of credit risk exposure imposed by active risk management.
  - Inappropriate approach to modelling rare default events could lead to model instability
  - Also additional complexity of the modelling approach does not necessarily makes model more realistic and could even slow down performance of the model. For example, modelling credit migration of reinsurers is not necessary, as in reality active management would take care of this, and additional complexity increases model run time.
- **Dependency modelling**
  - Modelling a particular dependency structure by means of using one gigantic correlation matrix is often inefficient and such that is difficult to calibrate/interpret and operate with. This could easily lead to model instability and inefficiency. Using, for example, pair-copula structures (vine copulae) instead is one of the ways around this issue.

Model design considerations

Aiming at increased model efficiency, transparency/auditability

- **Modular approach is desirable ('Lego' approach)**
  - Avoids rerunning global modules (when unnecessary) and saves on run time
  - Allows cut-down versions of the model that might be useful for a certain narrowly defined tasks
  - Makes the model structure more transparent, auditable and such that is easy to interrogate for specific scenarios leading to the outcome under investigation.

- **Single risk class vs. multi-array class structure**
  - When modelling class specific risks like UW, cats, reserving, etc. , one may consider the following two options:
    1. Modelling risks separately for each class; or
    2. Modelling risks using multi-array class data structure
  - The first option is difficult from the model governance point of view, but is relatively more efficient from the model performance point of view. In contrast, the second option is more convenient when updating the model with the new data inputs, but it could slow down the model performance.

Conclusions

- Understanding business requirements driving the needs for and the design of ICM.
    - *Risk Appetite Framework* – understanding company's risk utility function and using it in maximising business value under the constraints of external factors, such as regulators, rating agencies, investors, etc.
- Benefits of using ICM - how ICM can be used to develop and support Risk Appetite Framework. Understanding capital modelling challenges
    - Companies are yet to utilise the full potential of ICM. Those already having ICM will be busy rectifying issues related to model inefficiency and instability. Those without models still have time to build a proper one.
- Points to consider when building a good ICM – some recipes for better cat modelling.

THANK YOU!

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The author thanks *Insurance Australia Group* for giving him the opportunity to be part of the risk and capital working group that developed the **IAG Framework of Risk Appetite for Insurance Companies**.