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Economic Capital ("EC") – Framework and Implementation Challenges

Bonny Fu
FSA
EY Actuarial Services

Singapore Actuarial Society

EAAC

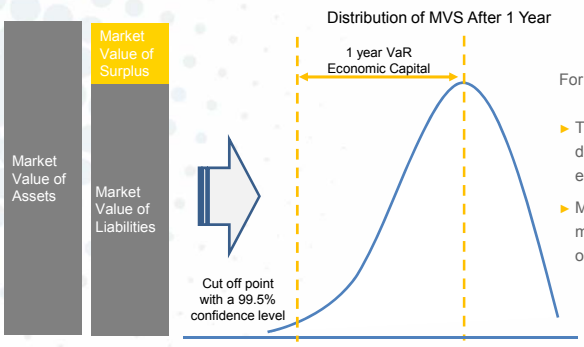
Agenda

- Economic Capital – Background
  - Definition of EC
  - Applications of EC
- Economic Capital – Framework and Implementation Challenges
  - Components of the EC Calculation
  - Modeling of MVL
  - Modeling of MVA
  - Modeling Approaches: Stochastic on Stochastic Vs Light Modeling
  - Model Input: Economic Scenarios
  - Model Validation
  - Risk Aggregation
- Economic Capital – Case Study

Economic Capital – Background

Background – Definition

Economic Capital: the amount of capital required to withstand a maximum reduction in market value of surplus ("MVS") under a market-consistent framework over a one year time horizon with a defined confidence level (for example 99.5%).

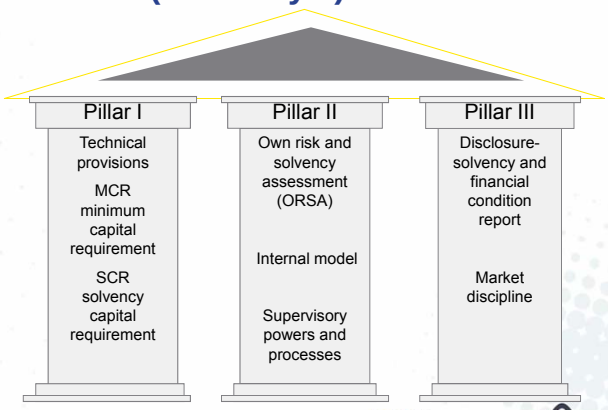


For Economic Capital calculation:

- The distribution of MVS should be determined based on the real world economic scenario;
- MVS should be determined based on the market consistent basis, which is based on risk neutral economic scenario.

Background – Applications of EC (Solvency II)

- The body driving the development of Solvency II, CEIOPS has pointed out that Solvency II SCR "**shares many features with economic capital**"
- Solvency II is a part of the convergence process of between regulatory and economic capital (with the inclusion of pillar II and III) management



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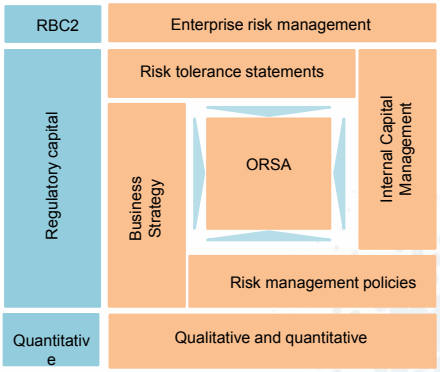
Background – Applications of EC (Singapore RBC 2 and ERM)

- Singapore regulator released RBC 2 consultation paper (subject to be approved) and guidance of ERM (effective from 1 January 2014)
- RBC 2 will be the quantitative framework, establishing regulatory capital requirements on insurance industry
- ERM framework comprises both qualitative and quantitative aspects, and is specifically tailored for each individual insurer's risk profile, tolerance and business strategy
- Own Risk and Solvency Assessment ("ORSA") is a part of the ERM framework. It **takes into account of economic capital** to reflect the company's own risk and financial conditions



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Background – Applications of EC (China Solvency II and ERM)

Current regime	Introducing China Solvency II and ERM

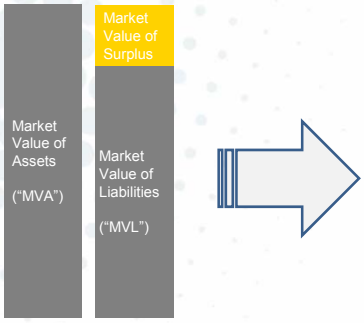
► Dynamic Solvency Test (DST) since 2007
► Report year end Solvency margins throughout the forecast period (three financial years)
► Base scenario should be consistent with the insurer's business plan
► CIRC has formulated the adverse scenarios for the DST
	► **China Solvency II**
	• 3 Pillar structure
	• In line with China Insurance market condition and needs as well as International supervisory standards
	• Risk-based as well as rule-based
	• Aim to release the final standard in 2016
	► **CIRC ERM guideline**
	• "Implementation Guidelines for Comprehensive Enterprise Risk Management of Life Insurance Companies" was released in Oct. 2010
	• Key requirements are;
	  • The CRO should be independent of sales, finance, investment and actuarial;
	  • The CRO must submit a comprehensive ERM Report approved by board to CIRC
	  • Risk exposures should be measured **using Economic Capital approach**

Economic Capital – Framework and Implementation Challenges

Framework – Components of the EC Calculation MVA & MVS

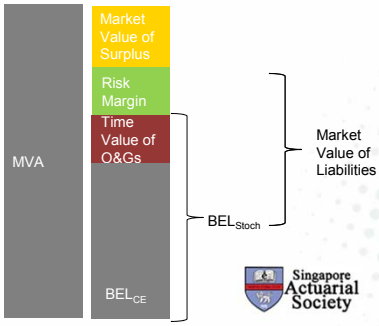
The calculation of EC requires:

- MVA
- MVL, which is BEL_{CE} + TVOG + RM
- MVS



MVA represents the market value of assets.

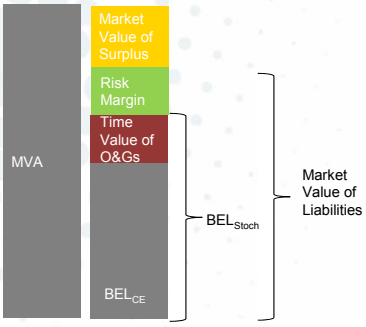
MVS represents the market value of surplus. It is the difference between market values of assets and liabilities.



Framework – Components of the EC Calculation MVL

The calculation of EC requires:

- MVA
- **MVL, which is BEL_{CE} + TVOG + RM**
- MVS



Best estimate liability ("BEL") has two components:

BEL_{Stoch} = BEL_{CE} + TVOG

a) **BEL_{CE}** – PV cash flows under the certainty equivalent (deterministic) economic scenario; plus

b) **Time value of Options & Guarantees ("O&Gs")** – PV cash flows under a range of stochastic scenarios. Time value of O&Gs can be defined as BEL_{Stoch} – BEL_{CE}, where BEL_{Stoch} is defined as the arithmetical average BEL across stochastic scenarios

Risk margin ("RM"):

- the portion of market value of liabilities in excess of BEL. It is also defined as the compensation, required by the market, to bear the risks of fluctuation of cash flows associated with the life insurance contract

MVL = BEL_{Stoch} + RM

Implementation Challenges – Modeling of MVL Guaranteed Minimum Credit Rate

Guaranteed minimum credit rate is determined based on the real world investment return assumption. The investment return in the real world is with risk premium; while investment return is risk free on the average basis for risk neutral economic scenario

- Should guaranteed minimum credit rate be revised with reference to the risk free investment return level when valuing based on the risk neutral economic scenario?

Example case – single premium universal life bancassurance product

- Initial premium deposit after premium loading and charges = 1 million
- Policy term is 1 year
- The maturity value is max(account value, premium increase @ GMCR 5%)
- The product is backed by 90% corporate bond with a yield to maturity of 8%, and 10% equity at the start
- The expect return assumption is 9% for pricing purpose
- Risk-free rate = 3%

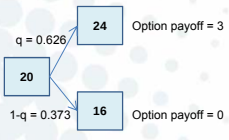
Value of the product payoff

- Maturity payoff = max (AV, Prem * 1.05) = max (AV – Prem * 1.05, 0) + Prem * 1.05
- The product payoff can be replicated by one government bond and one call option

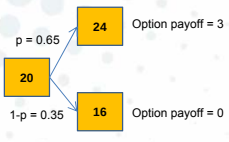
Implementation Challenges – Modeling of MVL Guaranteed Minimum Credit Rate (Cont.)

The strike price of the option is determined based on real world economy outlook. However, when valued based on the risk neutral economic scenario, only the probability distribution of economic scenario will shift, the strike price keeps unchanged.

Risk Neutral Pricing



Real World Pricing



Example call option specification

- Initial stock price = 20
- Call option strike price = 21
- Two possible future price = 24 (q = 0.65) or 16 (1-q = 0.35) under real world
- Risk-free rate = 5%

Law of one price

- Construct a risk-free portfolio: -8/3 unit of call option plus 1 unit of stock
- The portfolio payoff will be 16 regardless of stock price = 24 or 16, hence same price as a zero coupon government bond with redemption value 16
- -8/3*c + 20 = 16/ 1.05. Hence c = 1.79

Risk neutral world pricing

- Assume the risk neutral probability to price 24 is q, and to price 16 is 1 – q
- c = [q * 3 + (1-q) * 0]/ 1.05
- Hence q should be equal to 0.626

Real world pricing

- Assume the risk discount rate is r
- c = [0.65 * 3 + (1-0.65) * 0]/ (1+ r)
- Hence r should be equal to 9%

Implementation Challenges – Modeling of MVL Dividend Strategy

Par product's dividend rate is commonly linked to portfolio yield which is a blend of book yield (held-to-maturity and available for sale bonds) and market yield (held for trading assets).

- As all assets are marked to market in EC balance sheet, should the dividend rate for par products be linked to market yield of the asset portfolio when quantifying TVOG? The answer is: NO.

Example case – cash dividend participating products specification

- Single premium = 10,000
- Premium payment term and policy term = 10 year
- The pricing interest rate is 2.5%
- Cash dividend: (investment return rate - pricing interest rate) * cash surrender value * 90%
- Risk-free rate = 3%
- The backing asset is100% of held-to-maturity 10 year government bond

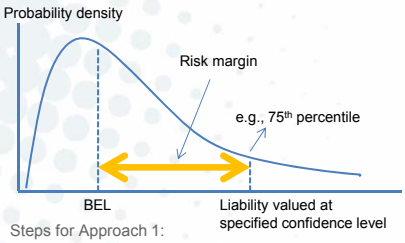
Year	PV @ market yield	1	2	3	4	5	6	7	8	9	10
Cash surrender value		1020	1040	1060	1080	1100	1120	1140	1160	1180	1200
Book yield		3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Cash dividend	42.42	4.59	4.68	4.77	4.86	4.95	5.04	5.13	5.22	5.31	5.4
Market yield V7		4.5%	-1.0%	-0.4%	1.3%	2.5%	3.0%	3.0%	6.0%	5.0%	5.5%
Cash dividend	118.40	22.95	0	0	0	34.65	5.04	20.52	57.42	0	0

Implementation Challenges – Modeling of MVL Risk Margin ("RM")

The RM is the portion of the market value of a liability that is in excess of BEL. It can also be defined as the compensation, required by market participants, to bear the risk of uncertainty of cash flows throughout the life of the insurance contract. Here are the common approaches to model RM.

Approach 1: Confidence Level

The RM is actually implied by the MVL because RM is the difference between MVL and BEL.



Steps for Approach 1:

1. Calculate best estimate liability stochastically
2. Plot a probability distribution of the best estimate liability
3. Calculate the risk margin based on the best estimate liability at the desired percentile on the distribution

Approach 2: Conditional Tail Expectation ('CTE')

This approach is similar to the confidence level approach, except the risk measure is replaced by Conditional Tail Expectation ('CTE'). The RM is thereby the difference between the CTE (e.g. at 60 percentile) and the mean of the BEL distribution.

Approach 3: Cost-of-capital ('CoC')

The cost-of-capital approach sets RM equal to the present value of the required risk premiums for each period, where the risk premiums are assumed to be proportional to the amount of capital required to support the liability.

Steps for Approach 3:

1. Calculate Capital Requirement ("CR") for each year
2. Multiply each of the CR's by the cost-of-capital rate
3. Discount the amounts calculated from step 2 using risk free yield curve at t = 0. The RM is the sum of the discounted values.

Slide 13

V7 Can market yield be negative as shown in this row?
Vincent.Tsang, 8/19/2013

Implementation Challenges – Modeling of MVA Investment Strategy

The strategic asset allocation ("SAA") can lead to different MVL and EC because:

- Different asset mix have different effective duration; and
- Different asset mix has different volatility level

- Assume the investment portfolio is changed according to cases [1] and [2] below, what are the expected impacts on MVL and EC?

[1] Same SAA, but bond target duration is 10 years → Same SAA but bond target duration is 5 years only

[2] 80% bonds, 20% equities → 40% bonds, 60% equities

Business types	Items	SAA Change Impact [1]	SAA Change Impact [2]
Non-par business	MVL	[1] No impact	[2] No impact
	EC	[1] Increase	[2] ?
Par business (credit rate dependent on market yield)	MVL	[1] Decrease	[2] Increase
	EC	[1] Increase	[2] ?

Implementation Challenges – Modeling of MVA Corporate Bonds

Corporate bond is supposed not to earn any extra risk premium under risk neutral world. However, a lot of insurers do not model credit and default risks explicitly.

- There are no credit and default assumptions in their economic scenario files. With such limitation, here follows two common industry modeling approaches

- Company A: model corporate bond as government bond

  Scale down the redemption / coupon amount to a risk free level, so that
  MV discounted at risk free yield curve = market value recorded in the balance sheet as of the valuation date

- Company B: Assume the credit spread can be exactly offset by default at the segment level and use goal seek to solve for a credit spread which offsets the default rate

  $MV(0) = \sum [Coupon(t) * ZCB\_Price(t) * (1+cs)^{(-t)}] + Redemption * ZCB\_Price(n) * (1+cs)^{(-n)}$
  $= \sum [Coupon(t) * (1+cs)^{(-t)}] * ZCB\_Price(t)] + [Redemption * (1+cs)^{(-n)}] * ZCB\_Price(n)$

  Where, ZCB_Price means Zero Coupon (Government) Bond price
  - cs means credit spread
  - default probability = 1/(1+cs) V9

Implementation Challenges – Modeling of MVA Policy Loan

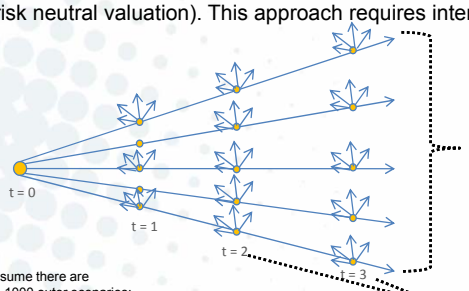
Policy loan is collateralized by cash surrender value. The policy will terminate automatically when the policy loan with the accrued interest is larger than the cash surrender value.

- Effectively, the policy loan is risk free. However, the policy loan interest charge rate is larger than risk free rate. How to reflect the excess interest rate above the risk free into EC market consistent balance sheet?

- Some insurers treat the excess interest rate ("policy loan interest charge rate" minus "risk free interest rate") as service charge income.
  - Best estimate liability = PV Benefit Outgo
    + PV Expense & Commission
    + PV Tax
    - PV Premium Income
    - PV Service Charge Income

Implementation Challenges – Approaches Stochastic on Stochastic Modeling

Economic capital requires stochastic on stochastic modeling approach to construct the distribution (based on real world risk distribution) of market value of surplus (based on risk neutral valuation). This approach requires intensive computation.



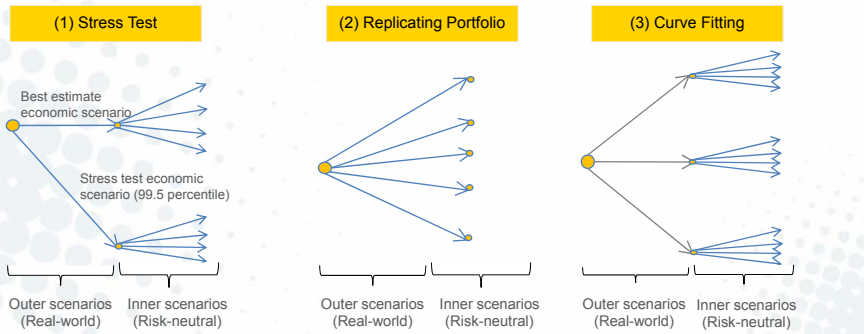
Outer (primary) scenarios (real-world):
Used to produce a range/ distribution of "market value of surplus" that is then used to identify the desired confidence level.

Inner (secondary) scenarios (risk-neutral):
Used to quantify market consistent balance sheet (and market value of surplus).

Assume there are
(1) 1000 outer scenarios;
(2) 1000 inner scenarios;
(3) 1000 liability model points; and
(4) 100 CPUs (running 2 model points per second per CPU).
Under this a situation, **it would take 58 days to complete the calculation**

Implementation Challenges – Approaches Lite Modeling

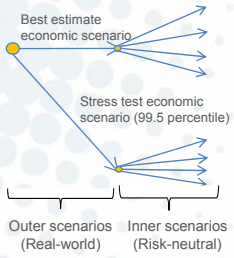
V12



Implementation Challenges – Lite Modeling Stress Test

Stress test approach

- Value the balance sheet under the best estimate economic scenario
- Value the balance sheet under the stress test economic scenario (99.5 percentile)
- EC is the difference between the market value of surplus of such above two economic scenarios

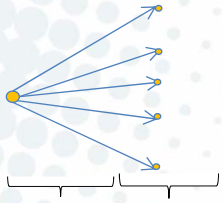


Pros	Cons
• Most widely used approach (similar as Solvency II QIS 5 standard formula approach) • Only need risk neutral stochastic model, quick development period • Shorter calculation time	• The stress test scenario needs to be carefully calibrated. The 99.5% worse scenario is not necessarily at 99.5% confidence level for market value of surplus • Difficult to calibrate the correlation matrix used for risk aggregation

Implementation Challenges – Lite Modeling Replicating Portfolio

Replicating portfolio approach

- Calibrate to determine a basket of widely traded assets which replicate the cash flow or Greeks or the liability model
- Generate real world risk factors through Monte-Carlo simulation and input them into the replicating portfolio
- Determine EC in accordance with the ordered market value of surplus at 99.5 percentile confidence level

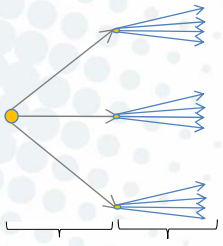


Pros	Cons
• It is a well developed technique • Works well with market risk • There is software available to support this approach	• Need stochastic model as well as replicating portfolio tool, long development period • Need other approaches to handle insurance risk • Need to regularly calibrate and validate the effectiveness of the replicating portfolio

Implementation Challenges – Lite Modeling Curve Fitting

Curve fitting approach

- Value balance sheet under sample real world risk factors and calibrate the regression parameters of the curve
- Generate real world risk factors through Monte-Carlo economic scenarios and input them into fitted curve
- Determine EC in accordance with the ordered market value of surplus at 99.5 percentile confidence level



Pros	Cons
• Works well with all risk factors, not just market risk • After calibration, curve fitting model is able to derive the distribution of MVS under the full risk spectrum within a limited time period	• Need stochastic model and regression model. Long development period • The calibration points for each risk should be carefully selected. The result may not be valid if the point for 99.5% worse scenario falls outside of the range of the selected calibration points • Need to fit and validate the curve effectiveness regularly

Implementation Challenges – Model Input Economic Scenario

Under risk neutral valuation framework, the difference of BEL under stochastic and certainty equivalent ("CE") economic scenario is time value of options and guarantees ("TVOG").

- How to construct CE economic scenarios, should it be based on the arithmetical average of stochastic economic scenario?

- Construct ZCB curve at future date based on the assumption that the implied forward yield at time zero remains unchanged

Forward Rate

2009
${}_1f_1$
${}_1f_2$
${}_1f_3$
…
${}_1f_n$
…
${}_1f_m$

Certainty ZCB Price

Term	2009	…	2009+t	…	…
1					
2					
3					
…					
n			$1/\prod_{i=0}^{n-1}[1+{}_1f_{t+i}]$		
…					
…					

Implementation Challenges – Validation Martingale Test

In risk neutral economic scenarios, each asset type will earn risk free rate on an average basis (martingale property).

- Martingale test need is to check the market consistency between the investment return and the discounting factor ("deflator") .

- Two levels martingale test:
  - Martingale check based on investment return of one period time interval

$$\frac{1}{n}\sum\left[\left(1+\text{RetRate}(i,t)\right)*\text{Deflator}(i,t)/\text{Deflator}(i,t-1)\right]=1\ ?$$

  - Martingale check based on accumulated investment return

$$\frac{1}{n}\sum\left[\prod\left(1+\text{RetRate}(i,t)\right)*\text{Deflator}(i,t)\right]=1\ ?$$

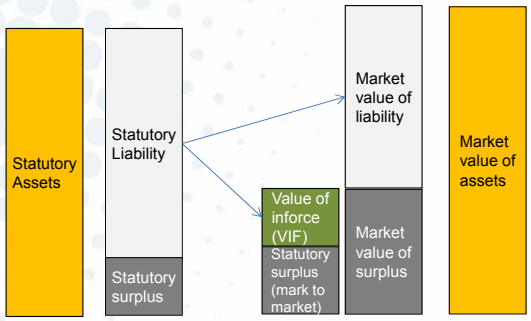
- CE scenario discounting factor should be close to the arithmetical average of stochastic economic scenario discounting factor to make sure that TVOG is zero for the business without embedded options and guarantees

$[\sum_{i=1,n}\text{Deflator}_{\text{Stoch}}(i,t)]/\ n = \text{Deflator}_{\text{CE}}(t)$

Implementation Challenges – Validation Model Leakage Test

Under risk neutral valuation framework, the discount rate is consistent with the risk free investment return rate. When there is no model leakage error (Asset(t) = Asset(t-1) + Prem(t) + InvRet(t) – ExpCom(t) – BenOut(t) – Profit(t) – Tax(t)), such below formula holds under both certainity equivalent economic scenario and on the average basis for stochastic economic scenarios

- Starting MVA (backing statutory liability) = PV BenOut + PV Exp&Com + PV Tax – PV PremInc + PV Profit



Liability =	Asset
• Best estimate liability = PV BenOut + PV Exp&Com + PV Tax - PV PremInc • VIF = PV Profit	• Starting Market value of assets (backing statutory liability)

Implementation Challenges – Risk Aggregations

Aggregation is the final step in the calculation of the EC. This involves combining the EC that has been calculated separately (by risk type) to arrive at the aggregate EC for the insurer.

- How should risks be classified into different types ?

- Definitions of risk types may differ among life insurers but some commonly used classifications are:
  - Market Risk: Equity, interest, volatility, credit spread widening, currency and etc
  - Credit Risk: Default Risk
  - Insurance Risk: Mortality, longevity, morbidity, lapse and etc.
  - Operational Risk

Implementation Challenges – Risk Aggregations

The aggregated EC for all risks will typically be less than the sum of the EC for each individual risks due to the diversification benefit.

- What are the commonly used aggregation approaches?

- **Approach 1 - Correlation Matrix:** EC will be quantified by individual risk factor, and then aggregated through the correlation matrix

- **Approach 2 - Copula Approach:** any multivariate distribution may be constructed from marginal distributions and a copula
  A copula is a statistical function to model and describe interrelationships between different risks. It transforms marginal distribution Fi(xi) of individual risks to the joint distribution.
  $F(x1, ..., xn) = C(F1(x1), ..., Fn(xn))$
  C is the copular function

- **Approach 3 - Scenario based Approach**
  In this approach, scenario generator will generate the real world scenarios which cover all risk types. Under this approach, the joint distributions of the risk factors have already taken place within the scenario generator and are embedded within the scenarios themselves. The aggregated EC will be calculated directly under these scenarios.

Pros	Cons
• Better approximation of analytical method • Intuitively simple and easy to implement	• Aggregated EC result is very dependent on the correlation assumptions • Estimates of inter-risk correlations are difficult to obtain

Pros	Cons
• More accurate for non-linearity (e.g. heavy tails) • Better estimation of EC at any given percentile	• Build a joint distribution can be very difficult

Pros	Cons
• Theoretically most accurate • Intuitive	• Calibration of the joint distribution of all the risk factors

Economic Capital – Case Study

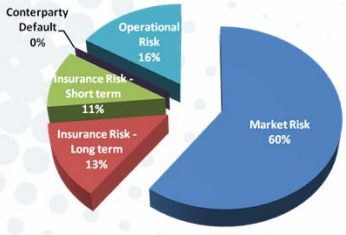
Case Study – Implementation Challenges for a China Life Reinsurer

- How to calibrate yield curve shock?
- Is the insurance risks calibration credible?
- How to improve the run efficiency of the dynamic model?
- How to validate the market consistent balance sheet?
- How to project future capital for risk margin calculation?
- How to reflect the diversification benefit based on a credible correlation matrix?

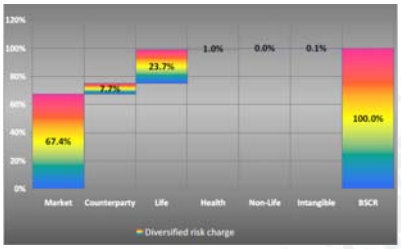
Case Study – Experience Sharing (1/3)

- Market risk is at the similar level with European life companies reported in QIS5 (Basic SCR excluding operation risk)

2011 EC Report
Diversified EC - XYZ company



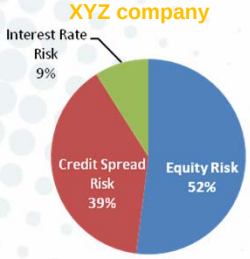
2011 QIS5 Report
Diversified BSCR - Life company



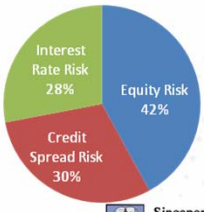
Case Study – Experience Sharing (2/3)

- Within market risks, equity risk and credit spread risk are higher than European companies reported in 2011 QIS5:
  - The equity shock in QIS5 is 40%, but calibrated to 60% for the China market.
  - Less interest rate risk because asset/liability duration matched well for XYZ, as a reinsurer.

XYZ company



Euro QIS5



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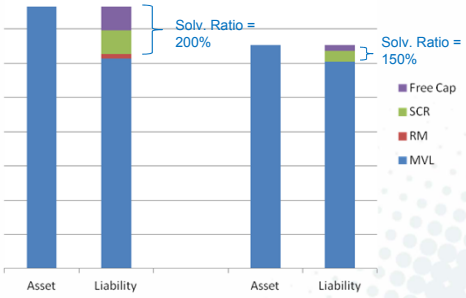
Case Study – Experience Sharing (3/3)

- EC is higher than solvency I capital requirement because EC considers the risks in a more comprehensively manner.
- Even when EC requires more capital, solvency ratio under EC basis improves.
  - The reason is statutory liability using 2.5% interest rate, but EC RN yield curve around 3.5~5%. So EC has lower liability and more available capital.

EC Balance Sheet

Statutory Balance Sheet



Note: a special fund is booked in both asset and liability side of EC B/S, that's why EC liability. Is not lower than stat. liability

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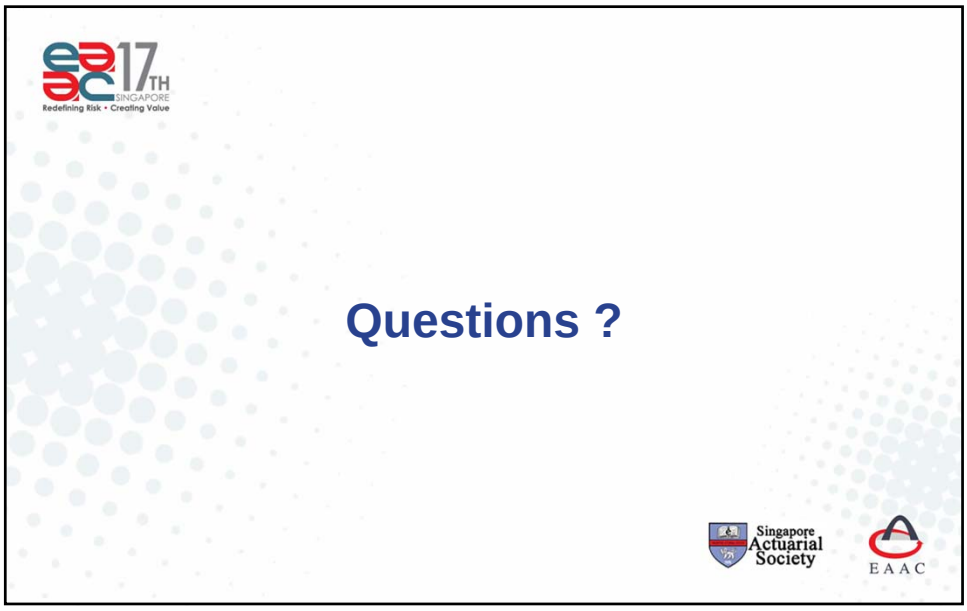
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