



SINGAPORE ACTUARIAL SOCIETY

6th SAS General Insurance Conference
Staying Ahead of the Game

Findings of the Diversification Benefit Working Party

Jim, Qin
Raymond, Cheung
Jaykishan, Jeyendran
Alex, Lee
Yiyan, Lin
Ka Weng, Loh
Zihao, Lu
Li Yuan, Ng
Yan, Zhu

29th / 30th May 2014
Resorts World Sentosa, Singapore

Disclaimer

The opinions expressed in this presentation and in the following slides are solely the views of the Diversification Benefit Working Party and do not represent that of the Singapore Actuarial Society (SAS) or the respective companies.

We have relied on the accuracy of the information from the sources used and have not independently verified this.

Special thanks to:

- Aon Benfield for the generous sponsorship of ReMetrica which was used extensively for this research*
- SAS and members of the Diversification Benefit Working Party for their contribution*

MAS RBC 2 Update

“MAS looked into the possibility of recognising diversification benefits when aggregating the risk requirements under RBC 2. ... In the absence of any conclusive studies to show otherwise, MAS proposes not to take into account diversification effects for the aggregation of risk requirements under RBC 2.”

Monetary Authority of Singapore, RBC 2 Consultation Paper June 2012

“4.15 In view of the consultation feedback and practices in other jurisdictions, MAS now proposes to allow for diversification benefits in the following ways:

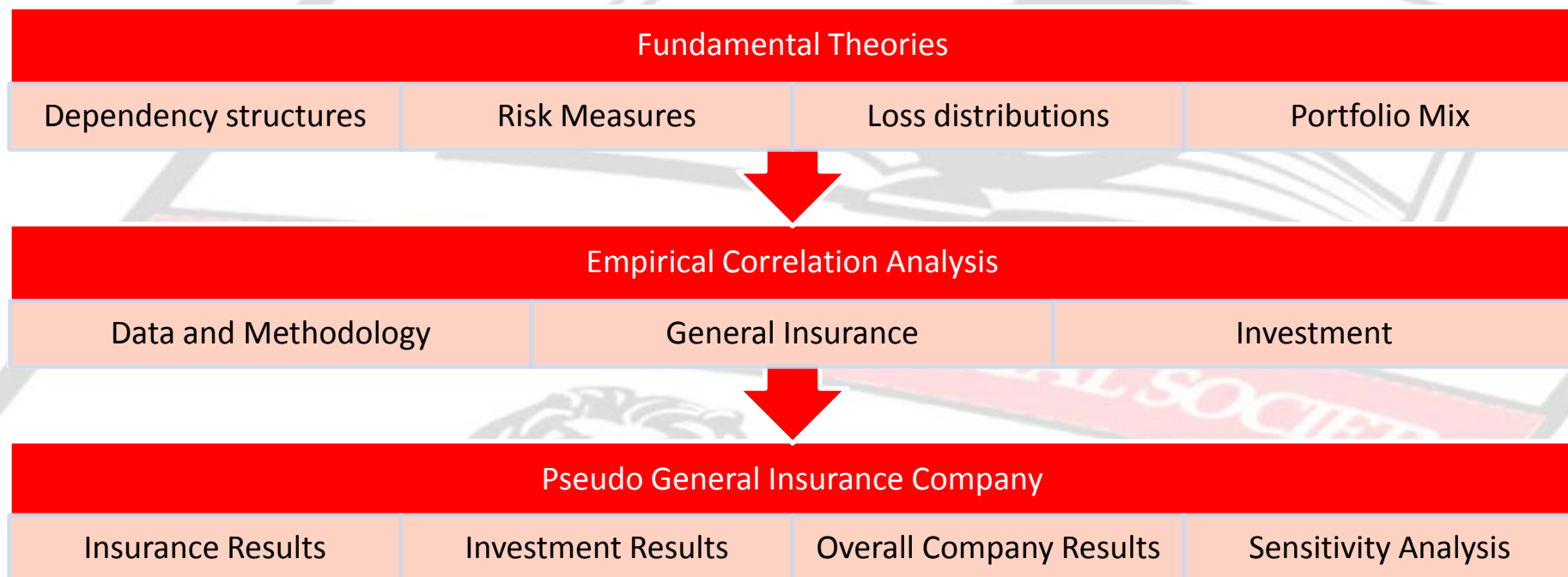
- Between C1 requirement and C2 requirement – We will assume that the C1 and C2 requirements are fully independent and not correlated. This is in line with the common understanding that insurance underwriting risks are generally not correlated with the economic cycle and financial market risks.”

Monetary Authority of Singapore, RBC 2 Consultation Paper March 2014

Objectives of Working Party Phase 1:

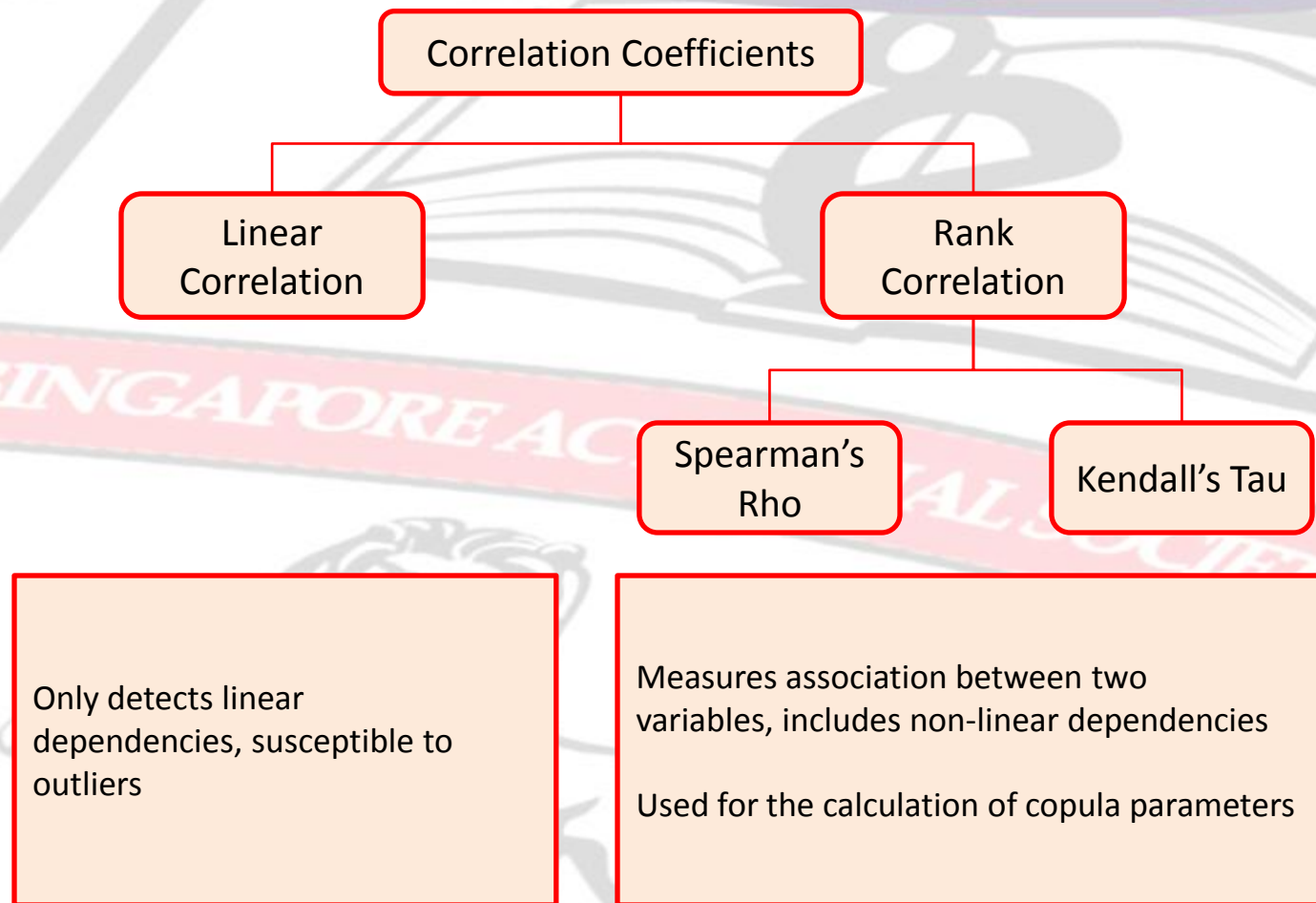
- Study of correlations and dependency structures between various risk types
 - Risk types analysed: Insurance Risk, Investment Risk, Investment Credit Risk
 - Risk types not included in analysis: Operational Risk, Catastrophe Risk, Non-Investment Credit Risk, Group Risk etc
- Determine if diversification benefit exists even during stressed periods and estimate the amount of diversification benefit for a common insurer

Agenda



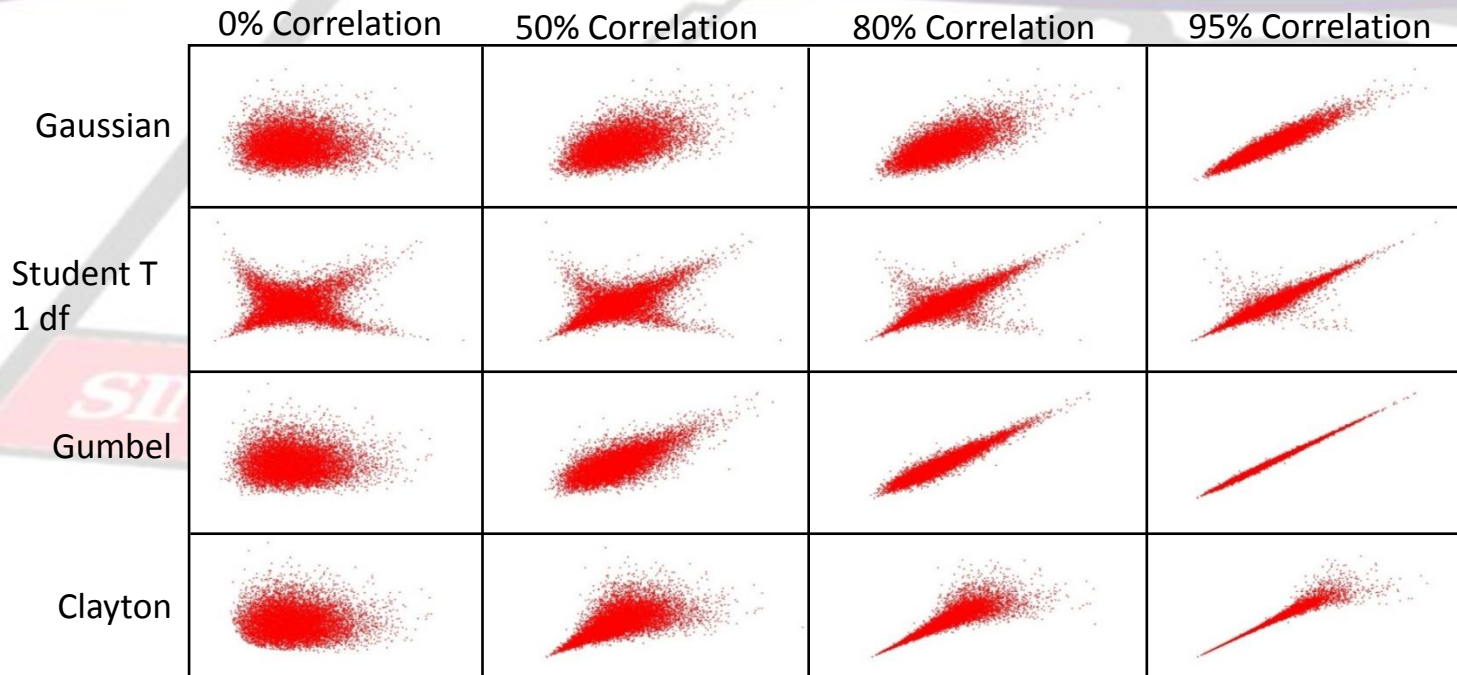
Fundamental Theories

1.1 Correlation coefficients



Fundamental Theories

1.2 Types of dependency structure



Copula	Class	Symmetry	Dependence
Clayton	Archimedean	Asymmetric	Strong Left Tail
Gumbel	Archimedean	Asymmetric	Strong Right Tail
Frank	Archimedean	Symmetric	Weak Tails, Strong Centre
FGM	Elliptical	Symmetric	Generally weak dependence
Gaussian	Elliptical	Symmetric	Moderate tail dependence
Student-t	Elliptical	Symmetric	Similar shape as Gaussian, stronger tail dependence

Fundamental Theories

1.3 Risk measures used for calculation of capital

Tail Value at Risk: (TVaR)

- Gives an expected value given a threshold
- Hard to obtain complete distribution of tail outcomes for proper modelling

Coefficient of Variation: (CoV)

- Gives a relative spread of the distribution
- Not useful if we are only concerned about tail values

Mean

Standard Deviation

Value at Risk: (VaR)

- Gives a point estimate
- Incoherent risk measure

Diversification Benefit %

Correlation	95% TVaR	VaR Equivalent	VaR Value
0%	29.5%	97.4% VaR	29.4%
25%	11.0%	98.5% VaR	11.1%
50%	3.5%	98.0% VaR	3.5%
75%	0.7%	97.2% VaR	0.7%

Calculation of diversification benefit:

$$DB\% = 1 - \frac{\text{Capital required at entity level}}{\text{Capital required for RF1} + \text{Capital required for RF2} + \dots}$$

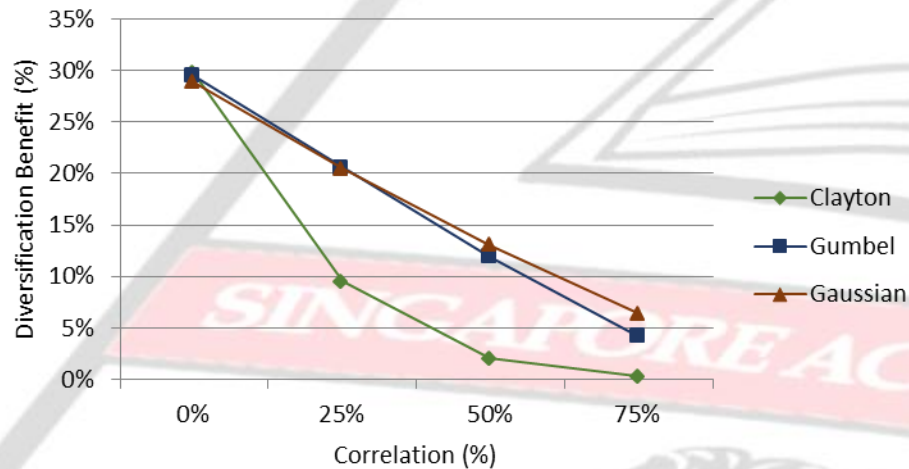


SINGAPORE
ACTUARIAL
SOCIETY

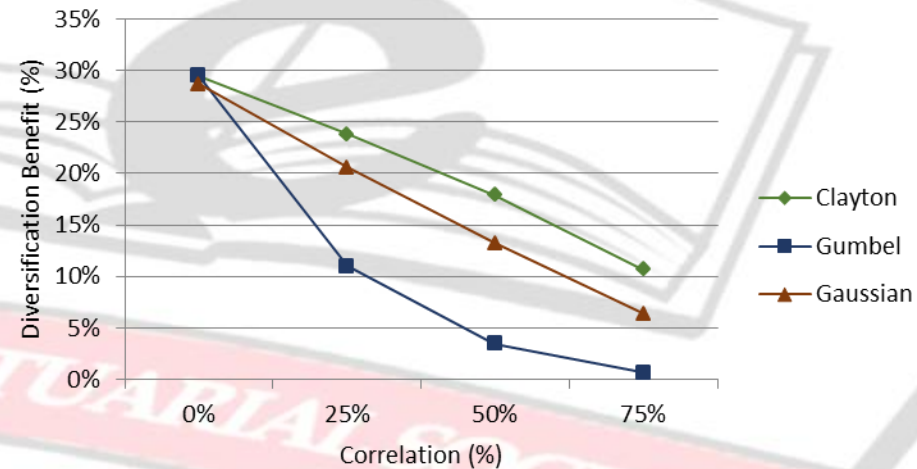
Fundamental Theories

1.4 Impact of dependency structures

Left tail evaluation using normal distribution (95% TVaR)



Right tail evaluation using normal distribution (95% TVaR)

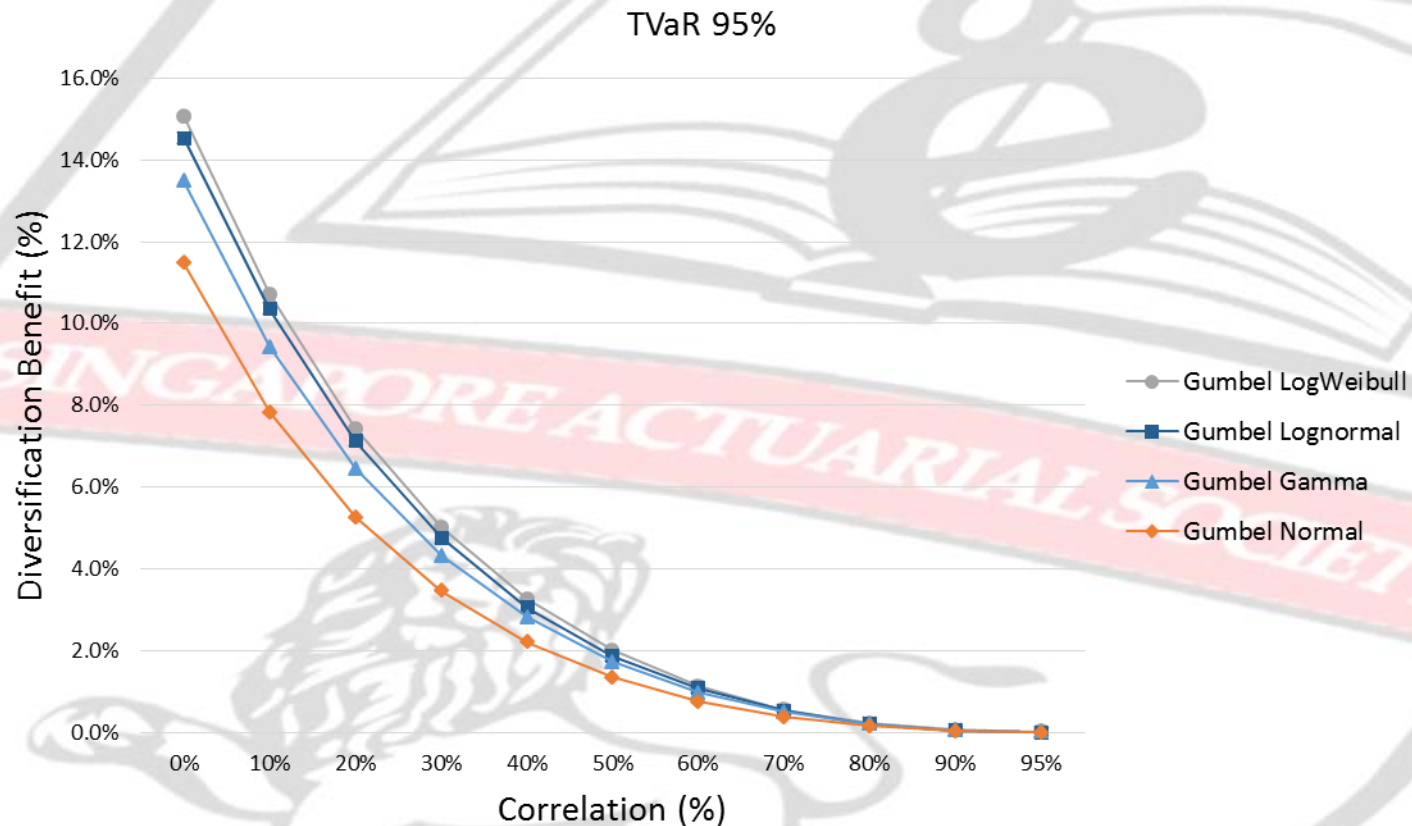


Holding the loss distribution constant while changing the correlation value and dependency structure:

The pattern displayed by Clayton for left tail is similar to the pattern displayed by Gumbel for right tail

Fundamental Theories

1.5 Impact of loss distribution

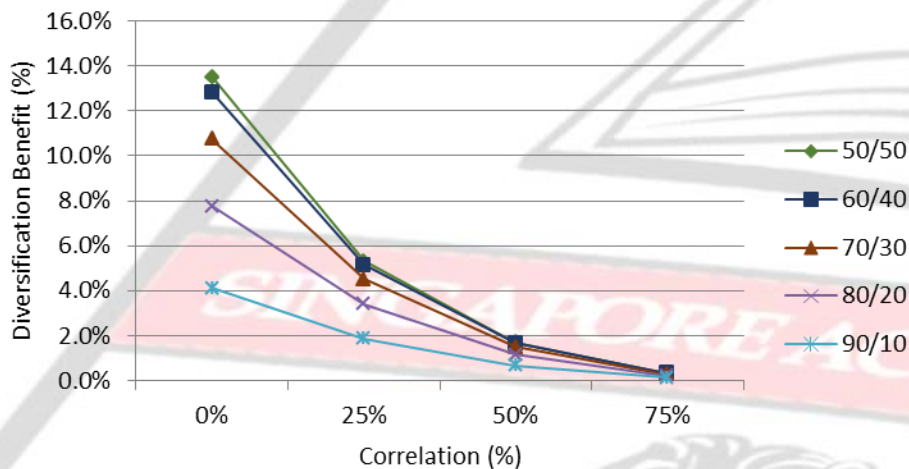


Distributions with thicker tails have higher diversification benefit

Fundamental Theories

1.6 Impact of portfolio mix and multiple risk factors

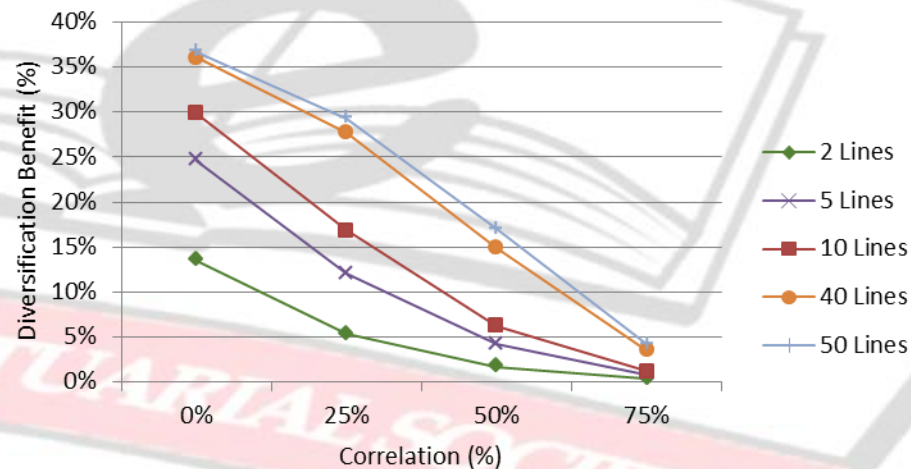
Portfolio Mix: 95% TVaR



Uneven portfolio mix decreases the amount of diversification benefit

The rate of decrease is also higher as the portfolio mix becomes increasingly uneven

Multiple Risk Factors: 95% TVaR



Increasing the number of risk factors increases the amount of diversification benefit



SINGAPORE
ACTUARIAL
SOCIETY

Fundamental Theories

Summary of findings

Dependency Structure

- Use Gumbel Copula when we model right tail dependency for loss distributions
- Use Clayton Copula when we model left tail dependency for returns distributions

Loss Distribution

- Diversification benefit curve is largely determined by the dependency structure
- Choice of underlying distribution has impact on the loss distribution, but not as significant compared to the choice of dependency structure

Uneven Portfolio Mix

- Presence of a dominant portfolio will reduce diversification benefit
- For instance, changing portfolio mix from 50:50 to 80:20 will reduce the diversification benefit significantly

Multiple Risk Factors

- Increasing the number of risk factors will increase (explicit) diversification benefit
- Segmenting the portfolio further gives more explicit diversification rather than implicit of a more grouped portfolio

Empirical Correlation Analysis

2.1 Data & Methodology

Data

Data Set	No. of Years	Total Sample Size/ Data Points
Investments	1999-2013	753 data points (Bloomberg Monthly)
General Insurance	2005-2012	88 ~ 240 data points (MAS Company Returns)
Life Insurance	1985-2012	28 (MAS Industry Statistics)

Note: The estimated correlation coefficients rely heavily on the number of data points available and hence may be quite volatile

Methodology

1. Calculate the empirical correlation coefficient (Rank Correlation) between risk factors
2. For Loss Ratio correlations, weight against exposure size to obtain industry average correlation
3. Calculate 95% confidence interval of coefficient

Empirical Correlation Analysis

2.2 General Insurance

	Weakly Positive Correlation (10%-20%)	Uncorrelated
Macro Factors	GWP Growth(t) vs GDP Growth(t-1) GWP Growth(t) vs Inflation(t)	Loss Ratio vs Inflation Loss Ratio vs GDP Growth
Insurance Factors	Loss Ratio(t) vs GWP Growth(t-1)	
Investment Factors		Loss Ratios vs Equity Returns Loss Ratios vs Bond Yields Between Insurance Loss and Investment Loss

SIF Line of Business Loss Ratio Correlation

Kendall	Marine			Fire			Motor			WC			PA			Health			Misc		
	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp
Marine																					
Fire	-11%	-1%	8%																		
Motor	-20%	-10%	0%	-5%	5%	15%															
WC	1%	11%	21%	-11%	-1%	8%	-1%	9%	19%												
PA	-15%	-6%	4%	4%	14%	23%	-2%	8%	18%	9%	18%	28%									
Health	1%	12%	23%	-17%	-6%	5%	-6%	5%	17%	-3%	8%	19%	-13%	-3%	8%						
Misc	0%	9%	18%	0%	10%	19%	-11%	-1%	9%	-11%	-1%	9%	-6%	4%	14%	2%	12%	23%			

Empirical Correlation Analysis

2.3 Investment (1)

Portfolio	Spearman Correlation	
	Pre & Post 2008 GFC	Pre 2008 GFC Only
MSCI Asia vs. MSCI World	60%	57%
MSCI Singapore vs. MSCI World	52%	48%
MSCI Singapore vs. MSCI Asia	76%	71%

Comments:

- Generally high correlation between Equity indices
- Equity correlation spiked after the crisis

Portfolio	Spearman Correlation	
	Pre & Post 2008 GFC	Pre 2008 GFC Only
MSCI Singapore vs. BofA Corp High Yield	39%	27%
MSCI Singapore vs. BofA Corp BBB-A	-3%	-9%
MSCI Singapore vs. BofA Corp AA-AAA	-7%	-14%

Comments:

- High yield bonds tend to have a high correlation with equity
- Highly rated bonds are less correlated with equity

Empirical Correlation Analysis

2.3 Investment (2)

Spearman Correlation Table with 95% confidence interval (1999-2013)

		Govt Bonds								
		UOB All			UOB Long			UOB Short		
		Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp
Equities	Singapore	-20%	-13%	-5%	-20%	-13%	-6%	-13%	-6%	1%
	Asia	-22%	-15%	-8%	-22%	-15%	-8%	-14%	-7%	0%
	World	-29%	-22%	-15%	-29%	-22%	-16%	-19%	-12%	-5%

Comments:

- Government bond indices tend to be negatively correlated with Equity indices

Source:

Govt Bond Index: UOB SGS Index

Public Equity Index: Morgan Stanley Capital International Index (MSCI)

Spearman Correlation Table with 95% confidence interval (1999-2013)

		Govt Bonds									Corp Bonds					
		UOB All			UOB Long			UOB Short			AA-AAA			BBB-A		
		Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp	Low	Avg	Upp
Govt Bonds	UOB All															
	UOB Long	99%	100%	100%												
	UOB Short	64%	68%	72%	58%	62%	67%									
Corp Bonds	AA-AAA	31%	37%	43%	32%	38%	44%	14%	21%	28%						
	BBB-A	27%	34%	40%	28%	34%	41%	12%	19%	26%	94%	95%	95%			
	High Yield	-9%	-2%	5%	-9%	-2%	5%	-6%	1%	8%	12%	19%	25%	22%	29%	36%

Source: Govt Bond Index: UOB SGS Index . Corp Bond Index: Bank of America Merrill Lynch Index

Comments:

- High yield bonds tend to be less correlated with Govt and Higher Rated bonds

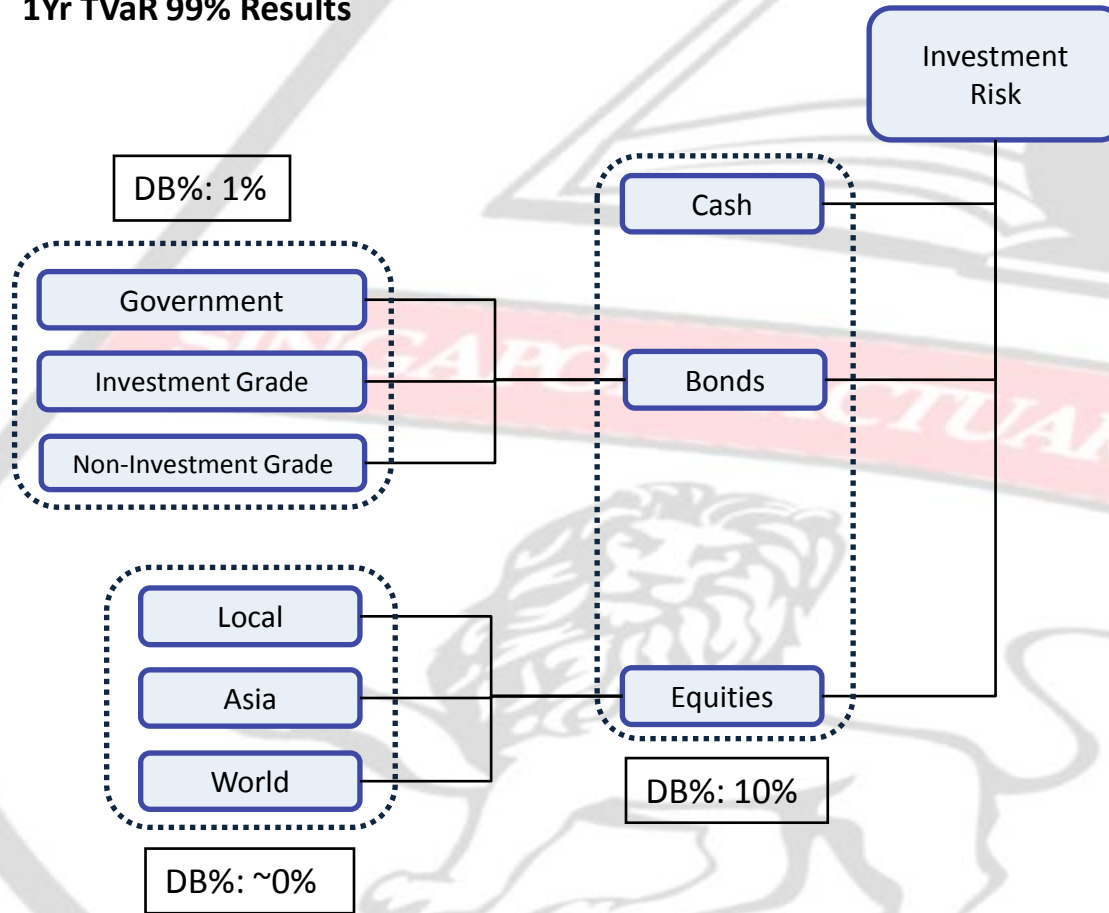


SINGAPORE
ACTUARIAL
SOCIETY

Pseudo General Insurance Company

3.1 Investment Results (Base Scenario)

1Yr TVaR 99% Results



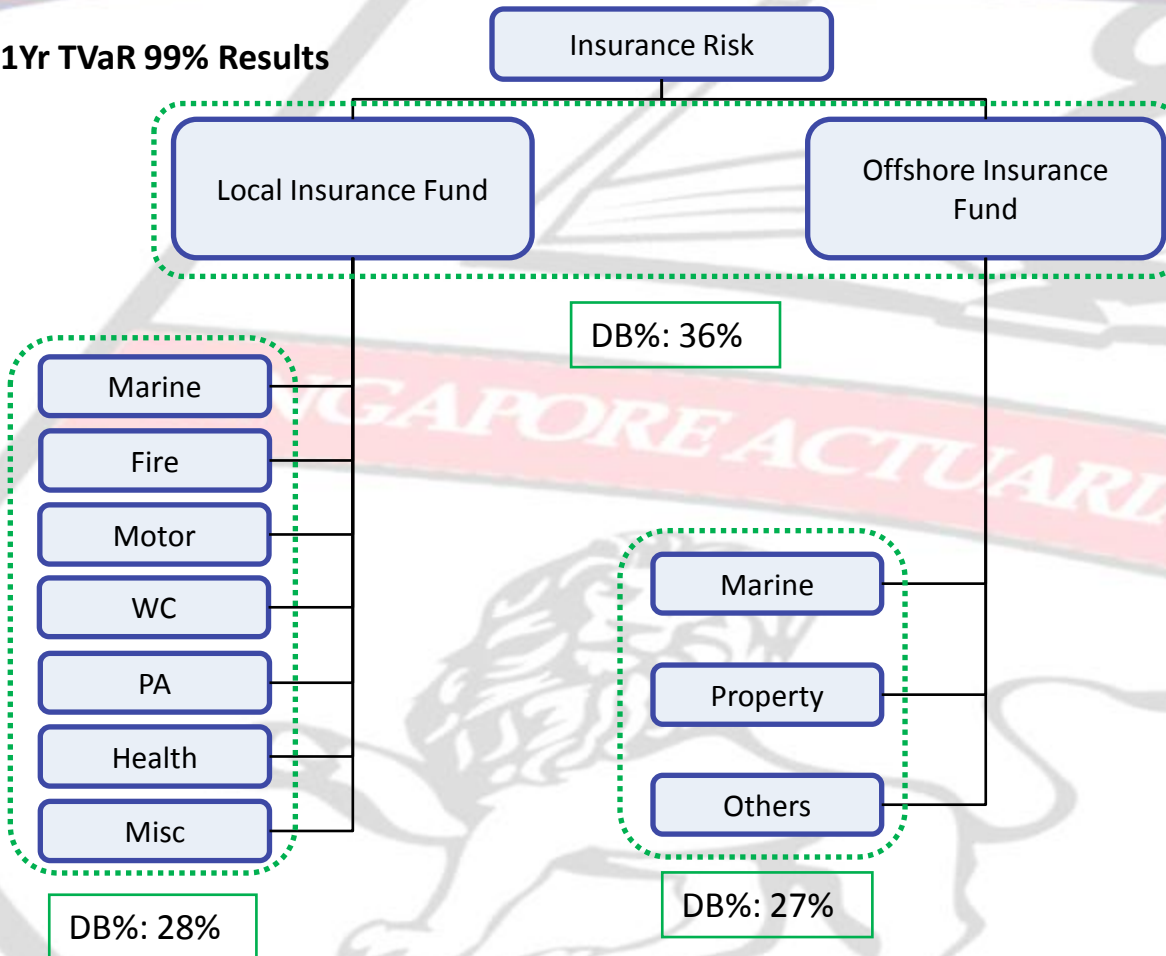
Correlation within bonds and within equities is high. Thus the diversification benefit observed is low. Default risk for bonds is excluded from our analysis but we expect default risk to increase the diversification benefit of holding bonds of different credit rating.

Overall asset correlation is lower and hence we observe a diversification benefit of 10%.

Pseudo General Insurance Company

3.2 Insurance Results (Base Scenario)

1Yr TVaR 99% Results



Correlation between lines of business is generally low. Thus we observed 28% and 27% diversification benefit for Local Insurance Fund and Offshore Insurance Fund respectively.

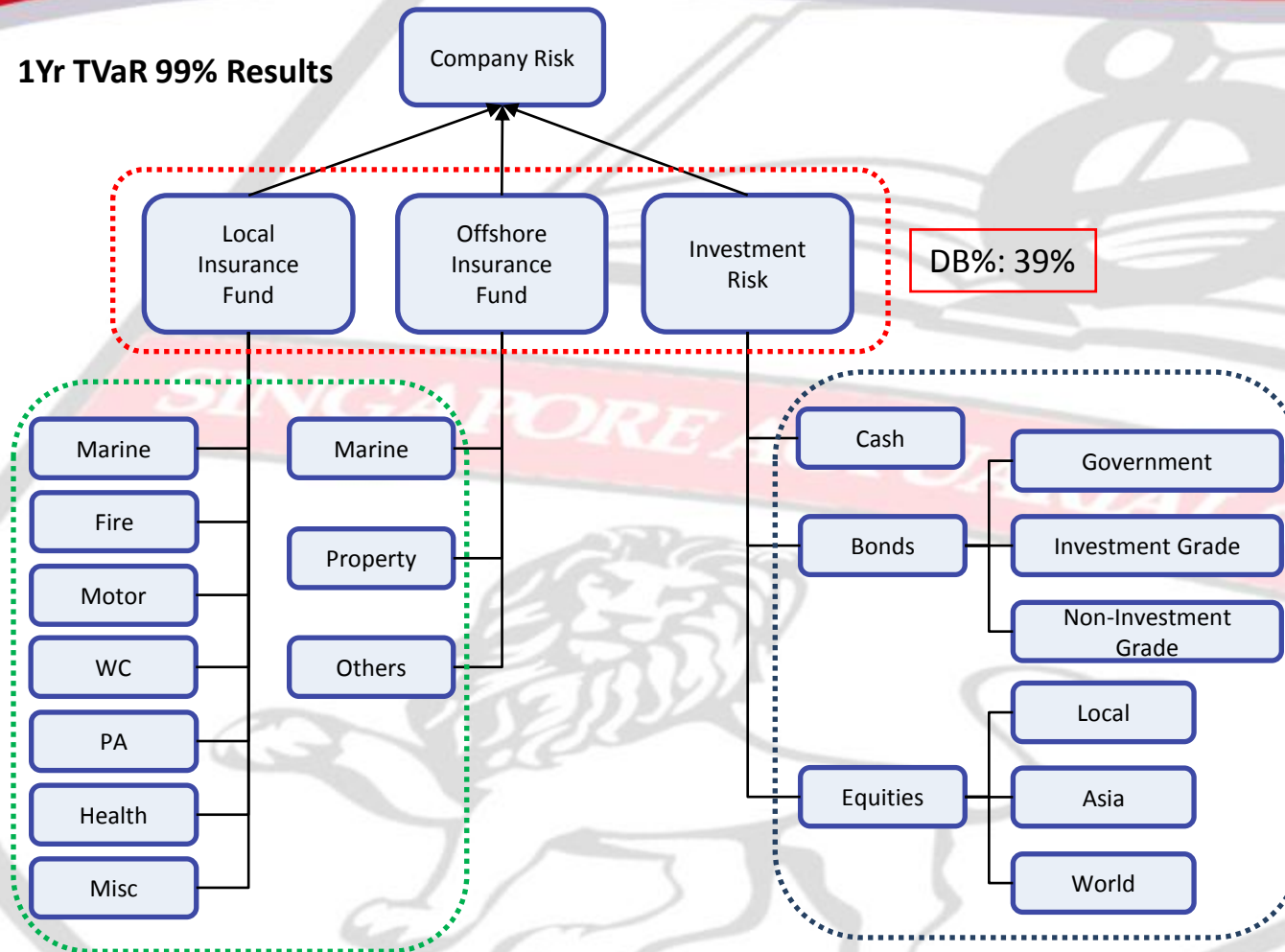
As Motor is a dominant line (46%), the diversification benefit is only slightly higher for Local Insurance Fund even though there is a higher number of lines.

Correlation between Local and Offshore funds is low thus there is an overall 36% diversification benefit for Insurance Risk.

Pseudo General Insurance Company

3.3 Overall Results (Base Scenario)

1Yr TVaR 99% Results



As insurance and investment risks are not highly correlated, we observed a 39% overall diversification benefit for the company

Pseudo General Insurance Company

3.4 Sensitivity Analysis

Base Scenario: Mean Parameters with 10% Correlation Floor

Sensitivity Scenario 1: 95th Percentile Parameters

Sensitivity Scenario 2: 50% Inter-Risk Correlations (Insurance Risk and Investment Risk)

Sensitivity Scenario 3: Personal Line Insurer

Sensitivity Scenario 4: Mean Parameters with 0% Correlation Floor

Sensitivity Scenario 5: Mean Parameters with 25% Correlation Floor

Sensitivity Scenario 6: Mean Parameters with 50% Correlation Floor

TVaR 99% Results	Base	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Diversification Benefit	10% Floor	95 th Percentile	50% Inter Risk Correlation	Personal Line Insurer	0% Floor	25% Floor	50% Floor
Investment Risk	10%	6%	10%	6%	10%	10%	9%
Insurance Risk	36%	30%	30%	14%	38%	27%	12%
Overall	39%	33%	30%	22%	42%	29%	13%

Comments:

- Scenario testing by increasing the floor correlation percentage indicated that there was almost no effect on investment risk, since it was already highly correlated above the floor. The greatest effect was from the inaccurate estimation of the intra-insurance correlation and also inter-risk correlation. However, even with a high floor of 50% correlation, we had still estimated 13% diversification benefit.
- As expected, a personal line insurer will have less diversification benefit as the risks are more concentrated in fewer lines, mainly in motor business.



**SINGAPORE
ACTUARIAL
SOCIETY**

Objectives – Phase 2

“The diversification benefits within C1 requirement for general insurers will be relooked at later, after the development of the insurance catastrophe risk requirement and the recalibration of premium liability and claims liability risk requirements for general business is close to finalisation. Currently, diversification across business lines is already implicitly allowed for in the determination of the PAD for general business.”

Monetary Authority of Singapore, RBC 2 Consultation Paper March 2014

Objectives of Working Party Phase 2:

- Define a correlation matrix to be applied within C1 and compare against RBC 2
- Include risks previously not modeled in Phase 1: Credit, Nat Cat, Reserving etc
- Compare the different regulatory framework with regards to diversification benefit