The Institute of Actuaries of Australia

Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance

20 November 2001

Robyn Bateup

Ian Reed

Tillinghast - Towers Perrin

Level 10
101 Collins St
Melbourne Vic 3000
GPO Box 5141AA
Melbourne Vic 3001
Tel: (03) 9270 8115
Fax: (03) 9270 8139

Management Consultants
and Actuaries

Tillinghast – Towers Perrin

20 November 2001

Ms Catherine Beall
Chief Executive Officer
The Institute of Actuaries of Australia
Level 7, Challis House
4 Martin Place
SYDNEY NSW 2000

Dear Catherine

Attached is Tillinghast's report "Research and Data Analysis Relevant to the Development of Standards and Guidelines on Liability Valuation for General Insurance".

We look forward to this paper providing a stimulus for further research by actuaries practising in the industry.

Yours sincerely

Robyn Bateup, FIAA
Director

Ian Reed
Consultant

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EXECUTIVE SUMMARY

In response to new legislative and regulatory requirements effective from 1 July 2002, Tillinghast–Towers Perrin ("Tillinghast") was engaged by the Institute of Actuaries of Australia ("IAAust"), in consultation with the Australian Prudential Regulation Authority ("APRA"), to undertake research relevant to the development of a "Professional Standard and Guidance Note on Liability Valuation for General Insurers". In particular, Tillinghast's scope of involvement was to undertake research and analyses in respect of net risk margins, as prescribed under Prudential Standard GPS 210 issued by APRA in November 2001.

Definition of Risk Margin

Prudential Standard GPS 210, issued by APRA in November 2001, aims to provide a consistent set of principles for the realistic measurement and reporting of insurance liabilities for all insurers. The insurance liability for each class of business is defined as the sum of:

- A central estimate of the outstanding claims liability;
- A central estimate of the premium liability; and
- The risk margin that relates to the inherent uncertainty in each of the central estimate values.

To ensure that insurers' reported liabilities are broadly consistent and sufficiently rigorous across the industry, Prudential Standard GPS 210 prescribes that the risk margin:

- Should be established on a basis that would be expected to secure the insurance liabilities of the insurer at a 75% level of sufficiency.
- Should, due to the highly skewed nature of the liability distributions of some classes of insurance, not be less than half of the coefficient of variation of the liability distribution.
- Should normally be determined having regard to the uncertainty of the net insurance liabilities, but consideration should also be given to any additional uncertainty related to the estimate of reinsurance recoveries.

Scope of Analysis

The IAAust Task Force (set up by IAAust to manage the process of developing the guidelines) specified the need for a simple and practical formula-driven approach for the net risk margins. In particular:

- It was generally understood that no "one size fits all" formula exists. However, a suitable, simple, practical approximation was sought.
- The resulting formula is aimed at use by small to medium-sized insurers. However, it may also be a useful guide for larger insurers' actuaries.

The scope, as determined and agreed with the Task Force sub-committee, was that the risk margins were to be developed as an indicative guide only, given:

- the lack of available data for detailed quantification, particularly premiums data due primarily to its commercial sensitivity;
- the restricted timeframe available for the analyses; and
- the recognition that, within each line of business, significant differences exist among insurers between the net outstanding claims liability and premium liability distributions.

Underlying this scope, the intention was to provide a tool for establishing risk margin benchmarks for the industry and guidance to actuaries within the industry.

Results

"Stand Alone" Risk Margins for the Net Outstanding Claims Liabilities for Primary Insurers

Tables A and B show the "stand alone" risk margins, before any allowance for diversification, for a sample of net outstanding claims liability sizes, for short and long tail lines of business respectively. The percentages in these tables are applied to the net central estimate of the claims liability in order to determine the risk margin.

TABLE A

Resulting Net Outstanding Claims Liability Risk Margins by Line of Business - Short Tail

Net Central Estimate OSC Liability $M	Dom Motor	House-holders	Comm Motor	Fire / ISR	Marine & Aviation	Mortgage	Cons Credit	Travel	Other
50	8.0%	9.3%	8.8%	9.8%	12.5%	13.5%	11.7%	9.3%	10.3%
100	6.7%	8.0%	7.7%	8.5%	12.0%	12.6%	10.5%	8.0%	9.6%
150	6.2%	7.5%	7.3%	7.9%	11.9%	12.3%	10.1%	7.5%	9.4%
200	6.0%	7.3%	7.1%	7.7%	11.8%	12.1%	9.8%	7.3%	9.3%
250	5.8%	7.1%	7.0%	7.5%	11.7%	12.0%	9.7%	7.1%	9.2%
300	5.7%	7.0%	6.9%	7.4%	11.7%	11.9%	9.6%	7.0%	9.1%
350	5.6%	6.9%	6.8%	7.3%	11.7%	11.9%	9.5%	6.9%	9.1%
400	5.5%	6.9%	6.8%	7.2%	11.7%	11.8%	9.5%	6.9%	9.1%

For example, for a $100 million net outstanding claims commercial motor liability, the "stand alone" risk margin (before any diversification benefit allowance) would be $7.7 million.

TABLE B

Resulting Net Outstanding Claims Liability Risk Margins by Line of Business - Long Tail

Net Central Estimate OSC Liability $M	Workers' Comp	CTP	Liability	Prof Indemnity
100	12.7%	15.3%	12.7%	12.7%
200	11.6%	13.9%	11.6%	11.6%
400	11.0%	13.0%	11.0%	11.0%
600	10.8%	12.7%	10.8%	10.8%
800	10.7%	12.6%	10.7%	10.7%
1,000	10.6%	12.5%	10.6%	10.6%
1,500	10.5%	12.3%	10.5%	10.5%
2,000	10.5%	12.3%	10.5%	10.5%

Appendices E and F show the resulting "stand alone" risk margins for finer divisions of the net outstanding claims liability sizes.

The "stand alone" risk margins in Tables A and B are calculated from the systemic and independent variances, by line of business, using formula 6.1, namely:

$$CV(X_i) = \sqrt{\left(a_i^2 + {b_i^2}/{n_i}\right)} \qquad (6.1)$$

where:

X_i = *Line of business i*

$CV(X_i)$ = *Coefficient of Variation for* X_i

n_i = *the amount of the net central estimate of outstanding claims liability for line of business i, in $millions*

$n_i^2 a_i^2$ = *systemic variance for line of business i*

$n_i b_i^2$ = *independent variance for line of business i*

Tables C and D set out our estimates of the systemic and independent components of the coefficient of variation, by line of business. For illustrative purposes, the systemic variance, independent variance and the coefficient of variation for an outstanding claims liability of $80 million (short tail) and $200 million (long tail) are also shown.

TABLE C

Short Tail Classes –Systemic Variance, Independent Variance and Coefficient of Variation by Line

Line of Business	Systemic Component (a_i^2) %	Independent Component (b_i^2) %	For an $80M Net Outstanding Claims Liability Systemic Variance ($n_i^2a_i^2$) $M	Independent Variance ($n_ib_i^2$) $M	Total Coefficient of Variation %
Dom Motor	0.6	50.0	38	40	11.1
Comm Motor	1.0	48.0	64	38	12.6
Householders	1.0	60.0	64	48	13.2
Travel	1.0	60.0	64	48	13.2
Fire/ISR	1.1	70.0	70	56	14.1
Other	2.0	40.0	128	32	15.8
Cons Credit	2.1	82.0	134	66	17.7
Marine	3.6	35.0	230	28	20.1
Mortgage	3.6	82.0	230	66	21.5

TABLE D

Long Tail Classes –Systemic Variance, Independent Variance and Coefficient of Variation by Line

Line of Business	Systemic Component (a_i^2) %	Independent Component (b_i^2) %	For an $200M Net Outstanding Claims Liability Systemic Variance ($n_i^2a_i^2$) $M	Independent Variance ($n_ib_i^2$) $M	Total Coefficient of Variation %
Workers' Comp	2.8	160	1,120	320	19.0
Liability	2.8	160	1,120	320	19.0
Prof Ind	2.8	160	1,120	320	19.0
CTP	4.0	300	1,600	600	23.5

"Stand Alone" Risk Margins for the Net Outstanding Claims Liability for Inwards Reinsurance

Proportional Inwards Reinsurance

In respect of proportional inwards reinsurance, for practical purposes we recommend applying the estimates of the systemic and independent variances shown in Tables C and D above, based on the aggregate size (across contracts) of the inwards reinsurance liabilities by line of business.

This practical approach produces risk margins that, when compared to the expected uncertainty of components of the inwards reinsurance portfolio, are:

- higher than expected for most quota share treaties, due to the accounting year reserving methodology generally employed for these contracts;
- higher than expected due to the diversification within a line of business from multiple contracts;
- lower than expected for proportional surplus treaties, due to the expected greater volatility of these treaty types;
- lower than expected for most facultative proportional reinsurance, due to the expected greater volatility of these treaty types; and
- lower than expected due to the use of the aggregate size (across contracts) of the inwards reinsurance liabilities rather than the aggregate risk margins (weighted by size) across the inwards reinsurance contracts.

Overall, we believe that the practical approach provides a reasonable balance of all the above effects.

Non-proportional Inwards Reinsurance

For non-proportional inwards reinsurance portfolios, we recommend that the multiples set out in Table E be applied, by line of business within the portfolio, to the risk margin that would have applied for a primary insurer having the same net outstanding claims liability size.

TABLE E

Risk Margin for Non-Proportional Inwards Reinsurance as a Multiple of Direct Insurer Risk Margin.

Line of Business	Multiple of Direct Risk Margin
CTP	1.7
Workers' Compensation	2.0
Liability	2.0
Professional Indemnity	2.0
Fire/ISR	1.9
All Other	1.6

The multiples in Table E are only appropriate for lower working layers of non-proportional inwards reinsurance portfolios. Higher multiples should be applied for contracts covering upper layers and/or contracts with significant exposure to catastrophes.

"Stand Alone" Risk Margins for the Net Premium Liability by Line of Business

We recommend expressing the premium liability risk margin as a multiple of the risk margin that would apply to a net outstanding claims liability of the same size as the premium liability.

Our recommended multiples of the net outstanding claims liability risk margin (for liabilities of the same size) to be applied for determining premium liability risk margins, are as follows:

- 1.75 for short tail lines of business; and
- 1.25 for long tail lines of business.

These ratios balance the effects of a number of factors, including but not limited to:

- The contribution to the net outstanding claims liabilities of claims incurred but not reported ("IBNR claims"), and the methods used to value these claims. The valuation of IBNR claims requires consideration to be given to similar effects that would be considered for a revised pricing basis, for example recent changes and trends in claims frequency and average claim size. As IBNR claims represent a lower proportion of the net outstanding claims liabilities for short tail lines of business than for long tail lines of business, the estimated uncertainty of the net outstanding claims liabilities of short tail classes would generally include less allowance for these "premium liability" effects. Hence, the multiple of the net outstanding claims liability risk margin would be expected to be higher for short tail lines of business.

- The above point is partially offset by the fact that the ratio in respect of short tail lines of business could be expected to be lower, due to the average accident date of the net outstanding claims liabilities. That is, the uncertainty (and hence risk margin) generally decreases with the maturity of the accident year, and the average age of the net outstanding claims liability would be expected to be greater for long tail lines of business.

- Allowance for multiple events (eg catastrophes). This allowance would be expected to be greater for short tail lines of business.

In respect of long term contracts (e.g. consumer credit, mortgage, warranty), the average outstanding policy duration would vary across insurers. As the premium liability risk margin needs to recognise the increased uncertainty in the premium liability for portfolios with longer outstanding policy durations, a simple multiple of the net outstanding claims liabilities with no allowance for the differing average outstanding policy durations is not appropriate. Following discussions with senior practising actuaries, we recommend that the following approach be adopted in respect of long term contracts:

- $1.25 \times \sqrt{t}$ for long term contracts, where t = mean outstanding policy duration (in years).

Diversification Discount for Total Net Insurance Liability

We recommend that a minimum total net insurance liability of \$30 million be required before any diversification benefit is applicable.

For practical use, in respect of allowing for diversification of the net insurance liabilities, we used least squares regression to derive the following recommended "rule of thumb" formula for the diversification discount:

$$\begin{aligned} \textit{Diversification Discount} = {} & 51\% \times (1 - 0.5 * C) \\ + \quad & 2.4\% \times N \text{, if } N > 2 \\ - \quad & 0.0139\% \times S \text{, if } S < \$550 \text{ million} \\ - \quad & 0.0013\% \times S - 7.0\% \text{, if } S >= \$550 \text{ million} \end{aligned} \tag{7.2}$$

Where:

$$C = \text{coefficient of concentration}$$

$$= \frac{\text{Net insurance liability for largest line of business (\$)}}{\text{Total net insurance liability (\$)}}$$

$$N = \text{number of lines of business}$$

$$S = \text{size of the insurer's total insurance liabilities in \$ million}$$

An insurer's diversification benefit is then calculated by applying the resulting diversification discount to the aggregate net insurance liability risk margins, across all lines of business.

This "rule of thumb" formula allows for:

- a greater diversification discount for lower concentrations of the insurance liabilities;
- a greater diversification discount for more lines of business written by the insurer; and
- a lower diversification discount for larger total insurance liabilities. This explains the residual error after allowing for the two effects above.

We tested the sensitivity of the resulting "rule of thumb" formula to the assumed correlation matrices. We concluded that, given the size of the total insurance liabilities compared to the size of the net risk margins, the sensitivity of the diversification benefit resulting from the recommended "rule of thumb" to significant changes in the assumed correlation matrices is not material.

Worked examples of the application of our recommendations are set out in Appendix G.

Commentary on Results

The risk margins in this report have been estimated in accordance with our interpretation of the requirements of Prudential Standard GPS 210, summarised above. In particular, please note:

- As agreed with the Task Force sub-committee, we considered risk margins for net liabilities only.
- We assumed that the central estimate of the net outstanding claims liabilities, to which the risk margins presented in this report may be applied, are determined in accordance with Professional Standard PS300 of the IAAust.
- We allowed for the estimated effects of the diversification of insurance liabilities across lines of business and across the outstanding claims and premium liabilities.
- Risk margins are calculated for each licenced insurer in isolation. No allowance is made for diversification of any Group's liabilities across more than one licenced insurer.

Changes in future claims environments (e.g. socio-economic changes, changes in policy coverage) may result in changes to the estimated liability distributions by line of business. Hence, as these analyses are based on historical data, the risk margins in this report may not remain appropriate over time. We understand that the IAAust envisages further research being undertaken, and we hope that this paper will provide a stimulus for further research. However, in the absence of further research, we recommend that the IAAust Task Force consider instigating regular reviews of the analyses presented in this report.

The risk margins presented in this report should be considered as guides only and representative of an "industry average" portfolio. The specific characteristics of an individual insurer's portfolio may result in significantly different liability distributions than presented in this report. For portfolios with materially different risk characteristics than the industry average, we recommend that individual assessment be undertaken.

Due to the lack of availability of comprehensive data suitable for rigorous statistical analyses, by necessity the conclusions drawn from our analyses have included a significant degree of actuarial judgement. To assist in this regard, we sought and received feedback from senior actuaries practising in the industry.

In order to preserve the confidentiality of the contributing entities' statistics, we have not included results of our analyses of individual insurers' portfolios.

Section 3 sets out the reliances and limitations of the conclusions drawn in this report in more detail.

Methodology

Primarily due to constraints imposed by the data available for this analysis, we estimated the risk margins separately for the net outstanding claims liability and the net premium liability. We estimated risk margins separately for primary insurance and inwards reinsurance.

"Stand Alone" Risk Margins for the Net Outstanding Claims Liability

In respect of primary insurers, we estimated the "stand alone" risk margins (ie before any allowance for diversification) for the net outstanding claims liabilities using the following approach:

- We estimated the net central estimate of the outstanding clams liabilities for each portfolio analysed using the chain ladder valuation approach applied to net claim payments and, where case estimates were also available, to net incurred claims costs.
- We estimated the standard error, or uncertainty, in the net central estimates of the outstanding claims liabilities, for each portfolio analysed, using the method developed by Thomas Mack (1993) and two different applications of the bootstrapping technique.

- We estimated the systemic variance (the element of the total coefficient of variation that is constant across the whole line of business, irrespective of the size of the liability) and the independent variance (the element of the total coefficient of variation that is related to the size of the liability) for each line of business. Where appropriate, to estimate the systemic variance we considered relevant US experience to be indicative of the underlying systemic component.

- In order to allow for any additional systemic or process error that may not have been captured in the data, and to allow for the assumed error arising from the tail liability beyond the data sample, we subjectively adjusted the analytical estimates of the systemic and independent variance calculated from our data samples. These subjective adjustments were made based on our experience from previous analyses of the uncertainty in liability estimates and feedback received from senior actuaries practising in the industry.

- Based on the estimated systemic and independent variances we calculated the coefficient of variation, and hence risk margin (assuming that the net outstanding claims liability follows a lognormal distribution), by line of business.

In respect of inwards reinsurance, we estimated the standard error in the central estimate of the liability separately in respect of proportional and non-proportional reinsurance. Hence, we estimated risk margins separately for proportional and non-proportional reinsurance.

"Stand Alone" Risk Margins for the Net Premium Liability

Estimating the uncertainty for the premium liability is considerably more problematic than estimating the uncertainty for the outstanding claims liability.

The coefficient of variation for the premium liability would generally be expected to be greater than the coefficient of variation for the outstanding claims liability (for the same liability amount) for a number of reasons, including, but not limited to: the premium liability having greater reliance on assumptions relating to unknown future experience and events; possible exposure to multiple claim events (e.g. catastrophes); potential changes in claims handling/processing procedures; and the fact that uncertainty generally increases with the decreasing age of an accident period.

We estimated the risk margin for the premium liability based on the following:

- The estimated standard error of the historical, net annual accident year loss ratios, for those portfolios for which net earned premium information was available (we assumed that the loss ratio follows a lognormal distribution).

- The estimated error/uncertainty derived for the net outstanding claims liability for the most recent accident year. For this purpose we used the Mack method on net claim payments and net incurred claims cost, where available. The uncertainty in the most recent accident year should be indicative of the uncertainty in the premium liability and may represent a lower bound. We assumed that the outstanding claims liability for the most recent accident year follows a lognormal distribution.

We analysed the ratio of the estimated premium liability risk margins derived above to the net outstanding claims liability risk margin by line of business (adjusted for the different size of the premium liability compared with the net outstanding claims liability).

We then expressed the premium liability risk margin as a multiple of the risk margin calculated using the independent and systemic variances determined for the net outstanding claims liability, but based on the size of the net premium liability.

Allowance for Diversification of the Total Insurance Liability

Due to the offsetting effects of certain experience between lines of business, the combined uncertainty of an insurer's total net insurance liability (the sum of the individual line of business net outstanding claims liabilities and net premium liabilities) is less than the sum of the uncertainty for the individual lines of business.

We estimated the variance of the total insurance liabilities allowing for the impact of correlations (on the systemic variance component only) between the net outstanding claims and the net premium liabilities, as well as between different lines of business. For this purpose, we subjectively selected correlation matrices, based on our market knowledge and input received from senior actuaries practising in the industry.

Using the estimated variance of the total insurance liabilities, we simulated statistics for 2,350 insurers based on various combinations of the amount of the insurance liability, the number of lines of business written (ranging from 2 – 8), the proportion of the total insurance liability in each line of business, and the split of the total insurance liability between the net outstanding claims liability and the net premium liability.

From the simulated results, we estimated the diversification benefit as the difference between the sum of the individual line of business "stand alone" risk margins (net outstanding claims liability and net premium liability) and the risk margin for the insurer's total insurance liabilities allowing for the impact of correlations.

We modelled the diversification discount in order to identify a simplified "rule of thumb" relationship for practical use. The total risk margin for an insurer, including an allowance for diversification, is then calculated by applying the "rule of thumb" diversification discount to the sum of the individual line of business "stand alone" risk margins. It is beyond the scope of this consultancy to provide an appropriate basis for allocating the diversification benefit back to the individual lines of business.

During the course of the consultancy, we attended regular meetings of the IAAust Task Force's sub-committee to present updates on progress to date. The sub-committee also organised a meeting of interested senior actuaries from both primary insurers and reinsurers. Both the sub-committee meetings and the meeting with senior actuaries practising in the industry proved to be a valuable source of feedback and information exchange, and assisted in increasing the value obtained from our analyses.

A detailed description of our methodology is set out in Section 6.

1 BACKGROUND AND SCOPE

1.1 Background

The Institute of Actuaries of Australia ("IAAust") is developing a "Professional Standard and Guidance Note on Liability Valuation for General Insurance", in response to new legislative and regulatory requirements which will be effective from 1 July 2002. The IAAust has formed a Task Force to manage this process. In addition, Guidelines will be developed to meet the Australian Prudential Regulation Authority's ("APRA") industry requirements. Tillinghast–Towers Perrin ("Tillinghast") was engaged by the IAAust, in consultation with APRA, to undertake research relevant to the development of these Guidelines.

Original Scope

The original terms of reference for Tillinghast's appointment were detailed in a letter of agreement dated 20 August 2001. In particular, it was agreed that Tillinghast's role, under the general oversight of the Task Force, would be as follows:

- Using data supplied by APRA, and any other suitable sources of industry data, to undertake and report on a high-level analysis of the experience and uncertainty of each of the classes of business identified in that data;
- Incorporate, in that analysis, the extrinsic sources of uncertainty;
- Where appropriate, source and analyse supplementary data. This might include more detailed data drawn from one or more insurers or from other studies, or broader data from international sources, for example.
- Where appropriate and practical, consider the correlations within the data analysed and correlations with external factors.
- Propose rules, suitable for inclusion by APRA in subordinate legislation, relating to acceptable levels or ranges of levels of:
  - — central estimates for outstanding claims;
  - — central estimates for unexpired risks; and
  - — risk margins.

- Propose practical procedures and algorithms for use by insurers who are not required to retain actuarial advisers in:
  - determining central estimates on an expected present value basis, both for outstanding claims and unexpired risks; and
  - setting risk margins.
- Consult and liaise, as appropriate, with relevant IAAust Committees and Task Forces, including the General Insurance Task Force, and with groups such as APRA, the Insurance Council of Australia ("the ICA") and other industry/professional organisations.
- Prepare a draft report on the above for discussion with the IAAust Presidential Group and the Task Force and, subsequently, produce a final report.

1.3 Revised Scope

The scope of the project outlined in the 20 August 2001 letter of agreement has changed significantly during the course of the consultancy.

The legislation defining the new prudential and regulatory requirements, to be effective from 1 July 2002, was passed by the Senate on 28 August 2001 with some significant changes from the original draft legislation proposed. In particular, the draft legislation provided insurers with total insurance liabilities of $20 million or less at the last reporting date, an exemption from the requirement to seek written advice from a valuation actuary in respect of the value of its insurance liabilities. This exemption was removed in the legislation passed by the Senate. Hence, all insurers will be required to seek the written advice of a valuation actuary unless a specific exemption is granted by APRA.

At a meeting of the Task Force sub-committee on 28 August, following the passing of the legislation by the Senate, it was agreed that Tillinghast should suspend work on both the rules for calculating ranges of acceptable levels of central estimates and the practical procedures for their calculation, subject to further instructions from the committee. That is, the scope of Tillinghast's involvement was amended to undertaking more extensive analyses in the provision of advice in respect of net risk margins only.

1.4 Agreed Approach

This project needed to balance:

- the need for detailed quantification;
- the practical constraints of the available data; and
- the timeframe available for the analyses.

The Task Force specified the need for a simple and practical formula-driven approach for the net risk margins, in particular:

- It was generally understood that no "one size fits all" formula exists. However, the simplest, practical approximation was sought.
- The resulting formula is aimed at use by small to medium-sized insurers. However it may also be a useful guide for larger insurers' actuaries.

The scope, as determined and agreed with the Task Force sub-committee, was such that the risk margins were to be developed as an indicative guide only, given:

- the lack of available data for detailed quantification, particularly premiums data due primarily to its commercial sensitivity;
- the restricted timeframe available for the analyses; and
- the recognition that, within each line of business, significant differences exist across insurers between the net outstanding claims liability and premium liability distributions. (The aim of this analysis is to provide indicative risk margins that cater for an "industry average" portfolio. As such, they may not accurately capture, or even fully reflect, the uncertainty in any individual insurer's central estimate of its insurance liabilities.)

Underlying this scope, there was an objective that the risk margins should provide a useful tool for establishing benchmarks and for providing guidance to actuaries within the industry.

It is envisaged that future studies by actuaries practising in the industry will continue to refine and extend the analyses presented in this report.

This report presents the results of our analyses, based on the revised scope of the project as outlined in the previous paragraphs. We estimated net risk margins, by the lines of business defined by APRA for insurers' annual returns, in respect of:

- Primary insurers' outstanding claims and premium liability; and
- Outstanding claims and premium liability for inwards reinsurance business.

During the course of the consultancy, Tillinghast attended regular meetings of the Task Force's sub-committee to present updates on progress to date. The sub-committee also organised a meeting of interested senior practising actuaries from both primary insurers and reinsurers in the industry.

Both the sub-committee meetings and the meeting with senior practising actuaries in the industry proved to be a valuable source of feedback and information exchange, and assisted in increasing the value obtained from our analyses.

We would particularly like to thank the following for their active contributions throughout this project:

- Robert Buchanan, Robert Buchanan Consulting Pty. Ltd.
- Tim Clarke, Swiss Re Australia Limited
- John de Ravin, Munich Reinsurance Company of Australasia Ltd
- Peter McCarthy, Ernst & Young ABC
- Blair Nicholls, QBE Insurance Australia Limited.
- Greg Taylor, Taylor Fry Consulting Actuaries
- Brett Ward, Royal & Sun Alliance Insurance Australia Limited

In addition, we would like to thank the following entities for providing data for these analyses:

- Allianz Australia Insurance Limited ("Allianz")
- CGU Insurance Limited ("CGU")
- QBE Insurance (Australia) Limited ("QBE" or "QBE Re")
- Royal & Sun Alliance Insurance Australia Limited ("RSA")
- TIO Finance and Insurance ("TIO")
- Zurich Australian Insurance Limited ("Zurich")
- The Victorian WorkCover Authority ("VWA")
- The WorkCover Authority of NSW ("NSW WorkCover")
- The Motor Accident Authority of NSW ("MAA")
- The Motor Accident Insurance Commission in Qld ("MAIC")
- Insurance Statistics Australia ("ISA")
- Gerling Global Reinsurance Company of Australia Pty Ltd ("Gerling Global Re")
- Hannover Re ("Hannover Re")
- Munich Reinsurance Company of Australasia Ltd ("Munich Re")
- Swiss Re Australia Ltd ("Swiss Re")

2 RELIANCES AND LIMITATIONS

In undertaking this review, Tillinghast relied on the following claim payment data, case estimate data and net earned premium data:

- data supplied by APRA;
- data obtained directly from insurers and reinsurers in Australia; and
- publicly available data taken from licenced insurers' annual returns lodged with the regulators in the United States of America.

Reliance was placed on, but not limited to, the information described in Section 4 of this report. We have used the information without independent verification. However, the data was reviewed, where possible, for reasonableness and consistency.

Due to the lack of availability of comprehensive data suitable for rigorous statistical analysis, by necessity the conclusions drawn from our analyses have included a significant degree of actuarial judgement. To assist in this regard, we sought and received feedback from senior actuaries practising in the industry.

The effects of systemic variation are not expected to be fully captured in the data. Consequently, additional subjective allowance for systemic effects has been made. However, our recommendations may need further adjustment by individual insurers' actuaries.

Individual claims data was not available for this analysis. To estimate the outstanding claims liability risk margins in this analysis we:

- Estimated the net central estimate of the outstanding claims liability using valuation approaches appropriate for data in aggregate format; and
- Analysed the uncertainty in these estimated net central estimates of the outstanding claims liability.

In particular, to estimate the net central estimate of the liability we used the chain ladder valuation approach, applied to both claim payments and incurred claims costs (where available). The use of individual claims data and/or the employment of different valuation approaches may result in a significantly different estimate of the uncertainty in the outstanding claims liability amount for an individual insurer.

It was beyond the scope of this project to derive estimated risk margins for all feasible portfolio characteristics. Instead, as requested, a simple, practical approximation has been sought.

The use of industry-wide risk margins may not be appropriate for an individual insurer or portfolio for a number of reasons, including but not limited to:

- The number of years the insurer has been writing the business;
- Differences in the type of risk underwritten;
- Differences in policy coverages;
- Recent changes in claims management practices; and
- The extent of reinsurance.

Data constraints restricted our choice of methods for analysing the uncertainty in insurance liabilities, to a separate examination of the outstanding claims liabilities and the premium liabilities. An alternative approach, had suitable data been available, would have been to analyse the total insurance liabilities and then apportion the resulting risk margins between the outstanding claims liabilities and the premium liabilities.

Any examination of the correlation between results for different lines of business needs a substantial amount of data, both historical time-series data and in terms of critical mass by line, to enable credible inferences to be drawn. Such data was not available for the Australian general insurance market. Therefore, we have subjectively selected an assumed correlation matrix between the major lines of business. As discussed in Section 7.5, we have tested the sensitivity of our results to alternative subjective assumptions. We have only considered correlations at the total provision level. It is beyond the scope of this project to consider correlations likely to be observable at lower levels (e.g. at the accident year level).

Our approach makes no allowance for the diversification of an insurer's liabilities:

- Within a line of business, across different states or countries.
- Across any lines of business not included in our correlation matrices.

In effect, we implicitly assumed a 100% correlation of insurance liabilities from these sources. The allowance for diversification will therefore be understated to the extent that the correlation is less than 100% in these instances.

We estimated separate risk margins for inwards reinsurance in respect of:

- proportional reinsurance, and
- non-proportional reinsurance.

We have not made any explicit allowance for different types of proportional and non-proportional reinsurance. In addition, we have not made any explicit allowance for the different reserving methodologies that are used by reinsurers for their different treaty types. For example, we understand that quota share treaties are commonly reserved on an accounting year basis rather than an exposure year or accident year basis.

The methodology used to estimate the uncertainty in the net central estimate of the outstanding claims liability did not make explicit allowance for all possible sources of uncertainty in the central estimate. For example, no explicit allowance was made for uncertainty due to:

- changes in the pattern of claims run-off.
- movements in the interest rate used to calculate the present value of future cash flows, resulting from changes in the duration of the liabilities;
- changes in future rates of claim inflation; or
- future reinsurance recoveries.

However, we subjectively adjusted the results of our analyses in order to allow for these additional sources of uncertainty. Based on discussions with senior actuaries practising in the industry, we consider that the adjusted results, in aggregate, include a reasonable estimate of the above sources of uncertainty.

We selected two generally accepted methods for estimating the uncertainty, or standard error, in the net central estimate of the outstanding claim and premium liabilities, namely the Mack Method and two applications of the Bootstrapping technique. Whilst we believe these methods produce reliable results, it is possible that the use of other methods could produce significantly different results. However, the impact of using alternative methods will have been tempered in this instance due to the overriding subjective adjustments that have been applied to the analytical results of our analyses.

To estimate the 75th percentile of the net outstanding claims liability and premium liability distributions (i.e. as required by the APRA standard), we assumed they follow a lognormal distribution. The choice of distribution was judgemental. However, the lognormal distribution is commonly used to model insurance claim cost portfolios. The lognormal distribution is asymmetric and provides for the probability of outcomes significantly greater than the central estimate. However, due its skewed nature, the 75th percentile of the lognormal distribution is less than the corresponding 75th percentile of a normal distribution with the same central estimate and standard error. The impact of reinsurance will generally reduce the positively skewed nature of the claim cost distribution. We have not investigated the impact of assuming other distributions.

The risk margins presented in this report should be considered as guides only and representative of an "industry average" portfolio. The specific characteristics of an individual insurer's portfolio may result in significantly different liability distributions than presented in this report. For portfolios with materially different risk characteristics than the industry average, we recommend that individual assessment be undertaken.

We have made no explicit allowance for the impact of different levels of reinsurance purchased by insurers.

We have not anticipated any extraordinary changes to the legal, social, or economic environment that might affect the cost, frequency, or future reporting of claims. In addition, our central liability estimates make no provision for potential future claims arising from loss causes not represented in the historical data (e.g., pollution, asbestos, latent injuries, terrorist acts, etc.) except insofar as claims of these types are included in the reported claims and are implicitly analysed.

Changes in future claims environments (e.g. socio-economic changes, changes in type of policy coverage) may result in changes to the estimated uncertainty by line of business.

Hence, as these analyses are based on historical data, the risk margins in this report may become inappropriate over time. We understand that the IAAust envisages further research over time, and we encourage such research, however, in the absence of such further research, we recommend that the IAAust Task Force give consideration to instigating regular reviews of the analyses presented in this report.

3 DISTRIBUTION AND USE

This report has been prepared solely for the internal use of the IAAust and APRA for the purpose of assisting in the development of Standards and Guidelines on the Liability Valuation for General Insurers (Prudential Standard GPS 210 and Guidance Note GGN 210.1). It is not intended or necessarily suitable for any other purpose.

Any distribution of this report is unauthorised without Tillinghast's prior written consent.

We hereby grant permission for distribution of this report to either or both of the IAAust's or APRA's independent advisors. Such distribution is provided on the conditions set out in our letter of engagement dated 20 August 2001.

Any reference to Tillinghast in relation to this analysis in any published document or any verbal report is not authorised without our prior written consent.

For the purposes of publications or other materials produced by the IAAust (or APRA), the IAAust (or APRA) may adopt the opinions or conclusions (or parts thereof) detailed in this report, provided that the IAAust (or APRA):

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- obtains Tillinghast's prior written consent to the proposed wording of the acknowledgment or any other references to Tillinghast in any such documents, and provided also that Tillinghast is permitted to review the entire document to ensure that the context of any references to Tillinghast and our work are appropriate.

We have performed the work assigned and prepared this report in conformity with its intended utilisation by persons technically familiar with the areas addressed and for the stated purposes only. Judgements as to the appropriateness of data, methods and assumptions contained in this report should be made only after studying the report in its entirety, as conclusions reached by a review of a section or sections in isolation may be incorrect.

Members of Tillinghast staff are available to explain or amplify any matter presented herein.

Tillinghast has been asked to consent to this research report being made available, via the IAAust's website, to members of the IAAust and other interested parties, for their information and review in support of the development and application of the new prudential standards for general insurers. As noted earlier, this research report was prepared for the IAAust's and APRA's internal use and benefit, and on the basis that no other party would be relying upon it. Tillinghast consents to this research report being made available in its entirety on the IAAust's website for the aforementioned purpose and consents to parties other than IAAust and APRA receiving this research report via the IAAust website, on the following basis:

- that each reader understands that we relied, without independent review or verification, on certain information as described more fully in our report, and that we considered such reliance appropriate since the report was not prepared for the purpose of distribution to parties other than IAAust and APRA;

- that each reader undertakes not to rely on our report or information contained herein in any way that would result in the creation of any duty or liability on the part of Tillinghast to that reader; and

- that each reader, having regard to the information contained in our report and the limitations described herein, understands that he/she should undertake sufficient review and additional investigation to ascertain whether, and the extent to which, the "industry average" benchmarks contained in our report are appropriate for that reader's work.

4 DATA

This section details the claims data we received for this analysis. In addition, we received further valuable information from discussions with, and feedback from, the Task Force sub-committee and other senior actuaries practising in the general insurance industry.

We used claims data from the following sources:

- APRA claim payments, case estimates and premium data for four years, up to and including the 2000/2001 balance date, for the Commercial Motor and Domestic Motor lines of business.

- Data from the following five primary insurers: CGU, RSA, Allianz, QBE and Zurich. Data from these insurers covered the following lines of business:

  — Fire/ISR, Homeowners, CTP, Workers' Compensation, Commercial Motor, Domestic Motor, Marine & Aviation, Mortgage, Travel, Other Accident, Liability.

  Some primary insurers provided gross and/or net claim payments data, gross and/or net case estimate data and net earned premium data, whilst others only provided a subset of this data. Data was provided for a minimum of the last four years up to and including the 2000/2001 balance date of each insurer. Due to its commercially sensitive nature, not many insurers provided net earned premium data.

- Data from the following five reinsurers: Gerling Global Re, Hannover Re, Munich Re, QBE Re and Swiss Re. Data from these reinsurers covered the following lines of business:

  — Fire/ISR, Homeowners, CTP, Workers' Compensation, Motor, Marine & Aviation, Accident, Professional Indemnity, Liability, Other.

  Some reinsurers provided gross and/or net claim payments data, gross and/or net case estimate data and net earned premium data, whilst others only provided a subset of this data. In particular, due to its commercially sensitive nature, not many reinsurers provided net earned premium data. The data was provided separately for proportional and non-proportional business. Data was provided for a minimum of the last four years up to and including the 2000/2001 balance date of each insurer.

- Claims data from the US Schedule P of the Annual Statements. Schedule P data was used for the following classes of business: Fire/ISR, Homeowners, Marine & Aviation, Medical Malpractice, Workers' Compensation, Other Liability for both direct writers and reinsurers.
- ISA Gross Claims Data for Public Liability and Products Liability lines of business.
- CTP data from the MAA, the MAIC and TIO.
- Workers’ compensation data from NSW WorkCover and the VWA.

5 DEFINITION OF RISK MARGIN

Prudential Standard GPS 210, issued by APRA in November 2001, aims to provide a consistent set of principles for the realistic measurement and reporting of insurance liabilities for all insurers. The insurance liability for each class of business is defined as the sum of:

- A central estimate of the outstanding claims liability;
- A central estimate of the value of the premium liability; and
- The risk margin that relates to the inherent uncertainty in each of the central estimate values.

To ensure that insurers' reported liabilities are broadly consistent and sufficiently rigorous across the industry, Prudential Standard GPS 210 prescribes that the risk margin:

- Should be established on a basis that would be expected to secure the insurance liabilities of the insurer at a 75% level of sufficiency.
- Should, due to the highly skewed nature of the liability distributions of some classes of insurance, not be less than half of the coefficient of variation of the liability distribution.
- Should normally be determined having regard to the uncertainty of the net insurance liabilities, but consideration should also be given to any additional uncertainty related to the estimate of reinsurance recoveries.

The risk margins in this report have been estimated in accordance with our interpretation of the requirements of Prudential Standard GPS 210, summarised above. In particular, please note:

- As agreed with the Task Force sub-committee, we considered risk margins for net liabilities only.
- We assumed that the central estimate of the net outstanding claims liabilities, to which the risk margins presented in this report may be applied, are determined in accordance with Professional Standard PS300 of the IAAust.

- We allowed for the estimated effects of the diversification of insurance liabilities across lines of business and across the outstanding claims and premium liabilities.

- Risk margins are calculated for each licenced insurer in isolation. No allowance is made for diversification of any Group's liabilities across more than one licenced insurer.

In addition, we followed the Guidance Note, GGN 210.1, issued by APRA in November 2001, which provides preliminary guidance for insurers and actuaries when determining the value of the risk margin under Prudential Standard GPS 210.

6 METHODOLOGY

6.1 Summary of Approach

Primarily due to constraints imposed by the data available for this analysis, we estimated the risk margins separately for the net outstanding claims liability and the net premium liability. We estimated risk margins separately for primary insurance and inwards reinsurance.

"Stand Alone" Risk Margins for the Net Outstanding Claims Liability

In respect of primary insurers, we estimated the "stand alone" risk margins (ie before any allowance for diversification) for the net outstanding claims liabilities using the following approach:

- We estimated the net central estimate of the outstanding clams liabilities for each portfolio analysed using the chain ladder valuation approach applied to net claim payments and, where case estimates were also available, to net incurred claims costs.

- We estimated the standard error, or uncertainty, in the net central estimates of the outstanding claims liabilities, for each portfolio analysed, using the method developed by Thomas Mack (1993) and two different applications of the bootstrapping technique.

- We estimated the systemic variance (the element of the total coefficient of variation that is constant across the whole line of business, irrespective of the size of the liability) and the independent variance (the element of the total coefficient of variation that is related to the size of the liability) for each line of business. Where appropriate, to estimate the systemic variance we considered relevant US experience to be indicative of the underlying systemic component.

- In order to allow for any additional systemic or process error that may not have been captured in the data, and to allow for the assumed error arising from the tail liability beyond the data sample, we subjectively adjusted the analytical estimates of the systemic and independent variance calculated from our data samples. These subjective adjustments were made based on our experience from previous analyses of the uncertainty in liability estimates and feedback received from senior actuaries practising in the industry.

- Based on the estimated systemic and independent variances we calculated the coefficient of variation, and hence risk margin (assuming that the net outstanding claims liability follows a lognormal distribution), by line of business.

In respect of inwards reinsurance, we estimated the standard error in the central estimate of the liability separately in respect of proportional and non-proportional reinsurance. Hence, we estimated risk margins separately for proportional and non-proportional reinsurance.

"Stand Alone" Risk Margins for the Net Premium Liability

Estimating the uncertainty for the premium liability is considerably more problematic than estimating the uncertainty for the outstanding claims liability.

The coefficient of variation for the premium liability would generally be expected to be greater than the coefficient of variation for the outstanding claims liability (for the same liability amount) for a number of reasons, including, but not limited to: the premium liability having greater reliance on assumptions relating to unknown future experience and events; possible exposure to multiple claim events (e.g. catastrophes); potential changes in claims handling/processing procedures; and the fact that uncertainty generally increases with the decreasing age of an accident period.

We estimated the risk margin for the premium liability based on the following:

- The estimated standard error of the historical, net annual accident year loss ratios, for those portfolios for which net earned premium information was available (we assumed that the loss ratio follows a lognormal distribution).

- The estimated error/uncertainty derived for the net outstanding claims liability for the most recent accident year. For this purpose we used the Mack method on net claim payments and net incurred claims cost, where available. The uncertainty in the most recent accident year should be indicative of the uncertainty in the premium liability and may represent a lower bound. We assumed that the outstanding claims liability for the most recent accident year follows a lognormal distribution.

We analysed the ratio of the estimated premium liability risk margins derived above to the net outstanding claims liability risk margin by line of business (adjusted for the different size of the premium liability compared with the net outstanding claims liability).

We then expressed the premium liability risk margin as a multiple of the risk margin calculated using the independent and systemic variances determined for the net outstanding claims liability, but based on the size of the net premium liability.

Allowance for Diversification of the Total Insurance Liability

Due to the offsetting effects of certain experience between lines of business, the combined uncertainty of an insurer's total net insurance liability (the sum of the individual line of business net outstanding claims liabilities and net premium liabilities) is less than the sum of the uncertainty for the individual lines of business.

We estimated the variance of the total insurance liabilities allowing for the impact of correlations (on the systemic variance component only) between the net outstanding claims and the net premium liabilities, as well as between different lines of business. For this purpose, we subjectively selected correlation matrices, based on our market knowledge and input received from senior actuaries practising in the industry.

Using the estimated variance of the total insurance liabilities, we simulated statistics for 2,350 insurers based on various combinations of the amount of the insurance liability, the number of lines of business written (ranging from 2 – 8), the proportion of the total insurance liability in each line of business, and the split of the total insurance liability between the net outstanding claims liability and the net premium liability.

From the simulated results, we estimated the diversification benefit as the difference between the sum of the individual line of business "stand alone" risk margins (net outstanding claims liability and net premium liability) and the risk margin for the insurer's total insurance liabilities allowing for the impact of correlations.

We modelled the diversification discount in order to identify a simplified "rule of thumb" relationship for practical use. The total risk margin for an insurer, including an allowance for diversification, is then calculated by applying the "rule of thumb" diversification discount to the sum of the individual line of business "stand alone" risk margins. It is beyond the scope of this consultancy to provide an appropriate basis for allocating the diversification benefit back to the individual lines of business

During the course of the consultancy, we attended regular meetings of the IAAust Task Force's sub-committee to present updates on progress to date. The sub-committee also organised a meeting of interested senior actuaries from both primary insurers and reinsurers. Both the sub-committee meetings and the meeting with senior actuaries practising in the industry proved to be a valuable source of feedback and information exchange, and assisted in increasing the value obtained from our analyses.

The following sections provide a detailed description of the methodology described above.

6.2 "Stand Alone" Risk Margins for the Net Outstanding Claims Liability for Primary Insurers

The estimated risk margin depends on the error or uncertainty in the net central estimate of the liability.

We considered the standard error of the net outstanding claims liability for an insurer as comprising components relating to:

- The standard error of the net outstanding claims liability for each line of business;
- The level of diversification within the total net outstanding claims liabilities of the insurer; and
- The level of aggregate reinsurance cover provided.

For these analyses we estimated the first two components only. We did not estimate the impact of different levels of aggregate reinsurance cover. However, we made subjective adjustments to the analytical results, which we believe provide reasonable estimates for the additional uncertainty from this and other sources.

6.2.1 Standard Error of the Net Outstanding Claims Liability by Line of Business

We calculated the risk margin for each line of business based on the estimated standard error, and the assumption that the net outstanding claims liability follows a lognormal distribution. The choice of distribution was subjective. However, the lognormal distribution is commonly used to model general insurance liability distributions.

The standard error of the net outstanding claims liability for an individual line of business is heavily correlated with both the size of the liability and the level of reinsurance cover provided. The size of the liability and the level of reinsurance cover are also highly correlated and, for these analyses, we analysed the impact on the standard error of the size of the net liability only. That is, we have not adjusted for the impact of different levels of reinsurance. The error or uncertainty in two portfolios with the same net central estimate of the outstanding claims liability, but different gross central estimates of the outstanding claims liability, will be different, and perhaps significantly so.

The standard errors derived from these analyses may be considered as allowing for a "nominal" or "industry average" level of reinsurance, by size of net outstanding claims liability.

The coefficient of variation of the net outstanding claims liability may be considered as comprising:

- an element that is constant across the whole line of business, irrespective of the size of the liability (the systemic component); and
- an element that is related to the size of the liability (the independent component).

Algebraically, this can be represented by the formula:

$$CV(X_i) = \sqrt{\left(a_i^2 + {b_i^2}/{n_i}\right)} \tag{6.1}$$

where:

X_i	=	*Line of business i*
$CV(X_i)$	=	*Coefficient of Variation for* X_i
n_i	=	*the amount of the net central estimate of outstanding claims liability for line of business i, in $millions*
$n_i^2 a_i^2$	=	*systemic variance for line of business i*
$n_i b_i^2$	=	*independent variance for line of business i*

To estimate the systemic and independent variance by line of business we:

- estimated the total standard error;
- estimated the systemic and independent components of the total standard error; and
- applied subjective adjustments to arrive at our final recommendations.

6.2.2 Estimated Total Standard Error

We estimated the central estimate of the net outstanding claims liability for each portfolio analysed using the chain ladder valuation approach applied to:

- Cumulative net claim payments (without adjustment for inflation), and
- Cumulative net incurred claims costs for portfolios for which case estimates were also provided (without adjustment for inflation).

A description of the chain ladder valuation approach is given in Appendix A.

The central estimate of the net outstanding claims liability may be considered as the mean value from the distribution of possible values of the liability.

There are a number of recognised and accepted methods available for estimating the uncertainty (or standard error) in central estimates, including methods developed by the following (refer Appendix I for details of publications describing these methods): Mack, Taylor/Ashe, Zehnwirth, Renshaw, Verrall, Wright. The different approaches to estimating the standard error can be summarised as:

- Methods which apply a least squares regression on the logarithm of the incremental claim amounts (Zehnwirth (1991), Renshaw (1989), Verrall (1990,1991)); i.e. assuming a lognormal distribution.
- Methods which use Generalised Linear Modelling ("GLM") techniques to regress the incremental claim amounts (Poisson distribution for Verrall (1991) and Gamma distribution for Mack (1991).
- Stochastic bootstrapping techniques.
- Mack's 1993 method based on the chain ladder approach.

To estimate the uncertainty, or standard error, in net central estimates we used the following methods:

- The method developed by Thomas Mack (1993) (the "Mack Method"). A brief summary of this method is given in Appendix B; and
- Two different applications of the bootstrapping technique (the "Bootstrapping method"). Various publications are available on applications of bootstrapping. A brief description of each of the two methods we used is given in Appendix B.

Our rationale for selecting the above methods included:

- their simplicity;
- the timeframe available for the analyses;
- their suitability to the aggregate data available for the analyses;
- their distribution-free calculation of the standard error;
- the general acceptance in the actuarial profession that these methods are appropriate for use in determining uncertainty in reserve estimates; and

- in respect of the Mack method, from Mack's paper neither the reserve estimates nor the standard errors were systematically higher or lower than for the other methods used for comparison (with the exception of the Taylor/Ashe method).

Our estimates of the total standard error for the estimated net outstanding claims liability for each portfolio allows for both:

- parameter estimation error, due to the variability of the historical data used to estimate the model parameters; and
- process variation, allowing for the variability of future experience around the model parameters.

6.2.3 Estimated Systemic and Independent Variance

To estimate the systemic and independent components of the standard error, we solved simultaneous equations in the form of equation (6.1) above, using our estimates of the total standard error calculated using the methods outlined in Section 6.2.2.

To estimate the systemic variance we considered the relevant US experience tobe indicative of the underlying systemic variance for certain lines of business. When considering the US experience, we allowed for the estimated effect on the systemic variance of differences in the cover generally provided under policies in the US market compared with the cover generally provided under policies in the Australian market.

6.2.4 Subjective Adjustment

Adjustment to the analytical estimates of systemic and independent variance, calculated from our data samples, is required to allow for:

- any additional systemic or process error that may not be captured in the data; and
- assumed error arising from the tail liability beyond the data samples provided.

By necessity, any adjustment contains a high degree of subjectivity.

We have adjusted the analytical estimates based on:

- our experience from previous analyses of the uncertainty in liability estimates; and
- feedback received from senior actuaries practising in the industry who have access to more detailed data, and have undertaken more rigorous statistical analyses.

Based on the estimated systemic and independent variances, we calculated the coefficient of variation, and hence risk margin (assuming a lognormal distribution), by line of business, for various sizes of the net outstanding claims liability.

Where possible, we compared these results with results from similar studies we have conducted in the past.

6.2.5 Adjustment for Level of Reinsurance

We have not made any explicit allowance for reduced (or increased) volatility in the net outstanding claims liability resulting from greater (or lower) reinsurance cover.

The recommended risk margins in this report may be considered as implicitly allowing for an "industry average" level of reinsurance cover, by line of business and by size of portfolio.

It is recognised that significant variations in the level and type of reinsurance cover exist in the industry, and further that this will obviously alter the net outstanding claims liability distribution and may require risk margins that are significantly different from those recommended in this report. It is beyond the scope of this analysis to provide risk margins that cater for all possible portfolio characteristics.

6.2.6 Risk Margin Cap

The application of formula (6.1) results in an unbounded variance, and hence risk margin, for lines of business with an infinitely small net outstanding claims liability. For practical application, we subjectively imposed a maximum risk margin for each line of business. It is beyond the scope of this consultancy to provide an appropriate basis for allocating the diversification benefit back to the individual lines of business. However, the maximum risk margin for each line of business applies after the allocation of any diversification benefit (see Section 6.4) to the line of business.

6.3 "Stand Alone" Risk Margins for the Net Outstanding Claims Liability for Inwards Reinsurance

In respect of inwards reinsurance, we estimated the standard error in the net central estimates (hence risk margin) separately in respect of:

- Proportional inwards reinsurance, and
- Non-proportional inwards reinsurance.

In the following sub sections, reference to a reinsurer also refers to the inwards reinsurance business of a primary insurer.

6.3.1 Standard Error of the Net Outstanding Claims Liability for Proportional Reinsurance

For most commonly used types of proportional reinsurance contracts, the uncertainty in central estimates for proportional inwards reinsurance portfolios would be expected to be the same as for the primary insurance portfolios, based on the size of the primary insurer's gross outstanding claims liability.

However, an inwards reinsurance portfolio's aggregate liabilities for each line of business may comprise:

- multiple contracts on the same portfolio; and/or,
- multiple contracts on different portfolios, for the same line of business.

To calculate the uncertainty in inwards reinsurance liabilities would therefore require:

- Separate assessment of the uncertainty for each contract;
- Provision for the correlation between multiple contracts on the same portfolio; and
- Provision for the correlation between multiple contracts on different portfolios but the same line of business.

Provision for these effects is problematic and requires selection of assumed correlation matrices and assumed "industry average" contract and portfolio mixes for each line of business. These assumptions would, by necessity, be highly subjective.

An alternative approach we considered was to calculate the risk margin in respect of proportional inwards reinsurance business as the size-weighted average of the risk margins for each contract, where:

- The risk margin for each contract would be based on the same independent and systemic components calculated for the line of business for a primary insurer's gross outstanding claims liability;
- The size used to calculate the risk margin for each contract would be equal to the size of the inwards reinsurance outstanding claims liability for the contract; and
- The weights would be equal to the sizes of the outstanding liabilities for each contract.

This approach calculates an approximate risk margin, assuming all contracts within a line of business are 100% pair-wise correlated. The actual risk margin requires calculation of the standard error of the aggregate liability by line of business, with the risk margin then calculated from the lognormal distribution. The standard error of the aggregate liabilities for a line of business is equal to the weighted average of the standard errors of the liability distribution for each contract. The risk margin approximation will be close if the liability distributions for each contract are not too highly skewed, which should be the case for quota share proportional reinsurance contracts.

A practical difficulty with this approach is that, for inwards reinsurance, the outstanding claims liability for each contract is required.

After discussions with senior practising actuaries, it was agreed that a practical approach to the calculation of the risk margin by line of business is as follows:

- The standard error (and hence risk margin) is calculated using the same independent and systemic components calculated for the line of business for a primary insurer's net outstanding claims liability.
- The liability amount is based on the inwards reinsurance aggregate net outstanding claim liabilities for each line of business, across all contracts and portfolios.

This practical approach produces risk margins that, when compared to the expected uncertainty of components of the inwards reinsurance portfolio, are:

- higher than expected for most quota share treaties, due to the accounting year reserving methodology generally employed for these contracts;
- higher than expected due to the diversification within a line of business from multiple contracts;
- lower than expected for proportional surplus treaties, due to the expected greater volatility of these treaty types;
- lower than expected for most facultative proportional reinsurance, due to the expected greater volatility of these treaty types; and
- lower than expected due to the use of the aggregate size (across contracts) of the inwards reinsurance liabilities rather than the aggregate risk margins (weighted by size) across the inwards reinsurance contracts.

Overall, we believe that the practical approach provides a reasonable balance of all the above effects.

6.3.2 Non-proportional Reinsurance

We estimated risk margins for non-proportional reinsurance liability portfolios using the methodology outlined in Section 6.2.1. For practical purposes, we expressed risk margins for non-proportional reinsurance as a multiple of the primary insurers' risk margin.

As for proportional reinsurance, the liability amount is based on the size of the inwards reinsurance net outstanding claims liability.

6.4 "Stand Alone" Risk Margins for the Premium Liability

Estimating the uncertainty for the premium liability is considerably more problematic than estimating the uncertainty for the outstanding claims liability.

The coefficient of variation for the premium liability would generally be expected to be greater than the coefficient of variation for the outstanding claims liability (for the same size of liability) for a number of reasons, including, but not limited to:

- The liability having greater reliance on assumptions related to unknown future experience and events;
- Possible exposure to multiple claim events, e.g. catastrophes;
- Potential changes in claims handling/processing procedures; and
- The fact that uncertainty generally increases with the decreasing age of an accident period.

We estimated the risk margin for the premium liability based on the following:

- The estimated standard error of the historical, net annual accident year loss ratios, for those portfolios for which net earned premium information was available (we assumed that the loss ratio follows a lognormal distribution).
- The estimated error/uncertainty derived for the net outstanding claims liability for the most recent accident year. For this purpose we used the Mack method on net claim payments and net incurred claims cost, where available. The uncertainty in the most recent accident year should be indicative of the uncertainty in the premium liability and may represent a lower bound. We assumed that the outstanding claims liability for the most recent accident year follows the lognormal distribution.

We analysed the ratio of the estimated premium liability risk margins derived above to the net outstanding claims liability risk margin by line of business. We adjusted for the different size of the premium liability compared with the net outstanding claims liability by line of business.

We then expressed the premium liability risk margin as a multiple of the risk margin calculated using the independent and systemic variances determined for the net outstanding claims liability, but based on the size of the net premium liability.

6.5 Allowance for Diversification of the Net Outstanding Claims Liability Only

For an insurer's total net outstanding claims liability portfolio, the combined risk is less than the sum of the risks for the individual lines of business, due to the offsetting effects of different experience between lines of business.

6.5.1 Correlation Applied to the Total Variance

To allow for diversification across lines of business, we subjectively selected an assumed correlation matrix between the net outstanding claims liabilities of certain lines of business. The selected correlation matrix was based on our market knowledge and input received from senior actuaries practising in the industry.

For the purpose of simulating the diversification discount, we treated the aggregate inwards reinsurance liabilities as one line of business. That is, we assumed correlations to apply between the net outstanding claims liabilities for certain lines of business and the aggregate inwards reinsurance liabilities (across all lines of business within the inwards reinsurance portfolio). An alternative approach would be to consider the line by line correlations between the liabilities for primary insurance and inwards reinsurance business.

We applied the assumed correlation matrix to the total variance of the net outstanding claims liability by line of business (i.e. both the systemic and independent components of the net outstanding claims liability variance) and estimated the variance of the insurer's total net outstanding claims liability, using the following formulae:

$$Y = \sum_{i=1}^{N} X_i$$

$$Var(Y) = \sum_{i=1}^{N} Var(X_i) + 2\sum_{i<>j} \rho_{ij}\sigma_{X_i}\sigma_{X_j} \tag{6.2}$$

where:

X_i = *line of business i*

$Var(X_i)$ = *variance of net central estimate for line i from equation (6.1)*

ρ_{ij} = *correlation between net outstanding claims liability for lines of business i and j.*

σ_{X_i} = *standard error in the net central estimate of the net outstanding claims liability for line of business i.*

6.5.2 Correlation Applied to the Systemic Variance Only

We also estimated the variance of an insurer's total net outstanding claims liability assuming an implied correlation matrix applicable to the systemic component of the variance only. This is a more theoretically correct approach than applying a correlation matrix to the total variance. For this purpose, we derived the following formulae:

$$Y = \sum_{i-1}^{n} X_i$$

$$CV(X_i) = \sqrt{a_i^2 + b_i^2 / n_i}$$

$$Var(Y) = \sum n_i^{\ 2}\left(a_i^2 + b_i^2 / n_i\right) + 2\sum_{i<>j} a_i a_j \rho_{ij}^{*} n_i n_j \qquad (6.3)$$

where:

X_i = *line of business i*

$n_i^2 a_i^2$ = *systemic variance for line of business i from (6.1)*

$n_i b_i^2$ = *independent variance for line of business i from (6.1)*

n_i = *the amount of the net central estimate of outstanding claims liability for line of business i*

ρ_{ij}^{*} = *implied correlation between line of business i and j in respect of the systemic variance only.*

The derivation of formula (6.3) is shown in Appendix C.

We derived the implied correlation matrix applicable to the systemic component of the variance only, by equating the variances in formulae (6.2) and (6.3) and solving for the implied correlations. This derivation was based on a selected industry average net outstanding claims liability size and portfolio mix by line of business.

To calculate the risk margin for an insurer with multiple lines of business, we therefore estimated the coefficient of variation of the insurer's total net outstanding claims liability, allowing for the impact of the implied correlation between lines of business on the systemic component only of the coefficient of variation of each individual line of business.

From the estimated mean and variance of the total net outstanding claims liability (Y) for the insurer, we calculated the risk margin for the insurer assuming the total net outstanding claims liability follows a lognormal distribution.

6.5.3 Diversification Discount for the Net Outstanding Claims Liability

Using the implied correlation matrix applicable to the systemic variance only, the estimated coefficient of variation for each line of business, and the formulae (6.3), we simulated statistics for the net outstanding claims liability for 700 insurers based on various combinations of:

- Total net outstanding claims liability for the insurer;
- The number of lines of business written (ranging from 2 - 8 lines);
- The allocation of the total net outstanding claims liability across lines of business (i.e. the proportion of the total net outstanding claims liability in each line of business).

From the simulated results we compared:

- The sum of the individual line of business "stand alone" risk margins, with
- The risk margin for the total insurer's net outstanding claims liability calculated using the assumed correlation matrix and formulae (6.3) above.

We defined the risk margin "diversification discount" for the net outstanding claims liability as follows:

$$\textit{Diversification Discount} \quad = 1 - \frac{TRM}{IRM}$$

where:

IRM = *The sum of the individual line of business "stand alone" risk margins ($).*

TRM = *Overall insurer total risk margin with allowance for assumed correlations (using formula (6.3)) ($).*

Our methodology makes the following implicit assumptions:

- The same lines of business in more than one state or territory are 100% correlated with each other.
- Lines of business not included in our assumed correlation matrix are 100% correlated with each other.

In isolation, these implicit assumptions will result in a conservative estimate of the diversification discount.

We modelled the diversification discount in order to identify a simplified "rule of thumb" relationship for practical use. Allowing for diversification across the net outstanding claims liabilities only, we found the following "rule of thumb" form suitable:

$$\textit{Discount} \quad = \quad X\% \times (1\text{-}C)$$

where:

C = coefficient of concentration

$$= \frac{\text{Net outstanding claims liability for largest line of business (\$)}}{\text{Total net outstanding claims liability (\$)}}$$

For inwards reinsurance, we used the same methodology as for primary insurers, as outlined above. This implicitly assumes that multiple reinsurance contracts within a line of business are 100% correlated.

We also repeated this process allowing for the impact of the assumed correlation between lines of business on the total coefficient of variation of each individual line of business (i.e., both the systemic and the independent components).

6.6 Allowance for Diversification of Total Insurance Liability

We estimated the variance of the total insurance liabilities (that is, the net outstanding claims liabilities plus the premium liabilities) allowing for the following:

— The diversification of the insurance liabilities across the net outstanding claims and the net premium liabilities.

— The diversification of insurance liabilities across different lines of business.

6.6.1 Correlation Across the Net Outstanding Claims Liability and the Net Premium Liability

Due to the offsetting effects of certain experience between lines of business, the combined uncertainty of an insurer's total net insurance liability (the sum of the individual line of business net outstanding claims liabilities and net premium liabilities) is less than the sum of the uncertainty for the individual lines of business.

To allow for the diversification of insurance liabilities across the net outstanding claims liability and net premium liability, we subjectively selected an assumed correlation between the systemic variance component of the two liabilities. We selected one correlation for all "short tail" lines of business and another one for all "long tail" lines of business.

6.6.2 Correlation Across Different Lines of Business

To allow for the diversification of the insurance liabilities across lines of business, we estimated the variance of the aggregate net insurance liabilities by applying the derived correlation matrices to the systemic components of:

- the net outstanding claims liability by line of business, and
- the net premium liability by line of business.

The derivation of the net outstanding claims liability correlation matrix was described in Section 6.5.2.

We estimated the implied correlation matrix applicable to the net premium liability based on the following approach:

- We assumed that the correlation matrix applicable to the total variance of the net premium liability is the same as that assumed for the net outstanding claims liability (Section 6.5.1).
- We derived the implied correlation matrix applicable only to the systemic component of the variance of the net premium liability. This derivation was based on an industry average net premium liability size and portfolio mix by line of business.

This implied net premium correlation matrix is slightly different from the implied net outstanding claims correlation matrix, derived in Section 6.5.2, due to differences in the liability sizes and proportions by line of business.

6.6.3 Diversification Discount for Total Insurance Liabilities

We estimated the variance of an insurer's total net insurance liability based on:

- The estimated coefficient of variation for the net outstanding claims liability by line of business (Sections 6.2 and 6.3);
- The implied correlations between the net outstanding claims liability for each line of business (Section 6.5.2);
- The estimated coefficient of variation for the net premium liability by line of business (Section 6.4);
- The implied correlations between the net premium liability for each line of business (Section 6.6.2); and
- The assumed correlation between the net outstanding claims liability and the net premium liability for each line of business (Section 6.6.1).

The implied correlation between lines of business was only applied to the systemic components of the variances of the insurance liabilities.

Note that we assumed that the net outstanding claims liability of one line of business is independent of the premium liability of another line of business. To the extent that any correlations exist between the net outstanding claims liability of one line of business and the premium liability of another line of business, our derived diversification benefit would be overstated.

From the estimated mean and variance of the total insurance liability for the insurer, we calculated the risk margin for the insurer assuming the total net insurance liability follows a lognormal distribution.

Using the estimated variance of total insurance liabilities (from Sections 6.6.1 and 6.6.2) we simulated statistics for the insurance liability for 2,350 insurers based on various combinations of:

- Total insurance liability for the insurer;
- The number of lines of business written (ranging from 2 - 8 lines);
- The allocation of the total insurance liability across lines of business (i.e. the proportion of the total insurance liability in each line of business); and
- The allocation of the insurance liability by line of business across the outstanding claims and premium liability (i.e., the proportion of the insurance liability in the net outstanding claims liability and net premium liability in each line of business).

We estimated the diversification discount for total insurance liabilities using a similar methodology to that used for estimating the diversification discount for the net outstanding claims liability (Section 6.5.3).

We modelled the diversification discount in order to identify a simplified "rule of thumb" relationship for practical use. However, a relationship similar to that derived for the net outstanding claim liabilities considered in isolation (see Section 6.5.3), did not provide a satisfactory description of the diversification discount for the total insurance liabilities.

We therefore derived a "rule of thumb" relationship for the diversification discount for the total insurance liabilities of the form:

$$\textit{Discount} \quad = \quad X\% \times (1\text{-}C) + f(N) + f(S)$$

Where:

$$C = \text{coefficient of concentration}$$

$$= \frac{\text{Net insurance liability for largest line of business (\$)}}{\text{Total net insurance liability (\$)}}$$

N = number of lines of business

S = size of insurance liabilities in $ million

For inwards reinsurance, we used the same methodology as for the primary insurer outlined above. This implicitly assumes that multiple reinsurance contracts within a line of business are 100% correlated.

7 RESULTS

The following sub sections summarise the results of our analyses.

In order to preserve the confidentiality of the contributing entities' results, we have not included results of our analyses of individual insurers' portfolios. The results presented in this section therefore represent our final recommendations, after allowance for subjective adjustment to the analytical results of each individual portfolio.

7.1 "Stand Alone" Risk Margins for the Net Outstanding Claims Liability For Primary Insurers

Table 7.1 shows our recommended estimates of the systemic and independent components of the coefficient of variation for each "short tail" line of business included under the APRA returns. For illustrative purposes, the systemic variance, independent variance and the coefficient of variation for an outstanding claims liability of $80 million are also shown.

Table 7.2 shows comparable results for "long tail" lines of business and the resulting systemic variance, independent variance and the coefficient of variation for an outstanding claims liability of $200 million.

TABLE 7.1

Short Tail Classes –Systemic Variance, Independent Variance and Coefficient of Variation by Line

Line of Business	Systemic Component (a_i^2) %	Independent Component (b_i^2) %	For an $80M Net Outstanding Claims Liability: Systemic Variance ($n_i^2 a_i^2$) $M	Independent Variance ($n_i b_i^2$) $M	Total Coefficient of Variation %
Dom Motor	0.6	50.0	38	40	11.1
Comm Motor	1.0	48.0	64	38	12.6
Householders	1.0	60.0	64	48	13.2
Travel	1.0	60.0	64	48	13.2
Fire/ISR	1.1	70.0	70	56	14.1
Other	2.0	40.0	128	32	15.8
Cons Credit	2.1	82.0	134	66	17.7
Marine	3.6	35.0	230	28	20.1
Mortgage	3.6	82.0	230	66	21.5

TABLE 7.2

Long Tail Classes –Systemic Variance, Independent Variance and Coefficient of Variation by Line

Line of Business	Systemic Component (a_i^2) %	Independent Component (b_i^2) %	For an $200M Net Outstanding Claims Liability: Systemic Variance ($n_i^2a_i^2$) $M	Independent Variance ($n_ib_i^2$) $M	Total Coefficient of Variation %
Workers' Compensation	2.8	160	1,120	320	19.0
Liability	2.8	160	1,120	320	19.0
Professional Indemnity	2.8	160	1,120	320	19.0
CTP	4.0	300	1,600	600	23.5

We make the following comments on Tables 7.1 and 7.2:

- The results were presented at a regular meeting of the Task Force sub-committee, attended by interested senior practising actuaries in the industry, at which all interested parties were invited to provide feedback.
- We received feedback from a number of senior actuaries following this meeting. All respondents gave broad support for the results, recognising the reliances and limitations inherent in the analyses.

The direct application of formula (6.1) (refer Section 6.2.1) produces an unbounded coefficient of variation (and hence risk margin) for portfolios with infinitely small net outstanding claims liabilities. For practical purposes, we recommend imposing a subjectively selected cap on the risk margin for each line of business. This recommended risk margin cap for each line of business applies after the allocation of any diversification benefit to the line of business.

Table 7.3 shows the risk margin caps we selected by line of business.

TABLE 7.3

Selected Risk Margin Caps

Line of Business	Risk Margin Cap %	Maximum Liability Size for Which Risk Margin Cap Applies $M
Domestic Motor	20%	1.25
Commercial Motor	25%	2.00
Householders	25%	2.00
Travel	25%	2.00
Fire/Isr	30%	1.25
Other	30%	1.00
Consumer Credit	30%	0.75
Marine	30%	0.25
Mortgage	30%	0.75
Workers' Compensation	30%	1.00
Liability	30%	1.00
Professional Indemnity	45%	0.50
CTP	45%	0.50

Appendices E and F provide summaries of the "stand alone" risk margins, by size of net outstanding claims liability and line of business, based on the systemic and independent variances in Tables 7.1 and 7.2, and allowing for the risk margin caps in Table 7.3.

7.2 "Stand Alone" Risk Margins for the Net Outstanding Claims Liability For Inwards Reinsurance

7.2.1 Proportional Inwards Reinsurance

As discussed in Section 6.3.1, after discussions with senior practising actuaries, for practical purposes it was agreed to calculate the risk margin by line of business using the following approach:

- The standard error (and hence risk margin) is calculated using the same independent and systemic variance for the line of business as determined for a primary insurer's net outstanding claims liability of the same size.
- The size is based on the aggregate net outstanding claim liabilities of the inwards reinsurance portfolio for each line of business, across all contracts and portfolios.

Hence, the recommended estimates of the systemic and independent variance shown in Tables 7.1 and 7.2 are also applicable to proportional inwards reinsurance portfolios.

7.2.2 Non-proportional Inwards Reinsurance

Analysis of the error or uncertainty in the net outstanding claims liability by line of business is more problematic for non-proportional inwards reinsurance portfolios than for primary insurers' portfolios due to:

- The presence of nil incurred cost or nil payment amounts in the data triangles.
- Significant changes in the exposure by accident year.
- Significant differences in the nature and extent of the coverage across reinsurance portfolios. That is, portfolios are generally less homogenous across reinsurers than for insurers.
- The maximum limit may have been reached by a reinsurer for a particular cover.

However, we estimated the systemic and independent variance for non-proportional inwards reinsurance portfolios, by line of business, for the portfolios for which data was available.

For each line of business, we compared the estimated inwards reinsurance risk margin, by outstanding claims liability size, with the risk margins that would have applied for a primary insurer having the same outstanding claims liability size.

Table 7.4 shows the estimated ratio, derived from our analyses, of the inwards reinsurance risk margin to a primary insurer's corresponding risk margin.

TABLE 7.4

Risk Margin for Non-proportional Inwards Reinsurance as a Multiple of Direct Insurer Risk Margin.

Line of Business	Multiple of Direct Risk Margin
CTP	1.7
Workers' Compensation	2.0
Liability	2.0
Professional Indemnity	2.0
Fire/ISR	1.9
All Other	1.6

The multiples in Table 7.4 are only appropriate for the lower working layers of non-proportional inwards reinsurance portfolios. Higher multiples should be applied for contracts covering upper layers and/or contracts with significant exposure to catastrophes.

7.3 "Stand Alone" Risk Margins for the Premium Liability

The results of our analyses in respect of premium liability risk margins are based on very few portfolios.

We estimated the premium liability risk margins based on the methodology outlined in Section 6.4. We then expressed the premium liability risk margin as a multiple of the risk margin calculated using the independent and systemic variances determined for the net outstanding claims liability, but based on the size of the net premium liability.

We grouped results by short tail and long tail lines of business. The estimated ratios of the premium liability risk margin to the net outstanding claims liability risk margin (for liabilities of the same size) are as follows:

- 1.75 for short tail lines of business; and
- 1.25 for long tail lines of business.

These ratios balance the effects of a number of factors, including but not limited to:

- The contribution to the net outstanding claims liabilities of claims incurred but not reported ("IBNR claims"), and the methods used to value these claims. The valuation of IBNR claims requires consideration to be given to similar effects that would be considered for a revised pricing basis, for example recent changes and trends in claims frequency and average claim size. As IBNR claims represent a lower proportion of the net outstanding claims liabilities for short tail lines of business than for long tail lines of business, the estimated uncertainty of the net outstanding claims liabilities of short tail classes would generally include less allowance for these "premium liability" effects. Hence, the multiple of the net outstanding claims liability risk margin would be expected to be higher for short tail lines of business.

- The above point is partially offset by the fact that the ratio in respect of short tail lines of business could be expected to be lower, due to the average accident date of the net outstanding claims liabilities. That is, the uncertainty (and hence risk margin) generally decreases with the maturity of the accident year, and the average age of the net outstanding claims liability would be expected to be greater for long tail lines of business.

- Allowance for multiple events (eg catastrophes). This allowance would be expected to be greater for short tail lines of business.

In respect of long term contracts (e.g. consumer credit, mortgage, warranty), the average outstanding policy duration would vary across insurers. As the premium liability risk margin needs to recognise the increased uncertainty in the premium liability for portfolios with longer outstanding policy durations, a simple multiple of the net outstanding claims liabilities with no allowance for the differing average outstanding policy durations is not appropriate. Following discussions with senior practising actuaries, we recommend that the following approach be adopted in respect of long term contracts:

- $1.25 \times \sqrt{t}$ for long term contracts, where t = mean outstanding policy duration (in years).

7.4 Diversification Discount – Net Outstanding Claims Liability Only

Table 7.5 shows the assumed correlation matrix applicable to the total variance (i.e. both the systemic and independent components) in order to estimate the variance of the aggregate net outstanding claims liability for an insurer with multiple lines of business.

TABLE 7.5

Assumed Total Variance Correlation Matrix between Lines of Business (%)

	Liability	CTP	W/Comp	Prof Indemnity	Inwards Re	Fire/ISR	Motor	House	Other
Liability	100	25	25	25	25	0	0	0	0
CTP	25	100	35	25	25	0	25	0	0
W'Comp	25	35	100	25	25	0	0	0	0
Prof Indemnity	25	25	25	100	25	0	0	0	0
Inwards Re	25	25	25	25	100	5	5	5	5
Fire/ISR	0	0	0	0	5	100	10	10	5
Domestic Motor	0	25	0	0	5	10	100	20	10
H'Holders	0	0	0	0	5	10	20	100	10
Other	0	0	0	0	5	5	10	10	100

The total variance correlation matrix in Table 7.5 was subjectively selected, based on our market knowledge and input from senior practising actuaries in the industry. The assumed correlation matrix in Table 7.5 applies to the total variance of the net outstanding claims liability for each line of business.

Table 7.6 shows the implied correlation matrix applicable to only the systemic component of the variance in the net outstanding claims liability for each line of business. Table 7.6 was derived from:

- The total variance correlation matrix (Table 7.5),
- The methodology outlined in Section 6.5.2,
- An industry average net outstanding claims size and portfolio mix by line of business (see Appendix D).

TABLE 7.6

Derived Correlation Matrix Applicable to the Systemic Variance Only of the Net Outstanding Claims Liability (%)

	Liability	CTP	W/Comp	Prof Indemnity	Inwards Re	Fire/ISR	Motor	House	Other
Liability	100	35	40	45	45	0	0	0	0
CTP	35	100	50	40	40	0	55	0	0
W'Comp	40	50	100	45	50	0	0	0	0
Prof Indemnity	45	40	45	100	55	0	0	0	0
Inwards Re	45	40	50	55	100	15	15	15	10
Fire/ISR	0	0	0	0	15	100	40	35	10
Domestic Motor	0	55	0	0	15	40	100	75	25
H'Holders	0	0	0	0	15	35	75	100	20
Other	0	0	0	0	10	10	25	20	100

The implied correlations applicable to only the systemic component of the variance (Table 7.6) are, as expected, higher than the assumed correlations applicable to the total variance (Table 7.5).

Using the derived correlation matrix in Table 7.6, the estimated coefficient of variation for each line of business, and formulae (6.3) from Section 6.5.2, we simulated statistics for the net outstanding claims liability for 700 insurers (refer to Section 6.5.3).

We calculated the diversification discount for each of the simulations.

Based on the results of the simulations, we recommend that a minimum total net outstanding claims liability (or net premium liability) of $15 million be required before any diversification benefit is applicable.

For practical use, in respect of only allowing for diversification across the net outstanding claims liabilities, we recommend the following "rule of thumb" formula:

$$\textit{Diversification Discount} = 59\% \times (1\text{-}C) \qquad (7.1)$$

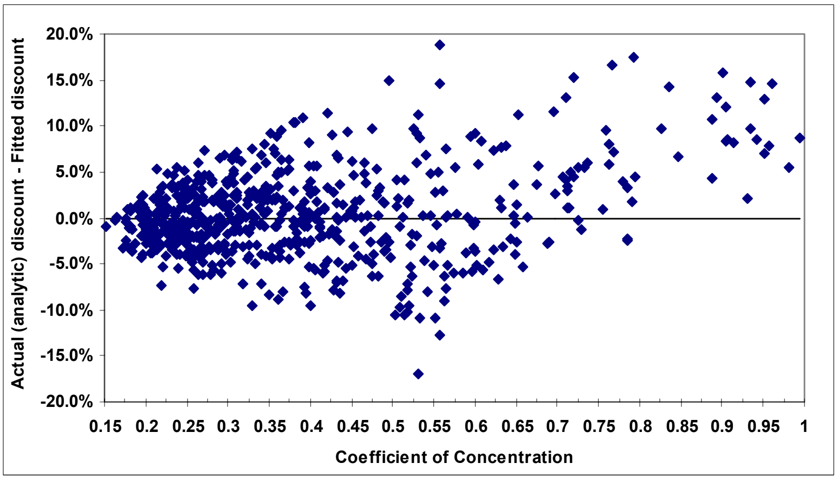
Where:

$$C = \text{coefficient of concentration}$$

$$= \frac{\text{Net outstanding claims liability for largest line of business (\$)}}{\text{Total net outstanding claims liability (\$)}}$$

Chart 7.1 shows a residual plot of the actual diversification discount against the fitted discount calculated according to the "rule of thumb" formula 7.1.

Chart 7.1 –Actual Diversification Discount less Fitted Discount for Net Outstanding Claims Liabilities Only



We make the following comments on Chart 7.1:

- For 91% of the simulations, the fitted discount is within 10% of the actual discount.
- For 98% of the simulations, the fitted discount is within 15% of the actual discount.
- For all of the simulations, the fitted discount is within 20% of the actual discount.
- The residual plot suggests that the fitted discount under-estimates the actual discount for coefficients of concentration above 0.7. The "rule of thumb" formula may therefore be conservative for insurers that are heavily concentrated in one line of business. We have not adjusted the formula to remove this effect.

We also calculated the diversification discount allowing for the impact of the assumed correlation (Table 7.5) between lines of business, on the total coefficient of variation of each individual line of business (i.e. both systemic and independent components). In this case the diversification discount could be represented by the formula:

$$\textit{Diversification Discount} = 55\% \times (1\text{-}C)$$

However, if considering the net outstanding claims liabilities in isolation, we recommend adopting the "rule of thumb" formula (7.1) for practical use in determining the diversification discount.

For inwards reinsurance we adopted the same methodology, and the same correlation matrix, for estimating the diversification discount as for direct insurers. Hence, if considering the net outstanding claims liabilities in isolation, the resulting diversification benefit "rule of thumb" formula is the same as for primary insurers, namely formula (7.1).

7.5 Diversification Discount – Total Net Insurance Liability

Table 7.7 shows the assumed correlations, applicable only to the systemic components of the variances, between the net outstanding claims and the net premium liabilities. By necessity, the assumed matrix is highly subjective.

TABLE 7.7

Assumed Correlation Between Net Outstanding Claim Liability and Net Premium Liability for a Line of Business (%)

Line of Business	Correlation
Short Tail	50
Long Tail	75

Table 7.8 shows the derived correlation matrix applicable only to the systemic component of the variance of net premium liabilities, by line of business.

TABLE 7.8

Derived Correlation Matrix Applicable to the Systemic Variance Only of the Net Premium Liability (%)

	Liability	CTP	W/Comp	Prof Indemnity	Inwards Re	Fire/ISR	Motor	House	Other
Liability	100	50	65	75	55	0	0	0	0
CTP	50	100	80	65	50	0	50	0	0
W'Comp	65	80	100	90	65	0	0	0	0
Prof Indemnity	75	65	90	100	75	0	0	0	0
Inwards Re	55	50	65	75	100	10	10	10	10
Fire/ISR	0	0	0	0	10	100	25	20	10
Domestic Motor	0	50	0	0	10	25	100	45	20
H'Holders	0	0	0	0	10	20	45	100	15
Other	0	0	0	0	10	10	20	15	100

Table 7.8 was derived from:

- The total variance correlation matrix (Table 7.5);
- The methodology outlined in Section 6.6.2; and
- Selected industry average net premium liability size and mix by line of business (Appendix D).

Using the correlation matrices in Tables 7.6, 7.7 and 7.8, we simulated statistics for the total insurance liabilities for 2,350 insurers (see Section 6.6). Details of the assumptions used to produce the simulated results are included in Appendix D.

We calculated the diversification discount for each simulated result.

Based on the results of the simulations, we recommend that a minimum total net insurance liability of \$30 million be required before any diversification benefit is applicable.

For practical use, in respect of allowing for diversification of the net insurance liabilities, we used least squares regression to derive the following recommended "rule of thumb" formula:

$$\begin{aligned} \textit{Diversification Discount} &= 51\% \times (1 - 0.5 * C) \\ &+ \quad 2.4\% \times N \text{, } \textit{if } N > 2 \\ &- \quad 0.0139\% \times S \text{, } \textit{if } S < \$550 \textit{ million} \\ &- \quad 0.0013\% \times S - 7.0\%\text{, } \textit{if } S >= \$550 \textit{ million} \end{aligned} \tag{7.2}$$

Where:

C = coefficient of concentration

$$= \frac{\text{Net insurance liability for largest line of business (\$)}}{\text{Total net insurance liability (\$)}}$$

N = number of lines of business

S = size of the insurer's total insurance liabilities in \$ million

We recommend adopting the "rule of thumb" formula (7.2) when adjusting for the diversification of the total insurance liabilities. This "rule of thumb" formula allows for:

- a greater diversification discount for lower concentrations of the insurance liabilities;
- a greater diversification discount for more lines of business written by the insurer; and
- a lower diversification discount for larger total insurance liabilities. This explains the residual error after allowing for the two effects above.

Charts 7.2, 7.3 and 7.4 show residual plots of the actual diversification discount against the "rule of thumb" formula (7.2) discount.

Chart 7.2 –Actual Diversification Discount less Fitted Discount for Total Insurance Liabilities

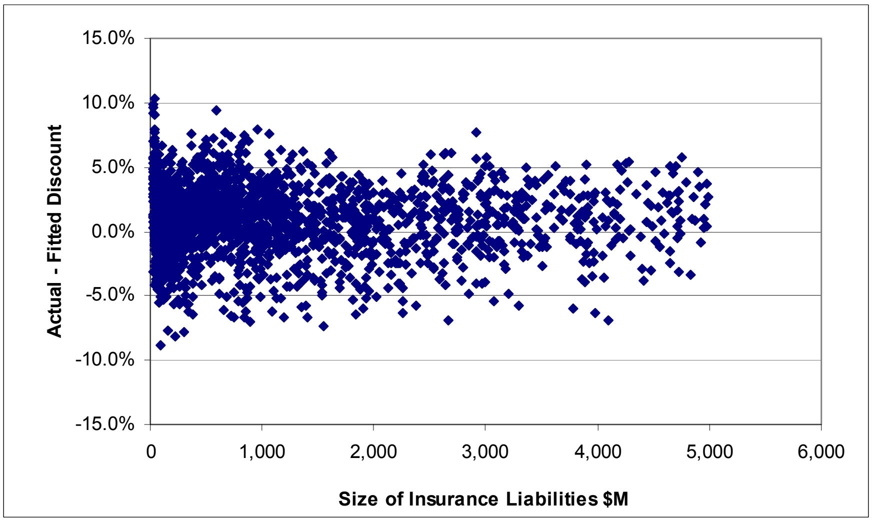


Chart 7.3 –Actual Diversification Discount less Fitted Discount for Total Insurance Liabilities

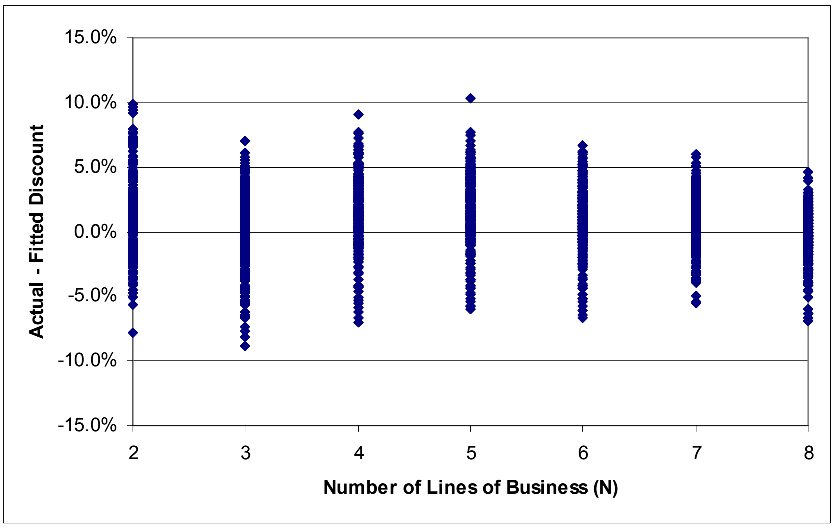
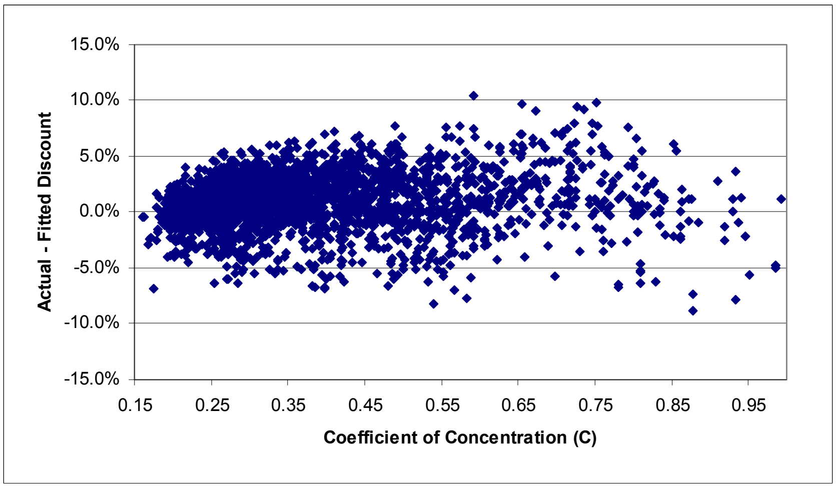


Chart 7.4 –Actual Diversification Discount less Fitted Discount for Total Insurance Liabilities



We make the following comments on Charts 7.2, 7.3 and 7.4:

- For 94% of the simulations, the fitted discount is within 5% of the actual discount.
- For all of the simulations, the fitted discount is within 10% of the actual discount.

We tested the sensitivity of the resulting "rule of thumb" formula to the assumed correlation matrices. Appendix H provides details of the results. We concluded that, given the size of the total insurance liabilities compared to the size of the net risk margins, the sensitivity of the diversification benefit resulting from the recommended "rule of thumb" to significant changes in the assumed correlation matrices (as detailed in Appendix H) is not material.

7.6 Examples of Application of Recommendations

Worked examples of the application of our recommendations are set out in Appendix F.

APPENDIX A - DESCRIPTION OF CHAIN LADDER TECHNIQUE

The chain ladder method was used to estimate the central estimate of the outstanding claims liability. This method uses ratios of cumulative claim payments to estimate the ultimate incurred claim costs. The outstanding claims liability is calculated by subtracting the payments made to date from the ultimate incurred claims cost.

The method involves the following steps:

- Historical claim payments by accident period and development period are accumulated to produce cumulative claim payment triangles by accident period and development period.

- Ratios of cumulative claim payments between successive development periods are calculated and analysed for trends.

Based on averages and trends, development ratios are selected for future development periods and applied to the current cumulative claim payments to determine the ultimate incurred claim cost for each accident period.

APPENDIX B - BRIEF DESCRIPTIONS OF METHODS ADOPTED FOR ESTIMATING UNCERTAINTY IN OUTSTANDING CLAIMS LIABILITIES

B.1 The Mack Method

For a detailed description of this methodology please refer to Mack (1993). The following paragraphs provide a brief summary of the method.

The Mack Method provides a distribution free formula for calculating the standard error of the chain ladder estimates of the outstanding claims liability.

The Mack Method includes an explicit estimate of both:

- The process variance; and,
- The parameter estimation variance.

In addition to the standard error for each accident year, a formula is provided for the standard error of the total outstanding claims liability estimate, which considers the correlations between the estimates for the individual accident years. Allowance for correlations between the estimates for each accident year increases the standard error of the outstanding claims liability.

B.2 Bootstrapping Technique

We have used two applications of the bootstrapping technique in this analysis. For the purpose of this report these are labelled “Bootstrap 1” and “Bootstrap 2”. The bootstrapping techniques we used for this analysis are based on bootstrapping suitably defined residuals rather than bootstrapping the observations directly.

The bootstrap technique requires calculating suitably chosen residuals for the chosen model. The bootstrap process then involves resampling, with replacement, from the residuals. Having obtained the bootstrap sample, the valuation model is then refitted and the statistic of interest calculated. The process is repeated a large number of times with each simulation providing a new bootstrap sample and statistic of interest, in our case the outstanding claims liability.

The bootstrap standard error in the outstanding claims liability is then calculated as the standard error of all the simulations. The bootstrap standard error calculated in this way provides a measure of the estimation error only and adjustment is required to allow for the process error.

The bootstrapping technique is also distribution free. The net liability distribution is calculated directly from the simulation results.

The bootstrapping process produces anomalous results if the residuals used to compute the pseudo-observations in the bootstrap sample display heteroscedasticity. In particular, a random allocation of residuals that display heteroscedasticity would result in anomalous results when large residuals, generally observed at later development periods, are allocated to early development periods. We have controlled the impact of this in our bootstrap data samples by the imposition of restrictions on the residuals allocated to each development period.

The following paragraphs provide a brief description of the techniques used in this analysis.

B.3 Bootstrap 1

Before applying the bootstrapping technique, we fitted a chain ladder model to the available data, and calculated a central estimate of the net outstanding claims liability. This application of bootstrapping starts with the cumulative payment triangles which are replaced with pseudo-observations.

In the triangle of past claim payments, let x denote a typical observation. Let x^* be the fitted (or model expected) value associated with x. The fitted value x^* is calculated from the ultimate incurred claims cost for the accident year, based on the selected chain ladder factors.

For example, for accident year 1996, second development year:

x = *actual cumulative payments*

= *74,316.406*

(and let $ln(x)$ = *11.216)*

x^* = *chain ladder modelled value*

= *ultimate incurred cost for 1996 divided by future development from development year 2 from chain ladder factors.*

= *73,225.0 say.*

(and $ln(x^*)$*)* = *11.201*

The next step is to calculate all the standard residuals, $x - x^*$. (In our case we have taken logs to avoid the problem of negative payments at a later stage in the calculations). From the triangle of standard residuals we made selections for each development year, and selected scaling factors by fitting a curve through the selected standard residuals. We then calculated "scaled" residuals for all observations by dividing the standard residuals by the scaling factor k, that is:

$$\Upsilon = (x - x^*) / k,$$

so that var(Υ) is the same for all observations.

For example, accident year 1996, second development year:

$ln(x) - ln(x^*)$ = *0.015*

k = *0.0432*

scaled deviation = *0.343*

A random sample (with replacement) is drawn from the set of scaled deviations. A new triangle is constructed by adding the sampled deviation to the original fitted value:

$$x\sim \; = \; x^* + k\,\Upsilon$$

The model is then fitted to the new triangle of pseudo-observations and a new projected value of outstanding claims is obtained. This value incorporates variability of the past data used to estimate the model parameters ("parameter error").

In order to estimate the variability of future experience about model predictions ("process error"), a further random drawing from the scaled deviations is needed.

Each of the future claim payment cells produced as a result of the projection from the pseudo-observations (i.e. cells below and to the right of a stepped line in the "pseudo-observations" triangle) has a sampled deviation added to it. The value of the net outstanding claims liability resulting from these adjusted projected claim payments incorporates variability from both parameter error and process error.

As a final step, we have scaled the results so that fitted past payments agree with actual past payments.

These steps have been repeated 1000 times, redrawing different random samples from the deviations each time. As a result, 1000 estimates of the value of outstanding claims liability are produced.

The net liability distribution may be calculated directly from the simulated results.

B.4 Bootstrap 2

For a detailed description of this methodology please refer to England and Verrall (1999). The following paragraphs provide a summary of the method.

This application uses a simple "spreadsheet" methodology that, combined with a suitably defined residual, produces an estimate of the standard error of the net central estimate of the outstanding claims liability estimate that is similar to the error estimated using more complex stochastic modeling techniques (e.g. Generalised Linear Modelling techniques or GLMs).

For this application we used the unscaled Pearson residual, calculated using observations from the incremental claim payment triangle and the modeled incremental claim payment triangle.

The unscaled Pearson residual is calculated for each observation in the triangle as:

$$r_P = \frac{(C - m)}{\sqrt{m}}$$

where : C = *observed incremental claim payment in period;*

m = *modelled incremental claim payment, calculated from the ultimate incurred claim costs and selected chain ladder factors.*

A bootstrap observation (C*) is then computed by inverting formula (B.4) above, based on a random sampling of the residuals.

The outstanding claims liability is computed for each bootstrap data sample and the (bootstrap) standard error of the net outstanding claims liability may be computed directly from the simulated results.

We simulated 1000 observations to derive a distribution of the net outstanding claims liability.

The bootstrap sample standard error is an estimate of the parameter estimation error. However, as described in England and Verrall's paper, for comparison with the error estimated by a comparable stochastic GLM, which more fully describes each accident period and development period effect, fitted to incremental paid claims data, an adjustment is required to allow for the number of parameters estimated in the model. To allow for the number of parameters, the parameter estimation error (bootstrap error) calculated above is multiplied by n/(n-p), where: n is the number of observations in the data triangle; and p is the number of parameters estimated by the comparable GLM. For example, a data triangle with 10 rows of data has 55 observations. In this example, n equals 55 and p equals 19 (10 accident period parameters, 10 development period parameters less the selected base line cell).

The total standard error of this bootstrap technique is equal to the sum of the parameter estimation error and process variation error and may be represented as:

$$SE = \sqrt{\phi R + \frac{n}{n-p}(SE_{bootstrap}(R))^2}$$

Where $\phi = \frac{\sum r_p^2}{n-p}$, which is the Pearson scale parameter

r_p, = the unscaled Pearson Residual

$SE_{boostrap}$ = the standard error obtained by the bootstrap method

R = central estimate of the reserve

APPENDIX C - DERIVATION OF FORMULA 6.3

We assumed the following relationship:

$$\mathrm{Var}[\mathrm{X_i}] = (a_i^2 + \frac{b_i^2}{n_i})n_i^2 = a_i^2 n_i^2 + b_i^2 n_i = \mathrm{Var}[\mathrm{A_i}] + \mathrm{Var}[\mathrm{B_i}]$$

where:

A_i = systemic effect

B_i = independent effect

We assumed that the correlation between the different lines of business is only applicable to the systemic process.

This implies that the covariance, CoV(B_i, B_j)=0, for all i and j where i<>j

Then

$$Var[Y] = \sum_{i=1}^{K} \mathrm{var}[X_i] + 2\sum_{i<>j}(E[(A_i + B_i)(A_j + B_j)] - E[A_i + B_i]E[A_j + B_j]$$

$$= \sum_{i=1}^{K} \mathrm{var}[X_i] + 2\sum_{i<>j} Cov(A_i, A_j)$$

because:

CoV(A_i, B_j)=0, for all i and j where i<>j (the two processes are independent),

and CoV(B_i, B_j)=0, for all i and j where i<>j

Hence:

$$Var[Y] = \sum_{i=1}^{K} n_i^2 (a_i^2 + \frac{b_i^2}{n_i}) + 2\sum_{i \neq j} a_i a_j \rho_{i,j} n_i n_j$$

APPENDIX D - ASSUMPTIONS USED TO DERIVE DIVERSIFICATION BENEFIT "RULE OF THUMB".

This Appendix describes the assumptions used to determine the "rule of thumb" formula for the diversification discounts derived for both the net outstanding claim liability risk margins in isolation, and for the total insurance liability risk margins.

D.1 Selected "Industry Average" Liability Mix by Size and Line of Business

Table D.1 shows the mix, by line of business, of the net outstanding claims and net premium liability, used to determine the correlation matrices for application to the systemic components only of the variance (refer Sections 6.5.3 and 6.6.2).

TABLE D.1

Selected Industry Average Liability Mixes

Line of Business	Net Outstanding Claims Liability $M	Net Premium Liability $M	Total Insurance Liability $M
Liability	123	41	165
CTP	313	105	419
Workers' Comp	88	30	117
PI	57	20	77
Fire/Isr	22	49	71
Domestic Motor	26	59	85
Householders	25	57	82
Other	42	96	138
Inwards Re	52	52	104
Total	749	508	1,257

The selected mix of the net outstanding claims liability by line of business was based on:

- The total industry mix of net provisions by line of business, as published in Table 7 of APRA's "Selected Statistics on the General Insurance Industry, Year Ending December 2000" ("December 2000 APRA statistics").

- An assumed industry average size of 5% of the total industry. This is equal to the average size of the top 20 insurers, based on total industry premium revenues in Table 6 of the December 2000 APRA statistics.

D.2 Derivation of Simulated Portfolios.

Net Outstanding Claims Liability Portfolios

To model the diversification discount, considering net outstanding claims liabilities in isolation, we simulated net outstanding claims liability portfolios based on a random selection of:

- The number of lines of business (ranging from 2 to 8). We simulated equal numbers of results, for each possible value for the number of lines of business.
- The size of the net outstanding claim liability. We imposed minimum and maximum liability sizes depending on the number of lines of business.
- The allocation of the net outstanding claim liability across the lines of business written.

Table D.2 shows the constraints imposed on the size of net outstanding claim liability, according to the number of lines of business.

TABLE D.2

Size of Net Outstanding Claims Liability ($M), by Number of Lines of Business

Number of Lines of Business	Lower Bound $M	Upper Bound $M
2	5	400
3	5	600
4	10	800
5	15	1,500
6	20	2,000
7	20	3,000
8	30	3,000

Net Premium Liability Portfolios

We derived the corresponding net premium liability portfolio for each simulation by applying a randomly simulated multiple to the simulated net outstanding claims liability portfolio. We imposed minimum and maximum values for the premium liability multiple. Table D.3 shows the minimum and maximum multiples imposed.

TABLE D.3

Premium Liability (% of Net Outstanding Claims Liability)

	Liability	CTP	Workers' Comp	PI	Fire/Isr	Domestic Motor	House-holders	Other	Inwards Re
Lower Bound	5	5	5	5	150	150	150	150	100
Upper Bound	60	60	60	60	300	300	300	300	100

Net Insurance Liability Portfolios

The total net insurance liabilities for each simulation is calculated as the sum of the net outstanding claims liability and the net premium liability, for each line of business.

APPENDIX E - RESULTING NET OUTSTANDING CLAIMS LIABILITY RISK MARGINS BY LINE OF BUSINESS – SHORT TAIL

Short Tail Classes Risk Margin by size of outstanding claims liability by line of business									
Net Outstanding Claims Liability ($ million)	Domestic Motor	Householders	Commercial Motor	Fire/ISR	Marine & Aviation	Mortgage	Consumer Credit	Travel	Other
0	20.0%	25.0%	25.0%	30.0%	30.0%	30.0%	30.0%	25.0%	30.0%
10	13.9%	15.2%	14.1%	16.1%	15.3%	18.5%	17.6%	15.2%	14.3%
20	10.8%	12.1%	11.3%	12.8%	13.6%	15.8%	14.5%	12.1%	12.1%
30	9.4%	10.7%	10.0%	11.3%	13.0%	14.6%	13.1%	10.7%	11.2%
40	8.6%	9.8%	9.3%	10.4%	12.7%	14.0%	12.3%	9.8%	10.7%
50	8.0%	9.3%	8.8%	9.8%	12.5%	13.5%	11.7%	9.3%	10.3%
60	7.6%	8.9%	8.5%	9.4%	12.3%	13.2%	11.3%	8.9%	10.1%
70	7.3%	8.6%	8.2%	9.1%	12.2%	13.0%	11.1%	8.6%	9.9%
80	7.1%	8.4%	8.0%	8.8%	12.1%	12.8%	10.8%	8.4%	9.8%
90	6.9%	8.2%	7.9%	8.6%	12.1%	12.7%	10.7%	8.2%	9.7%
100	6.7%	8.0%	7.7%	8.5%	12.0%	12.6%	10.5%	8.0%	9.6%
110	6.6%	7.9%	7.6%	8.3%	12.0%	12.5%	10.4%	7.9%	9.6%
120	6.5%	7.8%	7.5%	8.2%	11.9%	12.4%	10.3%	7.8%	9.5%
130	6.4%	7.7%	7.5%	8.1%	11.9%	12.4%	10.2%	7.7%	9.5%
140	6.3%	7.6%	7.4%	8.0%	11.9%	12.3%	10.1%	7.6%	9.4%
150	6.2%	7.5%	7.3%	7.9%	11.9%	12.3%	10.1%	7.5%	9.4%
160	6.2%	7.5%	7.3%	7.9%	11.8%	12.2%	10.0%	7.5%	9.4%
170	6.1%	7.4%	7.2%	7.8%	11.8%	12.2%	10.0%	7.4%	9.3%
180	6.0%	7.4%	7.2%	7.7%	11.8%	12.1%	9.9%	7.4%	9.3%
190	6.0%	7.3%	7.2%	7.7%	11.8%	12.1%	9.9%	7.3%	9.3%
200	6.0%	7.3%	7.1%	7.7%	11.8%	12.1%	9.8%	7.3%	9.3%
210	5.9%	7.2%	7.1%	7.6%	11.8%	12.1%	9.8%	7.2%	9.3%
220	5.9%	7.2%	7.1%	7.6%	11.8%	12.0%	9.8%	7.2%	9.2%
230	5.8%	7.2%	7.0%	7.5%	11.7%	12.0%	9.7%	7.2%	9.2%
240	5.8%	7.1%	7.0%	7.5%	11.7%	12.0%	9.7%	7.1%	9.2%
250	5.8%	7.1%	7.0%	7.5%	11.7%	12.0%	9.7%	7.1%	9.2%
260	5.8%	7.1%	7.0%	7.5%	11.7%	12.0%	9.7%	7.1%	9.2%
270	5.7%	7.1%	7.0%	7.4%	11.7%	11.9%	9.6%	7.1%	9.2%
280	5.7%	7.1%	6.9%	7.4%	11.7%	11.9%	9.6%	7.1%	9.2%
290	5.7%	7.0%	6.9%	7.4%	11.7%	11.9%	9.6%	7.0%	9.2%
300	5.7%	7.0%	6.9%	7.4%	11.7%	11.9%	9.6%	7.0%	9.1%
310	5.7%	7.0%	6.9%	7.3%	11.7%	11.9%	9.6%	7.0%	9.1%
320	5.6%	7.0%	6.9%	7.3%	11.7%	11.9%	9.6%	7.0%	9.1%
330	5.6%	7.0%	6.9%	7.3%	11.7%	11.9%	9.5%	7.0%	9.1%
340	5.6%	6.9%	6.8%	7.3%	11.7%	11.9%	9.5%	6.9%	9.1%
350	5.6%	6.9%	6.8%	7.3%	11.7%	11.9%	9.5%	6.9%	9.1%
360	5.6%	6.9%	6.8%	7.3%	11.7%	11.8%	9.5%	6.9%	9.1%
370	5.6%	6.9%	6.8%	7.2%	11.7%	11.8%	9.5%	6.9%	9.1%
380	5.5%	6.9%	6.8%	7.2%	11.7%	11.8%	9.5%	6.9%	9.1%
390	5.5%	6.9%	6.8%	7.2%	11.7%	11.8%	9.5%	6.9%	9.1%
400	5.5%	6.9%	6.8%	7.2%	11.7%	11.8%	9.5%	6.9%	9.1%

APPENDIX F - RESULTING NET OUTSTANDING CLAIMS LIABILITY RISK MARGINS BY LINE OF BUSINESS – LONG TAIL

Long Tail Classes

Risk Margin by size of outstanding claims liability by line of business

Net Outstanding Claims Liability ($ million)	Workers' Comp	CTP	Liability	Prof Indemnity
20	18.1%	22.2%	18.1%	18.1%
40	15.5%	18.9%	15.5%	15.5%
60	14.0%	17.1%	14.0%	14.0%
80	13.2%	16.0%	13.2%	13.2%
100	12.7%	15.3%	12.7%	12.7%
120	12.4%	15.0%	12.4%	12.4%
140	12.1%	14.6%	12.1%	12.1%
160	11.9%	14.3%	11.9%	11.9%
180	11.7%	14.1%	11.7%	11.7%
200	11.6%	13.9%	11.6%	11.6%
250	11.3%	13.5%	11.3%	11.3%
300	11.2%	13.3%	11.2%	11.2%
350	11.1%	13.1%	11.1%	11.1%
400	11.0%	13.0%	11.0%	11.0%
450	10.9%	12.9%	10.9%	10.9%
500	10.8%	12.8%	10.8%	10.8%
550	10.8%	12.8%	10.8%	10.8%
600	10.8%	12.7%	10.8%	10.8%
650	10.7%	12.7%	10.7%	10.7%
700	10.7%	12.6%	10.7%	10.7%
750	10.7%	12.6%	10.7%	10.7%
800	10.7%	12.6%	10.7%	10.7%
850	10.6%	12.5%	10.6%	10.6%
900	10.6%	12.5%	10.6%	10.6%
950	10.6%	12.5%	10.6%	10.6%
1,000	10.6%	12.5%	10.6%	10.6%
1,100	10.6%	12.4%	10.6%	10.6%
1,200	10.6%	12.4%	10.6%	10.6%
1,300	10.5%	12.4%	10.5%	10.5%
1,400	10.5%	12.4%	10.5%	10.5%
1,500	10.5%	12.3%	10.5%	10.5%
1,600	10.5%	12.3%	10.5%	10.5%
1,700	10.5%	12.3%	10.5%	10.5%
1,800	10.5%	12.3%	10.5%	10.5%
1,900	10.5%	12.3%	10.5%	10.5%
2,000	10.5%	12.3%	10.5%	10.5%
2,100	10.5%	12.3%	10.5%	10.5%
2,200	10.5%	12.3%	10.4%	10.5%
2,300	10.4%	12.2%	10.4%	10.4%
2,400	10.4%	12.2%	10.4%	10.4%
2,500	10.4%	12.2%	10.4%	10.4%
2,600	10.4%	12.2%	10.4%	10.4%
2,700	10.4%	12.2%	10.4%	10.4%
2,800	10.4%	12.2%	10.4%	10.4%
2,900	10.4%	12.2%	10.4%	10.4%
3,000	10.4%	12.2%	10.4%	10.4%

APPENDIX G - EXAMPLES OF APPLICATION OF RECOMMENDED APPROACH

TABLE G.1

Insurer A: Example of Calculation of Insurance Liability Risk Margin

	CTP	Fire	Inwards Re - Liability		Total
			Prop'l	Non-prop'l	
Outstanding Claims Liability Risk Margin					
- Discounted Net Outstanding Claims Liability $M	300.0	30.0	60.0	60.0	450.0
- Risk Margin (Appendices E&F)	13.3%	11.3%	14.0%	14.0%	N/A
- Inwards Reinsurance Factors to Apply to the Risk Margin Percentage (Table 7.4)	N/A	N/A	N/A	2.0	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	39.9	3.4	8.4	16.8	68.5
Premium Liability Risk Margin					
- Net Premium Liability $M	100.0	70.0	60.0	60.0	290.0
- Risk Margin (Appendices E&F)	15.3%	9.1%	14.0%	14.0%	N/A
- Premium Factors to Apply to the Risk Margin (Section 7.4)	1.25	1.75	1.25	1.25	N/A
- Inwards Reinsurance Factors to Apply to the Risk Margin Percentage (Table 7.4)	N/A	N/A	N/A	2.0	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	19.1	11.1	10.5	21.0	61.8
Total Insurance Liability					
- Total Risk Margin Before Allowance for Diversification Benefit $M	59.0	14.5	18.9	37.8	130.3
- S = Total Insurance Liability $M	400.0	100.0	120.0	120.0	740.0
- C = [Largest S] / [Total S], ie CTP					54.1%
- N = Number of Lines of Business					3
- Diversification Discount					36.5%
- Diversification Benefit $M					47.5
Insurance Liability Total Risk Margin After Allowance for Diversification Benefit $M					
$M					**82.8**
Percentage of Total Insurance Liabilities					**11.2%**

TABLE G.2

Reinsurer B: Insurance Liability Risk Margin - Proportional Reinsurance

	CTP	Fire	Liability	Total
Outstanding Claims Liability Risk Margin				
- Discounted Net Outstanding Claims Liability $M	300.0	30.0	60.0	390.0
- Risk Margin (Appendices E&F)	13.3%	11.3%	14.0%	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	39.9	3.4	8.4	51.7
Premium Liability Risk Margin				
- Discounted Net Premium Liability $M	100.0	70.0	60.0	230.0
- Risk Margin (Appendices E&F)	15.3%	9.1%	14.0%	N/A
- Premium Factors to Apply to the Risk Margin (Section 7.4)	1.25	1.75	1.25	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	19.1	11.1	10.5	40.8
Total Insurance Liability				
- Total Risk Margin Before Allowance for Diversification Benefit $M	59.0	14.5	18.9	92.5
- S = Total Insurance Liability $M	400.0	100.0	120.0	620.0
- C = [Largest S] / [Total S], ie CTP				65%
- N = Number of Lines of business				3
- Diversification Discount				33.9%
- Diversification Benefit $M				31.4
Insurance Liability Total Risk Margin After Allowance for Diversification Benefit $M				
$M				**61.1**
Percentage of Total Insurance Liabilities				**9.9%**

TABLE G.3

Reinsurer B: Insurance Liability Risk Margin - Non-proportional Reinsurance

	CTP	Fire	Liability	Total
Outstanding Claims Liability Risk Margin				
- Discounted Net Outstanding Claims Liability $M	300.0	30.0	60.0	390.0
- Risk Margin (Appendices E&F)	13.3%	11.3%	14.0%	N/A
- Inwards Reinsurance Factors to Apply to the Risk Margin Percentage (Table 7.4)	1.7	1.9	2.0	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	67.8	6.4	16.8	91.1
Premium Liability Risk Margin				
- Discounted Net Premium Liability $M	100.0	70.0	60.0	230.0
- Risk Margin (Appendices E&F)	15.3%	9.1%	14.0%	N/A
- Premium Factors to Apply to the Risk Margin (Section 7.4)	1.25	1.75	1.25	N/A
- Inwards Reinsurance Factors to Apply to the Risk Margin Percentage (Table 7.4)	1.7	1.9	2.0	N/A
- Risk Margin Before Allowance for Diversification Benefit $M	32.5	21.2	21.0	74.7
Total Insurance Liability				
- Total Risk Margin Before Allowance for Diversification Benefit $M	100.3	27.6	37.8	165.8
- S = Total Insurance Liability	400.0	100.0	120.0	620.0
- C (CTP) = [Largest S] / [Total S]				64.5%
- N = Number of Lines of business				3
- Diversification Discount				33.9%
- Diversification Benefit $M				56.3
Insurance Liability Total Risk Margin After Allowance for Diversification Benefit $M				
$M				**109.5**
Percentage of Total Insurance Liabilities				**17.7%**

APPENDIX H - SENSITIVITY OF THE "RULE OF THUMB" DIVERSIFICATION DISCOUNT FORMULA TO THE ASSUMED CORRELATION MATRIX

We tested the sensitivity of the recommended "rule of thumb" formula, for calculating the diversification discount when considering the total insurance liabilities, to the following changes in the correlation matrices applicable to the systemic component only (Tables 7.6 and 7.8):

- A 20% reduction in all the assumed correlations (ie 80% of the correlations set out in Tables 7.6 and 7.8);
- A 20% increase in all the assumed correlations; and
- A 50% increase in all the assumed correlations, subject to a maximum correlation of 100%.

Charts H.1, H.2 and H.3 shows, for each of the 2,350 scenarios, the difference between:

- the revised diversification benefit based on a "rule of thumb" derived using the alternative correlation matrix, and
- the diversification discount based on the recommended rule of thumb.

Chart H.1 – A 20% Reduction in all the Assumed Correlations

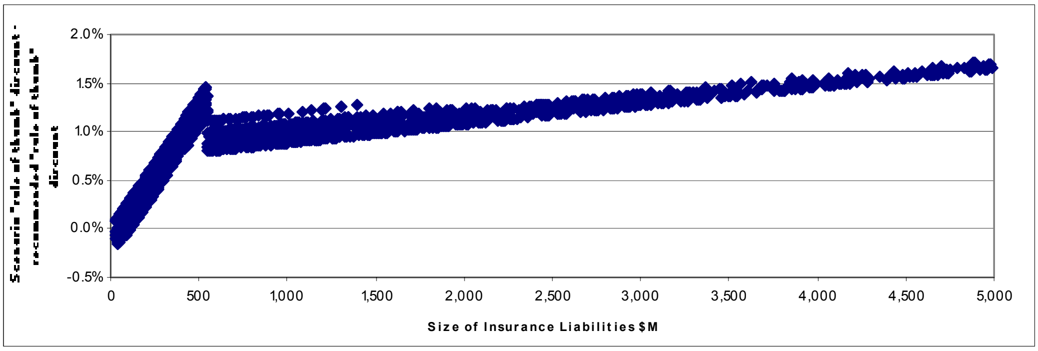


Chart H.2 – A 20% Increase in all the Assumed Correlations

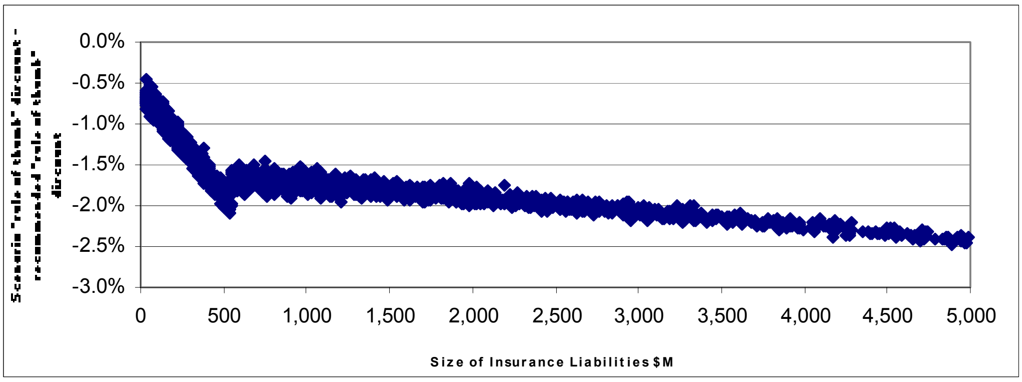
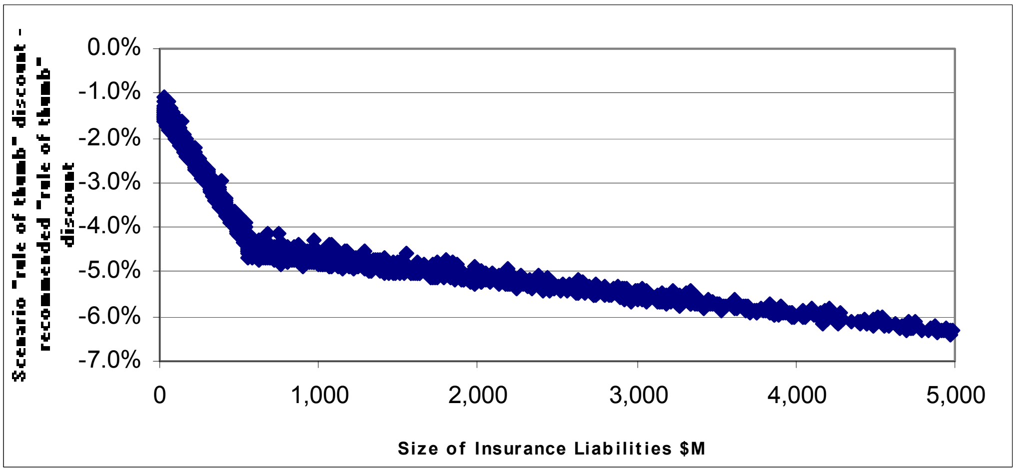


Chart H.3 – A 50% Increase in all the Assumed Correlations



We make the following comments on Charts H.1, H.2 and H.3:

- if all the correlations were 20% lower than we assumed, the recommended "rule of thumb" understates the diversification discount applicable to the total insurance liabilities by between 0% and 1.8%, depending on the size of the total insurance liabilities (Chart H.1).

- if all the correlations were 20% higher than we assumed, the recommended "rule of thumb" overstates the diversification discount applicable to the total insurance liabilities by between 0.5% and 2.5%, depending on the size of the total insurance liabilities (Chart H.2).

- if all the correlations were 50% lower than we assumed, the recommended "rule of thumb" overstates the diversification discount applicable to the total insurance liabilities by between 1% and 6.5%, depending on the size of the total insurance liabilities (Chart H.3).

Given the size of the total insurance liabilities compared to the size of the net risk margins, we do not believe that the sensitivity, to significant changes in the assumed correlation matrices (as detailed above), of the diversification discount resulting from the recommended "rule of thumb", is material.

APPENDIX I - BIBLIOGRAPHY

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