BMA
BERMUDA MONETARY AUTHORITY

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Bermuda Monetary Authority

Bermuda Insurance Property and Casualty Market

Catastrophe Risk and Stress Testing Analysis

2022 Report

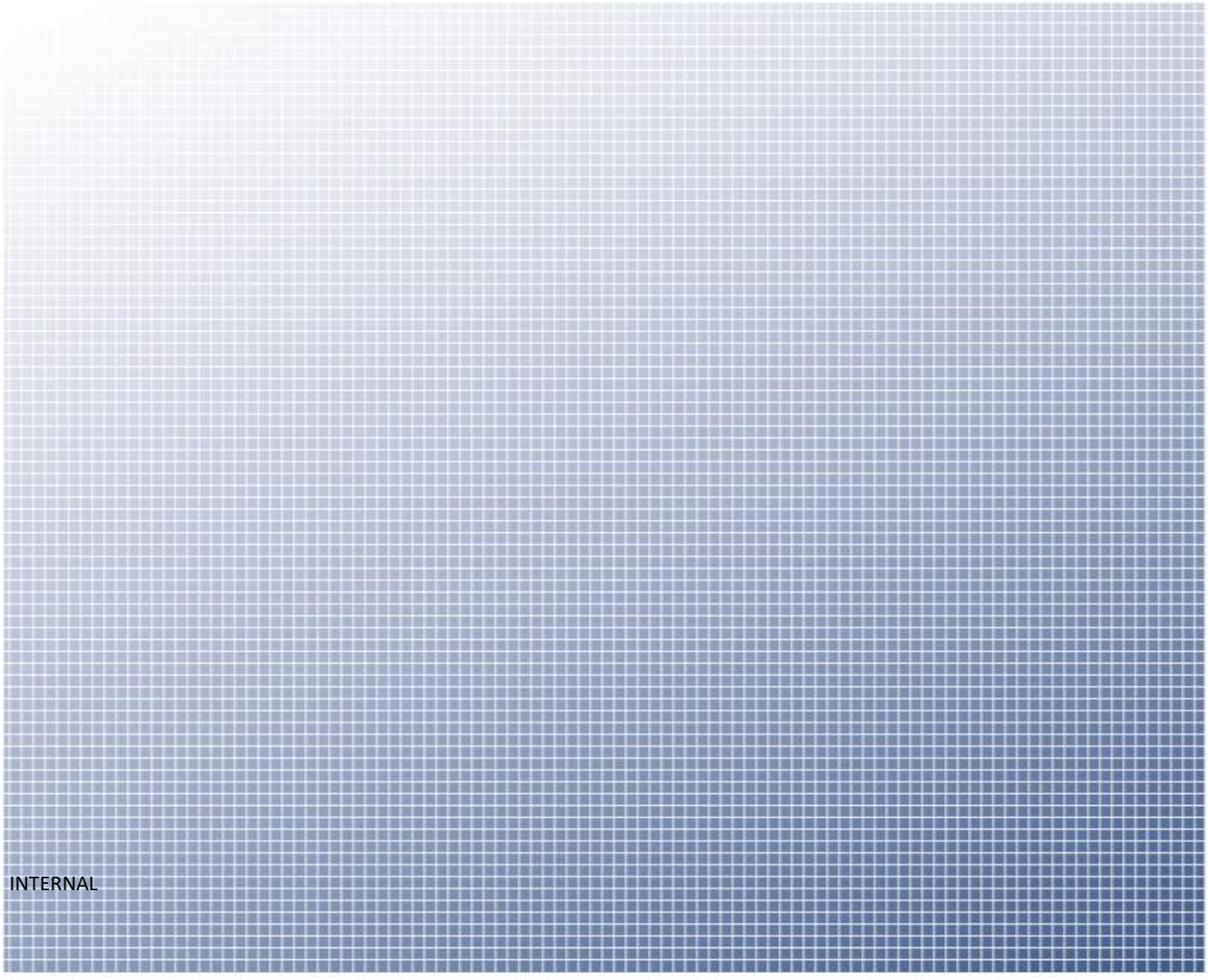

Table of Contents

Acronyms

AAL	Average Annual Loss
A&E	Asbestos and Environmental
BMA	Bermuda Monetary Authority
C&S	Capital and Surplus
Cat	Catastrophe
Cat Return	Catastrophe Risk Return and Schedule of Risk Management
CSR	Capital and Solvency Return
CPR	Constant Prepayment Rate
EP	Exceedance Probability
MBS	Mortgage-Backed Security
PML	Probable Maximum Loss
RDS	Realistic Disaster Scenarios
The Authority	Bermuda Monetary Authority
SPI	Special Purpose Insurer
TVaR	Tail Value at Risk

Foreword

The Bermuda Monetary Authority (Authority and BMA) continually monitors trends and market developments, including evolving risks and business models. As part of its macroprudential mandate and given the Bermuda market's relatively high concentration of Catastrophe (Cat) risk, the Authority prioritises maintaining a broad understanding of Bermuda insurers' Cat exposure, including the stress testing analysis and the identification of any concentration of risk in Bermuda.

The assessment of Cat risk exposure and stress testing at the micro and macro levels are fundamental elements of the Authority's overall supervisory framework. Catastrophe risk exposure assessment and stress testing allow the Authority to evaluate insurers' capital adequacy under adverse financial markets and underwriting conditions. The results of the assessment provide a comprehensive understanding of the sector's general vulnerability to shocks.

During 2022, Bermuda's international (re)insurance sector, like other global hubs, faced the risk of pricing challenges derived from the high inflation (real and social) environment and uncertainty of the valuation of assets and liabilities. Furthermore, the unprecedented tightening of monetary policy has driven a sharp increase in the cost of capital.

The increased severity and frequency of Cat events, among others related to climate change developments, continues to affect (re)insurers' strategies and outcomes. While the 2022 Cat events, including Hurricane Ian, have been 'earnings' events, they have intensified the hardening rates . This has led insurers to increase retentions, restrict coverage, and restructure programmes to control premium budgets.

Ultimately, this resulted in a decrease in the Cat exposure assumed by Bermuda reinsurers.

Overall, as shown in this report, Bermuda insurers remain well capitalised to absorb any unlikely and potentially significant losses, with the capital remaining to settle policyholder obligations and meet regulatory capital requirements.

Ricardo Garcia
Managing Director

Bermuda Insurance Market Stress Testing Report

This is the Authority's third standalone, annual *Catastrophe Risk and Stress Testing Analysis Report* and is the result of an analysis conducted by the BMA's staff.

About the Authority

The Authority was established by statute in 1969. Its role has evolved over the years to meet the changing needs of Bermuda's financial services sector. Today, it supervises, regulates and inspects financial institutions operating in the jurisdiction. It also issues Bermuda's national currency, manages exchange control transactions, assists other authorities with detecting and preventing financial crime and advises the Government on banking and other financial and monetary matters.

The Authority develops risk-based financial regulations to apply to the supervision of Bermuda's banks, trust companies, investment businesses, investment funds, fund administrators, money service businesses, corporate service providers, insurance companies, digital asset businesses and digital asset issuances. It also regulates the Bermuda Stock Exchange and the Bermuda Credit Union.

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1. Executive Summary

Overall, the 2022 Cat Risk Return and Schedule of Risk Management (together 'Cat Return') results show that the gross loss exposure assumed by Bermuda insurers decreased by 11.51% (from $225.02 billion in 2021 to $199.11 billion in 2022). Furthermore, the value of global gross estimated potential loss assumed by Bermuda insurers on the major Catastrophe (Cat) perils (combined) has also decreased from $209.47 billion in 2021 to $180.14 billion in 2022; this represents a decrease from 26% to 23% of the global market share. The decrease in the Cat exposure assumed by Bermuda can be attributed to the hardening market.

An analysis of the Exceedance Probability (EP) curves demonstrates that Bermuda insurers are more exposed to the Atlantic Hurricane peril than any other peril, with gross average modelled losses over all companies ranging from $832 million for 1-in-50-year events up to $1.59 billion for 1-in-1,000-year events. Other perils show lower modelled losses for the 1-in-50 and 1-in-1,000-year events with some variation between firms. The use of reinsurance is widespread and is generally more pronounced for lower frequency return periods for the Atlantic Hurricane and North American Earthquake perils.

The stress test results demonstrated that the Bermuda insurance market is resilient to potential adverse impacts, including the financial market, Cat and other underwriting loss scenarios. These results highlight the industry's overall resilience and establish the insurers' ability to absorb these unlikely and potentially large losses while still having capital remaining to settle policyholder obligations and meet regulatory capital requirements.

Table 1.1 – Key findings

Description	*US$ or percent*	*Notes*
Gross loss exposure	$199.11 billion	-11.53% decrease year-on-year
Ceded loss	$121.67 billion	-13.79% decrease year-on-year
Net loss exposure	$77.44 billion	-7.74% decrease year-on-year
Global share of gross estimated exposure on the major Cat perils	$180.14 billion	23% of global share
Total pre-stress capital and surplus	$129.76 billion	Participating insurers only
Total post Cat-stress (aggregate of Largest Three Cat Scenarios) capital and surplus - net	$94.21 billion	Participating insurers only
Average capital and surplus post aggregate of Three Largest Cat Underwriting Scenarios - net	70.4%	4.22% increase year-on-year
Average capital and surplus post 'Other Underwriting Loss' Scenarios	88.73%	-1.58% decrease year-on-year
Average capital and surplus post 'Insurer's Own Worst Case' Scenario	66.11%	4.09% increase year-on-year
Average capital and surplus post aggregate of 'Largest Three Terrorism Stress' Scenarios	81.44% / 88.87%	Gross and Net respectively
Average capital and surplus post 'Cyber Stress' Scenario	89.79% / 93.04%	Gross and Net respectively
Average capital and surplus post 'Mortage Insurance Loss' Scenario	82.92% / 88.48%	Shock 1 and 2 respectively
Average capital and surplus post 'New Latent Liability' Scenario	91.84%	-2.27% decrease year-on-year
Average capital and surplus post 'Deterioration in Existing US A&E and UK Asbestos' Scenario	94.38%	7.63% increase year-on-year
Average capital and surplus post a combination of four Financial Market Scenarios	75.7%	Most severe scenerio
Average ceded exposure	61%	-1.6% decrease year-on-year

Source: BMA

2. Introduction

Bermuda's insurance sector is regulated and supervised by the Authority. As part of its regulatory and supervisory measures, the Authority requires all Class 3B and Class 4 insurers to submit a Capital and Solvency Return (CSR), which includes a Cat Return detailing the insurers' Cat risk management practices.[1]

Within the Cat Return, insurers report their Cat exposures, their EP curves (for various return periods), their Average Annual Losses (AAL) and their Probable Maximum Losses (PML). In addition, insurers are required to carry out rigorous and comprehensive forward-looking stress tests to measure the sensitivity of their statutory capital and surplus in various adverse financial market and underwriting conditions. The Cat Return also serves as a point of reference in the prudential filings for the quantification of Cat risk assumed in Bermuda.

Drawing from the information in the Cat Returns, this report gives an overview of the Cat risk exposure assumed by Bermuda's insurance sector. It also assesses the sector's capacity to absorb shocks from various adverse financial market and underwriting conditions. The report considers whether Bermuda insurers are adequately capitalised to withstand severe but remote losses from various possible events that might adversely impact their balance sheets (i.e., statutory admitted assets, admitted liabilities and capital and surplus). The report also reviews Bermuda insurers' levels of reliance on reinsurance, including the identification of risk concentrations.

Stress testing is a valuable supervisory tool for the BMA as it provides supervisors with a forward-looking perspective of the resilience of individual insurance entities and the whole sector. The main objective of stress testing is to assess the capacity of individual insurers and the entire sector to absorb the impact of various extreme, but not inconceivable, adverse events. Stress testing can also be used to assess the effect of tail events beyond the measured level of confidence. Furthermore, the stress and scenario testing results help the Authority identify any concentration of risk and new and/or emerging risks and assess how insurers respond to such risks.

The Authority does not use the stress testing exercise to determine required capital levels. Nonetheless, the results of this exercise help the Authority to assess if the risk assumed by Bermuda insurers is commensurate to each insurer's risk appetite. This information ultimately

[1] For the purpose of this report, insurers also include reinsurers.

informs the Authority's risk-based supervisory approach and any capital adequacy concerns identified during this exercise are addressed as part of the Authority's regular supervisory routine.

Information Box

Class 3B and Class 4 insurers are the largest property and casualty commercial insurers in Bermuda's market and are required to maintain statutory capital and surplus of at least 99% Tail Value at Risk (TVaR) over a one-year time horizon.

Aggregate Statistics for Classes 3B and 4, 2022 (In US$ billions)

Net written premiums	66.1
Net earned premiums	62.2
Net income	3.8
Total claims	39.5
Total assets	283.4

Source: BMA

3. Methodology

The report was produced using aggregated and non-aggregated data from the Bermuda CSR filings of Class 3B and Class 4 legal entities for the period ended 31 December 2022.[2] Specifically, the following schedules from the CSR were used as data sources:

- Schedule V(e) – Schedule of Risk Management: Stress/Scenario Test
- Schedule X(a) – Catastrophe Risk Return: EP Curve Total
- Schedule X(c) – Catastrophe Risk Return: EP Curve for Regions-Perils
- Schedule X(e) – Catastrophe Risk Return: Accumulations Overview
- Schedule X(g) – Catastrophe Risk Return: Reinsurance Disclosures

The BMA only aggregated data when it was possible to do so. For example, the Authority did not use aggregated EP curve data, while it did use aggregated AAL data. Furthermore, EP curves were not aggregated as they represent upper quantiles of distributions and quantiles are not additive functions. On the other hand, AALs represent averages over distributions and can be aggregated without logical inconsistencies. When data could not be aggregated, an augmented boxplot, presenting percentiles and averages, was used to describe the distribution of the variable within the industry. Care has been taken not to identify individual insurers to preserve the confidentiality of the CSR filings,

The exclusion of all other classes, such as Special Purpose Insurers (SPI), limited the conclusions that could be gleaned from the results of this survey. Therefore, the results should be viewed as reflecting a segment of the industry and not the exposure of the entire Bermuda insurance market, which is expected to be larger than what is presented in this report.[3] It should also be noted that having excluded the long-term (life) insurers, the report does not consider mortality Cat risk.

The stress/scenario impact and effects reported here are those that were observed immediately upon the occurrence of the event (stress/scenario) as determined by the insurer's internal or vendor model(s), both with and without the effect of reinsurance and/or other loss mitigation

[2] Not all insurers have 31 December year-ends. Therefore, the data used in the report may not fully reconcile with the BMA Annual Report, which will include fall-end underwriting data.
[3] The Bermuda insurance market includes the Bermuda reinsurance market and SPIs.

instruments. The stress/scenarios were run against the insurers' balance sheet positions and aggregated in-force exposures as of 1 January 2023.[4]

To assist the Authority with comparability, insurers were required to provide a description of the vendor model(s) used to perform the stress/scenario tests, including the model and the version used for each stress/scenario. As the acquisition of a vendor package is not an obligation, insurers sometimes use internal models. Where an internal model was utilised, the insurer was required to include information on the internal model's key assumptions and parameters.

The analysis in this report was based only on the original CSR data input. No reference was made to other supporting documents required separately as part of the CSR filing. These additional documents were also reviewed by the Authority's supervisory team at the micro level in the context of individual insurers. As such, subtle nuances provided from an insurer's full return that might otherwise impact these results are not reflected in this report.

Bermuda Stress Testing Guidelines

This report only provides an overview of the stress/scenarios carried out by insurers. Each year, the Authority publishes a detailed description along with guidelines for each stress/scenario analysis, including any assumption made. This guide and the '2022 Capital and Solvency Return: stress/scenario analysis – Class 4, Class 3B and Insurance Groups' can be found on the Authority's website.[5]

[4] Where the fiscal year does not correspond to the calendar year, in-force exposures on the day following the fiscal year-end were used rather than 1 January 2023.

[5] https://www.bma.bm/document-centre/reporting-forms-and-guidelines-insurance

4. Bermuda's Cat Risk Exposure[6]

For the year 2022, the year-on-year gross loss exposure assumed by Bermuda insurers decreased by 11.52%, from $225.02 billion in 2021 to $199.11 billion in 2022. The amount of ceded loss decreased by 13.77%, from $141.10 billion in 2021 to $121.76 billion in 2022. As such, the net loss exposure assumed by Bermuda insurers decreased by 7.72%, from $83.92 billion in 2021 to $77.44 billion in 2022. These results are detailed in Table 4.1 below. With a gross loss impact of $26.94 billion and a net loss impact of almost $10.02 billion, the Gulf Windstorm peril had the highest gross and net loss exposure, followed by the Northeast Hurricane peril ($24.59 billion gross and $10.08 billion net) and San Francisco Earthquake peril ($23.44 billion gross and $8.46 billion net).

Table 4.1 - Cat Risk Exposure – Impact of Named Perils (in US$)

Standardised Cat Peril	Gross Loss Impact	Ceded Loss Impact	Net Loss Impact	Gross Loss Impact Ceded (in Percent)
Gulf windstorm (onshore)	26,942,571,343	16,920,540,241	10,022,031,102	63
Northeast hurricane	24,590,783,523	14,510,085,850	10,080,697,673	59
San Francisco earthquake	23,440,015,806	14,983,232,457	8,456,783,350	64
Pinellas hurricane	21,461,413,671	14,878,585,231	6,582,828,440	69
Miami-Dade hurricane	20,270,186,407	14,577,418,183	5,692,768,224	72
Los Angeles earthquake	19,102,023,065	12,032,345,875	7,069,677,190	63
Carolinas hurricane	13,554,681,288	8,285,421,821	5,269,259,467	61
European windstorm	10,475,921,850	5,883,251,791	4,592,670,060	56
Japanese earthquake	10,284,994,617	4,612,021,878	5,672,972,738	45
Japanese typhoon	5,294,663,715	2,743,023,739	2,551,639,976	52
New Madrid earthquake	4,724,211,238	2,119,884,038	2,604,327,199	45
Aviation collision	4,533,484,822	2,488,408,765	2,045,076,057	55
Major cruise vessel incident	3,536,635,730	2,028,270,963	1,508,364,768	57
US oil spill	3,437,545,405	2,185,270,415	1,252,274,990	64
Marine collision in Prince William	3,040,737,617	1,810,682,871	1,230,054,746	60
US Tornadoes	2,227,285,092	741,973,221	1,485,311,870	33
Australian flooding	1,322,282,365	507,942,961	814,339,404	38
Australian wildfires	874,139,791	364,385,171	509,754,620	42
Total	**225,017,438,032**	**141,101,708,994**	**83,915,729,037**	**63**

Source: BMA

Based upon the Lloyd's-developed Realistic Disaster Scenarios' (RDS) ultimate industry settlement estimated values ($797.64 billion), the global share of gross estimated potential loss assumed by Bermuda insurers from the major Cat perils (combined) decreased by about 3.0%.[7] The decrease in exposures from the global share assumed by Bermuda entities on various perils was partly offset by the strengthening of the US Dollar (US$), which has reduced the total

[6] The data provided in Tables 4.1 and 4.2 is for Class 3B and 4 insurers only and was extracted from the CSR annual filings. The CSR filings for a handful of insurers that fall within these classes were still under review when this report was put together and that data was not included in this report. Therefore, the results are reflective of a segment of the industry and not the total potential/impact.

[7] The insurers are required to run the Lloyd's-developed RDS as specified in Lloyd's Handbook on "Realistic Disaster Scenarios – Scenario Specification 2022" using aggregates in force at 1 January 2023.

industry loss for the Japanese Earthquake, European Windstorm and Japanese Typhoon perils, which are estimated in local currencies and converted to US$ values (see Table 4.2. below).[8]

Table 4.2 - Bermuda Loss to Industry Loss using Lloyd's Developed RDS (in US$)

Standardised Cat Peril	Estimated Total Industry Loss	Estimated Bermuda Share (Gross)	Bermuda Share (in percent)
Gulf Windstorm (onshore)	111,000,000,000	26,942,571,343	24
Northeast Hurricane	81,000,000,000	24,590,783,523	30
San Francisco Earthquake	80,000,000,000	23,440,015,806	29
Pinellas Hurricane	134,000,000,000	21,461,413,671	16
Los Angeles Earthquake	78,000,000,000	19,102,023,065	24
Miami-Dade Hurricane	131,000,000,000	20,270,186,407	15
Carolinas Hurricane	39,000,000,000	13,554,681,288	35
Japanese Earthquake	61,001,680,000	10,284,994,617	17
European Windstorm	25,676,400,000	10,475,921,850	41
New Madrid earthquake	44,000,000,000	4,724,211,238	11
Japanese Typhoon	12,962,857,000	5,294,663,715	41
Total	**797,640,937,000**	**180,141,466,524**	**23**

Source: BMA

The decrease in the Cat exposure assumed by Bermuda can be attributed to the hardening market, which has resulted in primary insurers increasing retentions, restricting coverage, and or restructuring programmes to control premium budgets.

5. Exceedance Probability Curves

This section presents some outputs from the Cat models in Bermuda on an aggregated basis. Insurers were asked to produce EP curves for the following named perils: Atlantic Hurricane, North American Earthquake, European Windstorm, Japanese Earthquake and Japanese Typhoon perils.

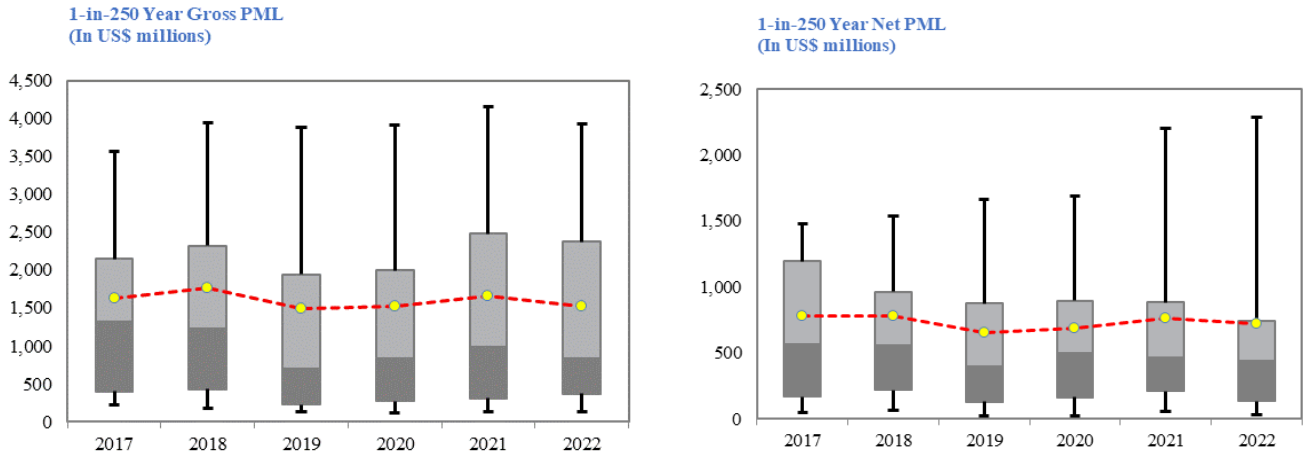
Data was compiled from the EP curves by drawing their distribution from a cross-section of firms for named perils across return periods. The BMA used a boxplot for each peril and for each return period, which includes the mean, median, and 10^{th}, 25^{th}, 75^{th} and 90^{th} percentiles of the EP curves.[9]

[8] The Authority uses the Oanda exchange rate as of 1 January 2022 to convert the non-US$ values into US$ values

[9] EP curves cannot be aggregated by summing individual EP curves since an event for one company can be completely unrelated to the event of another company, even for the same peril and the same return period. For example, a "1-in-250" year event such as the North America Earthquake means something different for a company with exposure in San Francisco versus a "1-in-250" year event for a company with exposure in Northern California outside of a large urban centre. Moreover, the simple addition of EP curves does not recognise diversification benefits because it assumes that all events for all perils and all return periods can occur at the same time, even if some events may be mutually exclusive.

Historical trends for the gross and net 1-in-250-year PML for aggregate exposures for the past five years were evaluated. For the purposes of the BMA's analysis, the 1-in-250-year event is the most representative of the extreme risk to which an insurer is exposed. The following panel presents the distribution of the PML for the aforementioned return period.

Panel 5.1 - Gross and Net 1-in-250 PML



Source: BMA

Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median) and the 10th and 90th percentiles (whiskers).

Insurers decreased their average gross 1-in-250-year exposure between 2021 and 2022 by 8.23%. The variation within the sample in 2022 decreased for gross exposures, with some companies having large changes in their exposures and many smaller firms having smaller changes in exposures. The 90th percentile gross 1-in-250-year exposure was $3.92 billion, a decrease of 5.83% compared to 2021.

Average net 1-in-250-year exposure decreased by 5.64% between 2021 and 2022; however, the variation of exposures within samples increased. The 90th percentile 1-in-250-year net exposure reached $2.28 billion.

The largest exposure for Bermuda insurers is the Atlantic Hurricane peril, with the average gross exposure between $832.34 million for a 1-in-50-year event and up to $1.59 billion for a 1-in-1,000-year event. This is an average figure with variation among firms. For example, at the 90th percentile of losses, there are firms with 1-in-50-year exposures of $2.02 billion, while there are firms who exceeded $3.51 billion in exposures for a 1-in-1,000-year event for the same peril. The BMA's net-to-gross exposure ratio and corresponding descriptive statistics are presented in a table on the next page.

Table 5.1 – Net-to-Gross Exposure for Atlantic Hurricane (In Percent)

Return Period	1-in-50	1-in-100	1-in-250	1-in-500	1-in-1,000
Mean	49.3	50.4	52.7	54.8	56.6
Median	44.5	47.1	49.1	51.4	53.6

Source: BMA

The data shows that reinsurance purchases become less pronounced at higher-risk layers. The median insurer retains 44.5% of the gross exposure for 1-in-50-year events, while the median insurer retains 53.6% of the gross exposure for 1-in-1,000-year events. Average exposure per peril is also shown per return period for both gross and net in the tables below.

Table 5.2 - Average Gross Exposure (In US$ Millions)

Return Period	1-in-50	1-in-100	1-in-250	1-in-500	1-in-1,000
Atlantic Hurricane	832.34	1,010.83	1,239.84	1,411.57	1,591.07
NA Earthquake	532.04	718.89	952.84	1,113.59	1,251.35
European Windstorm	248.41	319.30	402.91	455.76	506.57
Japanese Earthquake	159.84	222.74	292.67	329.59	359.49
Japanese Typhoon	171.29	207.79	241.86	267.19	296.84

Source: BMA

Table 5.3 - Average Net Exposure (In US$ Millions)

Return Period	1-in-50	1-in-100	1-in-250	1-in-500	1-in-1,000
Atlantic Hurricane	337.64	423.54	557.05	673.35	805.83
NA Earthquake	225.12	294.82	406.25	506.57	610.30
European Windstorm	124.00	153.32	188.88	214.27	240.28
Japanese Earthquake	93.55	125.12	160.60	179.78	194.87
Japanese Typhoon	94.43	111.14	128.78	143.89	161.16

Source: BMA

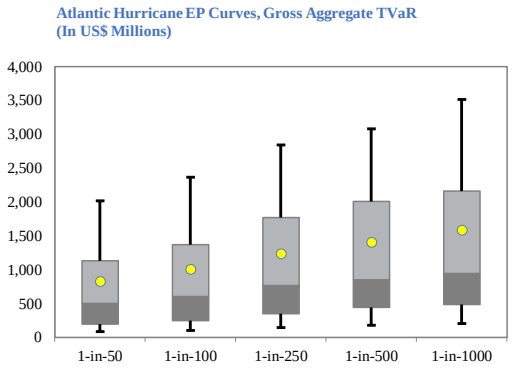
As mentioned previously, the largest exposure across all return periods is the Atlantic Hurricane peril, followed by the North American Earthquake peril. The aggregate gross and net EP curves, which include all the Cat risks in an insurer's portfolio, are also plotted.

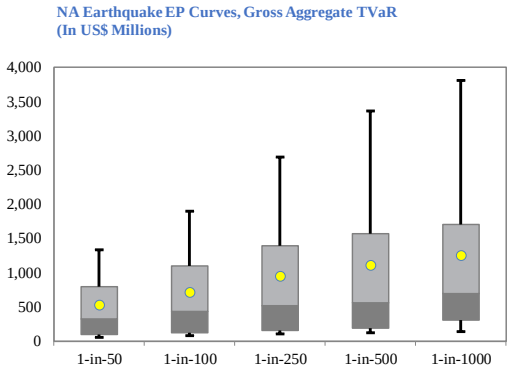
Table 5.4 - Average Exposure for All Perils (In US$ Millions)

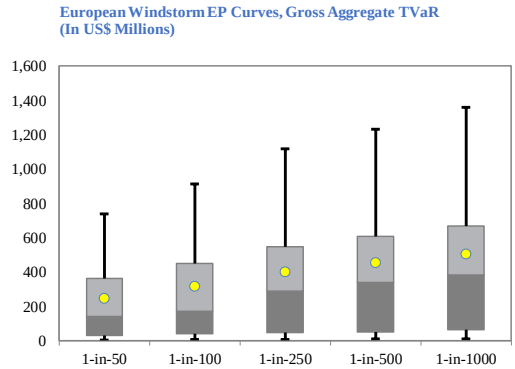
Return Period	1-in-50	1-in-100	1-in-250	1-in-500	1-in-1,000
Gross	1,102.4	1,289.4	1,526.9	1,709.8	1,910.3
Net	478.2	572.6	722.2	850.9	999.0

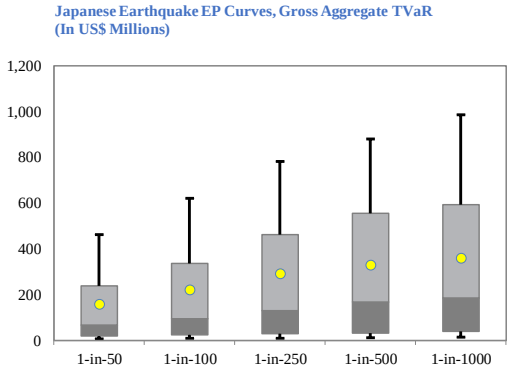
Source: BMA

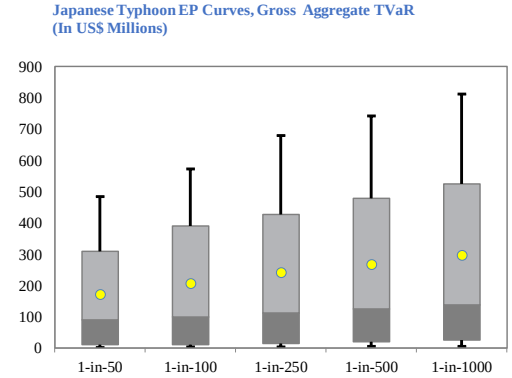
Panel 5.2 - Gross EP Curves for Named Perils









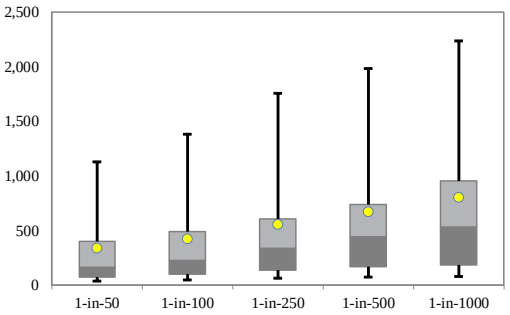


Source: BMA.

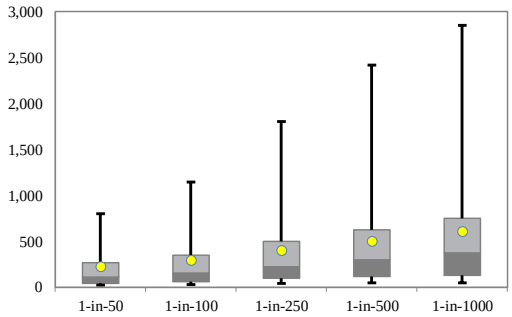
Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers).

Panel 5.3 - Net EP Curves for Named Perils

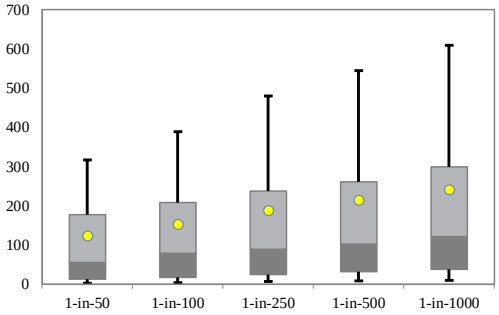
Atlantic Hurricane EP Curves, Net Aggregate TVaR
(In US$ Millions)



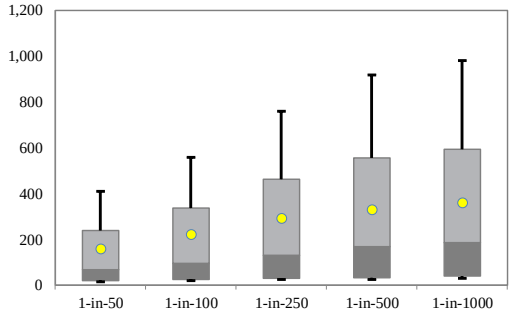
NA Earthquake EP Curves, Net Aggregate TVaR
(In US$ Millions)



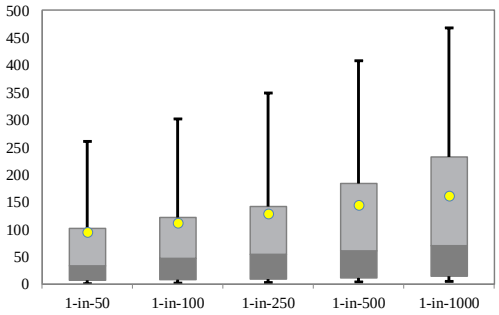
European Windstorm EP Curves, Net Aggregate TVaR
(In US$ Millions)



Japanese Earthquake EP Curves, Net Aggregate TVaR
(In US$ Millions)



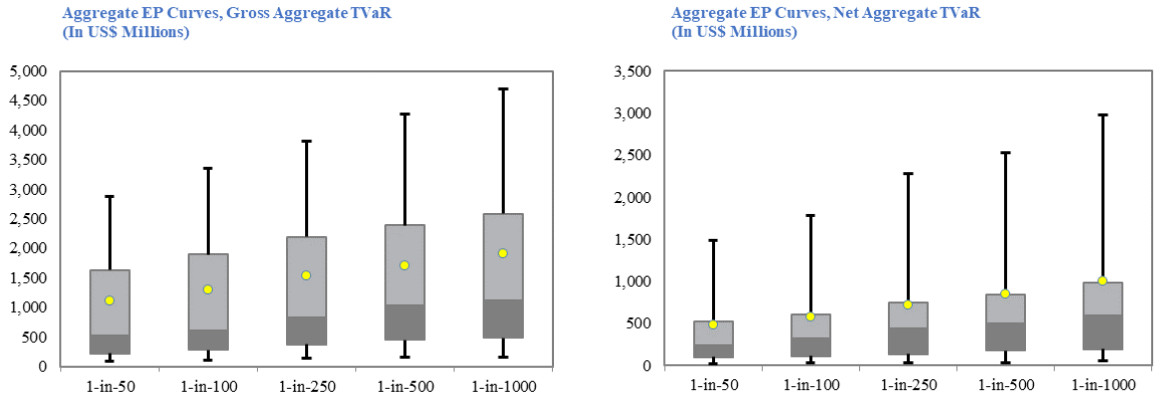
Japanese Typhoon EP Curves, Net Aggregate TVaR
(In US$ Millions)



Source*:* BMA

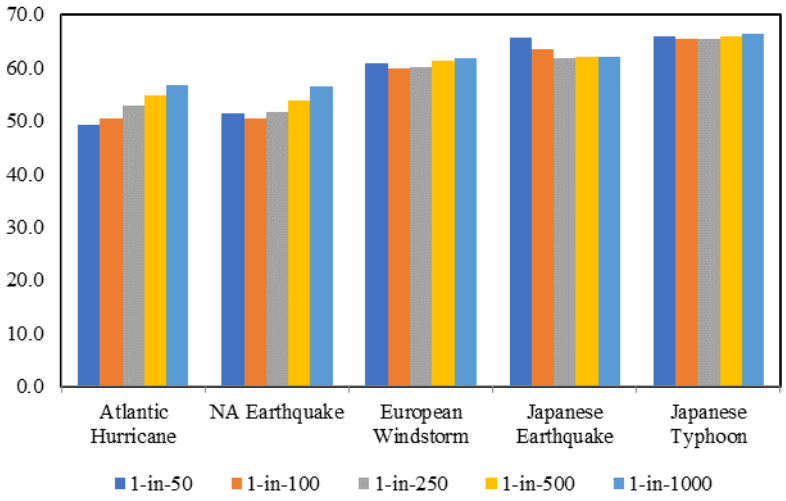
Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers).

Panel 5.4 - Gross and Net Aggregate EP Curves for all Perils



Source: BMA
Note: Boxplots include the mean (yellow dot), the 25th and 75th percentiles (grey box, with the change of shade indicating the median), and the 10th and 90th percentiles (whiskers).

Figure 5.1 - Average Net-to-Gross EP Exposure per Peril and Return Period (Aggregate EP Curves, in Percent)



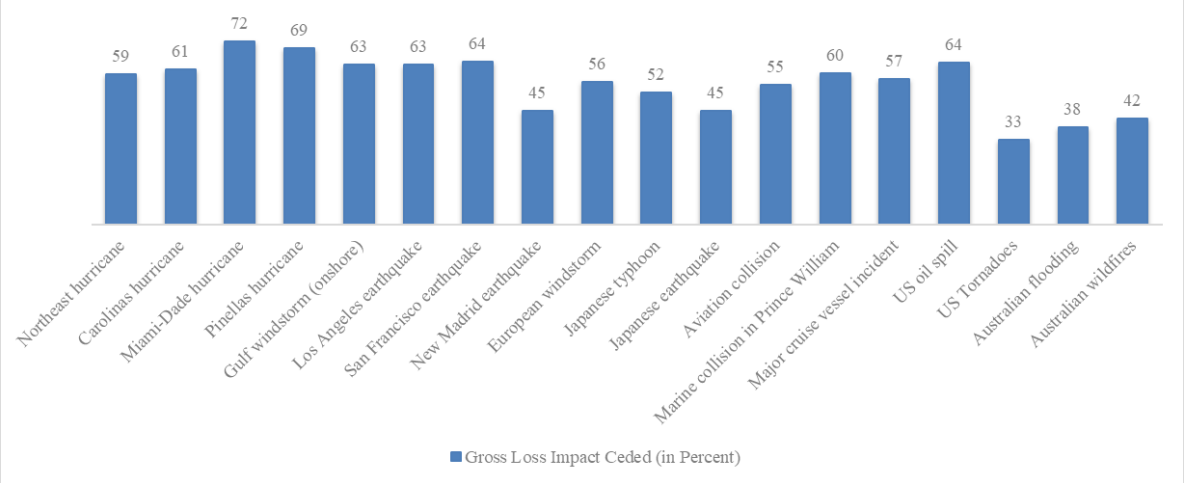
Source: BMA

For the Atlantic Hurricane peril, the ratio of net-to-gross exposure increases as the return period increases. The rarer the event, the more the insurer retains risk on average. This is true only for the Atlantic Hurricane peril; the other perils have no monotonic relationship between retention and return periods. Nevertheless, for the Japanese Typhoon peril, the average retention ratios are close for almost all return periods. The Atlantic Hurricane and North American Earthquake, however, are the major perils where significant variation in the use of reinsurance per return period is evident.

6. Reliance on Reinsurance

The Authority also assesses the level of insurers' reliance on reinsurance and/or other loss mitigation instruments for each peril.[10] Overall, observing the aggregate loss impact, the results shows that the level of reinsurance reliance (gross loss ceded) has decreased by about 13.77% compared to last year and varies across each peril (see Figure 6.1 below). This is in line with the decrease in the level of exposure assumed by Bermuda entities. Typically, perils that have the potential for the largest losses, such as the Gulf Windstorm, Miami-Dade Hurricane, Pinellas Hurricane and San Francisco Earthquake, are heavily reinsured.

Figure 6.1 - Gross Loss Impact Ceded (In Percent)

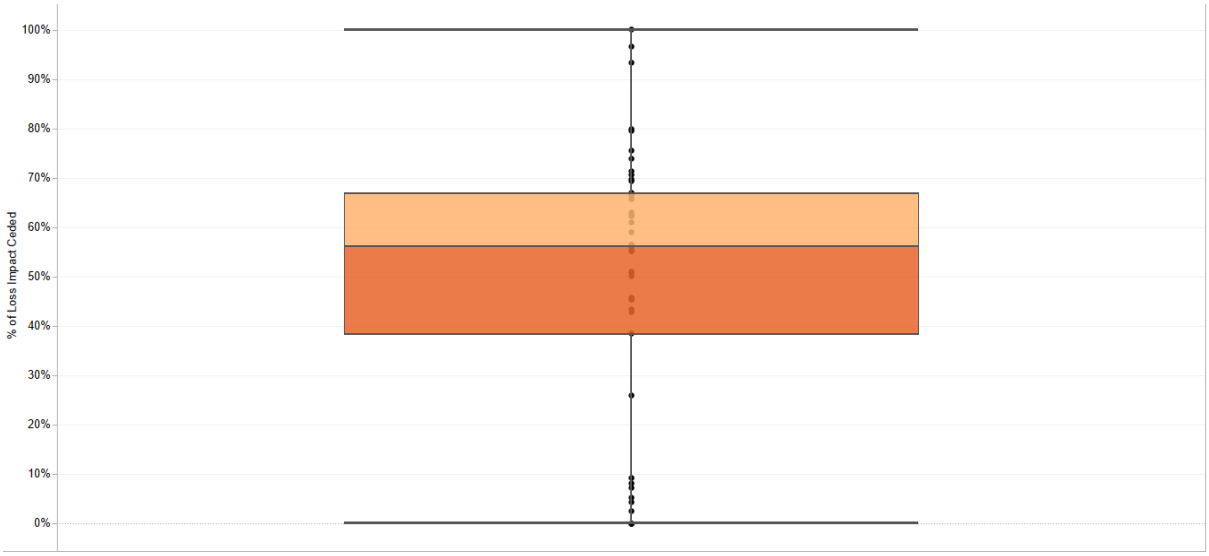


Source: BMA

[10] Bermuda is predominately a reinsurance-based International Financial Centre, thus, 'insurers' reliance on reinsurance' for the purpose of this section include insurance and reinsurance undertakings that reinsure their risks with other reinsurance undertakings i.e., retrocession.

On average, insurers ceded about 61.11% of gross losses in 2022, compared to 62.71% in 2022 (see Figure 6.2 below).

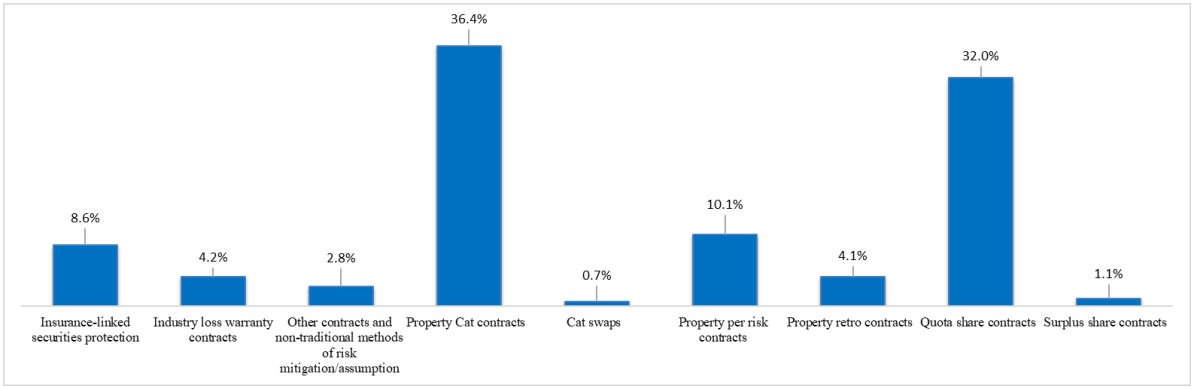
Figure 6.2 - Loss Impact Ceded



Source: BMA
Note: Boxplot includes the 25th and 75th percentiles (orange boxes, with the change of shade indicating the median). Each whisker is, at most, 1.5 times the interquartile range, and the dots represent outliers.

The results also show that Bermuda insurers use various reinsurance methods to cede some of their catastrophe exposure, which can include traditional property catastrophe contracts, quota share contracts, insurance-linked securities protection and industry loss warranties contracts. Compared to last year, property catastrophe contracts and quota share contracts have decreased slightly by 0.2% and 0.1%, respectively.

Figure 6.3 - Reinsurance Strategy - Aggregate Occurrence Limit (In Percent)



Source: BMA

7. Cat Risk Underwriting Scenarios

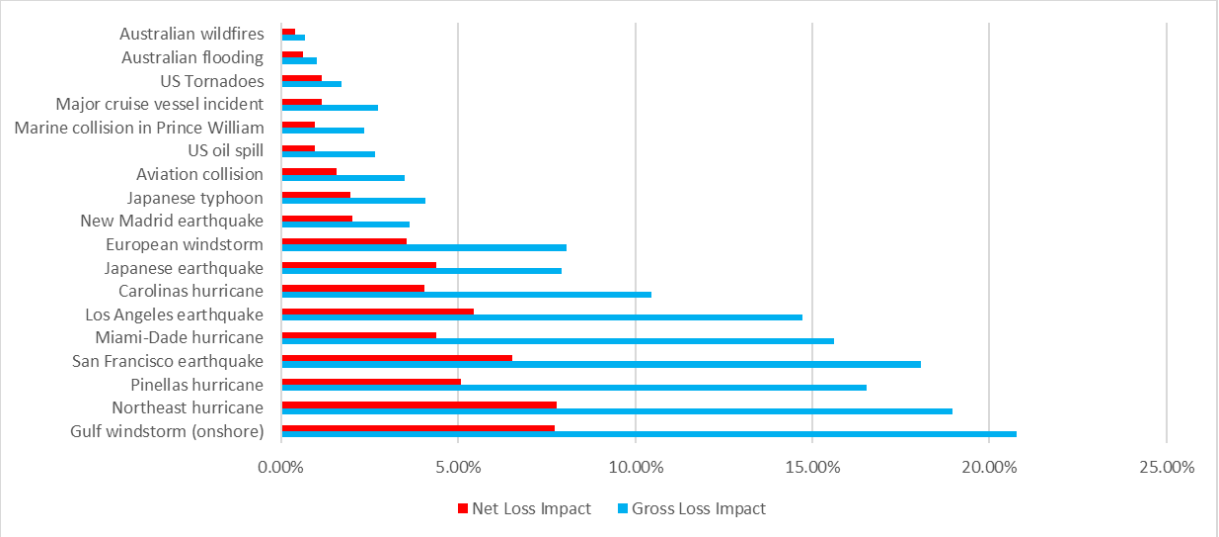
The Authority assesses Cat risk stress tests at three different levels. First, using both the Lloyd's RDS and other scenarios designed internally by the Authority, each insurer was required to estimate its loss impact for 18 standardised Cat underwriting loss scenarios. The details on each underwriting loss scenario and the key assumptions that insurers use as a guide to estimate their market share can be found on the BMA website (see "Section 3 - Methodology" above). Second, if the 18 standardised RDS underwriting loss scenarios provided by the Authority did not align fully with the insurer's underwriting exposure, the insurer was required to submit three of its own highest underwriting loss scenarios. Third, the insurer was required to consider and provide estimates for its worst-case underwriting loss scenario based on its own independent underlying assumptions.

Cat risk scenarios

In general, the 2022 Cat underwriting loss scenario results show that not only is the Bermuda insurance market resilient to potential Cat underwriting loss impacts arising from all major perils underwritten, but it will still hold satisfactory capital to settle policyholder obligations and meet regulatory capital requirements.[11] Out of the 18 standardised underwriting loss scenarios, the Gulf Windstorm (onshore) peril had the largest potential adverse effect with an estimated gross loss impact to statutory capital and surplus of 20.76% (and 7.72% net loss impact), followed by the Northeast Hurricane peril, which had the potential to deplete 18.95% (and 7.77% net loss impact) of the market's total statutory capital and surplus.[12,13] The Australian Wildfires peril had the least impact with only 0.67% gross and 0.39% net impact on the statutory capital and surplus. The gross impact from each of the other perils ranges from 1.02% to 16.54%, with many of the perils (10) incurring a gross loss impact of less than 10% (see Figure 7.1 below).

[11]The underwriting loss impact and associated assumptions reported by insurers are probabilistic outcomes and represent calculated estimates. Actual results may significantly differ from these estimates.
[12]Gross loss impact is before any reinsurance and/or other loss mitigation instruments.
[13]Total capital and surplus include only capital and surplus for insurers that underwrite Cat risk (i.e., capital and surplus for insurers that do not underwrite Cat risk is not included).

Figure 7.1 - Stress Testing - Cat Loss Scenarios
(As a Percentage of Total Capital and Surplus)

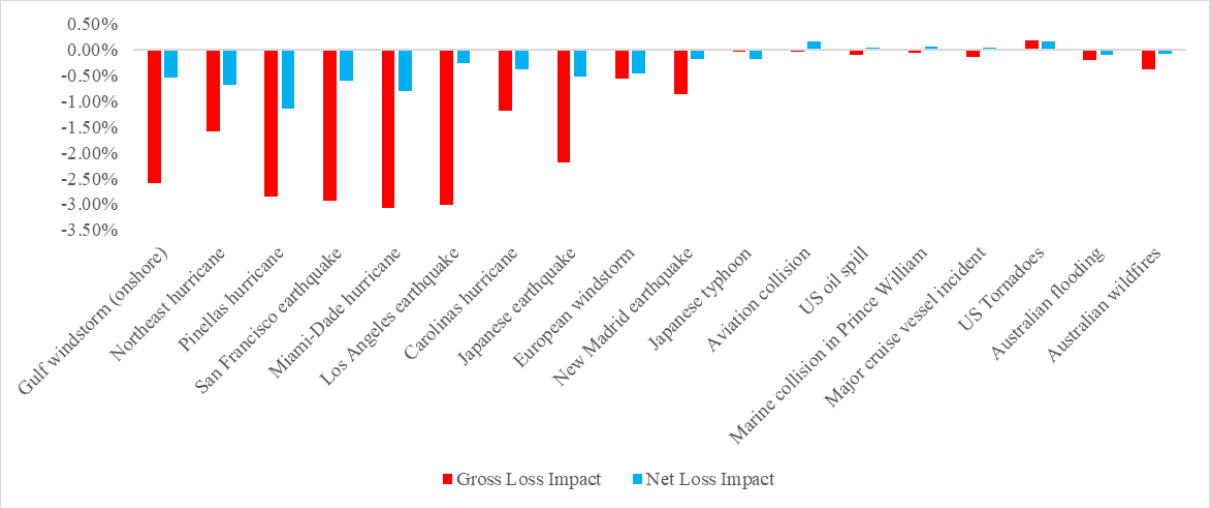


Source: BMA

While the year-on-year ceded loss exposure has decreased, overall, insurers have taken on less gross exposure, resulting in a decrease in the net loss exposure compared to 2021. On the other hand, the insurers' year-on-year aggregate statutory capital and surplus has slightly increased by 0.98%.[14] The increase in the statutory capital and surplus, despite the reduction in the exposure, has effectively contributed to the reduction of the severity of both the gross and net impact to the Bermuda insurers' balance sheet—The Miami-Dade Hurricane had the highest year-on-year decrease of 3.07% gross and 0.81% net loss impact, followed by Los Angeles Earthquake and San Francisco Earthquake, which had a 3.00% and 2.94% (0.27% and 0.61% net) decrease, respectively. All the other perils' gross loss impact decreased by an average of 0.97% (0.26% net) (see Figure 7.2 below).

[14] The increase in capital and surplus is driven primarily by the increase in the level of capital held by several insurers.

Figure 7.2 – Year-on-Year (2020 and 2021) Gross and Net Loss Impact Change (In Percent)



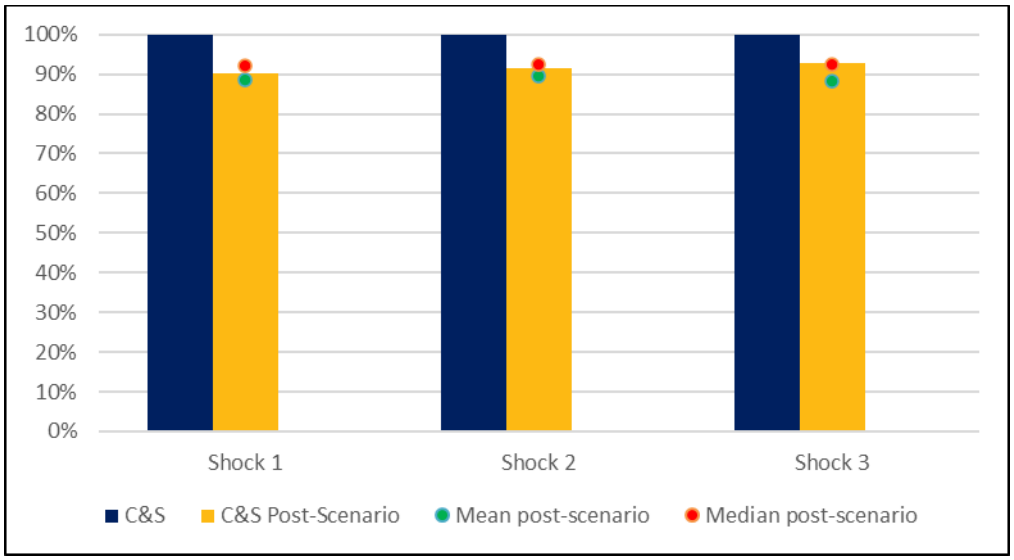
Source: BMA

Other underwriting loss scenarios

Sometimes, the underwriting scenarios under the Cat risk scenarios above either do not apply or partially apply to the insurer, resulting in de minimis loss projections. In this case, the insurer was required to submit three of its own underwriting loss scenarios. Typically, insurers that underwrite a significant amount of casualty business (where the potential arising from casualty losses exceeds that from property) fall under this category.

For each of the three scenarios, insurers were required to include a detailed description of each scenario, including related key assumptions. In addition, the insurer was required to include the post-stress positions on aggregate statutory assets and statutory liabilities that would be observed immediately upon the occurrence of the event, both with and without the effect of reinsurance and/or other loss-mitigation instruments. Figure 7.3 shows the results from these scenarios.

Figure 7.3 - Capital and Surplus (C&S) Post Other Underwriting Loss Scenarios



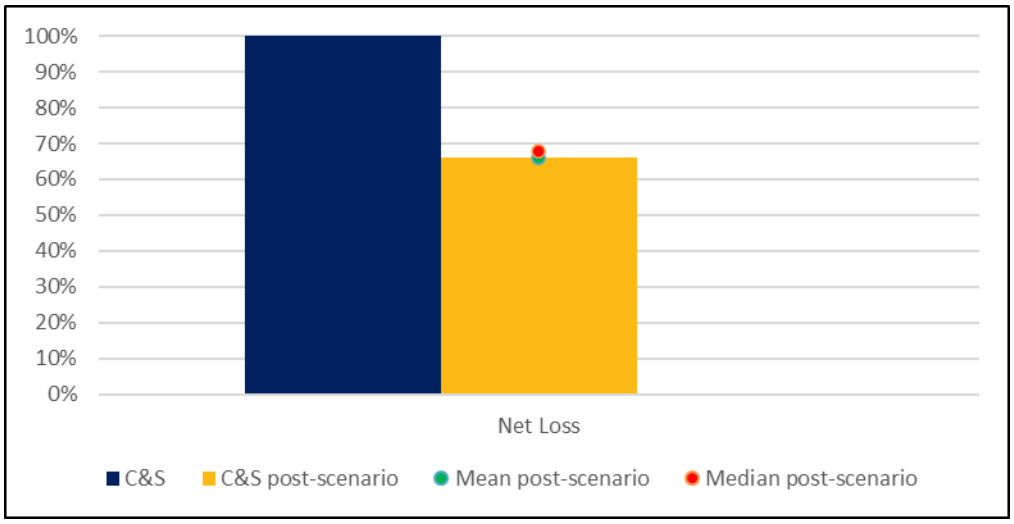
Source: BMA

As shown in Figure 7.3, insurers could comfortably withstand these scenarios, with the majority of insurers returning a significantly high percentage of their statutory capital and surplus for each. Across these scenarios, the average mean and median post-stress capital and surplus returned by Bermuda insurers was 88.73% and 90.31%, respectively.

Insurer's own worst-case scenario

An insurer's own worst-case scenario presents a more severe impact and is generally the insurer's most remote and extreme test. The net mean and median post-stress capital and surplus returned by Bermuda insurers for this scenario were 66.11% and 67.97%, respectively (see Figure 7.4).

Figure 7.4 - Capital and Surplus Post Insurer's Own Worst-Case Scenario



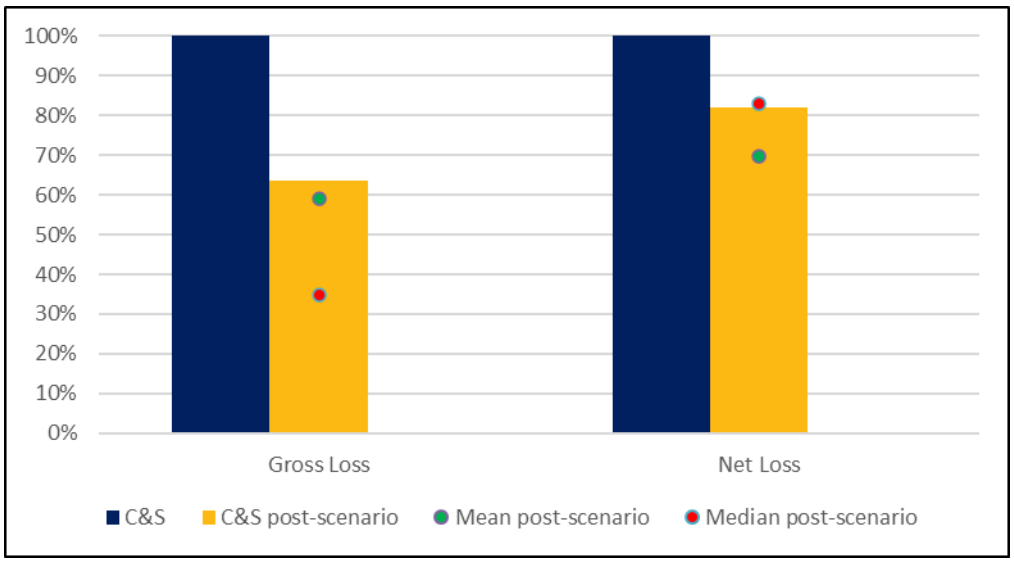
Source: BMA

Loss simulations scenario

Insurers were required to run a series of loss simulations or other analysis related to extreme tail events that include all policies at the beginning of the year. These scenarios were substantiated with the relevant underlying assumptions.

The result of a series of loss simulations or other analysis related to extreme tail events scenario shows that the mean and median capital and surplus post gross loss impact will be medium/low (e.g., 58.95% and 34.76%, respectively). Nevertheless, after factoring in the exposure ceded, the post-stress capital and surplus for the majority of insurers is significantly higher (i.e., mean of 69.62% and median 83.03% - see Figure 7.5).

Figure 7.5 - Capital and Surplus Post Loss Simulations – Tail Events



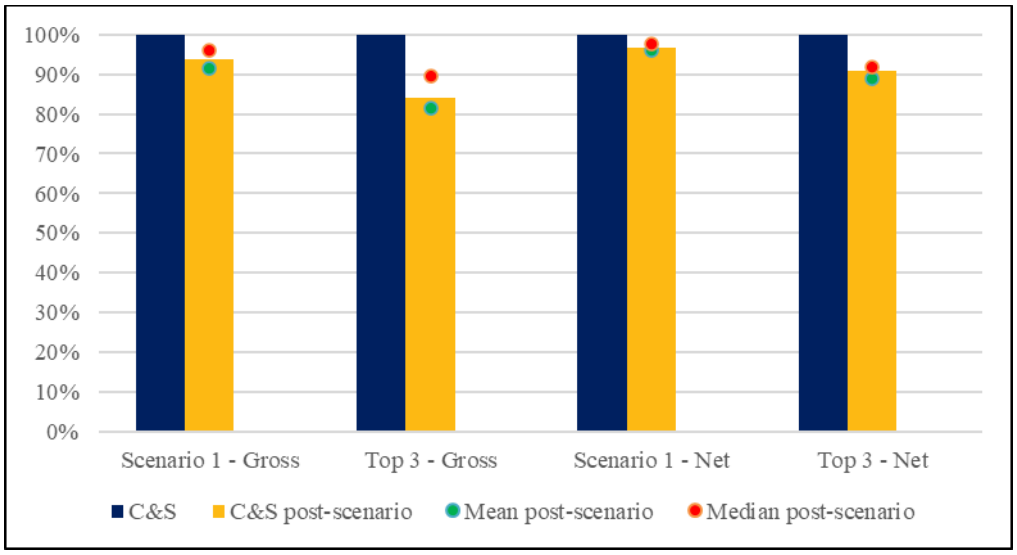
Source: BMA

8. Terrorism, Cyber Risk and Mortgage Insurance Scenarios

Terrorism stress scenario

It is appropriate to consider terrorism exposure in both absolute terms and for realistic scenarios of loss. The Authority requires insurers to carry out a separate stress test for terrorism coverage by estimating the potential loss impact using a standardised scenario of an explosion of a two-tonne bomb.[15] The results from the test show that all entities could comfortably withstand their worst impact from this standardised scenario, retaining on average 91.57% of the statutory capital and surplus on a gross basis and 96.03% on a net basis. Moreover, the results illustrate that all the insurers' balance sheets can comfortably withstand the impact from three of their largest terrorism exposures combined (i.e., insurers will retain, on average, 81.44% of the statutory capital and surplus on a gross basis and 89.03% on a net basis – see Figure 8.1).

Figure 8.1 – Capital and Surplus Terrorism Stress Scenario



Source: BMA.

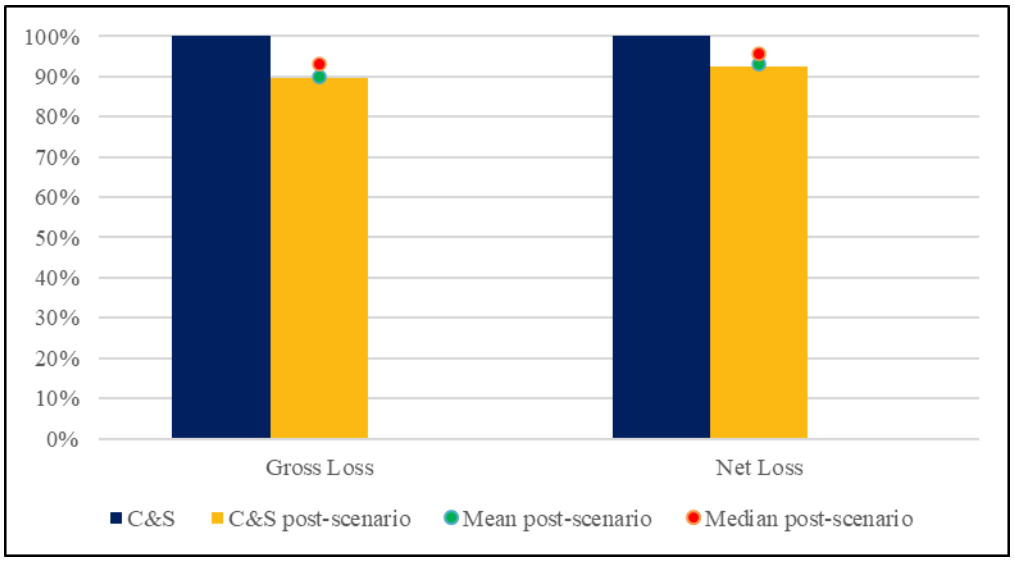
Cyber stress scenario

Insurers were required to provide cyber risk data, including their estimated aggregate exposure, their own cyber risk worst-case annual aggregate loss scenarios and the underlying assumptions. The insurance-specific cyber stress scenario data shows that the insurers' own worst impacts from cyber risk would have a minor effect on their statutory capital and surplus, both on a gross basis and on a net basis. It also shows the mean and median statutory capital

[15] For a detailed description of this scenario, please refer to the Authority's Cat Risk Return Guidelines.

post the cyber risk stress was at 89.79% (93.04% net) and 93.26% (95.70% net), respectively (see Figure 8.2).[16]

Figure 8.2 - Capital and Surplus Cyber Stress Scenario



Source: BMA.

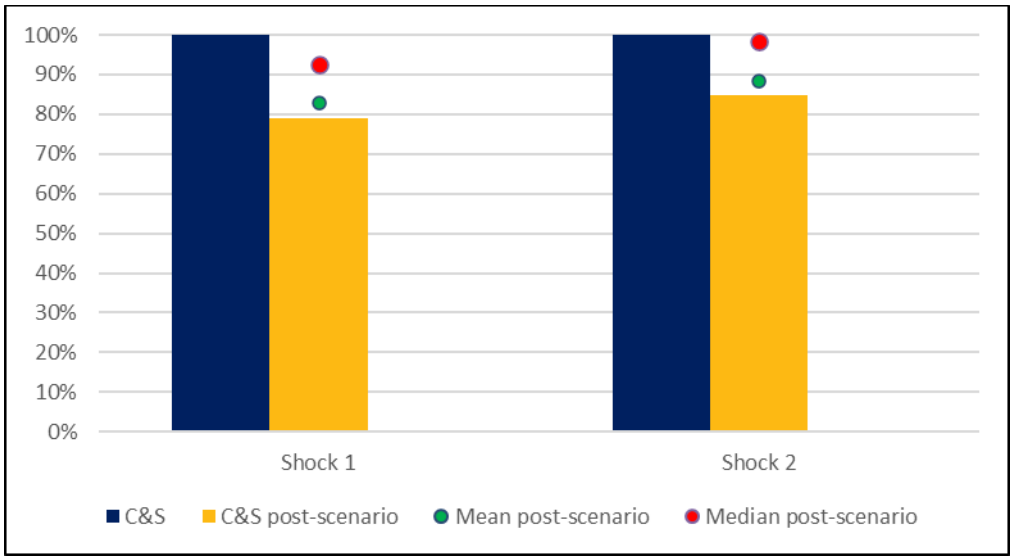
Mortgage insurance scenario

Insurers that write mortgage business were required to shock their exposure for this business using two different scenarios. For the first scenario (shock 1), insurers were required to increase the default rate to 9.47% (equivalent to approximately 99.5% TVaR) for their mortgage book and apply it instantaneously. For the second scenario (shock 2), insurers were required to assume the default rate to be 5.5% (equivalent to approximately 90% TVaR) for their mortgage book and apply it instantaneously.

In addition, for both shocks 1 and 2, insurers holding agency Mortgage-Backed Security (MBS) and securities as investment assets subject to prepayment risk were required to shock these investments by assuming that the MBS will prepay at an annual Constant Prepayment Rate (CPR) of 40% instantaneously. If the 40% CPR produced capital gains, the insurer had to stress the CPR at 0%, 5% and 10%. The expectation is that if using a CPR of 40% produces a gain, then applying a substantially lower MBS prepayment shock rate of 10% or less will likely produce capital losses. Figure 8.3 illustrates the results from this scenario.

[16] The BMA publishes a separate annual Bermuda Cyber Underwriting Report.

Figure 8.3 - Capital and Surplus Mortgage Insurance Loss Scenario



Source: BMA.

The results of these scenarios show the mean and median post-stress capital and surplus returned by the Bermuda insurer were 82.92% (shock 1), 88.48% (shock 2), 92.54% (shock 1) and 98.37% (shock 2), respectively.

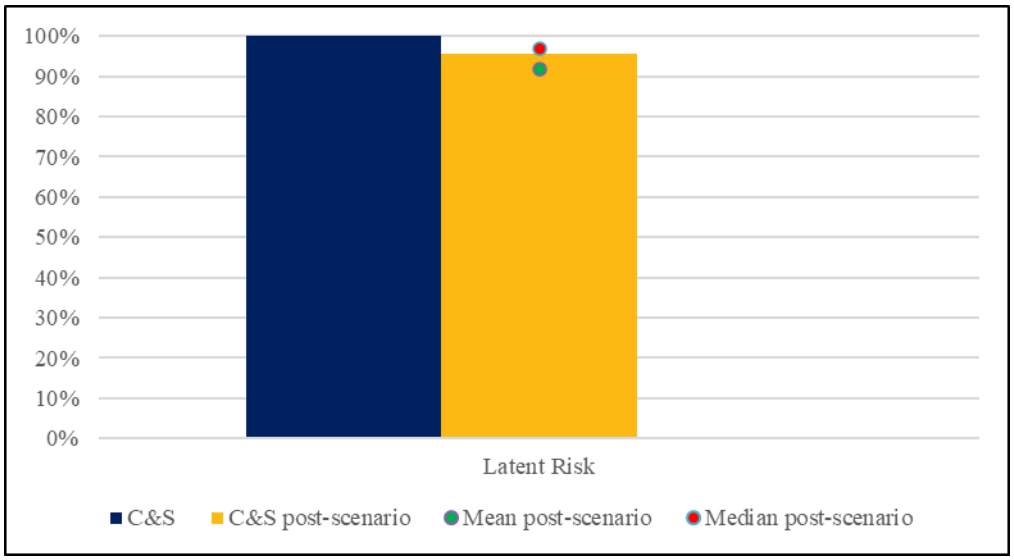
9. Liability Loss Accumulation Scenarios

Insurers were also required to run stress tests on scenarios that estimate potential insurance loss accumulations relating to liability exposures. The scenarios aim to capture risk on liability exposures that are generally not adequately reflected by historical claims experience. Such risks tend to materialise slowly and impact many exposure years. Specifically, insurers were requested to stress their balance sheets under two separate scenarios, a new latent liability scenario and an Asbestos and Environmental (A&E) scenario, which assumes deterioration in existing US A&E and UK asbestos reserves.

The new latent liability test aims to cover a 'mass tort' event. For example, after a court decision, a general and potentially legally enforceable opinion could emerge that characterises a specific product or substance as causing observed, or potential future, adverse effects, such as bodily injury, property damage or environmental damage. This is expected, during that year and the years that follow, to lead to claims on the product liability insurance of the producers, followed by mass litigation against companies that are distributing or using or have distributed or used, the product or substance. These developments are expected to lead to an accumulation

of potentially worldwide claims on general commercial liability and worker compensation/employer liability insurance policies. The scenario takes into consideration that the amount recognised at the end of the one-year time horizon is smaller than the maximum possible ultimate loss from the scenario due to the incompleteness of available information and uncertainty of the subsequent development. Figure 9.1 below shows the results of this scenario with the mean and median post-stress capital and surplus returned by the Bermuda insurer at 91.84% and 96.71%, respectively).

Figure 9.1 - Capital and Surplus New Latent Liability



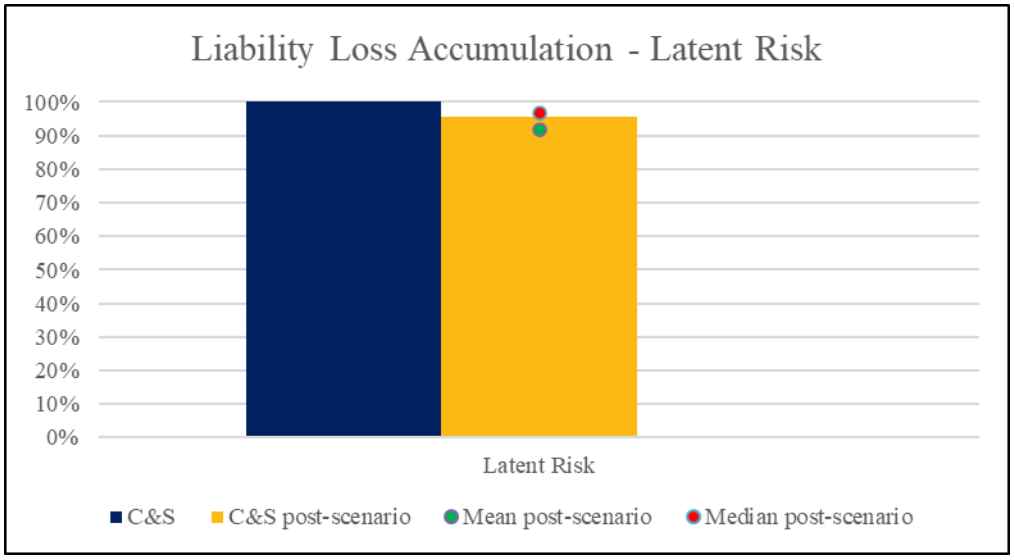
Source: BMA

The A&E scenario aims to reflect potential deterioration in existing US Asbestos, US Environmental and UK Asbestos reserves.[17] For the US A&E stress, the scenario takes into consideration potential under-reserving by referencing survival ratio market benchmarks, an increase in projected claims inflation and an increase in projected asbestos claims due to medical advances.[18] For the UK asbestos stress, the scenario takes into consideration new claims arising beyond 2050, a deterioration in the projected number of claims up to 2050, an increase in the projected claims due to medical advances and an increase in projected claims inflation. Figure 9.2 below shows the results of this scenario with the mean and median post-stress capital and surplus returned by Bermuda insurers at 94.38% and 98.15%, respectively).

[17] Insurers with total US A&E and UK Asbestos net reserves of less than $50 million do not need to calculate this scenario.

[18] A survival ratio is a common market benchmark for assessing the reserve strength of A&E reserves. It is defined as the number of years that current reserves will suffice (survive) if average future payments equal average current payments.

Figure 9.2 - Capital and Surplus the Deterioration in Existing US A&E and UK Asbestos



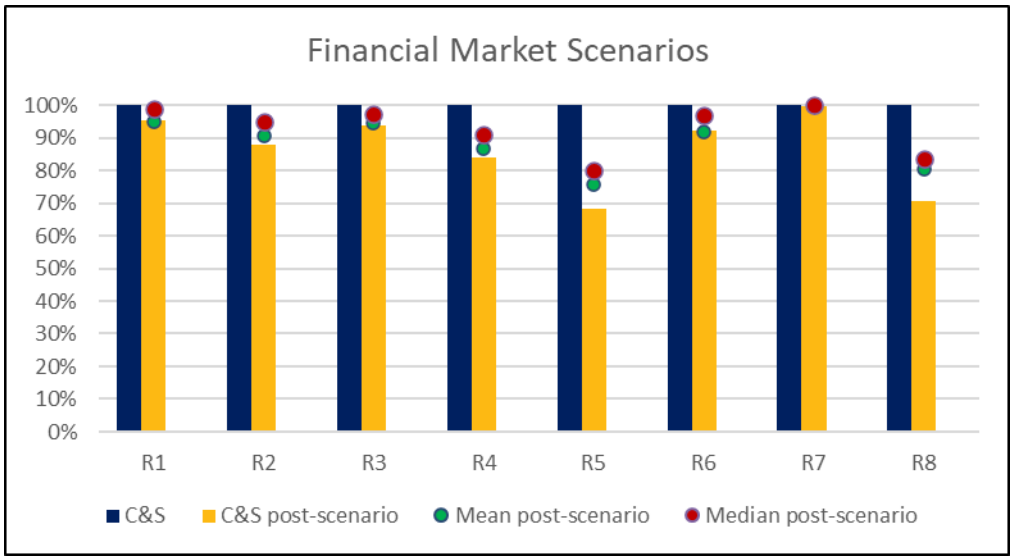
Source: BMA

10. Financial Market Scenarios

The financial market scenarios comprise capital market-related single-factor shocks triggered by specific risk factors (i.e., equity returns, credit spreads and defaults). The calibration of these shocks was based on historical data about the evolution of interest rates, exchange rates and equity markets. Furthermore, considering the continued sovereign risk concerns and their implications on the investment performance of insurers, the financial market scenarios included haircuts on sovereign bonds. The ongoing volatility due to political risk and volatility of capital flows also warrants shocks on foreign currency positions.

Specifically, the insurer (depending on the insurer's exposure to capital market-related factors) was required to quantify the impact on its statutory balance sheet from eight different financial market scenarios. Figure 10.1 shows the capital and surplus after these various scenario impacts.

Figure 10.1 - Capital and Surplus - Financial Market Scenarios



Source: BMA

R1 (Severe decline in equity prices) - assumes a decrease of 40% of the value of equities in a portfolio. This stress scenario is consistent with the 'Black Monday' crash of 1987. The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 95.03% and 98.92%, respectively.

R2 (Alternative investment and real estate) - focuses on assets that have a low correlation with financial markets and less liquidity compared with typical financial assets. Such assets include investment holdings in hedge funds, real estate, private placements, and venture capital,

among others. R2 requires those assets to be decreased in value by 40%. For assets such as hedge funds with lockup periods, venture capital and real estate in illiquid markets, the (re)insurer reported whether sudden decreases in their value could entail inability for rapid sale and whether this effect had material consequences. The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 90.72% and 95.07%, respectively.

R3 (Extreme US yield curve widening) - assumes an extreme movement upwards of the US yield curve. The insurer is required to stress its balance sheet for this scenario using a risk-free yield curve[19]provided by the Authority for valuations of assets and liabilities. The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 94.52% and 97.13%, respectively.

R4 (General widening of credit spreads) - assumes that credit spreads widen across different rating classes. The widening reflects the increase of the perceived credit risk in the market. The insurer was required to stress all positions, including those available for sale and held to maturity. Structured finance products, asset-backed securities, and agency and non-agency MBSs must be included as well. If there was no rating for an asset, the insurer needed to assume that the rating was below BB. The result of this scenario shows that the mean and median post-stress capital and surplus retained by the Bermuda insurance market were 86.64% and 91.10%, respectively.

R5 (R1 to R4 combined) - is the most severe financial market scenario as it assumes a combination of a decrease of 40% of the value of equities in a portfolio (R1), a decrease in value of alternative investment and real estate (R2) by 40%, extreme movement upwards of the US yield curve (R3) and credit widening across different rating classes (R4). The results showed that the majority of insurers can withstand this scenario, with the mean and median post-stress capital and surplus returned by the Bermuda insurance market being 75.25% and 79.92%, respectively.

R6 (Foreign currency shocks) - assumes an equal percentage, provided by the Authority, of depreciation and/or appreciation of foreign exchange positions in both assets and liabilities.[20]

[19] This yield curve is a product of a bespoke BMA scenario generator. It represents the 99th percentile yield curve of all simulated paths of interest rates for each maturity.

[20] The scenario estimation horizon covers daily exchange rate movements from 2000 to 2019. A GARCH (1,1) model was used to generate the scenarios. Due to Brexit, the GBP/USD shock increased by considering the 99.9th percentile of projected depreciation.

The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 91.98% and 96.73%, respectively.

R7 (Escalation of sovereign risk) - assumes that the weakest sovereigns will have to undergo a haircut in the face value of their debt. Both available-for-sale and held-to-maturity bonds were stressed. The haircuts were based on the realisation of a prolonged pan-European banking crisis in Europe, which would cause sovereign defaults. Only a handful of Bermuda insurers are exposed to this scenario. The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 99.76% and 99.90%, respectively.

R8 (Inflation and monetary policy risk) - simulates a scenario like the 1973 inflationary scenario. The insurer was required to apply each inflation scenario (low, medium, high, and severe) for three years assuming no initial action to curb inflation from the US Federal Reserve.[21] The insurer also needed to assume that in year four, the US Federal Reserve would change its stance and increase rates to maintain the current real interest rate. Therefore, the insurer had to raise the yield curve across maturities for one year by 510, 730 and 1,130 basis points, respectively, for the medium, high and severe inflation scenarios. These scenarios demonstrate that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 80.61% and 83.39%, respectively.

In addition, insurers were required to submit a detailed qualitative disclosure of the impact upon both their statutory statement of income and liquidity positions of a rating downgrade of their Bermuda legal entities or groups by two notches or below A-, whichever was lower. The disclosure needed to cover and indicate the relative impact/severity of collateral requirements, loss payment triggers on in-force policy contracts, clawbacks and/or other adverse financial and liquidity implications of the downgrade.

[21] Each inflation scenario corresponds to the 50th, 80th, 90th and 99th percentile of the historical annual US core inflation rates from 1957 until 2016.

Appendix I - The Bermuda Framework for Cat Risk Supervision

As it is one of the largest property Cat reinsurance centres in the world, Bermuda has a comprehensive framework of Cat risk supervision. The supervisory framework rests on three pillars:

1) Cat capital charge in prudential filings;
2) Supervisory assessment of prudential filings; and
3) Public dissemination of Cat risk data on an aggregated basis.

The first pillar includes the capital charge for Cat risk that the insurer must uphold as part of its solvency capital requirement. The capital charge is a combination of a BMA in-house factor plus an insurer-specific factor, which the insurer supplies. Once the capital charge for Cat risk has been calculated, it is further blended into the overall capital charge, allowing for diversification.

Within the prudential filings, some schedules comprise the Cat risk-return. The Cat risk-return questionnaire contains qualitative information on the process of Cat risk modelling, such as the type of models and the frequency of the modelling process. In addition to the qualitative information, the insurer provides quantitative information such as AALs, PMLs and EP curves for major perils.

In the second pillar, the supervisory process validates the prudential filings. Since part of the calibration of the Cat risk capital charge hinges on the insurer's assumptions, the BMA validates the results with a set of tools. The Cat risk-return is one source of cross-validation.

Finally, the BMA prescribes a set of stress tests based on Lloyd's RDS, which are reported on in the prudential filings. The insurer must show its capital position before and after the relevant RDS and is required to provide several scenarios should the RDS be insufficient for the type of exposures in its portfolio. The insurer is also obligated to provide a reverse stress test that will render its business non-viable.

Regarding the third pillar, the BMA publicly publishes aggregated data of the Bermuda Cat risk returns for the market and its macro-prudential surveillance framework for the insurance sector.

Appendix II - Pricing Dynamics

The following panel shows the pricing dynamics of the Bermuda Cat market over time based on aggregated data only.

Panel 1. AAL, Risk and Pricing Ratios[22]

Source: BMA staff calculations

Note: The ratios are calculated only for modelled exposures and modelled premium.

The gross AAL decreased between 2021 and 2022 to 9.36 billion, compared to $10.42 billion in 2021. Similarly, the net AAL decreased to $5.28 billion in 2022 compared to $6.01 billion in 2021.

Panel 1 plots the risk and pricing dynamics to show the ratios of the Cat AAL to Cat premium on both a gross and net premium basis. The AAL represents the modelled estimation of the expected Cat losses, and the gross premium includes provisions for profit and expenses. The relationship between these gross and net ratios is an indication of the amount of expenses, profit and other loadings charged to insured entities. The BMA observes that, on average, both the gross and net ratios have been steadily decreasing over the last three years. For 2021, the gross ratio stands at 55.5%, while the net ratio stands at 60.37%. The decrease in these ratios is

[22] The Authority only uses modelled exposures and premium.

consistent with the hardening of the insurance market and the reduction of Cat Exposure by Bermuda insurers.

The BMA also plots the ratio of Cat premium to Cat exposures, which can be seen in the second row of Panel 1. For 2022, the ratio increased slightly on a gross basis to 1.12%, while on a net basis, the ratio stood at 1.87%.