

December 2021

Bermuda Monetary Authority

Bermuda Insurance Property and Casualty Market

Catastrophe Risk and Stress Testing Analysis

2020 Report



Foreword

This report gives a high-level overview of the Catastrophe (Cat) risk exposure and stress testing analysis in Bermuda. With the relatively high concentration of Cat risk in Bermuda's market, a broad understanding of this exposure, including the identification of any concentration of risk in Bermuda, is central to the Bermuda Monetary Authority (Authority or BMA) and other stakeholders and markets globally.

The assessment of Cat risk exposure and stress testing, at both the micro and macro level, are fundamental elements to the Authority's overall supervisory framework, allowing it to evaluate the insurers' capital adequacy under adverse financial market and underwriting conditions. The results of these assessments provide a comprehensive understanding of the sector's general vulnerability to shocks.

This report does not directly assess the impact of the COVID-19 pandemic; however, since the pandemic outbreak, the Authority has taken a proactive stance to evaluate its impact on Bermuda's insurance sector. Overall, the COVID-19 impact on the Bermuda insurance market has been an 'earnings' event affecting the insurers' income statements and not a capital event affecting their solvency positions.

It should be noted however, that some insurance events, directly and indirectly, linked to the COVID-19 pandemic, are still unfolding, increasing the overall uncertainty associated with assessing the full impact of the pandemic on the sector. Accordingly, the Authority emphasises to insurers the need to take prudent measures, including avoiding actions that significantly reduce liquidity and capital through until insurers have sufficient clarity as to the underwriting and financial exposure resulting from COVID-19. The Authority has increased the frequency and level of supervisory colleges and information exchanges with other regulators and engages in bilateral meetings with relevant international partners, including the European Insurance and Occupational Pensions Authority, National Association of Insurance Commissioners and International Association of Insurance Supervisors.

Gerald Gakundi
Director, Supervision (Insurance)
Bermuda Insurance Market Stress Testing Report

This is the second, standalone, annual *Catastrophe Risk and Stress Testing Analysis Report* published by the Authority. The content of this report is the result of the analysis carried out by BMA staff.

About the Authority

The Authority was established by statute in 1969. Its role has evolved over the years to meet the changing needs in 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 Government on banking and other financial and monetary matters.

The Authority develops risk-based financial regulations that it applies 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 issuances and digital asset businesses. It also regulates the Bermuda Stock Exchange and the Credit Union.

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This publication is available on the BMA website: www.bma.bm

Acronyms

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

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1. Executive Summary

Overall, the 2020 Cat Risk results showed that the gross loss exposure assumed by Bermuda insurers increased by 7.5% (from \$193.7 billion to \$208.3 billion). Furthermore, the global share of gross estimated potential loss assumed by Bermuda insurers on the major Cat perils (combined) has increased by 3.0%, to 24.0% (from \$181.9 billion to \$193.1 billion).

An analysis of the exceedance probability curves demonstrates that Bermuda insurers are more exposed to Atlantic Hurricane than any other peril, with gross average modelled losses over all companies stretching from \$817.1 million for the "1-in-50" year events up to \$1.5 billion for the "1-in-1,000" year events. Other perils show lower modelled losses for the "1-in-50" and the "1-in-1,000" year events with significant variation between firms. The use of reinsurance is widespread and is generally more pronounced for lower frequency return periods for Atlantic Hurricane and North American Earthquake.

The stress test results demonstrated that the Bermuda insurance market is resilient to potential adverse impacts from various global adverse 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 potential large losses while still having capital remaining to settle policyholder obligations and meet regulatory capital requirements.

The table below highlights some of the key findings from this report.

Table 1.1 – Key Findings

Description	US\$ or percent	Notes
Gross loss exposure	\$208.3 billion	7.5% increase year-on-year
Ceded loss	\$132.0 billion	7.1% increase year-on-year
Net loss exposure	\$76.5 billion	8.1% increase year-on-year
Global share of gross estimated exposure on the major Cat perils	\$193 billion	24% of global share
Total pre-stress capital and surplus	\$106 billion	Participating insurers only
Total post Cat-stress (aggregate of Largest Three Cat Scenarios) capital and surplus - net	\$78.5 billion	Participating insurers only
Average capital and surplus post aggregate of Three Largest Cat Underwriting Scenarios - net	56.10%	2.9% decrease year-on-year
Average capital and surplus post Other Underwriting Loss Scenarios	89.5%	3.2% increase year-on-year
Average capital and surplus post Insurer's Own Worst Case Scenario	62.2%	2.7% increase year-on-year
Average capital and surplus post aggregate of Largest Three Terrorism Stress Scenarios	82.7% / 85.4%	Gross and net respectively
Average capital and surplus post Cyber Stress Scenario	89.9% / 93.6%	Gross and net respectively
Average capital and surplus post Mortgage Insurance Loss Scenario	89.3% / 95.4%	Shock 1 and 2 respectively
Average capital and surplus post New Latent Liability	93.9%	0.4% increase year-on-year
Average capital and surplus post Deterioration in Existing US A&E and UK Asbestos	83.3%	4.9% decrease year-on-year
Average capital and surplus post a combination of four Financial Market Scenarios	70.4%	Most severe scenario
Average ceded exposure	58.6%	0.4% decrease year-on-year

Source: BMA

2. Introduction

Bermuda's insurance sector is regulated and supervised by the Authority. As part of the BMA's regulatory and supervisory measures, it requires all Class 3B and Class 4 insurers¹ to submit a Capital and Solvency Return (CSR), which includes a Cat Risk Return and Schedule of Risk Management (Cat Return) detailing the insurers' Cat risk management practices.

Within the Cat Return, insurers report their Cat exposures, Exceedance Probability (EP) curves (for various return periods), Average Annual Losses (AAL) and Probable Maximum Losses (PML). Additionally, insurers are required to carry out rigorous and comprehensive forward-looking stress tests to measure the sensitivity of their statutory capital and surplus to various adverse financial markets 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.

This report gives a high-level overview of the Cat risk exposure assumed by Bermuda's insurance sector. The report also assesses the sector's capacity to absorb shocks from various adverse financial markets and underwriting conditions. The report also considers if 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). Finally, the report reviews Bermuda insurers' level of reliance on reinsurance, including identification of any concentration of risks.

Stress testing is a valuable supervisory tool for the BMA. It provides supervisors with a forward-looking perspective of the resilience of individual insurance entities and the sector as a whole. 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, new and emerging risk and assess how insurers respond to such risk.

The Authority does not use the stress testing exercise to determine required capital levels. Nonetheless, this exercise's results help the Authority assess if the risk assumed by Bermuda insurers is commensurate to each insurer's risk appetite. This information ultimately feeds into the Authority's risk-based supervisory approach. Accordingly, any capital adequacy concerns

¹ For the purpose of this report, insurers also include reinsurers and groups.

identified during this exercise are dealt with as part of the Authority's normal supervisory routine.

Information Box

Class 3B and Class 4 insurers are the larger 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, 2020. (In US\$ billions)

Net written premiums	49.2
Net earned premiums	47.6
Net income	7.1
Total claims	35.9
Total assets	281.3

Source: BMA

3. Methodology

The report was produced using aggregated and non-aggregated data from the Bermuda Capital and Solvency Return (CSR) filings of Class 3B and Class 4 legal entities for the period ended 31 December 2020². 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 is possible to do so. For example, the Authority did not use aggregated EP curve data, while it used aggregated AAL data. EP curves were not aggregated as they represent upper quantiles of distributions, and quantiles are not additive functions. AALs, contrastingly, as they represent averages over distributions, can be aggregated without logical inconsistencies. When data could not be aggregated, an augmented box plot, 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)³, limits the conclusions that can be gleaned from the results of this survey. Therefore, one should view the results as being reflective of a segment of the industry and not the entire exposure of the Bermuda insurance market⁴, which is expected to be larger than what is presented in this report. 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 in this publication are those that would be observed immediately upon the occurrence of the event (e.g., stress/scenario) as determined by the insurer's internal or vendor model(s) (both with and without the effect of reinsurance and/or

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 BMA publishes an annual Alternative Capital Report.

⁴ The Bermuda insurance market includes the Bermuda commercial market, SPIs and other limited purpose entities such as captives.

other loss mitigation instruments). The stress/scenarios were run against the insurers' balance sheet positions and aggregated in-force exposures as of 1 January 2021⁵.

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

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

Bermuda Stress Testing Guidelines

This report only provides a high-level overview of the stress/scenarios carried out by insurers. Each year, the Authority publishes a detailed description and guidelines for each stress/scenario analysis, including assumptions. This guide, '2020 Capital and Solvency Return: stress/scenario analysis – Class 4, Class 3B and Insurance Groups', can be found on the Authority's website⁶.

⁵ 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 2021.

⁶ <https://www.bma.bm/document-centre/reporting-forms-and-guidelines-insurance>

4. Bermuda's Cat Risk Exposure⁷

For 2020, the year-on-year gross loss exposure assumed by Bermuda insurers increased by 7.5% (from \$193.7 billion to \$208.3 billion). The amount of ceded loss increased by 7.2%, from \$123.0 billion to \$131.8 billion, effectively meaning the net loss exposure assumed by Bermuda insurers increased by 8.2%, from \$70.7 billion to \$76.5 billion (see Table 4.1 below). With a gross loss impact of almost \$27.7 billion and net loss impact of almost \$9.9 billion, Gulf Windstorm has the highest gross and net loss exposure followed by San Francisco Earthquake (\$23.9 billion - gross and \$8.2 billion - net) and Northeast Hurricane (\$23.1 billion - gross and \$9.3 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)	27,659,957,139	17,673,780,340	9,986,176,799	64
San Francisco Earthquake	23,929,490,707	15,733,741,325	8,195,749,382	66
Northeast Hurricane	23,133,899,789	13,836,094,594	9,297,805,195	60
Pinellas Hurricane	22,548,988,770	15,546,900,040	7,002,088,731	69
Miami-Dade Hurricane	22,201,461,282	16,028,694,724	6,172,766,558	72
Los Angeles Earthquake	20,990,343,459	13,846,397,458	7,143,946,001	66
Carolinas Hurricane	13,994,702,053	9,307,355,872	4,687,346,181	67
Japanese Earthquake	13,252,976,756	7,216,668,171	6,036,308,585	54
European Windstorm	11,103,216,857	6,321,666,210	4,781,550,647	57
New Madrid (NM) RDS	5,914,339,276	3,030,052,496	2,884,286,780	51
Japanese Typhoon	5,374,182,052	2,569,720,560	2,804,461,492	48
Aviation Collision	3,594,654,847	2,333,792,823	1,260,862,024	65
US Oil Spill	3,320,346,844	2,189,204,106	1,131,142,738	66
Major Cruise Vessel Incident	3,299,058,226	1,972,054,158	1,327,004,067	60
Marine Collision in Prince William	2,692,953,516	1,729,566,377	963,387,139	64
Australian Flooding	1,823,916,734	774,764,423	1,049,152,311	42
US Tornadoes	1,739,796,656	822,186,521	917,610,135	47
Australian Wildfires	1,711,108,758	900,388,189	810,720,569	53
Total	208,285,393,721	131,833,028,386	76,452,365,335	63

Source: BMA

Based upon the Lloyd's of London-developed RDS' ultimate industry settlement estimated values⁸ (\$814.0 billion), the global share of gross estimated potential loss assumed by Bermuda insurers from the major Cat perils (combined) increased by about 3.0%, from \$181.9 billion to

⁷ 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 small number 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, one should view the results as being reflective of a segment of the industry and not the total potential/impact.

⁸ The insurers are required to run the Lloyd's of London developed RDS as specified in Lloyd's of London Handbook on "Realistic Disaster Scenarios – Scenario Specification 2020" using aggregates in force at 1 January 2021.

\$193.0 billion. This increase was driven primarily by the exposures from Gulf Windstorm that increased its global share by 6.0% (see Table 4.2. below).

Table 4.2 - Bermuda Loss to Industry Loss using Lloyd's of London-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	27,659,957,139	25
Northeast Hurricane	81,000,000,000	23,133,899,789	29
San Francisco Earthquake	80,000,000,000	23,929,490,707	30
Pinellas Hurricane	134,000,000,000	22,548,988,770	17
Los Angeles Earthquake	78,000,000,000	23,929,490,707	31
Miami-Dade Hurricane	131,000,000,000	22,201,461,282	17
Carolinias Hurricane	39,000,000,000	13,994,702,053	36
Japanese Earthquake	72,950,521,218	13,252,976,756	18
European Windstorm	27,555,484,115	11,103,216,857	40
New Madrid (NM) RDS	44,000,000,000	5,914,339,276	13
Japanese Typhoon	15,501,985,759	5,374,182,052	35
Total	814,007,991,092	193,042,705,389	24

Source: BMA

5. Exceedance Probability Curves

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

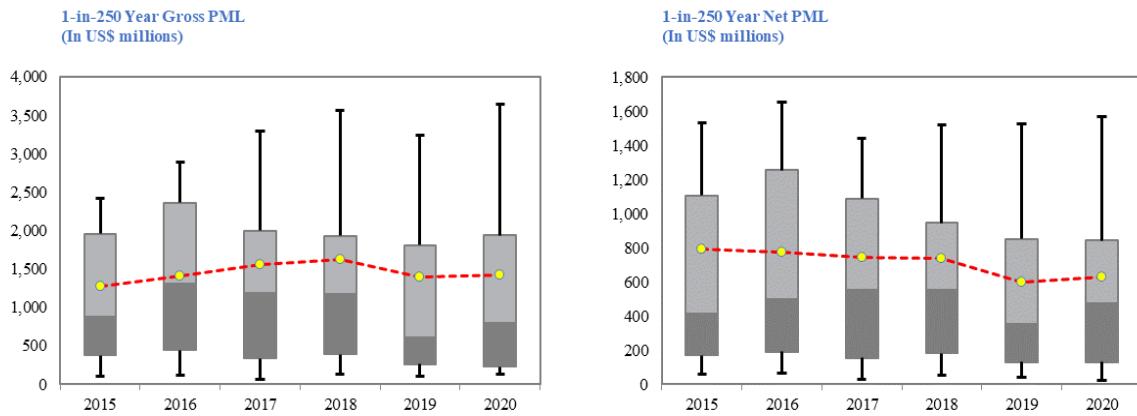
Data is compiled from the EP curves by drawing the distribution of EP curves from a cross-section of firms for named perils across return periods. The BMA illustrates a box plot for each peril and each return period, including the mean, median, 10th, 25th, 75th and 90th percentiles of the EP curves⁹.

The BMA evaluated historical trends of the gross and net “1-in-250” year PML for aggregate exposures for the past five years. For the purposes of the BMA’s analysis, the “1-in-250” year

⁹ EP curves cannot be aggregated by summing individual EP curves since an event for one firm can be completely unrelated to the event of another company even for the same peril and the same return period. For example, the outcome of a 1-in-250 year event North America Earthquake is 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 large urban centres. Moreover, the simple addition of EP curves does not recognise diversification benefits since it assumes that all events for all perils and for all return periods can occur at the same time even if some events may be mutually exclusive.

event is the most representative of the extreme risk that an insurer is exposed to. 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 have increased their average gross “1-in-250” exposure between 2019 and 2020 by 2.6%. The variation within the sample in 2020 increased for gross exposures, with some companies having significant changes in their exposures and many smaller firms with more minor changes in exposures. The 90th percentile gross “1-in-250” exposure reached \$3.6 billion and increased by 12.8% since 2019.

Average net “1-in-250” exposure increased by 5.3% between 2019 and 2020, while the variation of exposures within samples also increased. The 90th percentile “1-in-250” net exposure increased marginally by 2.8% in 2020, reaching \$1.6 billion.

The largest exposure for Bermuda insurers is Atlantic Hurricane, with average gross exposure between \$817.1 million for a “1-in-50” year event, up to almost \$1.5 billion for a “1-in-1,000” year event. This is an average figure with significant variation within firms. For example, at the 90th percentile of losses, there are firms with “1-in-50” year exposures above \$1.7 billion, while there are firms who exceed \$2.9 billion exposures for a “1-in-1,000” year event for the same peril. The BMA calculates the net-to-gross exposure ratio and presents some descriptive statistics in the following table.

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	50.3	51.5	53.8	55.7	57.6
Median	46.4	50.0	51.9	53.8	55.4

Source: BMA

The data shows that the purchasing of reinsurance becomes less pronounced at higher-risk layers. For example, the median insurer retains 46.4% of the gross exposure for “1-in-50” year events, while the median insurer retains 55.4% 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	817.1	984.8	1,196.4	1,351.8	1,506.1
NA Earthquake	520.4	696.4	913.0	1,053.0	1,182.3
European Windstorm	264.8	338.9	429.5	488.0	542.5
Japanese Earthquake	209.8	289.0	387.7	435.5	474.2
Japanese Typhoon	196.1	237.7	275.1	302.6	335.0

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	310.6	390.6	513.9	618.8	732.9
NA Earthquake	201.2	268.4	370.3	458.1	556.6
European Windstorm	121.4	149.1	185.9	211.6	241.6
Japanese Earthquake	97.2	131.3	176.2	199.3	219.7
Japanese Typhoon	87.2	104.0	121.1	133.8	148.6

Source: BMA

As mentioned before, the largest exposure across all return periods is Atlantic Hurricane, followed by NA Earthquake. The aggregate gross and net EP curves, which include all the catastrophic risks in an insurer’s portfolio, are also plotted.

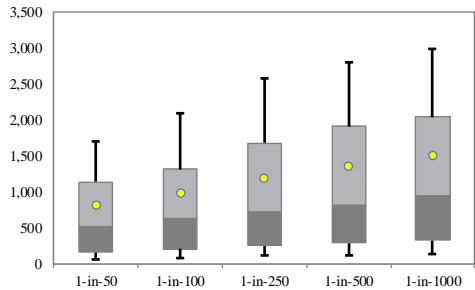
Table 5.4 - Average Exposure for All Perils (In US\$ Millions)

Return Period	1-in-50	1-in-100	1-in-250	1-in-500	1-in-1,000
Gross	1,035.4	1,210.8	1,425.1	1,587.2	1,749.8
Net	414.2	499.0	629.7	742.8	864.4

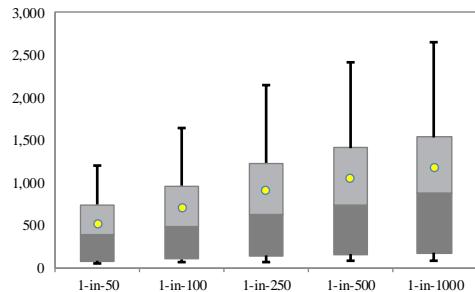
Source: BMA

Panel 5.2 - Gross EP Curves for Named Perils

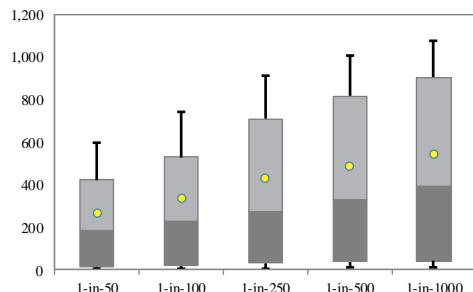
Atlantic Hurricane EP Curves, Gross Aggregate TVaR
(In US\$ Millions)



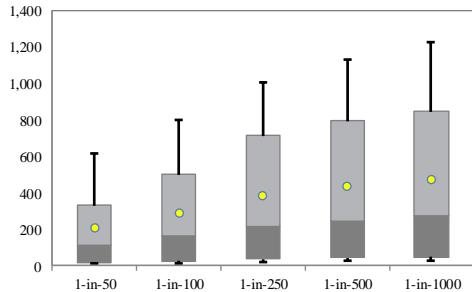
NA Earthquake EP Curves, Gross Aggregate TVaR
(In US\$ Millions)



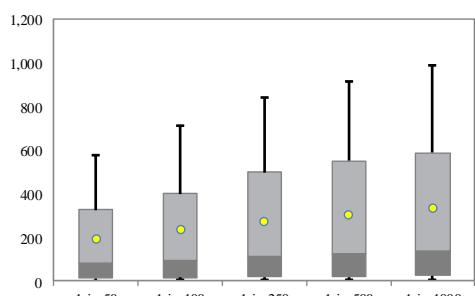
European Windstorm EP Curves, Gross Aggregate TVaR
(In US\$ Millions)



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



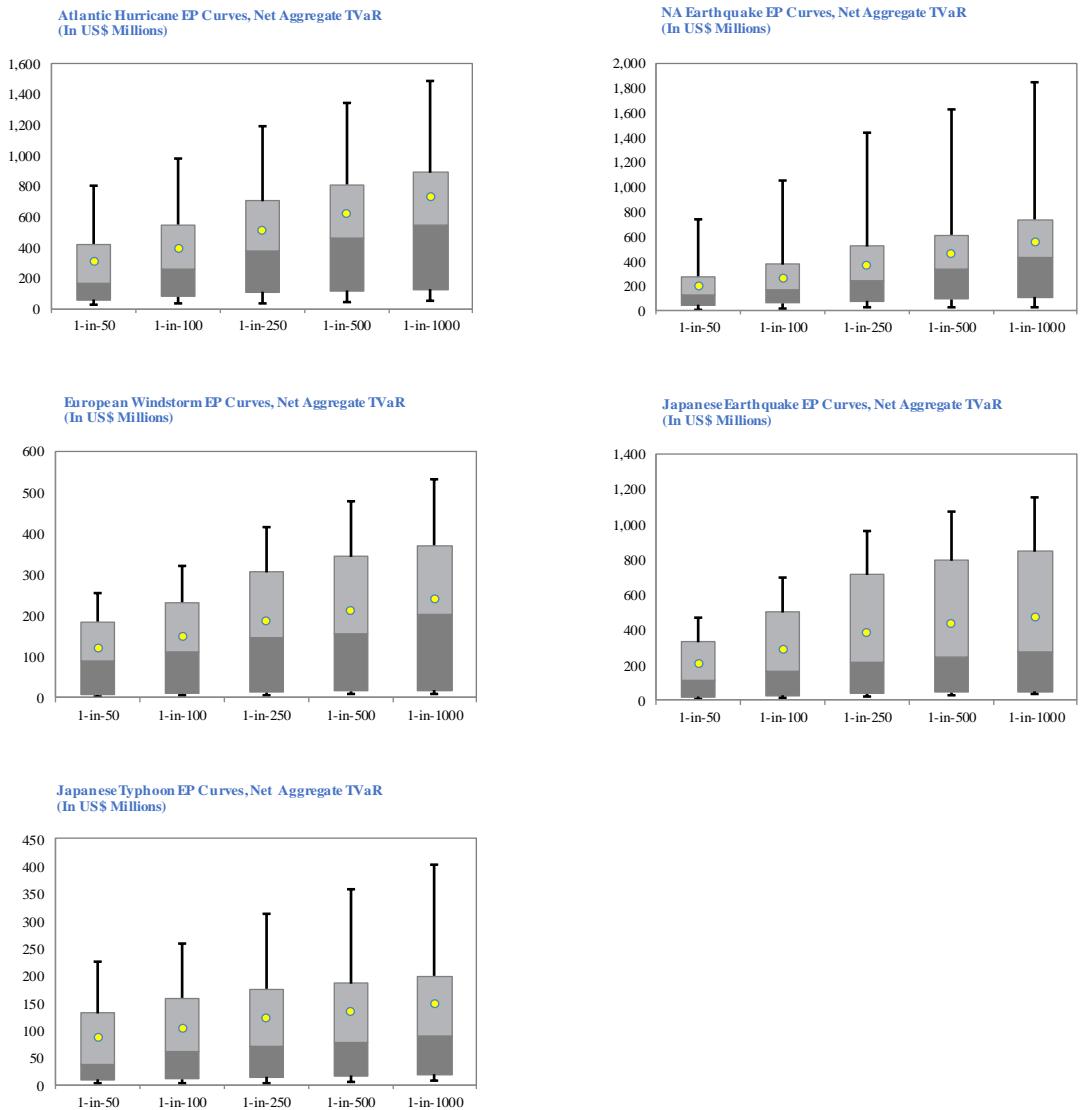
Japanese Typhoon EP Curves, Gross Aggregate TVaR
(In US\$ Millions)



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).

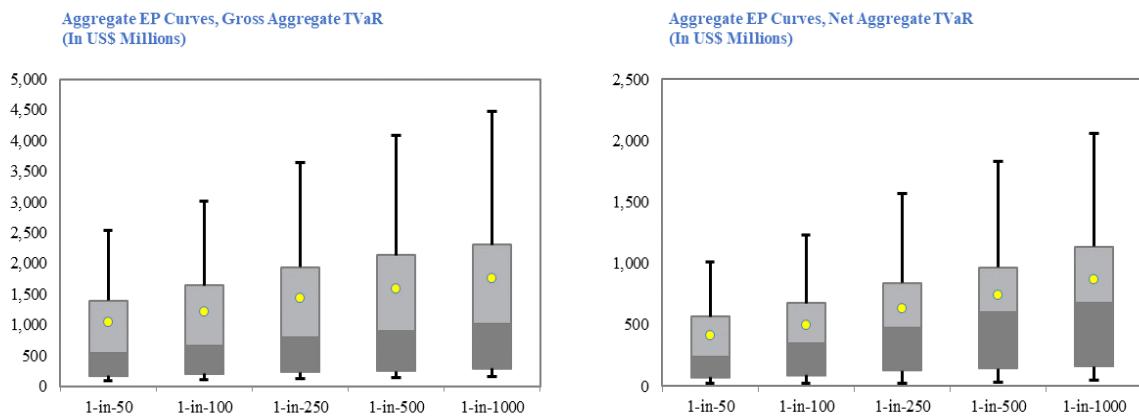
Panel 5.3 - Net EP Curves for Named Perils



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).

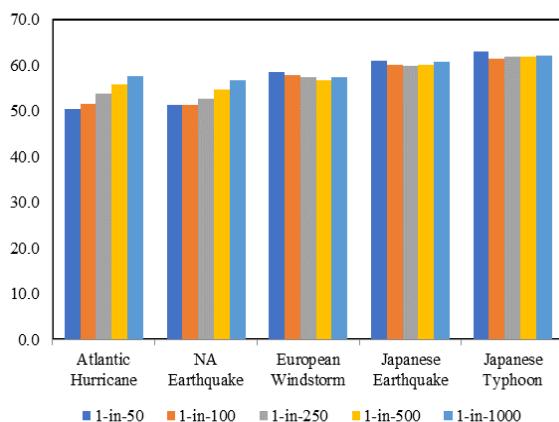
Panel 5.4 - Gross and Net Aggregate EP Curves for all Perils



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

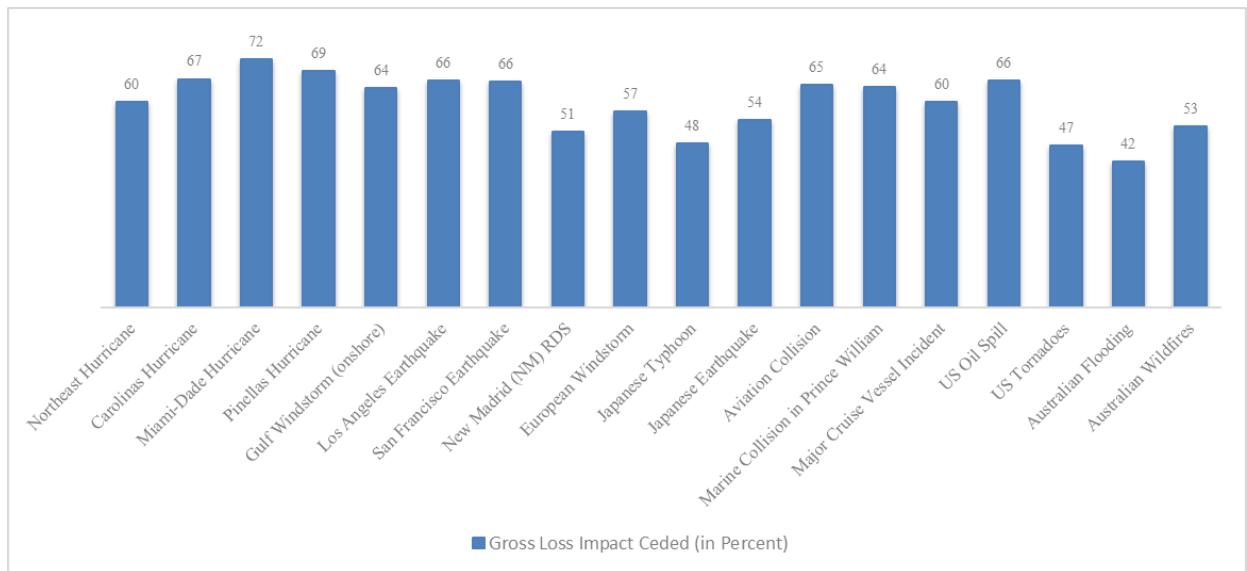
For Atlantic Hurricane, the ratio of net-to-gross exposure increases as the return period increases. The rarer the event, the more the insurer retains risk on average. This is true only for Atlantic Hurricane and NA Earthquake, while there is no monotonic relationship between retention and return periods for the other perils. Nevertheless, for the Japanese Typhoon, the average retention ratios are close for almost all return periods. Nonetheless, Atlantic Hurricane and NA Earthquake 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 peril¹⁰. Overall, observing the aggregate loss impact, the results demonstrate that the level of reliance on reinsurance has increased by about 7.1% compared to 2019 and varies across each peril (see Figure 6.1 below). Typically, perils that have the potential for the largest losses, such as Gulf Windstorm, Miami-Dade Hurricane, Pinellas Hurricane and San Francisco Earthquake, are heavily reinsured.

¹⁰ Bermuda is predominately a reinsurance-based international financial centre, thus, “insurers’ reliance on reinsurance”, for the purpose of this section, includes insurance and reinsurance undertakings that reinsurance their risks with other reinsurance undertakings (e.g., retrocession).

Figure 6.1 - Gross Loss Impact Ceded (In Percent)



Source: BMA

On average, insurers ceded about 58.6% of gross losses, which is a decrease of about 0.4% compared to 2019 (see Figure 6.2 below).

Figure 6.2 - Loss Impact Ceded

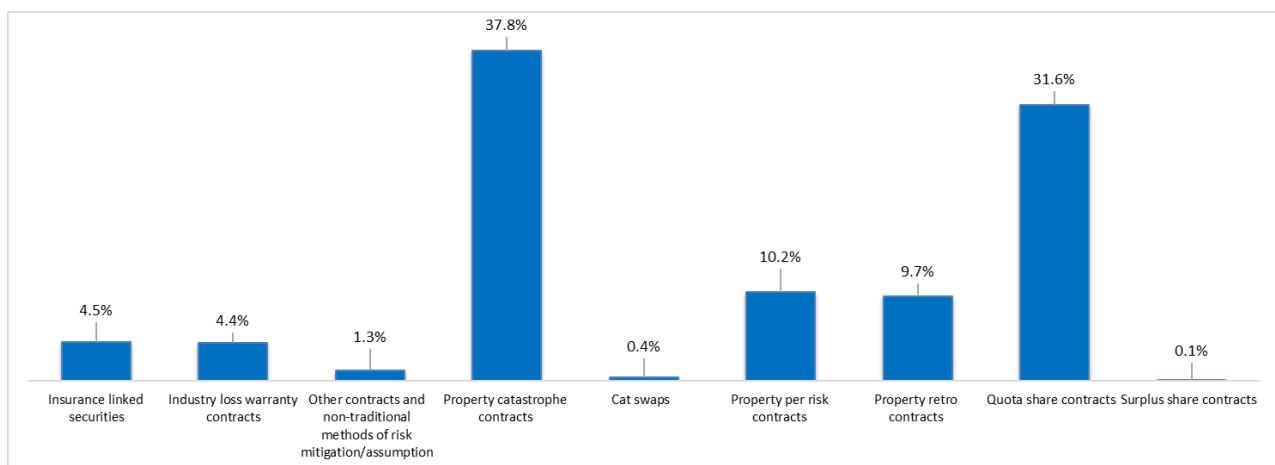


Source: BMA

Note: Boxplot includes the 25th and 75th percentiles (orange box 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 showed that Bermuda insurers use various reinsurance methods to cede a portion of their catastrophe exposure, including traditional property catastrophe contracts, quota share contracts, insurance-linked securities and industry loss warranties contracts, among others. Compared to 2019 the use of property Cat contracts has decreased by 3.2%, and the use of quota share contracts has increased by 4.4%.

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



Source: BMA

7. Cat Risk Underwriting Scenarios

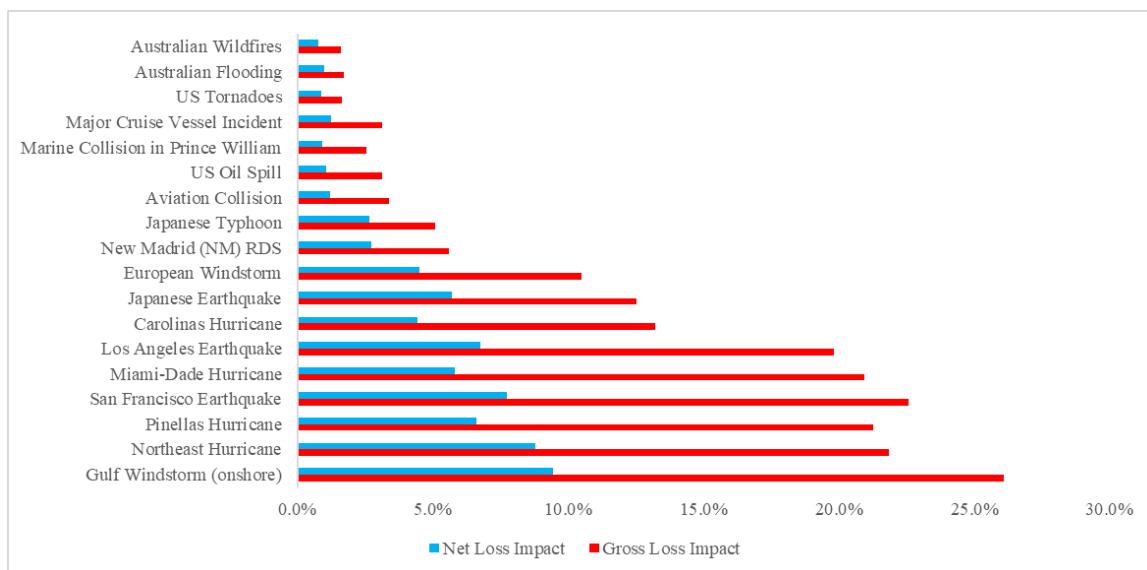
The Authority assesses Cat risk stress tests at three levels. First, using both the Lloyd's of London RDS and other scenarios designed internally by the Authority, each insurer is required to estimate its loss impact for 18 standardised Cat underwriting loss scenarios. Details on each underwriting loss scenario's key assumptions that insurers use as a guide to estimate their market share may be found on the BMA website (see the methodology section above). Second, the insurer is required to submit to the Authority three of its own highest underwriting loss scenarios if the 18 standardised RDS underwriting loss scenarios provided by the Authority do not fully align with the insurer's underwriting exposure. Third, the insurer is 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 2020 Cat underwriting loss scenario results showed that the Bermuda insurance market is resilient to potential Cat underwriting loss impacts arising from all major perils

underwritten¹¹, and it will still hold sufficient capital to settle policyholders' obligations and meet regulatory capital requirements. Out of the 18 standardised underwriting loss scenarios, Gulf Windstorm (onshore) had the largest potential adverse effect with an estimated gross loss impact¹² to statutory capital and surplus of 26.1% (and 9.4% net loss impact). This is followed by the San Francisco Earthquake, which could deplete 22.6% (and 7.7% net) of the market's total statutory capital and surplus¹³. Australian Wildfires had the least impact, with only 1.6% gross and 0.8% net impact on the statutory capital and surplus. The gross impact from each of the other perils ranges from 1.6% to 21.8%, with the majority of the perils (12) having a gross loss impact of less than 15.0% (see Figure 7.1 below).

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



Source: BMA

Even though the year-on-year ceded loss exposure increased, overall, the insurers have taken more exposure resulting in an increase in the net loss exposure compared to 2019. Nevertheless, year-on-year, the insurers aggregate statutory capital and surplus decreased by 10.4%¹⁴. The decrease in the statutory capital and surplus has effectively slightly increased the severity of both the gross and net impact to the insurers' balance sheet, with the Los Angeles Earthquake

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.

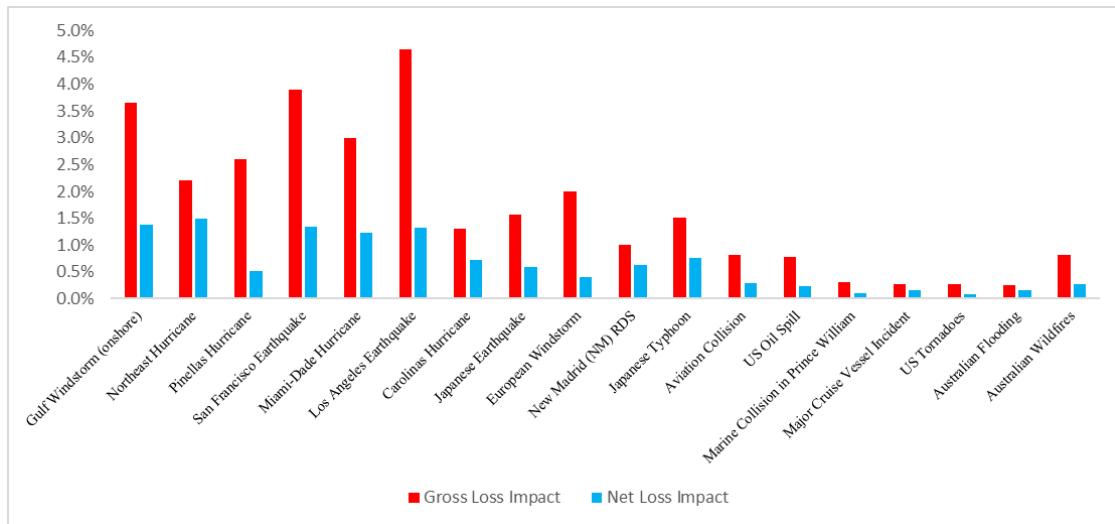
¹² Gross loss impact is before any reinsurance and/or other loss mitigation instruments.

¹³ Total capital and surplus includes 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).

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

having the highest year-on-year increase of 4.7% gross and 1.3% net loss impact. This was followed by San Francisco Earthquake and Gulf Windstorm that had a 3.9% and 3.6% gross increase (1.3% and 1.4% net), respectively. All the other perils' gross loss impact increased by an average of 1.2% (0.5% net) (see Figure 7.2 below).

Figure 7.2 – Year-on-Year (2019 and 2020) Gross and Net Loss Impact Change (In Percent)



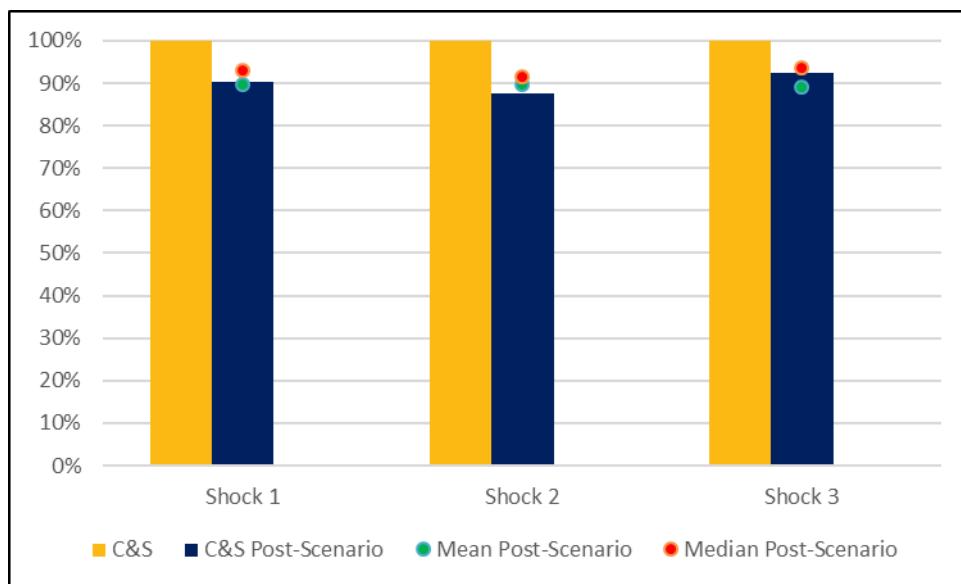
Source: BMA.

Other underwriting loss scenarios

Where the underwriting scenarios under ‘Cat Risk Underwriting Scenarios’ above either do not apply or partially apply to the insurer resulting in de minimis loss projections, the insurer is 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, would fall under this category.

For each of the three scenarios, insurers are required to include a detailed description of each scenario, including related key assumptions. The insurer must also 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 below shows the results from these scenarios.

Figure 7.3 - Capital and Surplus Post Other Underwriting Loss Scenarios



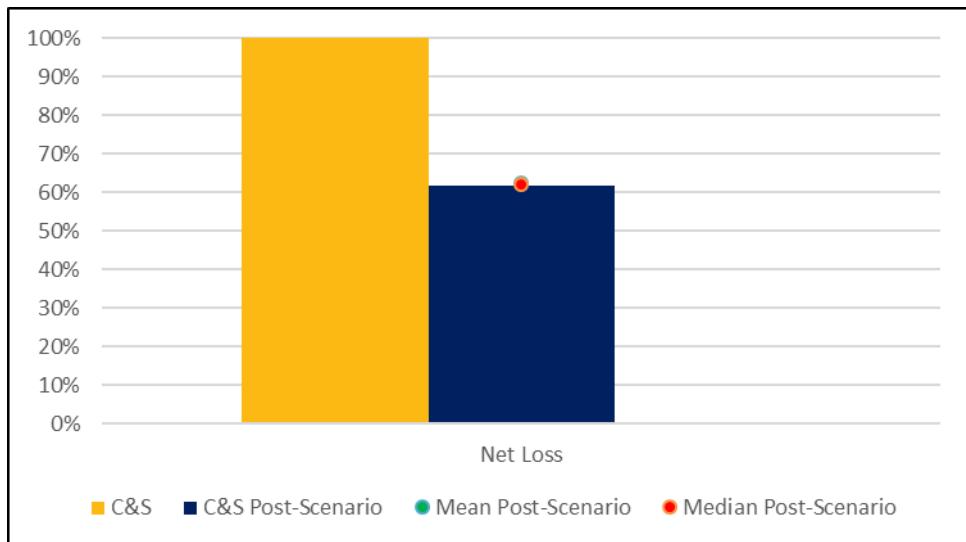
Source: BMA

As shown in Figure 7.3 above, insurers would comfortably withstand these scenarios, with the majority of insurers returning a significantly high percentage of their statutory capital and surplus after each of these scenarios. For these three scenarios, the average mean and median post-stress capital and surplus returned by the Bermuda insurers was 89.5% and 92.8%, respectively.

Insurer's own worst-case scenario

An insurer's own worst-case scenario presents a more severe impact, and this is generally the insurer's own most remote and extreme test. For this scenario, the net mean and median post-stress capital and surplus returned by Bermuda insurers were 62.3% and 62.4%, respectively (see Figure 7.4 below).

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



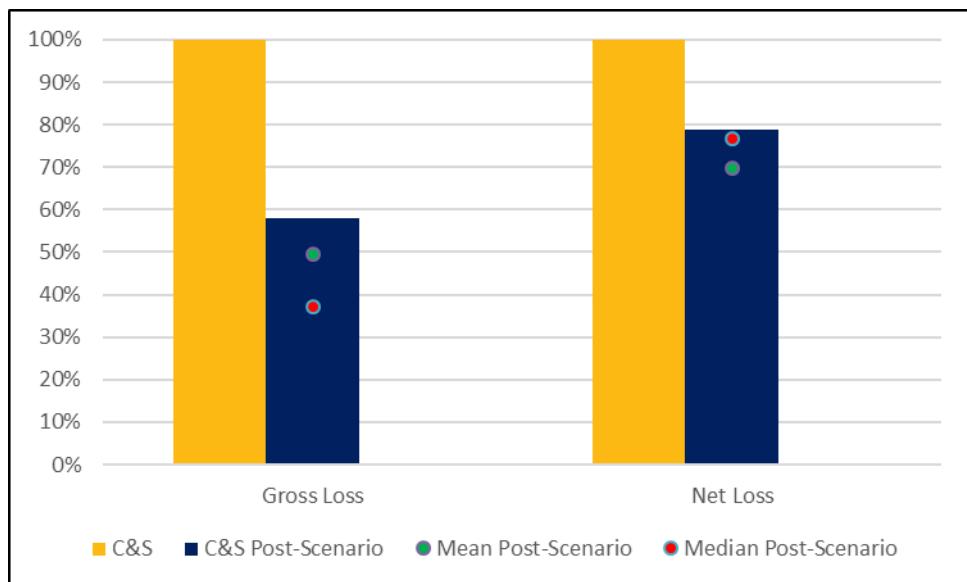
Source: BMA.

Loss simulations scenario

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

The result of a series of loss simulations or other analysis performed related to extreme tail events scenario shows that the mean and median capital and surplus post-gross loss impact will be low (i.e., 31.9% and 31.4%, respectively). Nevertheless, after factoring in the exposure ceded, the post-stress capital and surplus for the majority of insurers are significantly higher (i.e., mean of 70.6% and median 76.1%) (see Figure 11.2 below).

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



Source: BMA.

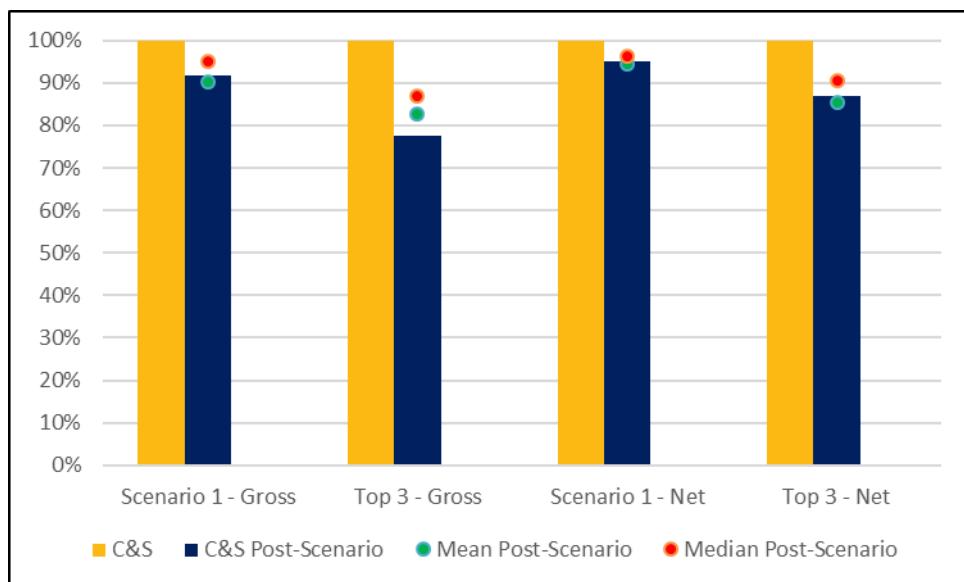
8. Terrorism, Cyber Risk and Mortgage Insurance Scenarios

Terrorism stress scenario

The Authority believes it is appropriate to consider terrorism exposure in both absolute terms and for realistic scenarios of loss. Thus, insurers are required 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 bomb¹⁵. The results from the test show that all entities would comfortably withstand their worst impact from this standardised scenario, retaining on average 91.6% of the statutory capital and surplus on a gross basis and 95.1% on a net basis. Additionally, the results showed that almost all of the insurers' balance sheets would comfortably withstand the impact from three of their largest terrorism exposures combined (i.e., insurers will retain, on average, 77.5% of the statutory capital and surplus on a gross basis and 86.9% on a net basis) (see Figure 8.1 below).

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

Figure 8.1 – Capital and Surplus Terrorism Stress Scenario



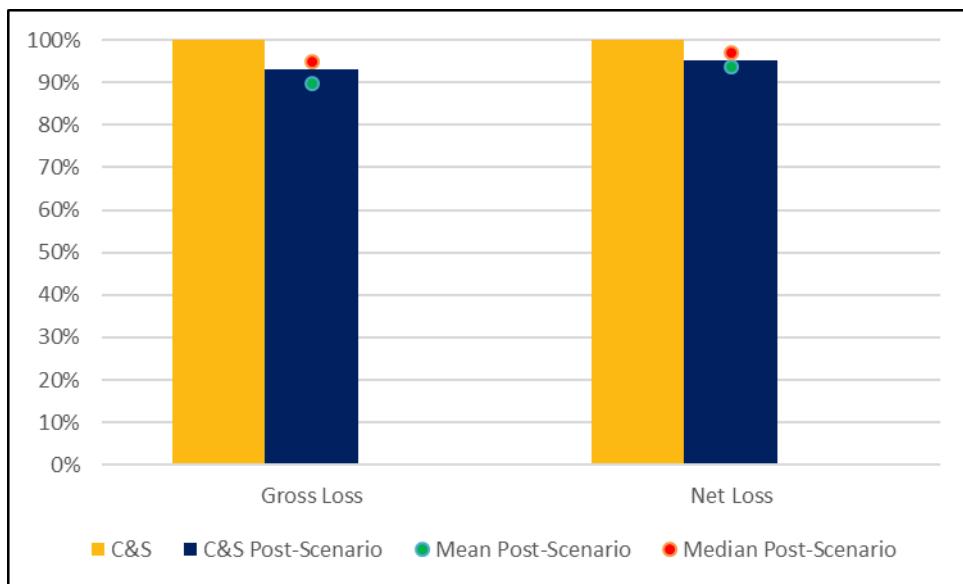
Source: BMA

Cyber stress scenario

Insurers are 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. Post the cyber risk stress; the mean and median statutory capitals are 89.9% (93.6% net) and 95.0% (97.0% net), respectively (see Figure 8.2 below¹⁶).

¹⁶ The BMA publishes a separate annual report of cyber underwriting risk.

Figure 8.2 - Capital and Surplus Cyber Stress Scenario



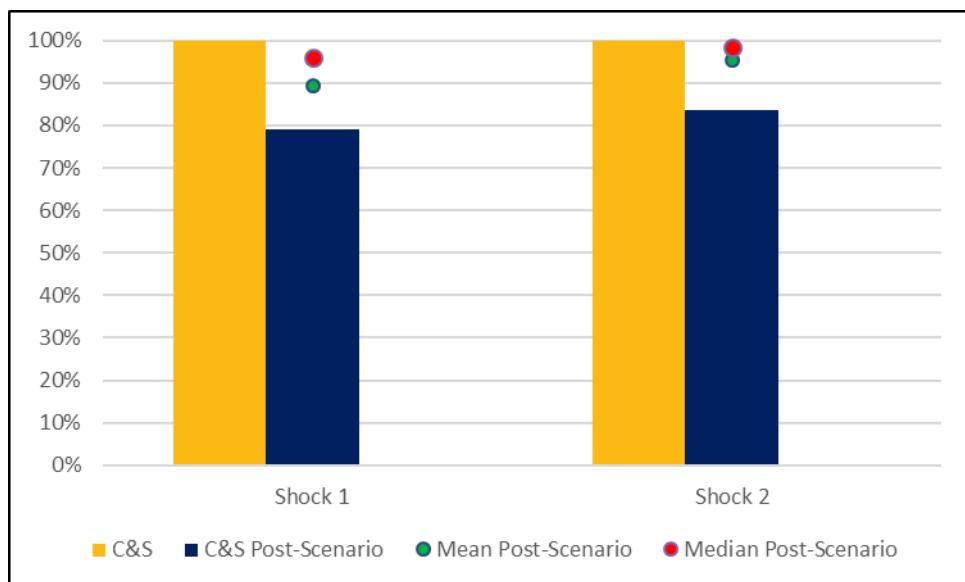
Source: BMA

Mortgage insurance scenario

Insurers that write mortgage business are required to shock their exposure for this business to different scenarios. In the first scenario (shock 1), insurers are required to increase the default rate to 9.47% (equivalent to approximately 99.5% TVaR) for their mortgage book and applied instantaneously. For the second scenario (shock 2), insurers are required to assume the default rate to be 5.5% (equivalent to approximately 90.0% TVaR) for their mortgage book and applied instantaneously.

Additionally, for both shocks 1 and 2, insurers holding agency Mortgage-Backed Security (MBS) and securities as investment assets subject to prepayment risk are 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 produces capital gains, the insurer is 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 below shows results from this scenario.

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 89.3% (shock 1), 86.1% (shock 2), 95.4% (shock 1) and 98.4% (shock 2), respectively.

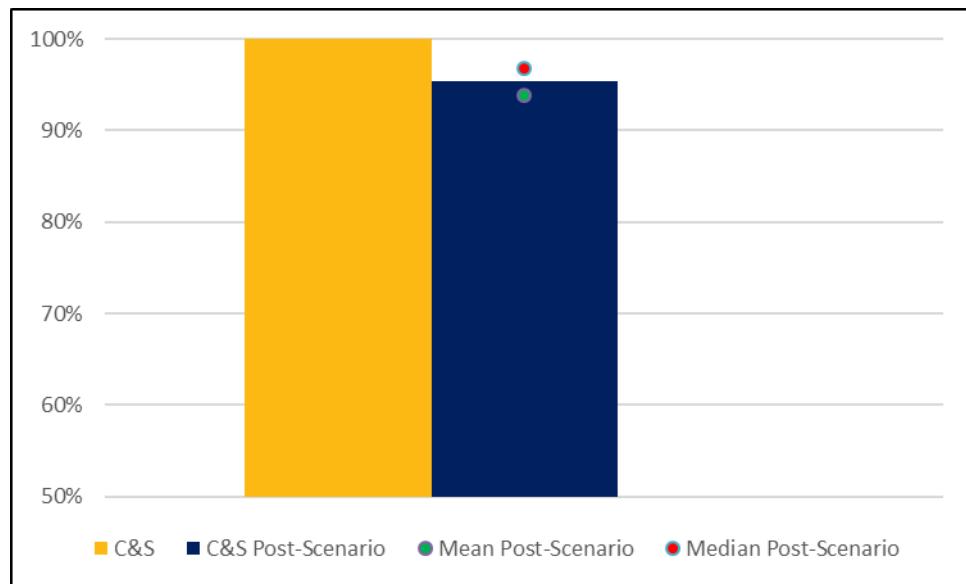
9. Liability Loss Accumulation Scenarios

The insurers are 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 are 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 Latent Liability test aims to cover a “mass tort” event. For example, following a court decision, a general and potentially legally enforceable opinion emerges that a specific product or substance causes observed or potential future adverse effects such as bodily injury, property damage or environmental damage. This is expected to lead, during the year and later, to claims on the product liability insurance of the producers, , followed by mass litigation against the companies distributing or having distributed, using or having used the product or substance. This leads to an accumulation of potentially worldwide claims on general commercial liability

and workers' compensation/employers liability insurance policies. The scenario above considers 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 incompleteness of available information and uncertainty of the subsequent development. Figure 9.1 below shows the results from this scenario.

Figure 9.1 - Capital and Surplus Latent Liability



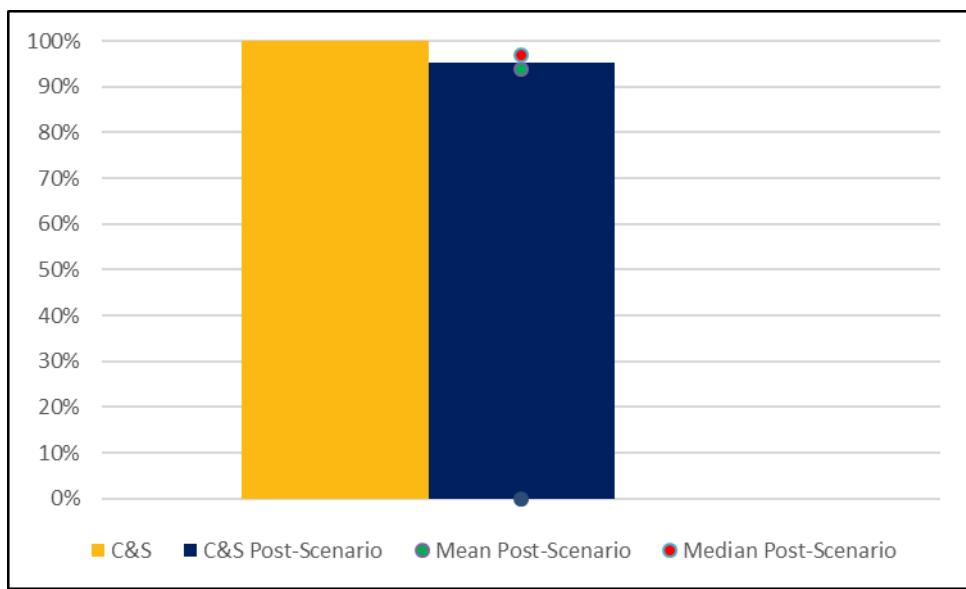
Source: BMA

The A&E scenario aims to reflect potential deterioration in existing US Asbestos, US Environmental and UK Asbestos reserves¹⁷. For the US A&E stress, the scenario takes into consideration potential under-reserving by referencing survival ratio¹⁸ market benchmarks, an increase in projected claims inflation and an increase in projected asbestos claims due to medical advances. For the UK asbestos stress, the scenario considers new claims arising beyond 2050, a deterioration in the projected number of claims up to 2050, an increase in projected claims due to medical advances and an increase in projected claims inflation. Figure 9.2 below shows the results from this scenario.

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 Deterioration in Existing US A&E and UK Asbestos



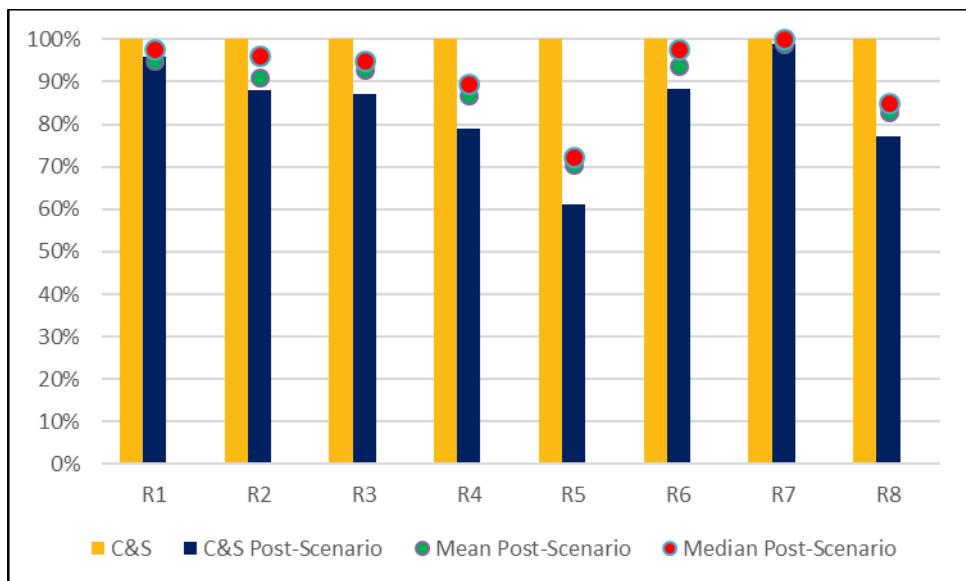
Source: BMA

10. Financial Market Scenarios

The financial market scenarios comprise capital market-related single factor shocks triggered by specific risk factors (equity returns, credit spreads and defaults). The calibration of these shocks is based on historical data about the evolution of interest rates, exchange rates and equity markets. Furthermore, in light of continued sovereign risk concerns and its implications on the investment performance of insurers, the financial market scenarios include 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, is required to quantify the impact on its statutory balance sheet from eight different financial market scenarios. Figure 10.1 below shows the capital and surplus post 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 40.0% 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 94.9% and 97.6%, 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 40.0%. For assets such as hedge funds with lockup periods, venture capital and real estate in illiquid markets, the (re)insurer should report whether sudden decreases in their value could entail inability for rapid sale and whether this effect has 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 91.1% and 96.3%, 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 curve¹⁹, provided by the Authority, for valuations of assets and liabilities. The result of

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

this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market were 92.8% and 95.0%, 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 is required to stress all positions, including available for sale and held to maturity. Structured finance products, asset-backed securities, agency and non-agency MBSs, must be included as well. If there is no rating for an asset, the (re)insurer must assume that the rating is 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 86.6% and 90.1%, respectively.

R5 (Combine R1 to R4) - is the most severe financial market scenario. It assumes a combination of a decrease of 40.0% of the value of equities in a portfolio (R1), a decrease in value of alternative investment and real estate (R2) by 40.0%, 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 would withstand this scenario, with the mean and median post-stress capital and surplus returned by the Bermuda insurance market being 69.9% and 74.1%, respectively.

R6 (Foreign currency shocks) - assumes an equal percentage, provided by the Authority²⁰, of depreciation and/or appreciation of foreign exchange positions in both 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 93.8% and 97.9%, 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 should be stressed. The haircuts are based on the realisation of a prolonged pan-European banking crisis in Europe, which will 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 99.0% and 99.9%, respectively.

R8 (Inflation and monetary policy risk) - simulates a scenario similar to the 1973 inflationary scenario. The insurer is required to apply each inflation scenario (e.g., low, medium, high,

²⁰ The scenario estimation horizon covers daily exchange rate movements from 2000 up 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.

severe)²¹ for three years, assuming no initial action to curb inflation from the US Federal Reserve. The insurer should also assume that the US Federal Reserve changes its stance and increases rates to maintain the current real interest rate in year four. Therefore, the insurer should 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 scenario. The result of this scenario shows that the mean and median post-stress capital and surplus returned by the Bermuda insurance market was 82.8% and 85.1%, respectively.

Additionally, insurers are required to submit a detailed qualitative disclosure of the impact upon both their statutory statement of income and liquidity positions of a ratings downgrade of their Bermuda legal entities or groups by two notches or below A-, whichever is lower. The disclosure should cover and provide an indication of the relative impact/severity of collateral requirements; loss payment triggers on in-force policy contracts; claw-backs; 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

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

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

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

Within the prudential filings, there are schedules that comprise the Cat risk-return. The Cat risk-return contains a questionnaire of qualitative information on the process of Cat risk modelling, including 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. Another source of validation is the stochastic scenario generator that has been developed in-house by the BMA. This model runs on a spreadsheet and performs Monte Carlo simulations on the balance sheets of individual insurers by shocking assets and liabilities and producing income statements which are used to estimate probabilities of insolvency and financial results based on different return periods.

Finally, the BMA prescribes a set of stress tests based on Lloyd's of London RDS that are reported in the prudential filings. The insurer has to show the capital position before and after the relevant RDSs, while the insurer should provide its own scenarios should the RDS be insufficient for the type of exposures of 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 Cat risk returns for information purposes of the market as well as for its macroprudential surveillance framework for the insurance sector.

Appendix II - Pricing Dynamics

The panel below shows the pricing dynamics across time of the Cat market based on aggregated data (only).

Panel 1. AAL, Risk and Pricing Ratios²²



Source: BMA staff calculations

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

The gross AAL increased between 2019 and 2020 and reached \$10.0 billion compared to \$8.4 billion in 2019. Net AAL reached \$5.2 billion in 2020 compared to \$4.5 billion in 2019.

Plots of the risk and pricing dynamics were drawn to show the Cat AAL to Cat premium ratios on both a gross and net premium basis in panel 1. The AAL largely represents the modelled

²² The Authority only uses modelled exposures and premium.

estimation of the expected Cat losses, and the gross premium includes provisions for profit and expenses. The relationship between these gross and net ratios indicates the amount of expenses, profit and other loadings charged to insured entities. The BMA observes that, on average, this ratio had been steadily decreasing up to 2017. For 2020, the gross ratio stands at 73.9%, while the net ratio stands at 58.6%.

The BMA also plots the ratio of Cat premium to Cat exposures, which can be seen in the second row of panel 5. For 2020, the ratio dropped further on a gross basis to 1.1%, while the ratio stood at 1.9% on a net basis.