BMA
BERMUDA MONETARY AUTHORITY

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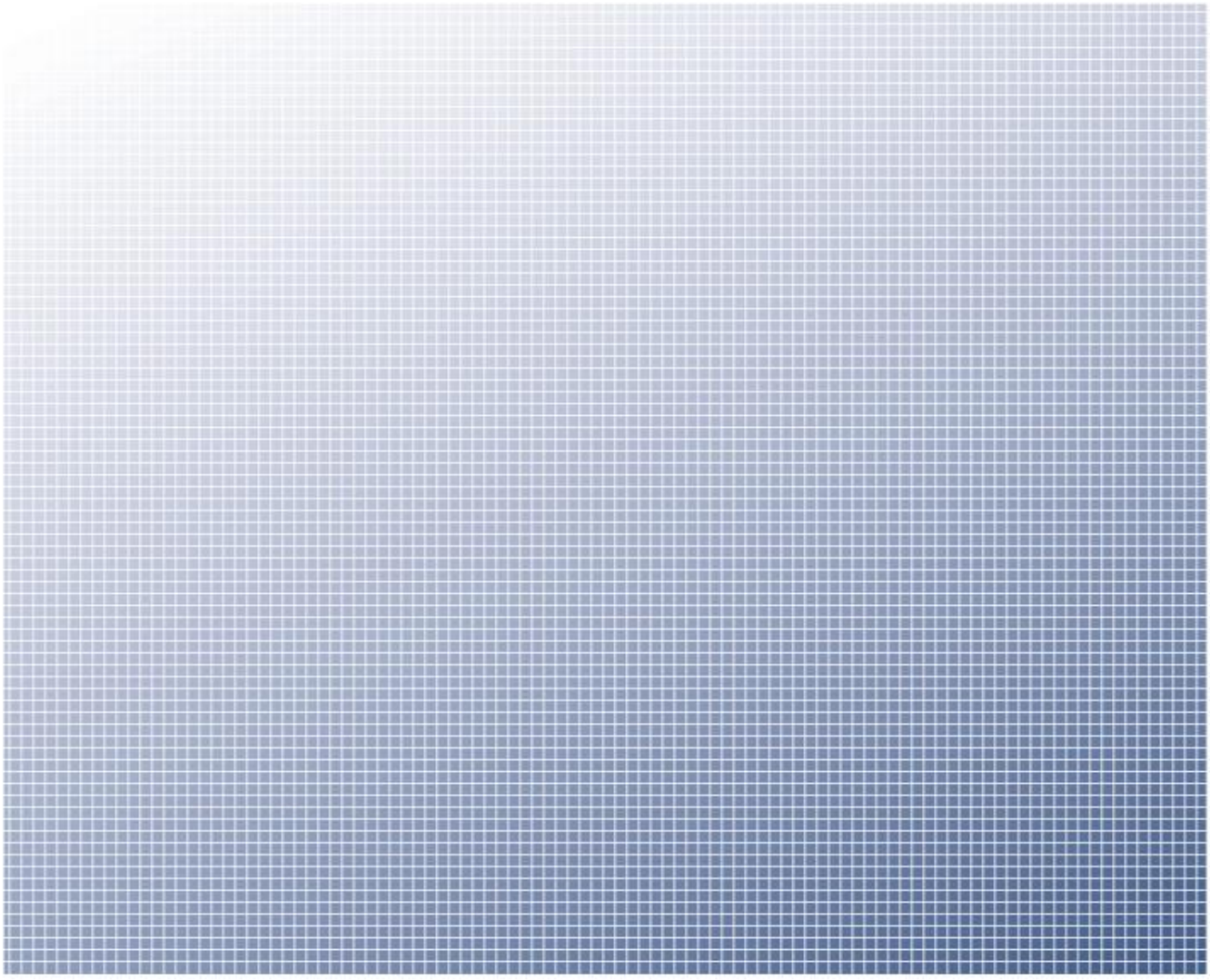
Bermuda Monetary Authority

Catastrophe Risk Modelling

2019 Report



Foreword

Bermuda is predominantly an insurance-based international financial centre, specialising in the niche of catastrophe reinsurance, including a broad range of other risks, and is host to one of the three largest reinsurance markets in the world.

With such a relatively high concentration of catastrophe risk in Bermuda's market, a broad understanding of catastrophe modelling practices in Bermuda is central to the Bermuda Monetary Authority's (Authority or BMA) supervisory framework. As insurers significantly rely upon internally built and external vendor models to assess catastrophe exposures, this information is also important to Bermuda insurers and other stakeholders and markets around the globe.

Realising the significant role that Bermuda plays as a leader in the regulation of the catastrophe market, and in an effort to continue to reemphasise our commitment to high standards of transparency, the Authority produces this report on an annual basis, to give a high-level overview of the catastrophe modelling practice in Bermuda.

Compared to 2018, the 2019 report found that modelling practices seem to be in a steady state, with variations in certain areas such as estimated loading factors. With respect to model usage, the Authority observed that mainly two external vendors are used, AIR Worldwide (AIR) and Risk Management Solutions (RMS). Bermuda insurers also develop their own in-house models in case external vendor models do not (sufficiently) cover specific risks/perils. Finally, the Authority observed variations in modelling practices between groups and legal entities.

Craig Swan
Deputy Chief Executive Officer

Modelling Practices Report

This is the first stand-alone annual Modelling Catastrophe Risk Report published by the Authority. In previous issues, this report formed a part of the annual Catastrophe Risk in Bermuda: BSCR Stress Testing and Modelling Practice Analysis Report. However, to allow for the better exposition of results, it was decided to have an independent report on catastrophe modelling practices. The content of this report is the result of analyses carried out by BMA staff. The report covers both insurers and reinsurers.

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 the detection and prevention of 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 and digital asset businesses. It also regulates the Bermuda Stock Exchange and the Credit Union.

BMA Contact Information

Bermuda Monetary Authority
BMA House
43 Victoria Street
Hamilton

P.O. Box 2447
Hamilton HMJX
Bermuda

Tel: (441) 295 5278
Fax: (441) 292 7471
E-mail: enquiries@bma.bm

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

ACRONYMS

AAL	Average Annual Loss
AIR	AIR Worldwide
AMO	Atlantic Multi-decadal Oscillation
BMA	Bermuda Monetary Authority
BSCR	Bermuda Solvency Capital Requirement
Cat	Catastrophe
Cat Return	Catastrophe Risk Return and Schedule of Risk Management
CSR	Capital and Solvency Return
EQECAT	Catastrophe Risk Management (CoreLogic)
EP	Exceedance Probability
IFC	International Financial Centre
Mph	Miles per hour
PML	Probable Maximum Loss
RMS	Risk Management Solutions
RDS	Realistic Disaster Scenarios
Authority	Bermuda Monetary Authority
SPI	Special Purpose Insurer
SST	Sea Surface Temperatures
TVaR	Tail Value at Risk

CONTENTS

1. EXECUTIVE SUMMARY

This report highlights the Catastrophe (Cat) modelling practices of Bermuda (re)insurers. (Re)insurers rely substantially on models to project losses and to assist them in capital and solvency calculations. The Authority, in its prudential supervisory work, tracks trends in the usage of models in order to form views and supervisory responses in the management of catastrophe risk.

In 2019, Bermuda legal entities' average loading factor in the accumulation process has dropped to 6.1% compared to 8.3% in 2018. For groups, the average loading factor stood at 5.5% in 2019 compared to 8.4% in 2018. For 2019, fewer legal entities have assumed the Atlantic Multi-decadal Oscillation (AMO) long-term view of exposure rather than the near-term view. For groups, the picture was more balanced with groups equally taking a long-term and near-term view.

AIR and RMS are the most frequently used modelling software (together or standalone), with RMS becoming the leading model for groups. In-house modelling[1] was utilised by 40.4% of legal entities and by 44.4% of groups in 2019. Additionally, 47.6% of legal entities and 43.8% of groups reported that they use more than one model in their accumulation process. Legal entities mostly use their models on a quarterly basis, with 44.7% of insurers doing so, while 44.4% of groups accumulate as frequently.

[1] An in-house model is a proprietary model built by an insurer.

2. INTRODUCTION

Bermuda's insurance sector is regulated and supervised by the Authority. As part of our regulatory and supervisory measures, the Authority requires all Class 3B and Class 4 insurers to submit a capital and solvency return, which includes a Catastrophe Risk Return and Schedule of Risk Management (Cat Return), as part of their annual statutory filing, detailing the insurers' Cat risk management practices.

The global insurance market and the Bermuda market, in particular, significantly rely upon vendor models to assess Cat exposures. If the vendor models underestimate potential losses arising from events, the industry as a whole may have capital levels impacted. Therefore, a comprehensive understanding of the modelling practices in Bermuda is a central aspect of the Authority's supervisory framework.

The report contributes to the understanding of Bermuda as an insurance-based International Financial Centre (IFC) and a leader in the regulation of the market for Cat (re)insurance. This report ultimately demonstrates the contribution of Bermuda to risk mitigation of natural Cats, and its contribution to global capacity for risk-taking, while also emphasising the commitment of the Authority to a high standard of transparency.

3. METHODOLOGY

The report was produced using aggregated and non-aggregated data from the Bermuda Capital and Solvency Return (CSR) filings of Class 3B, Class 4 legal entities and insurance groups for the period ending 31 December 2019[2]. Specifically, the following schedules from the CSR were used as data sources:

- Schedule X(e) – Cat Risk Return: Accumulations Overview
- Schedule X(f) – Cat Risk Return: Data Analysis

The exclusion of other insurer classes, such as Special Purpose Insurers (SPIs)[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 market[4], which is expected to be larger than what is presented in this report.

[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] SPIs are significant contributors to Cat risks underwritten in Bermuda with these details included in the BMA's annually published Alternative Capital Report.
[4] Bermuda insurance market includes the Bermuda reinsurance market.

It should also be noted, that having excluded the long-term (life) insurers, the report does not consider mortality catastrophic risk.

The analysis of the accumulation process is based on responses from insurers in the 2019 and previous years' CSR filings. The accumulation process provides insights into the relationship between the modelling process of insurers and the actual management of those risks from an operational point of view.

The analysis in this report was based purely on original CSR data input. No reference was made to other supporting documents separately required as part of the CSR filing. These additional documents are 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.

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% TVaR over a one-year time horizon.

Aggregate Statistics for Classes 3B and 4, 2019. (In US$ billions)

Net written premiums	**45.9**
Net earned premiums	44.6
Net income	11.3
Total claims	31.2
Total assets	244.3

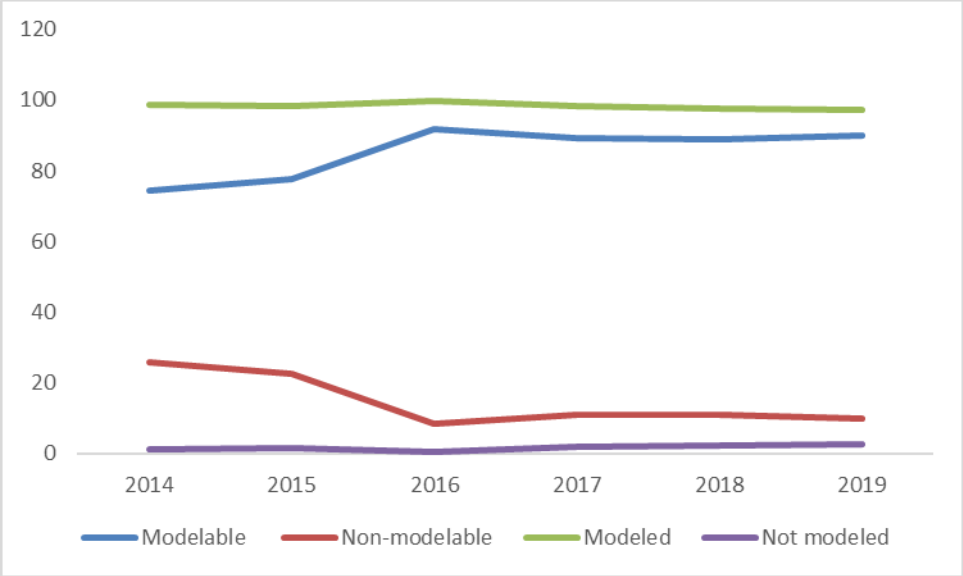
Source: BMA

4. PML AND ACCUMULATION PROCESS

The accumulation process is an important component of the modelling process and is an integral part of the insurer's risk management framework. In Bermuda, the accumulation of catastrophe risks is a multifaceted risk management process. Part of this accumulation process is the modelling practices of insurers. As part of the CSR filing, the Authority collects, on an annual basis, information about the accumulation process from the prudential filings of companies.

The 2019 CSR filing showed that 90% of the Cat risk exposure underwritten in Bermuda is modelable using vendor Cat models and that 97% of Cat risks were modelled. The percentage of both modelable and modelled exposure remained similar compared to 2018[5].[6].

Figure 1. Modelable and Modelled Exposure



Source: BMA staff calculations.

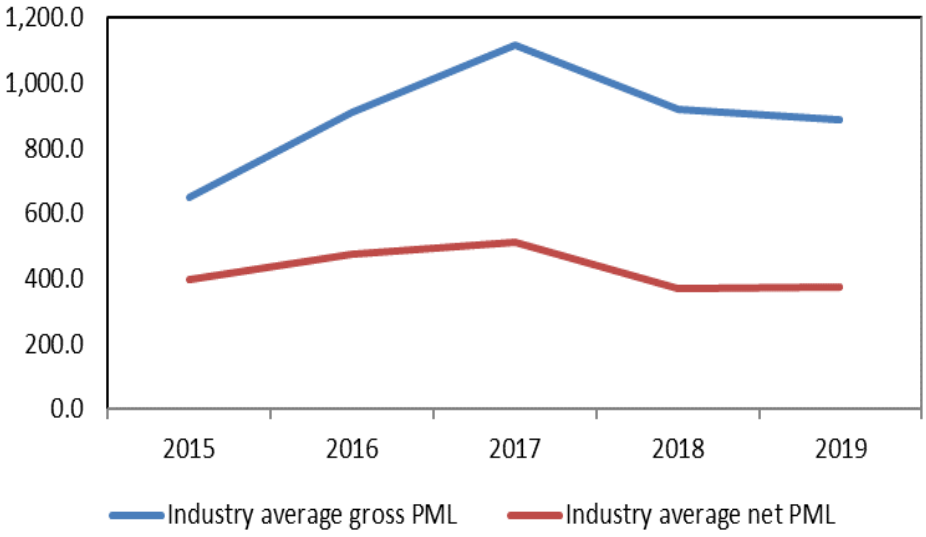
4.1 PMLS AND ACCUMULATION PROCESS - LEGAL ENTITIES

[5] Modelable exposure refers to the exposure that can be simulated through a vendor Cat model; Non-Modelable exposure refers to exposure that cannot be simulated through a vendor Cat model or where there are no Cat models that assess the risk of the region-peril under consideration; Modelled exposure refers to risks that the insurer modelled. Where exposures are not modelable through the use of vendor Cat models (i.e. Non-modelable exposure), insurers often use models developed in-house to evaluate risk. As such, very few exposures are "not modelled".

[6] Reasons for non-modelled risk may include data limitations that prevent the exposure from being run through a vendor (or in-house) Cat model. This may be due to: 1) lack of resolution of the data or lack of completeness of the data, which render the data insufficient to produce credible modelling results; 2) model deficiency, where the model is deemed to be inadequate to produce credible results; and/or 3) there is no accessible model to assess the peril under consideration.

This section presents aggregated results from the statutory filings of insurers for the year 2019. Bermuda Class 3B and 4 insurers are required to file the catastrophe risk schedule, which is a questionnaire addressing modelling practices. The catastrophe risk schedule also includes quantitative information about catastrophe exposures. With respect to quantitative metrics, Bermuda insurers report metrics on the Average Annual Loss (AAL), PML and factor loadings. The latest data is provided in the following figures and tables. The PML is defined as the 99.0% TVaR on an aggregate basis.

Figure 2. Gross and Net Average Industry PML (In US$ millions)



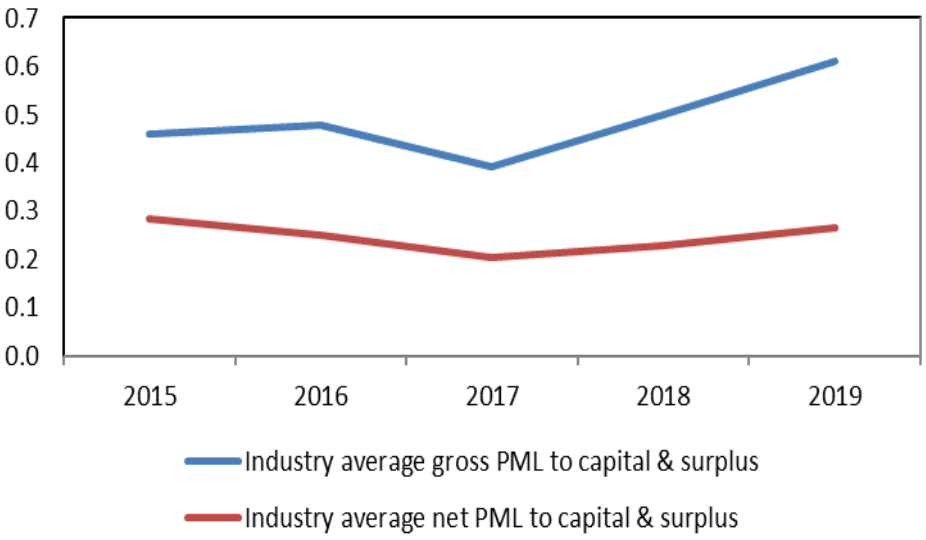
Source: BMA staff calculations.

Table 1. PML (In US$ millions)

	2019	2018	2017	2016	2015
Industry average gross PML	888.4	918.7	1,118.0	910.0	648.9
Industry average net PML	372.0	369.6	509.8	476.2	398.1

Source: BMA

Figure 3. Gross and Net Industry PML to Capital and Surplus (In percent)



Source: BMA staff calculations.

Table 2. PML Ratios (In percent)

	2019	2018	2017	2016	2015
Industry average gross PML to capital and surplus	61.1	49.9	39.3	47.7	46.1
Industry average net PML to capital and surplus	26.6	22.8	20.3	24.9	28.3

Source: BMA.sample removes certain outliers that distort the ratios.

Table 1 represents the average PML for legal entities in dollar amounts. The PML for 2019 experienced a decrease on a gross and an increase on a net basis.

Table 2 presents ratios of the gross and net PML to capital and surplus. This ratio expresses whether the available capital and surplus can withstand a loss equal to 99.0% TVaR. On a gross basis, in 2019, a 99.0% TVaR aggregate loss was expected to consume 61.1% of available capital and surplus. This ratio has been increasing since 2017. On a net basis, this ratio exhibits a similar pattern with the past years, at 26.6%.

Table 3 presents the loading factors that are used as add-ons to the output of catastrophe modelling. These factors compensate for model error as well as increased conservatism in the modelling process, and they are applied to the PML. For example, if the Cat model yields a PML of US$100, a 5.0% factor would raise the PML to U$105.

Table 3. Loading Factors[7] (In percent)

	2019	2018	2017	2016	2015
Average loading factor	6.1	8.3	6.7	5.4	5.9

Source: BMA

In 2019 the average loading factor reached 6.1%, representing a decrease compared to 2018. One should be cautious about the interpretation of the factor since vendor models over time strive to become more accurate while also becoming more conservative, thus reducing the need for higher safety buffers.

The loading factor is estimated using variations of either an analytical portfolio approach where insurers analyse the total output of the model and back-test the results according to the total loss experience; or insurers will take a per risk view and blend the experience of single lines of business into the total portfolio PML. The responses can be found in table 4.

Table 4. Loading Factor Estimation Methods (In percent of respondents)

	2019	2018	2017	2016	2015
Determined analytically	44.7	42.1	36.4	29.6	20.4
Estimated	55.3	57.9	63.6	70.4	80.0

Source: BMA

In 2019, 55.3% of insurers estimated the loading factor while 44.7% determined it analytically through modelling.

Another interesting modelling practice is the usage of AMO. AMO refers to the alteration of Sea Surface Temperatures (SST) in the Northern Atlantic from cool to warm phases. These phases last for several years. Since the mid-1990s, a warm phase has existed. A correlation has been observed between warm SSTs and more frequent severe hurricanes and other destructive weather phenomena. Bermuda insurers responded as to whether they consider loadings for this risk factor on near-term or long-term views.

[7] The loadings reflect the cumulative loading regardless of the level applied (i.e. within the accumulation process or post the accumulation process/applied to the PML). The same applies for legal entities and groups.

Table 5. AMO Factor Consideration (In percent of respondents)

	2019	2018	2017	2016	2015
Near-term frequency	63.0	65.9	61.5	74.3	89.5
Long-term frequency	37.0	34.1	38.5	25.7	10.5

Source: BMA

In 2019, 63.0% of insurers utilised the near-term AMO factor for their modelling of Atlantic hurricane exposures, while 37.0% utilised the long-term factor. The AMO factor relates to trends in hurricane frequencies taken into account in modelling Atlantic hurricane exposures, and the financial losses that stem from hurricane activity. Near-term frequency and long-term frequency estimations have been converging and this explains the fact that more insurers are using the long-term view.

Part of the questionnaire asks about the vendors that insurers use. This gives an indication of whether insurers are forming their modelling opinions on one or multiple models. This also allows identification of the more prevalent Cat model vendors in the market. In addition, the questionnaire asks how frequently insurers perform portfolio modelling (or 'accumulations', in BMA jargon), and whether insurers develop their own models apart from vendor models. The next table summarises the responses.

Table 6. Vendor Model Usage and Licensing (In percent of respondents)

Model Usage	**2019**	**2018**	**2017**	**2016**	**2015**
AIR only	21.4	24.4	18.9	12.5	9.1
EQECAT only	0.0	0.0	0.0	0.0	0.0
RMS only	31.0	31.7	40.5	40.6	39.4
AIR and RMS	47.6	43.9	40.5	43.8	45.5
AIR and EQECAT	0.0	0.0	0.0	0.0	0.0
EQECAT and RMS	0.0	0.0	0.0	0.0	0.0
AIR, EQECAT and RMS	0.0	0.0	0.0	3.1	6.1
Model Licensing	**2019**	**2018**	**2017**	**2016**	**2015**
AIR only	15.2	20.0	17.5	13.9	7.7
EQECAT only	0.0	0.0	0.0	0.0	0.0
RMS only	21.7	24.4	27.5	25.0	17.9
AIR and RMS	63.0	55.6	55.0	58.3	66.7
AIR and EQECAT	0.0	0.0	0.0	0.0	0.0
EQECAT and RMS	0.0	0.0	0.0	0.0	0.0
AIR, EQECAT and RMS	0.0	0.0	0.0	2.8	7.7

Source: BMA

RMS seems to be the most commonly used standalone model. Moreover, the use of three models in tandem seems to be the exception, with EQECAT receiving no share of use since 2016. Additionally, it appears that no single insurer has used all three models since 2016 to perform their accumulations.

Table 7. Model Frequency Usage (In percent of respondents)

	2019	2018	2017	2016	2015
Ad-hoc	0.0	2.2	0.0	0.0	0.0
Annual	2.1	2.2	2.4	0.0	0.0
Semi-annual	6.4	2.2	2.4	0.0	0.0
Quarterly	44.7	44.4	54.8	52.6	43.9
Monthly	23.4	24.4	19.0	26.3	24.4
Weekly	0.0	0.0	2.4	2.6	2.4
Daily	14.9	15.6	14.3	13.2	22.0
Real time	8.5	8.9	4.8	5.3	7.3

Source: BMA

Insurers use and update Cat modelling in fixed periods, usually quarterly and monthly. Each quarter, either renewals or supervisory reporting are the most common reasons to run the catastrophe models, with 44.7% of insurers reporting quarterly use in 2019, up from 44.4% in 2018. Real-time use has slightly dropped to 8.5% of insurers in 2019, compared to 8.9% in 2018.

Table 8. Model Frequency and Business Units Differences (In percent of respondents)

	2019	2018	2017	2016	2015
Yes	40.9	37.8	30.0	39.5	36.6
No	59.1	62.2	70.0	60.5	63.4

Source: BMA

Insurers were asked whether different business units use Cat models at different frequencies. In 2019, 59.1% of respondents said that they do not perform accumulations at different frequencies while this percentage was 62.2% in 2018.

Table 9. Internal Model Usage (In percent of respondents)

	2019	2018	2017	2016	2015
Yes	40.4	33.3	33.3	34.2	39.0
No	59.6	66.7	66.7	65.8	61.0

Source: BMA

In 2019, insurers developed internal catastrophe models at a similar level to 2015, which had seen a dip between 2016 and 2018. In 2019, 40.4% of insurers developed their own stochastic model. Insurers with very specialised lines of business outside the cover of traditional vendors are more likely to develop such in-house models to capture their unique risks.

We also asked insurers how their Cat risk modelling reflects their reinsurance and retrocessional purchases. The responses are shown in Table 10.

Table 10. External Reinsurance Model Usage (In percentage of respondents)

	2019	2018	2017	2016	2015
The company has minimal Cat exposure protection and, as such, gross is effectively net	6.5	6.7	20.0	10.5	12.2
The accumulations are calculated on a gross basis with reinsurance protections calculated approximately outside of the system	4.3	4.4	0.0	2.6	0.0
The accumulations are calculated on a gross basis with reinsurance protections calculated explicitly outside of the system	2.2	2.2	5.0	5.3	7.3
The accumulations are calculated on a gross basis with the effect of reinsurance protections calculated explicitly for some types of protection within the system	32.6	40.0	30.0	31.6	26.8
The accumulations are calculated on a gross basis with the effect of reinsurance protections calculated explicitly for each type of protection within the system	54.3	46.7	45.0	50.0	53.7

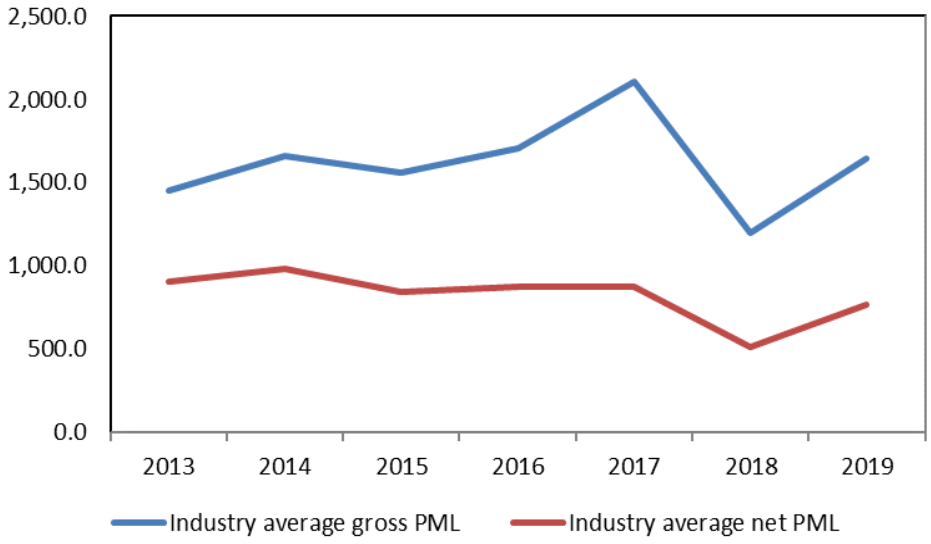
Source: BMA

We observe that the number of insurers that purchase little or no external Cat reinsurance has dropped from 20.0% of respondents in 2017 to 6.5% of respondents in 2019. The vast majority of insurers model Cat risk by taking into account explicitly external reinsurance either for some types or for each treaty separately. In 2019, 86.9% of respondents consider explicitly either some external reinsurance or all reinsurance treaties in their Cat modelling. In 2019, only 6.5% of respondents do not consider directly external reinsurance in their modelling practices, compared to 6.6% in 2018.

4.2 PMLS AND ACCUMULATION PROCESS - INSURANCE GROUPS

The same data for legal entities is also collected from insurance groups.

Figure 4. Gross and Net Average Industry PML (In US$ millions)



Source: BMA staff calculations

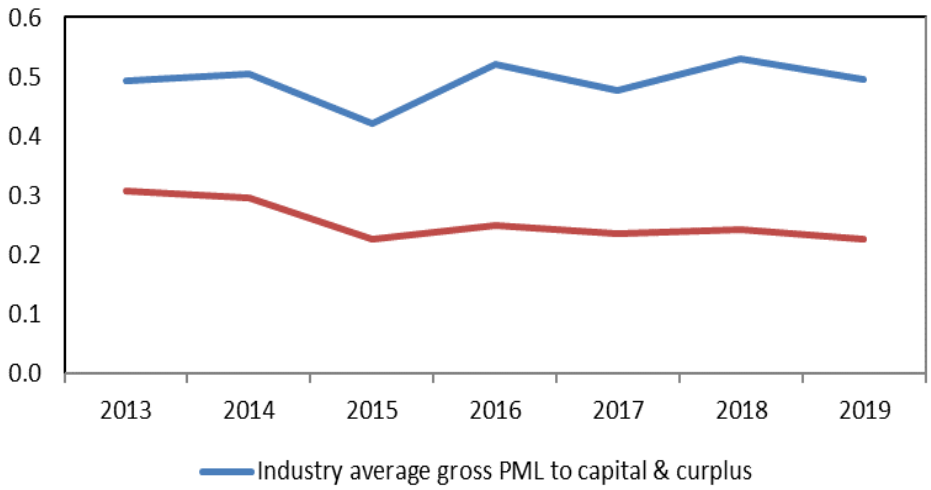
Table 11. PML (In US$ millions)

	2019	2018	2017	2016	2015
Industry average gross PML	1,643.5	1,193.9	2,105.5	1,705.7	1,563.0
Industry average net PML	768.1	513.5	873.9	870.2	842.9

Source: BMA

We observe an increase both in gross and net exposures, and an attenuation of the gross exposure by extensive reliance on reinsurance.

Figure 5. Gross and Net Industry PML to Capital and Surplus (In percent)



Source: BMA staff calculations

Table 12. PML Ratios (In percent)

	2019	2018	2017	2016	2015
Industry average gross PML to capital and surplus	49.6	53.0	47.8	52.0	42.0
Industry average net PML to capital and surplus	22.7	24.2	23.6	25.0	22.6

Source: BMA

As in the case of legal entities, the BMA reports the average loading factors for groups in Table 13.

Table 13. Loading Factors (In percent)

	2019	2018	2017	2016	2015
Average loading factor	5.5	8.4	8.3	6.8	7.6

Source: BMA

The loading factor for groups has dropped for 2019 compared to 2018. In 2019, the average loading factor was 5.5%. Again, changes in the loading factor, especially downwards, do not necessarily imply less conservatism but the fact that models are incorporating additional assumptions, reducing the need for externally imposed assumptions. The increased use of internal models, noted previously, also makes it less likely to adjust a vendor model, given that the internal model carries the insurer's view of the appropriate risk calculation.

Table 14 shows how groups estimate loading factors, either estimated or analytically determined.

Table 14. Loading Factor Estimation Methods (In percentage of respondents)

	2019	2018	2017	2016	2015
Determined analytically	40.0	33.3	33.3	35.7	40.0
Estimated	60.0	66.7	66.7	64.3	60.0

Source: BMA

In 2019, 60.0% of groups estimated their factors non-analytically by relying on expert judgement.

Table 15. AMO Factor Consideration (In percent of respondents)

	2019	2018	2017	2016	2015
Near-term frequency	50.0	53.3	52.9	58.8	64.7
Long-term frequency	50.0	46.7	47.1	41.2	35.3

Source: BMA

In 2019, 50.0% of groups used near-term frequency of the AMO compared to 53.3% in 2018. Model results are converging based on either near-term or long-term frequency of the AMO factor. Thus, insurers use both the near-term and long-term view equally.

Table 16 displays the statistics on the model vendor licensing and usage for Bermuda groups.

Table 16. Vendor Model Usage (In percentage of respondents)

Model Usage	**2019**	**2018**	**2017**	**2016**	**2015**
AIR only	18.8	30.8	12.5	18.8	6.3
EQECAT only	0.0	0.0	0.0	0.0	0.0
RMS only	37.5	23.1	37.5	31.3	37.5
AIR and RMS	43.8	46.2	50.0	43.8	56.3
AIR and EQECAT	0.0	0.0	0.0	0.0	0.0
EQECAT and RMS	0.0	0.0	0.0	0.0	0.0
AIR, EQECAT and RMS	0.0	0.0	0.0	6.3	0.0
Model Licensing	**2019**	**2018**	**2017**	**2016**	**2015**
AIR only	6.3	15.4	11.1	16.7	5.9
EQECAT only	0.0	0.0	0.0	0.0	0.0
RMS only	25.0	23.1	22.2	16.7	17.6
AIR and RMS	68.8	61.5	66.7	61.1	70.6
AIR and EQECAT	0.0	0.0	0.0	0.0	0.0
EQECAT and RMS	0.0	0.0	0.0	0.0	0.0
AIR, EQECAT and RMS	0.0	0.0	0.0	5.6	5.9

Source: BMA

In groups, RMS usage is now taking the largest share either standalone or in combination with other models. Again, the market is concentrated between two vendors.

Table 17. Model Frequency Usage (In percent of respondents)

	2019	2018	2017	2016	2015
Ad-hoc	0.0	6.7	0.0	0.0	0.0
Annual	5.6	6.7	5.6	5.6	5.9
Semi-annual	11.1	6.7	5.6	5.6	5.9
Quarterly	44.4	53.3	55.6	44.4	35.3
Monthly	22.2	13.3	16.7	27.8	35.3
Weekly	0.0	0.0	0.0	0.0	0.0
Daily	16.7	13.3	11.0	11.1	11.8
Real time	0.0	0.0	5.6	5.6	5.9

Source: BMA

Accumulation frequency follows similar patterns for groups and legal entities as well. Most groups perform accumulations quarterly, as 44.4% of respondents did in 2019 compared to 53.3% in 2018. Annual accumulations continue to be performed by some groups, with 5.6% of respondents doing so in 2019.

Table 18. Model Frequency and Business Units Differences (In percentage of respondents)

	2019	2018	2017	2016	2015
Yes	50.0	61.5	64.7	64.7	52.9
No	50.0	38.5	35.3	35.3	47.1

Source: BMA

When it comes to whether different business units employ different frequencies of accumulations, the picture is more evenly split for groups compared to legal entities. Exactly half of groups have frequency differences compared to 40.9% of legal entities. The diversity of the groups is much more pronounced than legal entities, and it is expected that groups will employ different modelling practices across their entities. The BMA also surveyed groups on the use of internal models.

Table 19. Internal Model Usage (In percentage of respondents)

	2019	2018	2017	2016	2015
Yes	44.4	46.7	44.4	44.4	47.1
No	55.6	53.3	55.6	55.6	52.9

Source: BMA

As of 2019, 55.6% of groups do not use internally developed models, while 44.4% do. A similar picture is evident for legal entities.

Table 20. External Reinsurance Model Usage (In percentage of respondents)

	2019	2018	2017	2016	2015
The company has minimal Cat exposure protection and, as such, gross is effectively net	5.6	6.7	6.3	0.0	0.0
The accumulations are calculated on a gross basis with reinsurance protections calculated approximately outside of the system	5.6	0.0	0.0	0.0	0.0
The accumulations are calculated on a gross basis with reinsurance protections calculated explicitly outside of the system	0.0	6.7	0.0	5.6	5.9
The accumulations are calculated on a gross basis with the effect of reinsurance protections calculated explicitly for some types of protection within the system	27.8	20.0	31.3	22.2	29.4
The accumulations are calculated on a gross basis with the effect of reinsurance protections calculated explicitly for each type of protection within the system	61.1	66.7	62.5	72.2	64.7

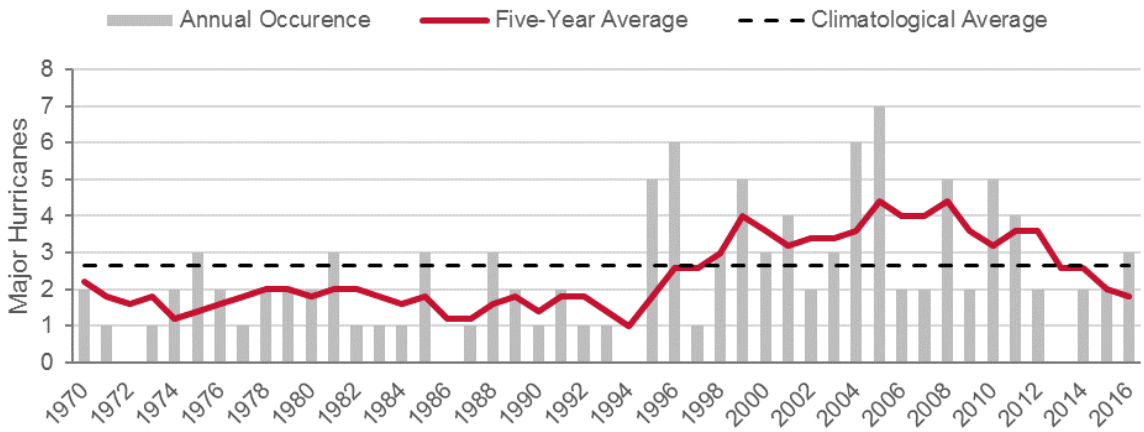
Source: BMA

On the group level, models are used for their outward reinsurance treaties. In 2019, 5.6% of groups did not have external reinsurance treaties due to minimal Cat exposure. In terms of the percentage modelling explicitly for all treaties within the Cat model, it was 61.1% for groups compared to 54.3% for legal entities.

APPENDIX I - AMO

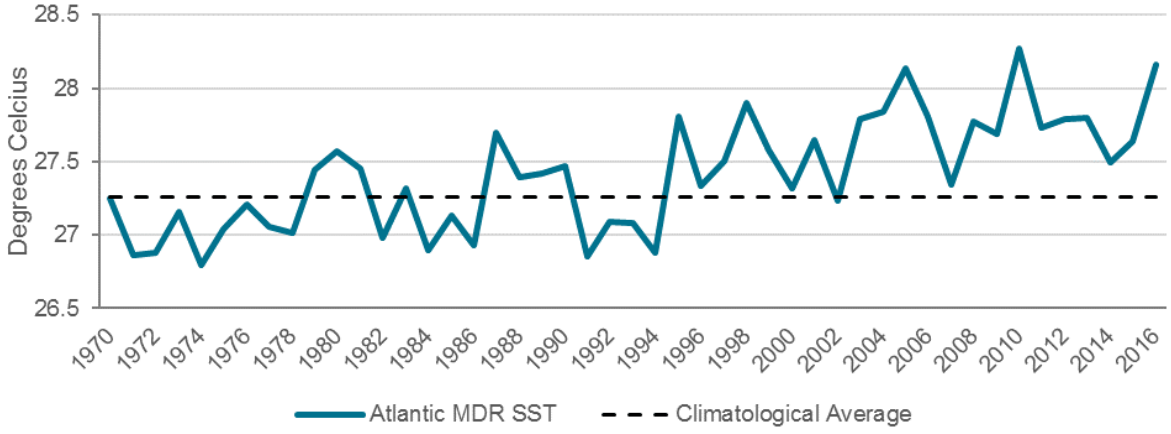
The AMO is a switch in many catastrophe risk models and is used as a predictor of future hurricane activity. As a predictor, it uses SST in order to estimate hurricane activities since warm water is one of the fuels of a hurricane. In past years, SSTs have been rising but the last four-year trend shows that the number of hurricanes is declining. This is shown in figures 6 and 7.

Figure 6. Number of Hurricanes



Source: RMS

Figure 7. Sea Surface Temperature



Source: RMS

Assuming a four to five year near-term trend, catastrophe models would show that the number of hurricanes is expected to decline, while a longer-term view over the past 20 years could indicate that this is a temporary phenomenon. According to RMS, for the first time since its introduction, the RMS Medium-Term Rate forecast (MTRof) has dipped slightly below the long-term rate. For the US as a whole, the new 2017-2021 medium-term rate forecast MTRof hurricane landfall frequency is now 1.0% below the long-term rate for Category 1–5 storms,

and 6.0% for major hurricanes (Category 3–5 storms). Therefore, for conservatism, more companies are switching to the long-term view.