USING EARTHQUAKE CATASTROPHE MODELS FOR REINSURANCE PRICING: CURRENT APPROACHES, CHALLENGES AND BENEFITS FROM CATATROPHE MODEL EVALUATIONS

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Abstract: *Every year, thousands of insurance companies around the world are transferring catastrophe risk to reinsurance companies and other third parties in order to manage their risk against natural disasters. Each reinsurance company has to come up with adequate catastrophe costing in order to sufficiently price the risk underwritten, account for risk accumulation and align with solvency requirements. For earthquakes, as for other perils, the companies can license and use catastrophe models, developed for evaluating the risk and potential losses for the insured portfolios of assets. But unlike other perils, which are by nature more frequent, there is usually no or little history of earthquake losses for the insured portfolios. Therefore, connecting cat model results to loss experience and coming up with a price is not straightforward. At the same time, the contract prices can also be driven by external factors, such as the (insurance) market conditions or even more general financial trends. Expert knowledge about the natural hazards and vulnerabilities and market experience are necessary skills, due to the large uncertainties involved in the risk estimations and the complexities of the market respectively. This study outlines briefly the current pricing approaches used for earthquake risk management within the reinsurance industry and aims to highlight, through some case studies, the challenges and the large benefit from detailed model evaluations.*

Introduction

Natural disasters have the potential for severe financial loss to individuals, commercial activity and governmental institutions. One possible way of protection against natural hazard economic impact is insurance coverage. Depending on the country, the availability of insurance solutions for protection against seismic risk may differ significantly. In Europe, earthquake coverage is – with a few exceptions – sold on a voluntary basis. Insurance coverage against earthquake risk can be bought on the market as a stand-alone policy, or as an extension to a base policy, generally a fire or household insurance. This coverage may be offered by private insurance companies or through public insurance schemes, or some combination of both. Notable are the mandatory government schemes such as the Turkish Catastrophe Insurance Pool (TCIP) and the Pool Against Natural Disasters (PAID) in Romania, which both were set up with standalone products sold by private companies but managed centrally. Considering the level of seismicity in many European countries, the insurance penetration for Earthquake coverage is very low. In Italy for instance, only 1% of the residential sector is believed to be insured against earthquakes.

As major earthquakes and other event losses can become a significant financial burden to an insurance company, insurance companies need to manage their risk depending on the risk appetite and the solvency requirements (Solvency II, EU 2009). One way of risk transfer, is transfer from the insurer to one or several reinsurance companies. This is usually done via a treaty, on which reinsurance companies can participate with different shares. In everyday business, reinsurance companies need to develop an adequate premium for such a treaty that allows them to compete with other reinsurance companies in the market and that also allows for sufficient profit. In addition, adequate pricing is also relevant to the reinsurers risk management and capital requirement.

For the regions with the most significant earthquake exposure a common tool for risk assessment are the probabilistic seismic risk models (either internal or vendor models). The available tools for

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seismic risk assessment can vary, depending on the significance of the insured exposure and the seismicity of the region. Vendor models have started developing after Hurricane Andrew and Northridge Earthquake in the beginning of 90s and at first, they were very USA focused. Until today, the US models have a high level of detail and are very developed since the US insurance sector is a big part of the global total. Earthquake models exist for North and South America, Europe and Asia Pacific and almost all the earthquake prone countries with insured assets. While the list of available models is long, there is definitely a big diversity regarding the quality and uncertainty of these models. Therefore, a good understanding around the models is required in order to make the best use of their outcome.

The output of catastrophe models are loss curves expressing the estimated losses as a function of return periods, i.e. the expected losses, at any given exceedance probability. Since the reinsurance contracts have (mostly) an annual duration, an annual expected loss must be calculated, either for the entire spectrum of probabilities/return periods or for the distinct layers of the CatXL treaties (In the case of earthquake coverage, the risk is most often ceded via non-proportional, excess of loss treaties (CatXL) and less often with proportional, quota share treaties).

Case study: pricing of treaties with EQ coverage in Greece

An example of an earthquake loss assessment for a cedant, calculated with two different cat models is shown in Figure1 (losses scaled for data protection). The suggested layers for the reinsurance program are indicated in the figure. By calculating the annual expected loss for every suggested layer, the reinsurer has to come up with an adequate annual premium to cover this program. The main reinsurance participants in the program may quote their estimated premium price and then a negotiation around the price is initiated with the cedants (represented directly or via brokers). The reinsurance participants with smaller shares are often not given the chance to quote a price but only provided the final terms and are asked if they agree or not to participate in the program. All the reinsurance participants need to make informed decisions for each program and also carry out their portfolio assessments and accumulation of risks to assess their risk levels with all their programs.

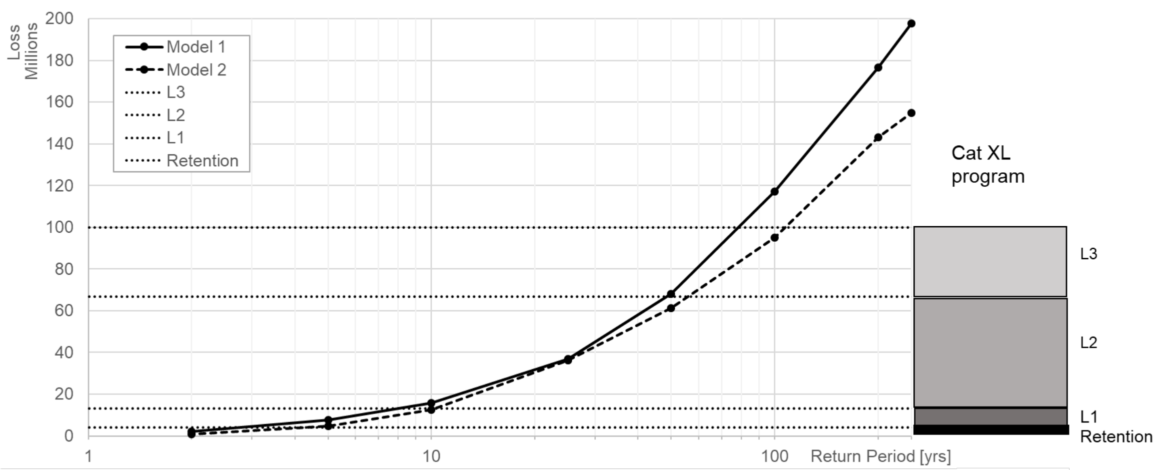

Figure 1. Loss estimates (scaled values) by two vendor models and indicated retention and layers for the Cat XL program for a cedant with EQ exposure in Greece.

In this section we are sharing the loss assessment carried out with two vendor earthquake models for two cedants with exposure in Greece. The curves shown in Figure 2 (top) are the OEP (occurrence exceedance probability) loss ratios (of the net losses divided by the total insured value) as a function of the return periods. According to Model 1, the two cedants have very similar loss ratios across the entire range of return periods (also demonstrated in Figure 2, bottom right). On the other hand, Model 2 estimates the losses to be much lower for both cedants (compared to the Model 1 estimates) and also the two cedants to have significant differences in their loss performance according to Model 2. If we were to compare the two models (Figure 2, bottom left), we can see that the model comparison is different for the two cedants. For both cedants and almost for the entire range of return periods, model 2 is lower than model 1. The difference is more pronounced for cedant 2 and in general more evident in the high frequency range.

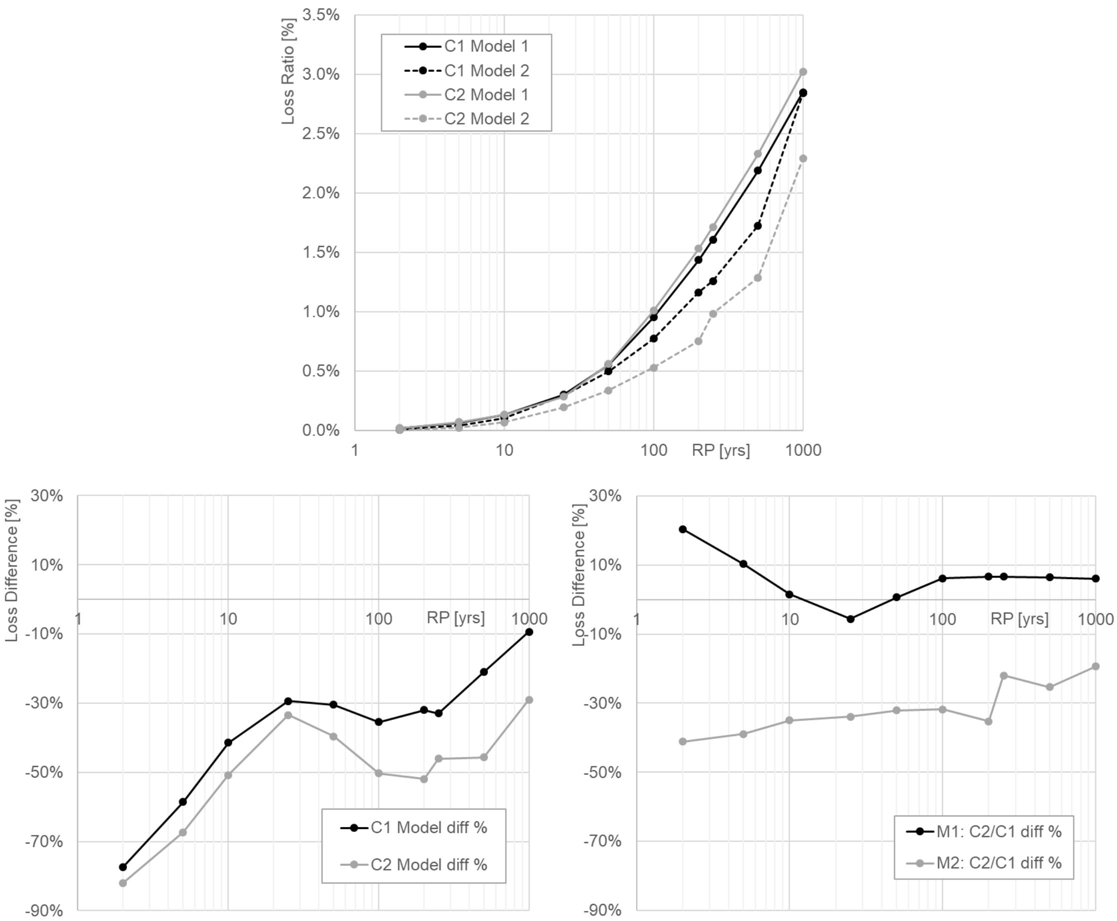

Figure 2. Loss ratio comparison for two Greek cedants, estimates with two different vendor models (Top), loss estimate difference between the two models (Bottom left) and cedant loss ratio difference according to the two models (Bottom right).

It is very difficult to understand where these differences are attributed to without a more detailed evaluation of the components of the two models. With quantifying the differences of the two models in their hazard and vulnerability modules, we can understand which assumptions have led to these differences in the output and make an informed decision regarding which model we would like to trust more than the other and how to proceed forward with the necessary pricing for the modelled exposure.

In order to quantify the impact of using different models to pricing, we can calculate the relation between the provided annual premium, the layer structure and the annual loss estimates per layer and express it as return periods. For example, if a cat layer has a premium of 1 million and a limit of 10 million, to be profitable, 10 years without an event should pass. We can repeat the calculation with the expected losses for each layer (as calculated with cat models). The layer limit divided by the expected annual loss will give us the return period without a loss in the layer, necessary for the program to be profitable. If the RP calculated by the model is longer than the RP according to the premium, then the program is profitable. We carried out the above calculation with the loss estimates and layer structure for the two case-study cedants. In Figure 3, we can see the RP per layer, according to the premium and the two models, for Cedant 1 (left) and Cedant 2 (right). In case of Cedant 1, the models suggest that for Layer 1 and 2, there will be more losses than collected premium and only for Layer 3, the program can be profitable for the reinsurer. For Cedant 2, a contradicting picture is shown between the models. According to Model 1, the program is only profitable for the top layer. Model 2 though has a contradicting view, that all layers are profitable with only exception layer 1, with marginally non-profitable contribution. If we followed the model output blindly we will result to opposite decisions for Cedant 2, just depending on which model we are using.

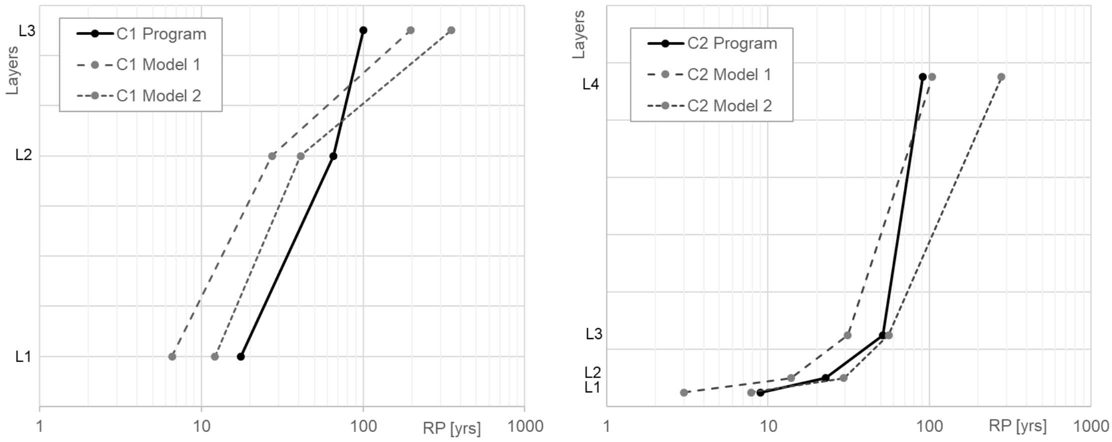

Figure 3. Comparison of modelled expected annual losses and proposed premium for Cedant 1(left) and Cedant 2 (right)

The comparisons of the two model estimates show how different the model outputs can be and how their differences are reflected in the pricing. Lastly, the model estimates may look unrealistic compared to loss history. For example, for Cedant 1 (as shown in Figure 1), the models suggest that the reinsurance program is triggered every 3 or 4 years (with Model 1 or 2 respectively). In reality, there was not a loss exceeding the program retention since the 1999 Athens Earthquake. Therefore, the model estimates for the low return periods may be deemed unrealistic and a modification may be necessary when forming the final view of risk for the treaty.

Challenges in earthquake risk pricing

As we have seen in the case study, the challenges in seismic risk pricing stem from the challenges in its quantification, but also other independent factors as the general market trends. Among the most common challenges are the lack of (reliable) models and/or lack of loss history. preventing from having a link between the actual portfolio performance and the modelled performance. In the case of earthquake models, usually, while models can provide loss estimates for buildings, contents and business interruption, in many cases, they may be lacking secondary effect models, such as tsunami models, earthquake induced landslides, liquefaction etc. With the lack of model components and in many regions, due to the rare nature of the phenomenon, lack of loss history, a detailed model evaluation to assess its components (hazard, vulnerability and financial module) can add value to the procedure and provide a better idea for its adequacy for the particular portfolio. After all, catastrophe models are developed to represent the industry-like portfolios and if an insurance company is an outlier in terms of portfolio distribution, it needs to be acknowledged and accounted for during pricing. The users of models must understand the model capabilities, assumptions and limitations and be able to communicate them to non-expert groups, who may not understand the science behind the models but still need to use their outputs. For example, the official pricing requirements may only be looking at certain loss metrics (e.g. AAL and 200-year return period loss estimates) but the uncertainty of these metrics must be communicated and eventually accounted for. A good understanding of the market conditions and the client specific setting is obviously beneficial in all cases. The right expertise should be sought within the analytical and underwriting teams, in order to ensure the most adequate pricing.

Regarding the independent market conditions that also have an impact in pricing, we can mention that the reinsurance market is facing a low-rate cycle in all lines of business for the last few years. In the past, the market used to react after big catastrophic events, with significant increase in the rates (higher premiums). This was not the case after the 2017 major hurricane losses (Harvey, Irma, Maria) that devastated the U.S.A. and caused high losses to both the insurance and reinsurance industry. This unprecedented low cycle is continuing and causing pressure to all the insurance companies to reduce costs and have more precise risk assessment and management.

Epilogue

The purpose of catastrophe models remains the same since their inception and it is to quantify the risk of natural disasters (and more recently also man-made perils), in order to enable its transfer and management by various insurance vehicles. The models themselves have seen a big evolution since their first creation, almost three decades ago. They have become in many cases a lot more sophisticated and potent. Therefore, a deep understanding around their capabilities, limitations and uncertainty is a prerequisite for adequate use. Insurance and reinsurance companies need to come up with risk estimates based on these model outputs that are of crucial importance for their success. Another good development we are experiencing is the shift from black-box models towards more transparent solutions, where the model providers are willing to share more information and data behind their assumptions and model components and work together with clients to combine their knowledge and eventually come up with better solutions. As the need for transparency and more tailored solutions has become more obvious, new, smaller model providers and consultants have grown to provide alternative solutions and tailored products. In the past, the model infrastructure and the IT behind the model platforms, prevented the user company from being able to use multiple solutions and models from different providers. Nowadays we are shifting towards more cloud solutions without the need of local installations and even more promising, the development of open source platforms (OASIS LMF) where smaller model developers can use to facilitate their models. Additionally, more open source data and models are becoming publicly available, such as the products from GEM Foundation (), that can are great resources for independent model validation. Being able to see multiple models, choose the most adequate or even adjust the model components based on own insights, are generally a huge step forward. There is definitely enough momentum to expect further positive evolutions in the future.

With all the faced challenges and the changes expected in the future, there is a clear need for bridges between the different disciplines involved in catastrophe risk management. Natural scientists and engineers are necessary to combine their expertise with underwriters, actuaries, data scientists and programmers. It is worth investing in connecting all the knowledge pieces between the different functions in the industry and combining scientific knowledge, technological literacy and a good market understanding in order to aim united for the development and evolution of robust and holistic solutions for risk management and eventually a good foundation for risk mitigation against earthquakes and all other disasters.

Of course, the seismic risk mitigation does not finish at the insurance or reinsurance industry assessments. Seismic risk remains a big issue for insured, insurable and uninsurable exposures, human activity and above all human lives. Its quantification is the first step to its mitigation. It is very important to succeed calculating risk but more important to succeed in teaching seismic risk to the next generations, in order to provide them the knowledge foundation for protection against it. Therefore, global efforts, as for example the work led by the Global Earthquake Model Foundation (GEM) during the last decade, in homogenizing existing seismic risk models and filling for gaps all over the globe, are remarkable and must be supported in order to continue their important vision.

References

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GEM Foundation Publications: https://www.globalquakemodel.org/publications

OASIS Loss Modelling Framework https://oasislmf.org/