NON-DAMAGE BUSINESS INTERRUPTION INSURANCE POLICIES DURING THE COVID-19 PANDEMIC*

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DOI: 10.51558/2303-680X.2022.20.1.41

Abstract

Pandemic risks, such as Covid-19, are difficult to insure as they are characterized by multiple factor risks and losses and involve different types of businesses and people simultaneously. The scarcity of time series and statistical data prevents insurers from developing correct pricing. We propose a model of catastrophe risk with Non-Damage Business Interruption (NDBI) policies to manage the pandemic risk due to the spread of Covid-19. The model employs a Monte Carlo simulation of different lockdown scenarios: the frequency and severity distributions of losses of Italian SMEs. The main results show the importance of a Covid-19 lockdown exposure NDBI policy, which benefits not only SMEs but also the insurer.

Keywords: Covid-19, insurance policies, reinsurance, catastrophe risk

JEL: C15, G22

1. Introduction

A catastrophe is an event which occurs very rarely. In its broadest sense, a catastrophe is something that exceeds the capability of those affected to cope with, or absorb, its effects; in the context of natural hazards, the driver is an extreme event causing widespread and usually sudden damage or suffering (Mitchell-Wallace et al., 2017; Niehaus, 2002; Doherty, 1997; Jaffee & Russell, 1997; Klein & Wang, 2009). Catastrophe risks arise from extreme and irregular events. In insurance, catastrophes can be divided into two broad categories: catastrophes connected to human activity (man-made or technological disasters) and those generated by nature itself (natural catastrophes) (Swiss Re, 2002, p. 4). In recent months, the aforementioned natural disasters have been joined by the Covid-19 pandemic. Across the European Union/European Economic Area (EU/EEA), there has been a considerable further increase in Covid-19 infections and the current situation represents a major threat to public health (ECDC, 2020, p. 1). However, the Covid-19 pandemic has had not only a huge impact on the health system but also serious effects on an economic and financial level. In particular, the Covid-19 pandemic has slowed down the Italian economy sharply: income and spending power have been reduced for 32% of workers; moreover, 70% of these workers did not meet their financial obligations; a small percentage (12%) did not repay loans or pay for utilities.

In this paper, we propose a model for the pricing of a "Non-Damage Business Interruption" (NDBI) insurance policy (classified in the field of non-life insurance classes "financial loss or miscellaneous financial loss") with associated "catastrophe excess of loss," which is a form of non-proportional reinsurance that protects the insurance company against an accumulation of losses due to single events (Mata, 2006; Finken & Laux, 2009; Lakdawalla & Zanjani, 2012; Stone, 1973;). The above-mentioned model with standard frequency-severity is based on three main steps:

1. simulation of the lockdown scenario (if and how many lockdowns occur in the territory in a year) by the Monte Carlo method;
2. where there has been a lockdown, simulation of the number of SMEs that decide to report closure to the insurer (frequency);
3. estimation of the amount by which SMEs that have experienced interrupted activity (severity) should be compensated, obtaining the distribution of the global compensation, which is useful for the purpose of calculating the relevant actuarial values.

We focus our attention on Italy, because some theoretical studies and empirical surveys showed that in this country the percentage of

* The paper was presented at the 7th International Scientific Conferences ICEI 2021, held in Tuzla and published in the Proceedings

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companies covered by an adequate insurance “blanket” appears to be rather low. Among the reasons given for the lack of insurance coverage, the ones that undoubtedly stand out are poor perception of exposure to risk and the high cost of insurance services (Lagasio et al., 2022). After all, firms mainly cover risks of fire, theft, and robbery along with civil responsibility for third parties and employees, whereas little attention is given to the risk of interruption of business activity, particularly when it comes to taking out ad hoc insurance policies (Santoboni et al., 2012, p. 56).

The paper is organized as follows. In section 1 we describe some of the current ways of managing catastrophe-related risks with insurance contracts. Section 2 describes the model. Section 3 describes and discusses the obtained results. Section 4 concludes.

2. Theoretical framework

To mitigate the devastating effects related to the spread of Covid-19, business interruption (BI) policies play a fundamental role in the insurance sector. BI policies generally represent the extension of another insurance policy called a property policy, which protects the insured company in the case of interruption of its business, in order to cover the relative loss of profit or the higher expenses to be incurred (Rose & Lim, 2002). BI policies can be divided into property coverage policies (damage), autonomous (non-damage) policies (BI), and contingent policies. In BI “damage” policies, the insured risk is constituted by a specific direct material damage, “physical damage,” which is suffered by the company assets in the presence of specific events (earthquake, flood, fire). These in turn differ with regard to: (i) named perils – only damages caused by catastrophic events indicated and specified in the policy are covered; and (ii) all risks – these cover losses and/or damage caused by any risk, unless the event that occurred is specifically excluded from coverage.

From the foregoing, it is clear that BI policies linked to property-type policies can find concrete application only in the event that the interruption of the insured company's business has suffered material and physical damage. In insurance practice, new BI policies called "non-damage" are spreading. These policies give the insured company the same protection and coverage as the BI "damage" with a substantial difference; in fact, the interruption of the company's business or that of one of its departments or plants is derived from events that did not necessarily cause material damage but were the so-called "trigger events,” events that have the effect of interrupting the activity of a specific business but without causing physical damage to this activity, which is instead, as seen, typical and necessary for the property cover to be activated. In the last decade, due to the spread of various epidemics such as SARS, MERS, and Zika, various insurance companies stipulated NDBI policies for companies that apply in the absence of material damage, which operate in order to protect businesses from interruptions or loss of profit deriving from risks that include not only epidemics but also the consequences of measures issued by the authorities, such as power blackouts, strikes, and cyber-attacks. Therefore, the best policies (NDBI) to protect the insured company in the presence of the current Covid-19 pandemic have in summary filled a void of damage coverage that is not provided for in any other traditional policy.

3. Model

The choice to consider the BI policy is due to the fact that business interruption is one of the greatest risks perceived by companies across the country, especially in the latter period with the spread of Covid-19. Small and medium-sized enterprises (SMEs) are the most vulnerable to the NDBI Covid-19 risk, in fact, as they do not have the same financial strength as large companies, the interruption of their business for months could also lead to default. Despite the impact of the health emergency, which forced many of these companies to reduce or stop their activities, in Italy currently only 3% of SMEs (according to the requirements of the European Commission, in terms of employees, turnover, and activity in the balance sheet, there are 148,531 SMEs present in Italy, of which 123,495 are small enterprises and 25,036 are medium-sized) are specifically insured with a BI policy. The objective of the practical case under consideration is to perform the pricing for an

NDBI insurance product, including the signing of a non-proportional "catastrophe excess of loss" type reinsurance treaty.

In this regard, the aforementioned loss of profits model is applied following an approach not of a "tailored" type, which consists of calculating the insurance policy on the basis of separate accounting data for each individual company, but of a "general" type, taking on average the balance sheet data of all SMEs in the country that are currently guaranteed by a BI policy (3%). Specifically, the technical analysis of the practical case in question was carried out by observing the following moments:

1. empirical distribution of the aggregate damage, after having described and analyzed the statistical bases for the definition of the technical bases, applying the Monte Carlo simulation with a frequency-severity model;
2. calculation of the tariff premium, after having found the average of the empirical distribution of the aggregate damage (fair premium) and having applied an appropriate safety loading;
3. calculation of the Solvency Capital Requirement (SCR), adopting the internal model and using the Value at Risk 99.5% (VaR), as regards the premium sub-module of the Non-Life Underwriting Risk;
4. calculation of the reinsurance premium, using a reinsurance model for "catastrophe excess of loss," having established the full scope of the catastrophe and calculated the global compensation retained by the insurer and that assigned to the reinsurer.

It was also assumed that:

- the NDBI policy for "lockdown," given the current emergency in Italy, is mandatory;
- coverage of the policy in question is annual and occurs only in the case of the "lockdown" event;
- the policy guarantees a maximum monthly coverage during the year;
- 3% of Italian SMEs sign the NDBI policy contract with the analyzed company;
- no other company, in addition to those already insured, signs an NDBI insurance contract with the company analyzed during the year.

3.1 Hypotheses and Monte Carlo simulation

The objective of the discussion is to model the distribution of the global compensation that the insurance will have to pay to the policyholders in a year, in fact, from this distribution, by calculating significant values, such as the expected value, variance, and quantiles, which are useful actuarial values (VaR, SCR, fair premium). To do this, 100,000 Monte Carlo simulations were run using a frequency-severity model.

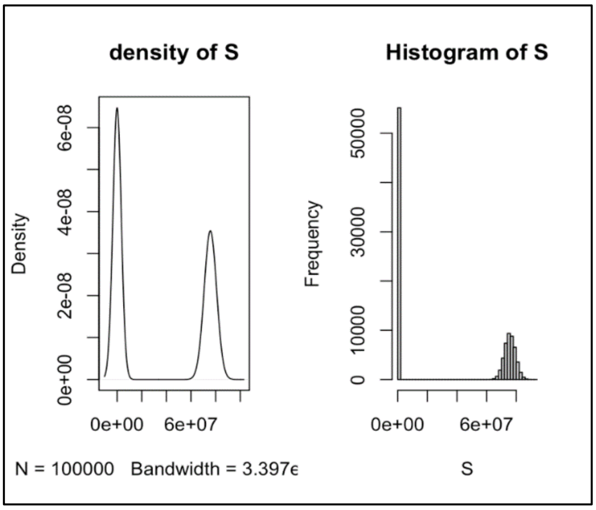

Figure 1. *Empirical distribution of aggregate damage S*
Source: Authors' research

The following probabilistic assumptions were made:

- the variable number of "lockdowns" N in a year follows a Poisson distribution with "lambda" parameter 0.6 (the probability of a lockdown occurring in a year will be equal to 0.4511884%);
- for j ranging from 1 to 4456 (number of insured risks), let Ij be the probability that the j-th SME will close during the year due to the "lockdown". It has been hypothesized that the Ij conditioned to N > 0 are independent and identically distributed (i.i.d.) and follow a Bernoulli distribution with parameter 0.7; therefore, given the fact that the "lockdown" has occurred, each chooses independently from the other;

- the sum of Ij is the total number of SMEs to be compensated by the insurer; therefore, it is necessary to simulate a number of variables equal to the aforementioned sum in order to obtain the value in euros to be compensated. Therefore, let Yj be the variable that represents the compensation relating to the j-th SME, which is supposed to be identically equal to 0 if N is equal to 0; in fact, if the "lockdown" does not occur, the damage to be compensated is 0 and distributed according to a lognormal when N > 0. The parameters of the lognormal are such as to replicate the mean (21,239.754) and the variance (13,668,108,333) of the average monthly profit for an SME;
- to further emphasize the independence between the value of the global compensation and the total number of claims reported, it was decided to multiply the expected value of Yj by a factor ranging from 1 to 1.3 depending on the value of the sum of the Ij, which we call M, which is distributed according to a binomial (sum of independent Bernoulli distributions).

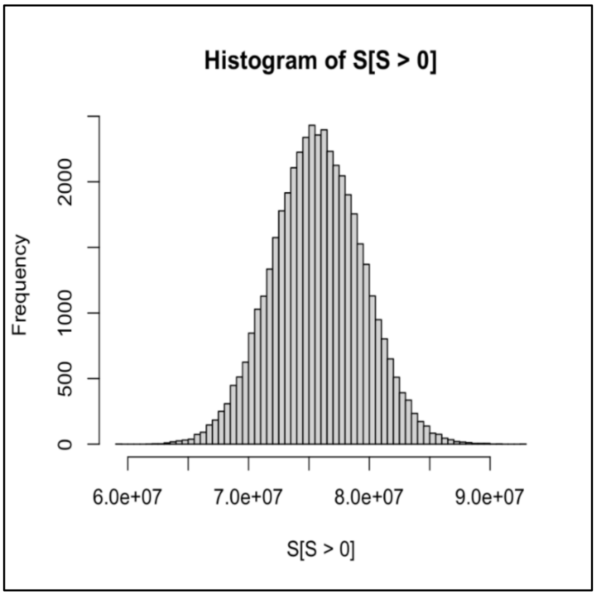

Figure 2. *Empirical distribution of aggregate damage S > 0*
Source: Authors' research

The algorithm of the model operates as follows:

- A number of simulations equal to 100,000 are performed. In each simulation i:
- The number of lockdowns that occurred in that situation is simulated; if N is equal to zero, Si will be equal to zero; if, on the other hand, N > 0, and under the aforementioned hypotheses it is assumed that only the first lockdown will be covered by a premium, proceed in this way:

1. 4456 Bernoulli Ij are simulated and then added together to obtain the number Mi of the complaints relating to the i-th simulation;
2. The factor ranging from 1 to 1.3 to be multiplied by the mean of Yj is calculated and Mi lognormal values are simulated;
3. The value of Si will be equal to the sum of the Mi lognormal values, which correspond to the compensation relating to the single SME that has decided to close; the observed distribution is shown in Figure 1.

We observe a mass of probability concentrated at zero when the insured event does not occur, while a probability distribution shifted to the right, as shown in Figure 2, represents the value of the global compensation in the case that the lockdown event occurs, and it is the sum of the *lognormal*. Since insurance is actuarially fair, when the premium, by definition, is equal to the expected claims, from the empirical distribution of the aggregate damage, the "fair" premium (P) is the expected value of the distribution. Therefore, the estimate made for the premium will be the sample mean of the simulated values of S in the formula:

$$\sum_{i=1}^{Nsim} Si/Nsim = E(S) = P.$$

It is appropriate to use a "function" that associates a real number (pure premium) to the probability distribution of S. Given the particular shape of the distribution of S caused by the high variability of the insured event, the principle for the calculation of the pure premium deemed appropriate in this report was the principle of the standard deviation. Based on this principle, the loading of safety is proportional to the standard deviation of S in the formulas:

$\prod = P + \gamma\sigma(S)$; with $\gamma > 0$.

Finally, after having found the pure premium, an additional safety loading is carried out using the principle of "constant loading" for the calculation of the gross premium (C) in the formulas:

$C = \prod + b$; with $b > 0$.

The loading is independent of the riskiness of the contract and takes into account:

1. contract acquisition costs, such as the purchase commission which constitutes the agent's remuneration;
2. premium collection costs, such as the collection commission paid to the agent as compensation for handling the collection of the premiums;
3. general management expenses which include various items of general expenses incurred by the insurance company for the administration of the contract.

The expected value of the distribution E(S) is equal to €34,203,481, and having therefore set this value for P, the pure premium, given the high variability, using the formula of the above standard deviation principle applied, with $\gamma = 0.664$, is Π = €59,277,367. The gross premium, or the premium that takes into account the acquisition, management, and collection costs, using the constant loading principle, equal to €200 per contract, will be C = Π + 200 * Nrisc = 60,168,567.33€; it is possible for this value to be much higher than the expected value of the distribution of the aggregate damage E(S), but this is the result of the high variability present in this policy portfolio, just think of the range of distribution (the minimum value and the maximum value). The insurance company in question will be obliged to reclaim a sum from the policyholder (each company that wants to protect itself against the "NDBI" risk due to "lockdown" following the spread of the Covid-19 pandemic and the damage it produces) towards payment of an annual premium of €13,502.82. This value seems reasonable considering that to protect itself against this imminent risk, an SME today in Italy should be willing to pay a premium of about €1.125 per month to the insurance company in question.

3.2. *SCR Premium Non-Life Underwriting Risk*

The SCR is calibrated to ensure that all quantifiable risks to which an insurance or reinsurance undertaking is exposed are taken into account. It will cover the existing business as well as the new business which should be recorded over the next 12 months and is calculated as an aggregate value for all lines of an insurance policy. As for the existing business, it will cover only unexpected losses; and it corresponds to the VaR of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a period of one year. FST (x) = P(ST <= x) is the distribution function of the surplus in T > 0, which, for simplicity, we suppose to be continuous and strictly increasing. Once a probability has been set (which should be thought of as "small," i.e., less than 0.5), the VaR of the position is defined as the ε-quantile of S with the opposite sign; we have:

VaRε(ST) = –xε = –FST-1(ε) . ST.

Having found the VaR at 99.5% of the distribution, which is equal to €85,179,047, to calculate the SCR using the internal model, it will be necessary to subtract the volume of premiums from the 99.5% VaR with an annual time horizon.

The value of the SCR Internal Model (SCR_IM) that the insurance company will have to guarantee for the solvency of the current risk in the portfolio will be equal to €25,010,479.67.
Meanwhile, for the calculation of the premium SCR second standard formula, the Solvency directive provides that the SCR is equal to 3 * σ * V, where "σ" in the XVI non-life class (pecuniary losses) is equal to 0.17 * NpLob (100%), and V ("C" in our study) is the volume of premiums in the portfolio. The SCR_SF according to the standard formula is, therefore, equal to 3 * 0.17 * €60,168,567.33 = €30,685,969.34. Since the SCR required by the Solvency II directive, with the standard formula, is greater than that obtained with the internal model, we observe the convenience for the insurance company of adopting the internal model for the calculation of its SCR.

Furthermore, a fundamental objective of the insurer, in order to provide useful information on the riskiness of the portfolio in question, is to keep the probability low enough, in particular equal to a given threshold ε that is considered acceptable: ε = Pr{G < –W} = Pr{X > W + P + r}, that is, the probability of the event "the random charge for compensation exceeds the sum of the total amount of pure premiums (P + r) and the solvency margin (W) initially available to the insurer in relation to the portfolio." The probability of the event {X > W + P + r} is properly called the annual probability of ruin of the insurer in relation to the portfolio; in our model it is ε = 0.005.

3.3 *"Catastrophe Excess of Loss" reinsurance*

In order to reduce the annual probability of ruin, ε, we assume that the insurer decides to sign a non-proportional reinsurance treaty of the "Catastrophe Excess of Loss" type. This type of reinsurance refers to claims arising from a single catastrophic event which affects multiple contracts in the portfolio. In formulas, with reference to a portfolio of civil liability insurance consisting of n contracts stipulated at the same time and with an annual duration, having fixed the priority LC, let S be the global compensation relating to the amount to be paid by the insurer, which is SA = min(S;LC); on the other hand, the amount transferred to the reinsurer, in the event that no upper limitation (scope) is envisaged, is SR = max(S – LC; 0), while in the event that we will have a partial scope (realistic hypothesis), SR = min [max(S – LC; 0); QC], also indicating with K the random number of catastrophes affecting the portfolio during the year and with Sh (h = 1, 2, ..., K) the global compensation corresponding to the h-th catastrophe in chronological order. If it is fully established that a catastrophe has occurred, Lc, the global compensation retained by the insurer is:

$$XA = \sum_{h=0}^{K} \min(Sh; Lc)$$

while the global compensation assigned to the reinsurer is:

$$XR = \sum_{h=0}^{K} \max(Sh - Lc; 0).$$

To define the priority, that is, the monetary amount such that if the aggregate damage exceeds this value the compensation is paid by the reinsurer, a graph of the aggregate damage S given S > 0 is constructed, as in Figure 3, and the priority L is obtained as the average of this distribution, which is equal to €75,714,971. The priority in reinsurance practice is generally partial, and therefore a scope is introduced; that is, the maximum amount within which the reinsurer undertakes to compensate the aggregate damage is taken as the scope Q, the upper limit of acceptance for the reinsurer, which is the quantile of the distribution of S at 95%, and this amount is equal to €81,833,004. The value of the damage borne by the reinsurer is therefore equal to SR = min [max (S – L, 0), Q] and the "fair" premium (Pr) that the reinsurer will charge in order to assume the risk will be the expected value of SR; Pr = E(SR) = €661.525,40. In addition, a safety loading is made for the pure premium, adopting as before the principle of the standard deviation greater than that carried out by the insurance company. The pure reinsurance premium (Πr), in this case with γ = 0.665, will be Πr = Pr + γ *s.d. (min (max(S – L, 0), Q)) = €1.746.382; it is further assumed that a safety loading for expenses equal to that of the insurance policy is made using the principle of "constant loading," considering the loading independent of the riskiness of the contract, suitable for management expenses which include various items of general expenses incurred by the reinsurer for the administration of the contract. The reinsurance gross premium (Cr) is equal to:

Cr = Πr + 200 * Nrisc = € 2,637,582.

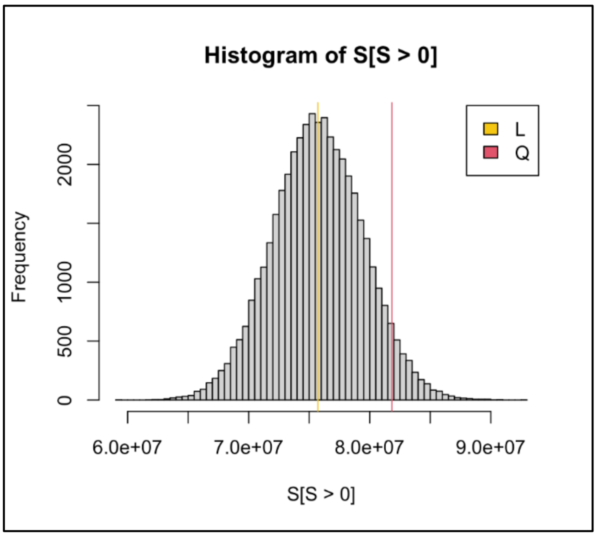

Figure 3. *Distribution of S [S > 0], Priority (L) and Flow (Q)*
Source: Authors' research

Post reinsurance, the compensation payable by the insurer will be Spr = S – Sr. The premium volume remaining in the insurance company (Πpr) will be equal to Πpr = Π – Πr = €57,530,985.33 = Cpr = C – Cr, and the pure premium and gross premium post reinsurance are the same, since the same loading for expenses was carried out by both parties and the same technical bases were used for the assessment of the damage. As regards the SCR to be set aside following reinsurance, taking into consideration the internal model, equal to the VaR - the amount of the premiums in the portfolio; this time, however, taking into consideration the VaR of the post reinsurance distribution (plus the expected value of expenses), we get SCRpr_IM = €19,075,186. The SCRpr_SF obtained with the standard formula 3 * 0.17 * Cpr is instead = €29,340,802.52. Once again, the convenience for the insurance company of adopting the internal model is confirmed. As expected, the amount of premium collected has decreased; however, we note that the capital to be set aside for solvency requirements has decreased by more than the total decrease in the amount of premium collected. In fact, observing two percentage changes, we note how, post reinsurance, against a change in the expected profit (Πpr – Π)/Π * 100 of (–2.94612%), the SCRpr_IM decreased by (–23.73123%) and in fact the profitability index Upr/SCRpr_IM increased, ranging from 1.002535 (pre-reinsurance) to 1.222924 (post-reinsurance).
The confirmation of the reinsurance benefit can also be seen in the decrease in the probability of ruin post-reinsurance ε (ε_r). In the 100,000 simulations carried out, post reinsurance, a case of losses greater than the SCRpr_IM never happened.

εr = sum (Πpr – Spr < (–SCRpr)) / Nsim = 0.

Finally, the simulation of the frequency-severity model algorithm was replicated, with 40,000 risks in the portfolio (40,000 SMEs are insured; therefore, we assume that the insurance company has about 27% of the SMEs in Italy in its portfolio). In conclusion, by observing the values of the new simulation, it is interesting to note that as the number of SMEs in the portfolio increases, the convenience of adopting the internal model for calculating the SCR increases. In fact, despite the increase in the value of the SCR internal model, the result of the SCR_IM/NRA for each individual risk has decreased from €5,612.76 (in the analysis seen above with 4,456 risks) to €5,248.40. The standard SCR formula that increases proportionally with the increase in premiums (a consequence of the 3 * σ * V formula), going from 4,456 risks in the portfolio to 40,000, also increases the value of the SCR_SF/NRA relating to each single claim.

4. Conclusions

The result of the model developed in the paper highlights, for the historical period that we are all experiencing, the importance of a "Covid-19 lockdown exposure NDBI policy," which not only benefits SMEs for the reasonable gross premium required to cover the net profit that would have been lost in a month due to business interruption, but also, from the results obtained, allows the insurer to reach a profit margin, which increases when a reinsurance treaty is signed (in our case "catastrophe excess of loss"). The actuarial values that are generated by the simulation algorithm improve as the risks (number of SMEs insured) present in the portfolio increase; this suggests that, if this policy were not just stipulated by 3% of SMEs but sold on a wide scale throughout the national territory, it would also be a relief for the public system brought to its knees by the pandemic crisis and which alone does not seem to be succeeding in supporting Italy's ailing SMEs. Moreover, despite the awareness and the timely reaction of the insurance market, in the near future it will be necessary to find and at the same time innovate pandemic risk transfer solutions as well as to structure adequate mechanisms that allow the risk to be divided between insurers and reinsurers, capital market and governments, creating a system of close collaboration between all the parties. However, the catastrophe model remains the only solution able to quantify and assess a catastrophe risk and try to manage it.

References

1. Doherty, N. A. (1997). Innovations in managing catastrophe risk. *The Journal of Risk and Insurance*, 64(4), 713–718. DOI: https://doi.org/10.2307/253893

2. ECDC (2020). Rapid Risk Assessment: Increased transmission of COVID-19 in the EU/EEA and the UK – thirteenth update (https://www.ecdc.europa.eu/sites/default/files/documents/RRA-COVID-19-EU-EEA-UK-thirteenth-update-23-Oct-2020.pdf)
3. Finken, S., & Laux, C. (2009). Catastrophe bonds and reinsurance: the competitive effect of information-insensitive triggers. *Journal of Risk and Insurance*, 76(3), 579–605.
4. Jaffee, D. M., & Russell, T. (1997). Catastrophe insurance, capital markets, and uninsurable risks. *Journal of Risk and Insurance*, 65, 205–230. DOI: https://doi.org/10.2307/253729
5. Klein, R. W., & Wang, S. (2009). Catastrophe risk financing in the United States and the European Union: A comparative analysis of alternative regulatory approaches. *Journal of Risk and Insurance*, 76(3), 607–637. DOI: https://doi.org/10.1111/j.1539-6975.2009.01308.x
6. Lagasio, V., Santoboni, F., Tremoglie, D. (2022). COVID-19: Managing a Catastrophe Risk with Non- Damage Business Interruption Policies, *Risk Management Magazine*, 17(1), 36-49.
7. Lakdawalla, D., & Zanjani, G. (2012). Catastrophe bonds, reinsurance, and the optimal collateralization of risk transfer. *Journal of Risk and Insurance*, 79(2), 449–476. https://doi.org/10.1111/j.1539-6975.2011.01425.x
8. Mata A. J. (2006). *Catastrophe Excess of Loss*, Encyclopedia of Actuarial Science (Vol. 1). John Wiley & Sons. Print
9. Mitchell-Wallace, K., Jones, M., Hillier, J., & Foote, M. (2017). Natural Catastrophe Risk Management and Modelling: A Practitioner's Guide. John Wiley & Sons.
10. Niehaus, G. (2002). The allocation of catastrophe risk. *Journal of Banking & Finance*, 26(2/3), 585–596. DOI: https://doi.org/10.1016/S0378-4266(01)00235-7
11. Rose, A., & Lim, D. (2002). Business interruption losses from natural hazards: conceptual and methodological issues in the case of the Northridge earthquake. Global *Environmental Change Part B: Environmental Hazards*, 4(1), 1–14. DOI: https://doi.org/10.1016/S1464-2867(02)00012-8
12. Santoboni F., Vento G.A., Porretta P., (2012), Corporate insurance and debt capacity: empirical evidence from Italy. *Journal of Governance and Regulation*, 1(4), 54–75. ISSN: 2220-9352. DOI:10.22495/jgr_v1_i4_p5.
13. Stone, J. M. (1973). A theory of capacity and the insurance of catastrophe risks (Part II). *Journal of Risk and Insurance*, 40, 339–355. DOI: https://doi.org/10.2307/252115
14. SWISS RE (2002). Natural catastrophes and man-made disasters in 2001: man-made losses take on a new dimension. *Sigma*, No. 1/2002.