UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER THESIS

AN ANALYSIS OF THE EFFECTS OF NATURAL DISASTERS ON INSURANCE

Ljubljana, June 2025 LUCIJA UDIR

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ABSTRACT

The frequency and severity of natural disasters are increasing, leading to significant challenges for the insurance industry and society as a whole. Recent catastrophic events highlighted vulnerabilities in areas where people and infrastructure are insufficiently prepared for such disasters. A notable concern is the high insurance gap, as many properties remain uninsured or underinsured. This lack of preparedness places a greater financial burden on governments and communities to fund recovery efforts.

As the risk of claims grows, insurance companies are compelled to adjust premiums to account for larger and more frequent claims. However, these rising costs often lead to decreased affordability and accessibility of insurance for policyholders, further exacerbating the issue of underinsurance.

This master's thesis addresses these challenges by analyzing data from the Slovenian insurance industry, offering a comprehensive overview of past natural disasters and their economic impacts. It investigates correlations between catastrophic events, premiums, loss ratios, and overall losses, offering insights into their effects on insurer stability and insurance accessibility.

The research highlights the systemic challenges faced by policymakers, insurers, and policyholders in addressing the insurance gap. It emphasizes the need for adaptive strategies to strengthen resilience, reform insurance practices, and mitigate the growing risks associated with natural disasters.

KEY WORDS

Insurance, natural disasters, extreme weather events, catastrophic events, insurance payouts, premiums, insurance gap, loss ratio.

SUSTAINABLE DEVELOPMENT GOALS

POVZETEK

Povečana pogostost in intenzivnost naravnih nesreč postavljata pred zavarovalništvo in širšo družbo vedno večje izzive. Nedavni katastrofalni dogodki v Sloveniji in po svetu so razkrili številne pomankljivosti. Ena ključnih težav je visoka zavarovalna verzel, saj številne nepremičnine niso zavarovane ali pa so zavarovane v nezadostnem obsegu. To povečuje finančno breme, ki ga po katastrofalnih naravnih dogodkih nosijo tako vlada kot lokalne skupnosti.

Zavarovalnice morajo zaradi pogostejših narevnih nesreč prilagajati premije, da pokrijejo večje in pogostejše zahtevke. Višje premije zmanjšajo dostopnost in povečajo stroške zavarovanj, kar še poglobi problem nezadostnega zavarovanja.

Magistrsko delo se osredotoča na analizo izzivov, ki jih naravne nesreče prinašajo slovenski zavarovalniški industriji. S pregledom preteklih dogodkov in njihovih ekonomskih posledic preučuje povezavo med naravnimi nesrečami, škodnimi količniki, premijami in skupnimi izgubami. S tem delo razkriva vpliv naravnih nesreč na finančno stabilnost zavarovalnic in dostopnost zavarovanj za zavarovance.

S spremembami v pogostosti in intenziteti naravnih nesreč se odpirajo številni izzivi, povezani z zmanjševanjem zavarovalne vrzeli in krepitvijo odpornosti sistema. Delo tako izpostavlja pomen prilagajanja zavarovalnih praks ter razvoja učinkovitih pristopov k upravljanju naraščajočih tveganj, ki jih prinašajo podnebne spremembe in z njimi povezani ekstremni vremenski pojavi.

KLJUČNE BESEDE

Zavarovanje, naravne nesreče, ekstremni vremenski pojavi, katastrofalni dogodki, zavarovalnine, premije, zavarovalna verzel, škodni količnik.

CILJI TRAJNOSTNEGA RAZVOJA

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LIST OF ABBREVIATIONS

sl. – Slovene

- **ATTR** – Attritional claims: Smaller claims not classified as natural disasters or large claims (sl. običajne škode).
- **CAT**: catastrophic events (sl. katastrofalne naravne nesreče).
- **EIOPA**: European Insurance and Occupational Pensions Authority (sl. Evropski organ za zavarovanja in poklicne pokojnine).
- **PCS**: Property Claim Services.
- **EEA:** European Economic Area (sl. Evropski gospodarski prostor).
- **NoC:** Number of claims (sl. Število škodnih zahtevkov).

1 INTRODUCTION

1.1 The definition and overview of the research subject

In recent decades, the frequency and severity of natural disasters have increased, resulting in substantial economic repercussions around the world. The global economic loss from natural disasters in 2023 reached 380 billion USD, with insured losses estimated at 118 billion USD. Natural disasters, such as floods, hurricanes, and earthquakes, are characterized by their sudden, unexpected, and severe nature, resulting in loss of life, damage to buildings, and health issues. These events have far-reaching consequences, prompting the Property Claims Service (PCS) to define catastrophes as events causing at least 25 million USD in direct insured losses to properties, impacting a significant number of policyholders and insurers (Smolka (2006)). Property Claim Services (PCS) unit is the internationally recognized authority on insured property losses from catastrophes in the United States, Canada, and other regions. PCS data is widely used by insurers, reinsurers, and catastrophe bond investors to assess risk and manage claims.

Natural disasters vary worldwide. Europe faces recurring floods leading to economic losses, while tornadoes pose significant threats in the US. In Asia, floods, earthquakes, and landslides cause substantial economic damage (Kalfin et al. (2022)). Some natural disasters occur periodically, while extreme events deviate significantly from these patterns. Extreme events are defined by their low occurrence probability and wide area of impact. The area affected is crucial, with events causing significant regional or global consequences classified as extreme. For an extreme event to become a disaster, it must affect populated areas. In insurance, extreme events occur less than once in 1000 years, on either a global or regional scale, shaping their classification and planning horizon (Smolka (2006)).

One such extreme event was Hurricane Andrew, which struck the United States on August 24, 1992. With 25 billion USD in insured losses, the storm devastated South Florida, destroying 25,500 homes and damaging 101,000. The impact led to the insolvency of 16 insurers. In response, Florida established insurance pools like the Citizens Property Insurance Corporation to cover high-risk properties (Sansone (2022)).

Andrew profoundly reshaped the insurance industry. It exposed the limitations of existing risk assessment methods, spurring the development and widespread adoption of catastrophe (CAT) modeling. This shift enabled insurers to better quantify and price natural disaster risks. The storm also highlighted the need for robust reinsurance structures, fostering the growth of specialty insurers focused on wind and hurricane coverage. Additionally, it drove regulatory changes, such as stronger building codes and improved risk

mitigation practices, ultimately enhancing the industry's resilience to future catastrophic events.

Following Hurricane Andrew, several other catastrophic events have reshaped the insurance industry. Hurricane Katrina in August 2005 caused over 1,800 deaths and 125 billion USD in damages, particularly devastating New Orleans. In September 2022, Hurricane Ian hit Florida and Cuba, causing over 50 billion USD in damages and severe flooding (Rudden (2024)). The Tohoku earthquake and tsunami in March 2011 caused around 300 billion USD in damage and triggered the Fukushima nuclear disaster, affecting global disaster preparedness and nuclear safety. Hurricane Irma in September 2017 caused 50 billion USD in damages across the Caribbean and the United States, while Hurricane Ida in 2021 caused 75 billion USD in damages, with extreme flooding in the U.S. These events highlighted the growing risks of natural disasters and the need for enhanced resilience and preparedness.

1.2 Research Purpose and Questions

Natural disasters inherently involve the risk of significant losses, establishing a deeply interconnected relationship between catastrophic events and their economic consequences. As the frequency of such events increases, the likelihood of resulting losses, ranging from infrastructure damage to socio-economic setbacks, also rises. In our research, we aim to analyze data specifically for Slovenia, investigating the correlation between natural disasters and economic losses. Our focus will be on understanding the impact of catastrophic risks on key metrics such as loss ratios, premiums, and overall losses within the insurance industry.

The loss ratio, defined as the ratio of losses incurred to premiums earned, serves as a primary measure of the profitability of insurance companies. By examining various factors influencing these metrics, we seek to gain insights into how catastrophic risks affect insurance performance and profitability. Additionally, we hypothesize that catastrophic events exert a dual impact on insurance premiums. On one hand, these events are expected to drive insurance rates upward, increasing the total premiums for a given number of policies. On the other hand, higher premiums may lead to a reduction in the number of policies written, due to rationing of insurance coverage and the potential withdrawal of insurers.

Our research will address the following key questions:

- Which natural disaster occurs most frequently in Slovenia?
- What is the relationship between natural disasters and losses in Slovenia and the EU?

- How much have premiums increased for Slovenian insurance companies following major natural disasters?
- How do unexpected catastrophes and extreme events affect earned premiums?
- What role does the state of Slovenia play before and after natural disasters, and how does its national system for disaster protection influence the insurance market?
- How significant is the insurance gap in Slovenia, Europe, and globally?

1.3 Research Structure and Methodology

The master's thesis consists of two main sections: the theoretical and the empirical parts. In the theoretical section, we focus on constructing a comprehensive substantive framework to facilitate a more detailed analysis of primary data in subsequent chapters. Given the extensive scientific literature on natural disaster insurance, we adopt a deductive approach to theory formulation. This approach moves from general to specific, starting with an exploration of the broader topic of natural disasters and insurance before narrowing down to the specific impacts of these events on the insurance industry.

In the theoretical part of the thesis, we define key terms such as "natural disasters" and "extreme events" to establish a clear foundation for the analysis. Following this, we discuss the crucial role of insurance in supporting recovery efforts after catastrophic events, emphasizing its significance in mitigating the economic consequences of such disasters. Furthermore, we examine the nuanced impacts of natural disasters and extreme events on insurance premiums, losses, and loss ratios. Our research explores how these factors shape the financial landscape of the insurance market.

In the empirical section of the thesis, we collect and analyze data on natural disasters, their associated losses, insurance premiums, and the number of insurance policies written. We gather data from reliable sources such as EIOPA, the Slovenian Insurance Association, the Insurance Supervision Agency, Sistat, and the Swiss Re Institute. Using the R programming language, we apply statistical techniques such as regression analysis, time series analysis, and correlation analysis to identify trends in premiums, losses, and loss ratios.

As part of our research process, we utilize generative artificial intelligence tools, including ChatGPT, to aid in idea generation, topic selection, and structuring our research. Specifically, we use these tools to explore potential areas of analysis and refine our research questions. Additionally, ChatGPT was used in Chapters 4 through 6 to assist with linguistic and grammatical improvements, ensuring clarity and consistency in academic writing. However, all analysis, interpretation, and conclusions are our own, and we ensure that AI-assisted content aligns with ethical research standards and academic integrity guidelines.

1.4 Structure of the Thesis

In the first part of the thesis, the chapter Insurance of Natural Disasters provides an overview of non-life insurance in Slovenia, with a focus on those most affected by natural disasters. It examines different types of insurance, distinguishing between basic and additional risks, and highlights Slovenia's significant insurance gap, particularly regarding flood and earthquake coverage. The role of government initiatives, including the potential for parametric insurance, is also discussed.

The second part of the thesis, Data Sources, presents the datasets used for analyzing the impact of natural disasters on the Slovenian insurance industry. It describes sources such as the Geographic Atlas of Natural Disasters, reports on economic losses, and insurance data from the Slovenian Insurance Association. The chapter also outlines the methodology for collecting and processing this data.

In the third part of the thesis, corresponding to Analysis of Natural Disasters Data, the study investigates the frequency, severity, and economic consequences of natural disasters in Slovenia. The chapter explores historical trends and statistical distributions of disaster events, providing insight into the patterns of occurrence and financial losses.

The fourth part, Analysis of Insurance Claims Related to Natural Disasters, consists of several subsections that analyze different aspects of insurance claims. It examines the number of claims filed due to natural disasters, trends in insurance payouts, premium adjustments following disaster events, market responses from insurance companies, and the correlation between disasters and loss ratios. Furthermore, the analysis of the number of insurance policies explores whether natural disasters lead to an increase or decrease in policy uptake.

Finally, the thesis concludes with the Conclusion chapter, summarizing the key findings and emphasizing their implications for the Slovenian insurance industry. The conclusion reflects on the broader significance of the study, offering insights into potential regulatory improvements and future research directions.

1.5 Literature Review

In this study, a variety of sources have been consulted to gain a comprehensive understanding of the relationship between natural disasters and the insurance sector. Key literature has provided the theoretical foundation and contextual insights for the research, focusing on how catastrophic events impact insurance markets, the role of insurance in recovery, and the broader financial consequences of extreme events. This key literature

not only informed the structure of the thesis but also served as the initial inspiration for the research topic.

The work of Born & Viscusi (2006) serves as a foundation for the main hypothesis of this thesis. The authors discuss how catastrophic risks can lead to higher premiums, reduced loss ratios, and insurers withdrawing from high-risk markets. This master thesis investigates whether these effects are applicable to Slovenia.

Similarly, Kousky (2019) provides a comprehensive analysis of the role of natural disaster insurance in recovery and risk reduction. Her work underscores the importance of insurance in mitigating financial damages and highlights the critical role of public-private partnerships in improving resilience to future events. Kousky's research is central to understanding how insurance mechanisms can support post-disaster recovery, which aligns directly with our analysis of the insurance gap and the effectiveness of the Slovenian insurance market in addressing natural disaster risks. Specifically, her findings on the discrepancy between insured and uninsured losses provide important context for understanding the impact of natural disasters on insurance policies and premiums in Slovenia.

Another key contribution comes from Smolka (2006). This paper explores the challenges faced by insurers in managing risks linked to extreme natural events. Smolka emphasizes the distinction between regular natural disasters and extreme events. Smolka's framework on extreme events, such as floods or earthquakes with low occurrence probabilities but high impact, provides critical context for analyzing how insurance companies adjust their risk models in Slovenia.

For a more localized perspective, we referred to the work of Komac (2021). This article served as the starting point for our research, as we were interested in understanding the financial burden that natural disasters place on Slovenia and who bears these costs. Komac's work provided valuable insights into public funds allocated for prevention, response, and recovery, as well as a comparison of these funds with private investments in insurance and the resulting damages.

The paper by Ferlan & Mikoš (2002), is another significant contribution to understanding the specific challenges faced by property insurance in the aftermath of natural disasters in Slovenia. Their findings suggest that, despite advancements in insurance coverage, the costs of natural disasters often exceed what the insurance system can cover. This paper guided our investigation into the financial burden of natural disasters on the Slovenian insurance industry and the role of public funding in mitigating these costs.

Additionally, data from relevant sources, such as the Geographic Atlas of Natural Disasters in Slovenia (Komac et al. (2023)) and Slovenian Insurance Association statistics,

have been used in this research. More details on the data used for our analysis can be found in Section 3: Data Sources.

2 INSURANCE OF NATURAL DISASTERS

2.1 Insurance Types

According to ZZvar-1 ("Zakon o zavarovalništvu (ZZavar-1)" (2015)) insurance is classified into the following types of non-life insurance based on the main risks they cover:

(1) Accident insurance,
(2) Health insurance,
(3) Land vehicle insurance,
(4) Rolling stock insurance,
(5) Aircraft insurance,
(6) Marine insurance,
(7) Goods in transit insurance,
(8) Fire and natural forces insurance,
(9) Other property damage insurance,
(10) Vehicle liability insurance,
(11) Aircraft liability insurance,
(12) Marine liability insurance,
(13) General liability insurance,
(14) Credit insurance,
(15) Suretyship insurance,
(16) Miscellaneous financial loss insurance,
(17) Legal expense insurance,
(18) Assistance insurance.

Natural disasters primarily affect the following types of insurance (Bešter et al. (2013)):

- Insurance against fire and natural forces: This insurance explicitly covers damages caused by various natural events, including fire, storms, and other natural disasters such as earthquakes, floods, and landslides. It is designed to protect property from the direct consequences of these natural phenomena.
- Other property damage insurance: While this insurance mainly covers damages caused by events like hail or frost, it can also be impacted by certain natural disasters, especially those not covered under Insurance against fire and natural forces, depending on the specific terms of the policy.

- Vehicle insurance (land, rolling stock, aircraft, marine): These types of insurance cover physical damage or loss to vehicles, which can also result from natural disasters such as floods, storms, or earthquakes. Vehicles may suffer direct damage from environmental events or indirectly due to accidents caused by hazardous conditions.
- Goods in transit insurance: Natural disasters can disrupt transportation and cause damage to goods in transit, including goods in transit carried by road, rolling stock, air, or sea. Insurance covering goods in transit addresses losses caused by natural calamities during transit.
- Miscellaneous financial loss insurance: This type of insurance can cover financial losses due to natural disasters indirectly, such as lost profits, rent or income loss, or unforeseen business costs that arise from disruptions caused by events like floods, storms, or earthquakes.

2.2 Insurance Coverage for Natural Risks

A core responsibility of the insurance sector is to innovate continuously and strengthen public trust. Underpinning this effort is the recognition that people view insurance as a safeguard for times when things go wrong. Among the most significant risks are also climate risks.

In principle, insured risks are divided into basic and additional risks. Basic risks are those that occur most frequently and threaten the majority of insureds, which is why insurers typically offer them in packages. These commonly include fire, lightning, explosion, storm, hail, impact of a motor vehicle into the insured building, aircraft crash, and demonstrations (Bešter et al. (2013)).

Additional risks can be covered by paying an additional premium. These include snow load, flooding, torrents, high water, water overflow, landslide, land subsidence, and avalanche, as well as earthquakes. The condition for insuring additional risks is that basic risks are insured and that a separate premium is calculated for each additional risk.

Below are definitions of the following risks: fire, lightning, storm, hail, snow load, floods, high and underground water, landslide, land subsidence, and avalanche, as well as earthquake.

- Fire: Fire is defined as a flame that originates outside of a designated hearth or leaves it and spreads of its own power. A thing is not considered damaged by fire if it has been exposed to useful fire or heat (ironing, drying, roasting, baking, cooking, heating, smoking), or if it was burned, scorched, or charred due to a cigarette, ember, lamp, stove, or short circuit in electrical installations and appliances.

- Lightning: A lightning strike is a direct hit of a lightning bolt with its thermal and destructive force on the insured object. The damage caused by the impact of objects knocked down or thrown by the lightning onto the insured property is also covered.
- Storm: A storm is wind blowing at a speed of at least 62 kilometers per hour (8th degree on the Beaufort scale). It is considered a storm if, in the location where the insured object is, the wind broke branches, uprooted trees, or damaged well-maintained buildings. Damage caused by objects knocked down or thrown by the storm onto the insured object is also covered.
- Hail: Hail is precipitation in the form of larger ice pellets, which, upon hitting the insured object, crack, chip, or otherwise damage it. Damage caused by water leakage through openings made by the hail is also covered.
- Snow Load: Snow load is the force with which snow, due to its weight, damages the residential property.
- Flood, Flash Flood, High and Groundwater: A flood occurs when rivers, lakes, or seas overflow their banks, breach levees, or break dams, causing water to inundate land where insured objects are located.
- Landslide, Land Slip, and Avalanche: A landslide is the movement of earth on sloped terrain, accompanied by noticeable surface cracks and deformation, which can cause significant structural damage to buildings. A land slip involves the geological separation and rolling of solid chunks of earth, which may hit and damage structures. An avalanche is the sliding of snow masses down mountain slopes.
- Earthquake: An earthquake is the natural shaking of the ground caused by geophysical processes inside the Earth, leading to destruction or damage to the insured property.

In the insurance industry, losses arising from natural disasters are categorized into two groups: natural disasters (in Slovenian: ujme) and so-called CAT events. CAT events (Catastrophic Events) are extreme occurrences where the financial damage exceeds a certain threshold, often defined by reinsurance agreements (e.g., 1 million EUR).

In Slovenia, insurance companies, offer protection against different natural disasters, with two key segments being particularly affected: Motor Comprehensive Coverage and Fire-Civil Insurance. Various insurers market Fire-Civil insurance products under different names, including Zavarovanje doma, Paket Dom, Dom, GRAWE DOM, Moj dom, etc. Despite the differences in branding, these policies typically provide coverage for comparable core risks, with optional add-ons available to meet the specific needs of policyholders.

In response to evolving consumer needs, insurers have also begun packaging these policies to include a broader range of risks and coverage amounts. This streamlined approach enables homeowners to protect both their residential property and its equipment with a single, comprehensive insurance policy.

2.3 Insurance Gap

Globally, there is a significant gap between total losses and insured amounts, known as the insurance gap. The impact of natural disasters on insurance companies varies depending on the extent of insurance coverage in the affected regions. In wealthier countries, a larger percentage of losses from natural disasters are typically insured compared to lower-income countries.

However, even in developed countries, there can be substantial insurance gaps for disaster losses, especially without compulsory or subsidized premiums (Kousky (2019)). To assess potential losses, insurers need to understand the average frequency of catastrophic events and focus on how much a region deviates from this long-term average (Benali & Feki (2017)).

According to European Insurance and Occupational Pensions Authority (EIOPA) (2024), Slovenia demonstrates notable gaps in coverage for certain perils, particularly floods and earthquakes. For flood risk, Slovenia is one of three countries, along with Romania and Croatia, showing a substantial insurance gap. This indicates that a significant portion of properties remains uninsured against pluvial and fluvial flooding. In the case of earthquakes, Slovenia ranks among countries with the highest insurance gaps, alongside Greece, Italy, Romania, and Bulgaria. Earthquake risk remains a critical concern across Europe due to low insurance penetration, driven by high premiums and limited consumer awareness. Greece and Italy, in particular, exhibit the highest overall scores for natural catastrophe insurance gaps, reflecting their combination of high hazard exposure and insufficient insurance coverage. For windstorms, the insurance gap across Europe is minimal. This is attributed to relatively high insurance penetration in areas of high windstorm risk. Similarly, Slovenia does not feature prominently in the wildfire category, where Southern European countries such as Portugal and Greece are most affected due to climate change-induced increases in wildfire frequency and intensity.

In light of these concerns and the August 2023 floods, the Insurance Supervision Agency conducted an in-depth assessment to evaluate the insurance gap for natural disaster risks in Slovenia (Agencija za zavarovalni nadzor (2024)). This evaluation employed three different methods to comprehensively estimate the extent of the gap.

The first method involved a direct comparison of data from the Statistical Office of the Republic of Slovenia (SURS) on the total number of houses and apartments in the country with the data on the number of active home insurance policies in 2023. The results show that only 21% of houses are fully insured, meaning that over three-quarters of houses lack adequate protection. Furthermore, 79% of houses lack earthquake insurance, and 65% are without flood insurance coverage. Notably, nearly one-third of houses have no home insurance at all. For apartment units, the insurance gap is even wider, reaching 87%;

approximately two-thirds of apartments are entirely uninsured, with only 17% carrying flood insurance.

The second estimation approach utilized data from the 2022 Household Budget Survey. According to this survey, 20% of homeowners had no expenditure on home insurance. For the remaining 80%, data from Slovenian insurers suggest that roughly half of the insured have flood insurance, while approximately one-third have earthquake insurance. These figures imply an insurance gap of 60% for flood coverage and 75% for earthquake coverage. Encouragingly, the percentage of households with no insurance expenditure has shown a downward trend, falling from over 25% in 2015 to just under 20% in 2022.

In the third approach, data on the claims paid by Slovenian insurers for damages from the August 2023 floods were compared with the government's estimates of actual building damages. The government estimates direct flood damage from August to total 384.7 million EUR for partially or completely destroyed buildings, with an additional 118.8 million EUR in partial damage. Slovenian insurers estimate that the total claims paid amount to 152.3 million EUR, underscoring the extent of the insurance gap for flood coverage.

The study also indicates that the lowest-income groups spend an average of 1.8% of their income on insurance, a share that decreases progressively among higher-income groups. Encouragingly, the rate of insurance coverage among the financially most vulnerable population is on the rise.

At the time of writing this master's thesis, the Slovenian government was exploring options to enhance collaboration with the insurance industry to address the issue of the insurance gap. One promising approach under consideration was parametric insurance, which could offer innovative ways to close this gap.

2.4 Managing Catastrophic Risks in Insurance

Natural disasters pose a growing threat globally, challenging the resilience of communities and the financial stability of insurers. Managing these risks requires a multifaceted approach that integrates efforts from insurance companies, public funding mechanisms, and government policies. This section explores the strategies employed by these stakeholders to mitigate the impact of catastrophic events.

Catastrophic risks pose significant challenges for insurers, including the potential for insufficient resources to cover large-scale losses and the impact on rate structures. In high-risk areas, catastrophes often lead to higher premiums, resulting in decreased loss ratios. However, when unforeseen and severe catastrophes occur, they can have broader effects, such as reducing the total premiums earned. This happens because fewer policies are

sold, as the increased cost of insurance may drive some customers away, and some insurers may withdraw from affected regions or even entire countries altogether (Born & Viscusi (2006)).

Insurance serves as a crucial tool in fostering resilience by providing financial protection, aiding post-disaster recovery, and incentivizing risk reduction efforts. However, maximizing its benefits requires comprehensive risk management supported by governments and stakeholders. Mitigating disaster threats involves a range of measures. For instance, insurance providers implement premium discount programs tailored to incentivize homeowners in high-risk areas to adopt specific mitigation measures, such as wildfire-resistant landscaping and seismic retrofitting for older structures. These initiatives not only enhance individual preparedness but also contribute to overall community resilience by reducing the likelihood of catastrophic losses during disasters.

Similarly in Slovenia, insurance companies implement various discount programs to encourage homeowners in high-risk areas to adopt risk-reduction measures. For example, auto insurers offer discounts to vehicle owners living in residential houses with garages or carports, reducing potential damage during severe weather events (Zavarovalno združenje Slovenije (2020)).

Insurers also provide flexible coverage options that promote sustainable building practices by offering lower premiums for properties that meet higher construction standards, such as flood-resistant designs or fireproof materials. Additionally, insurance companies advise homeowners on effective risk mitigation strategies, such as installing smoke detectors or reinforced doors to safeguard against water damage. Technological advancements, including smart home devices, allow insurers to customize policies based on individual risk profiles. Devices like smart thermostats help prevent freezing pipe by adjusting temperatures during extreme cold, while smart water heaters remind homeowners when maintenance is needed. Some insurance companies further enhance protection by offering real-time alerts for severe weather events, such as heavy rainfall or hailstorms.

Public funding initiatives drive forward hazard mitigation endeavors, spanning from bolstering infrastructure resilience to fostering community preparedness. Furthermore, incentive schemes stimulate homeowner engagement in risk reduction endeavors by offering financial rewards for proactive measures. Proposals advocating for loan-insurance linkages seek to streamline access to funding for mitigation investments. Governments also often act as a last-resort reinsurer for rare or uninsurable risks, focusing on risk management and reduction through regulatory measures and emergency planning (Born & Viscusi (2006) and Kousky (2019)).

While insurers manage and mitigate risk through pricing adjustments and incentive programs, governments play a crucial role in addressing catastrophic risks as well. Their

efforts often include implementing regulations that complement those of insurers, enhancing resilience on a larger scale. This is typically achieved through measures such as flood insurance mandates and the enforcement of stringent building codes designed to better protect structures from natural disasters.

In Slovenia, this need for robust disaster preparedness was underscored by the severe floods in 2023, which presented significant challenges for both the government and insurance companies. In response, the state provided higher compensation to insured individuals than to those without insurance, sending a clear message about the importance of adequate insurance coverage.

Since these floods, the Slovenian government has been intensively focused on improving preparedness for natural disasters. Part of this prevention strategy includes implementing flood protection measures and urban planning policies that ensure construction takes place only in safe areas. One example is the national flood protection plan for the Lower Savinja Valley, which aims to transition to a more sustainable and integrated management of waterways in light of climate change, thus enhancing resilience to extreme events (Slovensko Zavarovalno Združenje (2024b)).

Furthermore, both the insurance sector and the government are working towards a partnership model to enhance readiness for natural disaster risks. It is suggested that the state could assume coverage for extreme risks through tailored models, which would allow insurers to provide coverage for additional cases that are currently not insurable. Such a model could lower the cost of insurance products, reinforcing the idea that the state and insurance industry serve as complementary rather than substitutive forces in risk management. This integrated approach not only improves the viability of insurance products but also aligns with broader public funding initiatives aimed at hazard mitigation, emphasizing the shared responsibility between the state, public and the insurance sector in preparing for and responding to disasters (Slovensko Zavarovalno Združenje (2024a)).

In addition to that, Slovenia has a comprehensive disaster management system that emphasizes prevention, preparedness, response, and recovery, aiming to protect people, property, and the environment from natural disasters.

Before a disaster, Slovenia prioritizes prevention and preparedness through earthquake-resistant construction, flood control, public education, early warning systems, risk management plans and regular emergency drills. During a disaster, emergency response is managed 24/7 by the Center for Emergency Notification (CORS) and regional centers, coordinating firefighting, medical aid, and rescue efforts. After a disaster, focus shifts to providing relief such as food, shelter, and medical care—assessing damage, initiating reconstruction, and promoting long-term recovery and resilience.

The Administration of the Republic of Slovenia for Protection and Rescue (URSZR) coordinates disaster management, ensuring readiness and resource mobilization across sectors.

The floods of 2023 were not the first disaster to reshape the insurance sector in Slovenia. A pivotal moment in this regard came after the 1895 Ljubljana earthquake, which prompted the introduction of building regulations aimed at mitigating future earthquake risks. In 1963, earthquake-resistant design standards were established, updated in 1981 for high-rise buildings. In 2005, Slovenia adopted Eurocode 8 (EC8), transitioning fully by 2008. Since then, EC8 and the seismic hazard map have been the standard for construction. In 2011, ARSO released an updated seismic intensity map for civil protection (Uprava Republike Slovenije za zaščito in reševanje (2018)).

Recognizing that the future holds a projected increase in disaster risk, attributed to factors such as climate change and widespread development, the imperative for robust disaster risk management becomes apparent. Hence, proactive measures aimed at reducing disaster vulnerability and improving resilience are essential to effectively tackle the increasing challenges posed by natural disasters.

2.5 Reinsurance and Catastrophe Bonds

Reinsurance and catastrophe bonds (CAT bonds) play an essential role in risk management for insurance companies. This section explores these two distinct yet complementary mechanisms, explaining how they work together to help insurers manage potential losses from catastrophic events.

Reinsurance is a fundamental risk management tool in which insurers transfer portions of their risk portfolios to reinsurance companies, thereby sharing the liability in case of significant losses. A key form of reinsurance is Cat XL (Catastrophe Excess of Loss) reinsurance, a non-proportional method designed specifically for catastrophic events. Under Cat XL, insurers are protected when large-scale disasters cause numerous smaller claims, which collectively pose substantial liability. A distinguishing feature of Cat XL reinsurance is the definition of a claim event, where all disasters occurring within a pre-defined time window (typically 72 hours) are treated as a single event. This approach limits the insurer's exposure to cumulative losses from a single event (Zavarovalno združenje Slovenije (n.d.)).

Reinsurance is often structured to cover lower, more probable loss layers, with reinsurers typically responsible for a portion of these initial, smaller claims (Trottier & Lai (2017)). However, traditional reinsurance may carry certain limitations:

- Default Risk: Reinsurers themselves face default risk, which may impact their ability to pay out claims during severe events.
- High Premiums for Rare Events: Reinsurers tend to charge high premiums for low-probability, high-severity losses, limiting coverage for extremely rare but devastating events.

In Slovenia, the only two licensed reinsurance companies are Sava Re and Triglav Re, which play a key role in managing catastrophe risks through advanced reinsurance strategies.

According to the Solvency and Financial Condition Report of the Sava Insurance Group for 2022 the group employs non-proportional reinsurance coverages CAT XL, to protect both direct business within the group and accepted reinsurance business from outside the group (Sava Re d.d. (2023)).

In addition to CAT XL coverage, the group's earthquake insurance portfolio is secured through a quota share retrocession before the non-proportional coverage is triggered. This setup limits the group's maximum potential loss in a severe event to the CAT XL coverage priority amount, plus the cost of renewing the coverage. For group business, the CAT XL priority for the first loss event is set at 7.5 million EUR, with subsequent losses covered at a 5 million EUR priority. For accepted reinsurance business outside the group, the CAT program priority was reduced to 3 million EUR in 2022.

CAT bonds on the other hand are a type of Insurance-Linked Security (ILS) traded on the capital markets and are commonly used to supplement reinsurance. Issued by insurers, CAT bonds allow for direct capital market investment to cover catastrophe risk. They are structured so that, in the event of a specified catastrophic occurrence, bond investors might lose some or all of their principal, which is then used to cover the insurer's losses (Taylor (1999)).

Key benefits of CAT bonds include:

- Collateralization: CAT bonds are fully collateralized, reducing credit risk for insurers. This makes them a reliable form of capital, especially compared to traditional reinsurance.
- Higher Coverage for Severe Losses: Unlike reinsurance, CAT bonds are often designed to cover high-severity, low-frequency events, such as a catastrophic earthquake or hurricane.
- Diversification and Pricing Stability: CAT bonds provide insurers with additional capital sources and are less sensitive to the operational risks that traditional reinsurers face. They offer an opportunity for diversification and tend to offer more stable pricing over time.

In 2023, the CAT bond market saw record growth, driven by increased capital inflows and a surge in new issuances, particularly from sponsors seeking to expand their risk-bearing capacity. The total outstanding CAT bond volume reached 43.1 billion USD, reflecting the rising demand for alternative risk transfer instruments in an environment of escalating natural disasters (Hansen et al. (2024)).

2.6 Catastrophic Risk in Property Insurance

Based on Article 157, Paragraph 1, Point 12, and Article 501, Paragraph 1, Point 2, of the Insurance Act (Official Gazette of the Republic of Slovenia, No. 93/15) (Agencija za zavarovalni nadzor (n.d.)), the Insurance Supervision Agency has issued a decree regarding the application of the Property Insurance Catastrophe Risk Submodule. This decree establishes clear guidelines and standards for effectively managing the risks associated with catastrophic events and liability. In this context, several key definitions are provided:

- Cumulative Catastrophic Event: A catastrophic event impacting multiple insurance policies, where the effects on individual policies cannot be easily determined.
- Individual Catastrophic Event: A catastrophic event affecting multiple insurance policies collectively, where the effects on individual policies can be easily determined, or a catastrophic event impacting only a single policy;
- 200-Year Catastrophic Event: A catastrophic event corresponding to the value-at-risk threshold with a 99.5% confidence level.

Insurance companies classify losses considered under the property insurance catastrophe risk submodules as resulting from either a ”cumulative catastrophic event” or an ”individual catastrophic event.” The insurer also determines whether these events affect specific known insurance policies.

When calculating losses due to natural disasters in European Economic Area (EEA) regions, insurers consider whether there was one major event or two, affecting one or multiple regions. So rather than assuming multiple catastrophic events across each region, they focus on a limited number (one or two) impacting broader areas. For regions outside the EEA, if there isn't already a specified number of natural disaster events to calculate risk, insurers will distribute the potential loss for events like storms, hail, and floods across two separate events. This approach mirrors what they do within the EEA, providing consistency. When insurers have flexibility in determining how many rare catastrophic events they should consider, they will choose the event that, after applying risk mitigation techniques (like reinsurance), requires the largest capital buffer. This ensures that the insurer is adequately prepared for the most financially significant potential event.

When insurers can't pinpoint which insurance policy a gross loss impacts, they use reinsurance to divide the loss into parts using one of these methods:

- Largest Contribution Method: Assign the gross loss to the component that contributes the most.
- Allocation Method: Spread the gross loss across components based on their contributions before allocation, or use a similar breakdown approach as for capital requirements.
- Combination Method: Choose between the two methods above, whichever requires higher capital after reinsurance.

Insurers must apply reinsurance protection at one of several specified levels. These levels include different zones within a single region, various regions, and a distinction between countries that are part of the European Economic Area (EEA) and those that are not. Additionally, insurers can categorize their coverage by different catastrophe sub-modules or differentiate between various types of disaster risks, such as annual loss limits or risks associated with human and natural disasters.

Insurers can include reinsurance premiums in their financial calculations if they demonstrate to the insurance supervisory authority that these premiums stem from a gross event defined in the catastrophe sub-module. This allows for a proper reflection of reinsurance costs. Additionally, insurers must consider potential exposures to other or subsequent events arising from reinsurance activities when calculating overall losses, ensuring a complete assessment of financial impacts. Consequently, they are required to account for reinsurance premiums or other cash flows from reinsurance protection, integrating all related financial aspects into their statements.

Insurers must determine the level of required solvency capital for the property insurance catastrophe sub-module at which they will apply aggregate reinsurance contracts, considering risk reduction techniques and expected returns from reinsurance in the event of a gross event. When combining the required solvency capital across different property insurance catastrophe sub-modules, insurers need to separate reinsurance costs from receipts. If reinsurance isn't applied at a specific level for the combined amount, costs should be allocated using a suitable distribution method.

3 DATA SOURCES

In this section, we will describe the data sources that are used to analyse the effects of natural disasters on the insurance industry in Slovenia. The data encompasses both insurance-related statistics and records of natural disasters.

To thoroughly examine the influence of natural disasters on the insurance sector, data has been primarily drawn from the Geographic Atlas of Natural Disasters in Slovenia (Geografski atlas naravnih nesreč v Sloveniji) (Komac et al. (2023)). This comprehensive dataset documents various natural disasters, including floods, earthquakes, droughts, and other significant events in Slovenia. It provides valuable insights into the frequency, magnitude, and geographic distribution of these events, all of which are essential for assessing their impact on insurance claims and overall market dynamics.

In addition to the Geographic Atlas, we have consulted various other sources to enrich our analysis. These include detailed reports on economic losses from climate-related events in Europe ("Economic losses from climate-related extremes in Europe (1980-2022)" (2023)).

The primary data on insurance is sourced from the Slovenian Insurance Association (Sistat (2023), Slovensko Zavarovalno Združenje (n.d.), and Slovensko zavarovalno združenje (2014a, 2014b, 2014c)), available through their official statistics portal zav-zduzenje.si. The data is also extracted from the Statistical Insurance Bulletin (Statistični zavarovalniški bilten), which provides comprehensive information on various insurance metrics such as the number of policies, premiums, claims, and market shares of different insurance companies operating in Slovenia.

4 ANALYSIS OF NATURAL DISASTERS DATA

Understanding the frequency and severity of natural disasters is crucial for assessing their economic consequences, particularly in the insurance sector. The first part of this section is based on data from CATDAT, provided by RiskLayer GmbH, which systematically tracks economic losses and fatalities caused by weather- and climate-related extremes across EEA member countries ("Economic losses from climate-related extremes in Europe (1980-2022)" (2023)). This dataset covers the period from 1980 to 2022 and includes breakdowns by country, EU-27, and the EEA-32 region. The analysis highlights that hydrological (e.g., floods), meteorological (e.g., storms), and climatological (e.g., heatwaves and droughts) hazards are the primary drivers of financial losses, both insured and uninsured, measured in million EUR (2022 prices).

Across the European Union (EU), economic losses from climate-related extremes have escalated over time. The annual average economic losses (in constant 2022 EUR prices) have increased from 8.5 billion EUR in the 1980s to 44.5 billion EUR during 2020-2023. The highest losses occurred in 2021 (63.0 billion EUR), 2022 (56.0 billion EUR), and 2002 (45.7 billion EUR). The increasing trend is attributed to both the growing frequency and intensity of extreme events, driven by human-induced climate change, and the rising value of assets in vulnerable areas.

Slovenia exhibits particularly high economic losses per capita (8,693 EUR) and per square kilometer (862,448 EUR), ranking among the top three EU countries in both metrics. This heightened vulnerability is due to its geographic and climatic conditions, which make it susceptible to floods, storms, and other extreme events. Slovenia's challenges mirror broader European trends, where hydrological hazards (e.g., floods) account for the largest share of losses, followed by meteorological events (e.g., storms) and climatological events (e.g., heatwaves and droughts).

Despite its high losses, Slovenia has one of the lowest insurance coverage rates in the EU, with less than 2% of total losses being insured. This contrasts starkly with countries like Denmark and Luxembourg, where over 35% of losses are insured. The limited insurance coverage in Slovenia exacerbates the financial burden on individuals and public finances.

To better understand the historical context and frequency of natural disasters in Slovenia, we also rely on data from the Geographic Atlas of Natural Disasters in Slovenia (Komac et al. (2023)). This dataset spans the period from the 14th century to 2022 and includes detailed records of natural disasters that have occurred across Slovenia. For our analysis, we will focus on the records from 1980 to 2022, which will allow us to examine trends in the frequency and distribution of natural disasters over this period.

The summary statistics (Table 1) revealed several key insights into the frequency and types of natural disasters during the observation period (Komac et al. (2023)).

Table 1: Average and standard deviation of natural disasters (1980–2022, 2014–2022).

Disaster	**Mean 80–22**	**SD 80–22**	**Mean 14–22**	**SD 14–22**
Flood	0.79	1.42	1.22	2.28
Sea Flooding	0.26	0.49	0.56	0.53
Sleet	0.09	0.29	0.11	0.33
Landslide	0.77	1.07	0.78	0.67
Avalanche	1.00	1.72	0.22	0.44
Strong Wind	0.28	0.63	0.33	0.50
Earthquake	0.09	0.29	0.11	0.33
Warm Weather	0.47	0.67	0.44	0.73
Cold Weather	0.58	1.72	0.22	0.44
Heavy Rain	0.42	1.18	0.33	0.71
Tornado	0.09	0.29	0.00	0.00
Storm	1.12	1.55	1.56	1.42
Heavy Snowfall	0.61	1.16	0.56	0.73
Lightning	0.02	0.15	0.00	0.00
Collapse	0.37	0.62	0.00	0.00
Forest Fire	2.35	4.13	1.00	1.32
Debris Flow	0.05	0.31	0.00	0.00
Hail	0.19	0.50	0.33	0.71
Windthrow	0.02	0.15	0.00	0.00
Thunderstorm Gust	0.02	0.15	0.00	0.00
Drought	0.02	0.15	0.00	0.00
Heat Wave	0.07	0.26	0.22	0.44

Source: Own work.

- Average Occurrence: On average, approximately 9.67 natural disasters occur annually in Slovenia. This indicates a consistent exposure to various natural events, highlighting the relevance of insurance coverage in mitigating the impacts of these occurrences.
- Most Frequent Disasters: The most common type of natural disaster recorded was forest fires, with an average of 2.35 incidents per year. Over the entire period (1980-2022), there were a total of 101 forest fires, making it the most significant contributor to natural disaster events in Slovenia.
- Other Notable Disasters: Floods are also frequent, with a mean occurrence of 0.79 per year, totaling 34 instances over the period. In contrast, other types of disasters, such as landslides, snow avalanches, and strong winds, occurred less frequently, with median values close to zero.
- Distribution of Events: The data show a wide range in the number of incidents per year for different disaster types. For example, the highest number of forest fires in a single year was 19, while for other events, such as landslides and strong winds, the numbers were significantly lower.

4.1 Total Number of Natural Disasters Over Time

In this section, we analyze the most significant variations in the dataset (Komac et al. (2023)) by identifying years with the highest and lowest numbers of natural disasters, and by exploring trends in these variations.

We began by identifying the years with the highest and lowest disaster counts. The year with the highest number of disasters recorded is 2003, with a total of 28 events. In contrast, the lowest number of disasters recorded is 1, which occurred in the years 1981, 1988, 1991, and 1992.

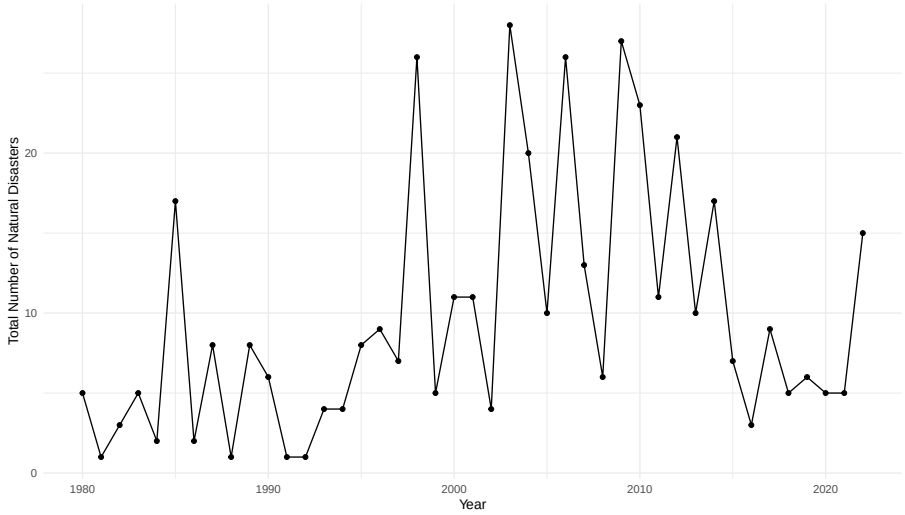
To investigate the overall trend in the number of natural disasters, we plotted the total number of disasters for each year (Figure 1). This graph illustrates considerable fluctuations, with large variations in the annual disaster counts. The noticeable irregularities suggest that the number of disasters does not follow a consistent pattern and shows considerable variability from year to year.

To identify long-term trends and smooth out short-term fluctuations, we calculate a moving average. A moving average helps to smooth out short-term fluctuations by averaging values over a specific period, allowing us to observe broader trends without the noise of annual variability. For this analysis, we used a 5-year moving average (Figure 2).

The plot in Figure 2, despite smoothing out short-term fluctuations, still reveals considerable variability over the years. While some periods show higher average disaster counts,

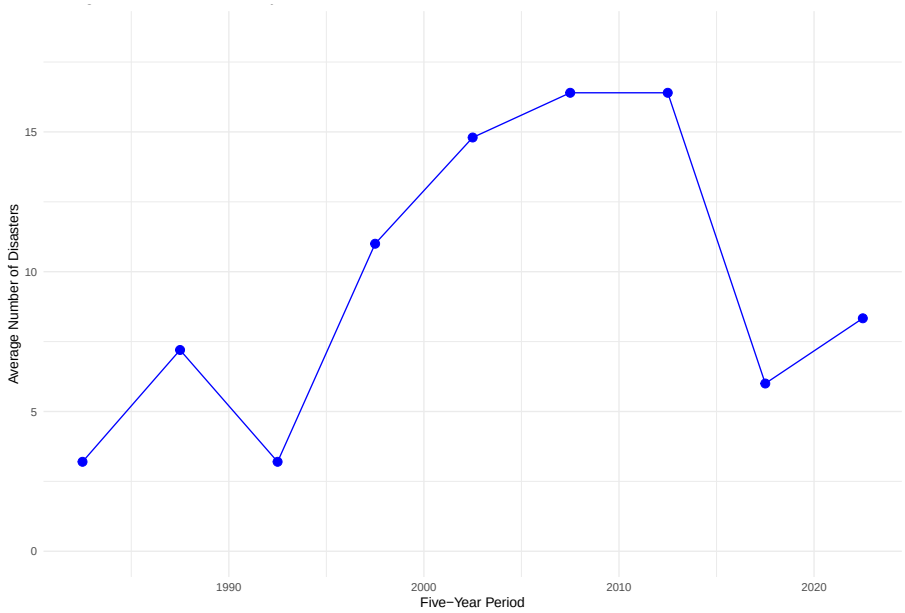
there is no consistent upward or downward trend. This suggests that the number of natural disasters does not follow a clear long-term pattern of increase or decrease, but rather exhibits fluctuations across different periods.

Figure 1: Total number of natural disasters over the years.



Source: Own work.

Figure 2: Average number of disasters by five-year periods.



Source: Own work.

4.2 Correlation Analysis

This section explores the correlation between different types of natural disasters to determine if certain disasters tend to occur together. This type of analysis is particularly

important in the context of insurance, as understanding correlations can inform risk assessment and help insurers manage potential exposure to multiple correlated risks. For instance, if an insurance policy covers natural disasters that are highly correlated, such as heavy rainfall and floods or droughts and wildfires, the insurer may face a higher financial risk. When two or more disasters are likely to occur together, the cumulative damage caused by these events can result in significant claims that exceed expectations, thereby threatening the insurer's stability. Conversely, disasters with low or negative correlations may offer more manageable risk profiles, as the occurrence of one type of disaster does not significantly increase the likelihood of others happening simultaneously.

The analysis of high correlations (greater than 0.50) revealed several significant relationships (Komac et al. (2023)):

- Heavy Snowfall and Snow Avalanches: Heavy snowfall increases the amount of snow accumulation on slopes, which can create unstable snowpacks. As a result, when the snow accumulates to a certain threshold, it is more likely to trigger avalanches. Thus, the correlation between these two events is moderate (0.53), as a significant amount of snow is often required before avalanches occur.
- Drought and Snow Avalanches: The correlation between droughts and snow avalanches (0.55) might seem counterintuitive at first. However, prolonged droughts can affect snowpack stability by altering temperature patterns. When a region experiences a drought, the ground and atmosphere may become drier and warmer, impacting how snow settles and bonds. As a result, when snowfall finally occurs, the snowpack may be weaker and more prone to avalanches, especially during sudden shifts from dry to wet conditions.
- Drought and Sea Floods: A moderate to high positive correlation (0.55) suggests that droughts are frequently associated with sea floods. The combination of low water storage capacity during droughts, sudden increases in runoff, coastal erosion, and rising sea levels can create conditions that make coastal areas more vulnerable to flooding once the drought ends.
- Heavy Rainfall and Floods: This correlation is more straightforward, as heavy rainfall often leads to soil saturation, reduced water absorption, and the overflow of rivers and streams, directly resulting in floods. The moderate to high correlation (0.56) reflects the natural sequence where excessive rain leads to flooding in vulnerable areas.
- Drought and Hail: Drought conditions can lead to higher levels of atmospheric instability, especially in the presence of thunderstorms, which can result in the formation of hail. Warm, dry conditions create the right environment for the development of strong updrafts in storms, causing hailstones to form. This is why the positive correlation (0.57) between droughts and hail is relatively high.
- Windfall and Heavy Snowfall: The highest positive correlation (0.73) is between windfall and heavy snowfall. Windfall refers to strong winds causing trees or other structures

to fall, while heavy snowfall creates heavy, wet conditions that increase the likelihood of wind and snow-related damage. The strong correlation between these two suggests that in areas where heavy snowfalls occur, wind gusts tend to be stronger, leading to increased instances of windfall.

The analysis of low correlations (less than -0.15) revealed several weak or negative relationships (Komac et al. (2023)):

- Frost and Sea Floods: The low negative correlation (-0.15) between frost and sea floods suggests that these events are unlikely to occur together. Frost typically occurs in colder temperatures and is associated with clear skies, dry air, and low humidity. On the other hand, sea floods are usually the result of high tides, storms, or storm surges, which are more likely to occur during warmer and wetter conditions. Therefore, the occurrence of frost, which usually happens in colder periods, tends to coincide with times of reduced storm activity, thus reducing the likelihood of simultaneous sea floods.
- Tornado and Sea Floods: Similarly, the low negative correlation (-0.17) between tornadoes and sea floods indicates that these two events rarely occur at the same time. Tornadoes are localized, highly intense storms that develop under specific atmospheric conditions, such as warm, humid air colliding with cold, dry air. Tornadoes tend to occur inland, where the necessary conditions for their formation are more likely. Sea floods, however, typically result from coastal storm surges, high tides, or extreme weather systems.
- Landslides and Sea Floods: There is a low negative correlation (-0.16) between landslides and sea floods, because landslides are typically triggered by factors like heavy rainfall, seismic activity, or rapid snowmelt, often in mountainous or hilly terrain.
- Forest Fires and Sea Floods: During times of drought, when forest fires are most likely to occur, sea floods are less common because they are associated with periods of excess water, such as storms or floods. This lack of overlap in conditions contributes to the low negative correlation (-0.20) between forest fires and sea floods.
- Heavy Snowfall and Sleet: Heavy snowfall typically happens when temperatures are below freezing, and snowflakes form in cold air. Sleet, on the other hand, occurs when raindrops freeze before reaching the ground, which usually happens when the air is cold but not freezing at the surface. For sleet to form, the atmosphere needs to have a temperature inversion, where the higher atmosphere is warmer than the surface. This makes the simultaneous occurrence of heavy snowfall and sleet uncommon, leading to negative correlation (-0.17).
- Landslides and Sleet: When sleet occurs, the freezing ground reduces the amount of water that can seep into the soil, making landslides less likely. Thus, the conditions needed for both events are often not conducive to one another, leading to a negative correlation (-0.20).

- Forest Fires and Sleet: Similarly, a low negative correlation (-0.17) is noted between forest fires and Sleet.
- Strong Winds and Landslides: A low negative correlation (-0.19) is observed between strong winds and landslides. Strong winds can cause tree damage or soil erosion, but they are less likely to directly trigger landslides, which generally require heavy rainfall or other specific conditions.

4.3 Distribution Analysis

Natural disasters follow a specific distribution, as most events occur in the summer months, from June to August, although events may still arise in other months. In this section, we analyse the distribution of the total number of natural disasters. The aim is to identify the best-fitting probability distribution for our data.

Based on the analysis, the data on the number of natural disasters, obtained from Geographic Atlas of Natural Disasters in Slovenia (Komac et al. (2023)), follow a negative binomial distribution with the following estimated parameters:

- Shape parameter or the target number of successes: 1.94, indicating the dispersion level of the distribution.
- Mean Parameter: 9.68, representing the expected number of natural disasters.

The standard error for the size parameter is approximately 0.50, which accounts for about 25% of the estimated value. This suggests a moderate level of uncertainty in estimating dispersion. Meanwhile, the standard error for the mean parameter is around 1.16, indicating a relatively precise estimation of the expected number of events.

In summary, the negative binomial distribution appears to be a good fit for modeling the total number of natural disasters, capturing both the overdispersion and variability observed in the data.

5 ANALYSIS OF INSURANCE CLAIMS RELATED TO NATURAL DISASTERS

Continuing from the previous section, we now turn our focus to the financial impact of natural disasters, specifically the number of insurance claims they generate.

5.1 Analysis of Number of Insurance Claims Related to Natural Disasters

The primary focus of this analysis is the dataset of losses from natural disasters (Slovensko Zavarovalno Združenje (n.d.)), which provides detailed information on damages from natural disasters across various insurance types during the period from 2014 to 2022. The insurance types under consideration include (Slovensko Zavarovalno Združenje (n.d.)):

- Insurance of land motor vehicles,
- Aircraft insurance,
- Marine insurance,
- Goods in transit insurance,
- Insurance against fire and natural forces,
- Other damage insurance,
- Miscellaneous financial loss insurance.

We begin our analysis by calculating the key statistical indicators for each type of natural disaster over the period from 2014 to 2022 (Slovensko Zavarovalno Združenje (n.d.)).

- Hail: The number of hail-related insurance claims averages 13,938.3 per year, but this figure varies significantly, as shown by a standard deviation of 5,724.7. The highest number of claims was filed in 2022, with 21,423 claims, while the lowest occurred in 2014, with just 4,609 claims.
- Storm Wind: Number of claims due to windstorms average 12,932.0 per year, with a standard deviation of 7,486.5. The most claims were filed in 2017 (28,646), and the fewest in 2021 (5,758).
- Lightning Strike: The average number of lightning strike-related insurance claims is 8,929.9 per year, with a standard deviation of 2,321.5, showing moderate variability. The highest number of claims occurred in 2014, with 12,189 claims, and the lowest in 2021, with 5,653 claims.
- Flooding: Number of claims due to Flooding average 3,990.1 per year, with substantial variability (standard deviation of 3,004.3). The highest number of claims occurred in 2014 (11,435), and the lowest in 2015 (808).
- Fire: The average number of fire-related insurance claims is 2,237.9 per year, with a standard deviation of 136.2, indicating low variability. The highest number of claims was recorded in 2019, with 2,519 claims, while the lowest occurred in 2015, with 2,101 claims.
- Storm: The number of storm-related claims averages 874.3 per year, with a standard deviation of 306.9. The highest number of claims occurred in 2018 (1,365), and the lowest in 2015 (482).

- Snow Load: Number of claims related to the weight of snow average 270.7 per year, with a standard deviation of 396.9. The highest number of claims was recorded in 2014 (1,185), and the lowest in 2019 (36).
- Landslide: Landslides average 110.3 claims annually, with a standard deviation of 35.7. The highest number of claims was recorded in 2014 (193), and the minimum in 2015 (72).
- Spring Frost: Number of spring frost claims average 108.2 annually, with a standard deviation of 85.9. The highest number of claims occurred in 2021 (234), and the minimum in 2022 (21).
- Earthquake: The average number of earthquake-related insurance claims is 82.6 per year, with significant variability, as reflected by a standard deviation of 146.5. The highest number of claims was filed in 2020, with 464 claims, while the lowest occurred in 2017, with just 4 claims.
- Glaze Ice: The number of Glaze ice claims average 57.9 annually, with a standard deviation of 128.9. The highest number of claims occurred in 2014, totaling 401, while the fewest claims were recorded in 2019, with only 5.
- Extreme Temperature: The average number of claims related to extreme high or low temperatures is 6.6 per year, with a standard deviation of 6.9, indicating considerable variability. The highest number of claims was recorded in 2014, with 24 claims, while the lowest occurred in 2022, with just 1 claim.
- Total Claims: In total, the number of claims across all categories averages 43,538.8 per year, with a standard deviation of 9,924.9. The highest number of claims was recorded in 2017, totaling 59,599, while the fewest claims were filed in 2015, with 28,091 claims.

The analysis of these data (Slovensko Zavarovalno Združenje (n.d.)) reveals several key findings regarding the number of insurance claims due to natural disasters. In 2017, the number of insurance claims related to natural disasters reached its peak, largely driven by severe storms and widespread fires. One of the most impactful events that year was an intense drought, officially declared a natural disaster, which caused significant damage to agriculture, with losses exceeding 65 million EUR. This drought mainly affected the eastern, southern, and southwestern regions of Slovenia, exacerbating fire risks in already dry landscapes (Cegnar et al. (2022)).

In 2017, wildfires burned an area of 1,684 hectares, significantly exceeding other years. Notable wildfires included the March 28 fire near Bač in Ilirska Bistrica, which scorched 137 hectares, the August 3 fire between Divača and Rodik, covering 95 hectares, and the August 6 fire in the municipality of Komen, which burned 116 hectares.

On the other hand, the year with the fewest reported claims was 2015. Many natural disasters, including floods and fire, had their minimum values in this year, making it the period with the lowest overall claims.

Among the different types of natural disasters, hail stands out as the one with the highest average number of claims, averaging 13,938.3 claims per year. In contrast, extreme temperature-related claims are the least frequent, with an average of only 6.6 claims per year, indicating that these events are relatively rare or less impactful in terms of insurance claims.

In terms of variability, certain natural disasters show a large fluctuation in the number of claims from year to year. For instance, flooding has a substantial standard deviation of 3,004.3. Similarly, storm wind claims have a very high standard deviation of 7,486.5, reflecting considerable year-to-year differences. While glaze ice has a relatively low average number of claims (57.9), it has a high standard deviation of 128.9, indicating that in certain years, this disaster can result in a disproportionately high number of claims. Unlike other disasters, the consistency in fire claims indicates that fire risks are relatively predictable.

The analysis of the Škode iz naslova naravnih nesreč dataset (Slovensko Zavarovalno Združenje (n.d.)) reveals that hail and storms are the most significant contributors to insurance claims, both in terms of frequency and variability. This suggests that insurance products related to these natural disasters require careful risk assessment and premium pricing strategies. The high variability observed across different types of natural disasters underscores the importance of continuous monitoring and adjustment of insurance policies to account for changing patterns in natural disaster occurrences.

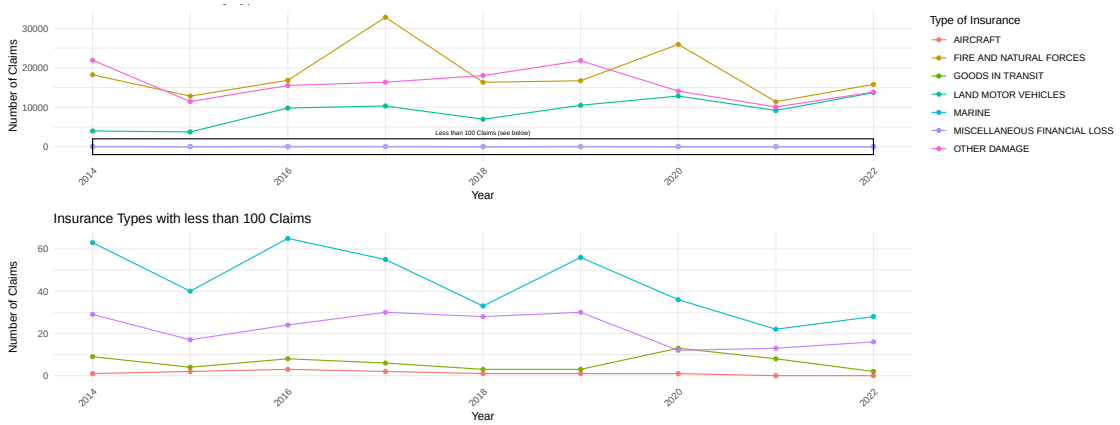
5.1.1 Trend of Claims Across Different Insurance Types

The objective of this analysis was to examine how the trend of insurance claims by insurance type has evolved over time (Slovensko Zavarovalno Združenje (n.d.)). Specifically, we aim to analyse the annual data on insurance claims segmented by different types of insurance. As well as identify trends in the frequency and amount of claims for various types of insurance over the years.

The graph in Figure 3 illustrates the number of insurance claims across different types of insurance over the years. The most noticeable trend is the substantial fluctuations in claims related to specific types of insurance, particularly in the years 2014, 2017, and 2022.

Fire and elemental damage insurance shows the highest number of claims overall, with notable peaks in 2017 (32,823 claims) and 2020 (25,956 claims). After a peak in 2017, there was a drop in 2018, followed by fluctuations up to 2022. The exceptionally high number of claims in 2017 can be attributed to severe weather events, particularly storms and hail. In that year, storms caused 28,646 reported damages, significantly higher than in any other year. Hail also contributed substantially, with 8,718 claims.

Figure 3: Trend of insurance claims by type.



Source: Own work.

Another line of business with consistently high claim numbers, especially in the earlier years (over 21,000 in both 2014 and 2019) is other damage insurance. The claims in this category decline notably after 2020, with a minimum in 2021 (10,079 claims). Insurance of Land Motor Vehicles had an increase of the number of claims, starting from 3,987 in 2014 to a peak of 13,698 in 2022. This upward trend may be partially influenced by extreme weather events, particularly hail and storms, which can cause significant damage to vehicles. For instance, in 2016 and 2017, hail-related claims were notably high, with 18,083 and 15,941 reported cases, respectively. Similarly, in 2022, hail caused 21,423 claims—the highest in the observed period—likely contributing to the peak in vehicle insurance claims that year. Additionally, the increase could reflect a growing number of insured vehicles, higher traffic density, or changes in claim reporting practices.

The number of claims for marine insurance is much lower compared to other categories, generally remaining below 70 annually. The numbers fluctuate but show no clear upward or downward trend, suggesting a stable but relatively low-risk profile for this type. Similarly insurance of various financial losses has consistently low claim numbers, fluctuating between 12 and 30 annually. These lower values could reflect a niche market. Number of Aircraft claims are rare, with values mostly between 0 and 3 claims per year. The number of claims for Goods in transit insurance are also relatively low but show some variability, peaking at 13 in 2020 and then dropping in subsequent years.

5.1.2 Frequency of Damages for Different Types of Insurance

In this section, we analyse which types of insurance are most frequently affected by specific natural disasters (Slovensko Zavarovalno Združenje (n.d.)). The goal was to identify and quantify the insurance types that experience the highest frequency of claims for each type of natural disaster.

Table 2 lists the insurance types most affected by each type of natural disaster, along with the total number of claims reported for insurance coverage specifically due to particular natural disasters during the period from 2014 to 2022 (Slovensko Zavarovalno Združenje (n.d.)).

Table 2: Most affected insurance types for various natural disasters.

Natural Disaster	**Insurance Type**	**Total Number of Claims**
Storm	Fire insurance	75,354
Hail	Casco (road vehicles)	66,585
Lightning	Home insurance	50,105
Flood	Home insurance	16,896
Fire	Fire insurance	9,457
Windstorm	Fire insurance	3,551
Snow load	Fire insurance	1,029
Spring frost	Crop insurance	881
Sleet	Fire insurance	371
Earthquake	Fire insurance	286
Landslide	Fire insurance	251
Extreme temperature	Machinery breakdown	19

Source: Own work.

- Storms and hail are among the most frequently reported natural disasters, with specific insurance types such as fire insurance and comprehensive insurance for road motor vehicles being particularly impacted.
- Lightning strikes and floods also result in a significant number of claims, with home insurance being most frequently affected by these events.
- Snow load and spring frost have a relatively lower frequency of claims compared to more common natural disasters like storms and hail.
- Extreme temperature events are reported with the lowest frequency of claims, suggesting they are less common or have less impact compared to other types of natural disasters.

To further explore the impact of natural disasters on insurance types, we analysed the average number of claims for the most common natural disasters (Slovensko Zavarovalno Združenje (n.d.)). Fire and Natural Forces insurance experienced the highest number of claims, primarily due to windstorms, with a total of 80,182 claims and an average of 8,909 per windstorm event. This aligns with the fact that "Insurance against fire and natural disasters" is the most widely held insurance type. This relationship will be further examined in Section 5.6, where we analyze the patterns and trends in insurance claims related to natural disasters.

Similarly, Land Motor Vehicles insurance was heavily impacted by hail, resulting in 66,640 claims and an average of 7,404 per event. Other Damage insurance, mainly affected by lightning strikes, recorded 61,711 claims, averaging 6,857 per event. In contrast, Marine insurance had fewer claims, with 285 cases of windstorm-related damages and an

average of 32 per event. Goods in Transit and Miscellaneous Financial Loss insurance reported fewer claims, with fire being the predominant cause. Overall, the findings indicate that windstorms and hail are among the most frequent and impactful natural disasters in terms of insurance claims, particularly in fire and motor vehicle-related policies.

5.1.3 Comparison of Reported Number of Claims and Number of Claims Due to Natural Events Across Different Insurance Types

This section aims to compare the reported number of all claims (Slovensko zavarovalno združenje (2014a)) and claims due to natural events (Slovensko Zavarovalno Združenje (n.d.)) across different insurance types over several years. The goal is to analyse the proportion of these claims relative to the total number of insurance claims within each insurance type.

If the claims were divided into categories such as:

- ATTR – Attritional claims: Smaller claims not classified as natural disasters or large claims.
- Natural Disasters – Claims classified as natural disasters but not as CAT events.
- CAT – Catastrophe claims: Claims classified as natural disasters where the total claim amount for a single event date exceeds a predefined threshold, indicating catastrophic events.

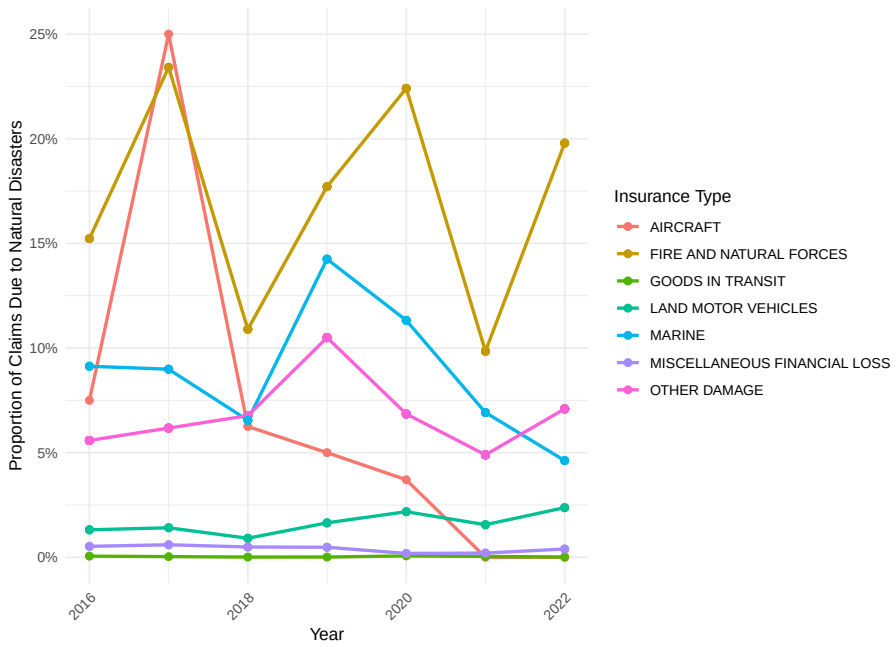
We would notice that the ATTR claims remain relatively stable over the years, with smaller fluctuations. In contrast, Natural Disasters and CAT claims show more pronounced volatility, especially in certain years. CAT claims, in particular, are highly impacted by major natural events, leading to significant peaks in claims numbers during catastrophic years, such as 2017.

Figure 4 presents a line chart that illustrates the proportion of reported number of claims due to natural events across different insurance types. The chart demonstrates the varying impact of natural events over time on different types of insurance.

- Insurance against fire and natural forces consistently exhibits the highest proportion of claims caused by natural disasters. The peak occurs in 2017 with over 25%, followed by fluctuations in subsequent years. By 2022, the proportion is nearly 20%. This aligns with the finding from Section 4, which highlights that the number of natural disasters reached its peak during the year 2017.
- Marine Insurance shows notable volatility, with a significant peak in 2019 at over 25% and a sharp decline afterward. By 2022, the proportion has decreased significantly, indicating a lower impact of natural disasters in recent years.

- Other Damage Insurance displays a steady increase, starting at around 5% in 2016 and reaching 10% in 2019. This suggests a growing trend of natural disaster-related claims in this category.
- Motor Vehicle Insurance shows a stable but gradual increase in claims related to natural disasters, starting with around 1% in 2016 and rising to over 2% in 2022.
- Aircraft Insurance and Goods in transit insurance consistently have low proportions of claims caused by natural disasters, with occasional small spikes in certain years.
- Various Financial Loss Insurance has consistently low proportions of natural disaster-related claims throughout the period, indicating that this type of insurance is less impacted by such events.

Figure 4: Proportion of reported number of claims due to natural disasters by insurance type.



Source: Own work.

5.2 Analysis of Insurance Payouts

This subsection analyzes insurance payouts related to natural disasters, focusing on trends, effectiveness, and financial impact. We begin with basic statistics to understand the data, then assess whether payouts are rising or falling over time. We compare average and total payouts across insurance types to identify financial strain and risk exposure. The analysis will also compare the total gross insurance payouts with the frequency of claims, explore how payouts are distributed, and whether certain events or insurance categories are more affected. We examine correlations between damages and payouts, highlight anomalies, and assess the evolving financial impact of disasters on individuals and legal entities.

We will primarily focus on data from the period 2014 to 2022, as detailed in (Slovensko Zavarovalno Združenje (n.d.)).

5.2.1 Statistics of Payouts by Natural Disasters

In this section, we will perform an analysis of basic statistical indicators related to insurance payouts (Slovensko Zavarovalno Združenje (n.d.)). We also identify the years in which these minimum and maximum payouts occurred and calculate the difference between the minimum and maximum payoff values for each insurance type to understand the variability in the data (Table 3).

Table 3: Summary of payouts by type of natural disaster.

Variable	**Mean**	**SD**	**Min**	**Max**	**Min Year**	**Max Year**
Storm	901,664	296,566	401,662	1,312,698	2015	2016
Landslide	519,429	278,036	173,888	1,041,706	2020	2016
Flood	7,159,061	5,799,834	1,300,948	21,345,547	2015	2014
Earthquake	91,396	172,396	3,501	540,751	2019	2020
Fire	25,072,875	6,523,156	16,729,874	36,228,454	2016	2021
Spring frost	1,956,555	2,391,527	77,517	6,608,733	2018	2017
Snow Load	567,606	844,790	45,161	2,541,424	2019	2014
Hail	24,457,954	12,072,899	6,992,579	45,906,974	2015	2022
Lightning	4,883,090	1,027,783	3,409,036	6,216,226	2021	2019
Windstorm	11,534,031	7,770,925	4,749,930	28,885,075	2021	2017
Extreme temperature	198,646	514,204	876	1,565,683	2016	2021
Sleet	2,403,929	6,930,174	10,526	20,882,882	2020	2014
ALL	79,749,903	18,204,821	38,758,691	98,534,904	2015	2022

Source: Own work.

Our analysis reveals the following key findings. Firstly, we identified the two natural disasters with the highest average payout. The types with the greatest average payout are Fire and Hail, with average payouts of 25,072,875 EUR and 24,457,954 EUR, respectively. Specifically, fire was the leading cause of significant payouts across various property and business insurance types, while hail was particularly damaging for certain types of vehicle and crop insurance. Conversely, the natural disaster causing the least average payout is Earthquake, with 91,396 EUR.

We also examined the difference between the minimum and maximum payouts for each natural disaster, uncovering the natural disaster with the greatest variability. Hail stands out with the highest difference of 38,914,395 EUR, indicating significant fluctuations in the payout amounts.

Additionally, our analysis revealed that the year 2014 saw the most frequent occurrence of maximum payout values, highlighting it as the year with notably high payouts. Moreover, the natural disaster with the highest standard deviation, reflecting the greatest variability in payouts, is Snow Load with a standard deviation of 12,072,900.

5.2.2 Trends and Variability in Insurance Payouts

In this section, we examine how insurance payouts have evolved over time and identify insurance types with the greatest variability in payouts (Slovensko Zavarovalno Združenje (n.d.)). We identified several insurance types with notably high or low average payouts. The insurance type with the highest average payout is fire insurance and insurance against certain other non-industrial and non-commercial hazards, with an average payout of 4,229,264 EUR. This is followed by comprehensive insurance for road motor vehicles, excluding rolling stock, which has an average payout of 2,023,250 EUR. Fire insurance and insurance against certain other industrial and commercial hazards also show substantial average payouts, reaching 1,710,374 EUR. Home insurance follows closely with an average payout of 1,419,010 EUR, and crop and fruit insurance rounds out the top five with an average payout of 937,585.3 EUR.

On the other hand, some insurance categories exhibit minimal or no average payouts. Travel insurance, all other watercraft insurance, insurance against hazards in postal and telecommunications traffic, and insurance against burglary and robbery all report an average payout of zero.

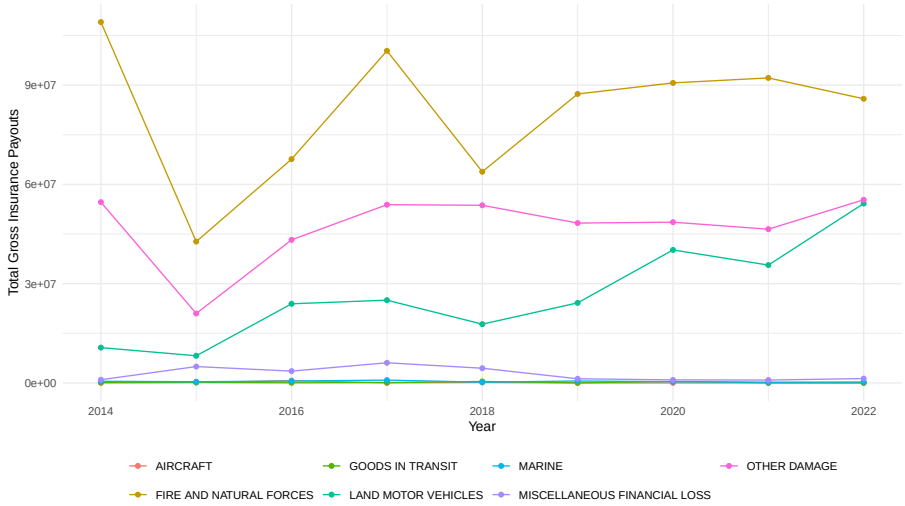
These findings highlight a significant disparity in the efficiency of different insurance types. Categories like fire insurance and comprehensive vehicle insurance are associated with higher average payouts, suggesting they may involve greater risks or higher-value claims. Conversely, the insurance types with lower or zero average payouts may either have fewer claims, smaller claim amounts, or may not be effectively utilized by policyholders.

Figure 5 illustrates the trends in insurance payouts from 2014 to 2022. The lines represent the total payouts for each type of insurance over the years. Significant fluctuations are observed, especially in Insurance against fire and natural forces, which consistently has the highest payouts. Fluctuation is primarily driven by extreme weather events, particularly storms and hail. Other insurance types display more stable or moderate growth trends.

As illustrated in Figure 5, Marine and Aircraft insurance experienced minimal to no gross payouts throughout the period from 2014 to 2022. These types of insurance are geared towards niche markets, which is why they show such limited activity in terms of payouts.

Fire and elemental damage insurance, on the other hand, consistently recorded the highest payouts over the entire period. This category displayed some fluctuations, with a dip in 2015, a sharp peak in 2017, followed by a more stable and consistent increase in payouts after 2017. As discussed in previous sections, these fluctuations are primarily driven by the occurrence of extreme weather events.

Figure 5: Trends in insurance payouts over time.



Source: Own work.

It's also notable that 2015 was a year of relatively low payouts for Fire and elemental damage insurance, Other damage insurance, and Land and motor vehicle insurance. All these insurance types experienced a significant peak in 2017. However, payouts for Land and motor vehicle insurance showed a noticeable upward trend thereafter, reflecting increase in claims and the growing number of vehicles on the road.

Another aspect of our analysis focused on identifying which insurance types exhibited the greatest variability in payouts. The results indicate that the insurance types with the highest variability in payouts are as follows (Slovensko Zavarovalno Združenje (n.d.)):

(1) Fire insurance and insurance for some other risks outside of industry and trade - Standard deviation: 3,803,300 EUR. The fluctuations can be attributed to various factors. The most significant peak occurred in 2017, with a total of 36,533,954 EUR in claims, largely driven by an exceptionally high number of storm-related damages (393,894 EUR, which represents a notable deviation from the average claim amount (296,140 EUR) observed in other years.) and wildfire-related claims (11,158,652 EUR). In contrast, 2018 saw a drop in total claims to 21,125,352 EUR, with a significant reduction in storm-related damages (231,115 EUR) and wildfire-related claims (5,892,867 EUR). However, fluctuations continued in subsequent years, with another notable increase in 2020 (34,028,236 EUR). This rise was driven by a surge in flood-related claims (4,460,608 EUR) and a sharp spike in fire-related damages (19,202,522 EUR). By 2022, the total claims amounted to 33,001,332 EUR, with significant payouts for hail damage (12,070,308 EUR) and fire-related claims (10,410,380 EUR).

(2) Comprehensive insurance for motor vehicles with their own propulsion, excluding rolling stock - Standard deviation: 3,329,565 EUR. One of the most significant peaks occurred in 2022, with total claims reaching 27,071,302 EUR, driven primarily by

hail damage (23,189,214 EUR) and fire-related claims (2,192,845 EUR). Another notable year was 2020, with total claims amounting to 20,046,245 EUR. The primary driver was hail-related claims, which peaked at 15,771,192 EUR, alongside increased fire-related damages (2,195,381 EUR). This aligns with severe hailstorms recorded that year, causing significant damage to vehicles. The lowest claim year was 2015, with total claims of 4,068,389 EUR, a stark contrast to later years. This was due to significantly lower storm (32,482 EUR) and hail (2,122,659 EUR) claims, indicating relatively stable weather conditions.

(3) Fire insurance and insurance for some other risks in industry and trade - Standard deviation: 2,274,137 EUR. One of the most notable peaks occurred in 2014, with total claims reaching 22,670,856 EUR. This was primarily driven by fire-related damages (7,870,582 EUR) and frost damage (12,487,223 EUR). In contrast, 2015 saw a sharp drop to 3,442,274 EUR, mainly due to a reduction in frost-related claims, which were entirely absent that year. Another high-claim year was 2019, with total claims of 15,162,799 EUR. Fire-related claims dominated this period (11,905,405 EUR). Additionally, hail (571,540.6 EUR) and strong winds (1,277,390 EUR) contributed to the higher overall payouts.

The data (Slovensko Zavarovalno Združenje (n.d.)) highlights the significant role of fire incidents, particularly in industrial environments, in driving insurance claims. Additionally, fluctuations in extreme weather events, including frost, hail, and storms, contribute to the variability in claims. The trends suggest that both climate-related risks and industrial fire incidents are key factors affecting claim totals over time.

These insurance types have shown considerable fluctuation in payouts, indicating significant variability in the associated risks.

5.2.3 Impact of Natural Disasters

In this section, we address two key questions. First, we examine which types of natural disasters result in the highest total insurance payouts, regardless of how frequently they occur. Second, we explore the average insurance payout per incident for each disaster type to determine which events are the most severe on a per-incident basis.

To address these questions, we first analyze the gross insurance payouts associated with various natural disasters to identify those that impose the greatest financial burden on insurers (Slovensko Zavarovalno Združenje (n.d.)). Among the most financially devastating are fires, which top the list with total payouts amounting to 225,655,877 EUR. This is closely followed by hailstorms, which have inflicted a total payout of 220,154,584 EUR. Storms also contribute substantially to insurance payouts, with a total damage of 103,806,277 EUR. Other significant contributors include floods, high water, and torrents, collectively

causing damages of 64,431,553 EUR, and lightning strikes, which account for 43,947,811 EUR in total damages. These figures indicate that certain types of natural disasters, particularly fires and hailstorms, have a disproportionately large impact on insurance payouts, making them critical areas of concern for insurers.

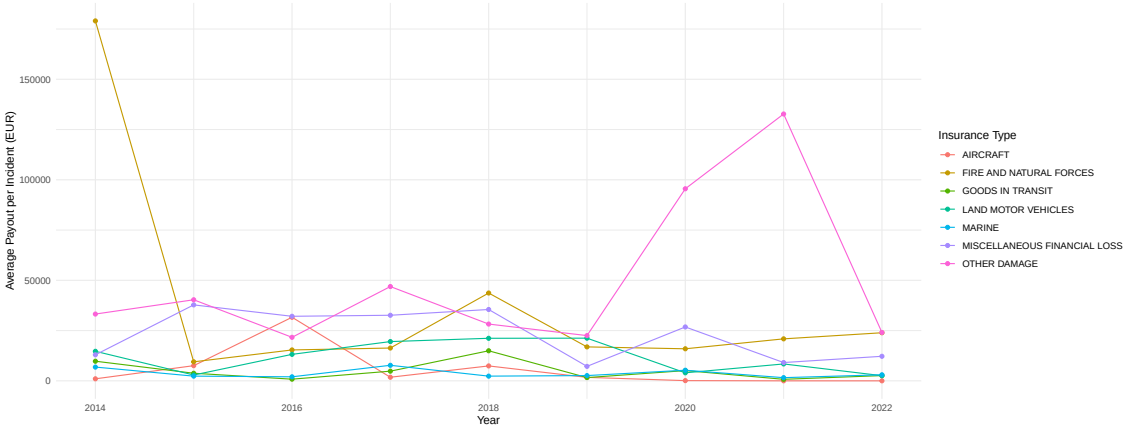
On the other end of the spectrum, some natural disasters have caused relatively minimal financial damage. Thunderstorms, for instance, have resulted in total payout of only 8,114,973 EUR. Snow loads, which cause significant damage in certain regions, have led to damages totaling 5,108,455 EUR. Landslides, including both earth and snow slides as well as land subsidence, have caused even less damage, with a total of 4,674,860 EUR. Extreme temperatures, whether high or low, have had a minor financial impact, with total damages amounting to 1,787,817 EUR. The least financially impacting disaster in this analysis is earthquakes, which have caused just 822,565 EUR in total damages.

Now, we analyze the average insurance payout per incident, reflecting the severity of claims across various types of natural disasters and insurance policies. The goal was to determine how much insurance compensation was allocated per individual incident. We calculated the average payout per incident by dividing the total payout amount by the number of claims for each insurance type and disaster. The results of our analysis are summarized as follows (Slovensko Zavarovalno Združenje (n.d.)):

- For each insurance type and year, we calculated the average payout per incident across different natural disasters:
  - Fire insurance for electrical power companies with an average payout per incident of 1,359,898 EUR in 2014.
  - Combined property insurance with an average payout per incident of 782,500 EUR in 2021.
  - Mining insurance with an average payout per incident of 374,748 EUR in 2020.
  - Construction insurance specifically for fire with an average payout per incident of 272,163 EUR in 2017.
- Next, we calculated the average payout per incident across all years (2014–2022) and all natural disasters to identify the insurance type with the highest overall average payout. The results are as follows:
  - The insurance type with the highest average payout per incident over the period 2014-2022 is Fire insurance for electrical power companies with an average payout per incident: 23,182 EUR.

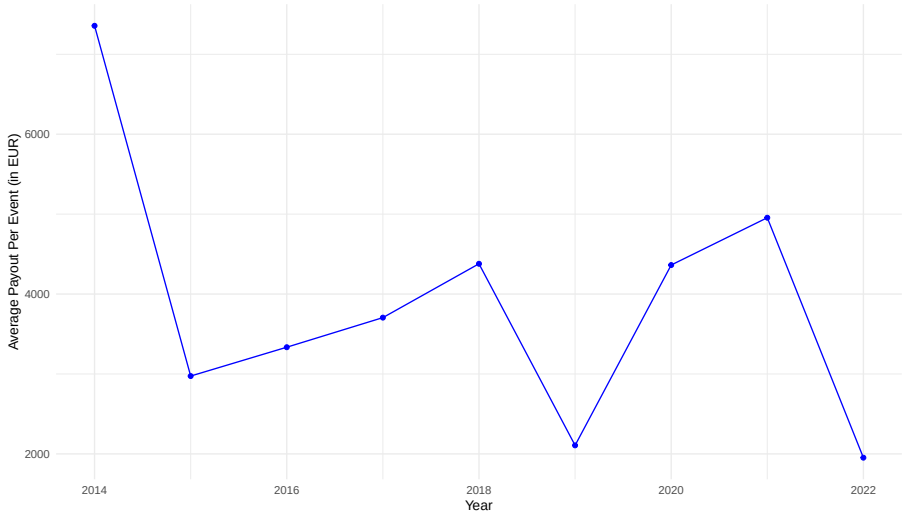
To assess how the average damage per event has changed over time for each insurance type, we calculated the average damage per event. The following Figure 6 visualizes these changes, showing trends in average damage per event for various insurance types from year to year.

Figure 6: Change in average payout per event over time.



Source: Own work.

Figure 7: Change in average payout per event over time.



Source: Own work.

Figure 7 illustrates the change in average payout per event over time across all types of insurance. The line plot shows trends in average payout, indicating fluctuations over the observed period. We can clearly see two significant peaks standing out.

The first major spike in 2014 is primarily driven by fire insurance for energy sector property, which recorded an exceptionally high average payout of 143,176 EUR per incident. On May 10, 2014, a fire broke out at the Iskra Mehanizmi facility, causing damage worth several hundred thousand EUR. On September 17, 2014, a fire at the Alpeks company in Celje destroyed 90 percent of the stock and caused damage exceeding one million EUR. On October 26, 2014, the premises of M Caravaning in the Šenčur Business Zone were destroyed by fire, causing damage amounting to several hundred thousand EUR. On December 10, 2014, a fire in the Vulkanija Adventure Park near Grad in Goričko completely destroyed the interior of the park's building, causing significant material damage

(Republika Slovenija, Ministrstvo za obrambo, Uprava Republike Slovenije za zaščito in reševanje, Urad za operativo – Center za obveščanje Republike Slovenije (n.d.)).

The second peak in 2020 and 2021 can be attributed primarily to insurance claims related to mining and business interruption due to fire. In 2020, there was a large payout for mining insurance (74,950 EUR per incident). Additionally, business interruption insurance due to fire saw a notable increase (26,796 EUR per incident). In 2021, the trend continued with mining insurance payouts remaining high (25,956 EUR per incident), while combined property insurance (82,524 EUR per incident) and assembly insurance (11,948 EUR per incident) also saw significant spikes.

5.2.4 Comparison of Frequency and Payouts in Insurance

In this analysis, we examined how the amount of aggregate insurance payouts varies with the frequency of claims across different types of insurance. We focused on comparing the total aggregate payouts with the recorded number of claims for each type of insurance to evaluate relative risk and potential exposure.

Using (Slovensko Zavarovalno Združenje (n.d.)) data we identified the top five insurance types with the highest average payout per claim and five insurance types with the lowest average payout per claim.

Insurance Types with Highest Average Payout per Claim:

(1) Mining Insurance: 252,264 EUR/claim.
(2) Business Interruption due to Fire: 67,227 EUR/claim.
(3) Aircraft Insurance: 46,726 EUR/claim.
(4) Event Insurance: 24,987 EUR/claim.
(5) All Other Insurance for Land Motor Vehicles: 15,230 EUR/claim.

Insurance Types with Lowest Average Payout per Claim:

(1) Home Assistance Insurance: 260.28 EUR/claim.
(2) Glass Insurance: 533 EUR/claim.
(3) Animal Insurance: 600 EUR/claim.
(4) Homeowner's Insurance: 884 EUR/claim.
(5) Film Production Insurance: 1,000 EUR/claim.

Other Property Damage insurance experienced a substantial increase in the average payout per claim, rising by 872 EUR, from 1,445 EUR in 2014 to 2,317 EUR in 2022. As over time, claims within this category have become larger, due to an decrease in the frequency and increase in severity.

Motor Vehicle insurance also saw a noteworthy increase in the average payout per claim. This increase could reflect inflation in vehicle repair and replacement costs, or it may indicate that the severity of motor vehicle accidents has increased. The frequency of claims in this category also saw a significant rise, with 7,934 claims reported in 2014 compared to 27,358 claims in 2022. This increase in both frequency and severity suggests that more motor vehicle accidents are occurring, and those that do occur involve greater damage and higher costs.

Marin insurance payouts grew by 917 EUR, from 4,007 EUR in 2014 to 4,924 EUR in 2022. The frequency of claims decreased slightly, with 126 claims in 2014 compared to only 56 in 2022. Despite the reduction in frequency, the claims that were filed were larger in value.

In contrast, Insurance against fire and natural forces saw a decrease of 421 EUR in the average payout per claim, from 3,216 EUR in 2014 to 2,796 EUR in 2022. The number of claims decreased from 32,833 in 2014 to 30,052 in 2022. While the frequency of claims remained relatively stable, the severity of the claims diminished, which may suggest improvements in fire prevention, construction standards, and natural disaster resilience.

Goods in transit insurance experienced a significant rise of 3,227 EUR in average payouts, reflecting a sharp increase from 9,785 EUR in 2014 to 13,021 EUR in 2022. This increase suggests greater logistical challenges and higher-value claims in shipping, freight, and Goods in transit insurance. The frequency of claims remained relatively low, with 18 claims reported in 2014, compared to 4 claims in 2022. Although the overall number of claims decreased, the severity of these claims increased significantl.

The Various Financial Loss insurance type exhibited the most dramatic increase in average payouts, soaring by 28,622 EUR, from 16,935 EUR in 2014 to 45,557 EUR in 2022. This large increase points to growing complexities in financial loss claims, which may be due to more sophisticated financial instruments and increased coverage for diverse business interruptions and operational risks. The number of claims decreased from 57 in 2014 to 29 in 2022, indicating a reduction in the frequency of claims. However, the severity of the claims increased substantially, reflecting a trend toward more complex and costly financial losses.

Furthermore, some types of insurance, such as Aircraft Insurance and Event Insurance, experienced complete elimination of claims payouts by 2022. Aircraft Insurance reported a payout of 5,000 EUR in 2014 but saw no claims or payouts in 2022, while Event Insurance shows no payouts in either 2014 or 2022.

Table 4 shows the change in the average insurance payout per claim over the period from 2014 to 2022 for various types of insurance.

Table 4: Average Payout per Claim and Change Between 2014 and 2022 by Insurance Type.

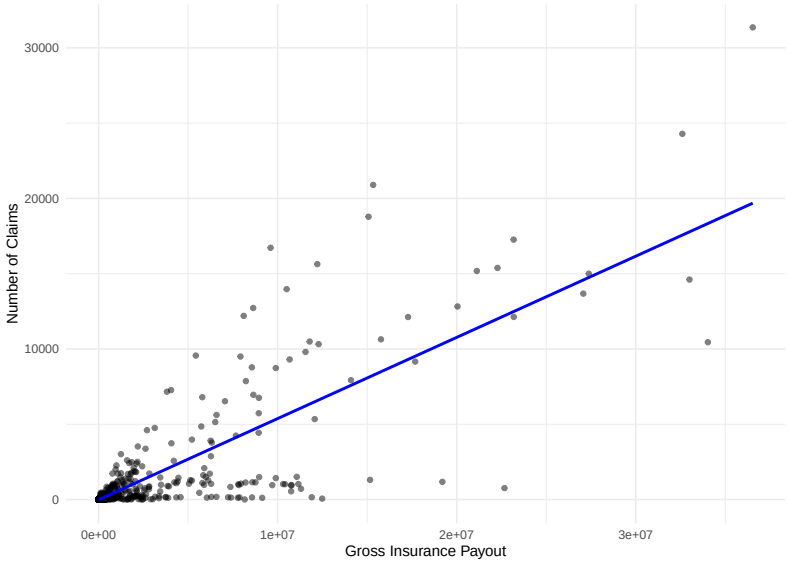
Insurance Type	**Avg Payout per Claim in 2014 (EUR)**	**Avg Payout per Claim in 2022 (EUR)**	**Change (EUR)**
Other Property Damage	1,445	2,317	872
Motor Vehicle	1,331	1,977	646
Marin	4,007	4,924	917
Fire and Natural Disaster	3,216	2,796	-421
Goods in transit	9,785	13,021	3,227
Various Financial Loss	16,935	45,557	28,622

Source: Own work.

5.2.5 Correlation Between Gross Insurance Payouts and Number of Claims

Is there a strong correlation between the amount of gross insurance payouts and the number of claims? To determine whether there is a significant relationship between the amount of insurance payouts and the number of claims across different insurance types, a correlation analysis was conducted. This analysis helps in understanding whether higher premiums are associated with a greater number of claims. The Pearson correlation coefficient was calculated to quantify the strength of the linear relationship between these two variables. Additionally, a scatter plot 8 with a fitted linear regression line was created to visually assess the correlation (Slovensko Zavarovalno Združenje (n.d.)).

Figure 8: Correlation between gross payout and number of claims.



Source: Own work.

The correlation coefficient between gross insurance payouts and the number of claims is 0.823, indicating a strong positive correlation. However, while the correlation is evident, the key question is whether the payouts increase at a greater rate than the number of

claims. In other words, are payouts growing more rapidly than the frequency of claims, or is there a proportional increase?

Figure 8, which includes all insurance types specified in Section 5, with the fitted linear regression line further suggests that while the relationship between the number of claims and payouts is strong, there may be instances where payouts increase at a greater rate than the number of claims. This could be due to factors like larger individual claim amounts or higher-value claims becoming more frequent. Most data points cluster around the line, indicating a consistent pattern across different insurance types. Outliers were identified by setting a threshold at the 99th percentile of gross insurance premiums, allowing for the detection of extreme values that might influence the overall correlation.

5.2.6 Identification of Outliers

Are there any exceptional events that caused unusually high gross insurance payouts? To identify exceptional events leading to unusually high insurance payouts, we set a threshold based on the 99th percentile of gross insurance premiums.

The distribution of gross insurance premiums was analysed, and a histogram (Figure 9) was generated to visualize the distribution with vertical dashed line representing the threshold for outliers.

Additionally, a detailed analysis was performed on time periods and individual events to identify anomalies. Outlier events were filtered based on the threshold, and their characteristics were examined to understand the nature of these exceptional payouts.

The analysis revealed several instances of exceptionally high insurance payouts. The following is a summary (Table 5) of the most significant outlier events and their gross payout (Slovensko Zavarovalno Združenje (n.d.)):

Table 5: Major natural disaster events.

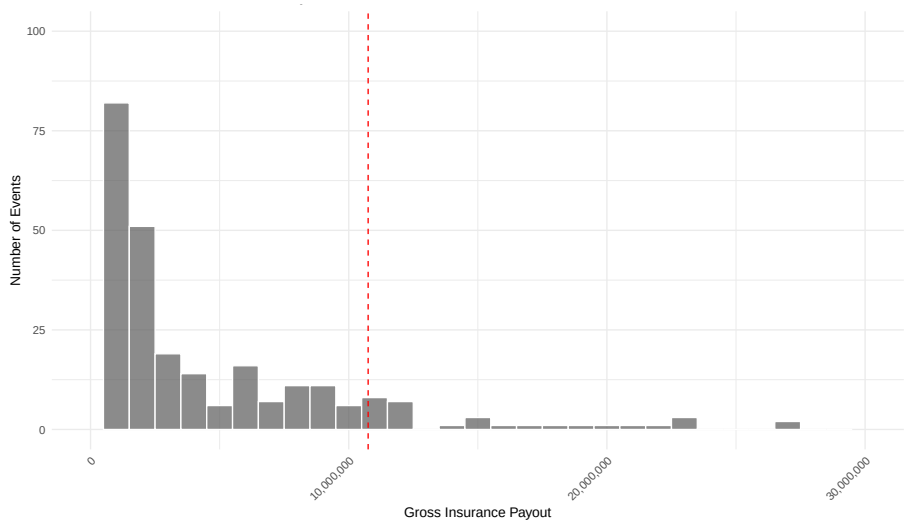
Year	**Type of Disaster**	**Payout (EUR)**
2014	Sleet	12,487,223
2017	Fire	11,158,652
2017	Storm	15,334,868
2019	Fire	11,905,405
2020	Hail	15,771,192
2020	Storm	12,216,260
2021	Fire	19,202,522
2021	Hail	14,095,509
2022	Hail	35,259,522

Source: Own work.

Significant payouts over the years have been closely linked to severe weather events, which resulted in increase of premiums. Notably, the 2014 sleet event (12.5 million EUR payout) did not immediately trigger premium hikes, but the 2017 fires (11.2 million EUR) and storms (15.3 million EUR) marked a turning point, contributing to a 0.74% increase in 2017 premiums. The 2019 fire (11.9 million EUR) further pressured insurers, leading to a 4.98% premium rise in 2019. The trend continued in 2020 and 2021, driven by severe hailstorms (15.8 million EUR in 2020, 14.1 million EUR in 2021) and fires (19.2 million EUR in 2021), prompting a 6.56% increase.

However, the most dramatic shift occurred in 2022–2023, when a record-breaking hailstorm in 2022 (35.3 million EUR payout) forced insurers to adjust, resulting in a 15.05% surge in premiums in 2023—the largest increase in the observed period. This pattern suggests a lag between extreme weather events and premium adjustments. Section 5.3 provides a deeper exploration of premium trends.

Figure 9: Distribution of gross insurance payouts with extreme values (vertical dashed line indicating outlier threshold).



Source: Own work.

5.2.7 Proportion of Natural Disasters in Total Insurance Claims

What proportion of the total insurance claims payout is attributed to natural disasters? To determine the proportion of total insurance payout related to natural disasters, we examined insurance data (Slovensko zavarovalno združenje (2014a)) and the dataset (Slovensko Zavarovalno Združenje (n.d.)).

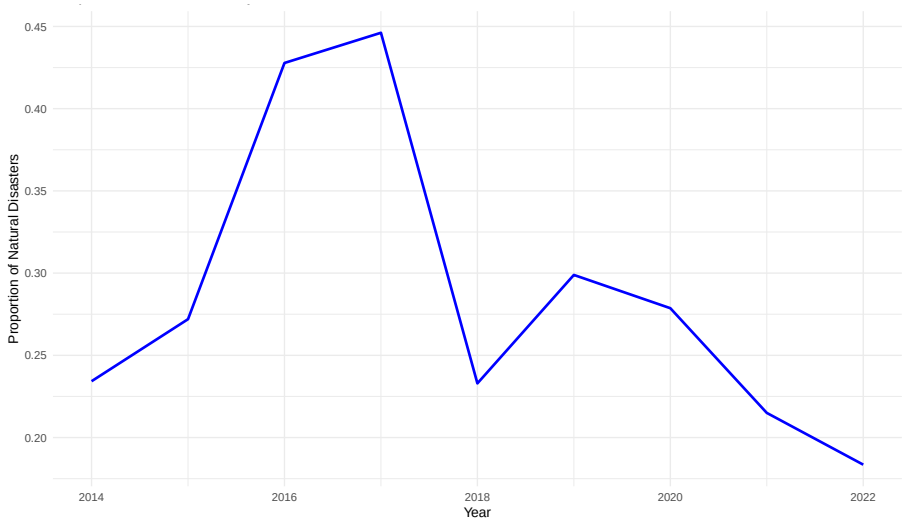
The analysis revealed that the insurance type with the highest average proportion of payout due to natural disasters was Fire and Elemental Disasters Insurance, with an average proportion of 70.3%. The second highest was Other Damage Insurance with an average

proportion of 36.0%. Conversely, Goods Transportation Insurance had the lowest average proportion of natural disaster-related payouts, at 3.7%.

Figure 10 presents the proportion of insurance payouts due to natural disasters over time. It includes all insurance types listed in Section 5. This graph highlights how the share of payouts attributed to natural disasters has evolved each year.

Figure 10 shows that the proportion starts at a value of approximately 0.22 in 2014. There is a sharp increase between 2014 and 2016, reaching a peak value of approximately 0.45 around 2016. After the peak in 2016, the proportion begins to decline sharply, reaching its lowest point around 2018, at approximately 0.20. A brief recovery is observed between 2018 and 2020, where the proportion rises to around 0.35. From 2020 onwards, the proportion experiences a consistent decline, reaching its lowest point in 2022, at approximately 0.17.

Figure 10: Proportion of insurance claims due to natural disasters over the years.



Source: Own work.

5.3 Premiums Analysis

This subsection presents an analysis of various datasets related to insurance premiums. The data covers different aspects, including the total gross written premiums made by insurance companies to legal and natural persons between 2002 and 2022 (Sistat (2023)). Additionally, we examine gross written premiums per month for different types of insurance from 2016 to 2024 (Slovensko zavarovalno združenje (2014b)), per quarter (Slovensko zavarovalno združenje (2014a)), and net premiums for individual insurance companies over the period from 2012 to 2022 (Slovensko zavarovalno združenje (2014c)).

5.3.1 Analysis of Gross Written Premiums

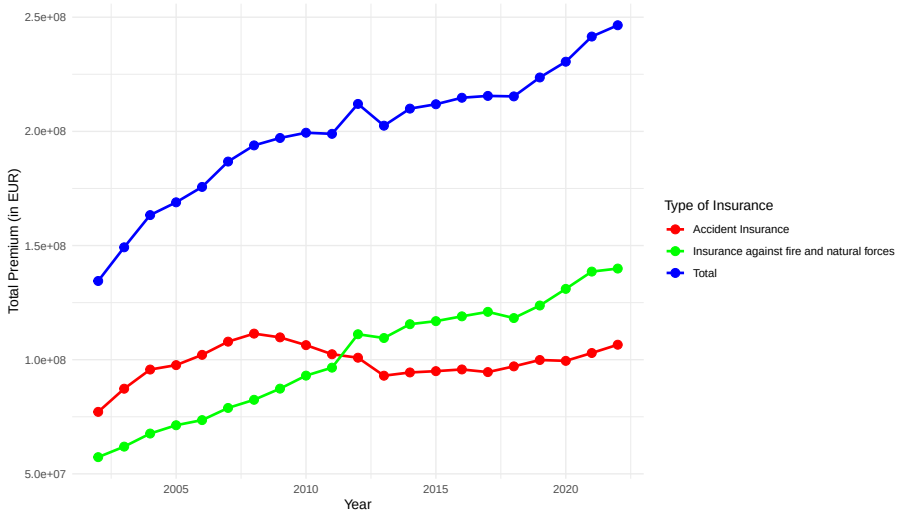
This section examines the dataset Gross Written Premiums (Sistat (2023)), which provides data across various insurance types from 2002 to 2022, distinguishing between legal and natural persons. The primary focus of this analysis is on two specific types of insurance: Accident Insurance (Nezgodno zavarovanje) and Insurance against fire and natural forces (Zavarovanje požara in elementarnih nesreč). These insurance types are of particular interest due to their direct exposure to risks associated with natural disasters.

A longitudinal analysis of gross written premiums over the two-decade period reveals that gross written premiums have exhibited a consistent upward trajectory across most insurance categories. While most insurance categories have demonstrated sustained growth, accident insurance premiums initially increased but experienced a subsequent decline in later years.

Figure 11 illustrates the trends in accident insurance, insurance against fire and natural forces, and the total premiums for all insurance types (Sistat (2023)):

- Accident Insurance: Gross written premiums increased from 77.2 million EUR in 2002 to 106.6 million EUR in 2022, reflecting an average annual growth rate of 1.4 million EUR.
- Insurance against fire and natural forces: Premiums grew from 57.3 million EUR in 2002 to 139.9 million EUR in 2022, with an average annual growth rate of 3.9 million EUR.

Figure 11: Gross written premiums from 2002 to 2022.



Source: Own work.

Figure 12: Gross written premiums by insurance type and business entity.

Source: Own work.

- Total Premiums Across All Insurance Types: Gross written premiums across all insurance categories rose from 841.2 million EUR in 2002 to 2.6 billion EUR in 2022, representing an average annual growth rate of 84.8 million EUR.

While these figures illustrate overall market expansion, it is also important to examine how premium growth varies between different types of policyholders. Specifically, trends differ between natural persons and legal entities, reflecting distinct risk exposures and insurance needs. Figure 12 presents the evolution of gross written premiums for natural persons (left graph) and legal entities (right graph), revealing distinct patterns (Sistat (2023)).

- Natural Persons:
  - A steady increase in premiums until approximately 2010, reaching a peak of just over 80 million EUR.
  - After 2010, premiums exhibited moderate fluctuations, yet a general upward trend emerged from 2015, culminating in a final value of approximately 85 million EUR in 2022.
- Legal Entities:
  - Premiums demonstrated a more consistent and rapid increase, particularly from 2000 onward, reaching approximately 80 million EUR by 2022.
  - While some volatility was observed between 2010 and 2015, the overall trajectory remained positive, with a pronounced growth trend after 2016.
  - Notably, legal entities outpaced natural persons in premium growth, particularly after 2010.

Natural persons typically have personal and family-related risks to cover, such as home and auto insurance. Their insurance needs tend to be more stable and predictable. However, their ability and willingness to pay premiums are often influenced by broader macroeconomic factors, such as employment rates, wage growth, and inflation. While premiums for individuals generally grow steadily, economic downturns or shifts can lead to pauses or declines in this growth, which helps explain the fluctuations observed after 2010. Additionally, individual premiums are more price-sensitive, as insurers tailor rates based on factors like risk profiles, age, and health status. As a result, premium growth remains relatively consistent, unless there are significant changes in market conditions or consumer behavior.

Legal entities on the other hand face a wider array of risks, including property damage, liability, and business interruption insurance. Because businesses are more vulnerable to economic and operational shifts, their insurance needs tend to fluctuate more than those of individuals. For example, a company may significantly increase its coverage following a major expansion or in response to regulatory changes. Businesses are also more directly impacted by broader economic trends such as GDP growth, market demand, or industry-specific crises. The volatility observed between 2010 and 2015, for instance, may reflect economic uncertainty or the lingering effects of the 2008 financial crisis. Premium growth for legal entities is typically driven by evolving risk assessments, the expansion of coverage portfolios, and the scale of operations. Larger businesses, in particular, may negotiate higher premiums to secure more extensive policies, resulting in more substantial annual growth. After 2010, legal entities often outpaced natural persons, likely reflecting a rise in the complexity of business risks post-crisis. Moreover, businesses are influenced by a range of regulations, including environmental laws and industry-specific rules. Shifts in these regulations can trigger swift adjustments in premiums, further contributing to the volatility observed in legal entity premium growth.

To better understand market dynamics, an additional dataset was analyzed (Slovensko zavarovalno združenje (2014b)), which provides monthly gross written premiums across different insurance types. The objective of this analysis was to identify long-term trends within the insurance industry. Between 2016 and 2023, gross written premiums exhibited substantial growth across all analyzed insurance categories, with particularly pronounced increases in the following segments.

Between 2016 and 2023, various insurance types saw significant growth. Marine insurance experienced a remarkable increase of over 3,000%, rising from 7.6 to 241 million EUR. Land motor vehicle insurance nearly doubled (+88%), reaching 3 billion EUR, while other property insurance grew by 57% to 1.43 billion EUR. Aircraft insurance and various financial loss insurance increased by 56% and 53%, respectively. Insurance

against fire and natural forces rose by 31%, and goods in transit insurance saw a more modest growth of 19%.

These trends are further examined in the following sections, which explore the correlation between annual premiums and the number of claims across various insurance types, as well as the impact of natural disasters on insurance dynamics.

5.3.2 Correlation between Annual Premium and Number of Claims by Insurance Type

In this analysis, we calculated the correlation between annual premiums and the number of claims due to natural disasters for various types of insurance. Specifically, we computed three distinct correlation coefficients for each insurance type (Slovensko zavarovalno združenje (2014b)):

(1) Correlation in the Same Year: This reflects the relationship between the number of claims and the annual premium for the same year.
(2) Correlation for Year + 1: This measures the relationship between the number of claims in a given year and the annual premium in the following year.
(3) Correlation for Year + 2: This assesses the relationship between the number of claims in a given year and the annual premium two years later.

These correlation coefficients provide insights into how the annual premiums relate to the number of claims filed over time and are summarized in Table 6:

Table 6: Correlation between annual premium and number of claims by insurance type.

Insurance Type	**Correlation (Same Year)**	**Correlation (Year + 1)**	**Correlation (Year + 2)**
Other Property Insurance	-0.422	-0.782	-0.183
Aircraft Insurance	-0.392	-0.651	-0.588
Motor Vehicle Insurance	0.516	0.102	0.570
Marine Insurance	-0.541	-0.763	-0.467
Fire and natural forces	-0.372	-0.264	-0.200
Goods in transit Insurance	-0.457	0.735	0.595
Various Financial Loss Insurance	-0.130	0.128	-0.493

Source: Own work.

For other Property Insurance there is a negative correlation across all years, with the strongest negative correlation observed in the following year ($i+1$), at -0.782. This suggests that a higher number of claims leads to reduced premiums, possibly due to insurers' risk adjustments or decreased demand following large losses.

Aircraft Insurance also shows consistent negative correlations across all periods, with a peak negative correlation of -0.651 in the subsequent year. This trend might indicate a slow recovery in premium collections after a year with high claims, potentially due to market-specific factors or insurer caution following high-risk periods.

Unlike other types, motor vehicle insurance demonstrates positive correlations, especially in the same year (0.516) and in the second year after claims (0.570). This could imply that insurers adjust premiums more directly and rapidly in response to current claim levels, reflecting this market's high responsiveness to loss frequency.

Marine Insurance shows negative correlations, notably strong in the year following high claims (-0.763). The sustained negative correlation suggests that high claim years lead to decreases in premiums, potentially due to increased risk aversion or regulatory adjustments in response to claims.

For Insurance against fire and natural forces moderate negative correlations in all three years suggest that claims do not heavily impact premiums immediately, with a weaker response over time. This may imply that insurers for fire and disaster risks face challenges in adjusting premiums as directly in response to claim events.

Goods in transit insurance shows a unique pattern, with a strong positive correlation (0.735) in the year following a high claim year. This indicates that claim activity likely leads to higher premiums in subsequent years, possibly due to heightened risk perception or re-evaluation of premiums by insurers.

Various Financial Loss Insurance has mostly negative correlations, with a notably weak negative correlation in the same year (-0.130) and a stronger negative correlation two years after a claim-heavy period (-0.493). This could reflect the tendency of financial loss insurers to delay premium adjustments or implement gradual changes over time.

In general, the results illustrate a mix of responses among different insurance types in reaction to claim numbers. Motor vehicle and Goods in transit insurances show positive correlations, indicating premium adjustments in response to claims. However, most other insurance types exhibit negative correlations, especially in the years following claim events. This suggests that while certain insurance markets, such as motor vehicle insurance, adjust premiums promptly and proportionally to claims, other markets, such as property and aircraft insurance, may take longer to adjust or delay increases to avoid market destabilization.

5.3.3 Correlation between Annual Premiums and Number of Natural Disasters

This analysis examines the relationship between the frequency of natural disasters in Slovenia and the total premiums collected in the same year, as well as one and two years later (Komac et al. (2023) and Slovensko zavarovalno združenje (2014b)). Table 7 shows the number of natural disasters per year from 2016 to 2022, along with the correlations between disaster frequency and total premiums collected.

Table 7: Correlation between the number of natural disasters and total premium collected over different years.

Correlation (Same Year)	Correlation (Year + 1)	Correlation (Year + 2)
0.651	0.004	-0.061

Source: Own work.

Moderate positive correlation of 0.651 for the same year indicates that higher natural disaster frequencies in a given year are associated with increased premium totals within that year. This may reflect an immediate market response, with premium adjustments occurring in the same period as heightened risk awareness.

The near-zero correlation of 0.004 between the disaster frequency and premiums collected one year later implies that premiums may not be significantly influenced by the prior year's disaster frequency. This finding suggests that premium adjustments do not consistently carry over to the following year.

The slightly negative correlation of -0.061 suggests a minor, delayed effect, potentially reflecting a trend where premiums are slightly reduced two years after higher disaster frequencies. However, this effect is weak, indicating limited long-term impact on premium totals.

These results underscore that while immediate disaster frequency has a positive effect on premiums, the lagged impact remains minimal. This trend points to a potential for insurers to adjust premiums promptly in response to immediate risks but not necessarily based on historical disaster counts.

5.3.4 Correlation Analysis between Payouts and Premiums by Insurance Type

The following analysis examines the relationship between annual payouts associated with natural disasters and premiums across various insurance types (Slovensko Zavarovalno Združenje (n.d.) and Slovensko zavarovalno združenje (2014b)). The correlation is assessed for the same year, as well as with one- and two-year offsets, to capture potential delayed effects. Table 8 summarizes these correlations, highlighting the variability in correlation across different insurance lines.

Motor Vehicle Insurance shows a consistently high positive correlation across all time frames, suggesting that premiums are closely aligned with payouts.

Insurance against fire and natural forces exhibits a moderate positive correlation, especially in the one-year offset, suggesting a lagged effect where premiums adjust following high-claim years.

Marine and Aircraft Insurance generally display negative correlations, indicating that premiums and payouts may not be tightly aligned, possibly due to the irregular and potentially large nature of claims in these categories.

Various Financial Loss Insurance has negative correlations in the same and one-year offsets but shifts to a positive correlation in the two-year offset, which may suggest that premiums are adjusted in response to long-term trends in claims.

Table 8: Correlation between annual payouts and premiums by insurance type, assessed for the same year, one-year and two-year offset.

Insurance Type	Correlation (Same Year)	Correlation (Year + 1)	Correlation (Year + 2)
Other Property Insurance	0.538	-0.118	-0.381
Aircraft Insurance	-0.208	-0.151	-0.608
Motor Vehicle Insurance	0.798	0.637	0.714
Marine Insurance	-0.441	-0.583	-0.318
Insurance against fire and natural forces	0.376	0.487	0.145
Goods in transit Insurance	-0.283	-0.248	-0.163
Various Financial Loss Insurance	-0.517	-0.134	0.304

Source: Own work.

5.4 Analysis of Insurance Companies

Building on Born & Viscusi (2006) assertion that unforeseen and significant catastrophes can prompt insurers to withdraw from certain markets, we will analyze the impact of these events on the financial stability and strategic decisions of insurance companies in Slovenia. As highlighted in previous sections, 2016 saw the highest insurance payouts due to natural disasters, particularly from fire-related claims, while 2017 experienced the highest number of claims, driven by storms and fires.

To explore these dynamics further, this section analyzes the various types of insurance offered by members of the Slovene Insurance Association (SZZ) from 2012 to 2023 (Slovensko zavarovalno združenje (2014c)). Zavarovalnica Triglav d.d. holds the largest market share, significantly outpacing other companies. Other notable players include Zavarovalnica Sava d.d., Vzajemna zdravstvena zavarovalnica d.v.z., and Adriatic Slovenica d.d., which merged with GENERALI zavarovalnica d.d. in 2020.

Table 9 provides a detailed analysis of key statistics for each insurance type, including the average number of insurers offering a specific type of insurance, the minimum and maximum number of insurers, and the market share percentages over this period.

Figure 13 illustrates the trends in the number of insurance companies offering specific types of insurance and their corresponding market share over the years.

- Insurance against fire and natural forces: This type consistently had the highest number of insurance companies offering it, emphasizing its widespread importance. Its market share was stable over the years.

Table 9: Summary Statistics for Different Types of Insurance (2012–2023).

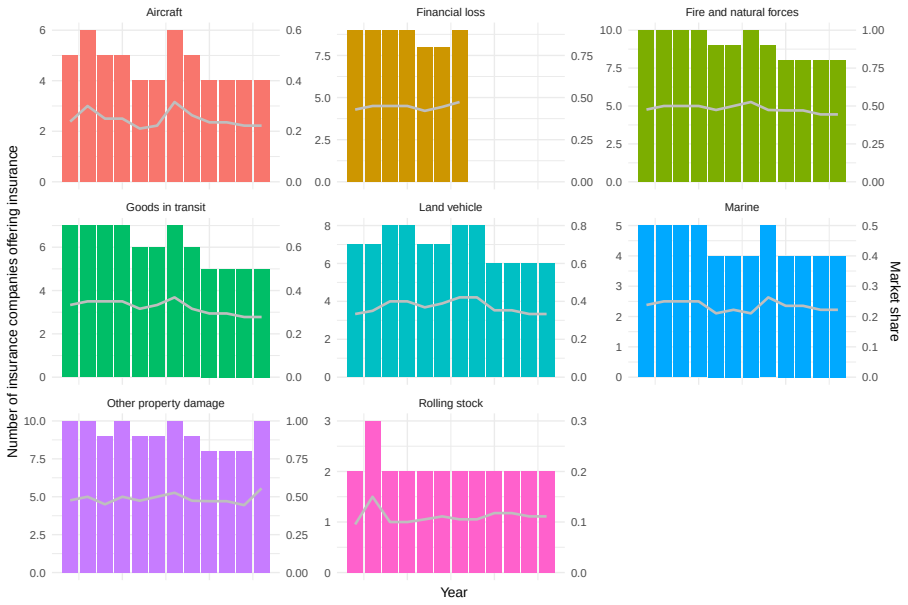
Insurance Type	Number of insurers			Market share (%)		
	Avg.	**Min.**	**Max.**	**Avg. Share (%)**	**Min. (%)**	**Max. (%)**
Aircraft insurance	4.67	4	6	24.71	21.05	31.58
Fire and natural forces	9.08	8	10	48.17	44.44	52.63
Miscellaneous financial loss insurance	8.71	8	9	44.54	42.11	47.37
Insurance of goods in transit	6.08	5	7	32.17	27.78	36.84
Insurance of land motor vehicles	7.00	6	8	37.13	33.33	42.11
Rolling stock insurance	2.08	2	3	11.08	9.52	15.00
Marine insurance	4.42	4	5	23.41	21.05	26.32
Other damage insurance	9.17	8	10	48.68	44.44	55.56

Source: Own work.

- Other Damage Insurance: Similar to fire insurance, this type maintained a high level of availability among companies and had a consistently strong market share.
- Niche Insurances: Rolling stock insurance, Aircraft Insurance and Marine insurance were offered by fewer companies but showed steady market share trends. These types cater to specialized needs.
- Fluctuating Trends: Insurance of Goods in Transit and Insurance of Land Motor Vehicles displayed moderate fluctuations in both the number of companies offering them and their market shares, suggesting varying demand.

The years 2016 and 2017, which were significantly impacted by natural disasters, appear to have influenced the number of insurance companies offering specific types of coverage. As observed in the data, while some insurance types such as Insurance against fire and

Figure 13: Number of insurance companies and their market share (gray line) from 2012 to 2023.



Source: Own work.

natural forces, and Other Damage Insurance maintained stable numbers of insurers, other categories like Aircraft Insurance and Insurance of Goods in Transit saw a slight decrease in the number of insurers during these years. For example, in 2016, the number of insurers offering Aircraft insurance dropped to 4, and similarly, marine insurance saw a decline in the number of providers. However, other sectors like Insurance against fire and natural forces maintained a steady presence of insurers, with only a minor reduction in the number of companies offering this type of coverage.

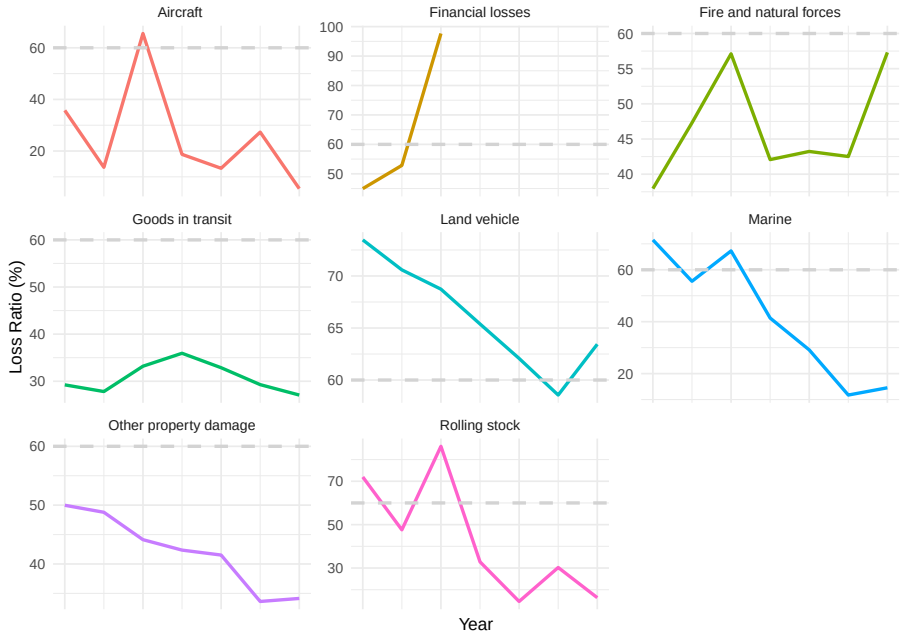
5.5 Analysis of Loss Ratio

The Loss Ratio is a crucial indicator in the insurance industry, representing the ratio of incurred claims to earned premiums. The analysis of Loss Ratios across various insurance types for the period 2016–2022 reveals notable trends and variability (Slovensko zavarovalno združenje (2014a)). Aircraft insurance had the lowest average Loss Ratio at 25.68%, with a significant range from a minimum of 5.42% in 2022 to a maximum of 65.54% in 2018, indicating fluctuations in performance. On the contrary, insurance against fire and natural disasters maintained relatively stable Loss Ratios, ranging from 37.95% in 2016 to 57.31% in 2022, with an average of 46.78%. Insurance of goods in transit also exhibited stability, with a narrow range between 27.07% in 2022 and 35.94% in 2019, and an average of 30.77%.

Conversely, some insurance categories displayed higher averages and greater variability. Insurance of land motor vehicles showed the highest average Loss Ratio at 66.04%, peaking at 73.47% in 2016 and reaching a low of 58.56% in 2021, reflecting sustained high risk and profitability challenges. Insurance of miscellaneous financial losses also faced significant variability, with an average of 65.16% and a maximum Loss Ratio of 97.67% in 2018, suggesting periods of financial strain. Similarly, rolling stock insurance and marine insurance demonstrated wide ranges in Loss Ratios. Rolling stock insurance fluctuated from a low of 14.59% in 2020 to a high of 86.11% in 2018, while marine ranged from 11.74% in 2021 to 71.51% in 2016, indicating fluctuating risks tied to these categories.

Lastly, other damage to property insurance had a stable performance, with Loss Ratios averaging 42.08% and ranging narrowly between 33.63% in 2021 and 49.98% in 2016. Overall, the data highlights significant variability in risk and profitability across insurance types. Particularly high Loss Ratios, such as those for land motor vehicles and miscellaneous financial losses, point to potential areas of concern. To provide better insights, Figure 14 shows the trends in Loss Ratio across the years 2016–2022 for the selected insurance types.

Figure 14: Loss Ratio Trends for Insurance Types (2016–2022).



Source: Own work.

The article by Born & Viscusi (2006) stated that the loss ratio decreases following catastrophic events due to upward adjustments in insurance rates. This section investigates whether these effects also hold true for Slovenia.

To explore the relationship between the number of natural disasters and insurance performance metrics, we calculated the correlation between the number of natural disasters during one year and the average loss ratio in the following year (Komac et al. (2023) and Slovensko zavarovalno združenje (2014a)). The result showed a positive correlation of 0.725, indicating a strong relationship. This suggests that an increase in the number of natural disasters is associated with a higher loss ratio in the following year.

The accompanying Figure 15 illustrates this trend, showing the year-over-year variation in the number of natural disasters and the average loss ratio. The data reveals a significant increase in the loss ratio after years with a higher frequency of catastrophic events, highlighting the financial strain such disasters place on insurers.

To further explore the hypothesis we analyzed relationship between the number of claims due to natural disasters and the loss ratio (Slovensko Zavarovalno Združenje (n.d.) and Slovensko zavarovalno združenje (2014a)). The correlations for each insurance type are summarized in Table 10.

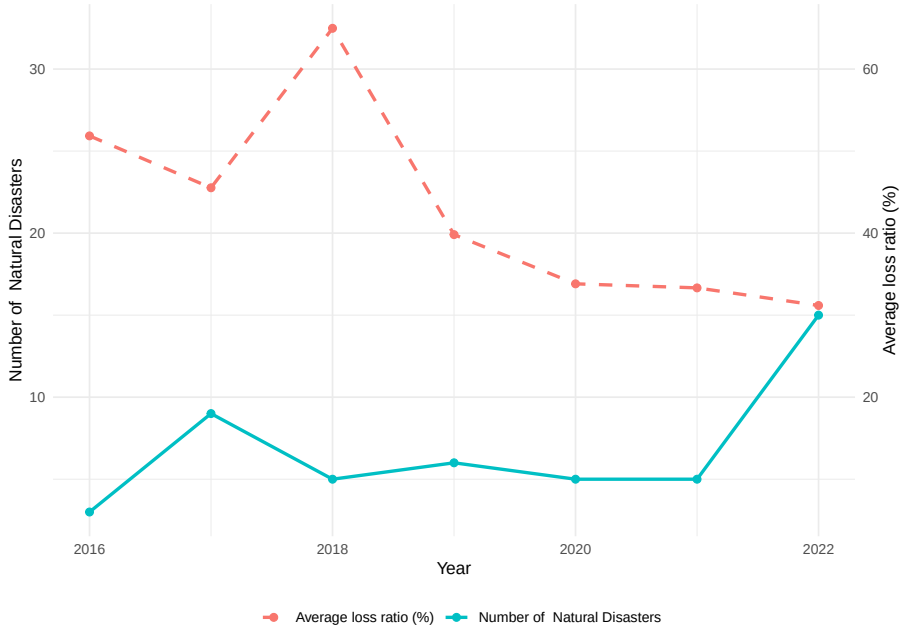
The analysis reveals varying relationships between the number of claims and loss ratios:

- High positive correlations: Marine (0.692) indicate a strong direct relationship.

- Moderate positive correlations: Other damage to property insurance (0.499) and Aircraft insurance (0.354) show a moderate direct relationship.
- Negative correlations: Insurance of goods in transit (-0.711) and Insurance of land motor vehicles (-0.464) suggest an inverse relationship.

In conclusion, our analysis does not support Born's hypothesis for Slovenia. Instead, we find that catastrophic events tend to increase the loss ratio, indicating a different dynamic in the Slovenian insurance market.

Figure 15: Number of Natural Disasters and Average Loss Ratio (2016–2022).



Source: Own work.

Table 10: Correlations between the number of claims and the loss ratio for different types of insurance.

Insurance Type	**Correlation**
Aircraft insurance	0.354
Insurance against fire and natural disasters	0.155
Insurance of goods in transit	-0.711
Insurance of land motor vehicles	-0.464
Marine insurance	0.692
Other damage to property insurance	0.499

Source: Own work.

5.6 Analysis of the Number of Insurance Policies

In this section, we examine the number of insurance policies between the years 2016 and 2022 (Slovensko Zavarovalno Združenje (n.d.)).

- Aircraft insurance: The average number of insurance policies in this category is 220, with the number varying between 169 and 292. The trend shows an increase in the number of insurances, with the maximum observed in 2022 and the minimum in 2017.
- Insurance against fire and natural disasters: This insurance type has one of the largest number of insurances, with 603,708 policies on average. The number ranged from a minimum of 544,928 in 2016 to a maximum of 712,150 in 2022, showing a general increase in policies over time.
- Insurance of goods in transit: On average, 15,831 policies were sold, with a minimum of 9,462 and a maximum of 21,173. The highest number of policies occurred in 2022, while the minimum occurred in 2019.
- Insurance of land motor vehicles: This category exhibits the largest volume of insurances with an average of 1,233,753 policies. The minimum and maximum values range from 1,045,120 in 2017 to 1,362,905 in 2022, indicating a consistent upward trend.
- Insurance of miscellaneous financial losses: This category had an average of 92,010 policies. The minimum number of policies occurred in 2016 with 79,841, while the maximum was 105,674 in 2018.
- Rolling stock insurance: The data for this category shows an average of 34 policies, with values ranging from 21 to 71. The highest number of policies was seen in 2022, while the minimum occurred in 2016.
- Marine insurance: On average, there were 4,484 policies, with a minimum of 3,051 and a maximum of 8,640. The highest number occurred in 2022, and the minimum in 2019, reflecting some fluctuation in this category.
- Other damage to property insurance: The average number of policies was 1,059,131, ranging from 922,246 in 2017 to 1,293,373 in 2022, indicating steady growth over the years.

In general, most insurance types saw growth in the number of policies over this period, with Insurance against fire and natural disasters and Insurance of land motor vehicles showing particularly strong upward trends. However, categories like Aircraft insurance and Insurance of miscellaneous financial losses exhibited more modest changes. These trends could reflect broader shifts in the Slovenian market, including responses to evolving risk profiles and changing customer demand.

The article by Born & Viscusi (2006) suggests that catastrophic events reduce the total number of insurance policies underwritten. To examine this hypothesis in the context of Slovenia, we analyzed the relationship between the number of natural disasters and the total number of insurance policies written each year from 2016 to 2022.

We calculated the correlation between the number of natural disasters in one year and the number of insurances in the following year. The result was a positive correlation of 0.725, indicating that, despite the hypothesis suggesting a reduction in the number of

insurance policies following catastrophic events, the data actually shows a strong association between an increase in natural disasters and an increase in the number of insurances in subsequent years. The accompanying Figure (16) visualizes the trends in both the number of natural disasters and the total number of insurance policies over time.

This analysis contradicts Born's hypothesis that natural disasters lead to a decrease in the number of policies underwritten. In our case, the data suggests that the increase in natural disasters corresponds with a higher number of insurance policies in subsequent years. It may be indicative of insurers' responses to higher risks, with increased coverage to address the emerging concerns from disasters, or an effect of rising awareness and demand for insurance after catastrophic events.

In addition to examining the impact of natural disasters on the number of insurance policies, we also analyzed the relationship between the number of claims due to natural disasters and the total number of insurances. The Table 11 summarizes the correlation results for each insurance type.

- Strong negative correlations: Insurance types such as Aircraft insurance (-0.755), Marine insurance (-0.669), and Other damage to property insurance (-0.720) show a strong negative relationship, suggesting that an increase in claims due to natural disasters is associated with a decrease in the number of policies underwritten in these categories.
- Weak positive correlations: Insurance types like Insurance against fire and natural disasters (0.099) and Insurance of land motor vehicles (0.098) exhibit weak positive correlations, indicating a slight increase in policies despite higher claims.

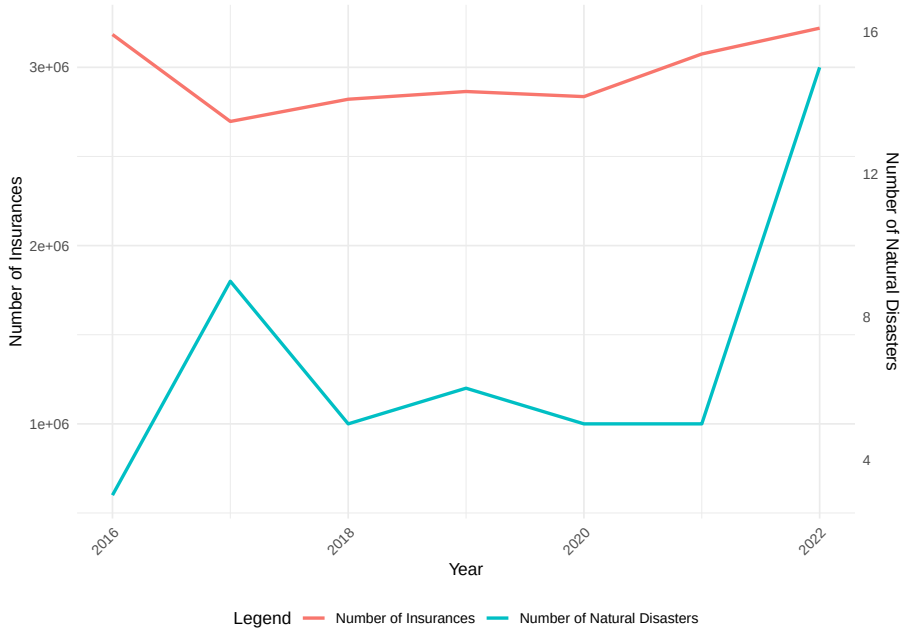
This analysis suggests that for some insurance types, such as Aircraft insurance and Other damage to property insurance, natural disasters lead to a reduction in the number of policies, which aligns with Born's (2006) assertion that catastrophic events reduce the number of policies. However, for other types of insurance, such as Insurance of land motor vehicles, the relationship is weak or even positive, indicating that Born's theory does not universally apply in Slovenia.

Table 11: Correlation between the number of claims due to natural disasters and the number of insurances for different types of insurance.

Insurance Type	**Correlation**
Aircraft insurance	-0.755
Insurance against fire and natural disasters	0.099
Insurance of goods in transit	-0.343
Insurance of land motor vehicles	0.098
Marine insurance	-0.669
Other damage to property insurance	-0.720

Source: Own work.

Figure 16: Number of Insurance policies and Natural Disasters Over Time (2016–2022).



Source: Own work.

6 CONCLUSION

This master's thesis explores the significant impact of natural disasters on the Slovenian insurance industry, focusing on premiums, loss ratios, market trends, and policy availability. By analyzing historical data, this study provides insight into how insurers and policyholders respond to catastrophic events. The findings challenge conventional assumptions, particularly those presented by Born & Viscusi (2006), which suggest that natural disasters lead to fewer policies. Our study reveals that natural disasters prompt both insurers and consumers to adjust their behavior. Insurers often respond by expanding their policy offerings, while consumers become more inclined to purchase insurance following significant events. This reactive behavior challenges the assumption that catastrophic events lead to a decline in policy numbers.

The differences between the Slovenian and U.S. insurance markets help explain why the findings diverge from Born's hypothesis. The U.S. insurance market is highly fragmented, with state-level controls and fixed capital standards, limiting insurers' flexibility. This regulatory environment can restrict insurers' ability to increase policies after catastrophic events, as price constraints and static risk models play a significant role. In contrast, Slovenia operates within the European Union's centralized regulatory framework under Solvency II, which enables dynamic financial analysis and more individualized risk assessments. This flexibility allows Slovenian insurers to respond proactively, increasing coverage after natural disasters. As a result, Slovenia has witnessed a rise in policies

following such events, unlike the U.S., where stricter price regulations and slower adjustments may reduce policy numbers.

The EU's competitive market, with fewer pricing restrictions, further supports insurers' ability to adapt to increased demand for coverage, unlike the U.S., where stringent price regulations can dampen policy growth. Overall, Slovenia's regulatory environment fosters a more responsive insurance market, facilitating an increase in policies after natural disasters, in contrast to the U.S., where the impact of such events may lead to fewer policies being written.

However, despite this more adaptable regulatory environment, Slovenia still faces a significant insurance gap, leaving many homes and properties uninsured or underinsured, especially against major risks like flooding and earthquakes. Low-income households are particularly vulnerable, as they are less likely to invest in comprehensive coverage, exacerbating their financial risk in the wake of disasters.

Between 1980 and 2022, the most frequent natural disaster in Slovenia was forest fires, with an average of 2.35 incidents per year. Other notable disasters, such as floods and storms, showed considerable variability in their occurrence.

The analysis of premiums revealed a complex relationship between disaster frequency and insurance premiums. The correlation between natural disaster claims and premiums suggests that premiums typically rise in response to disaster events, though the effect diminishes over time. While natural disasters prompt an immediate adjustment in premium rates, the long-term impact on premiums appears to be relatively minimal.

Moreover, the variability in loss ratios across insurance sectors highlights the financial strain imposed by natural disasters, with some sectors, like motor vehicle insurance, reacting more swiftly than others, such as Insurance against fire and natural forces. The strong correlation between natural disasters and loss ratios reinforces the need for insurers to continuously refine their risk models and coverage strategies to ensure financial resilience in the face of increasing disaster risks. Insurers have implemented various risk-reduction measures, such as discounts for policyholders who engage in preventive actions to mitigate disaster risks.

Slovenia's disaster management system, which prioritizes prevention, preparedness, response, and recovery, plays a crucial role in mitigating the impact of natural disasters. Government initiatives, such as flood protection programs and earthquake-resistant construction standards, contribute significantly to reducing the risks posed by catastrophic events. Collaboration between the government and the insurance industry is also essential

in addressing the insurance gap. One promising approach for closing this gap is the introduction of parametric insurance, an innovative solution that could offer more tailored and flexible coverage, especially for extreme and unpredictable risks.

In conclusion, the findings of this research challenge conventional beliefs about the effects of natural disasters on insurance markets and emphasize the need for a more adaptable and forward-thinking approach in the Slovenian insurance industry.

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