Research on the Role and Limitations of Catastrophe Bonds in Risk Hedging: A Case Study of Renaissance

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Abstract. In recent years, with the global climate change and the frequent occurrence of extreme natural disasters, the traditional reinsurance industry has faced unprecedented pressure in terms of claims settlement, especially when handling with extreme tail risks. Therefore, in this context, catastrophe bonds, as an innovative type of insurance-related securities, have been issued in the market to transfer and hedge extreme tail risks. This not only enhances the ability of risk dispersion, but also provides a new path for the capital management and optimization in the insurance and reinsurance industries. Thus, this paper collects and compares the market data of catastrophe bonds and reinsurance rates from 2021 to 2024 and analyzes the case of catastrophe bonds issued by Renaissance. It conducts a study on the relationship between catastrophe bonds and the reinsurance industry, as well as their substitutability for the reinsurance industry. The study finds that catastrophe bonds can effectively enhance the solvency of reinsurance companies in extreme tail risk scenarios and alleviate the capital pressure caused by frequent natural disasters to a certain extent. However, catastrophe bonds cannot replace the reinsurance industry. The relationship between them is complementary rather than substitutive.

Keywords: Catastrophe bonds, Reinsurance, Substitutability, Hedging Risk.

1. Introduction

Since the 21st century, the frequency and intensity of global natural disasters have been increasing continuously. Traditional catastrophe insurance and reinsurance have long been the main tools for transferring and mitigating disaster risks. However, when extreme loss events occur, the underwriting capacity of insurance companies and reinsurers is often insufficient, leading to rising costs and capital shortages. To address this limitation, catastrophe bonds, as an innovative risk-related security, have gradually developed. They introduce disaster risks into the capital market, achieving risk dispersion and providing additional underwriting capacity. Empirical studies show that catastrophe bonds often have higher yields and have a lower correlation with traditional assets, thus becoming an effective alternative risk transfer tool. The existing research is very limited focuses on the characteristics of catastrophe bonds themselves. However, catastrophe bonds are often issued by insurance companies or reinsurance companies. There is very limited any research on the correlation and complementarity between the reinsurance industry and catastrophe bonds, nor any more specific case analyses to prove it. In the context of the significant "hardening" of the reinsurance market in recent years, this research gap becomes particularly important, highlighting the need for further exploration of alternative risk transfer tools. This study analyzes the relationship between catastrophe bonds and the reinsurance industry at two levels. It examines the market performance of both catastrophe bonds and the reinsurance industry from a macro perspective, and conducts a detailed analysis based on data and data trends. At the micro level, Renaissance was selected as an example to study the case where Renaissance issued catastrophe bonds to hedge risks and its company's approach to risk classification. By comparing the data of Renaissance's catastrophe bond yields and reinsurance rates, the stability and risk dispersion effect of catastrophe bonds were evaluated in detail, and its supplementary nature to traditional reinsurance was further explored. Finally, the conclusion was drawn. The structure of this article is as follows. This research begins with a literature review, then analyzes the data of global catastrophe bonds and reinsurance industry from a macro perspective from 2021 to 2024, and subsequently provides an example analysis of the case of "Renaissance Reinsurance" from a micro

level. Finally, the influence of "inflation" on this study is excluded, and the limitations of this study are listed, leading to the conclusion.

2. Organization of the Text

2.1. Literature Review

Catastrophe Insurance (The following text is referred to as "Cat bonds"), one of the most commonly daily insurance used financial products in modern society, is broadly defined as aim at mitigating the risks of lower-probability but higher-loss natural disaster, for instance, the earthquake or hurricanes, and providing the basic economic protection and post-disaster economic compensation for policyholders after the natural disaster [1]. Nevertheless, due to the high relevance and extreme losses often associated with catastrophic events, traditional insurance companies often find it difficult to compensate for all the risks independently. Hence, as a supplement, reinsurance companies were born. Reinsurance helps insurance companies enhance their underwriting capabilities through the transfer risks mechanism and provide insurance funds support [2]. But market always form the significant price fluctuations after the catastrophic events. In that case, catastrophe bonds, as the core form of insurance-related securities (ILS), have gradually developed. Catastrophe bonds securitize both of insurance and reinsurance and transfer the risks of them into the capital market. The inventors of catastrophe bonds receive the higher returns during the periods when no disaster occurs than another ordinary capital bonds. However, after a disaster happens, they also need to undertake the risk of specific losses that may arise during such events [3] [4]. This mechanism not only expands the underwriting capacity of insurance companies, but also naturally transfers risks to the market. By having investors bear the risks, it achieves the effect of risk dispersion and reduction. It also reduces the concentration risks in the insurance and reinsurance markets and incorporates the capital market into the disaster risk-sharing system [5].

According to the existing research, catastrophe bonds have unique advantages in risk transfer. The essence of catastrophe bond is to transfer the risk of natural disasters and the risk of huge payouts by insurance companies and reinsurance companies after such disasters to the financial market. This can alleviate the compensation pressure on insurance companies and reinsurance companies [6] [7]. Meanwhile, the yield of catastrophe bonds is much higher than that of ordinary bonds, and it has a low correlation with other bonds in the financial market. Therefore, it provides an important channel for investors to reduce risks in their portfolio [8].

However, the existing studies are all based on the performance of catastrophe bonds in the global market, but there are few specific case analyses, especially the analysis and research on the issuance of catastrophe bonds by Bermuda reinsurance companies. At the same time, the existing studies also lack research on the complementarity between reinsurance and catastrophe bonds. Therefore, this study, based on the latest data of the global catastrophe bond market from 2021 to 2024 and the case of catastrophe bond issuance by Bermuda reinsurance companies, analyzed the risk hedging effect of catastrophe bonds and its complementarity with reinsurance, providing new evidence for academic research and industry practice.

2.2. Methodology and Framework

This study adopts a step-by-step approach from the macro level to the micro level to conduct a comprehensive analysis of the market performance of catastrophe bonds and their complementarity with reinsurance.

From the macro perspective. The research will analyze the global catastrophe bond market data from the year 2021 to 2024, including important indicators such as issuance scale, yield rate and default rate, and compare them with the global reinsurance rates during the same period. Through statistical calculations and comparative analysis, the characteristics of catastrophe bonds in terms of risk transfer efficiency and pricing mechanism can be determined.

From a micro perspective, this article will conduct a detailed study on the case of Bermuda Reinsurance Company's issuance of catastrophe bonds, treating the company as the main research object. By comparing and analyzing the stratification strategy of 'core capital' and 'third-party capital' adopted by Bermuda Reinsurance Company, a detailed analysis was conducted on the case where extreme peak risks were transferred to capital market investors through catastrophe bonds, and the role of catastrophe bonds in risk sharing was discussed.

In summary, the main framework of this article is as follows: Firstly, through comparative analysis of global data to indicate the overall market trend. Secondly, by analyzing the case of Bermuda Reinsurance Company issuing catastrophe bonds. Finally, combining the results at the macro and micro levels, comparing the complementarity between catastrophe bonds and reinsurance, and drawing the research conclusion.

2.3. Analysis & Discussion

2.3.1. Conduct a macro analysis of market data

In order to analysis a comprehensive and systematic assessment of the development trend of the global catastrophe bond market from a macro perspective. This analysis needs to be conducted based on key indicators such as issuance scale, market stock size and yield level index. Especially in the 21st century, when global climate warming is taking place, natural disasters occur frequently, and the demand for risk diversification tools in the global capital market is constantly increasing. This consequently led to the further expansion of the catastrophe bond market [9]. To visually present this recent trend, this study selected the global catastrophe bond market data from 2021 to 2024 (seen Table 1) and combined graphical analysis to explore the evolving characteristics of the market.

Note: Among them, the level of returns is measured by the Swiss Re Global Cat Bond Total Return Index [10] as the macro market performance indicator. The default rate is estimated at 2.3% based on historical averages due to the lack of public data. This study considers the different statistical standards for “coupon” and “total-return” in public sources. Therefore, this paper uses the Swiss Re Global Cat Bond Total-Return Index as the main indicator to measure the overall market return (2023 = 19.69%; 2024 = 17.29%). At the same time, for the relevant data in 2021, Artemis' issuance-level data was used (such as the average coupon at the time of issuance in 2021 = 6.3%). This was done to supplement the new issuance pricing changes to observe the pricing mechanism at the issuance end. Regarding 2022, Swiss Re provided YTD = -0.35% (as of 2022-06-30) in the H1-2022 report, but the public summary did not provide the full-year total-return value. Therefore, this paper used the H1 indicator and Artemis' quarterly charts as references for the pricing/return in 2022 and noted the data limitations in the discussion. Thus, this study has certain limitations in terms of data and analysis.

Table 1. Global Catastrophe Bond Market Indicators (2021–2024)

Years	Annual issuance scale (billion US dollars)	Market stock size (in billions of US dollars)	Yield (%)	Reinsurance Rate Index (base=100)	Default rate (%)
2024	17.7	49.5	17.29	150	N/A
2023	15.4	45.6	19.69	140	N/A
2022	10.5	37.9	-0.35	105	N/A
2021	12.5	34.1	6.3	100	N/A
Note: The default rate is estimated at 2.3% based on historical averages due to the lack of public data.					

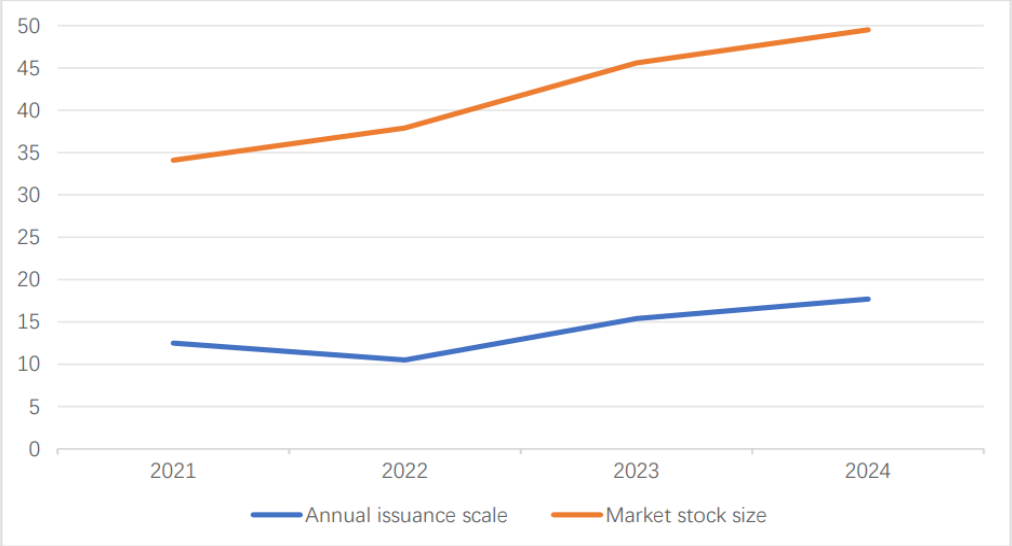

Figure 1. Catastrophe Bonds Annual Issuance vs Market Stock

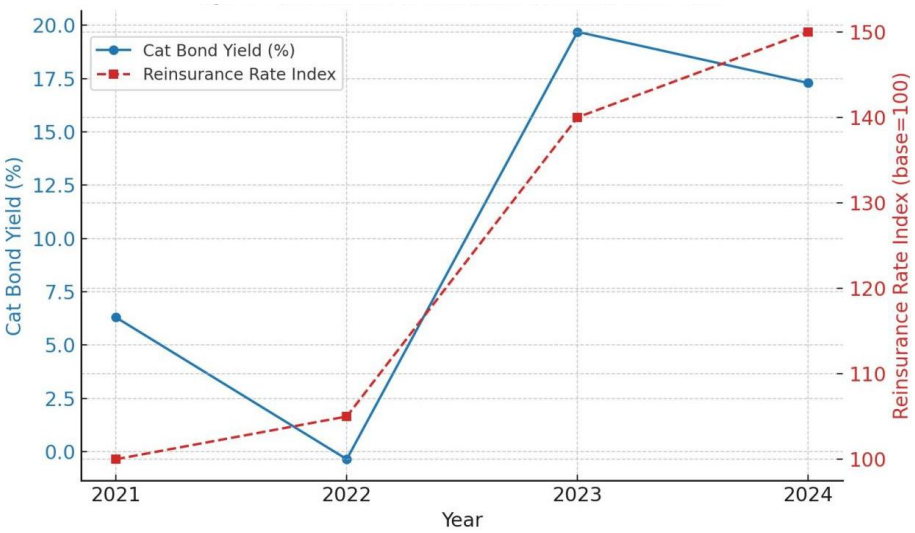

Figure 2. Cat Bond Yield vs Reinsurance Rate Index

By analyzing the Table 1 and Figure 1 [11], it is obvious that the annual issuance scale of global catastrophe bonds has increased from 12.5 billion US dollars in 2021 to 17.7 billion US dollars in 2024, representing a year-on-year growth of approximately 41.6% by computation that (17.7-12.5) ÷ 17.7 × 100%. That is, in Figure 1, the blue line representing the "Annual Issuance Scale" shows a trend of growth. Meanwhile, in Figure 1, the orange line representing the Market stock size also shows a trend of growth. The market stock size increased from 34.1 billion US dollars to 49.5 billion US dollars, representing a cumulative growth of approximately 45.2% by computation that (49.5-34.1) ÷ 34.1 × 100%. Thus, Combining Figure 1 and Table 1, the trend is steadily rising, indicating that the market is indeed continuously expanding. By analyzing Figure 1 and 2, it is notable that the market issuance scale experienced a slight decline in 2022, but rebounded rapidly in 2023, growing by 31.8%year-on-year (15.4-10.5) ÷ 15.4 × 100%, making it the year with the fastest expansion. This fluctuation is highly correlated with the frequent occurrence of natural disasters. This is because the “hurricane Ian” that hit Florida in 2022 led to an increase in reinsurance prices (the rate index rose from 100 to 105), which further drove the demand for catastrophe bonds in 2023, and the market issuance scale subsequently increased significantly. To be specific, it was because Hurricane Ian caused massive economic losses when it made landfall in Florida that several catastrophe bonds' compensation mechanisms were triggered. This resulted in negative yields in the catastrophe bond market in 2022, causing investors and institutions to develop a negative attitude towards the

catastrophe bond market. However, since no major natural disasters occurred globally in the following year (2023), the issuance scale of catastrophe bonds once again increased. This indicates that catastrophe bonds have, to a certain extent, played a supplementary role in the reinsurance market.

By analyzing Figure 2 and Table 1 [12], we aim to explore the trend relationship between the yield of catastrophe bonds and the reinsurance rate. The first point to emphasize is the connection between the trends and the relationship of the two. If the trends of the two are opposite or divergent, then the catastrophe bonds and the reinsurance industry have a complementary relationship; conversely, if they show the same trend, it is a substitutive relationship. This is because if their trends are the same, it indicates that they are driven by the same risk factor and have similar functions, forming a substitutive relationship; if their trends are opposite, it indicates that they respond differently to external shocks and have different functions, thus being able to complement each other. Based on Figure 2, it can be concluded that only in the period from 2022 to 2023, both the yield of catastrophe bonds and the rates in the reinsurance industry experienced significant increases. During the other periods, the trends were opposite. The main factor was that Hurricane Ian caused huge economic and property losses when it made landfall on September 28, 2022, thereby imposing a huge claim pressure on reinsurance companies, resulting in capital losses for the industry [13]. However, it also led to an increase in the demand for reinsurance from insurance companies, causing the reinsurance rates to rise. Additionally, this disaster triggered some compensation mechanisms for catastrophe bonds, leading to a resistance from investors towards catastrophe bonds. To attract capital in the market, the issuers (insurance companies) raised the yields of catastrophe bonds. However, this period was an exception. In other periods of Figure 2 or in longer-term and more macroscopic periods, catastrophe bonds provided capital for the reinsurance industry and successfully transferred risks to investors. Investors only needed to bear the low probability of compensation while obtaining a high probability of high returns. Thus, it can be seen that the two are still complementary.

Overall, the global catastrophe bond market continued to expand from 2021 to 2024, with the yield level remaining relatively stable outside of extreme disaster scenarios and the default rate being extremely low. This indicates that catastrophe bonds are playing an increasingly important role in global disaster risk management and risk transfer. However, the comparison of yields and reinsurance rates shows that they more often exhibit a complementary relationship rather than being completely substitution.

2.3.2. Micro-analysis of the RenaissanceRe case

In order to conduct a more comprehensive analysis of the complementary relationship between catastrophe bonds and the reinsurance industry from a macro to micro perspective, this study selected "RenRe Reinsurance" as a case for analysis. This research delved deeply into the asset structure of the company, its financial statements (taking 2023 as an example), and how it utilized the complementary relationship between the reinsurance and catastrophe bond markets to transfer risks to the market through catastrophe bonds.

Renaissance (RenRe), headquartered in Bermuda, is a leading reinsurer specializing in catastrophe risks such as hurricanes and earthquakes. Its core capital management is to balance underwriting risk, capital efficiency, and shareholder return. RenRe repeatedly emphasis in its annual reports that it relies not only on traditional reinsurance but also on insurance-linked securities (ILS), including catastrophe bonds, to diversify peak risk exposures. By issuing catastrophe bonds, the company transfers the peak and highest risks to capital markets investors, thereby protecting its balance sheet and improving capital efficiency [14]. This mechanism of transferring the risk of claims to the capital market perfectly illustrates the complementarity between catastrophe bonds and reinsurance.

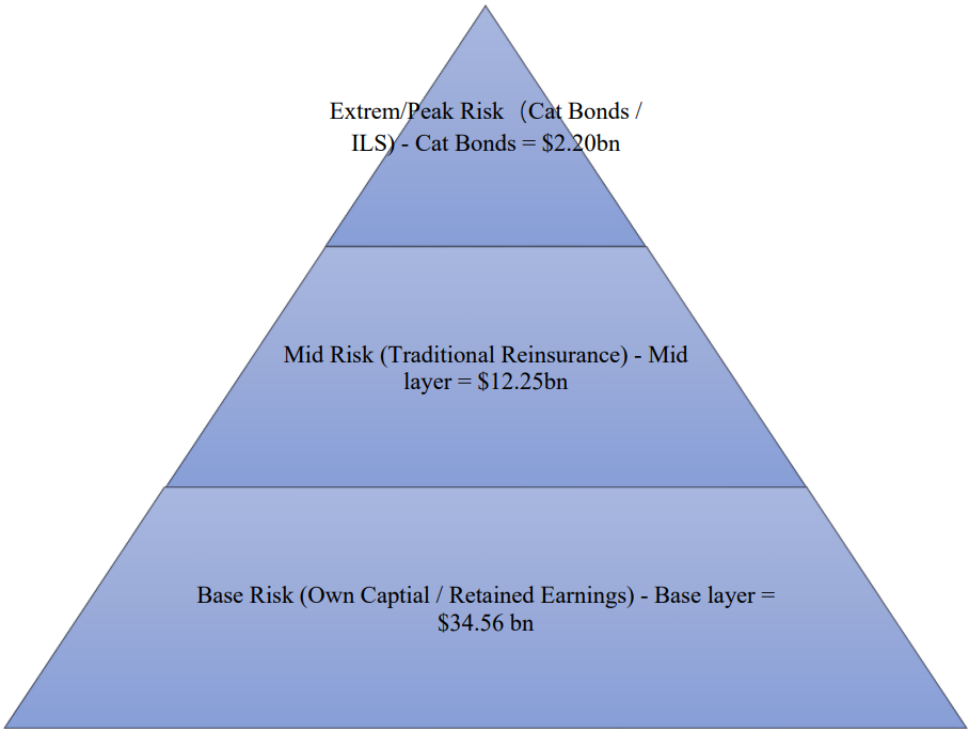

Figure 3. Illustrative Capital Layering at Renaissance (RenRe) (2023)

According to the risk layering logic presented in Figure 3 "Illustrative Capital Layering at Renaissance (RenRe) (2023)", RenRe has divided the company's risks into three levels: low loss - medium loss - extreme loss. Low loss generally refers to small-scale losses within $500, which can be managed by relying on the company's own capital and the traditional reinsurance industry; medium risk can be controlled, mainly relying on the traditional reinsurance industry. These two types of risks do not affect or influence the company's own financial situation. Thus, it can be concluded that the main role of the traditional reinsurance industry is to provide stable guarantees and reduce annual financial fluctuations, while the own capital is used to maintain the company's market reputation and financial stability. Therefore, RenRe regards these two as the main capital tools.

However, for the most extreme peak risks, due to the significant property fluctuations and high compensation amounts they bring about, RenRe uses catastrophe bonds to cover the most extreme and capital-intensive risks in order to hedge against the risks. This way, it can effectively reduce the consumption of its own capital, maintain underwriting capacity during the "hard period" of the reinsurance market, attract capital from the capital market, and transfer the huge compensation risks brought by disasters to the investors [15].

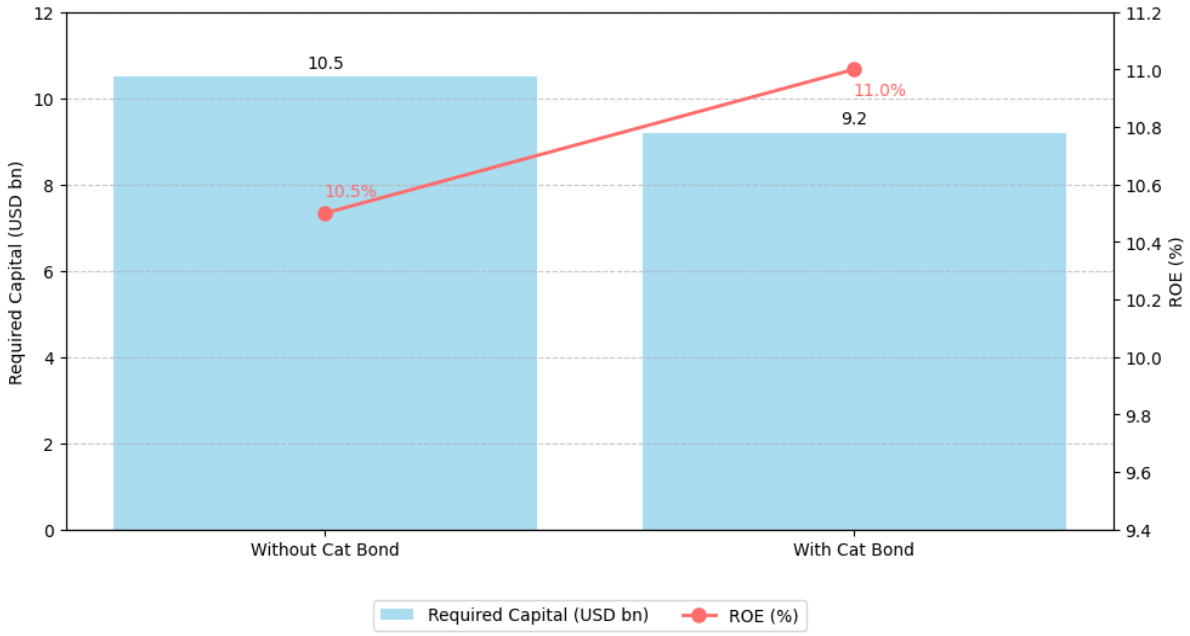

Figure 4. Comparison of Capital Requirement and ROE Without Cat Bonds vs With Cat Bonds

Figure 4 [16] illustrates the significance of Cat Bonds in the structure of RenRe Company. Firstly, the bar chart shows the comparison of RenRe's capital requirements with and without the protection of Cat Bonds, which is the value of "Required Capital ($bn)", equivalent to SCR (Solvency Capital Requirement), that is, the capital requirement for solvency. The purpose of this (Required Capital) indicator is to measure the minimum capital amount that a company must hold according to regulatory authorities or internal models in order to continue and operate its other businesses safely and cover all potential risks it faces.

Hence, using the data from 2023 as an example, when RenRe was operating without the protection of Cat Bonds, its capital requirement was 10.5bn.

Calculation steps:

According to RenRe's annual report, its net underwriting of catastrophic risks in 2023 was approximately $20 - $25bn in gross limits.

Generally, 25% - 40% of the gross PML (Probable Maximum Loss) is required as capital.

Assuming that RenRe transferred about $1.3bn of extreme risks to the investors of Cat Bonds (the issuance scale from 2022 to 2023), then without the protection of Cat Bonds, the required capital ≈ 25bn × 0.42 = ~10.5bn).

However, with the protection of Cat Bonds, the capital requirement decreased to 9.2bn (the required capital ≈ (25bn - 1.3bn) × 0.41 ≈ ~9.2bn). In this case, the company's risk exposure has significantly decreased, releasing the originally occupied 1.3bn capital. The released capital can then be used for dividends, share buybacks, or investment in higher-return projects.

Because RenRe has the protection of Cat Bonds, some of the risks have been transferred to the capital market, and the risks are borne by the investors. For the insurance company, the biggest loss is no longer the huge compensation amount caused by catastrophes, but the fixed and small premiums paid to the investors of Cat Bonds. This perfectly achieves the effect of risk hedging. For the 1.3 billion released capital, it led to a decrease in the net assets represented by the denominator when the company calculated ROE, while the numerator representing the net profit increased due to the risk transfer under the protection of Cat Bonds, so the ROE value increased.

Calculation steps:

ROE = Net Income / Average Equity

With the protection of Cat bonds: ROE = Net Income ($1.95bn) / Average Equity ($17.7bn) ≈ 11.0%

Without the protection of Cat bonds: Assuming that the net profit remains unchanged. ROE = Net Income ($1.95bn) / Average Equity ($17.7bn + $1.3bn) ≈ 9.5%

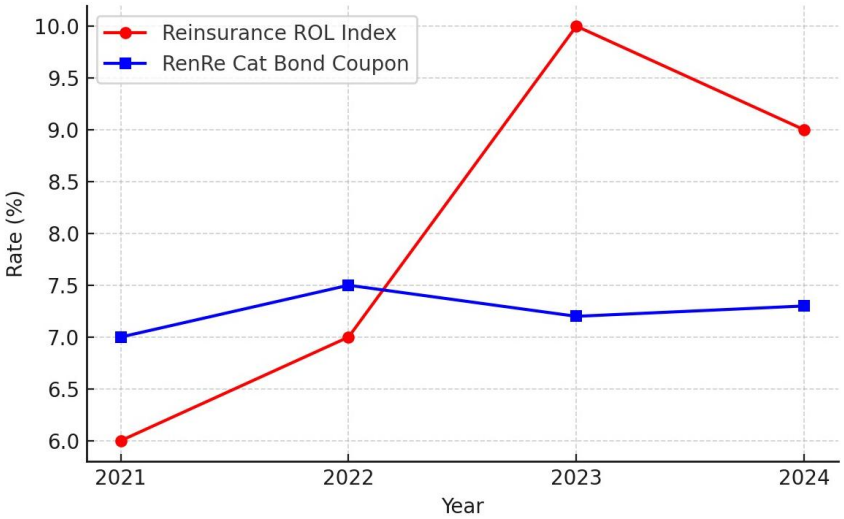

Figure 5. Reinsurance ROL Index vs Cat Bond Coupon Rate (2021-2024)

Figure 5 [17] shows the comparison between the Cat Bond Coupon of RenRe (Renaissance Re, a Lombardy reinsurance company) and its compiled Reinsurance ROL Index from 2021 to 2024. It can be seen that the Cat Bond Coupon was higher than the ROL Index from 2021 to 2022 because when the market was in a "soft market", the traditional reinsurance industry remained the mainstream, bearing most of the market risks, while Cat Bonds bore extremely high risks. The difference was not significant because the market risks were stable at that time. However, from 2023 to 2024, due to factors such as capital contraction in the post-pandemic era, frequent natural disasters, and unstable investment environment, the global property catastrophe reinsurance premium rate rose significantly (the year-on-year increase in 2023 was >30%), and at this time, the price of traditional reinsurance was extremely expensive (the ROL index soared). The reinsurance company raised the price significantly to cover losses and future risks; thus, the attractiveness of Cat Bonds became prominent. Although its interest rate was also rising, the market risk was relatively high during this period, and Cat Bonds were extremely good at handling extremely high risks. Therefore, the reinsurance company chose to issue Cat Bonds to hedge risks and protect the interests of the insurance company. This highlights the complementarity of the functions of Cat Bonds and the reinsurance industry in a "hard market".

In conclusion, based on the analysis of RenRe's financial statements and by comparing the data with and without the protection of Cat Bonds, it can be concluded that Cat Bonds play a significant role in risk hedging. By issuing Cat Bonds, the risk is transferred to the capital market, which reduces the capital requirements for repayment capacity, improves the efficiency of capital management, optimizes the capital structure, and thereby increases ROE. The role of reinsurance is to cover regular risks. While Cat Bonds, as a strategic tool, cover extreme tail risks, they help enhance capital efficiency and lock in long-term costs. The two complement each other, cooperate with and reinforce each other, thereby enhancing the capital efficiency of the enterprise.

2.3.3. Excluding the factor of inflation and the limitations of the research

Table 2. The Global Inflation Rate from 2021 to 2024

	Years			
	2021	2022	2023	2024
CPI (%)	4.7	8.7	6.8	5.9

The above analyses in this study were all conducted independently of the impact of inflation. Although inflation does raise interest rates, based on the following brief analysis, we can rule out the influence of inflation on this study.

To test whether the above conclusion might merely be an accidental phenomenon resulting from the increase in the inflation rate, this study examined the global annual inflation rates from 2021 to

2024. According to the data from the IMF [18], the global inflation rate increased significantly in 2022-2023, reaching 8.7% and 6.8% respectively. Although inflation does affect the interest rates of catastrophe bonds and causes them to rise, the coupon rate of catastrophe bonds, in addition to the interest rate, also includes a risk premium; the reinsurance rate is the same, and it is more influenced by natural disaster risks and capital-driven factors. If the changes in both are merely the effect of inflation, the trends of their changes should be roughly synchronous. However, during the period of higher global inflation rates from 2022 to 2024, the yield of catastrophe bonds issued by RenRe in Figure 5 remained a stable increase, and the yield of global catastrophe bonds in Figure 2 also maintained a relatively low increase during this period. The only reason that caused the yield of catastrophe bonds to increase significantly in 2022 was that the Ian hurricane triggered the compensation mechanism of multiple catastrophe bonds. While the increase in the reinsurance rate during this period was relatively high. From this analysis, it can be seen that the yield of catastrophe bonds and the reinsurance rate did not experience a significant and substantial increase at the same rate. This indicates that most of the differences in the fluctuations of catastrophe bond yields and reinsurance rates should be caused by market structures such as natural disaster risks, capital-driven factors, rather than inflation. Thus, the possibility of inflation being the sole explanatory variable can be ruled out; although inflation is a background factor, it is not sufficient to explain the significant divergence between the reinsurance rate and the yield of Cat Bonds.

In addition, it should be noted in this paper that due to the difficulty in accurately obtaining data such as catastrophe bond yields and reinsurance rates, the consistency of data on the internet is inconsistent. Some data are only available in commercial databases, which limits the depth of the research. Secondly, the existing data have differences in structure and statistical standards, resulting in certain deviations in direct comparisons. These factors may affect the robustness of the research conclusions.

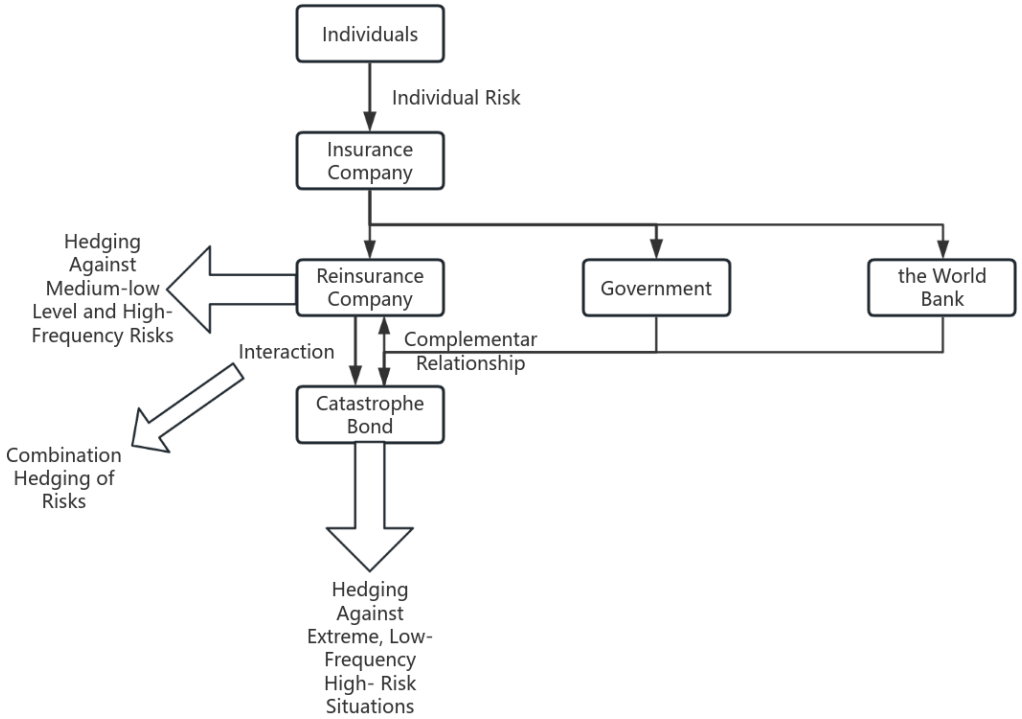

Figure 6. The formation mechanism of catastrophe bonds and the multi-level risk hedging framework

2.4. Summary

In summary, the catastrophe bonds and reinsurance industry are functionally complementary. Since individuals bear the initial risk and transfer it to insurance companies, and insurance companies can only bear some individual risks, it means that insurance companies achieve risk sharing through

large-scale averaging. However, for risks such as systemic risks, such as catastrophic natural disasters causing economic losses, insurance companies cannot achieve this through large-scale risk averaging. Therefore, insurance companies will transfer risks through two channels. For medium and low risks, insurance companies will attach these high-probability but medium-low risks to the traditional reinsurance industry because the occurrence probability of such risks is relatively high and requires the professional pricing and flexible claim management capabilities of reinsurance companies. For low-probability but extremely high risks, reinsurance companies will securitize the extreme risks for hedging because once such risks occur, they are likely to breach the capital of reinsurance companies and cause fluctuations in the market. Therefore, reinsurance companies will transfer these risks to a larger capital market for capital hedging. For example, RenRe, through the above analysis, it is concluded that this company uses the issuance of catastrophe bonds to hedge risks, improving the company's ROE indicators, reducing the company's capital requirements, and increasing capital efficiency. Therefore, catastrophe bonds and the reinsurance industry, as different mechanisms for hedging risks, respectively hedge risks at different levels. They do not operate independently but interlock and work together. This forms a dynamic balanced ecosystem where when one market's underwriting capacity is tight and prices rise, it will drive changes in demand and prices in another market. In simple terms, the complementarity of the two in covering the risk spectrum to ensure the stable operation of the entire insurance industry. Ultimately, for investors, catastrophe bonds are equivalent to a "major disaster insurance". Investors receive risk-free interest rates and the corresponding yields of catastrophe bonds when the market mechanism is not triggered. After the market initiates the compensation mechanism, investors will need to make huge payouts, but this is only a low-probability event. Due to the small impact of catastrophe bonds on the market, catastrophe bonds are usually an important tool for investors to hedge risks in their investment portfolios. By analyzing the market size of catastrophe bonds and reinsurance rates over the past five years (2021-2024) at the macro level, the market size of catastrophe bonds has continued to rise, gradually forming a complementary mechanism with the reinsurance industry.

3. Conclusion

This study, through the analysis of the return rates of global catastrophe bonds and reinsurance rates from 2021 to 2024, as well as an in-depth study of the Renaissance case, has reached the following conclusion: Catastrophe bonds and the reinsurance industry are functionally highly complementary to each other. Compared with the reinsurance industry, catastrophe bonds can effectively diversify and hedge extreme low-probability high risks, alleviate the capital pressure of reinsurance companies under the frequent occurrence of natural disasters, and transfer their risks to the capital market. Both have complementary characteristics in covering the risk spectrum. Therefore, they are a complementary relationship rather than an alternative relationship, and together they build a stable system for risk dispersion and capital.

This study not only fills the research gap in the complementarity of catastrophe bonds and reinsurance, but also provides new references for related insurance industries and investment institutions. For the insurance industry, this study explains the importance of catastrophe bonds in hedging extreme risks and provides new ideas for insurers to diversify risks. For investors, catastrophe bonds also have the advantages of high returns and low correlation in the investment portfolio and are an important tool for hedging the risks of the investment portfolio.

However, this study also has limitations. In particular, the related data is difficult to verify and obtain, which may affect the robustness of the conclusion, and the research years selected in this paper are short, only four years of data, which is difficult to support the relevant conclusion. Future research can combine more relevant data and long-term data analysis to conduct more in-depth research on the dynamic relationship between the catastrophe bond and reinsurance markets. At the same time, more continuous research can be conducted on the complementarity of the two in different

economic situations and natural disaster scenarios to provide more in-depth theoretical support for risk management practices

References are cited in the text just by square brackets. (If square brackets are not available, slashes may be used instead, e.g. /2/.) Two or more references at a time may be put in one set of brackets. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under a heading *References*, see our example below.

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