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Catastrophe Bonds: Analysis of the Performance as an Asset Class and Evaluation of Diversification Benefits

Katasztrófakötvények hozamának, diverzifikációs hatásának vizsgálata és befektetési eszközként való értékelése

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Introduction

Insurance linked securities are instruments that provide catastrophe risk coverage for insurance companies.

Catastrophic events can cause substantial financial damage to (re)insurance firms. Catastrophe risks were uninsured before the 1990's, but when the losses caused by Hurricane Andrew in 1992 led to 11 insurance companies going bankrupt, the industry realized it had to find a way to handle these risks, and these securities were developed.

The market of these instruments is growing at a fast pace, over the course of the last 15 years it became 8 times larger, reaching a size of \$52 billion in 2020.

Catastrophe bonds are a major category of insurance linked securities. CAT bonds are financial instruments, that transfer catastrophic risk from companies and governments to the capital markets. These securities are an effective risk transfer mechanism, that provide reinsurance coverage to companies that otherwise wouldn't be able to survive such losses.

These instruments are also attractive to investors. Since factors that drive financial markets have no influence on the occurrence of natural catastrophes, events such as financial crises and market corrections do not affect the returns of these bonds. Therefore, these instruments provide a great deal of diversification.

In order to have an understanding of the asset's function in the insurance industry, I firstly examine the traditional reinsurance model. I look at the strengths and effectiveness of the model, and I break down how it collapses when a natural catastrophe occurs. Then I examine the benefits of securitization, and how the process of transferring these risks to the capital markets is an effective risk transfer mechanism.

I examine the process of issuance of CAT bonds and describe how the standardization – which followed the 2008 financial crisis – made the structure more stable.

I analyze the structure of the asset class. I explain the payout processes, the triggers sponsors can issue the bonds with, and the loss events they can cover with the issuance of CAT bonds. I look at the trade-off regarding the choice of trigger and explain the mechanism of each one. Finally, I analyze the performance and the diversification benefit of the asset class.

1. Raising of topic

Not a lot of research have been done about the returns of these assets, so the aim of this paper is to analyze the performance of catastrophe bonds. Since CAT bonds have similar financial rating as high-yield corporate bonds, I will compare the two assets classes' performance over the 01.2016 – 09. 2021 period.

To track the performance of CAT bonds I will use a well-diversified CAT bond fund, the GAM Star Cat Bond Fund. As a proxy for high-yield corporate bonds I use the iShares iBoxx High Yield Corporate Bond ETF. To put both of the asset classes' performance in perspective, we will look at the performance of the stock and bond markets. The S&P 500 will represent the equity market, and the Vanguard Total Bond Market ETF will be our proxy for the bond market.

Firstly, I will analyze the absolute returns of all the assets. I will compare the performance of CAT bonds to all the other assets', and I will also look at how the occurrence of a natural catastrophe affects the returns of these assets.

Besides examining the absolute returns of the asset classes, it is also important to take the undertaken risk into account, in order to do that, I will calculate Sharpe ratios to compare the risk-adjusted returns.

I will also examine if these bonds really provide superior diversification benefits to investors compared to non-investment grade bonds. Therefore, I will measure the assets' sensitivity to both the equity and bond market. By calculating Treynor ratios we also will look at the assets' excess return to market risk ratios.

All in all, by examining if the returns reflect the assets class's financial ratings and also by analyzing the diversification benefit investors can achieve with this asset, my aim is to define the role of catastrophe bonds in an investment portfolio.

2. Technical Literature Review

2.1 Reinsurance and Securitization

In order to fully understand the asset's purpose, we will first analyze the traditional reinsurance model's efficiencies, advantages and also how it breaks down in when severe losses occur.

2.1.1 Reinsurance

The traditional insurance model – shown in Figure 1 – begins with individuals and businesses purchasing insurance contracts from insurance companies. They pay premiums, and in return insurance firms make contingent promises, so if the certain insured event occurs, they cover the hedgers' losses. The risks transferred by hedgers to the company are reduced by holding a diversified risk portfolio. Diversification is an effective way of risk mitigation, but it only works in case of risks that are statistically independent. Hence there is residual risk remaining, most of which the insurance company retains by holding it on its balance sheet. However, residual risk can be significant due to factors such as random fluctuations, there are times where the losses cannot be covered purely by the equity the company holds (*Cummins–Trainar, 2009*). These severe risks that cannot be covered by the company's capital are so called “tail risks” (*Edesses, 2015*). The tail risk can be reduced by transferring these risks to reinsurance companies by entering a reinsurance contract. A reinsurance contract provides insurance coverage for insurance firms. Reinsurance companies – much like insurance companies as mentioned before – can minimize their risk with diversification from underwriting risk for businesses from various geographical regions and also by insuring risk for various lines of insurance such as property, life, annuities, etc. (*Cummins–Trainar, 2009*). Reinsurance firms can also purchase insurance contracts, which are called retrocession (*Edesses, 2015*). As mentioned before, with diversification the risk is not completely eliminated, so ultimately there will be risk which has to be absorbed by the equity held by the companies. Equity is traditionally provided by investors who also minimize non-systematic risk by holding diversified investment portfolios. This is how in the economy the insurance industry acts as a risk-warehousing function which is mainly achieved by risk transferring and diversification. Also, thanks to diversification and risk transfer this model allows (re)insurance firms to underwrite significantly more risk than what it would be possible solely with the support of the amount of equity they hold. The efficiency of this model explains why this is the traditional and still prevalent model for reinsurance (*Cummins–Trainar, 2009*).

However, this model works best when the risks are uncorrelated, and the losses are not substantial (*Cummins–Trainar, 2009*). As noted before, diversification does not eliminate the risk. Also, reinsurance and retrocession are quite expensive and have their capacity limitations. When the correlation of the risks and the magnitude of the potential losses increase, the traditional model breaks down. The residual risk – that cannot be eliminated through internal pooling – is covered by the issuance of equity. Therefore, with the occurrence of large, highly skewed risks it is the capital base of the company that would have to absorb the substantial financial damage (*Cummins–Trainar, 2009*). The deficiency of this model showed in 1992, when after hurricane Andrew 11 insurance companies went bankrupt (*Morana–Sbrana, 2019*).

Because the losses caused by natural disasters are so substantial – for example hurricane Andrew caused \$17 billion of insured losses – the coverage the traditional model provides is simply not sufficient for the insurance company to pay out its claims (*Sterge–Stichele, 2016*).

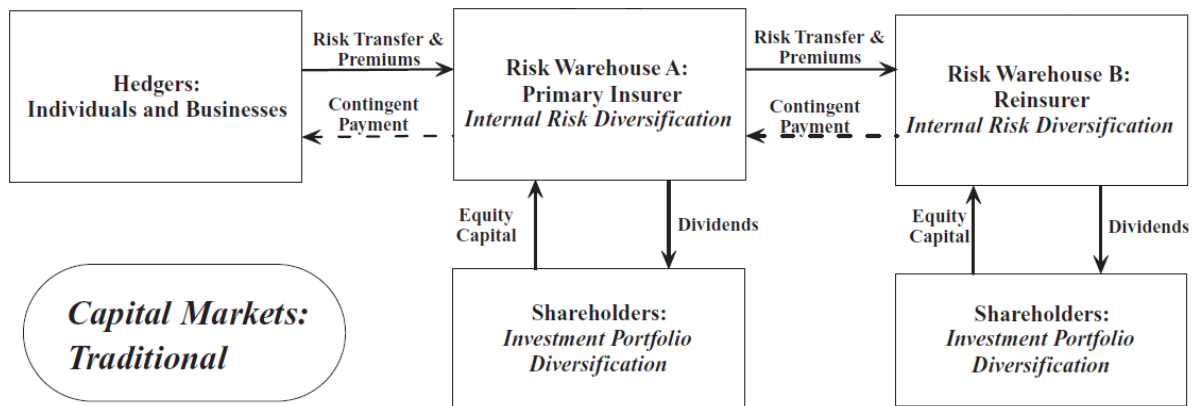


Figure 1: Traditional reinsurance model

Source: Cummins–Trainar, 2009

2.1.2 Securitization

As mentioned before in case of a natural catastrophe, where the magnitude of losses and the correlation of risks increase, the traditional reinsurance model breaks down (*Cummins–Trainar, 2009*). Also noted in the previous section, natural catastrophes cause major financial damage, up to tens of billions of dollars (*Sterge–Stichele, 2016*). These events are excessive compared to the capitalization of the reinsurance industry, however even the losses from the largest catastrophes would not exceed 1% of the total value of securities traded in the US alone (*Cummins–Trainar, 2009*). For insurance companies to survive these events, they have to transfer these kinds of low-frequency and high severity risks to the capital markets (*Blach–Wieczorek, 2014*). The most effective way to achieve this is by the process of securitization (*Cummins–Weiss, 2009*).

“Securitization involves the repackaging and trading of cash flows that traditionally would have been held on-balance-sheet. Securitizations generally involve the agreement between two parties to trade cash flow streams to manage and diversify risk or take advantage of arbitrage opportunities (*Cummins–Weiss, 2009, p.515*)”. The firms this way have access to a much larger pool of capital with the involvement of capital markets compared to the traditional reinsurance market (*Blach–Wieczorek, 2014*). This way insurance companies are able to transfer the risk to the capital markets, insulating their balance sheet from catastrophe risks (*Cummins–Weiss, 2009*).

Insurance-linked securities (ILS) were designed for this very purpose. ILS are securitized insurance risk products which can be traded on capital markets. With the issuance of these products insurers can hedge themselves from low-frequency and high severity risks. With the help of ILS insurance companies can protect themselves from the exposure that is caused by the flaw of the traditional insurance model, while at the same time also increasing the underwriting capacity of insurers by taking off weight of their balance sheet (*Blach–Wieczorek, 2014*). There are multiple types of ILS, but catastrophe bonds are by far the most successful (*Cummins–Weiss, 2009*).

Another flaw of the traditional model is that insurers have to renew reinsurance contracts every year, therefore they are exposed to cyclical price fluctuations of the market (*Ammar et al., 2015*). By having a maturity typically longer than one year, CAT bonds provide multi-year protection at a fixed price with no exposure to yearly price fluctuations (*Cummins, 2008*).

Given the previously mentioned issues it is clear why the issuance of CAT bonds is attractive to insurers. These products also offer unique characteristics from the investors point of view.

Firstly, these products provide a great deal of diversification. (*Cummins–Weiss, 2009*). Forces that drive financial markets have no influence on the occurrence of natural catastrophes (*Karlsson–Karneback, 2017*).

Therefore, ILS – and CAT bonds in particular – have a beta close to zero with respect to most investments. Which means CAT bonds are most likely not correlated with the other parts of the investors’ portfolio. By investing in these products, investors can hedge their portfolios against systematic risk (*Cummins–Weiss, 2009*).

Secondly, for accepting these kinds of severe risks, investors demand a sizable premium (*Blach–Wieczorek, 2014*). As a result, these instruments provide high yield to investors.

Similarly to their ratings, the yields of CAT bonds can be compared to high yield B or BB rated corporate bonds (*Edesses, 2015*).

Thirdly, CAT bonds are fully collateralized instruments. What that means for the investor is that compared to the majority of corporate issued financial products, here the investors are not exposed to the insolvency risk of the issuer (*Cummins, 2012*). Therefore, if the CAT bond is properly structured, the potential bankruptcy of the issuer will not affect the investors at all. Because of this reason CAT bonds are “pure play” securities, where the investors only bear the risk of the insured catastrophic event occurring. As a result of the demand from the investors’ side, issuers can get catastrophe coverage at a relatively low cost compared to reinsurance, although CAT bond issuance is primarily only accessible to large institutions whose balance sheet is reasonably large to amortize the excessive cost of structuring (*Cummins–Trainar, 2009*).

It is also important to note that CAT bonds are not substitutes for reinsurance, these instruments are solely used to cover peak risks as discussed before. When deciding on the risk model insurance companies first have to determine how much risk should they cover by issuing equity and how much risk should be covered by risk transfer. Then the ratio between the purchase of reinsurance contracts and CAT bond issuance has to be calculated. Throughout the decision making the structure of their risk portfolio and the cost effectiveness are the fundamental aspects (*Chang et al., 2020*).

As shown in Figure 2, natural catastrophes are showing an upward trend since the 1960’s. According to the data showed in this figure, the number of natural disasters occurred in 1986 was 150, the same statistic in 2005 was 432. As we can see the number of natural catastrophes almost rose by 200% percent in just 19 years. It was due to this rapid increase that insurance

companies had to find a solution that enabled them to pay out the claims while maintaining financial stability and solvency once such event occurred.

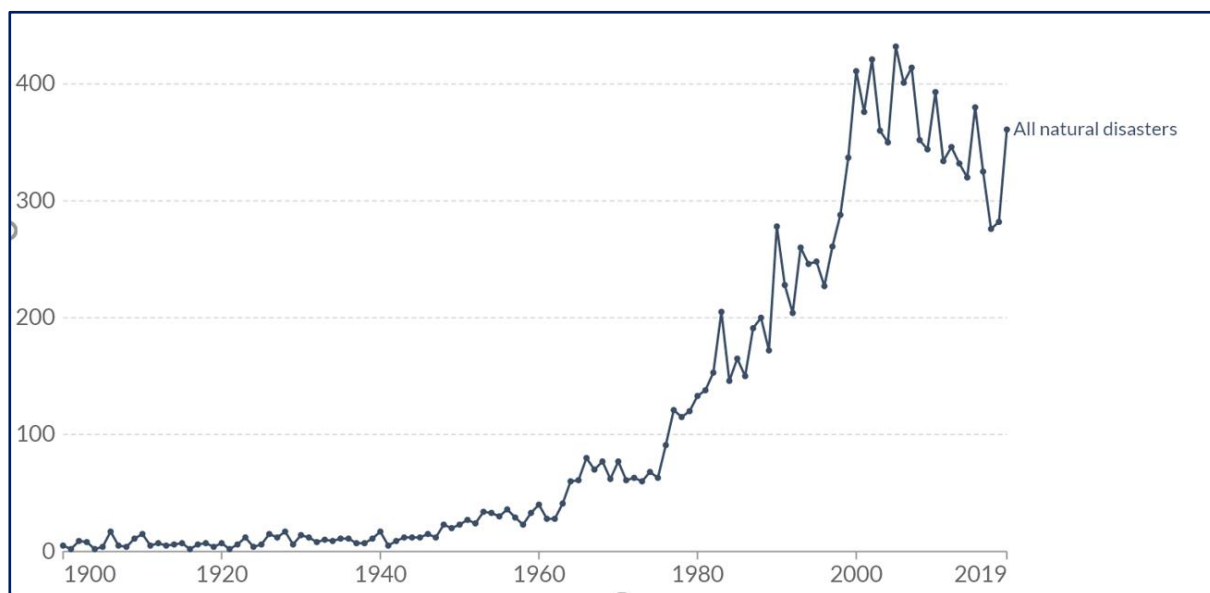


Figure 2: Number of recorded natural catastrophes 1900-2019

Source: ourworldindata.org

In Figure 3 we can see that the growth in the CAT bond market is quite substantial. The amounts of CAT bonds issued are growing rapidly, setting a record in terms of issuance volumes by almost each year. Same thing can be said about the whole ILS market, as shown in Figure 5. In 2005 the size whole market was bit over \$6.5 billion, which in 15 years grew by 8 times, reaching a size of \$52 billion by 2020.

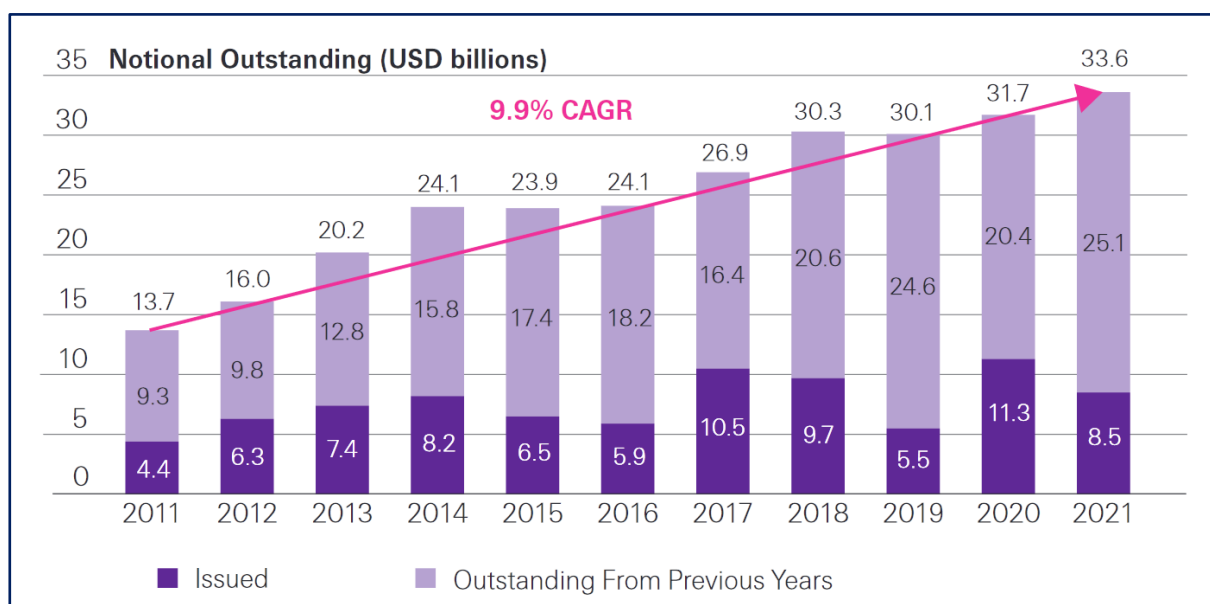


Figure 3: CAT bond yearly issuance and outstanding volume

Source: Swiss Re Capital Markets

To emphasize the size of losses that insurers have to face in case of a natural catastrophe, the losses caused by the 2017 hurricane season are showed in Figure 4. We see that in 2017 alone \$330 billion of losses occurred due to such events.

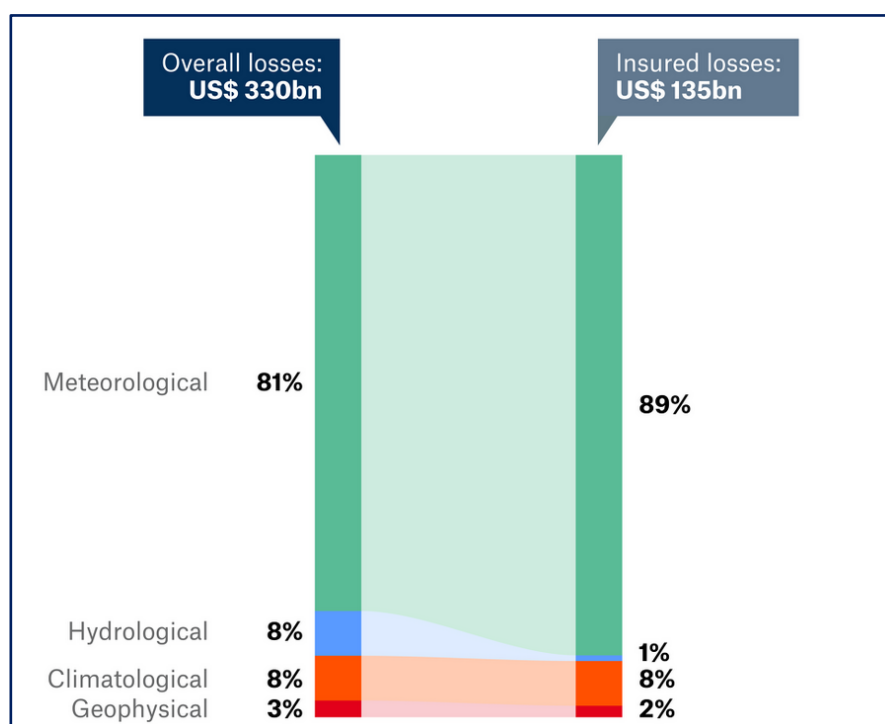


Figure 4: The losses caused by natural catastrophes in 2017.

Source: Munich Re

Out of the \$330 billion only \$135 billion worth of losses were insured despite the development of the CAT bond and ILS market, shown in the previous figures. Therefore, we can state that there is still a lot of room in the market for future expansion.

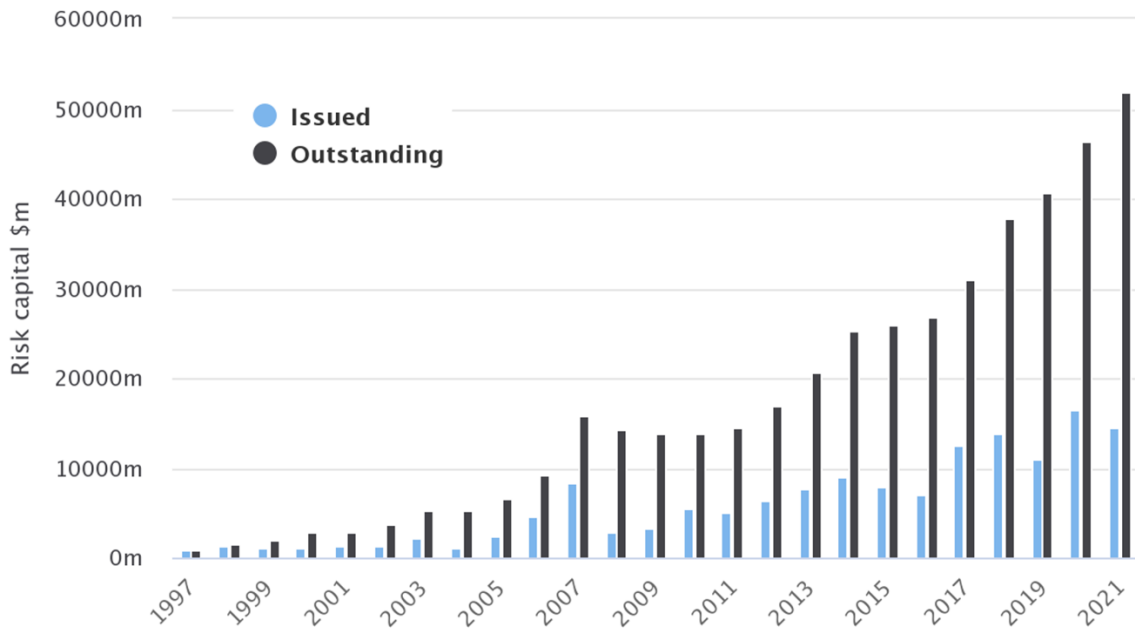


Figure 5: ILS and CAT bond issuance and outstanding volume by year

Source: Artemis.bm

2.2 Structure of Catastrophe Bonds

“CAT bonds are part of a broader class of assets known as *event-linked bonds*, which pay off on the occurrence of a specified event. Most event-linked bonds issued to date have been linked to catastrophes such as hurricanes and earthquakes, although bonds also have been issued that respond to mortality events (Cummins, 2008, p.25) ”.

The structure of CAT bonds was modelled on another asset class, where securitization proved to be very effective, asset-backed-securities (Cummins, 2008). Initially the design of CAT bonds varied, but with the development of the market the structure became standardized (Cummins, 2012).

Standardization was driven by the requirements of fundamental stakeholders, such as: investors, regulatory authorities, and rating agencies (Błach–Wieczorek, 2014).

2.2.1 Special Purpose Vehicle

To issue a CAT bond, the issuer - called the ceding company, cedant or sponsor – establishes a special purpose vehicle. The SPV is a separate legal entity which connects the sponsor with the investors (Błach–Wieczorek, 2014). There are several reasons why the establishment of the SPV is necessary. Firstly, the CAT bond from the sponsors’ aspect is a form of reinsurance. Therefore, without the intermediary role of the SPV, the investors would all have to get a license from the regulatory authority to offer a reinsurance contract. This way it is sufficient to only

get one license for the SPV. In other words, the SPV transforms the invested funds into reinsurance. There is also a way to ease the licensing process by setting up the SPV in an offshore location such as Bermuda or the Cayman Islands, which is also more convenient for the sponsor because of the favorable tax environment (*Edesses, 2015*). For every CAT bond issued there is a separate SPV established. Perhaps the most important role of the SPV is that it protects the investors from any losses should the sponsor go bankrupt (*Sterge–Stichele, 2016*). The investors are not exposed to the sponsor's general business and insolvency risk. In other words, the credit risk is eliminated (*Błach–Wieczorek, 2014*).

The structure of a CAT bond is shown in Figure 6. The principal, lent by the investors, is held in a trust which also acts as collateral in terms of the reinsurance contract. The principal is then invested following investment guidelines (*Sterge–Stichele, 2016*). Another advantage of issuing through an SPV is the transparency it gives to the investors in terms of the investment and release of the funds (*Cummins, 2008*). By investing the principal – held in the collateral account – the potential insurance payments are prefunded (*Chang et al., 2020*). After the investments, the trust receives fixed returns. Due to the nature of the fixed returns the fund is exposed to interest rate risk. This exposure is usually managed by entering an interest rate swap, where the trust swaps the fixed return for a floating return (*Błach–Wieczorek, 2014*). Usually, the returns are swapped for a 3-month floating rate, most commonly the 3-month LIBOR or US Treasury bill rate (*Karlsson–Karneback, 2017*). The investor receives the floating rate plus the risk premium. The premium is determined by the risk aversion of the investor and the probability of the occurrence of the underlying catastrophic event (*Karlsson–Karneback, 2017*). From the investors perspective the payments occur on a periodic basis, much like in the case of corporate bonds. These are usually quarterly payments (*Edesses, 2015*).

The CAT bond triggers when a catastrophic event occurs which exceeds predetermined trigger level before maturity (*Edesses, 2015*). In case of a loss event, an option - which is embedded in the bond - is triggered, and the funds are released from the SPV. The sponsor receives the funds and uses them to cover the losses caused by the catastrophe (*Cummins–Weiss, 2009*). From the investors' point of view the bond defaults, the investors might lose all the capital invested. The percentage of the principal lost may vary, in most cases the principal is fully at risk (*Błach–Wieczorek, 2014*). In return, the ceding company pays a premium for the embedded option to the investors (*Cummins–Weiss, 2009*). If the bond is not triggered, the investors receive the principal at maturity on top of the floating rate plus risk premium (*Błach–Wieczorek, 2014*).

The maturity of a CAT bond typically ranges from 3 to 5 years (*Edesses, 2015*). The market favors bonds that mature in more than one year. Firstly, it reduces the per period transaction cost by allowing the cedant to amortize the cost of the issuance over a longer period. Secondly, by issuing bonds with a longer maturity the sponsor is not exposed to the year-to-year fluctuations in reinsurance prices. The reason that we do not see CAT bonds issued with a maturity longer than 5 years is because, after a 4–5-year period sponsors like to adjust their underwriting risk profile. Another reason would be to reprice the premium to reflect new market information (mainly the frequency and the severity of the occurred catastrophes) (*Cummins, 2008*).

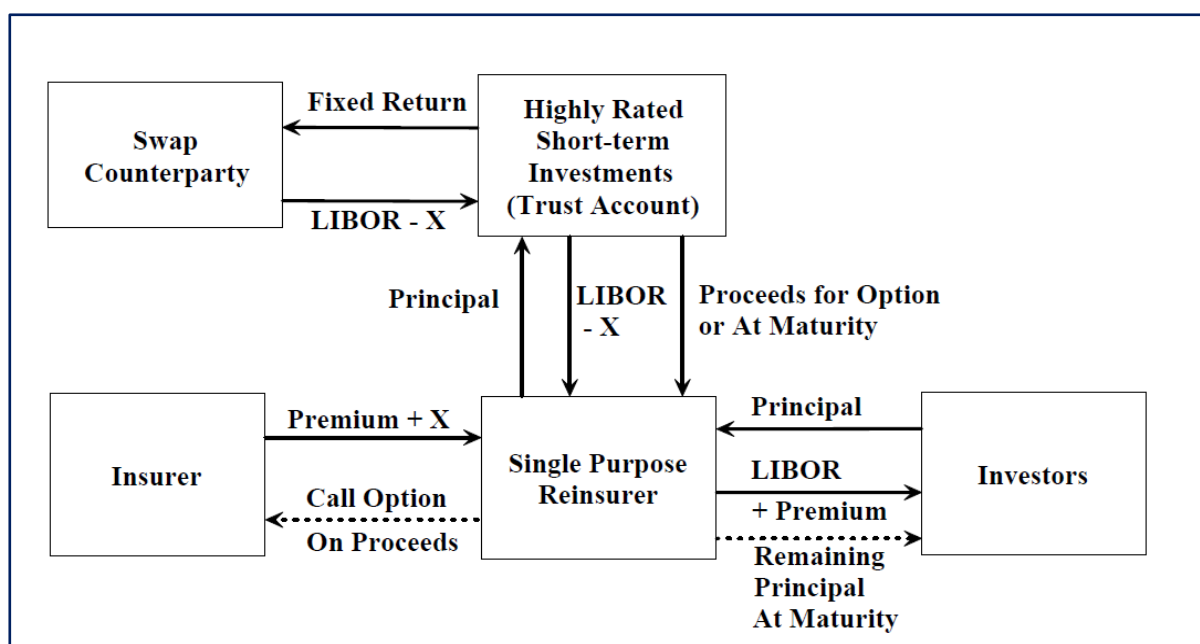


Figure 6: CAT bond structure

Source: Cummins–Trainar, 2009

As mentioned in the beginning of this section, CAT bonds are standardized. The process of standardization began after the 2008 crisis. As a result of the process, bonds are now rated plus with the development of the structure investors are now not exposed to the issuer's insolvency risk (*Karlsson–Karneback, 2017*). The Lehman bankruptcy and the following credit crisis had a very positive effect on the structure and market of CAT bonds. Before 2008 cedants had flexibility when it came to the investment of the funds in the SPV (*Sterge–Stichele, 2016*).

In 2008, four CAT bonds defaulted even though no catastrophic event occurred. The bonds did not trigger, however at maturity when the assets held in the SPV were sold off, the fund was not able to sell them for a price to fully redeem the bonds (*Sterge–Stichele, 2016*). That was possible because the SPV was allowed to invest the funds in a wide range of assets

including CDOs (collateralized debt obligations) (*Karlsson–Karnebäck, 2017*). The use of total return swaps was also accepted, some of the SPVs used total return swaps where Lehman served as the swap counterparty (*Krutov, 2010*).

Now the principal has to be invested in U.S Treasury money market funds, in order to defend the investors from these kinds of losses (*Sterge–Stichele, 2016*). Another important benefit of standardization is that CAT bonds are now being rated by credit rating agencies (*Karlsson–Karnebäck, 2017*).

Most CAT bonds are issued with a rating. It is critical because with the use of financial ratings investors can compare yields with other (similarly rated) corporate securities (*Cummins, 2008*). As discussed earlier, CAT bonds are protected from the sponsors general business and insolvency risk. Therefore, what the ratings indicate is solely the layer of catastrophe-risk that the investors are exposed to. In other words, what the rating tells us is the probability of the covered catastrophic event occurring (*Cummins, 2008*).

The probability of default is similar to high yield corporate “junk” bonds. Therefore S&P generally rates CAT bonds, below investment-grade, usually BB or B (*Edesses, 2015*).

2.2.2 Triggers

As previously noted, if no loss event occurs, the investors receive the principal plus the premium at maturity. However, if there is a catastrophic event which triggers the bond, the investors may lose all the funds invested. Given this structure, it is critical that the trigger event is precisely defined (*Ammar et al., 2015*).

The trigger also has a great impact on the pricing of the bonds (*Albertini–Barrieu, 2009*). The main thing to consider when choosing a trigger is the trade-off between basis risk and moral hazard (*Cummins–Weiss, 2009*). Basis risk is the risk that the funds the sponsor receives, in case of a loss event, is not sufficient to cover its insurance claims (*Ammar et al., 2015*). “*Moral hazard* is the risk that the existence of insurance will cause the policyholder to behave differently than he or she would without the insurance (*Hull, 2018, p.61*)”. Moral hazard is caused by the lack of transparency of the transaction to investors (*Cummins, 2012*). As a result of moral hazard, the sponsor is likely to take less careful approach when it comes to underwriting insurance in the area that the CAT bond covers. Meaning that the cedant has a motive to increase underwriting in that area in order to maximize income, at the expense of investors (*Lee–Yu, 2010*).

There are two major categories of triggers: indemnity and index (*Krutov, 2010*).

Indemnity Triggers

Issuers can choose to use indemnity triggers, in this case the sum paid to the sponsor is equal to its actual losses (*Krutov, 2010*). From the sponsors' perspective indemnity triggers are the most desirable when it comes to covering the financial damage caused by a catastrophe, since the payments are exactly the same amount that the sponsor has to pay to cover the claims. (*Albertini–Barrieu, 2009*). A CAT bond with this trigger is therefore a perfect hedge, there is no basis risk in this case. Unlike with other types of triggers the cedant can avoid an event where the CAT bond does not fully cover its losses. However, this perfect hedge comes at a cost, the insurance company has to disclose sensitive information about its underwriting practices and risk portfolio to investors (*Krutov, 2010*).

Indemnity triggers expose the investors to moral hazard the most. As mentioned earlier, the result of the lack of transparency could end up in a case where for example the sponsor underwrites more home insurance in a high hurricane-risk area – that is covered by the CAT bond – than it otherwise would have (*Edesses, 2015*). Another drawback from the investor's standpoint is that if a bond triggers they have to wait for all insurance claims to be settled before they can get the remaining part of the principal back. Which could mean that investors have to wait an extended amount of time, which perhaps would even exceed the period of maturity (*Edesses, 2015*). Therefore, investors require higher risk spreads for CAT bonds with indemnity triggers. Also getting an insight of the issuers' risk portfolio structure, loss history, exposures and claims handling practice is desired by a number of investors (*Albertini–Barrieu, 2009*).

Index Triggers

There are more transparent triggers, where the triggering of the bond is not based on the issuers' actual losses (*Albertini–Barrieu, 2009*). Which means the sponsors can be exposed to different levels of basis risk (*Krutov, 2010*). Here the loss event is determined by factors that are independent from the sponsor itself, such as: values of indexes, parameters of natural catastrophes and industry loss figures. As a result, moral hazard is reduced (*Krutov, 2010*).

Also, this way the investors receive the funds over a shorter period of time, because the indices are measurable more quickly than indemnity triggers (*Cummins, 2008*).

a.) Industry Loss Trigger

In the United States, industry loss verifications are well established, therefore it is possible to define a trigger where payouts are based on the losses of the whole industry in a specific area, for example, a state or an aggregation of states. The losses of an industry are surveyed and

published by independent institutions (*Albertini–Barrieu, 2009*). If the industry's losses exceed the amount predetermined, the issuer receives a payment based on the percentage it represents out of the industry (*Edesses, 2015*). Moral hazard is a lesser issue than in the case of indemnity triggers because the losses are published by an independent institution (*Ammar et al., 2015*).

On the other hand, basis risk is very much present. The issuers are exposed to the possibility that they will be more affected by a catastrophe than their peers in the industry (*Ammar et al., 2015*).

b.) Basic Index/Pure Parametric Trigger

With parametric triggers the payments are based on catastrophes' physical characteristics exceeding a specified value. For example, if an earthquake exceeds 7.0 in the Richter scale or wind speeds exceed 120 km/h, the bond triggers (*Edesses, 2015*).

Basic index triggers have the lowest moral hazard associated with them, on the other hand issuers are exposed to a significant level of basis risk (*Cummins, 2008*). There is a good possibility that the payout is poorly correlated with the losses of the sponsor. In the case of the example mentioned before where the bond triggers based on the wind speed exceeding 120 km/h, the catastrophe can cause severe financial damage with a wind even with a speed at 115 km/h. Regardless of the losses, the sponsor will not receive funds to cover them. However, there is also a possibility that the wind speed exceeds the amount, triggering the bond, without causing any damage to the sponsor (*Krutov, 2010*).

These are the most transparent triggers. Investors can get information on whether the bond triggered from a catastrophic event or not, quite easily. Also, the settlement process is a lot shorter compared to triggers previously discussed (*Ammar et al., 2015*).

Investors are also not exposed to risks regarding the underwriting practices of the sponsor (*Krutov, 2010*).

c.) Parametric Index Trigger

As stated in the last section, with the use of basic index triggers issuers are most exposed to significant basis risk. However, there is a way to mitigate this exposure while at the same time keeping the attractive characteristics of basic index triggers such as: transparency and faster payout process. Parametric index triggers are defined with a formula, where there are measuring stations defined, which are geographic areas where the certain physical characteristics are measured. The measuring stations are assigned a weight in order to define the sponsors exposure more precisely. To give an example, in 2008 Munich RE issued a CAT bond to cover its exposure to European windstorms. Munich RE used a parametric index trigger, the

measuring stations – the areas where they would record wind speeds – were set in 216 locations in several countries (UK, France, Germany, Belgium, Ireland, and Denmark). To determine if the bond triggered in case of an event, the physical parameters are multiplied by the weights, these values are aggregated, and if the aggregate exceeds the predetermined value, the bond triggers (*Albertini–Barrieu, 2009*). Given the nature of the formula, multiple catastrophic events could be covered with this trigger (*Krutov, 2010*).

d.) Modeled Portfolio Loss

It is also possible to maintain the attractive characteristics of indemnity triggers – namely the absence of basis risk – without having to expose investors to significant moral hazard with the use of modelled portfolio triggers (*Edesses, 2015*). The process of structuring starts off with the creation of a synthetic portfolio – a model which is aimed to mirror the portfolio of insurance policies that the insurance company is expected to hold throughout the maturity (*Krutov, 2010*).

In case of an event the specific parameters (e.g., wind speed) are entered into the model as inputs (*Albertini–Barrieu, 2009*). The bond is triggered when the synthetic portfolio's modelled losses are greater than the predetermined sum (*Krutov, 2010*). The model is created by an independent modeling firm for example: Applied Insurance Research (AIR) Worldwide, EQECAT, or Risk Management Solutions (RMS) (*Cummins, 2012*).

Thanks to the involvement of modeling firms the creation of the reference portfolio cannot be influenced by the sponsor which is a convenient way to reduce moral hazard (*Ammar et al., 2015*).

Also, because the payout is not based on actual claims, therefore the process can be executed a lot faster (*Edesses, 2015*).

Similarly to indemnity triggers the drawback of this trigger is that the cedant is required to reveal information about their portfolio of insurance. Also, the complexity of the synthetic portfolio demands investors to have the expertise and knowledge of modelling (*Krutov, 2010*).

Alternative Triggers

a.) Hybrid Triggers

There are also examples of using a combination of the previously examined triggers. With the use of hybrid triggers it is possible for the cedant to blend in more than one trigger in one bond in order to incorporate the desired features of each one, according to the parties' specific needs. For example, the bond could be issued with a combination of an indemnity and an index trigger. In this case the sponsor's losses have to exceed the predetermined level and also the event's

physical characteristic has to exceed the value specified in the trigger (*Albertini–Barrieu, 2009*).

b.) Second- or Third-Event Trigger

An insurance company might have enough funds to cover losses caused by one catastrophic event but would not be able to cover losses caused by a second one in the same or in the following year. In order to hedge this exposure, the sponsor can issue CAT bonds with second (or third) event trigger, where there would be a payout only after the second triggering event occurred (*Krutov, 2010*).

Trigger choices in issuances

In Figure 7, we can see what triggers were chosen with ILS issuances by year. In the early days of the market parametric triggers were popular. Throughout the years, with the development of the market, we see indemnity triggers being the most preferred followed by industry loss triggers.

When it came to the choice of trigger initially when the market wasn't of this size and investors still had a lot of uncertainty with the structure and mechanism, the minimization of moral hazard was the main aspect. However, with the development of the market, standardization, and investors' knowledge that came with experience, investors are willing to bear excessive moral hazard in return of a premium. As stated earlier the issuers prefer indemnity triggers because of the lack of basis risk.

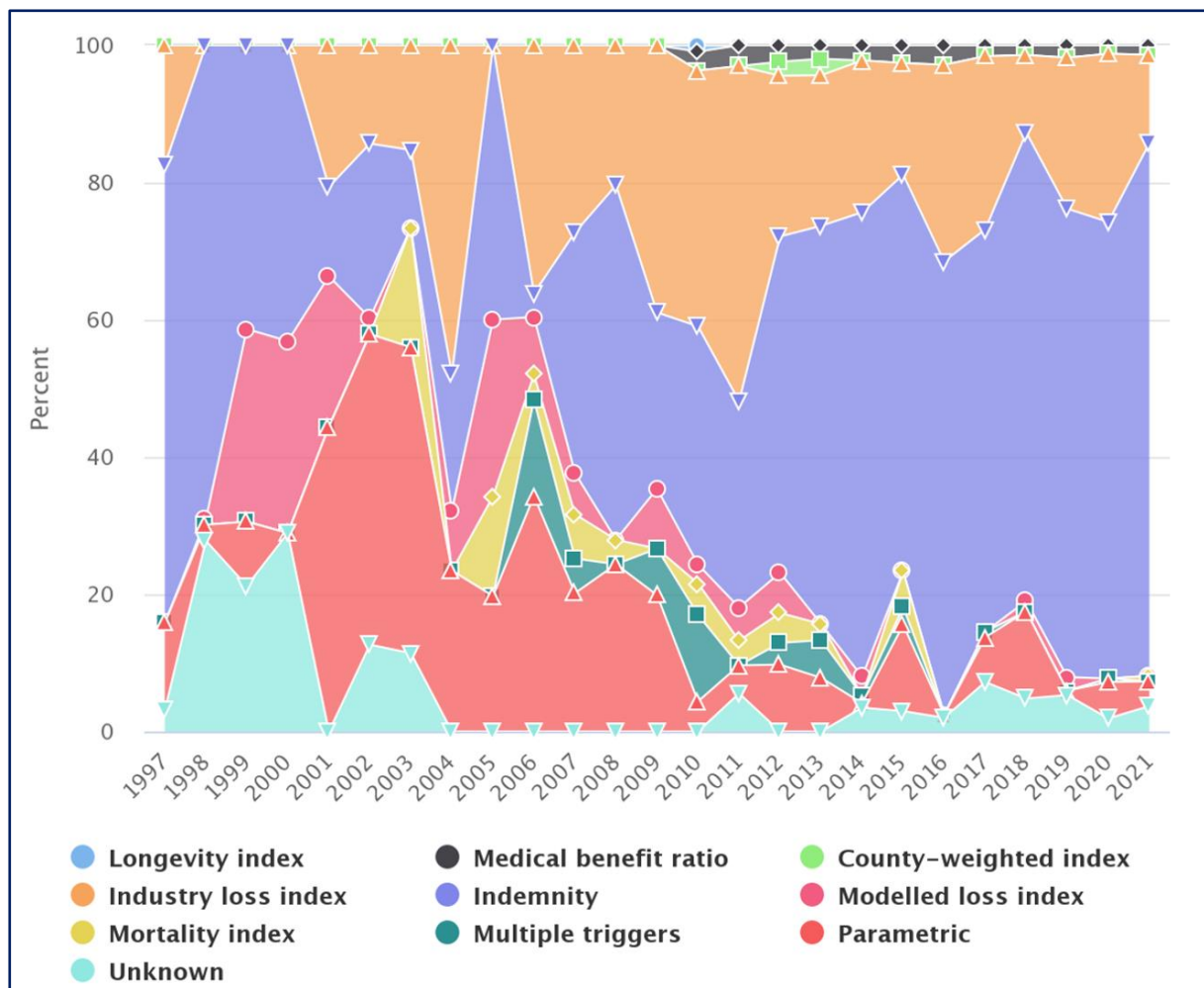


Figure 7: Triggers chosen for ILS issuances by year

Source: Artemis.bm

2.2.3 Perils

Besides defining the exact event when the bond triggers it is also important to specify what type of event it is covering.

Bonds initially only covered one type of peril, but with the development of the market the number of issuances with multiple perils have been increasing. Bonds with one peril only trigger when the specific event causes the damage. Choosing multiple perils is more convenient to the sponsor since it will get the payout no matter which causes the bond to trigger (*Krutov, 2010*).

Perils are also linked with the geographic region the bond covers, most common perils are US Hurricane, US Earthquake, European Wind, Japanese Typhoon and Japanese Earthquake. Since the World Trade Center attacks there has been an increased demand for covering terrorism risk, but so far only one CAT bond has been issued by FIFA which was meant to cover this peril (*Albertini-Barrieu, 2009*).

In Figure 8 displays the increase in multiple peril issuances, furthermore we can see that out of the single peril issuances, coverage of wind and earthquake risk are the most important to issuers.

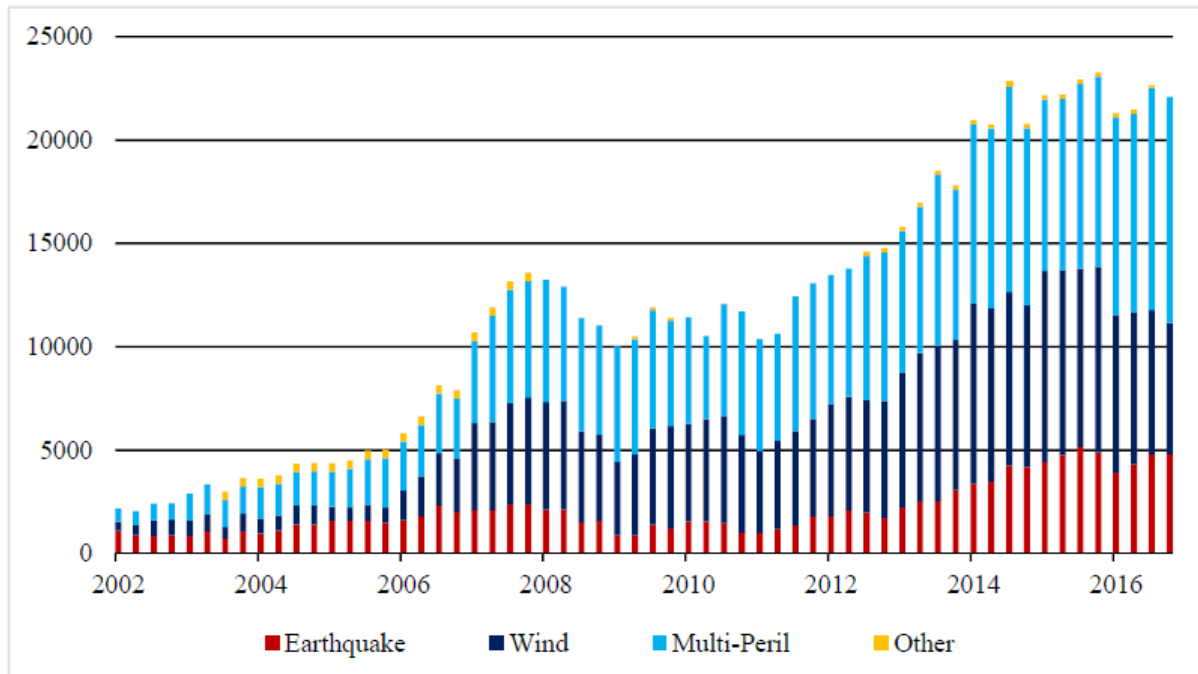


Figure 8: Outstanding CAT bonds' perils over time

Source: Drobetz et al. (2019)

2.2.4 Tranches

CAT bonds can be split up into separate classes called tranches. Each tranche has different probability of default, therefore also a different rating and a different coupon (*Albertini–Barrieu, 2009*).

Not all tranches have to be rated, it is possible that in one CAT bond there are rated and also non-rated tranches (*Krutov, 2010*).

As in the example shown in Figure 9, if the losses caused by a catastrophe exceed \$750M, Tranche A is triggered and the investors of Tranche A lose the predetermined percentage of their investment. If the losses do not exceed \$850M, then only tranche A is affected by the event, and the investors of Tranche B and C receive their principal and premium payments (*Krutov, 2010*).

Tranches with the higher probability of default – in Figure 9 that being Tranche A – receive higher coupon payments, the owners of the more protected tranches receive a smaller payment, i.e., the default rate is reflected by the coupon (*Edesses, 2015*).

The tranches also could cover different perils and geographic regions (*Albertini–Barrieu, 2009*). Various triggers also could be assigned to the different tranches (*Krutov, 2010*).

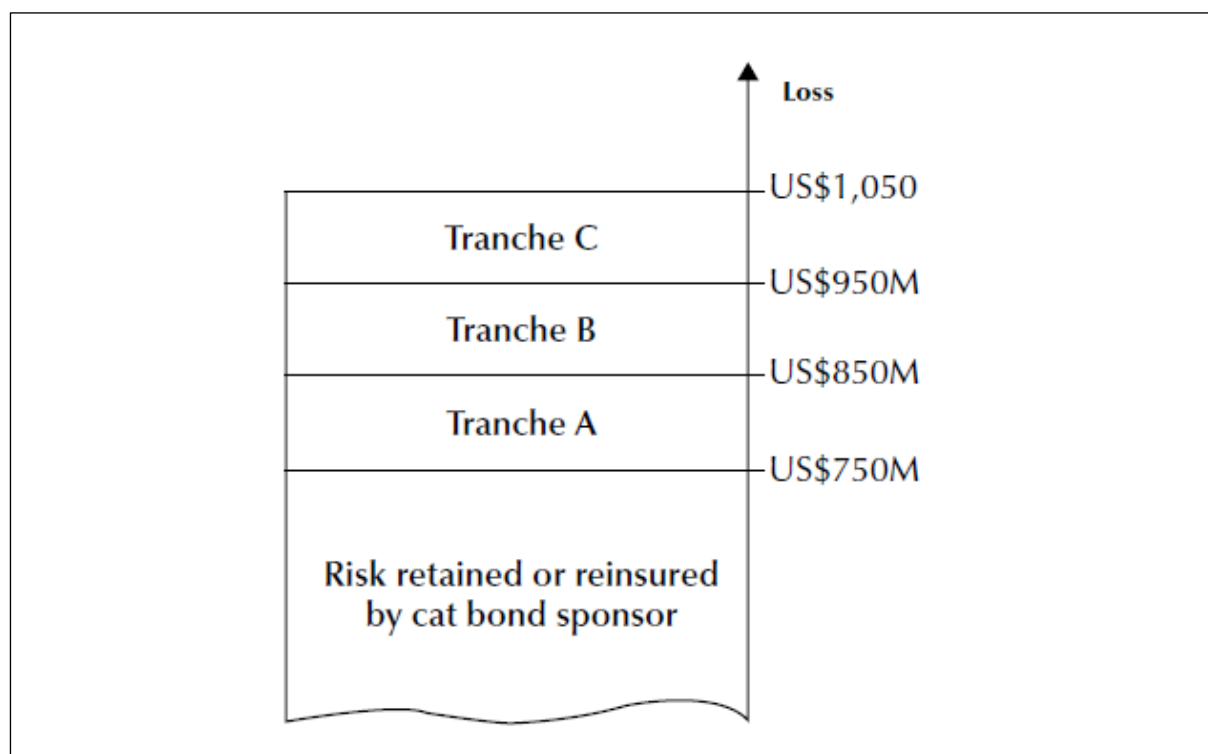


Figure 9: Example of a tranche structure in a CAT bond

Source: Krutov, 2010

3. Data and Methodology

In the results and discussion section I am going to analyze the performance and the diversification benefits of catastrophe bonds. The ratings of CAT bonds are similar to non-investment grade corporate debt's financial ratings. Therefore, I will compare two asset classes on this basis. My aim is to define the role of catastrophe bonds in an investment portfolio. For my research I use monthly prices of funds to track the performance of assets and asset classes. In this section we will take a look at the methodology of the analysis.

3.1 Sharpe Ratios

Besides looking at the absolute returns of the assets, it is important to take the risk embedded in the instruments into account. To do that, I calculate the Sharpe ratios of the assets.

The sharpe ratio was developed by William F. Sharpe in 1966. It is calculated by dividing the excess return of the asset by the asset's standard deviation. (*Berk–DeMarzo, 2014*). The excess return is the difference between the return and the risk-free rate. The yield of U.S Treasury bond is usually considered the risk-free rate (*Sharpe, 1966*).

It shows us how much would the return increase for a given increase in the undertaken risk. It is a useful tool to compare investment assets' returns, since it shows us how much excess return the investors gets per one unit of risk for each asset. The asset with the higher Sharpe ratio has the higher risk adjusted return, therefore we would prefer to hold that investment, purely based on the risk-return aspect (*Nielssen–Vassalou, 2004*).

3.2 Betas

In order to measure the systematic risk, I am going to calculate the betas of both assets.

Beta describes the sensitivity of an asset to the price movements of the market portfolio. The market portfolio theoretically would consist of all the assets in the economy. The beta of an asset shows us how the certain asset responds to the changes in the overall market. In practice the market portfolio is usually represented by a broad index such as the S&P 500 (*Brealey et al., 2001*).

The formula we use to calculate beta is $\rho\sigma/\sigma_M$. In the nominator: ρ represents the correlation between the returns of the asset and the returns of the market portfolio, σ is the volatility of the asset, i.e., the standard deviation of the asset's returns. The denominator is σ_M , which is the standard deviation of the market portfolio's return (*Hull, 2018*).

An asset that has a beta which is equal to 1, would mean that the investors of that certain asset are exposed to as much risk, as they would have been by investing in the market portfolio. An asset with a beta of 0, has no exposure to the fluctuations of the market, therefore owning that asset would be an ideal way of reducing the systematic exposure of our portfolio. Assets' can have betas greater than one, in that case the asset is highly sensitive to the price fluctuations of market portfolio. For every 1% move in the market, the assets would increase or decrease by more than 1%. (*Brealey et al., 2001*).

It is also worth noting that exposure to the market can be a disadvantage at times of financial crises, market corrections. However, owning an asset that is highly sensitive to the market portfolio can be an advantage at time where the market is performing well (*Hull, 2018*).

3.3 Treynor Ratios

When analyzing returns we can also take the assets' exposure to systematic risk into account with calculating Treynor ratios. This way we only consider the part of risk undertaken by investors that cannot be reduced by diversification. (*Treynor, 1965*).

The Treynor ratio was introduced by J.L. Treynor in 1965, and it is the ratio between the excess return and the asset's exposure to systematic risk. The nominator is the same as in the case of Sharpe indexes, but the denominator is the beta, instead of the volatility of the asset. An asset with a higher Treynor ratio has a better return per unit of market risk. (*Sharpe, 1966*).

When analyzing Treynor ratios we prefer assets with higher ratios when we are considering diversifying characteristic of an asset desirable. (*Treynor, 1965*).

4. Results and Discussion

In this section I am going to compare CAT bonds and high-yield corporate bonds from the aspects of absolute return, risk-adjusted return, exposure to market risk and return to systematic risk.

Firstly, I am going to introduce the funds, which I used to track the performances of the asset classes. The source for the monthly prices of the CAT bond fund is from swissfunddata.com, the data for the other funds are from yahoo.finance.com.

4.1 The Observed Funds

4.1.1 GAM Star Cat Bond Fund

The fund which is going to represent CAT bonds is the GAM Star Cat Bond USD Inc fund. According to data from GAM (2021c), this is an actively managed fund, domiciled in Ireland, which is focused on the CAT bond segment. The fund is managed by Fermat Capital Management, LLC and was incepted in 31.10.2011. The investment fund has \$2.244 billion invested in assets, the base currency being USD. The GAM Star Cat Bond fund is well diversified in the segment, it was invested in more than 150 CAT bonds or CAT bond related investment funds in 2020. 93.91% of the total assets is invested in CAT bonds, 2.85% in government bonds, 0.54% in corporate bonds, 0.09% in equities and 1.98% in currency forwards. The assets' ratings range from not being rated at all to B- and AA+.

4.1.2 iShares iBoxx High Yield Corporate Bond ETF

The proxy for high-yield corporate bonds is the iShares iBoxx High Yield Corporate Bond ETF. According to iShares (2021), this fund was incepted in 2007 and uses the Markit iBoxx USD Liquid High Yield Index as a benchmark index. It has \$19.2 billion of funds with 221.2 million of shares outstanding.

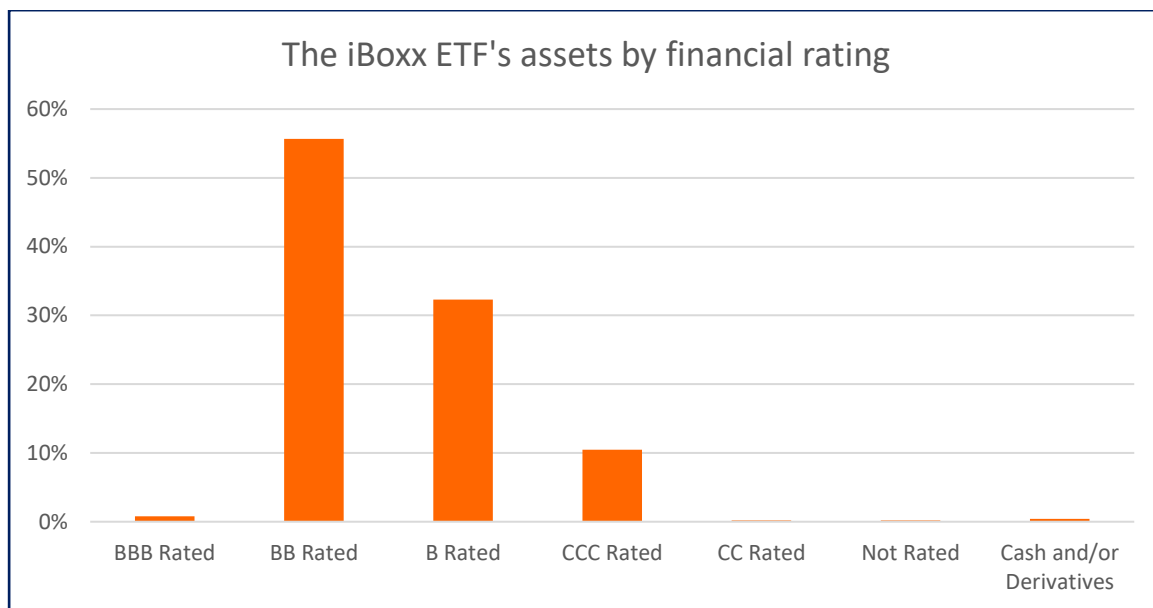


Figure 10: Ratings of the assets' of iBoxx (%)

Source: Own calculation based on data from iShares.com

Figure 10 shows that 56% of the invested assets' ratings are BB rated. 32% of the assets are B rated, 10% have CCC ratings. The fund is also diversified in terms of the maturity of the investments, 28% of the fund consists of bonds that have a 3–5-year maturity, bonds that mature in 0-1 years and 7-10 years both put out about 19%-19% of the whole fund – as seen in Figure 11.

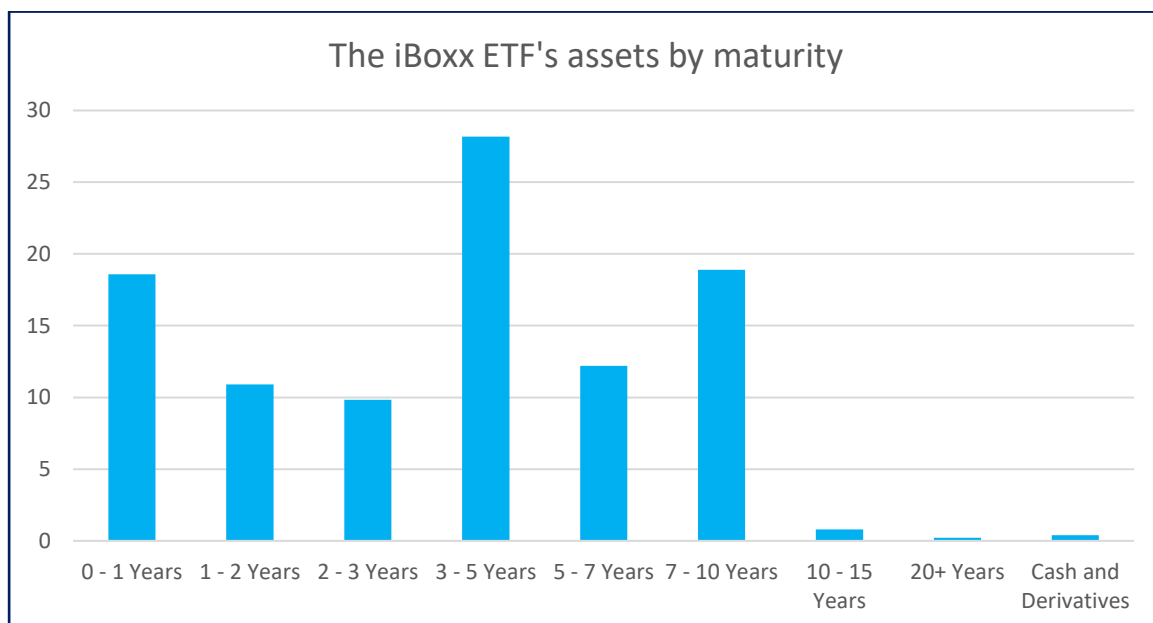


Figure 11: Breakdown of the assets' maturity (%)

Source: Own calculation based on data from iShares.com

4.1.3 Vanguard Total Bond Market ETF

The fund I use to represent the global bond market is the Vanguard Total Bond Market ETF. According to Vanguard (2021), the fund has \$315.7 billion of invested assets. The fund's objective is to track the performance of a broad, market-weighted bond index. The investors of this fund get exposure to investment grade USD denominated bonds. The fund does not have investments in inflation-protected or tax-exempt bonds.

The bonds in this fund have an average maturity of 8.7 years, and an average duration of 6.8 years. The majority of the assets (65.3%) stand of U.S. Government bonds, the fund also has 15.6% of BB rated corporate bonds, 12.1% A rated corporate debt. The rest of the assets are AA and AAA rated corporate bonds as of 30.09.2021.

4.1.4 S&P 500

For the equity market, I am using the S&P 500 as a proxy. According to S&P Gobal (2021), the S&P 500 was launched in 1957, it was the first market-cap-weighted stock market index. It measures the performance of 500 large-cap U.S. companies. To be included in the index, companies must have an unadjusted market-cap of \$13.1 billion or greater, the companies also have to be listed on eligible U.S. exchanges. The index covers 80% of the available market capitalization.

4.1.5 Risk-Free Rate

I am using the 3-month Treasury bill secondary market rate as the risk-free rate for my calculations.

4.2 Returns and Performance

A monthly breakdown of the returns is included in the appendix.

2016

Table 1: 2016's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	4.41%	8.17%	0.00%	9.84%
St.dev	0.01	0.04	0.04	0.10

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In this year the high-yield corporate bonds have done better than the GAM Star fund making an 8.17 percent annual return for investors compared to the CAT bonds' 4.41%. CAT bonds and high-yield corporate bonds both outperformed the Vanguard ETF with the investment grade corporate bond ETF rising only back to last year's level after a weak fourth quarter.

The S&P 500 outperformed all the examined assets with a 9.84% annual return.

In terms of each assets' worst month, CAT bonds did the best in this aspect, achieving 0.02% in its worst month compared to -0.92% of iBoxx, -2.41% of the Vanguard ETF and -4.81% of the S&P 500.

2017

Table 2: 2017's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	1.42%	0.44%	1.27%	18.74%
St.dev	0.08	0.02	0.01	0.04

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

The 2017 hurricane season strongly affected the performance of CAT bonds' this year. The -6.59% fallback in August – shown in Figure 12 – can be accounted for Hurricane Harvey, Hurricane Irma triggering several CAT bonds according to Artemis(2021b). However, despite the losses due to natural catastrophes CAT bond performance was superior to high-yield corporate bonds. CAT bonds also outperformed the Vanguard ETF this year with its 1.42 percent annual return. The iBoxx ETF performed rather poorly compared to 2016, rising by only 1.25% even in its best month.

In this year the S&P 500 once again gave the best return out of the observed assets by far gaining 18.74% in 2017.

2018

Table 3: 2018's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	1.89%	-7.10%	-2.75%	-6.59%
St.dev	0.01	0.04	0.03	0.12

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

2018 was a hard year for each asset. The iBoxx ETF fell back by 7.10% having a negative return in 6 out of the 12 months. The S&P 500 also had 3 months where it declined by more than 3% causing a major annual fallback of 6.59%. Investment grade corporate bonds performed better with a -2.75% decline also having negative returns half of the year.

According to Artemis(2021b), in 2018, there were several CAT bonds' which triggered – due to wildfires in California throughout the year, Hurricane Michael in October, Hurricane Florence in Aug-Sept – effecting the performance negatively.

CAT bonds still stand out with being not as volatile as the other assets – rising by 0.67% in its best month and falling by 1.01% in its worst – increasing by 1.89% in this year.

2019

Table 4: 2019's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	5.00%	8.94%	5.78%	30.43%
St.dev	0.02	0.06	0.03	0.18

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In 2019 – similarly to 2016 – iBoxx outperformed CAT bonds with about 4 percentage points. However, despite underperforming non-investment grade bonds the GAM Star fund hit a record in terms of the annual return over the observed period, being up by 5.00% by the end of the year. The S&P 500 also had its best year out of the years we are examining, with its outstanding 30.43% climb.

2020

Table 5: 2020's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	3.85%	-0.91%	5.01%	15.76%
St.dev	0.02	0.14	0.04	0.27

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Moving on to 2020, we can see how the markets reacted to the pandemic in March. Each asset had a fallback, the stock market was most affected by the pandemic, followed by non-investment grade corporate bonds.

CAT bonds also had a 0.81% decline in March, but the damage wasn't nowhere as significant as in the case of high-yield bonds' -10.01% fall. If we look at the year-end returns, we can see that the GAM Star fund rose by 3.85%, meanwhile the iBoxx ETF suffered a 0.91 percent decline over the period.

It is also worth noting that investment grade corporate bonds and equities both outperformed the high-risk assets in this year.

Table 6: 2021's annual returns and standard deviations.

	GAM	iBoxx	Vanguard	S&P
Annual return	2.29%	0.10%	-2.94%	14.42%
St.dev	0.01	0.02	0.03	0.08

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Over the 01.2021 – 09.2021 period CAT bonds outperform non-investment grade corporate bonds once again. The iBoxx ETF ends the year virtually flat with its 0.10% gain, while CAT bonds increase by 2.29%. It is also worth noting that both assets outperform the Vanguard ETF, but the S&P 500 increased by the most in this period as well.

Summary

Table 7: Annual returns by year and total returns

Period	GAM	iBoxx	Vanguard	S&P
2016	4.41%	8.17%	0.00%	9.84%
2017	1.42%	0.44%	1.27%	18.74%
2018	1.89%	-7.10%	-2.75%	-6.59%
2019	5.00%	8.94%	5.78%	30.43%
2020	3.85%	-0.91%	5.01%	15.76%
2021	2.29%	0.10%	-2.94%	14.42%
2016-2021	20.43%	9.35%	5.27%	111%

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In summary, over the observed period CAT bonds outperformed non-investment grade corporate bonds even though CAT bonds suffered significant fallback due to the 2017 hurricane season. The difference in returns over the 01.2016 – 09.2021 period is significant, CAT bonds increased by 20.43%, high-yield corporate bonds rose by 9.35%.

Table 8: Standard deviations by year

Years	Standard deviation			
	GAM	iBoxx	Vanguard	S&P
2016	0.01	0.04	0.04	0.10
2017	0.08	0.02	0.01	0.04
2018	0.01	0.04	0.03	0.12
2019	0.02	0.06	0.03	0.18
2020	0.02	0.14	0.04	0.27
2021	0.01	0.02	0.03	0.08

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

There was one year where CAT bonds outperformed all of the other assets. Due to COVID-19, high yield corporate bonds and equities had a major pullback. CAT bonds also had a minor decline in March 2020.

As one may have expected both the GAM Star fund and the iBoxx ETF outperformed investment grade corporate bonds, but if we compare the returns to equities, we see that S&P 500 – shown in Figure 12 – performed extremely well during this period, surging by 111% overall.

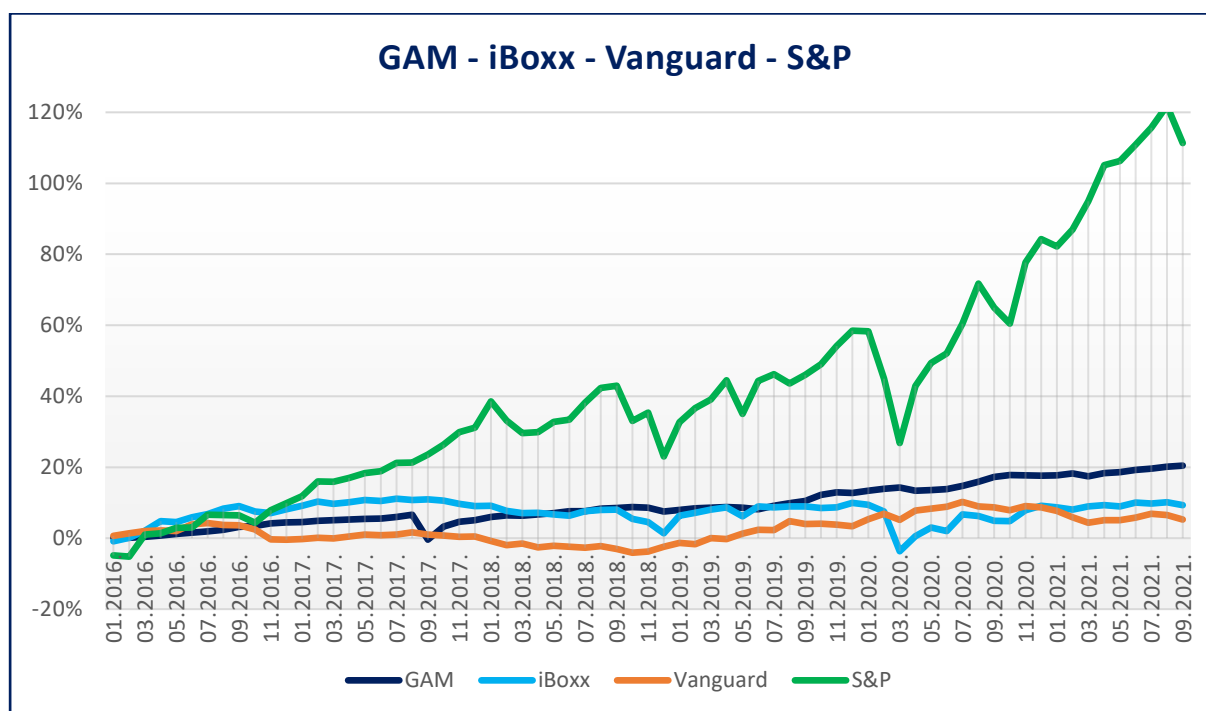


Figure 12: All four assets' performance over the period

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

4.3 The Analysis of the Investment Classes Based on Sharpe Ratios

We have looked at the returns of each asset, but it is important to also take the risk embedded in these securities into account to get a full picture regarding the performances. In order to do so, we will look at the Sharpe ratio of each asset by year.

The Sharpe ratio is the ratio between the excess return and the risk of the investment. The excess return is the difference between the return and the risk-free rate, and that is divided by the volatility of the asset (Nielssen–Vassalou, 2004).

As the risk-free rate, we are using the average of the 3-month Treasury bill rates – displayed in table 9 – from each year.

Table 9: The risk-free rate by year

Risk free rate	
2016	0.32%
2017	0.93%
2018	1.85%
2019	2.06%
2020	0.37%
2021	0.05%

Source: Own calculation based on data from fred.stlouisfed.org

Table 10: 2016 Sharpe ratios, annual returns, excess returns, standard deviations

2016				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	4.41%	4.10%	0.01	5.23
iBoxx	8.17%	7.86%	0.04	1.76
Vanguard	0.00%	-0.32%	0.04	-0.09
S&P 500	9.84%	9.53%	0.10	0.98

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

As mentioned before, in 2016 high yield corporate bonds had a greater annual return compared to CAT bonds, while also being more volatile. CAT bonds were the least volatile asset during this year, having a standard deviation of 0.01.

The result of having relatively high returns and low volatility CAT bonds have the highest risk-adjusted return by far compared to all the other assets.

It is also worth mentioning that while the S&P 500 had the greatest return over the period, it also was the most volatile.

The Vanguard ETF did not end the year with an increase nor a decline, therefore it has a negative Share ratio, which means that in 2016 investment grade bonds did not provide a return for the risk undertaken by the investors.

Table 11: 2017 Sharpe ratios, annual returns, excess returns, standard deviations

2017				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	1.42%	0.49%	0.08	0.06
iBoxx	0.44%	-0.49%	0.02	-0.25
Vanguard	1.27%	0.34%	0.01	0.24
S&P 500	18.74%	17.81%	0.04	4.63

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

The 2017 hurricane season had a great impact on the return of CAT bonds. Due to the losses of catastrophes, CAT bonds were the most volatile asset in 2017.

As noted in the previous section regardless of the bad year of CAT bonds, the GAM Star fund provided a higher return than the high-yield corporate bond ETF. Non-investment grade bonds had a lower return than the risk-free rate which results having a negative Sharpe ratio.

Table 12: 2018 Sharpe ratios, annual returns, excess returns, standard deviations

2018				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	1.89%	0.04%	0.01	0.03
iBoxx	-7.10%	-8.95%	0.04	-2.09
Vanguard	-2.75%	-4.60%	0.03	-1.65
S&P 500	-6.59%	-8.44%	0.12	-0.73

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

As noted in the previous section 2018 wasn't a good year for each asset. Only CAT bonds managed to end the year with a positive return, while also being the least volatile. Similarly to 2016, the equity market had the highest standard deviation in this year.

Table 13: 2019 Sharpe ratios, annual returns, excess returns, standard deviations

2019				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	5.00%	2.94%	0.02	1.62
iBoxx	8.94%	6.88%	0.06	1.15
Vanguard	5.78%	3.72%	0.03	1.14
S&P 500	30.43%	28.37%	0.18	1.61

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In 2019 the GAM Star fund proves to be the least volatile once again, having a standard deviation that is also lower than investment grade corporate bonds'. iBoxx outperformed CAT bonds with its 8.94% growth, while being quite a bit more volatile.

The equity market had an extremely good year increasing by 30.43%, however when it comes to risk adjusted returns CAT bonds outperform the S&P 500 – with a Sharpe ratio of 1.62 – even in the equity index's record year over the observed period.

Table 14: 2020 Sharpe ratios, annual returns, excess returns, standard deviations

2020				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	3.85%	3.49%	0.02	1.98
iBoxx	-0.91%	-1.27%	0.14	-0.09
Vanguard	5.01%	4.65%	0.04	1.21
S&P 500	15.76%	15.40%	0.27	0.57

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Another important year to focus on is 2020. As mentioned earlier, markets' fallback due to the pandemic was significant, CAT bonds also declined by 0.81% in March. The iBoxx ETF had an annual loss of 0.91%.

Thanks to the equity market's large decline, caused by the pandemic, and the surge which followed, the S&P 500 was the most volatile this year as well.

CAT bonds' risk-adjusted return is the highest out of the assets by far, despite the S&P 500 having a 15.76% annual return.

Table 15: **2021 Sharpe ratios, annual returns, excess returns, standard deviations**

2021				
Assets	Annual return	Excess return	St.dev	Sharpe ratio
GAM	2.29%	2.24%	0.01	1.99
iBoxx	0.10%	0.06%	0.02	0.04
Vanguard	-2.94%	-2.99%	0.03	-1.09
S&P 500	14.42%	14.38%	0.08	1.83

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In 2021 the trend continues: CAT bonds are the least volatile and provide the highest risk-adjusted return to investors. The investors of the S&P 500 were not exposed to as much risk this period as the previous 3 years, although this can easily change until the end of the year.

In this period both the GAM Star fund and the iBoxx ETF had a lower standard deviation than investment grade bonds and the equity market.

Table 16: **Sharpe ratios by year**

Year	Sharpe ratios			
	GAM	iBoxx	Vanguard	S&P
2016	5.23	1.76	-0.09	0.98
2017	0.06	-0.25	0.24	4.63
2018	0.03	-2.09	-1.65	-0.73
2019	1.62	1.15	1.14	1.61
2020	1.98	-0.09	1.21	0.57
2021	1.99	0.04	-1.09	1.83

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Table 17: **Sharpe ratios for the whole period**

Assets	GAM	iBoxx	Vanguard	S&P 500
Sharpe	2.29	0.48	0.55	2.99
St. Dev	0.09	0.17	0.08	0.37
Return	20.43%	9.35%	5.27%	111.34%

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

In comparison with non-investment grade corporate bonds, investors of CAT bonds always achieved higher returns, while a being exposed to less risk.

The Vanguard bond ETF also outperformed the iBoxx ETF when it comes to risk-adjusted return.

Investment grade corporate bonds had the lowest volatility, followed by CAT bonds.

The S&P 500 was the riskiest asset over the term, but its massive 111.34% gain could offset it, as a result it achieved the greatest risk to return ratio throughout the years.

4.4 Betas and the Role of CAT Bonds in Diversifying Systematic Risk

Besides the performance, another aspect which is important to focus on is the relation of the assets to general market movements, trends, fallbacks. For this we will look at the beta of CAT bonds and non-investment grade corporate bonds.

As mentioned in previous sections, the forces that drive financial markets have no influence on the occurrence of natural catastrophes (*Karlsson–Karnebäck, 2017*). Therefore, events such as financial crises or market corrections should not affect the returns of these bonds. Therefore, we can expect CAT bonds to have very little correlation with the markets.

In the following section we are going to measure the sensitivity of the GAM Star fund and the iBoxx ETF to the S&P 500 – which is going to represent the stock market – and also to the Vanguard ETF, which will represent the global bond market.

Table 18: The assets' betas by year

Year	Beta (S&P)		Beta (Vanguard)	
	GAM	iBoxx	GAM	iBoxx
2016	0.0002	0.21	-0.05	0.50
2017	0.90	0.24	-3.74	0.55
2018	0.01	0.25	-0.002	-0.41
2019	0.05	0.40	-0.16	0.003
2020	0.03	0.45	0.17	2.28
2021	-0.01	0.18	0.16	0.27

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Firstly, looking at the assets' sensitivity to the equity market, in the first year CAT bonds' beta is 0.0002, which means that it virtually had no correlation with the equity market, while non-investment grade corporate bonds have a positive 0.21 beta.

In 2017 CAT bonds show a strong correlation with the stock market with a 0.90 beta. However, as discussed before, in this year the GAM Star fund was heavily impacted by that year's hurricane season, which had no connection to the S&P 500's performance.

2018's and 2019's reassures us of the lack of correlation of CAT bonds to the S&P 500, in both years high yield bonds had a higher beta, 0.25 and 0.40.

2020 – the year of the pandemic – does not show a significant change from the CAT bond's perspective, on the other hand, the iBoxx ETF was correlated to the S&P 500 stronger this year.

In 2021, CAT bonds have a negative beta of 0.01, negative beta in this case means, that throughout that period, if the S&P 500 increased by 1%, CAT bonds declined by 0.03%.

Overall CAT bonds had a beta very close to zero with the stock market, with the exception of 2017's fall, which can be accounted for natural catastrophes occurring that year.

iBoxx's betas consistently fall into the 0.2-0.45 range over the whole period.

CAT bonds provide a great deal of diversification with respect to the S&P 500, meanwhile, high yield corporate bonds had a weak correlation with the stock market over the period.

When focusing on the sensitivity of the two assets to the global bond market, in the first year, CAT bonds have negative beta of -0.05, meanwhile for every 1% increase in the global bond market, the iBoxx ETF increased by 0.5%.

In 2017, the losses caused by the hurricane season distort the picture about correlation once again, showing an extreme -3.74 value. The iBoxx ETF shows a positive beta of 0.55, being even more correlated with the bond market than last year.

In 2018, both assets show negative betas, high yield corporate bonds' fell to -0.41 from last year's positive 0.55. Although CAT bonds were negatively correlated, the beta was very close to zero, -0.002.

Negative beta once again in 2019 for the GAM Star fund, in this year CAT bonds were more sensitive to the moves in the global corporate bond market than last year. Non-investment grade corporate bonds show close to no sensitivity this year, achieving a beta of 0.003.

In the year of the pandemic the iBoxx ETF was extremely exposed to systematic risk, with the fund falling 2.28% for every 1% decline in the global bond market. In 2020 the GAM Star fund showed a positive correlation.

In 2021 CAT bonds have the second year where the beta is positive over the period, the iBoxx ETF shows a similar exposure to systematic risk.

Overall CAT bonds' beta – with the exception of 2017 – ranged between -0.16 and 0.17, showing a negative correlation to the global bond market 3 out of the 5 periods – excluding 2017 once again.

High yield corporate bonds on the other hand show a positive correlation, with the exception of 2018. In the years of being positively in correlation with the global bond market,

betas range between 0.27 – 0.55 with two exceptions: in one year not being exposed to market risk at all (2019), and in one year being greatly sensitive to market fluctuations over the chaotic year of 2020.

Table 19: The assets' betas for the whole period

Betas	GAM	iBoxx
Beta(S&P)	0.04	0.38
Beta(Vanguard)	-0.09	0.76

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Based on the data from Table 19 above – which measures the betas over the whole period, 01.2016 - 09.2021 –, we can clearly state that CAT bonds provide superior diversification benefits to investors.

Non-investment grade corporate bonds show a great deal of correlation in relation with the bond market, also the asset class increases 0.38% for every 1% increase in the S&P 500.

4.5 Treynor Ratios

We have looked at the betas of both asset classes, in order to have a greater understanding of CAT bonds' and high-yield corporate bonds' performance and their role in an investment portfolio, we will look at the ratio of the excess returns and the assets' exposure to systematic risk. In a diversified portfolio, the asset's exposure to non-diversifiable, systematic risk is a major factor to focus on when it comes to asset allocation.

For this we are going to look at the Treynor ratios of both assets, which takes the assets' exposure to market risk into account. The nominator of the ratio is the same as in the case of Sharpe ratios, the risk premium, the denominator is the beta of the asset (*Sterbenz-Pilotte, 2006*).

The assets' the exposure to the equity market and the bond market both will be observed in this section.

Table 20: Treynor ratios, excess returns with S&P betas by year

Year	Excess return		Beta (S&P)		Treynor	
	GAM	iBoxx	GAM	iBoxx	GAM	iBoxx
2016	4.10%	7.86%	0.0002	0.21	233.66	0.38
2017	0.49%	-0.49%	0.90	0.24	0.01	-0.02
2018	0.04%	-8.95%	0.01	0.25	0.04	-0.36
2019	2.94%	6.88%	0.05	0.40	0.60	0.17
2020	3.49%	-1.27%	0.03	0.45	1.37	-0.03
2021	2.24%	0.06%	-0.01	0.18	-2.48	0.003

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Once again there are negative excess returns caused either by negative annual returns or the annual returns being lower than the risk-free rate.

In the first year CAT bonds have a substantial reward to market risk ratio compared to high-yield corporate bonds, thanks to the GAM Star fund not being affected by the moves in the equity market at all. In 2017 the Treynor ratio of CAT bonds fall to 0.01 due to the high beta caused by the fallback in this year. Similarly low Treynor ratio, caused by the lower excess return in 2018. The last three years show greater reward to systematic risk ratios. CAT bonds prove to have a beta close to zero in these years, achieving 0.60, 1.37 and 2.48 excess returns to each unit of systematic risk taken by the investors. In 2021 the Treynor ratio of the GAM Star fund is negative, however it is due to the asset being slightly negatively correlated to the S&P 500 over that period. When the negative beta is the cause for the Treynor ratio being less than zero, we have to look at the absolute value when comparing it to a positive ratio.

Moving to the Treynor indexes of the iBoxx ETF, 3 out of the 5 values are negative due to the excess returns being less than zero in that year. In 2016 and 2019 the fund has achieved great returns, however investors were exposed to market fluctuations a lot more than in the case of CAT bonds, therefore, when comparing the assets based on Treynor ratios, CAT bonds prove to be superior.

Table 21: Treynor ratios, excess returns with Vanguard betas by year

Year	Excess return		Beta (Vanguard)		Treynor	
	GAM	iBoxx	GAM	iBoxx	GAM	iBoxx
2016	4.10%	7.86%	-0.05	0.50	-0.77	0.16
2017	0.49%	-0.49%	-3.74	0.55	-0.001	-0.01
2018	0.04%	-8.95%	-0.002	-0.41	-0.20	0.22
2019	2.94%	6.88%	-0.16	0.003	-0.18	25.34
2020	3.49%	-1.27%	0.17	2.28	0.21	-0.01
2021	2.24%	0.06%	0.16	0.27	0.14	0.0002

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

As discussed before, the assets' exposure to the bond market varies quite a bit over the period, compared to the same statistic with regarding the equity market.

In the three years in which the iBoxx ETF fell, CAT bonds managed to end the year with an increase, therefore being a more desirable asset, regardless of its correlation with any market.

In the years when both assets managed to close the year with a positive return, CAT bonds have a higher excess return to volatility ratio two out of the three years. The one exception is 2019's data, when the high-yield ETF had little to no exposure to the bond market.

Table 22: Treynor ratios for the observed period

Betas	Treynor - whole period	
	GAM	iBoxx
Beta (S&P)	5.55	0.22
Beta (Vanguard)	-2.16	0.11

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

All in all, the diversification effect of CAT bonds is clear when we assume that the S&P 500 represents the whole market.

Looking at the assets' excess return to market risk ratios when the global bond market represents the whole market, CAT bonds have higher excess return to market risk ratio as well.

5. Conclusions and Recommendations

Table 23: **Conclusions per analyzed aspect**

Aspects	Conclusion
Sharpe ratios	CAT bonds have higher risk-adjusted returns
Betas	CAT bonds prove to be significantly less correlated with both the equity and bond markets
Treynor ratios	CAT bonds have superior excess return to market risk ratios

Source: Own research

In this paper I analyzed catastrophe bonds' and high-yield corporate bonds' performance and diversification effect over the 01.2016 – 09.2016 period.

In my research, the GAM Star Cat Bond Fund represents CAT bonds, as for the proxy for non-investment grade bonds, I used the iShares iBoxx High Yield Corporate Bond ETF. I also looked at two benchmarks, the Vanguard Total Bond Market ETF, which represents the bond market, and also the S&P 500, which was the proxy for the stock market.

Firstly, I looked at the absolute returns of the assets. Throughout the observed period, there were two years where CAT bonds' performance was significantly affected, due to because natural catastrophes occurring. Several CAT bonds were triggered in 2017, when Hurricane Harvey and Hurricane Irma occurred, causing the GAM Star Cat Bond Fund to decline by - 6.59% in August. The second year was 2018, where we can see a pullback in the performance of CAT bonds, due wildfires in California, Hurricane Michael and Hurricane Florence triggering several CAT bonds. Despite the 2017 year's loss events the GAM Star fund manages to end the year with an increase, outperforming the iBoxx ETF. CAT bonds also outperformed non-investment grade corporate bonds in 2018 despite the triggering events.

In 2016 and 2019 both assets had their best year in terms of performance. In both of those years, high-yield corporate bonds outperformed CAT bonds with almost a 4-percentage point difference.

Another year which is worth to point out is 2020, the year of the pandemic, where CAT bonds' performance seemed not to be affected at all by the market's reaction, closing the year with a 3.85% increase, compared to the 0.91% fall of the iBoxx ETF.

In order to get a better understanding of the performance I took the risks embedded in these instruments into account. With the use of Sharpe ratios, we can clearly state that CAT bonds have superior risk-adjusted returns. The GAM Star fund had a Sharpe ratio of 2.29 over

the whole period compared to the iBoxx ETF's 0.48. CAT bonds were the least volatile asset each year with the exception of 2017. Over the observed years the S&P 500 had an extreme 111% climb, however, it was also the riskiest asset to hold. Despite this extreme performance, CAT bond had superior risk-adjusted returns to the S&P 500, except for the year 2017.

I also examined the amounts of systematic risk the investors of these assets undertake. I measured the sensitivity of the assets to both the stock and bond market. In case of CAT bonds, the beta in 2017 is distorted by the previously mentioned catastrophes occurring. CAT bonds show little to now correlation with the equity market, the beta ranges between -0.01 and 0.05 when we exclude 2017, for the whole period it is 0.04. The asset's beta is negative when looking at the relation with the bond market, having a beta of -0.09 over the observed years. On the other hand, non-investment grade corporate show greater correlation with both markets. The equity market beta ranges from 0.18 to 0.45 by year, having a beta of 0.38 over the examined term. When it comes to the bond market, the correlation is much more significant, having a beta of 0.76, which means, for every 1% increase of the bond market, high-yield corporate bond also increases by 0.76%.

Lastly, I examined compared the assets' Treynor ratios, to get a greater understanding of the assets' role in an investment portfolio. Looking at the Treynor ratios, we see that CAT bonds have a much higher excess return to systematic risk ratios. In relation with the S&P 500, the ratio of the CAT bond is 5.55%, the iBoxx ETF has a 0.22% Treynor ratio over the whole period. In case of the exposure to the bond market, CAT bonds' value is 2.16% compared to the 0.11% of high-yield corporate bonds, over the same term.

In conclusion, throughout the period – which included two years where natural catastrophes triggered several CAT bonds, some years where there has been an extensive growth in the markets, and also major fallbacks due to COVID-19 – CAT bonds proved to have superior risk-adjusted returns, while at the same time also offering better diversification benefits to investors than non-investment grade corporate bonds.

It is also worth mentioning that, not being correlated to the market is beneficial at times of market corrections or stock market crashes – as seen in March 2020 –, but there are times where diversification is not beneficial. For example, in 2019, when the S&P 500 was up by more than 30% at the end of the year, owning an asset that was correlated to the market was very much an advantage.

In summary, CAT bonds are unique asset class, that not only offer high yields, but also a great deal of diversification to investors.

Summary

Catastrophe bonds are financial instruments, that transfer catastrophic risk from companies and governments to the capital markets.

In order to have an understanding of the asset's function in the insurance industry, in this paper I firstly examine the traditional reinsurance model. I look at the strengths and effectiveness of the model, and I break down how it collapses in the occurrence of a natural catastrophe. Then I examine how transferring these risks by securitization is an effective risk transfer mechanism. I analyze the structure of the asset class, by looking at the standardization process which followed the 2008 crisis, the process of issuance. I analyze the triggers sponsors can issue the bonds with, and the loss events they can cover with issuance of CAT bonds. I look at the trade-off regarding the choice of trigger and explain the mechanism of each one.

Finally, I analyze the performance and the diversification benefit of the asset class.

Not a lot of research have been done about the returns of the asset, this was the reason I choose to analyze this aspect.

When analyzing the return and diversification benefits, I compared the asset to high-yield corporate bonds, since the financial ratings of the asset classes are similar. I analyze the absolute returns; with the calculation of Sharpe indexes, I also look at the risk adjusted returns. I measure the amounts of systematic risk the investors undertake, by investing in these assets, by calculating betas and Treynor ratios.

I find that catastrophe bonds have higher risk-adjusted returns than non-investment grade corporate bonds over the observed period. The betas and Treynor ratios confirm that CAT bonds offer much greater diversification benefits to investors.

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Appendix

Appendix 1: Monthly breakdown of returns, annual returns, minimum and maximum returns and yearly standard deviation - 2016

Months	GAM	iBoxx	Vanguard	S&P
01.2016.	0.03%	-0.90%	1.16%	-4.81%
02.2016.	0.30%	1.68%	0.90%	-0.24%
03.2016.	0.34%	2.33%	0.78%	6.33%
04.2016.	0.46%	3.54%	0.39%	0.42%
05.2016.	0.31%	0.28%	0.02%	1.44%
06.2016.	0.36%	2.06%	1.89%	0.23%
07.2016.	0.45%	1.32%	0.24%	3.54%
08.2016.	0.78%	2.04%	-0.05%	-0.10%
09.2016.	0.27%	1.00%	0.29%	-0.14%
10.2016.	0.76%	-0.92%	-0.91%	-1.76%
11.2016.	0.25%	-0.04%	-2.41%	3.29%
12.2016.	0.02%	1.49%	0.39%	1.76%
Annual	4.41%	8.17%	0.00%	9.84%
Min	0.02%	-0.92%	-2.41%	-4.81%
Max	0.78%	3.54%	1.89%	6.33%
St.dev	0.03%	-0.90%	1.16%	-4.81%

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Appendix 2: Monthly breakdown of returns, annual returns, minimum and maximum returns and yearly standard deviation - 2017

Months	GAM	iBoxx	Vanguard	S&P
01.2017.	0.43%	0.53%	0.48%	1.21%
02.2017.	0.17%	1.25%	0.88%	3.41%
03.2017.	0.10%	-0.45%	0.37%	-0.73%
04.2017.	0.16%	0.75%	0.72%	0.93%
05.2017.	0.13%	1.03%	0.76%	0.98%
06.2017.	0.41%	0.03%	0.15%	0.32%
07.2017.	0.61%	1.02%	0.40%	1.60%
08.2017.	-6.59%	-0.01%	0.93%	-0.22%
09.2017.	3.72%	0.69%	-0.43%	1.82%
10.2017.	1.29%	0.24%	0.02%	2.14%
11.2017.	0.44%	-0.45%	-0.10%	2.49%
12.2017.	0.85%	-0.18%	0.09%	1.08%
Annual	1.42%	0.44%	1.27%	18.74%
Min	-6.59%	-0.45%	-0.43%	-0.73%
Max	3.72%	1.25%	0.93%	3.41%

St.dev	0.08	0.02	0.01	0.04
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Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Appendix 3: Monthly breakdown of returns, annual returns, minimum and maximum returns and yearly standard deviation - 2018

Months	GAM	iBoxx	Vanguard	S&P
01.2018.	0.42%	0.00%	-1.09%	5.22%
02.2018.	-0.09%	-0.78%	-1.02%	-3.64%
03.2018.	0.34%	-0.31%	0.64%	-2.74%
04.2018.	0.38%	0.68%	-0.73%	0.55%
05.2018.	0.51%	0.12%	0.70%	2.36%
06.2018.	-0.01%	-0.08%	0.20%	-0.01%
07.2018.	0.67%	1.75%	-0.06%	4.12%
08.2018.	0.17%	0.70%	0.72%	2.85%
09.2018.	0.20%	0.64%	-0.38%	0.59%
10.2018.	-0.12%	-2.10%	-0.74%	-7.33%
11.2018.	-1.01%	-0.58%	0.63%	1.57%
12.2018.	0.42%	-3.05%	1.56%	-10.16%
Annual	1.89%	-7.10%	-2.75%	-6.59%
Min	-1.01%	-3.05%	-1.09%	-10.16%
Max	0.67%	1.75%	1.56%	5.22%
St.dev	0.01	0.04	0.03	0.15

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Appendix 4: Monthly breakdown of returns, annual returns, minimum and maximum returns and yearly standard deviation - 2019

Months	GAM	iBoxx	Vanguard	S&P
01.2019.	0.43%	5.44%	1.02%	9.17%
02.2019.	0.17%	1.29%	0.04%	3.04%
03.2019.	0.11%	1.08%	2.05%	1.29%
04.2019.	-0.14%	0.85%	0.12%	3.41%
05.2019.	-0.45%	-1.95%	1.81%	-6.78%
06.2019.	0.99%	2.99%	1.13%	6.91%
07.2019.	0.61%	-0.23%	0.11%	0.30%
08.2019.	0.58%	0.70%	2.57%	-1.81%
09.2019.	1.57%	0.52%	-0.65%	2.33%
10.2019.	0.64%	-0.03%	0.55%	1.81%
11.2019.	-0.13%	0.40%	0.05%	2.96%
12.2019.	0.53%	1.51%	0.04%	2.77%
Annual	5.00%	8.94%	5.78%	30.43%
Min	-0.45%	-1.95%	-0.65%	-6.78%
Max	1.57%	5.44%	2.57%	9.17%

St.dev	0.02	0.06	0.03	0.13
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Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Appendix 5: Monthly breakdown of returns, annual returns, minimum and maximum returns and yearly standard deviation - 2020

Months	GAM	iBoxx	Vanguard	S&P
01.2020.	0.48%	-0.65%	1.83%	-0.59%
02.2020.	0.32%	-1.48%	1.81%	-8.70%
03.2020.	-0.81%	-10.01%	-1.69%	-13.10%
04.2020.	0.20%	6.98%	1.61%	16.59%
05.2020.	0.21%	3.88%	0.62%	6.11%
06.2020.	0.83%	-0.39%	0.86%	2.02%
07.2020.	0.98%	4.89%	1.50%	5.32%
08.2020.	1.15%	0.00%	-0.96%	6.45%
09.2020.	0.49%	-0.96%	-0.03%	-4.12%
10.2020.	-0.10%	0.08%	-0.47%	-3.42%
11.2020.	-0.01%	3.03%	1.06%	9.87%
12.2020.	0.07%	1.22%	-0.08%	3.02%
Annual	3.85%	-0.91%	5.01%	15.76%
Min	-0.81%	-10.01%	-1.69%	-13.10%
Max	1.15%	6.98%	1.83%	16.59%
St.dev	0.02	0.14	0.04	0.27

Source: Own calculations based on data from yahoo.finance.com and swissfunddata.com

Appendix 6: Monthly breakdown of returns, annual returns, minimum and max returns and yearly standard deviation - 2021

Months	GAM	iBoxx	Vanguard	S&P
01.2021.	0.39%	-0.49%	-0.69%	-1.34%
02.2021.	-0.63%	-0.43%	-1.49%	2.14%
03.2021.	0.76%	0.59%	-1.04%	3.39%
04.2021.	0.25%	0.54%	0.57%	4.72%
05.2021.	0.47%	-0.06%	0.16%	0.29%
06.2021.	0.37%	1.13%	0.96%	1.92%
07.2021.	0.39%	0.01%	1.20%	2.20%
08.2021.	0.28%	0.48%	-0.25%	2.63%
09.2021.	0.00%	0.00%	-1.11%	-4.89%
Annual	2.29%	0.10%	-2.94%	14.42%
Min	-0.63%	-0.49%	-1.49%	-4.89%
Max	0.76%	1.13%	1.20%	4.72%
St.dev	0.01	0.02	0.03	0.09

Source: Own calculations based on data from [yahoo.finance.com](https://finance.yahoo.com) and [swissfunddata.com](https://www.swissfunddata.com)