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The Future Potential for Terrorism Catastrophe Bonds

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Abstract

In recent years, the number of catastrophic events has risen sharply. This has led not only to tragic losses for those involved, but also to serious losses in the insurance industry. As a result, insurers are increasingly seeking protection themselves. Innovative solutions emerged in the insurance industry, such as protection through catastrophe bonds. This paper evaluates this innovative solution and in particular analyses the potential of catastrophe bonds to protect against terrorism risks. Thereby various factors are assessed which could influence the emergence of a terrorism catastrophe bond market. It is found that there are many arguments for the issuance of terrorism catastrophe bonds. However, there remain various uncertainties about the future of terrorism that cannot be overcome. Nevertheless, by reducing the complexity of catastrophe bonds and thus gaining the confidence of investors, the issuance of terrorism catastrophe bonds could be supported.

Keywords:

Risk Management, Insurance, Catastrophes, Catastrophe Bonds, Terrorism Insurance

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Table of Contents

- Plagiarism Statement 1**
- Abstract..... 2**
- Acknowledgements 3**
- Table of Contents..... 4**
- List of Figures 5**
- 1 Introduction 6**
 - 1.1 Goal setting and structure of the thesis 7
 - 1.2 Methodological approach..... 7
 - 1.3 Significance and contribution 8
- 2 Risk Management in the Insurance Industry 9**
 - 2.1 Catastrophe Risk Insurance..... 9
 - 2.1.1 Catastrophes and its impacts on the insurance sector..... 9
 - 2.1.2 Insurance risk management and reinsurance 11
 - 2.2 Cat Bonds 12
 - 2.2.1 Classification and structure 13
 - 2.2.2 Purpose and development 14
 - 2.2.3 Man-made cat bonds 16
 - 2.3 Terrorism Risk Insurance..... 17
 - 2.3.1 Historical statistics of terrorism 17
 - 2.3.2 Today's terrorism insurance situation 18
 - 2.3.3 Baltic PCC Limited (Series 2019) 20
- 3 Terrorism Cat Bond Market Potential..... 21**
 - 3.1 Availability 21
 - 3.1.1 Demand for terrorism insurance 21
 - 3.1.2 Offer of terrorism insurance..... 22
 - 3.1.3 Investor demand on the capital market 23
 - 3.2 Costs 24
 - 3.3 Planning Reliability..... 25
 - 3.3.1 Terrorism risk modelling 25
 - 3.3.2 Loss potential..... 27
 - 3.3.3 Other risks 27
 - 3.3.4 Security aspects for contracting parties 28
 - 3.4 Moral Hazard and Adverse Selection 29
- 4 Discussion 31**
- 5 Conclusion 33**
- References..... 35**
- Appendix..... 38**

List of Figures

Figure 1: Number of catastrophic events, 1970-201710

Figure 2: Insured vs uninsured losses, 1970–201710

Figure 3: Insurance, reinsurance and retrocession.....12

Figure 4: Illustration of cat bond structure.....13

Figure 5: Cat bonds & ILS risk capital issued & outstanding by year.....15

Figure 6: Cat bonds & ILS risk capital outstanding by risk or peril16

Figure 7: Total number of fatalities per year from terrorist attacks18

Figure 8: Terrorism catastrophe model components26

1 Introduction

The tragic terrorist attacks of 11 September 2001 claimed the lives of several thousand people. This led to terrible losses for those involved and their families. In addition, these attacks resulted in insured losses of over 30 billion US dollars borne by nearly 150 insurers. In the history of insurance, these attacks were the most expensive man-made catastrophes. Life, health, commercial real estate, business interruption and general liability insurance lines, each paid out losses running into billions. As a result, the capital base of most insurers was severely affected and many of them reduced their terrorism insurance offer (Kunreuther and Michel-Kerjan, 2004a). Moreover, the terrorist attacks on 11 September were not the only catastrophic events in recent years. A wide variety of catastrophes with record losses have occurred recently, ranging from natural to man-made disasters (Swiss Re, 2018). Due to the resulting potential losses in the billions, the insurance industry has to deal with its risk management in a targeted manner. Giant losses are difficult to bear by the traditional insurance companies and solutions are sought for how insurers can protect themselves against the drastic loss potential of catastrophes.

As an extension to traditional insurance, insurers can enter into reinsurance contracts. As so, they can protect themselves against potential huge losses and increase their risk capacity (Swiss Re, 2004). An additional method of increasing the capital base and spreading the risk is the use of catastrophe (cat) bonds. By issuing a cat bond, the claim risk from potential catastrophes can be transferred to the capital market. This form of risk transfer has increasingly been used in recent years to hedge against natural catastrophes (Swiss Re, 2018). As a result, bond sponsors, investors and rating agencies have been extensively examining the probability and severity of future natural catastrophes. Statistics on potential losses from defined catastrophe events were compiled and their risks assessed. However, much less is known about the damage potential caused by man-made catastrophes and in particular about terrorism (Coleman, 2006). One reason for this lack is the decisive difference between natural catastrophes and terrorism catastrophes: human interaction. The existence of human actions on terrorism makes it impossible to predict the likelihood and severity of future attacks and precisely these uncertainties make terrorism insurance so complex. Thus, innovative solutions are of great interest and various options are conceivable. This work deals with one possible solution, namely the protection through terrorism cat bonds. The research question to be examined in this thesis is therefore the following: What is the potential for a terrorism cat bond market?

This research question is motivated by the aforementioned increasing use of cat bonds to protect against natural disasters. An additional motivation is that a first terrorism cat bond was already successfully issued at the beginning of 2019. This cat bond protects the United Kingdom (UK) mainland against losses from terrorist attacks via the capital market. In view of the existing investor interest in this terrorism cat bond, the thesis examines the hypothesis that there is potential for further similar bonds. To assess this, the terrorism risk and its insurability are examined. In addition, various factors are analyzed that could influence the issuance of further terrorism cat bonds.

1.1 Goal setting and structure of the thesis

The aim of this thesis is, as a first step, to examine the risk management of the insurance industry. Special focus is placed on catastrophe insurance and the use and development of cat bonds. Followed, the catastrophic event of terrorist attacks will be discussed in more detail. Both the historical development of the attacks and the current terrorism insurance situation will be examined. As the latest event in terrorism insurance, the first stand-alone terrorism cat bond issued by Baltic PCC Limited will also be analyzed. After this analysis, the focus of this thesis is an estimation of the potential of further cat bonds in the area of terrorism. The potential of such a market is concentrated in the European area, as sufficient insurance data are available in Europe.

The potential for a terrorism cat bond market is assessed on the basis of various factors. For example, the availability of supply and demand is analyzed, which is a prerequisite for a formation of a cat bond market. In addition, the potential costs related to terrorism cat bonds as well as terrorism insurances are assessed. Following, various factors that influence the planning reliability are examined and evaluated. The last factor analyzed that could influence the emergence of a terrorism cat bond market is the problem of moral hazard and adverse selection in the area of terrorism insurance.

The thesis is structured as follows: an introduction in the first chapter, two chapters in the main part, followed by a discussion and a conclusion. The second chapter focuses on the risk management in the insurance industry. It defines catastrophe insurance and its characteristics and explains reinsurance. The aim of this chapter is to show the theory of the insurance risk management as well as the development of innovative solutions. A special focus is also on the analysis of the current situation of terrorism insurance and its recent innovations.

The purpose of the third part of this thesis is to analyze the potential of a terrorism cat bond market. Various factors are assessed and evaluated in relation to their impact on terrorism cat bonds. The different subchapters deal with the availability of supply and demand of terrorism cat bonds, the associated costs, possible influences to planning reliability and the moral hazard and adverse selection problem.

The last part of the thesis is dedicated to the discussion of the analyzed market potential and the conclusions of the work.

1.2 Methodological approach

An in-depth literature analysis was conducted to examine the posed research question. Therefore, different online libraries and databases for research papers and books about terrorism risk insurance and risk management in the insurance industry in general were scanned.

Special attention was paid to the development of alternative insurance solutions such as cat bonds, where the risk is transferred to the capital market. Swiss Re's quarterly reports provided a basis for the emergence and development of the cat bond market. In addition, the Artemis database, which deals with innovative insurance solutions such as cat bonds, was great support. A key focus of the work was the insurance of terrorism catastrophes. Here, the research carried out by Kunreuther was of great importance. Kunreuther has been analyzing terrorism cat bonds

since the beginning of the 20th century and his research thus offers in-depth insights. Moreover, the research findings of Nguyen provided support in addressing the question of the general insurability of catastrophic events.

For the assessment of the potential of a European terrorism cat bond market, an interview with Ian Coulman was a big help. Ian Coulman is the Chief Investment Officer (CIO) of Pool Re, the UK's terrorism reinsurer. Pool Re has been analyzing the cat bond market and its potential for covering terrorism risk for several years. As so, their expertise in this area was an useful asset.

In general, the scarcity of scientifically based data was a clear obstacle to the analysis of the research question. Moreover, finding an interviewee was also a big challenge. One reason for this is the fact that, for security reasons, a lot of data in the area of terrorism must be kept secret. In addition, the market information analyzed by insurance companies is generally kept private and therefore they do not want to share it in an interview.

1.3 Significance and contribution

Terrorist insurance has changed dramatically as a result of catastrophic events such as the attacks on September 11. Due to the rising number of attacks and their unpredictable loss potential, risk management in terrorism insurance can no longer be ignored. Insurance companies are looking for appropriate terrorism risk models to better assess their risks. In order to protect themselves and raise their insurance limits, insurance companies are looking for alternative insurance solutions. The issue of the first stand-alone terrorism cat bond at the beginning of 2019 raises the question of whether further similar bonds can be expected as terrorism coverage. This question is of great interest not only to the insurance companies themselves, but also to investors, the government and other stakeholders. Due to this broad spectrum of interested parties and the need for terrorism insurance in the event of a crisis, the topic is of great importance. An analysis of the potential innovative solutions is therefore essential if the demand for terrorism insurance is to continue to be met in the future. In this sense, this work offers any interested party an in-depth analysis of the potential of an innovative solution, namely the terrorism cat bonds. In addition, the research presented in this thesis can be informative for other forms of terrorism insurance.

The following section 2 thus examines risk management in the insurance industry in general. Special attention is also paid to the current situation of terrorism insurance. Then, in section 3, the potential of a terrorism cat bond market in Europe is assessed. The analysis is not clearly limited to Europe, but due to the lack of insurance data in other countries it would not be possible to make a global statement, especially in the area of supply and demand. The analysis is followed by a discussion and a final conclusion.

2 Risk Management in the Insurance Industry

Over the last decades, insurance markets have drastically changed. Various trends such as globalization of insurance institutions, deregulations, increased competition, and the development of new risks present challenges for insurance companies these days (Cummins, 2007, Intro). In addition, the increase in catastrophic events in recent years has caused additional difficulties (Nguyen and Lindenmeier, 2014). The next section analyses how insurance companies can deal with these challenges and how they can insure themselves against excessive risks.

2.1 Catastrophe Risk Insurance

The insurance industry is confronted with serious risks from possible catastrophes. The losses that can result from a catastrophic event can reach several billion and this can lead to disastrous economic consequences. One possible consequence is serious capital shortages in traditional insurance mechanisms (Nowak and Romaniuk, 2012). Although for a wide range of risks the private insurance solution has indeed proved to be a highly efficient risk management tool, the wave of recent major catastrophes has also raised doubts about its capacity. The frequency and magnitude of catastrophes can overtax the financial strength of the insurance market, at least in the short term. Moreover, the unpredictability of new forms of risk makes risk modelling very hazardous (OECD, 2005). The following section therefore examines catastrophic events and their losses in the past and their impact on insurance companies. Subsequently, the management of insurance risk as well as protection mechanisms for insurance companies themselves is analyzed in more detail.

2.1.1 Catastrophes and its impacts on the insurance sector

As Figure 1 shows, the number of annual catastrophe events has fluctuated significantly and increased since 1970. Such catastrophic disasters can be natural or man-made. Natural catastrophes refer to all disasters triggered by the force of nature. This includes for example hurricanes, floods or earthquakes. At such tragic events many individuals often lose their property and therefore many insurances are involved. The other group of possible catastrophic events are man-made catastrophes. These are triggered by human actions and usually a smaller part is affected and therefore less insurances are involved. Explosions, flight disasters, fires as well as terrorist attacks belong to this group. However, all war or warlike events are excluded from the term man-made catastrophes and therefore also not included in the number of events in Figure 1 (Swiss Re, 2018).

The estimated economic losses from both natural and man-made catastrophes around the world in 2017 were 337 billion US dollars.¹ This represents almost a doubling of the 2016 figure, where economic losses were estimated at 180 billion US dollars. These economic losses are

¹ The economic losses in 2017 are well above the inflation-adjusted average for the last ten years, which amounts to 190 billion US dollars. At 0.44% of global gross domestic product, catastrophe losses in 2017 were also significantly higher than the previous 10-year average of 0.25%. A major part of the losses in 2017 was caused by natural catastrophes. This was mainly due to hurricanes, severe storms, forest fires and floods. Furthermore, catastrophes occurred mainly in North America, the Caribbean and Europe (Swiss Re, 2018).

defined as all financial losses that are directly attributable to a catastrophe event. As Figure 2 shows, insured losses have also fluctuated considerably since 1970 and have increased significantly. However, there is still a difference between total losses and insured losses. This difference is known as the protection gap and includes all losses from catastrophes not covered by insurance. Over the last 26 years, the growth rate of total economic losses has outpaced the growth rate of insured losses (Swiss Re, 2018).

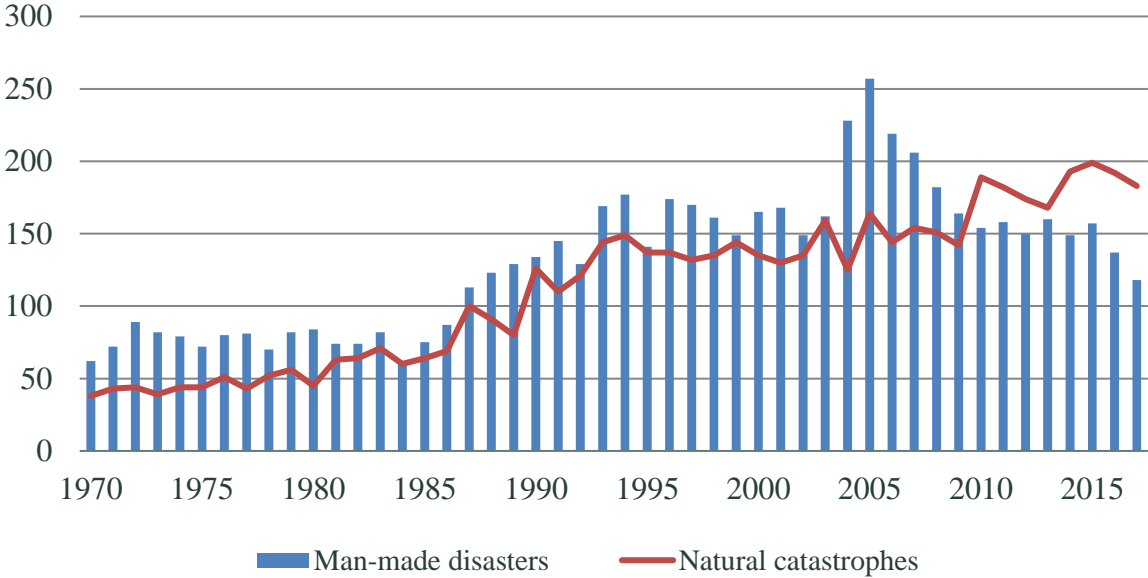


Figure 1: Number of catastrophic events, 1970-2017, Source: Swiss Re, 2018

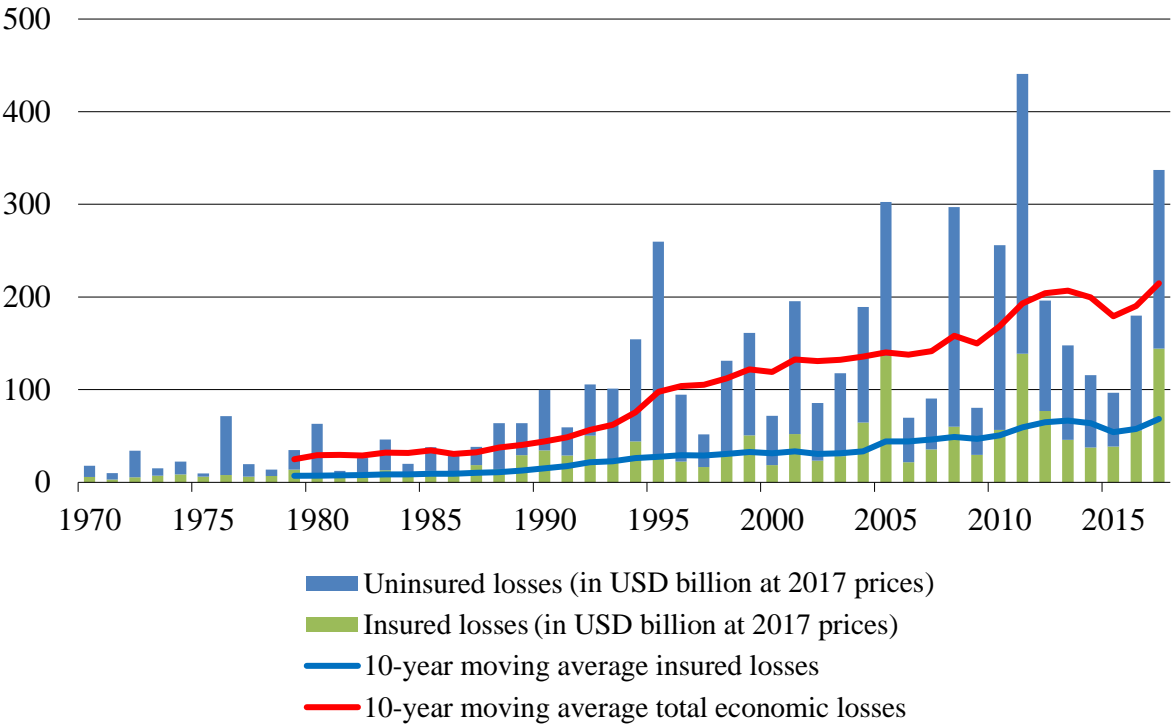


Figure 2: Insured vs uninsured losses, 1970-2017, Source: Swiss Re, 2018

These disastrous events can have devastating consequences not only for those affected but also for the insurance companies that have to cover the damage. For example, after Hurricane Andrew in 1992, which caused insured losses of 16 billion US dollars, more than 60 insurance companies had to file for bankruptcy. Furthermore, the insured losses from Hurricane Katrina in 2005 were even greater and are estimated at 40 to 60 billion US dollars (Muermann, 2008). It is also expected that the catastrophe-related loss potential will continue to worsen over the next 50 years as variables such as a growing population, the warming climate and urbanization change (Swiss Re, 2018). These huge losses can no longer be borne by the traditional insurance mechanism (Nowak and Romaniuk, 2012). Furthermore, in such a situation with frequent catastrophic events, the question arises whether the potential giant losses can still be insured at all (Nguyen and Lindenmeier, 2014).

2.1.2 Insurance risk management and reinsurance

After World War II, the topic of risk management began to be addressed (Dionne, 2013) and it is still an important part of modern business administration today. Companies as well as individuals are all affected by potential losses due to for example accidents, legal proceedings or catastrophic events. Thus, the issue of risk management remains discussed, as it is the art and science that tries to prevent such potential losses (Dorfman, 1998). Risk management attempts to maximize value by reducing the costs associated with various risks (Dionne, 2013). A solution for covering the potential costs of such risks is to take out insurance. The insurance companies redistribute the possible losses and compensate the insured party in the event of loss on the basis of a contract (Dorfman, 1998). Due to the increasing number of insured claims, the question arises how insurance companies can cover these heavy losses.

As a famous proverb from portfolio theory says, "Don't put all eggs in one basket!". In other words, it makes sense to invest in different assets because this reduces the volatility and thus the investment risk of the portfolio. Applied to the insurance industry, insurance companies should keep as many independent risks as possible in their portfolios. Uncertainty can be diversified, for example, by offering various insurance products. Such diversification is particularly effective if the risks are negatively correlated. A correlation coefficient of -1 would be highly desirable as this would neutralize the risks. Another outstanding role in the primary insurance industry is played by the balancing of risks in the collective and in time. The "law of large numbers" is the basic assumption here. This law states that experience shows that the greater the number or the longer the observation period of the underwriting units, the lower the random fluctuations (Nguyen, 2007, pp.83-84). This law applies to insurances, which serve small but frequent claims. But there exists on the other hand rare but large losses and it is therefore likely that losses will occur which are many times greater than the average expected loss (Lane and Mahul, 2008). As a result, many insurance companies had to file for bankruptcy due to such catastrophe events. Another major difficulty for the private insurance market is to solve the problem of risk diversification not only for one "point in time", but intertemporally find a solution how a smooth flow of annual premium income can be reconciled with a very uneven flow of annual claims payments (Jaffee and Russell, 1996). In order to counteract the potentially high claims payments, insurance companies can also insure themselves. In the case of risks that insurances cannot or do not want to fully bear themselves, they buy reinsurance.

As an insurance for insurers, reinsurance offers itself as a method of protection. Reinsurance can be used by insurances as a tool to manage major risks and capital. In addition, insurers can benefit from the product development capabilities and risk knowledge of reinsurers as well as obtain capital relief. Reinsurance is thus an essential component of the insurance system, making it safer and more cost-effective. It ultimately benefits policyholders, who receive more protection at reduced cost (Swiss Re, 2004).

Like insurance, reinsurance is basically a promise to pay possible future claims in return for a premium today. To ensure that this promise can be kept, reinsurers apply sophisticated risk management processes. Including risk monitoring and modelling, these processes ensure the alignment of the capital base and the risks assumed. Generally, reinsurers have a top-rated capital base and few reinsurers have gone bankrupt in the past (Swiss Re, 2004). Additionally, the reinsurance company can also buy reinsurance to cover its own risk. This reinsurance purchase by reinsurers is referred to as retrocession (Figure 3). It is important that every reinsurer has adequate reserves to cover the losses it is highly likely to have to cover (Edesess, 2015). The main objective of risk management in the insurance sector is therefore that all companies can survive in the long-term and as so guarantee their capital in catastrophe situations (Swiss Re, 2004).

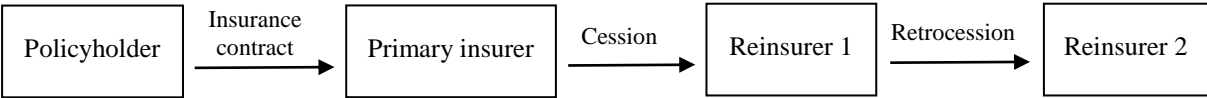


Figure 3: Insurance, reinsurance and retrocession, Source: Nguyen, 2007, pp.148

Despite several benefits, the reinsurance volume is not limitless. Reinsurance markets are limited in their capacity, especially for the reinsurance of catastrophe losses. In addition, reinsurance prices are very volatile over the cycle (Cummins and Weiss, 2009). Therefore, the traditional insurance solution with private insurers and reinsurers had to adapt to the catastrophic losses that occurred with the help of innovative approaches.

2.2 Cat Bonds

In search of alternative solutions that can better spread risk and create new capacity to insure against such extreme events, cat bonds emerged. Catastrophe derivatives were first introduced to the Chicago Board of Trade in 1993 (Muermann, 2008).² This section analyses the structure and classification as well as the development of these financial derivatives. In addition, a special class of cat bonds, the man-made cat bonds, will be examined in more detail.

² The first type of contracts traded on the Chicago Board of Trade were insurance futures and options on insurance futures. As their trading activity was very low, they were replaced by catastrophe spread options in 1995. These catastrophe spread options were based on underlying loss indices and were provided by an independent statistical office (Muermann, 2008).

2.2.1 Classification and structure

In order to protect itself from bankruptcy, which could be triggered by extreme events, the use of alternative risk transfer (ART) became inevitable with insurance companies. ART is generally understood to mean all insurance products, which function more like capital market instruments than classic insurance and reinsurance structures. In simple terms, ART products are often understood as products that fall under the heading of "convergence products" between capital and insurance markets. As so, ART products are the insurance industry's derivatives. (Culp, 2002, pp.351)

Cat bonds belong to the category of event-linked bonds, which pay off when a particular event occurs. The bonds are linked, for example, to natural catastrophes such as hurricanes and earthquakes or man-made events (Cummins, 2008). The aim of cat bonds is to cover the insurance from the masses in order to reduce the need for reserves and their coverage costs (Edesess, 2015). Cat bonds are therefore insurance-linked securities (ILS), a form of ART (Siu and Sip, 2019). Thus, a cat bond is an ILS, which represents a reinsurance of a defined risk in the form of a bond (Lane and Mahul, 2008). Figure 4 shows a typical structure of such cat bonds.

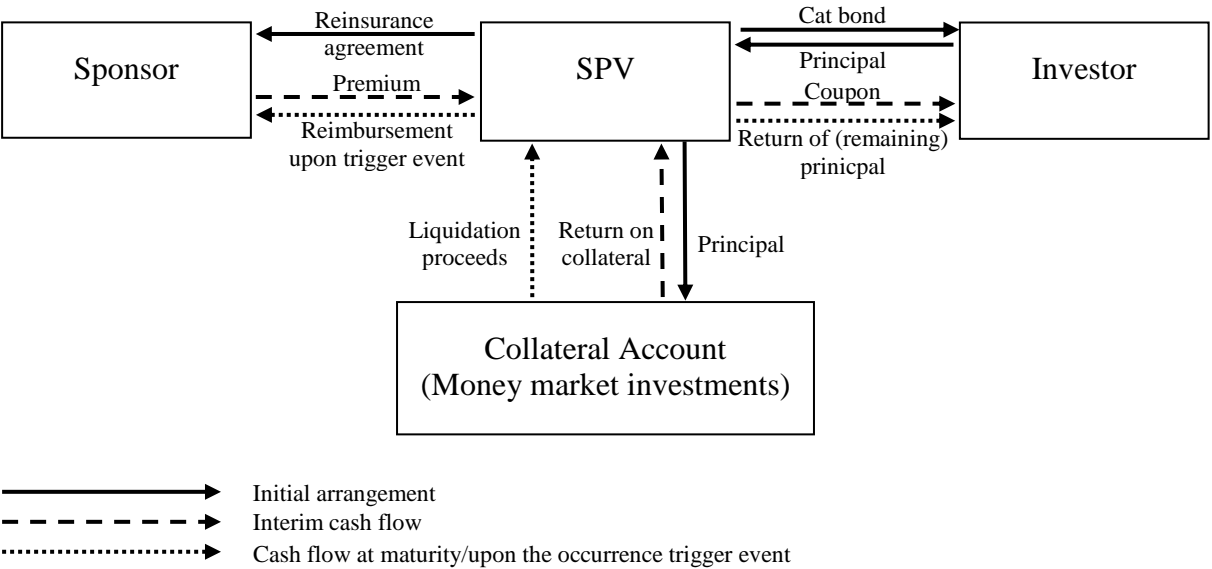


Figure 4: Illustration of a cat bond structure, Source: Siu and Sip, 2019

As with traditional bonds, many aspects must be agreed when issuing a cat bond. For the emergence of a cat bond a protection buyer is needed who wants to transfer part of his risk to the capital market. The protection buyer is generally referred to as the "sponsor". On the capital market, all business is usually transacted through a special purpose vehicle (SPV) developed specifically for the issuance of cat bonds. The SPV concludes a reinsurance contract with the sponsor where the two parties must agree on the various cat bond components such as the principal amount and the type of trigger mechanism as well as the coupon rates and the maturity. Once all components have been determined, the SPV then issues the cat bond to investors on

the capital markets. The cat bonds issued contain the default provisions stipulated in the reinsurance contract. The proceeds from selling the cat bonds are paid into a separate collateral account and investment is made in highly rated money market instruments in order to achieve a stable return. During the term of the bond, the SPV regularly pays coupon payments to the investors. Unless a trigger event occurs during the term of the cat bond, the collateral is realized at the end of the cat bond and the bond is redeemed at 100% of par. If, however, the determined event occurs, the SPV will reimburse the sponsor and thus liquidate all or part of the collateral. The redemption price of the cat bond will be reduced accordingly (Siu and Sip, 2019).

A catastrophic event must be covered by the sponsors if an identified trigger event occurs. Various trigger mechanisms are applicable, and the contracting parties must therefore define their trigger mechanism at the beginning of the contract. Examples of the various trigger mechanisms are the industry index triggers, the pure parametric triggers, the parametric index triggers and the indemnity triggers. When applying an industry index trigger, the ceding company receives back a percentage of the total industry losses that exceed a specified commitment point up to the amount of the remaining capital. A cat bond with a pure parametric trigger means that the sponsor's recovery depends solely on the location and extent of a disaster event. These triggers were additionally adapted to the so-called parametric index triggers, another trigger category. Furthermore, when a cat bond is placed with an indemnity trigger, the coverage is based on the ceding company's own business book and the bond therefore only covers if the ceding company suffers a specified loss volume. In addition, further adoptions of these trigger categories have developed, which represent modified rules on when the loss is covered by cat bonds given a catastrophic event occurs (Swiss Re, 2011).

The coupon that the investors receive for the bonds can be divided into two components. The first part of the coupon payment compensates the investors for the time value of their money which they make available for the term of the bond. This is usually based on the LIBOR rate. In a second part, the investors are also compensated for the risk taken by the potential loss. The resulting additional coupon rate for bearing this risk is often expressed as a percentage of the principal amount of the bond and can be described as a "risk premium" or "spread" (Bodoff and Gan, 2009).

2.2.2 Purpose and development

The aim of cat bonds is not to replace reinsurance, but rather to provide complementary risk-bearing capacity (Cummins, 2008). However, according to Jaffee and Russell (1996), the problem of potentially very high spending when a disaster event occurs, coupled with stable annual revenues, is more of a capital market problem than an insurance market problem. Cat bonds are therefore often issued to cover the high layers of reinsurance cover. Examples include protection against events that have a probability of occurrence of 0.01 or less and are therefore considered very rare but could represent very large losses upon occurrence. There are several reasons why the high protective layers of assignor may are not handled through traditional reinsurance, but through ILS. For example, an advantage of cat bonds is related to the credit risk of the counterparties. The ceding companies are often concerned about the reinsurer's credit risk in events of this magnitude. The advantage of reinsurance through bonds is that the bonds are fully collateralized, and thus eliminate credit risk concerns. Furthermore, the assignors tend

to have the highest reinsurance margins or price ranges above the expected loss among the high layers. As cat bonds have an advantage for investors due to the low correlation between catastrophic events and investment returns, even with lower spreads than high-layer reinsurance, cat bonds are attractive to investors. Additionally, cat bonds can offer multi-year protection, which is a further advantage over traditional reinsurance, which is usually valid for a period of one year. Thus, cat bonds can protect sponsors from cyclical price volatility in the reinsurance market. A consequent advantage of multi-year maturities is the ability to reduce costs on an annualized basis, as sponsors can spread the fixed cost of issuing bonds over multiple periods (Cummins, 2008).

These advantages have not remained unknown to sponsors and investors and it is not surprising that the ILS market has recorded robust growth worldwide. Insurers, reinsurers, corporations and governments continue to rely on capital market solutions to minimize the risk associated with extreme events (Swiss Re, 2011). Figure 5 shows the development of issued and outstanding cat bond and ILS risk capital in general since 1997.

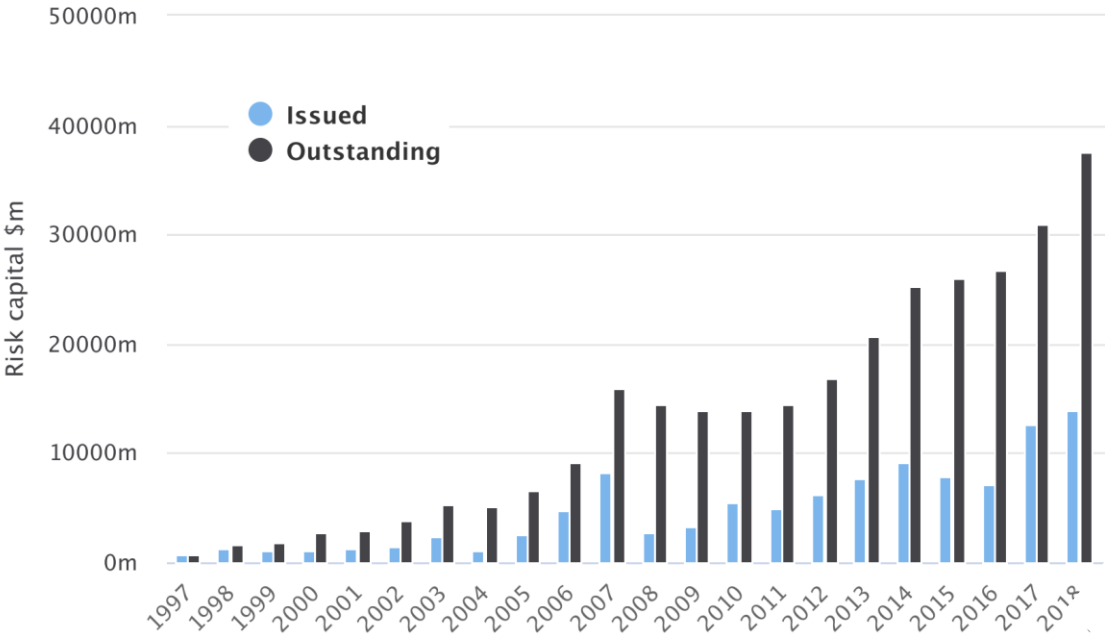


Figure 5: Cat bonds & ILS risk capital issued & outstanding by year, Source: Artemis, 2019a

The arguments in favor of ILS and particularly cat bonds have become even stronger after the severe hurricane season in 2005. In addition, the cat bond market proved its worth during the financial crisis. During this critical period, the ILS industry has largely withstood the pressure from the capital markets and has proven that its true foundation remains intact. Additionally, the financial crisis further supported the low correlation between insurance risk and credit risk as well as asset price risk. Over the past years, cat bonds have performed well for investors and are favorable compared to corporate bonds with similar credit standing and other benchmarks (Swiss Re, 2011).

Although ILS has consolidated its position as a complementary alternative to reinsurance, there is still a substantial way to go before it can unfold its full potential. However, the interplay of increasing catastrophe risk and global economic development is a powerful indicator that ILS could become very valuable. Catastrophic events are becoming increasingly severe and frequent and only few believe that this threat will have a negative trend in the near future (PwC, 2012). This would argue for increased ILS transactions and cat bonds in particular. However, according to an analysis by PwC (2012), the key to unlocking the full potential of cat bonds is to reduce its complexity and develop a better understanding of its structures work and the nature of its risk profile. Once these challenges are overcome by market participants, cat bonds may enter the mainstream.

2.2.3 Man-made cat bonds

The frequency and consequences of natural catastrophes are widely discussed in the literature. Much less is published about man-made disasters (Coleman, 2006). Man-made catastrophes are categorized in relation to human activities and different forms of disasters fall into this group. Examples of man-made catastrophes include explosions and major fires, shipping disasters, aerospace disasters, mining accidents, railway disasters, building or bridge collapses and terrorist attacks (Swiss Re, 2008). In a man-made catastrophe, there are often objects in confined spaces affected and therefore only a small number of insurances are covered. Excluded from the term man-made catastrophes in this context are war or war-like events (Swiss Re, 2008). Although man-made catastrophes, as shown in Figure 1, have also risen sharply since 1970, the number of cat bonds and ILS risk capital currently outstanding (May 2019) is largely attributable to natural catastrophes (Figure 6). For instance, 33.6% and thus a large part of the outstanding risk capital belongs to the peril "U.S. named storm and hurricane" and belongs to the coverage category of natural catastrophes (Artemis, 2019b).

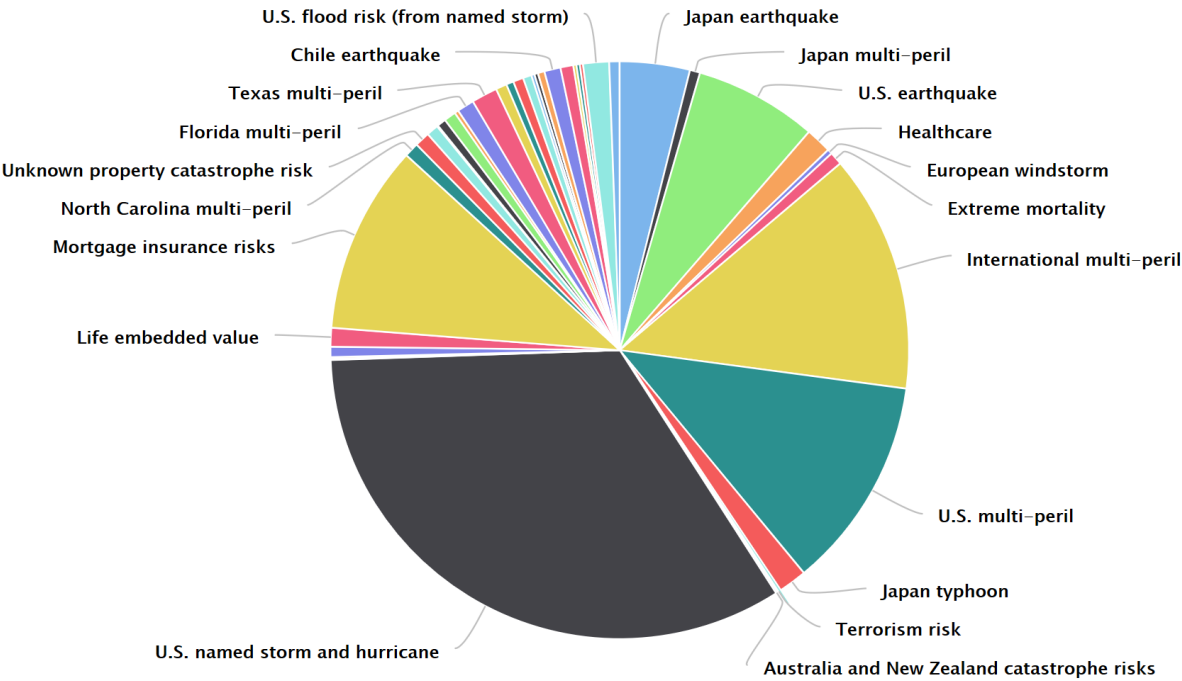


Figure 6: Cat bonds & ILS risk capital outstanding by risk or peril, Source: Artemis, 2019b

2.3 Terrorism Risk Insurance

A special form of man-made catastrophe risk is the subcategory of terrorism risk. Various terrorist attacks have shocked the world population in recent years. These include the terrorist attacks of 11 September 2001 on the World Trade Center, which, with insured losses of several billion US dollars, were the most expensive man-made catastrophes in history (Nguyen and Lindenmeier, 2014). In the aftermath of this attack, however, the threat of terrorism is far from resolved and continues to be discussed worldwide. One major question is how to bear this risk (WTW, 2018). Terrorism risk is undoubtedly a risk that is difficult to assess. There is data on terrorist attacks and therefore statistical material on the distribution of damage, but attacks such as 11 September have shown that the danger has been underestimated by far. Thus, due to the many uncertainties, the terrorism risk belongs in the grey area of insurability. New calculation models are necessary in the insurance industry, which also research and accumulate social, cultural and political reasons for terrorism risks (Nguyen, 2007, pp.8).

The terrorism risk may correspond to a certain extent to the risk of natural catastrophes. In both cases, potentially massive losses make diversification difficult, as single events can hit entire economies and multiple industries. The potential for accumulation between the different sectors is much higher than previously thought and needs to be better controlled. However, the main difference between terrorist and natural disasters is that the probabilities and impacts of natural hazards can be scientifically simulated. More difficulties arise when trying to simulate terrorism risk, which verifies the principles of insurability (Coomber, 2006). The aim of this section is therefore to analyze the insurance of terrorism risk and the difficulties involved.

2.3.1 Historical statistics of terrorism

The general idea behind the technique of terrorism is the psychological destabilization of the enemy. In earlier times, a goal of many terrorists was to create a chaotic environment by cruel actions in public places, which would unsettle and weaken their opponents. Often these were acts of protest against the regime or actions motivated by religious backgrounds. Around 1860, which can be seen as the beginning of modern terrorism, the invention of dynamite through the Industrial Revolution played an important role. However, although dynamite and other explosive materials have simplified the actions of today's terrorists, their strategies have not fundamentally changed (Chaliand and Blin, 2016, Preface).

The bomb attack on the King David Hotel in Jerusalem in 1946 can be named as the first attack which led to recognizable coverage by terrorism insurance. Although the basic strategy of terrorists has not changed completely, some changes have taken place in the course of the various attacks in history. In general, a shift in the focus of terrorists is visible. The best-known attacks in the past caused disastrous damage to the infrastructure and many years of planning were required for such an assassination. In contrast, today there are comparatively minor attacks carried out targeted particularly at people. This is done with the help of easily accessible weapons and less effort in planning is required (WTW, 2018). This can also be seen in the following Figure 7, which shows a clear increase in the annual number of recorded fatalities of persons due to terrorist attacks since 1970. The fatalities shown in the graph include all reported cases and thus show the total number of victims per year that died directly as a result of the

terrorist attacks. The data used in this graph are taken from the Global Terrorism Database (GTD). Since there is no generally accepted definition of terrorism, it is important to examine how GTD defines terrorism. According to GTD and thus also for the data in the graph, a terrorist attack is defined as “the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation” (Roser et al., 2018).

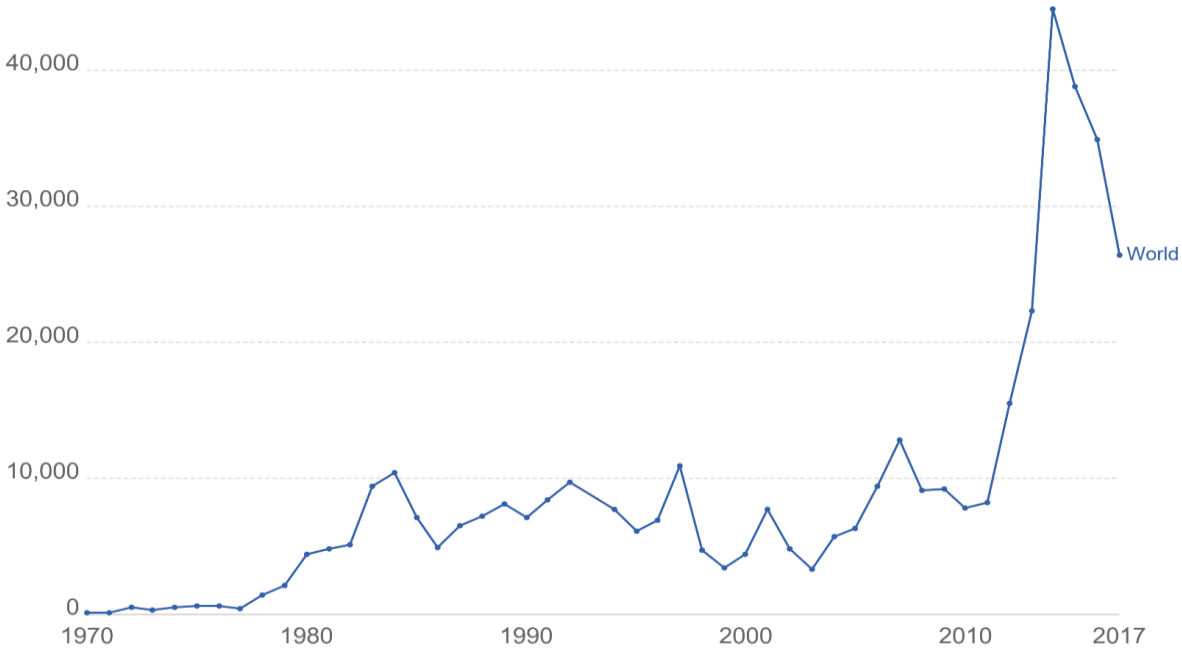


Figure 7: Total number of fatalities per year from terrorist attacks, Source: Roser et al., 2018

Known as 9/11, the terror attacks of 11 September 2001 can be mentioned as a turning point in world history. As the deadliest terrorist act, the 9/11 attacks have killed almost 3000 people (Roser et al., 2018).³ Al Qaeda, an Islamic terrorist group has recognized itself for this crime. As a result, terrorism has in Western countries often been associated with Islamic groups. Undoubtedly, this latest phase in the terrorism history has not yet come to an end, and violent actions are expected to take on new and diverse forms in the future (Chaliand and Blin, 2016, Preface).

2.3.2 Today's terrorism insurance situation

In general, it is difficult to define terrorism clearly, as it cannot easily be separated from alternative forms of violence such as war. As with any risk, however, the various interest groups must agree on a collective understanding and define the nature of the loss event. Another barrier to terrorism insurance coverage is the sheer size of the potential scenarios and the challenge of assessing their probability. The attack on 11 September 2001 can be seen as a turning point in the history of terrorism risk insurance. Before these attacks, the potential for terrorism risk

³ The assessment of the insured loss from the collapse of the Twin Towers at the World Trade Center was a very complex undertaking. Large claims were filed for a variety of risks including aviation, liability, property, business interruption and life insurance. In addition, losses were not limited to the New York area, but were global. The estimated value of paid insurance losses is 23.8 billion US dollars (Swiss Re, 2017).

losses seemed manageable for the private insurance industry. However, this changed and the insurance industry was forced to fundamentally review its risk tolerance. Immediately after 9/11, in the view of insurers, international terrorism was fundamentally uninsurable, and they reacted by limiting insurance cover and raising an extra premium. In contrast, awareness and demand for protection against this menace had increased. As a result, terrorism coverage was reassessed, and pricing changed (Coomber, 2006).

Predicting terrorist events and assessing their risks remains a complex challenge for insurers and reinsurers. A resulting lack of sufficient risk transfer possibilities reinforces the role of government support in terrorism insurance (WTW, 2018). According to Swiss Re, one of the world's leading reinsurers, terrorism risks are increasingly no longer meeting important criteria for insurability. This is because it is practically impossible to accurately assess the probability and magnitude of terrorist attacks. Consequently, Swiss Re shares a strong tendency towards a solution through cooperation between government and insurers. Thus, according to Swiss Re, companies with government participation could offer insurance protection against terrorism risks (Swiss Re, 2002).

In recent years, government-supported terrorism pools and systems have been introduced by many countries (WTW, 2018). However, the public-private partnerships that have been developed vary considerably from country to country. In France, for example, a new terrorism insurance program was set up after 9/11, under which insurance cover is compulsory. This means that insurers must provide cover but are reinsured through a pool of co-insurance with limitless government cover. The terrorism insurance program in Germany has been somewhat different, with insurance and reinsurance companies setting up a property insurance company with limited government support. Furthermore, terrorism coverage is not mandatory in Germany. The insurance obligation does not exist in the USA either, but insurers must provide it if their policyholders so wish. Moreover, in the US there is no risk sharing between insurers and thus no pool, but the state shares part of the risk with the insurers. These introduced public-private terrorism insurance solutions in France, Germany and the USA are just a few examples and other countries have introduced other coverage programs (Michel-Kerjan and Pedell, 2005). A possible disadvantage of the public-private solution is that the state assumption of risk at a premium that is not commensurate with the faced risk could lead to the unilateral subsidization of certain industries or companies and thus violate competition law (Nguyen, 2007, pp.2).

Insurers and reinsurers of terrorism risk have not yet made extensive use of the capital markets to cover their potential losses from terrorist attacks. Until recently, only two terror-related cat bonds were issued, but both insured multi-events and the terror risk was only part of the total risk. One was the bond issued by FIFA in August 2003 to protect its investment in the World Cup. With this multi-event bond, FIFA also protected itself against terrorist disasters. The second terror-related bond was launched by Swiss Re in 2003 and securitized the catastrophe mortality risk (Michel-Kerjan and Pedell, 2005). At the beginning of 2019, the first pure terrorism catastrophe bond was launched, which will be analyzed in more detail in the next section.

2.3.3 Baltic PCC Limited (Series 2019)

A 75 million pounds transaction by Baltic PCC Limited is the first stand-alone terrorism cat bond to be launched. The bond was sponsored by Pool Re, a reinsurance company supported by the UK government. In this launch in January 2019 the capital market is used for to hedge against the risk of terrorism. The sponsor Pool Re will be provided over three years with fully collateralized retrocessional reinsurance. Thus, Pool Re insures itself against losses caused by terrorist attacks on the UK mainland. The 75 million pounds were sold to ILS investors by Baltic PCC Limited. The proceeds from the sale will be used to collateralize the underlying retrocessional reinsurance arrangement between Pool Re and Baltic PCC. It has been established that this terrorism protection is triggered on an indemnity and cumulative annual basis. Meaning that Pool Re not only has coverage against major terrorist acts but also has frequency protection for a number of smaller attacks within a one-year risk period (Artemis, 2019c).

Losses of 500 million pounds will trigger the cover provided by Baltic PCC Limited. If the trigger occurs, the terrorism catastrophe bond will cover from 200 million pounds to an exhaustion point of 700 million pounds. For Pool Re, the bond covers property risks and cyber-terrorism risks, as well as some business disruptions. When the deal was launched on the ILS market, there was interest from investors on the capital market, what may indicate that investors are willing to support such cat bonds. This first settlement of a cat bond exclusively against terrorist attacks brings a completely new risk class to the cat bond market (Artemis, 2019c). According to Ian Coulman, Pool Re's CIO, the start into the capital market is only a sharing of this terrible risk with a broader spectrum of potential investors (Artemis, 2018).

The sponsor, Pool Re, is a reinsurance company established in the wake of a terrorist bombing in London, which resulted in a lack of insurance and reinsurance capital to cover terrorism (Jarzabkowski et al., 2018). Since Pool Re is supported by the government, its aim is to get taxpayers as far away from risk as possible. Additionally, a key objective for Pool Re is to protect the government's balance sheet and reduce its risk. As the reinsurance market offers only a finite amount of protection, opening up the capital markets appears to be an opportunity to complement protection. Moreover, the CEO of Pool Re points out that the sources of retrocessional protection through the ILS market was only a logical development for Pool Re. In addition, the terrorism protection gap is now larger than ever and is constantly growing. In such situation, the search for innovative and effective solutions is therefore particularly necessary (Artemis, 2018).

3 Terrorism Cat Bond Market Potential

After the major terrorist catastrophe events of recent years, which caused billions of insured losses, the supply of reinsurance for terrorism risk was scarce. Consequently, the price of reinsurance has risen sharply, and insurers have begun to work with the investment banking community and modelling firms to raise capital from other sources. The aim is to develop new types of financial instruments such as ILS to cover losses with an alternative risk transfer. One option is to transfer part of the risk to the capital markets and offer investors an attractive asset class. While the market for ILS has already covered a few terrorism risks, its potential is far from exhausted (Michel-Kerjan and Pedell, 2005). The launch of the first pure terrorism cat bond from Baltic BCC Limited raises the question of the potential for further similar bonds. The question of whether further countries will follow and also place terrorism cat bonds is particularly interesting. As insurance information is lacking in many underdeveloped countries, the following section focuses mainly on the potential of terrorism cat bonds in Europe (Cummins, 2007).

Much of the information in this section comes from an interview with Ian Coulman, Pool Re's CIO. Prior to the placement of the first pure terrorism cat bond, Pool Re extensively analyzed the potential market for terrorism cat bonds over several years. As a public-private reinsurer of terrorism risk for the UK, its analysis and results place particular emphasis on data from the UK. However, due to the fact that terrorism often crosses national borders, many of their analyses are not only results for the UK but also cover a much larger scope. Therefore, the following section analyses the potential to manage the risk of terrorism through cat bonds particularly in the region Europe. Although the borders outside Europe are not clearly defined, due to a lack of insurance information in many non-European countries, the following analysis cannot be generalized worldwide without further data. The terrorism cat bond market potential is analyzed and assessed on the basis of several factors that could influence its emergence.

3.1 Availability

For a market to emerge and be in equilibrium, both supply and demand must be equally present (Stiglitz and Weiss, 1981). In the case of the terrorism cat bond market, this means that on the one hand there must be demand for insurance cover, and an insurer or reinsurer must assume this risk and transfer it on the capital market. Moreover, there must also be a demand from investors for such cat bonds on the capital market. In addition, all contracting parties must agree on the applicable premiums, cover and returns to be provided. This section therefore analyses the potential of demand and supply in detail.

3.1.1 Demand for terrorism insurance

According to Ian Coulman, it is conceivable that the demand for terrorism insurance in Europe has increased in view of the various events of the last years. As Pool Re's CIO, he can focus specifically on the experience of the demand for terrorism coverage in the UK and its trend in recent years. Pool Re covers commercial property on the UK mainland against physical damage caused by terrorism. Much of the demand for cover is concentrated in major cities such as London, Manchester and Birmingham. One sector that has not been particularly concerned with

terrorism coverage for property has been small and medium-sized enterprises (SMEs). According to Pool Re, the reason for this lack of cover can be traced back to the attitude of "it will never happen to me". However, the 2017 London Bridge and Borough Market attack showed that small businesses lack cover. This shortage is particularly evident in connection with a non-damaged business interruption (NDBI). Pool Re was unable to provide cover for the NDBI until the beginning of this year. The resulting extension of the range of cover is expected to increase SME interest in terrorism cover. According to Ian Coulman, however, this increase in demand for specific NDBI cover could take some time.

In addition, Michel-Kerjan and Pedell (2005) examined the terrorism insurance demand for companies in several countries and found that by no means all companies protect themselves against the risk of terrorism. They then analyzed reasons why companies could not insure themselves against the risk of terrorism. One analyzed reason is that the way in which people make decisions in the face of uncertainty influences their decision to take out terrorism insurance. As research on insurance against other catastrophic risks has shown, the decision against insurance may be due to an "it cannot happen to me" effect. This possible reason is consistent with the reason assumed by Pool Re for SMEs. Another conceivable reason analyzed could be that the government cannot credibly assure in advance that it will not support companies in the event of an attack. Some companies may therefore believe that they will be backed by the government in the event of an attack, which reduces interest in purchasing insurance (Michel-Kerjan and Pedell, 2005).

When buying terrorism insurance, an important factor is often the requirement of financial protection of assets against all possible risks. Otherwise, the criteria for loans are not given. Fewer organizations are found that have extensively dealt with the nature of their terrorism risks where the insurance results from a natural conclusion of an extensive risk management process (WTW, 2018). It can therefore be expected that demand for terrorism insurance will continue to exist in Europe, although the full potential is far from exhausted (BIBA, 2019).

3.1.2 Offer of terrorism insurance

An important reason for the non-emergence of a market for terrorist cat bonds is the reluctance of reinsurers not to provide cover for the terrorism risk after the 9/11 attacks (Kunreuther and Michel-Kerjan, 2004b). Moreover, for capacity reasons, the comprehensive terrorism insurance cover cannot be provided by the private insurers alone. As so, the reluctance of reinsurers to do business makes government assistance necessary. Thus, offer of terrorism insurance is basically available in most European countries up to a certain limit, but often in the form of a public-private solution (WTW, 2018).

With the support of reinsurance, the private insurance market could take significantly more of the terrorism risk from the government balance sheets (WTW, 2018). Reinsurance can be used to provide more insurance policies with the same capital. This is because by purchasing reinsurance cover, insurers transfer their risks to reinsurers and therefore do not have to provide capital for these risks (Swiss Re, 2004). In return, reinsurers could transfer the terrorism risk to the capital market in order to increase their capital base. The increased capital base offers potential for further insurance coverage. According to Ian Coulman, it is conceivable that the

emergence of terrorism cat bonds will support the growth and development of the terrorism insurance market. This growth could also help encourage more insurance companies to adequately price protection and offer adequate coverage to their clients. The key is the ability to assess the risk of terrorism, what is a problem faced by most terrorism models. However, Pool Re's CIO believes that developing terrorism models and thinking about the likelihood of events could allow more insurance companies to assess risk and offer limited coverage to their clients. Also the statement that the path to the capital market was only a logical conclusion for Pool Re (Artemis, 2018) is a sign that more insurers and reinsurers could make use of ILS in the future which may support the growth and development of terrorism cat bond offers.

3.1.3 Investor demand on the capital market

The first pure terrorism cat bond issued by Baltic PCC Limited in the first quarter of 2019 was a highlight for the ILS market. According to reports, the cat bond was heavily oversubscribed which is a good sign for the market and could indicate investor interest in this asset class (Artemis, 2019). Also according to Ian Coulman, investor demand is clearly present. Pool Re began considering a terrorism cat bond some years ago after the first commercial retrocession placement of terrorism risk. This despite the fact that terrorism poses a different threat than the natural catastrophes already covered by cat bonds. Pool Re worked for several years with a number of brokers to establish contact with potential investors and participated in a number of ILS conferences and seminars. This has enabled them to further develop its modelling capabilities and make the terrorism risk more understandable to potential investors. As a result, investors have become more familiar and comfortable with the terrorism risk.

Nevertheless, there are still some investors who are not comfortable with the subjective nature of the probability of terrorism or the lack of validation of the modelling by third parties. In addition, the aforementioned reluctance of reinsurers to cover terrorism also has an impact on financial investors. Many view reinsurers as experts in the insurance market. Thus, when the reinsurance industry demands high premiums to protect against terrorism, investors also demand a sufficiently high interest rate to provide funds to cover losses from terrorism (Kunreuther and Michel-Kerjan, 2004b). Another factor that could influence the demand of terrorism cat bonds is that international terrorism is a matter of national security and the government can thus influence the risk of future attacks through appropriate counter-terrorism measures (Kunreuther and Michel-Kerjan, 2004a). This government influence could unsettle many investors. Moreover, the fear of investment managers of the impact on their reputation could be a possible reason for disinterest. This is due to the potential to lose money by investing in a new and unusual asset, as well as making profit based on the loss of human life (Kunreuther and Michel-Kerjan, 2004b).

But Ian Coulman believes that with the core group of capital market investors who bought the first stand-alone terrorism catastrophe bond, others are encouraged to monitor its development. Pool Re is also confident that a possible further issuance of terrorism cat bonds in the future will result in stronger demand from the capital markets. The prerequisite for this rising demand, however, is that no events have occurred that could lead to a loss of the cat bond released by Baltic PCC.

3.2 Costs

Since reinsurance deals with rare but potentially very large losses, there is concern about the high price of such insurance (Lane and Mahul, 2008). If a market can emerge is therefore not only a question of the insurance offer, but also the prices which have risen strongly due to the disastrous attacks (WTW, 2018). An offer of insurance can come about if the insurers are able to raise an appropriate premium. The appropriate premium consists of the expected loss, the risk premium and the administrative costs incurred. A risk premium is necessary because the actual claims payments can fluctuate around the expected value and the insurers would otherwise have to provide their equity for this. In the case of terrorism risks, the fluctuations around the expected loss are extremely high, so that a fair risk premium must be correspondingly high. In contrast, these events occur very rarely, which keeps the expected loss relatively small. This means that the risk premium accounts for a fairly high proportion of the total insurance premium, which can make the premium appear unreasonably high for the policyholder. In this case, the policyholder would forego insurance cover because the premium is too high from his point of view (Nguyen, 2008).

The key to adequate terrorism coverage and pricing is the ability to assess the risk of terrorism. The difficulties that arise in modelling the risk of terrorism are analyzed in more detail in the next section. However, important for the pricing of terrorism insurance is that to determine the risk, the severity of an event and the frequency is needed, which is the problem faced by most terrorism models. The reason for this unpredictability of severity and frequency of an event is its involved human nature. Additionally, the frequencies and consequences of a terrorist attack can change over time, as they are determined by a mix of strategies and counter-strategies that are dynamic. This also leads to dynamic uncertainties what are a challenge not only for potential investors, but also for insurers and reinsurers themselves. In addition, insurance contracts are often concluded for at least one year, and information on the risk for the entire period should be available for correct pricing (Kunreuther and Michel-Kerjan, 2004a).

The existence of dependencies is also challenging for the pricing of terrorism risk insurance and thus the terrorism cat bonds. It is difficult for an individual insurer to set incentives for measures to prevent terrorism and, unlike other insurances, premium reductions cannot be granted to policyholders who take preventive measures. This is due to the interconnectedness of companies, whereby the vulnerability to a terrorism risk depends not only on individual companies, but also on the security investments of other actors. All these interdependencies make fair pricing difficult (Kunreuther and Michel-Kerjan, 2004c).

From the perspective of the sponsor, the prevailing cost conditions in the insurance and reinsurance market significantly influence the attractiveness of cat bonds. The costs of issuing cat bonds compared to traditional reinsurance costs vary depending on the underwriting cycle of reinsurance. Extreme catastrophes can considerably undermine capital, limit supply and force the reinsurance price cycle from "soft" to "hard". This means that primary insurers and reinsurers are increasing rates to rebuild the surplus and recover losses. In a "hard" market environment, cat bond may be cheaper than reinsurance and an appealing alternative for sponsors (Swiss Re, 2011). In addition, the earnings of reinsurers providing terrorism coverage could come under pressure in the medium term due to rising inflation, falling support due to the

release of loss reserves from the previous year and higher regulatory capital requirements. This in turn should theoretically lead to higher prices as reinsurers seek to cover their rising cost of capital and achieve a margin. These higher prices could also influence the pricing and issuance of cat bonds on the capital market (OECD, 2011).

In general, pricing terrorism cat bonds is more challenging than pricing natural cat bonds. However, Ian Coulman believes that developing risk models and studying the likelihood of terrorism events could allow more insurance companies to assess risk and provide adequate coverage and pricing to their customers. Thanks to better information and modelling, this could improve the pricing of the risk for policyholders. As so, according to Pool Re's CIO, it is fair to assume that the insurance market will continue to evolve. In addition, the placement of the first pure terrorism cat bond on the capital market has helped modernize the market for terrorism insurance. With the idea of further developing the market, prices should also be made even more reasonable and understanding. This may also affect the pricing of terrorism cat bonds on the capital market.

3.3 Planning Reliability

Insurance markets work best when losses are random, relatively small and uncorrelated, and when there is a wealth of historical loss data to which statistical methods can be applied. Losses from terrorism can be disastrous and the inestimable frequency and probability of occurrence of terrorist attacks entails many risks (Kunreuther and Michel-Kerjan, 2004b). However, stable planning reliability would be of great importance and generally facilitates any economic activity. This section thus analyses various factors that may involve uncertainties or securities with regard to the planning of terrorism insurance.

3.3.1 Terrorism risk modelling

Terrorist risk estimates are of interest to all parties involved. Policyholders want a better understanding of their assets in relation to potential terrorist attacks to determine whether cover should be acquired. Insurers and reinsurers can use terrorism loss modelling to develop their prices and conditions such as exclusions, deductibles and limits of cover. In addition, loss modelling helps investors on the financial markets to assess their risk of terrorism cat bonds (Kunreuther and Michel-Kerjan, 2004b).

Data from historical events are a first starting point for risk modelling. Uncertainty in the assessment of the threat from terrorism arises because data on the activities of terrorist groups and current threats are kept secret for reasons of national security. Although data on some past catastrophes and the resulting losses are publicly available, data on potentially changing expectations, are often kept secret (Kunreuther and Michel-Kerjan, 2004b). However, even the existence of all historical data of terrorist attacks would not be sufficient for a concrete probability analysis, because there are two significant elements which distinguish the terrorism risk from the risk of natural catastrophes: intention and intelligence. As a result, the probability distribution is not sufficient to model the terrorism risk (Major, 2002). Terrorist attacks are rather a function of the malicious intentions of different groups of different sizes and with different objectives. Terrorist groups change over time and new groups emerge and old

dissolve. Moreover, the ability of individual terrorist groups to attract resources increases and decreases with major political and economic developments over time. This increases uncertainty about the frequency, severity and location of future terrorist activities, making the modelling of terrorism risk much more complex (Kunreuther and Michel-Kerjan, 2004b). Therefore, analysis techniques from war operations research and particularly from game theory can be of great help (Major, 2002). In the modelling framework (Figure 8), important components of terrorism catastrophe models are presented. The following analysis of the individual components illustrates how complex and uncertain terrorism models are.

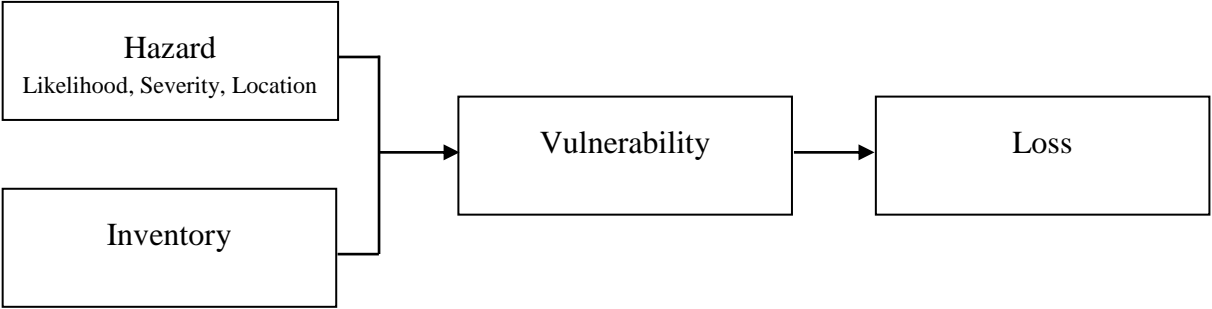


Figure 8: Terrorism model components, Source: Kunreuther and Michel-Kerjan, 2004b

In terrorism catastrophes risk modelling, the component Hazard addresses three basic issues: determining the likelihood of attacks, its severity, and the locations most likely to be affected by an attack in the future. Each element has its own difficulties and uncertainties. One difficulty in determining the probability of occurrence is, for example, the possibly positive or negative bias in expectations. This is because, after a dramatic attack, the likelihood of an attack may be overestimated, and the reverse may be the case if a terrorist attack is absent for an extended period of time. Furthermore, the severity of the attack depends on the chosen weapon type. The weapons used have also changed over time and are therefore difficult to predict. Difficulties and uncertainties in determining the location and mode of an attack in the future is reinforced by the different terrorist groups and their various objectives (Kunreuther and Michel-Kerjan, 2004b).

The Inventory component involves the risk that attacks may endanger not only the terrorist targets themselves, but also the surrounding objects. The damage resulting from an attack depends, among other things, on the amount of material used, explosives and the structure of the surrounding area. In addition, the magnitude of the damage depends on external factors such as wind direction and wind speed. This makes it particularly difficult to predict the risk of loss and the extent of the damage. In addition, terrorist attacks can affect several lines of insurance, such as life, liability, health and accident, or lead to severe stress on the psyche of a besieged nation (Kunreuther and Michel-Kerjan, 2004b).

Likewise, the Vulnerability component entails additional uncertainties for terrorism risk modelling. Research has been conducted into the effects of explosives on structures since the 1950s. Modelers have developed loss functions that analyze how different types of buildings react to various attacks. In the event of a terrorist attack with conventional and nuclear weapons, buildings suffer damage to their structural integrity and non-structural components. For non-

conventional weapons, it is likely that the structure of the building will not be compromised, but the resulting contamination can render it unusable over time and lead to significant remediation costs. In both cases, the loss functions identify building damage, content and loss of use (Kunreuther and Michel-Kerjan, 2004b). In addition, terrorism models must consider other losses in addition to building damage. The potential losses caused by terrorism and the resulting uncertainties for terrorism cat bond investors will be analyzed in more detail in the next section.

The terrorism models developed help with risk assessment, but it remains difficult to assess the probability of future terrorist attacks based on our current knowledge. Although a well-specified distribution of the expected loss in the statistical sense cannot currently be required by any of the terrorist models, the risk models can help investors to understand the risks under certain attack scenarios (Kunreuther and Michel-Kerjan, 2004b). However, most investors and rating agencies consider the developed terrorism models too untested and new to use for the design of cat bonds. Developing a sizeable market for terrorism cat bonds could therefore be difficult without the acceptance of terrorism risk models by key stakeholders (U.S. GAO, 2003).

3.3.2 Loss potential

The assessment of potentially gigantic losses is a particular challenge in the area of terrorism insurance today. Losses due to terrorist attacks do not only refer to the destruction of buildings, but also the number of fatalities, the workers' compensation, life insurance losses as well as losses from accident insurances. For each attack severity level, an average loss ratio can be calculated together with a probability distribution of the loss. This results in a damage distribution for each structure type linked to different loss states. These complex calculations show that the potential loss from terrorism is very difficult to estimate and involves many uncertainties and assumptions (Kunreuther and Michel-Kerjan, 2004b). Any negative external impact from an attack has additional loss potential and is extremely difficult to assess as it is not directly dependent (Kunreuther and Michel-Kerjan, 2004a). These side reactions and its possible additional losses must also be taken into account by investors on the financial market. Thus, in order to provide clarity for investors, it must be clearly defined which direct and indirect damages of a terrorist attack are covered by a terrorism cat bond.

An important factor in assessing the loss potential is also the maximum loss. The nature of the attacks plays an essential role here. Due to the uncertainty of the form of attacks in the future, which could include drones, cyberterrorism and radiological isotopes, the maximum loss potential of terrorist attacks can grow to infinity (BIBA, 2019). As so, that liability limits are generally agreed in the insurance industry. These limits are intended to make the loss potential more predictable for the insurer as well as investors and other stakeholders (Nguyen, 2008).

3.3.3 Other risks

Rating agencies also play their role in assessing the potential of a terrorism cat bond market (Michel-Kerjan and Pedell, 2005). Therefore, obtaining a financial rating is a critical step in issuing a cat bond because buyers use ratings to compare yields on cat bonds with other corporate securities (Cummins, 2008). According to Woo (2004), the investment grade rating

was an important reason for the successful placement of the FIFA cat bond on the capital markets. Thus, the development of terrorism risk models could encourage the issuance of more cat bonds (Michel-Kerjan and Pedell, 2005). However, the rating also entails risks and at present there are still many uncertainties and skepticism on the part of the rating agencies regarding the terrorism models (U.S. GAO, 2003).

Obviously, defining the default-trigger event plays an important role in structuring cat bonds. Any catastrophic trigger should be as measurable as possible and understood (Ma and Ma, 2013). There exist different types of trigger mechanisms with different levels of transparency to investors and different levels of basis risk to sponsors (Swiss Re, 2011). Therefore, it is important for any contracting party to determine an appropriate trigger mechanism and to be aware of its potential consequences. Defining a suitable trigger was also of great importance for the first cat bond from Baltic PCC, and according to Ian Coulman the set attachment point of the bond is related to the default risk. In order to be able to exclude as many risks as possible, the choice of the trigger is particularly important in the case of terrorism, which can lead to potential gigantic losses.

In addition, policyholders of terrorism risk are exposed to the danger of basis risk. This refers to the risk that the actual insurance loss may not correspond to the compensation payments resulting from the cover. For the transferring company, this basis risk represents a real danger if the actual loss exceeds the contractually agreed compensation payments (Nguyen, 2007, pp.312). Therefore, the basis risk is particularly problematic in the case of terrorism, as the potential loss is very difficult to estimate and can far exceed the principal value of the terrorism cat bond.

Another major risk is that the money invested in a terrorism cat bond, unlike investments in traditional high-yield bonds, can disappear immediately and without warning. This also leads to difficulties for those who market these new financial instruments. In the event of a large loss from the cat bond, the marketers of the new financial instruments could receive a lower annual bonus from their company and in the future doing business could become more difficult for them (Kunreuther and Michel-Kerjan, 2004b). This risk could lead to restraint on the part of marketers and investors.

3.3.4 Security aspects for contracting parties

There are several factors that can lead to more planning security through risk coverage with cat bonds. For example, the fact that cat bonds can have a maturity of several years facilitates the risk of price fluctuations. Since many reinsurance contracts can only be concluded for one year, parties seeking protection against terrorism are exposed to the potential cycle fluctuations of insurance premiums. This could lead to higher premiums, for example through a series of costly attacks. In addition, the multi-year maturity offers a planning advantage for the sponsors, as the fixed costs defined can be spread over several periods (Cummins, 2008).

Another planning reliability advantages of cat bonds is the hedging of the default risk. Default risk is defined as the risk that the contractual partner will no longer be able to meet its agreed obligations due to a lack of solvency and that insurance cover will therefore be cancelled. This potential default risk exists, for example, in traditional reinsurance for major catastrophes. The

decisive difference between cat bonds and other reinsurance mechanisms is that the capital is already made available when the contract is concluded (Nguyen, 2007,pp.314). This complete collateralization of the cat bonds is regarded as a clear risk reduction for sponsors. In addition, the risk can be spread across the broader financial markets and is therefore more diversified (OECD, 2011).

Additionally, an advantage of cat bonds is the low correlation between catastrophe events and investment returns. This diversification benefit may reduce the risks of investors' investment portfolios (Cummins, 2008) and in turn leads to greater planning reliability for investors.

3.4 Moral Hazard and Adverse Selection

Another factor to consider for the potential of a terrorism cat bond market is the problem of moral hazard. The existence of moral hazard may result in two parties changing their behavior because of a contract. Thus, moral hazard may be a factor limiting investors' understanding of the loss to be insured. This is due to the fact that an insured may increase his risk appetite and insurers may offer excessive cover against terrorism or pay claims without proper review after signing a reinsurance contract (U.S. GAO, 2003).

In addition, there can be a moral hazard problem linked to issuing terrorism cat bonds when terrorist groups are associated with financial institutions. An example of this is the broken off Pentagon terrorism futures market, experimented by DARPA.⁴ The problem is that a terrorist group supported by certain investors might have a financial interest in committing a terrorist attack against a certain public figure on whose life expectancy was set and to benefit from it (Kunreuther and Michel-Kerjan, 2004b). For a successful placement of a terrorism cat bond on the capital markets, there should therefore be no moral hazard that the issuer has an incentive to promote a terrorist attack (Woo, 2004). The question also arises as to whether the placement of terrorism cat bonds could directly motivate a terrorist group to carry out an attack if it fights against the Western financial markets.

Furthermore, it may be important for financial investors to know whether the cities or companies covered by the cat bond are taking counter-terrorism measures. Insurance cover, if properly designed, can play an important role in encouraging companies and institutions to invest in mitigation measures to limit the impact of an attack. A single insurer, however, may not be able to create this type of economic incentive on its own because of interdependencies (Michel-Kerjan and Pedell, 2005). If the incentive to take measures to prevent terrorism cannot be provided, this could lead to inadequate counter terrorism, which poses a moral hazard problem and increases the risk of investors to face a loss from a terrorism cat bond (Kunreuther and Michel-Kerjan, 2004a).

⁴ The Pentagon programme, often referred to as the "terrorism futures market", was intended to use the markets to assess geopolitical risks. The aim was to use the power of the financial markets as an information carrier for forecasting risks. However, this market was immediately closed down by the government as a problem was that terrorists who were determined to profit from their actions could easily buy derivatives. Moreover, the fear was that terrorist organizations could trade on the market to create disinformation (Wolfers and Zitzewitz, 2003).

Another problem known in the insurance industry is adverse selection. The term adverse selection is used in the insurance literature to describe the fact that the potential policyholder and the insurance company have different levels of information and that the policyholder takes advantage of this asymmetry of information. Accordingly, the problem for cat bonds is that the insurance company often has a better level of information than the potential investors on the capital markets. This can be exploited to the extent that the issuing insurance company takes advantage of its better level of information and only brings those parts of its portfolio into the cat bond which have an excess risk (Nguyen, 2007,pp.256-257).

4 Discussion

Following drastic terrorist catastrophe events and the resulting losses, the supply of insurance and reinsurance of terrorism risk became scarce. A public-private solution was therefore developed in many countries to provide protection against the disastrous attacks. There was also a search for alternative solutions to provide terrorism risk cover. One possibility is offered by cat bonds which transfer the risk to the capital market. Motivated by the first stand-alone cat bond for terrorism coverage from Baltic PCC Limited, this paper analyzed the potential of a terrorism cat bond market based on various factors.

As the first factor that could influence the emergence of a terrorism cat bond market, its availability was examined. The focus was on analyzing the demand for terrorism insurance, the offer of terrorism insurance and the potential demand from investors. With regard to the demand for terrorism insurance, it is shown that demand exists and seems to continue to exist in the future, but that its full potential is far from exhausted. Especially in the case of SME, the demand for terrorism insurance is insufficient. In an analysis of the offer of terrorism insurance, it was found that the government often provides assistance due to the reluctance of reinsurers and insufficient capacity of insurers. Transferring the terrorism risk to the capital market could, however, increase the capacity of insurance companies. In addition, Pool Re's statement that the capital market was only a logical step for them has the potential to lead other insurers to follow suit. Therefore, an offer of further terrorism cat bonds cannot be ruled out in the future. An analysis of investor demand revealed that many investors are still not comfortable with the unpredictable risk of terrorism. Nevertheless, the terrorism cat bond of Baltic PCC Limited was successfully placed on the capital market and investor interest was present. This could be an indication of investor demand for this risk. And according to Ian Coulman, if no negative event occurs and the investors of the issued terrorism cat bond do not incur significant losses, there is expected to be a demand for further bonds of this kind.

Another factor influencing the emergence of terrorism cat bonds is the associated costs. The premiums for terrorism insurance can appear far too high for the insured, as the risk of an attack is very small, but there is the potential for gigantic losses. In addition, many uncertainties associated with terrorism create difficulties for its correct pricing. However, as the terrorism insurance market continues to evolve and improve, it can be assumed that improvements will also be made in the area of pricing. This could have a positive impact on the pricing of cat bonds and may support the emergence of a terrorism cat bond market.

In addition, various factors were examined which influence the planning reliability of involved parties and thus have an influence on the emergence of a terrorism cat bonds market. Thereby, factors were analyzed that increase planning reliability and those that make it more complex and uncertain. The modelling of terrorism risk can be seen as one of the most important factors for the planning uncertainty of terrorism. All models contain many risks and uncertainties, such as predicting the probability, severity and location of a future terrorist attack. Moreover, there are no uniform risk models and the risk assessment can be carried out in various ways. Many risks and assumptions have been made in any model, making it difficult to have complete confidence in it. This could hinder the emergence of a terrorism cat bond market and it is of great importance to gain the confidence of investors in the terrorism models if a market is to

emerge. The loss potential resulting from an attack is another obstacle to planning reliability. Many different losses can result from a disaster, which at first glance may not be directly related to the terrorist attack. Complex calculations are used to illustrate possible loss scenarios. However, due to the uncertainty about the nature of future terrorist attacks, this is hardly estimable and often results in limitations of protection in insurance policies. It is therefore important for potential investors of cat bonds to be clear about the overall loss potential and to obtain information about the insurance limit. Furthermore, various different risks arising in connection with terrorism cat bonds were analyzed. Examples are the ratings of bonds, the determination of the trigger and possible consequences for investors investing in this new asset class. However, factors were also analyzed which have a positive influence on planning reliability. For example, the often multi-year term of the bonds, which can reduce some uncertainties about insurance costs in subsequent years. In addition, in the case of cat bonds the entire bond price is collateralized, which practically excludes default risks and thus offers security for the sponsors. In addition, the low correlation between investment returns and catastrophe events often provides planning reliability for investors. Thus, there are factors which increase the planning reliability of terrorism cat bonds, as well as factors which contain risks and thus make planning reliability problematic. A potential sponsor and the investors must therefore weigh these factors against each other for themselves. However, it is important that the parties are aware of them.

Finally, the problem of moral hazard and adverse selection and its influence on the emergence of a terrorism cat bond market was examined. The association of terrorist groups with financial institutions represents a major risk and a cautious placement of terrorism cat bonds is therefore of great importance. Moreover, moral hazard considerations are also significant in counter-terrorism measures and decisive for potential investors. In addition, the problem of adverse selection poses that often the two contracting parties have different levels of information. This may result in disadvantages for investors.

In summary, the analysis of the terrorism cat bond market potential shows that there are many factors in favor of placing further terrorism cat bonds. However, there exist many risks and uncertainties that need to be eliminated in order to gain the complete trust of investors, rating agencies and other stakeholders. Also from the interview with Ian Coulman a rather positive future for the terrorism cat bonds market was noticeable. The opinion of Ian Coulman, and thus representative of Pool Re, can be rated particularly highly, as Pool Re has dealt very closely with the topic of terrorist insurance and potential alternative solutions. Of particular note is his very clear answer that there is interest for this asset class among investors on the capital markets. This is a clear prerequisite for the possibility of the emergence of a terrorism cat bond market. And according to Ian Coulman, this interest can also be expected to exist in the future. It is conceivable that a smooth running of the terrorism cat bonds issued by Baltic PCC will arouse the interest of further investors. In addition, the further development of terrorism models may support the potential of a terrorism cat bond market.

5 Conclusion

The rise in catastrophic events in recent years and the resulting gigantic losses are creating difficulties for the insurance industry. As a result, insurance companies are faced with an increasing number of risk management issues. These catastrophes in the past led to serious capital problems for insurance companies. Thus, the search for protection against the potential risk of catastrophes, even for insurance companies themselves, is an emerging concern. A possible solution for insurance companies to protect themselves against the risk of loss due to catastrophes is reinsurance. Insurers can pass on their catastrophe risk to reinsurers and thus remove it from their balance sheets. However, since the capacity of reinsurance is not unlimited either, alternative solutions are increasingly emerging. Many alternatives are conceivable, one example being cat bonds. As insurance-linked securities, this asset class transfers the catastrophe risk on the capital market. This alternative risk transfer is already increasingly being used to hedge against natural catastrophes.

Natural catastrophes, however, are not the only risks that insurance companies have to contend with. Another catastrophe risk that has gained in importance due to the increasing number of events in recent years is the terrorism risk. Attacks such as 9/11 have shown what serious consequences terrorist attacks can have. Losses from several billions were recorded, which meant that the issue also gained importance in the insurance industry. A major difficulty for terrorism insurance cover is the presence of human actions in terrorist attacks. Because human actions influence the probability, severity and location of an attack, traditional risk models cannot be applied to terrorism. Thus, new models have been developed which, however, are not capable of eliminating all uncertainties. It is precisely these existing uncertainties that make terrorism insurance so complex and the question often arises as to whether the terrorism risk is still insurable at all.

The view is strongly held that the risk of terrorism can no longer be borne by private insurance companies alone. Public-private solutions are often advocated where the government offers a certain degree of protection. In addition, there is an increasing search for alternative solutions that can extend the limits of insurability. One such solution is the use of cat bonds, which draw on sources of capital from outside the insurance industry. The question of the potential of catastrophe bonds for use as protection against terrorism risks is particularly topical at present, as the first pure terrorism cat bond was issued at the beginning of 2019. Due to the successful settlement of this first terrorism cat bond, the potential for further similar bonds was analyzed in this thesis.

The analysis has shown that there is basically demand for and supply of terrorism insurance. Moreover, investor demand for terrorism cat bonds is also expected. However, the potential of terrorism cat bonds is limited by existing uncertainties. This is the case, for example, with regard to costs, since fair pricing would require the probability and severity of a catastrophe to be present. However, these components are not present in terrorism and therefore particularly the probability of future attacks cannot be estimated. Further risks in the area of terrorism insurance are the potential infinite losses that could result from an attack. Since terrorism cat bonds only cover the potential loss up to the bond price, immense insurance gaps can arise. This potentially infinite risk of loss in the area of terrorism often also entails the default risk of the

insurance counterparty, as it can no longer bear the high losses. Additional risks with terrorism insurance, as with most insurance contracts, are the danger of moral hazard or adverse selection. When issuing terrorism cat bonds, special care must be taken to ensure that no contracting party is connected to any terrorist party. Furthermore, attention must be paid to ensuring that counter-terrorism measures are not discontinued when the terrorism risk is transferred to the capital market. In addition, several factors of terrorism insurance through cat bonds were analyzed, which lead to more planning reliability. One example is the multi-year term of the bonds, which offers an advantage over the often one-year reinsurance, which is exposed to cyclical premium fluctuations. Moreover, the complete collateralization at the beginning of the bond offers the sponsor security that there is no default risk. Furthermore, the low correlation between the investment returns of the investors in general and the catastrophe event can be mentioned as a security benefit with regard to the portfolio returns of the investors.

In general, the analysis argues for the potential of a terrorism cat bond market. However, this is only possible if the asset class of cat bonds reduces its complexity so that investors can better understand its structure and assess their risk. In addition, rating agencies must also become more familiar with this new asset class so that they can make an accurate evaluation. Given the advantage of the uncorrelated nature of catastrophic events and investor returns, this asset class is of interest to many investors. As models are also being developed for a better assessment of future terrorist attacks, some risks in the area of terrorism insurance may be limited in the future. Thus, despite the persistent uncertainties in the area of terrorism, there are many arguments in favor of the potential of a terrorism cat bond market. Nevertheless, the use of terrorism cat bonds does not exclude a reinsurance solution or public-private insurance cover but is rather an additional alternative possibility to extend the insurance limit. As so, with the help of cat bonds in the area of terrorism insurance, it is intended to tackle the challenge of spreading the risks appropriately.

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Appendix

Interview with Ian Coulman, Chief Investment Officer of Pool Re

The interview was conducted on the 3rd of June 2019 via email.

What do you think is the demand for terrorism insurance in Europe? Is there a trend?

I would imagine there has been an increase in the demand for terrorism insurance in Europe given the various events experienced over the past 3-4 years, but I don't have any evidence to justify this. However, I can comment on the experience Pool Re has had over the past few years with regard to demand for terrorism cover in Great Britain. Pool Re only covers commercial property in the UK mainland from physical damage resulting from terrorism activity (excludes Northern Ireland) and much of the demand for cover is concentrated in major cities, such as London, Manchester and Birmingham. One sector that has not particularly sought terrorism cover for property has been those businesses categorised as small and medium enterprises (SMEs), which we believe has largely been as a result of the attitude, 'it will never happen to me'. However, the London bridge/Borough market attack of 2017 highlighted the lack of cover amongst small businesses, particularly in relation to non-damaged business interruption (NDBI). Unfortunately up until earlier this year Pool Re could not provide cover for NDBI, but that has now changed and we believe there is growing interest amongst SMEs to seek NDBI cover, but it is likely to take some time before we see a material increase in premium flow as insurance companies may simply offer the cover under existing insurance policies (it is worth noting that Pool Re is a reinsurer and that we do not have direct contact with the ultimate policy holder).

Could the use of terrorism cat bonds lead to a general increase in terrorism insurance?

I don't think there is necessarily a direct link with a terrorism cat bond leading to increase in terrorism insurance but I think it will support the growth and development of the terrorism insurance market, which may help encourage more insurance companies to price the cover accordingly and offer reasonable cover to their customers. Key to this is the ability to price the terrorism risk, which has for many years been amiss. As I am sure you will appreciate modelling any insurance related risk requires the severity of an event and the frequency of such events. Deterministic modelling can provide details on severity of events – if an explosive device is placed at a certain point or postcode models can determine the damage to surrounding buildings and the potential loss. In fact modelling the severity of events has developed significantly over the years and we believe Pool Re, in conjunction with the likes of Cranfield University, have developed a leading severity model using Computational Fluid Dynamics, which consider the pressure of the explosion and how it travels down streets and between buildings. The problem most terrorism models face is the frequency, or probability of an event occurring. The fact that human nature is involved in terrorism events makes it extremely difficult to determine the frequency of an event. However, I believe that developing these models and thinking more about the probability of events, in spite of their shortcomings, could allow more insurance companies to price the risk and offer limited cover to their customers.

In your opinion, is there potential demand from investors for terrorism cat bonds on the capital market?

Simply put yes. We began considering a cat bond, or ILS, approximately 3.5 years ago, following our first placement of commercial retrocession. The thinking was that terrorism offered a different peril to the more traditional hurricanes and storms that ILS/cat bonds cover and that as we had successfully placed £1.8bn of retrocession in 2015 the ILS market would also be interested. At first however, there was a reluctance to provide an indication of pricing or attachment levels, which all ties back to the development of modelling. Over the past 3 years or so we, in conjunction with a number of brokers, in particular Guy Carpenter Securities, kept in touch with potential investors and attended a variety of ILS conferences and seminars. As the modelling capabilities developed and we explained to potential investors the work that we were undertaking at Pool Re to better understand the risk, investors grew more comfortable with the terrorism risk. There remain some investors who are uncomfortable with either or both, the subjective nature of the probability and/or the lack of a third-party validation of our modelling, but we believe that with a core group of capital markets investors having bought the first stand-alone terrorism cat bond in the form of Baltic PCC others will be encouraged to monitor its development and when we come to issue again at some point in the future there will be stronger demand from the capital markets. This does however assume that there are no events that could cause a loss to Baltic PCC. Furthermore, a terrorism cat bond offers a totally uncorrelated peril to the more traditional natural perils that ILS or cat bond investor buy.

Could the transfer of terrorism risk to the capital market lead to better conditions for policyholders?

This partly links back to the second question, but if insurers can offer better risk reflective pricing, thanks to better information and modelling, and even take on some of the risk themselves it could improve the pricing of the risk for policyholders. It is probably fair to say that the market continues to evolve and in the same way our purchase of commercial retrocession has helped to modernise the market for terrorism insurance transferring risk to the capital markets will help to drive further change.

How do you assess the default risk in the event of a major terrorist attack when insuring with cat bonds?

The default risk has to do with the attachment point of the bond and therefore the expected loss. In Pool Re's case members retention is the first level of loss, following by £500 million of Pool Re's own investment portfolio. The £75 million ILS then shares a level of risk with the commercial retrocession programme. We then use the severity model and our own assumptions around probability, and while these are subjective they are quite conservative. From this we can determine an Expected Loss, which helps to inform investors the probability of the ILS experiencing partial or full loss. Baltic PCC also has a parametric trigger, which is such that if there is a certifiable event and it is of such magnitude that exceeds members retention and the first £500 million of Pool Re assets the ILS and commercial retrocession programme will suffer a loss.

Where do you see the greatest difficulties in the planning reliability of terrorism cat bonds?

The greatest challenge is in modelling the frequency of events. Predicting when and where a terrorist event will occur is very subjective given we are dealing with human interaction.

Do you think that a cat bond solution or a purely private solution of terrorism insurance (and thus the risk is less on the state balance sheet) could have an impact on the state's counter-terrorism measures?

I think it is important that the insurance industry work in tandem with government. Terrorism risk is such that in some cases the private sector either can't or won't cover it, hence the reason Pool Re was established in the first place. Furthermore, the private sector could be faced with an event that exceeds its capacity, thereby putting its solvency at risk. It is imperative that the state work in conjunction with the private sector to mitigate the risk of terrorism and counter-terrorism measures are one aspect of that. The private sector can help build greater resilience and protection through investing in risk mitigating initiatives and providing the necessary insurance cover, but the state must build effective counter-terrorism measures to help establish confidence amongst the risk-takers that while the risk remains the state is doing as much as possible to prevent it.