Terrorism Risk Insurance: Is it really working?

The Honors Program

Senior Capstone Project

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Abstract

This paper investigates terrorism risk insurance in the United States as well as those programs offered in other countries throughout the world. In the United States, particular attention is devoted to the interaction of government with private insurers to maintain an effective insurance program. An analysis is performed comparing terrorism insurance before and after the attacks on the World Trade Center on September 11, 2001. The paper looks into actual terrorist events that have occurred focusing on 56 world-wide events that are associated with property losses greater than $10 million. This paper not only investigates the losses that were incurred but also the way the event was insured, and how the Terrorism Risk Insurance Act (TRIA) program could help the insurer in the event of catastrophic loss.

Based on the 56 major events, a simulation is run in order to examine the losses and timing of potential future catastrophic events. Both property losses and the timing between events are simulated based on various distributions. For a variety of simulated events, the paper investigates how TRIA would pay out losses for the event as well as the effects that the event would have on the insurance industry. Rather than looking at the industry as a whole, particular attention will also be given to some of the top insurers for terrorism coverage. Using the findings from the data, the paper finally proposes changes to TRIA in order to create a better system of reinsurance for events with large losses.

Introduction

With an increase in the number of terrorist attacks occurring around the world in the past few years, including the shootings in San Bernardino, California, the attack on the Ariana Grande concert in Manchester, London, as well as the shootings at the Fort Lauderdale Airport in Florida, the effectiveness of the current method of insurance within the United States for terrorist related attacks has come into question. Insurance losses related to terrorist events are difficult to predict and can lead to the largest losses associated with one event. Due to the unpredictability and potential detriment to the company, many insurance companies have debated whether or not to include terrorism under basic coverage. The current method of insurance known as the Terrorism Risk Insurance Act or TRIA involves the interaction of the government with private insurance companies in the event of losses that are greater than $100 million. Since its inception in 2002, following the September 11th attacks on the World Trade Center, the act has still not been put to use. The ineffectiveness of the program over the past sixteen years creates major questions of what changes should be made to the program during its renewal in 2020 to make it more effective for the changing nature of terrorist attacks.

By first researching in depth the terms of the program created by the Terrorism Risk Insurance Act as well as similar programs that are available in other countries throughout the world, it is clear that differences exist between these programs. Within each of these programs, the losses associated with an individual attack are shared between the private insurer and a reinsurer, and are all backed by the countries government. The ineffectiveness of the TRIA program, however, can possibly be attributed to the large minimum of losses that must be met for the program to be initiated.

Using historical data represented by 56 world-wide catastrophic terrorist attacks with property losses totaling more than $10 million, the paper will investigate the probability of the occurrence of an event of that magnitude in a given year as well as the average losses that will be seen. Two different models will be created in order to predict future events based on the past data. Different distributions will be fit for each model based on the parameters obtained from the 56 events. Using this information, it will be shown how the current terms of the TRIA program will protect or fail to protect both individual private insurers as well as the private insurance industry as a whole. With the conclusions draw from the data analysis, the paper will propose changes to the TRIA program that will benefit insurance companies and improve the overall effectiveness of the program.

Literature Review

Introduction

Terrorist attacks have always created a large unknown for insurance companies due to both their unpredictability as well as their potential to create extreme amounts of loss. As a result, terrorism coverage as a part of insurance policies has been subject to much debate, not only in the United States but across the world as well. Before realizing the risk that these events carry, many insurance and reinsurance companies offered terrorism coverage to commercial entities as an extension of their normal property and casualty policy for little to no additional charge. Across the years, many countries throughout the world began to create government backed insurance programs that offered assistance in covering the losses related to terrorist attacks following the event of a catastrophic loss. It wasn't until the attacks on the World Trade

Center on September 11th, 2001 that the United States realized the potential benefits of similar program.

Approximately one year after the attacks of 9/11, the United States congress passed the Terrorism Risk Insurance Act (TRIA) in order to create a loss sharing opportunity for insurance companies in the result of catastrophic losses from terrorist attacks. This program however has so many guidelines that must be met before it is put into place, that it has yet to be used since its creation in November 2002. Due to the limited potential in its use, many studies have been conducted in order to assess how TRIA could be more effective. These studies include looking into how much damage must be sustained for insurance companies to have a major financial impact as well as how the distribution of losses can be altered so no one person is taking on a majority of the impact.

The Nature of Terrorism

All across the country, the nature and shape of terrorist attacks is changing and as a result, the way in which these attacks are insured needs to be adapting to these changes. Since the attacks on the World Trade Center on September 11, 2001 there has yet to be another attack that aimed to cause catastrophic amounts of physical damage. Instead the more recent attacks such as the shootings in San Bernardino, California or Orlando, Florida involve active assailants and are not large scale attacks. However, these events do demonstrate that the origin of the groups that initiate these attacks have reached U.S. soil (Johansmeyer and Gregory 2017). With less physical damage, these events do not qualify for reinsurance assistance under the Terrorism Risk Insurance Act, leaving all of the losses to be consumed by the private insurer.

Looking from a global perspective, similar trends can be seen, the economic costs that result from terrorist attacks are at the highest level they have reached since 2001. Even with the growing economic costs, there has been a shift from few major property attacks in a year to numerous smaller minor bombings and explosions. Each of these attacks are considered to be minor in terms of their property damage, meaning the total losses are less than $1 million (Global Terrorism Index 2015). Due to the small scale of these losses, they do not qualify for government assistance through the Terrorism Risk Insurance Act although looking at the year as a whole, the private insurance companies are facing as big of losses compared to 2001 when there was one loss over $25 billion which would have qualified for government reinsurance.

In addition to shifting to smaller scale attacks with less physical damage, terrorist attacks are also becoming more difficult to predict. The RAND corporation, a non-profit research organization that addresses challenges facing public and private sectors around the world, completed a study involving how to estimate the risk associated with these attacks. This study defines risk as "the expected consequence of an existent threat, which for a given target, attack mode, and damage type can be expressed as:

$$Risk = P(attack\ occurs) * P(attack\ results\ in\ damage \mid attack\ occurs) * E(damage \mid attack\ occurs\ and\ results\ in\ damage) = Threat * Vulnerability * Consequence.$$"

The RAND corporation focuses in on two approaches that can be used to estimate this risk. The first approach creates a link between population-based indicators and terrorism risk. This approach states that both population and density-weighted population have an effect on the exposure of a particular area to terrorism. The second approach further takes into account the

threat, vulnerability, and consequence in the above formula unlike the first approach. Known as the RMS Terrorism Risk Model, this approach relies on "models of specific threat scenarios, calculations of economic and human life consequences of each scenario, and assessments of the relative probability of different types of attacks on different targets." The model calculates expected annual losses based on the events that are predicted to occur (Willis, et al. 2005). The ability to predict the risks from terrorist attacks could be helpful in creating a program to protect insurance companies from the losses associated with the attacks.

Insurance Prior to 9/11

Until the attacks on the World Trade Center on September 11th, 2001, standalone terrorism coverage did not exist. Insurance companies did not see the risk associated with terrorist attacks and as a result, most insurance companies included terrorism coverage under basic commercial property coverage. Chris Folkman, the RMS senior director of product management, stated that prior to 9/11, terrorism insurance was a silent coverage and "it didn't keep underwriters up at night" (Boyer 2017). Private insurance companies did not fret over the risk of terrorism insurance as prior to the World Trade Center attacks, terrorist attacks were regarded as less risky in comparison to other catastrophic events.

Prior to the attack on September 11th, most insurance companies were prepared to handle catastrophic losses similar to 9/11. Catastrophe related to terrorist attacks can be seen as similar to other forms of catastrophe such as natural disaster. These events are difficult to predict and can result in large amounts of property loss. Before 9/11 the biggest individual loss did not come from a terrorist attack, it instead came from a natural disaster, Hurricane Andrew. The insurance losses related to Hurricane Andrew totaled approximately $16 billion and did not cause the

private insurers to flounder (Jerry 2002). Due to their ability to handle this event, insurance companies did not see the risk of carrying property coverage related to such catastrophic events, including both terrorist attacks and natural disasters.

Attacks on 9/11

The terrorist attacks on the World Trade Center on September 11th, 2001 remains to be one of the highest costing single events to be seen by insurance companies. The damage to the World Trade Center buildings was the greatest contributor to the overall loss, creating approximately $8 billion worth of loss. Damage to the Pentagon and other buildings that were also hit in the attack contributed nearly $6 million to the total losses. Further loss was created through the destruction of the four civilian aircrafts that were hijacked in the terrorist attack, totaling about $385 million. Damage to computers, furniture, cars, phones, electricity, etc., added up to a total loss amount of $12 million. The last loss amount was seen in clean-up costs of about $1.3 billion. In total, the loss related to the terrorist attacks on 9/11 totaled $27.6 billion (Blakely 2011). The chart seen in appendix A shows the distribution of the different losses shared among the total.

The September 11th attacks were the largest insured single event in the history of the insurance industry. Compared to the previous most expensive event, Hurricane Andrew, the attacks generated an additional $8 billion in losses (Towers Watson 2001). Although these losses were split between multiple private insurers and reinsurers, the event still caused many companies to be overwhelmed.

According to a study done by Towers Watson, the extreme magnitude of the losses of the attacks on September 11th caused a large disruptance in the insurance industry, in the property and casualty sector. Following the catastrophe, many private insurance companies questioned the

amount of reinsurance coverage they needed and sought greater protection. Private insurers feared that reinsurance companies would begin to exclude terrorism coverage from their plans, and as a result considered dropping this coverage too. Reinsurers found themselves unable to do business following 9/11 as they struggled to recoup from being hit with such large loss amounts. As a result, in the days following the attacks, a majority of reinsurance companies began renewing their policies with a new stipulation that terrorism coverage would be excluded from all policies. With reinsurance companies now excluding terrorism coverage, private insurance companies also excluded terrorism coverage where possible. Approximately one year after the attacks on the World Trade Center, the United States remained uncovered for a future terrorist attack (Grossi 2009). There would soon be a response from the government, known as the Terrorism Risk Insurance Attack.

A publication from the University of Pennsylvania titled *Insuring September 11th: Market Recovery and Transparency* examines the insurance market post 9/11 in regards to the market recovery following the shocks of the 9/11 attacks using economic models. This study looked at the price of insurance stocks as an indicator of how the industry recovered from the losses it was exposed to. Using economic models, it was found that "firms suffering the lowest losses, with less leverage, and with the highest growth potential would be best able to exploit the post-loss hard market and this would be reflected in stock price performance." Overall, even though the insurance industry suffered the largest losses it had seen in a single-event, the ability for the companies to retain their shareholders allowed for a strong recovery of the industry.

Terrorism Risk Insurance Act (TRIA)

The Terrorism Risk Insurance Act was passed by Congress in November of 2002 in response to the cancelation of terrorism coverage by private insurers and reinsurers following the catastrophe that was the September 11th attacks on the World Trade Center. This act requires that all insurers once again offer terrorism coverage to their commercial customers and in return, the Federal Government would provide a financial backstop similar to reinsurance (Terrorism Risk Insurance Act 2016). The goal of the program as stated by the NAIC (National Association of Insurance Commissioners), is "to develop a long-term plan to make terrorism insurance available and affordable." With the passage of the Terrorism Risk Insurance act take up rates for commercial terrorism coverage have risen from under 30 percent to more than 60% as coverage became more available (Legenza 2015). Since 2002, the program has been renewed three times with the most recent renewal in 2015 extending the program through 2020.

As of 2015, the most significant changes to come to the terrorism insurance program all reflected a change in the distribution of the losses that are shared amongst the private insurance company and the United States government. The overall goal of these changes was to reduce the role of the Federal Government. In addition, included in this renewal was a slight change to the trigger for the program. Prior to any payouts made under the program, the event must be determined to be an act of terrorism by the Secretary of Treasury in compliance with the Secretary of Homeland Security instead of the Secretary of State (Terrorism Risk Insurance Act (TRIA) n.d.).

Prior to receiving any Federal Aid under the Terrorism Risk Insurance Act, there are many criteria that must be met. The losses from the single event must meet a minimum damage level of

$5 million. In the event that the damage meets this amount, the event must be officially certified as a terrorist attack. This decision is made by the U.S Secretary of Treasury, the Attorney General, and the U.S. Secretary of Homeland Security. Once certified as an act of terrorism, the event must also meet the program trigger. Aggregate losses for the calendar year must total higher than $140 million (set to increase to $200 million by 2020). After all of these criteria are met the program is put into place (Legenza 2015). Once the program is put into place, the first payment is a deductible that is paid to the program by the individual insurers. This deductible is equal to 20 percent of the insurers direct earned premiums, or how much money they have brought in from their clients. The amount of deductible paid can vary significantly as it depends upon both the size of the insurance companies affected and the number of insurance companies affected. The remaining loss amount is shared between the copayment of the private insurer and the government backing. Under the 2015 TRIA renewal, the insurer copayment was set to 15%, which would then increase by one percent each year reaching 20% in 2020. The remaining percent would be paid for by the United States government. In the event that the government pays out for losses covered under the Terrorism Risk Insurance Act, the following year they will try to recoup part of that payment through surcharges to insurance companies. This surcharge is set to 140 percent of the difference between the amount paid and its required retention. The last term of the TRIA program, is that any losses over $100 billion dollars are not required to be paid for by either the private insurer or the US government (Hartwig and Wilkinson, Terrorism Risk Insurance Program 2015). The layout of TRIA can be seen through the diagrams included in appendix B.

Standalone Terrorism Insurance

In addition to TRIA, or opposed to TRIA, there is a stand-alone market for terrorism insurance that is also available for purchase by businesses. The stand-alone market came into existence in 2013 when there were fears in regards to whether or not the Terrorism Risk Insurance Act would be renewed. This market offers coverage to both TRIA participants as well as to those companies who chose not to pay for TRIA. Stand-alone coverage ranges from approximately $750 million to $2 billion and only includes property and casualty losses (Hartwig and Wilkinson, Terrorism Risk: A Constant Threat 2014).

Effectiveness of TRIA

The Terrorism Risk Insurance Act program is currently extremely limited. Very few lines of insurance are eligible for TRIA coverage, and within those lines even fewer events come close to meeting the TRIA guidelines. TRIA was specifically created for commercial entities and only cover property and casualty insurance losses. The program excludes private insurance lines, as well as life insurance and workers' compensation. While TRIA does very little to spread the losses incurred through terrorist attacks, it has been effective in increasing the take-up rate for terrorism coverage of commercial entities. Since the implementation of TRIA, the take up rate has rose from approximately 20% to near 60% (Carroll, et al. 2005). In addition to increasing the take-up rate, TRIA was also successful in both lowering and stabilizing the price of terrorism coverage to commercial entities. Through lowering the price, premiums were significantly lower which may have been a contributing factor to the increase of the take-up rate. The growing take-up rates can be seen in the graph in appendix C, which shows how the rate has changed in the three years following TRIA's implementation.

A study by the RAND corporation titled *The Federal Role in Terrorism Insurance: Evaluating Alternatives in an Uncertain World* looks into the interaction between the percent of uninsured losses and the cost to taxpayers both under TRIA and without any government program. Based on the two graphic shown in appendix D, it can be seen that the TRIA program has a large impact on the distribution of loss. The proportion of the graph that represents events with little uninsured loss as well as low costs to taxpayers increases by approximately 20% with the introduction of TRIA however the percent of scenarios that could cause taxpayers large sums of money increased by about 15%. So while TRIA helps to cover larger losses it also has the potential to cost taxpayers more money.

Another study by the RAND corporation titled *Distribution of Losses from Large Terrorist Attacks under TRIA* looks into how the losses under TRIA would be shared under three different terrorist attack scenarios, an aircraft impact, an indoor anthrax, as well as an outdoor anthrax. By looking at the graphic shown in appendix E, it can be seen that in all three scenarios, a majority of the loss incurred is uninsured. This is the amount that is not covered by other lines such as health and life insurance or worker's compensation. Essentially, the uninsured losses represent the amount that would be covered under TRIA, if the event were eligible. This amount is significantly greater for the outdoor anthrax event in comparison to the indoor anthrax event and the aircraft impact.

Many studies since the implementation of TRIA have proposed changes that could be made to the program in order to improve the loss sharing capabilities. A study by the RAND corporation suggests there are three ways that TRIA can be improved: through reducing uninsured losses, reducing the burden on commercial policyholders, and reducing the burden on

taxpayers. Through making terrorism insurance mandatory and increasing its coverage availability, uninsured losses would be transferred to the insurance company as well as to individual taxpayers. In a different suggestion, by raising the individual insurer deductible, more of the loss amount would fall on commercial entities and taxpayers allowing for less of an impact to the insurance company. The last suggestion involves decreasing the TRIA ceiling so that more losses can be covered under the program.

Programs in Other Countries

According to the United States Government Accountability Office, all terrorism insurance programs are essentially composed of the same parts yet differ in their cost-sharing distributions. Each of these programs begins with a deductible, which is the amount of losses paid by the policyholder prior to any payment from either the insurer or the reinsurer. Following the deductible, a coshare is set, which is the percentage of loss the policyholder is responsible for after the deductible is met. Each program includes a government backstop, or financial support from the government. This is where many programs differ as to when the government backstop is activated and what percent of the loss will be covered by the government. Some programs may also include different types of funding such as combination funding, pre-event funding, or post-event funding. Each of these funding methods helps to differ some of the loss that is incurred in a specific event.

The structures of terrorism insurance programs throughout the world vary, yet can be placed into three general categories. The first category involves programs with a multilayered structure comprised of insurers, reinsurers, and government intervention. Programs that fall into this first category can be seen in countries such as Australia and the United Kingdom. The second

category is comprised of programs in which the government provides all of the coverage for events in which the private insurer cannot handle the losses. Programs such as these can be seen in both Spain and Israel. The third category includes programs where insurers and reinsurers are forced to handle all of the loss from the event, there is no point in which the government of that country will step in to help cover the losses. Programs that fit into this third category can be seen in Austria and India. The program in the United States does not fall into any of these categories as it only includes coverage by the insurer and the government and as a result, this program often causes insurance companies to pay out the largest percentage of the overall losses (GAO 2016). The question, however, is which of these categories is most beneficial to the private insurers in mitigating risk.

In England, the Terrorism Insurance Program is known as Pool Re. This program was established as a response to the bombing of the Baltic Exchange in 1993. Since its creation, Pool Re has helped private insurance companies by providing near £600 million worth of claims. Pool Re is a reinsurance pool that individual insurers pay a premium to in order to qualify for the coverage. In the event of catastrophic loss, Pool Re will reimburse the cost of claims that individual insurers pay out. If the losses are too catastrophic and the reserves of Pool Re are exhausted, the UK government will cover the remaining losses (Pool Re 2017).

In Spain, the Terrorism Insurance Program is known as CCS (Consorcio de Compensacion de Seguros) which translates to the insurance compensation association. CCS was established in 1941 in order to deal with the large losses that had arisen from the Spanish Civil War. In the event of catastrophic losses that cannot be covered by the private insurer, all of the losses will be covered by CCS with unlimited state guarantee. In order for CCS to be utilized, there is no

minimum damage amount required. However, to receive coverage from CCS, policyholders must pay a surcharge to the program. These surcharges are used to finance the coverage system which is then backed by the Spanish government (OECF International Platform on Terrorism Risk Insurance n.d.).

Insurance Company Impact

With the passage of the Terrorism Risk Insurance Act in November 2002, many insurance companies that had previously dropped their terrorism coverage were forced to offer that policy once again. As they began to offer terrorism coverage again, many insurance companies began to pay close attention to their deductible to surplus (D/S) ratio under this policy. Among the top 30 insurers, which represent almost 70% of the TRIA market, the rating agency AM Best was able to determine that only seven insurance companies had a D/S ratio greater than 0.15. A deductible to surplus ratio of 0.15 or greater represents a company that will not see significant risk of bankruptcy or financial distress in the event of a catastrophic terrorist attack. Looking at a greater proportion of the insurance industry, it was found that 95 out of 450 (or approximately 20%) insurance companies had D/S ratios above that mark (H. Kunreuther, et al. 2014). Based on these numbers, even with the implementation of TRIA, many insurance companies would see a significant impact from terrorist attacks that generate large losses.

Methodology

The first research method used in this paper is historical research. Using this methodology, the paper will look into how terrorism insurance has changed within the United States throughout the years. It will focus on the creation of the Terrorism Risk Insurance Act in

2002 following the attacks on the World Trade Center in September of 2001 as well as how the Act has changed each time it was renewed.

The second method used is data manipulation, starting with a data set composed of nearly 150,000 records of terrorist attacks across the world dating from the 1970's until 2015. Focusing on the major events only, missing data for property losses was added to the dataset when available. The final data set used was composed of only events that had property losses totaling over $10 million, these events were labeled as 'catastrophic events'. This decision was made as events with small losses will not have an effect on the private insurer and the need for a reinsurance program for these events is negligible. After eliminating all irrelevant data from the dataset, the new dataset used in the paper is composed of 56 world-wide events, with 7 of those events occurring within the United States.

The final method used in the paper is analytical modeling. A modeling technique will allow the dataset to be used to its fullest potential by creating a way to determine an approximate loss amount for each event that may occur in the future. Using the dataset, that was comprised in the step above, a model will be fit to both the severity (amount of loss) and the occurrence (the timing between events). Looking at the graphs of the data, a distribution will be determined to fit the data correctly. In the event that no distribution fits the data, the log of the values will be taken in order to improve the accuracy of the chosen model. Using the two distributions, a simulation will be run which predicts when events will occur (after how many days) and approximate a loss value for that event. The simulation will be run to predict events over a large number of years in order to account for variations in the data. Following the simulation, the results will be analyzed

in order to assess how various events will affect insurance companies and to propose changes to the current TRIA program that will help to minimize these effects.

Data Analysis

The data used in this study comes from the Global Terrorism Database which states, "the National Consortium for the Study of Terrorism and Responses to Terrorism (START) makes the GTD available via an online interface in an effort to increase understanding of terrorist violence so that it can be more readily studied and defeated" (Global Terrorism Database 2017). Initially the dataset contained 170,000 terrorist attacks from 1970 until 2015. However, upon a close examination of the data it was found that many of these events had missing property values. Since this number was imperative to the study, I initially attempted to fill in this missing data using both predictive modeling and text mining in SAS Enterprise Miner. However, it was quickly discovered that there was little predictability amongst the other variables in determining property loss amounts. As a result, the cases with no property value were removed from the dataset.

After removing the cases with missing values, I also found that a majority of the cases had property loss amounts that were misleading as a result of the minimal amount of property damage caused in the attack. Since these events would not need the assistance of a reinsurance program and could be instead handled completely by the private insurance company, I made the decision to focus on only events with major losses. I set a lower limit for the amount of property loss at $10 million dollars, as I felt that these events were the ones that held potential to cause financial distress to the insurance industry.

There were two more decisions that I had in regards to finalizing the dataset that would be used. The first was in regards to including events that occurred pre-9/11 or not. Even though these events would not have been eligible for loss sharing under the TRIA program, they would be beneficial to determining how far apart events typically happen and often events occur within different loss brackets. Since all of the property loss amounts were cost adjusted to 2015, I chose to include all events in my study, including those that occurred before 2001. The final decision was whether or not to include world-wide events, or to focus solely on events that happened in the United States. Since, TRIA is a program specific to the United States it would be irrelevant to the study to determine how often events occur in other countries. However, these events would be helpful in predicting the loss amounts of future events. My final decision was to include worldwide events in the dataset and adjust my model when determining the frequency of events.

Lastly, before finalizing my dataset and beginning the modeling process I compared my data to a list of the top 20 costliest terrorist attacks in the world in order to ensure that the data was complete. Any events or information on the list that was missing or incorrect was adjusted for. The final dataset, after cleaning, consisted of 56 world-wide events, all with property losses greater than or equal to $10 million, 7 of which occurred within the United States. A snapshot of this data can be seen in appendix F.

Simulation

Models

In order to create a simulation of possible future terrorist, there were two variables that needed to be considered, frequency (how often the events occur) and severity (how much

damage is sustained). To properly fit a model to each of these variables, various parameters as well as a graph of the distribution of the data would be used.

The first step in creating a model for the frequency of the events was to create a new column in the dataset that represented the number of days between each event. Using this new column it was found that the mean was 291 days and the standard deviation was 365 days. The graph of this data was highly skewed to the right and did not fit any distribution well. In order to better fit the data to a distribution, I took the log of each of the values that represented the time between events. After taking the log of all the data, the new mean was 2.107 and the new standard deviation was 0.647. The distribution of these new values, which can be seen in appendix G, was normally distributed with a slight skew. As a result, a log-normal distribution would be used to model the frequency of events. The parameters for this distribution would be taken from the mean and standard deviation of the data set. However, the distribution will be adjusted by a factor of 1/8 since only 7 of the 56 total events in the dataset occurred within the United States.

In creating the model for the severity, the mean and standard deviation of the data were found to be $652 million and $3,610 million respectively. It is important to note that while the mean for this data is low, the standard deviation is incredibly large due to the unpredictability of the events. The distribution of this data was highly skewed with a majority of the data concentrated on the left tail end. As a result, the log of each of the property values were taken in an attempt to normalize the data and fit a distribution. The new mean of this data was 7.71 while the new standard deviation was 0.723. Unlike the frequency data, after taking the logs the severity data was still skewed, although noticeably less, which can be seen in appendix H. However, since the data has a lower bound set at $10 million (7 adjusted after taking the logs),

the data can be fit well with a pareto distribution. In order to use the pareto distribution as a model, the parameters x_m and α are needed. The parameter x_m is set to 7 as this represents the minimum amount. The parameter α can be found by matching the sample standard deviation from the data to the pareto standard deviation formula, $s = \frac{\alpha x_m}{(\alpha-1)(\alpha-2)}$. Using this method, alpha is found to be 11.7112. Comparing the mean and standard deviation from the data, 7.706 and 0.723, to the mean and standard deviation of the pareto model created, 7.654 and .720, it can be seen that the model is a good fit for the data.

Results

By modeling the frequency between events through a log-normal distribution and the severity of events through a log-pareto distribution, a simulation was created to determine when the next event could possibly occur and how much loss it would produce. A snapshot of the output can be seen in appendix I. After running the simulation multiple times, one thing that became clear is that there is very little predictability in when an attack can occur and how much loss it will cause. In one instance I saw that the next event would not occur for over ten years, yet in a different running I saw three events occurring within a five-year span. Typically, the losses from these events were between 10 million and 100 million, but occasionally there would be an event with losses in the billions and in rare instances there were events with losses in the trillions.

Looking at a ten-year span over 1,000 simulations, I was able to get a better understanding of how much loss would come to property insurance on average over the span of time. From this simulation, I found that approximately 200 of the 1,000 simulations, or 20%, had losses that were less than $100 million, meaning that they would not qualify for insurance

sharing under the Terrorism Risk Insurance Act. On the contrary, less than 50 of the 1000 simulations resulted in losses that were above the TRIA limit of $100 billion of losses.

To further confirm these findings, I ran the simulation 10,000 times in order to compensate for the extreme unpredictability that is seen in these events. From this simulation, I found that approximately 25% of all years have an event occur within them that results in losses over $10 million and only 3% of the years have multiple catastrophic events. Of these events, 18.85% of the events had losses between $10 and $100 million, 4.36% of the events had losses between $100 million and $1 billion, 0.98% had losses between $1 and $10 billion, 0.25% had losses between $10 and $100 billion, and only 0.16% of all of the events had losses that were in excess of $100 billion dollars. Based on these numbers, it can be seen that there is only a 5.59% chance of an event occurring having property losses that would allow the event to qualify for loss sharing under The Terrorism Risk Insurance Attack.

Insurance Impact

After discovering how likely certain events are to occur, I looked into how those events would impact the insurance industry. I also chose to look into three different events with different loss amounts. Those events were if losses were $27.6 billion (the same amount of loss that was caused by the attacks on the World Trade Center), $100 billion (an extremely rare occurrence), and $1 billion (a more likely occurrence). I chose to look into both how the events would impact individual insurers such as Liberty Mutual, State Farm, and Allianz as well as how the industry as a whole would be impacted. These insurance companies were chosen as they all have different surplus to premium ratios which would have an impact on how the amounts that they are paying out would affect their company. Liberty Mutual for example, has an average

surplus amount but a high direct earned premium. As a result, in the event the Liberty Mutual was sharing losses under TRIA they would be forced to pay a larger deductible compared to other insurance companies. State Farm has an extremely high surplus and a low direct earned premium. The high surplus would protect the company in the result of large losses that they would have to take on as their share under TRIA. Allianz has a low direct earned premium yet they also have a low surplus that is nearly equal to the premium. This suggests that the company would not be able to handle a lot of loss that could come from a catastrophic event. Lastly, for each insurance company I considered the impact when they were responsible for 1%, 10%, or 25% of the total loss, as one particular event would typically be shared by multiple insurers.

To examine the effects of the events on the insurance companies, I considered the percent of the surplus that the company would be paying out under the Terrorism Risk Insurance Act. If this amount is larger than 20%, it is considered to be dangerous to the financial stability of the insurance company. The distribution of the losses for these insurance companies can be seen in appendix J. For the $27.6 billion event, the only significant impacts were seen to the company Allianz. In this event, if Allianz had to take on either 10% or 25% of the total losses there would be a major hit to their finances. Liberty Mutual would also see some distress in the event that they were responsible for 25% of the losses as the percent surplus is nearing the 20% mark. For the $100 billion event, State Farm would again see little to no financial distress no matter what percent of the loss they covered. The financial stability of Liberty Mutual would begin to be dangerous when the company insured 10% of the losses. Allianz would most likely see financial distress in this event even if they were only to share 1% of the total loss. In the event that Allianz covered 25% of the $100 billion event, the company would not have enough surplus as their percent surplus is greater than 100% for this particular instance. For a $1 billion event, none of

the companies would see significant impacts to their financial stability no matter what percent of the loss they covered.

In order to look at the impact of the insurance industry as a whole, I considered the case where each of the top ten terrorism insurers were responsible for 100% of the loss. For this study I chose to focus on an event similar to the 9/11 attacks in regards to loss amount as I've seen that it is not extremely unlikely to happen and it also is where I began to see an impact on the insurers in the above study. Looking at the chart in appendix K, it can be seen that for nearly all combinations of surpluses and direct earned premiums, the financial stability of the insurance industry would see a major impact even with the use of the Terrorism Insurance Act. The percent surpluses ranged from 92.5% (if the industry was modeled by ACE INA) to 7.8% (if the insurance company was modeled by State Farm). This made it clear that the surplus to premium ratio has a significant impact of the ability of an insurer to handle catastrophic losses.

Limitations

The largest limitation in this paper was the lack of data. This was first seen with the dataset that was used. Many of the terrorist events that were recorded resulted in no property loss or an unknown amount of property loss. Additionally, upon a deep investigation I found that many events were missing from the dataset when cross referencing it with a list of the top 20 terrorist attacks world-wide. Overall, the number of events in the dataset with significant losses was extremely small. When only considering events in the United States where TRIA is used, there were only seven events where the losses were greater than $10 million. In an effort to overcome this limitation, I chose to use world-wide events and adjust the frequency to reflect only U.S. events.

The second limitation faced related to finding information related to how an event is insured. Since every event would have a different distribution of its losses across different insurance companies, depending on where the event happened, I could only look into instances of what could possibly occur. There is also a large number of possible insurance companies, all with different surplus to premium ratios, so it was difficult to look into each company.

Conclusions and Suggestions

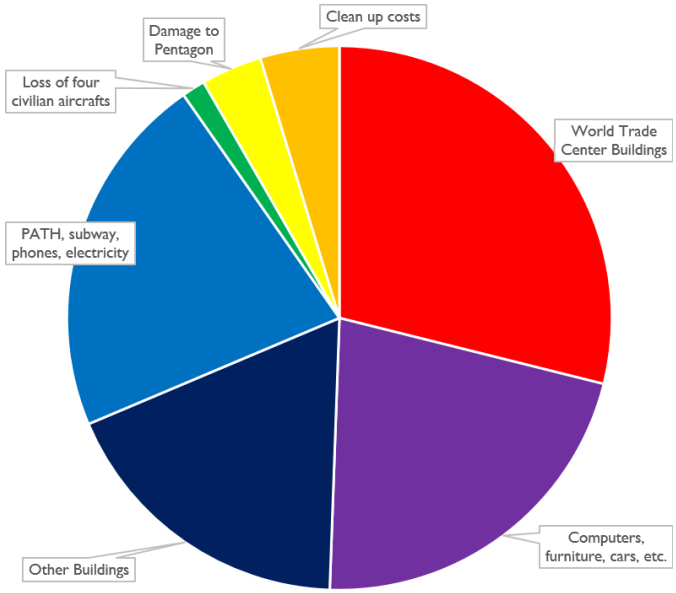
Currently, the program created by the Terrorism Risk Insurance Act is extremely limited in its potential support for the insurance company. Since the implementation of the act in November 2002 the program has not been used. Although we have seen many different instances of terrorist attacks throughout the years of the program, none of the events have met the program trigger. This brings up the debate on whether or not the program trigger should be lowered. Through my project, I was able to see that the most likely explanation for the program not being used is that the likelihood of an event happening that would trigger TRIA is fairly low. Based on my simulation, I found that there is only approximately a 5.59% annual chance of an event occurring with property losses between $100 million and $100 billion. For events smaller than this, TRIA is not as needed as the private insurance companies can handle the loss without it causing financial distress to the company.

Insurance companies should be more concerned as to when the next large event is going to occur and how large it will actually be. Since it is difficult to predict the magnitude and timing of the events, insurers should be mandated to keep a surplus for terrorism events. Since the implementation of TRIA in November 2003, $24.24 billion in terrorism premiums have been collected. However, since there has not been an event where these premiums were needed, they

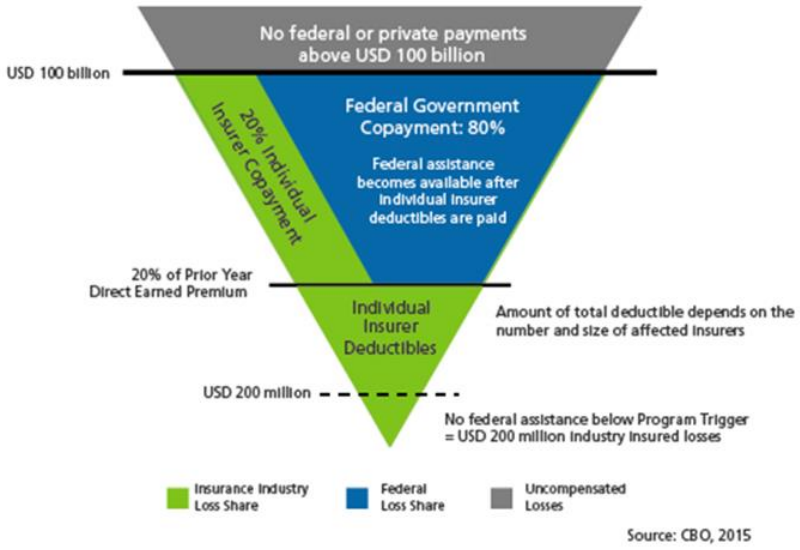
have instead become profit for the private insurance companies. Currently there is a debate as to whether to add a clause to the Terrorism Insurance Act during its renewal in 2020 that states a proportion of the surplus should be held in reserves for future events. As seen in my investigation, a large surplus (which can be created through a reserve system) has the largest impact in protecting an insurance company from financial distress after a catastrophic event.

Appendix

Appendix A: Distribution of Losses 9/11

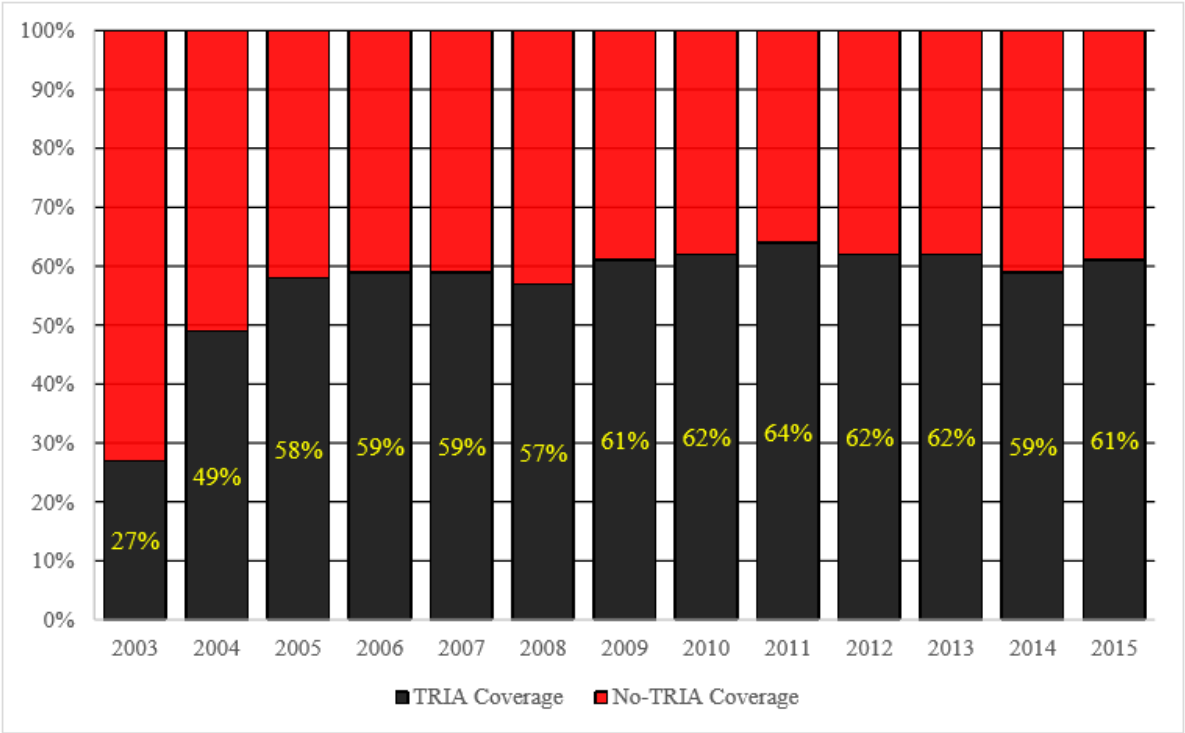


Appendix B: Layout of TRIA as of 2015



Appendix C: Terrorism Insurance Take-up Rates

Figure 3. TRIA Coverage Over the Period 2003–2015

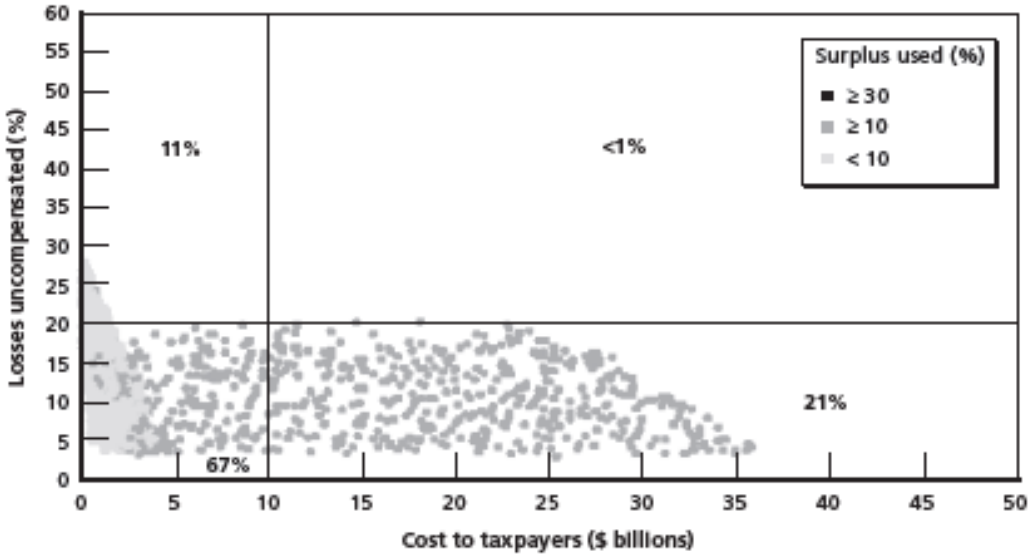


Sources: Authors with data from Marsh.

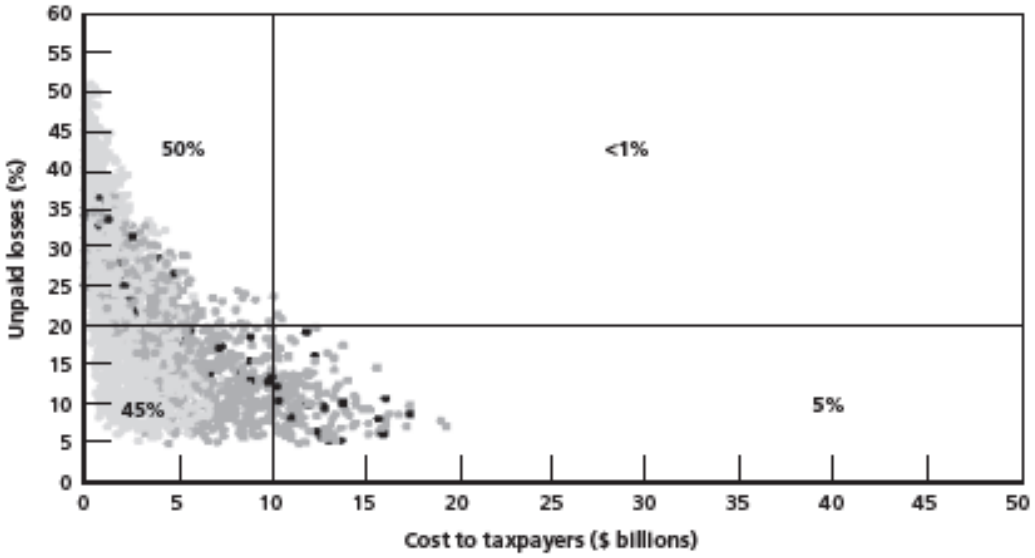
Appendix D: TRIA's Impact on Loss Distribution

Figure 3.1
Distribution of Losses for Conventional Attacks with and Without TRIA for a Range of Assumptions, Including That About the Hardness of the Existing TRIA Cap

A. TRIA
64% of these scenarios use more than 10% of industry surplus.



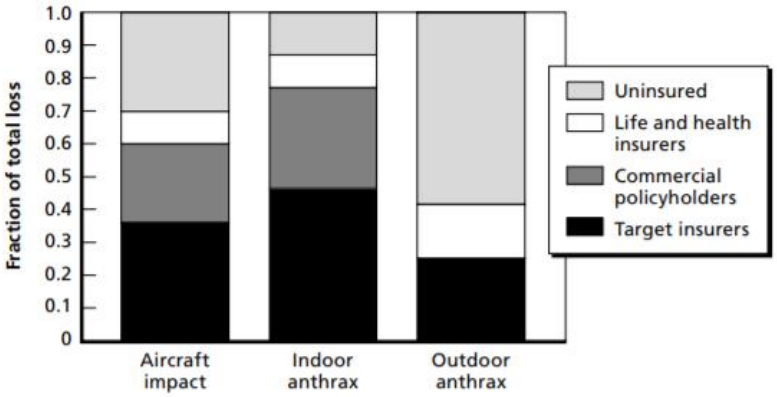
B. No government program
56% of these scenarios use more than 10% of industry surplus.



RAND MG679-2.1

Appendix E: Three Scenarios of Terrorist Attacks

Figure 4.1
Distribution of Losses Under TRIA for the Three Attack Scenarios

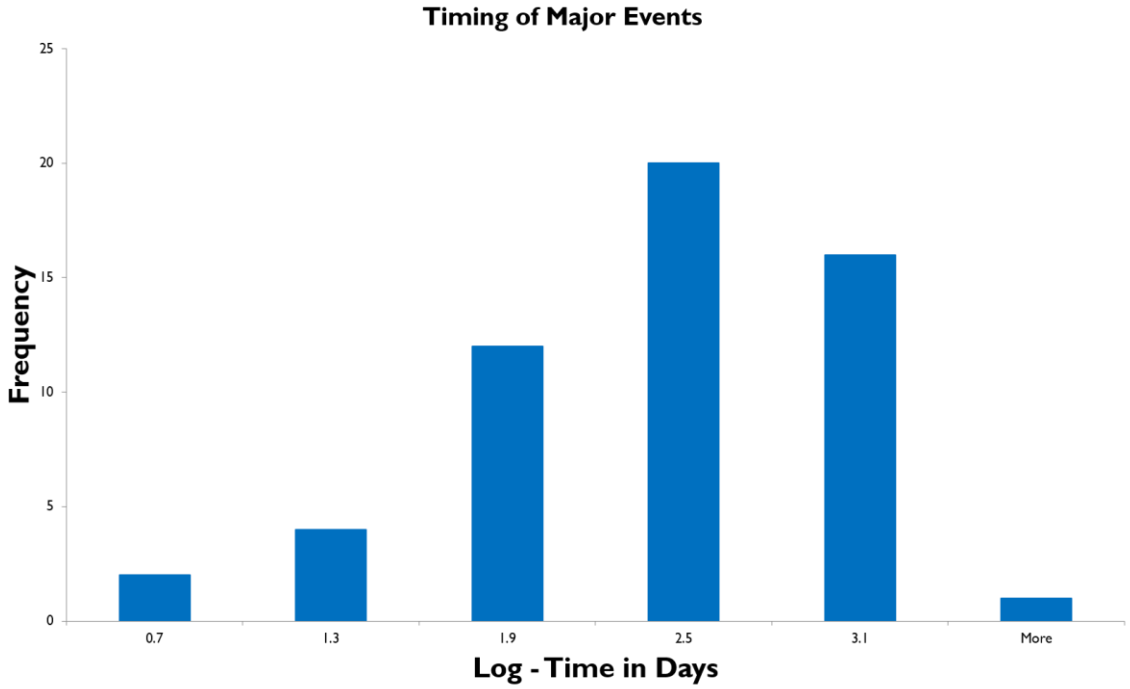


NOTE: Target insurers' share = deductible + co-payment, where deductible is calculated with Equation (4.3) (for aircraft impact and indoor anthrax) or Equations (4.4a) and (4.4b) (outdoor anthrax) and co-payment is given by Equation (4.5); commercial policyholders' share is given by Equation (2.1); life and health insurer share, $L_i^{L\&H}$, is from Table 3.2; and uninsured loss = $L_i^{total} - L_i^{TRIA} - L_i^{L\&H}$.

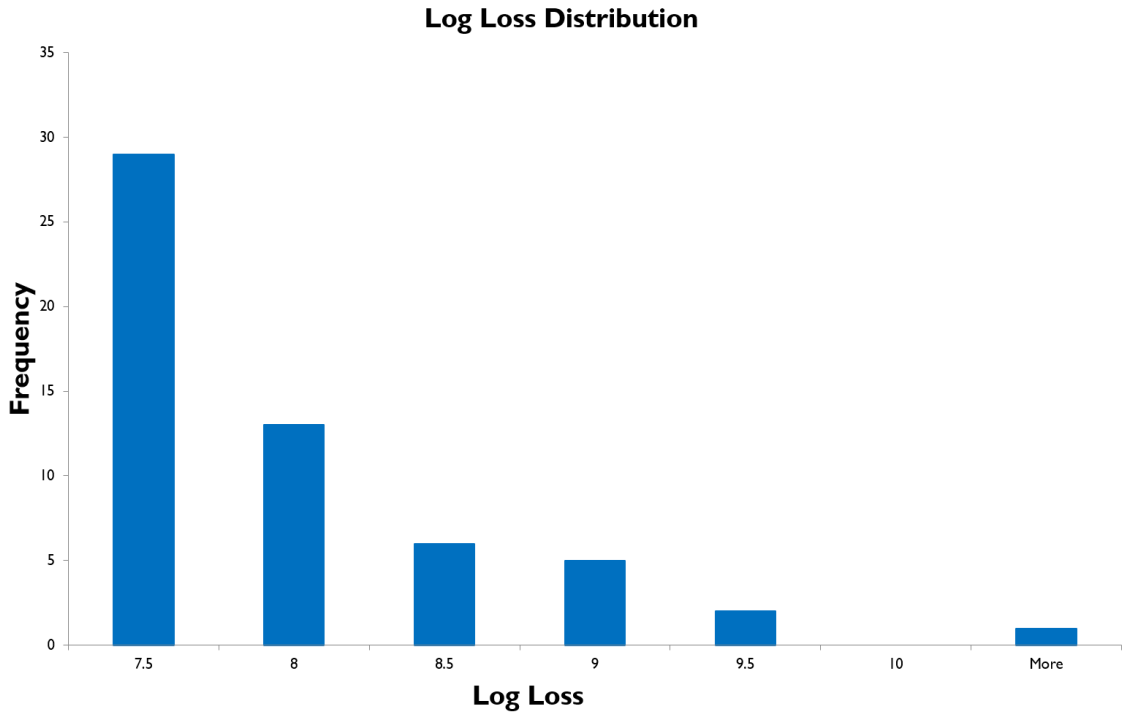
Appendix F: Data

date	timing	log(timing)	country	propvalue	log(propvalue)
9/6/1970				150000000	8.176091259
9/12/1970	6	0.77815125		170000000	8.230448921
12/17/1973	1192	3.076276255	98	10000000	7
9/7/1976	995	2.997823081	69	10000000	7
6/20/1977	286	2.456366033	98	30000000	7.477121255
9/13/1977	85	1.929418926	130	10000000	7
1/15/1978	124	2.093421685	185	12500000	7.096910013
6/24/1979	525	2.720159303	185	10000000	7
12/19/1980	544	2.7355989	78	50000000	7.698970004
1/12/1981	24	1.380211242	217	45000000	7.653212514
1/27/1982	380	2.579783597	61	12000000	7.079181246
4/18/1982	81	1.908485019	185	10000000	7
7/3/1982	76	1.880813592	88	10000000	7
7/27/1982	24	1.380211242	159	548000000	8.738780558
8/10/1982	14	1.146128036	159	107000000	8.029383778
7/25/1983	349	2.542825427		63000000	7.799340549
10/5/1983	72	1.857332496	145	10000000	7
10/10/1983	5	0.698970004	145	15000000	7.176091259
6/23/1985	622	2.793790385		200000000	8.301029996
6/11/1987	718	2.856124444	185	16000000	7.204119983
12/21/1988	559	2.747411808	603	75000000	7.875061263
12/31/1988	10	1	159	30000000	7.477121255

Appendix G: Distribution of Frequency



Appendix H: Distribution of Severity



Appendix I: Simulation Output

loss parameters	Description
11.71116703	alpha
7	Lower Bound
#events per year	
2.106505688	timing mean
0.646943375	timing SD

	Time of events (yrs)	Cumulative time (yrs)	Amount of loss	Cumulative loss
first event	4.9686	4.9686	$ 16,933,389.00	$ 16,933,389.00
second event	1.3166	6.2853	$ 23,573,959.47	$ 40,507,348.48
third event	22.7499	29.0352	$ 337,886,995.64	$ 378,394,344.11
	3.8488	32.8840	$ 30,298,748.35	$ 408,693,092.46
0	5.7542	38.6383	$ 16,995,467.15	$ 425,688,559.61
	12.0841	50.7223	$ 40,152,880.27	$ 465,841,439.88
	4.6380	55.3604	$ 15,931,600.73	$ 481,773,040.61
	6.9639	62.3243	$ 564,015,478.38	$ 1,045,788,518.99
	0.5883	62.9126	$ 24,722,637.60	$ 1,070,511,156.59
	0.3885	63.3011	$ 22,898,434.57	$ 1,093,409,591.16
	2.7343	66.0354	$ 35,842,336.06	$ 1,129,251,927.22
	3.4640	69.4994	$ 20,300,750.98	$ 1,149,552,678.21
	0.4671	69.9666	$ 10,163,127.38	$ 1,159,715,805.59
	6.4104	76.3770	$ 93,552,891.28	$ 1,253,268,696.87

Appendix J: Insurance Company Impact

Terrorism Loss Examples - 3 companies ($ in Billions)					**Loss Amount**	**$27.6(Billions)**	
Company	**Total Loss %**	Surplus	DEP - TRIA	20% Deductible (D)	Company Loss (L)	Company Pays =max(D,L) +max(17%(L-D),0)	Co % Surplus*
Liberty Mutual	**1%**	$16.80	$12.00	$2.39	$0.28	$0.28	1.6%
Liberty Mutual	**10%**				$2.80	$2.45	14.6%
Liberty Mutual	**25%**				$6.90	$3.16	18.8%
State Farm	**1%**	$65.30	$3.10	$0.62	$0.28	$0.28	0.4%
State Farm	**10%**				$2.80	$0.98	1.5%
State Farm	**25%**				$6.90	$1.69	2.6%
Allianz	**1%**	$3.60	$3.00	$0.61	$0.28	$0.28	7.7%
Allianz	**10%**				$2.80	$0.98	27.1%
Allianz	**25%**				$6.90	$1.68	46.6%

Terrorism Loss Examples - 3 companies ($ in Billions)					Loss Amount	$100(Billions)	
Company	Total Loss %	Surplus	DEP - TRIA	20% Deductible (D)	Company Loss (L)	Company Pays =max(D,L) +max(17%(L-D),0)	Co % Surplus*
Liberty Mutual	1%	$16.80	$12.00	$2.39	$1.00	$1.00	6.0%
Liberty Mutual	10%				$10.00	$3.68	21.9%
Liberty Mutual	25%				$25.00	$6.23	37.1%
State Farm	1%	$65.30	$3.10	$0.62	$1.00	$0.69	1.0%
State Farm	10%				$10.00	$2.22	3.4%
State Farm	25%				$25.00	$4.77	7.3%
Allianz	1%	$3.60	$3.00	$0.61	$1.00	$0.68	18.8%
Allianz	10%				$10.00	$2.21	61.3%
Allianz	25%				$25.00	$4.76	132.1%

Terrorism Loss Examples - 3 companies ($ in Billions)					Loss Amount	$1(Billions)	
Company	Total Loss %	Surplus	DEP - TRIA	20% Deductible (D)	Company Loss (L)	Company Pays =max(D,L) +max(17%(L-D),0)	Co % Surplus*
Liberty Mutual	1%	$16.80	$12.00	$2.39	$0.01	$0.01	0.10%
Liberty Mutual	10%				$0.10	$0.10	0.60%
Liberty Mutual	25%				$0.25	$0.25	1.50%
State Farm	1%	$65.30	$3.10	$0.62	$0.01	$0.01	0.00%
State Farm	10%				$0.10	$0.10	0.20%
State Farm	25%				$0.25	$0.25	0.40%
Allianz	1%	$3.60	$3.00	$0.61	$0.01	$0.01	0.30%
Allianz	10%				$0.10	$0.10	2.80%
Allianz	25%				$0.25	$0.25	6.90%

Appendix K: Insurance Industry Impact

Top Insurers for Terrorism Insurance					Loss Amount	27	
Company	Surplus	DEP – TRIA	Deduct. (20%)	D/S Ratio 20%	Company Paid	Gov't Paid	Co % Surplus
Liberty Mutual	$16.80	$12.00	$2.39	14.26%	$6.57	$20.43	39.1%
Travelers	$19.30	$10.90	$2.18	11.29%	$6.40	$20.60	33.2%
AIG	$29.20	$10.40	$2.08	7.14%	$6.32	$20.68	21.6%
Zurich Financial	$7.70	$6.70	$1.35	17.57%	$5.71	$21.29	74.2%
Hartford Insurance	$14.20	$5.80	$1.17	8.22%	$5.56	$21.44	39.2%
Chubb Group	$13.80	$4.90	$0.98	7.10%	$5.40	$21.60	39.2%
CNA	$10.00	$4.60	$0.92	9.23%	$5.35	$21.65	53.5%
Nationwide	$13.80	$4.50	$0.89	6.45%	$5.33	$21.67	38.6%
ACE INA	$5.70	$4.10	$0.82	14.41%	$5.27	$21.73	92.5%
State Farm	$65.30	$3.10	$0.62	0.95%	$5.10	$21.90	7.8%

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