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A Successful (Yet  
Somewhat Untested)  
Case of Disaster  
Financing: Terrorism  
Insurance under  
TRIA, 2002–2020

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# **A Successful (Yet Somewhat Untested) Case of Disaster Financing: Terrorism Insurance under TRIA, 2002–2020**

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## **Abstract**

The Terrorism Risk Insurance Act (TRIA), passed at the end of 2002, established a public-private partnership between the US federal government, private insurers, and all commercial enterprises operating on US soil. Renewed and modified by the US Congress and the president in January 2015 until December 2020, the TRIA program requires insurers to offer terrorism insurance to their commercial policyholders while providing insurers with free up-front financial protection up to \$100 billion against terrorist attacks in the United States. With the federal government providing a financial safety net, the private insurance sector can offer coverage against an uncertain risk that would otherwise be largely considered uninsurable, thus making terrorism insurance widely available and affordable. Overall premiums have been at about 2 to 6 percent of property premiums over the past four years, with the most significant increase recently for financial institutions (from 4 percent in 2012 to 9 percent in 2015). A significant portion of insurance policies, 23 percent according to a recent study by the US Treasury, which are typically those covering smaller firms, include terrorism coverage at no disclosed additional cost. TRIA is a successful case of public-private disaster risk financing that has received bipartisan political support. Yet it remains untested for large losses and it is unclear how the market and policymakers will react should another large-scale insured loss occur. TRIA also raises concerns about the indemnification of individual victims of a terrorist attack (in addition to workers' compensation).

**Key Words:** terrorism, insurance, national security, public-private partnerships, TRIA

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# A Successful (Yet Somewhat Untested) Case of Disaster Financing: Terrorism Insurance under TRIA, 2002–2020

Erwann Michel-Kerjan and Howard Kunreuther\*

## 1. Genesis of the TRIA Program

Terrorism has been a persistent threat in many parts of the world for decades; the first major terrorist attack in the United States occurred in February 1993. The terrorist organization Al Qaeda detonated a large truck bomb in the garage of the North Tower of the World Trade Center (WTC) in New York City, closing Tower 1 for six weeks and Tower 2 for four weeks. Although the building did not collapse (as the terrorists had planned), the attack killed six people and caused over \$750 million in insured losses (Kunreuther and Michel-Kerjan, 2004).

In April 1995, Timothy McVeigh detonated a bomb outside the Alfred Murrah Federal Building in downtown Oklahoma City, killing 168 people and injuring another 700. This attack damaged 324 buildings within a sixteen-block radius and resulted in about \$650 million in damage. The federal government owned the main building and self-insured against potential losses so there were no claims filed with private insurers. The Oklahoma City bombing demonstrated that the terrorism threat could emanate from domestic sources and that a successful attack could inflict massive losses with readily available materials and not a great level of sophistication.

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Then came the devastating coordinated attacks by Al Qaeda on September 11, 2001. The attacks killed over 3,000 people and injured another 2,250 and resulted in record insured losses of nearly \$45 billion, now second only to Hurricane Katrina as the most costly insured disaster in the world (in 2016 prices) (Wilkinson and Hartwig, 2010). Due to the international nature of insurance and reinsurance markets, nearly 120 insurers and reinsurers, many of them headquartered outside of the United States, paid these losses.

There have been a number of recent publications on terrorism risk insurance (Michel-Kerjan, Raschky, and Kunreuther, 2015; LaTourrette and Clancy, 2014; Willis and Al-Shahery, 2014; Dworsky and Dixon, 2014; Wilkinson and Hartwig, 2013); insurance industry reports on the take-up rates and terrorism pricing (AON Benfield, 2013; Marsh, 2013) and other topics by the US government and international organizations (President's Working Group on Financial Markets, 2010; 2014; Congressional Research Service, 2013, 2014; Government Accountability Office, 2014; OECD, 2005; 2010). What is absent in this literature is a rigorous scientific approach for determining the economic losses associated with different credible modes of attacks against specific locations in the United States that quantifies how those losses would be shared among different stakeholders, namely American taxpayers (the federal government), insurers, and commercial firms whether they are insured against terrorism or not. This will be a focus of this paper.

We first discuss the need for a public-private partnership that has made terrorism coverage widely available and affordable, given most insurers' refusal to provide terrorism coverage following 9/11, which left American corporations largely uncovered and the government de facto liable should relief have to be provided after an attack. We then briefly outline the current risk-sharing structure under the Terrorism Risk Insurance Act (TRIA) and characterize expected losses from three types of terrorist attack scenarios—one conventional (10-ton truck bomb) and two non-conventional (sarin contamination and nuclear explosion)—in downtown Chicago, Illinois; Houston, Texas; Los Angeles, California; and New York City, New York, using modeling capability of the modeling firm Risk Management Solutions (RMS). We quantify the loss distribution across stakeholders under different scenarios, loss levels and locations of the attack. Combining market data on insurers operating in these four states provided from the rating agency AM Best, we then determine loss sharing under the 2015 TRIA legislation.

### ***1.1. Making Terrorism Insurance Available and Affordable Via a Public-Private Partnership***

Two factors play a role in insurers' behavior with respect to pricing and coverage decisions about terrorism risk and other low-probability high-consequence events: the impact of large losses, and the ability to characterize the likelihood of an event occurring in the future. Until insurers have experienced significant losses from a particular extreme event, they are likely to treat the probability of such an event as below their threshold level of concern.

In the case of terrorism, notwithstanding the World Trade Center bombing of 1993, the Oklahoma City bombing of 1995 and other costly attacks outside of the US, (e.g., the 1993 and 1996 bombings in the financial district of London, UK), the likelihood of large claims payments from terrorist attacks in the US was still deemed by insurers to be quite small because prior to 9/11, the insurance industry had never suffered catastrophic terrorism losses. In fact, actuaries and underwriters did not price the risk associated with terrorism nor did they exclude this coverage from their standard commercial policies (Kunreuther and Michel-Kerjan, 2004).

But following their \$44 billion loss (2015 prices) from the 9/11 terrorist attacks, many global reinsurers refused to continue to provide insurers with protection against severe losses from another attack (Cummins and Lewis, 2003). These insurers concluded that they could not offer terrorism insurance because the uncertainties surrounding the likelihood and consequences of another large-scale terrorist attack were viewed as so significant that they considered the risk to be uninsurable by the private sector alone.

Since terrorists are likely to design their strategy as a function of their resources and knowledge of the vulnerability of the entity they want to attack, the nature of the risk is continuously evolving. Moreover, the nature of terrorist organizations, their modus operandi and possible targets change over time. For instance, Al Qaeda is today a very different organization than it was in 2001, and yet very different from ISIS. The dynamic uncertainty associated with the ever changing nature of terrorism makes the likelihood of future terrorist events extremely difficult to estimate in a given year, the typical length of a commercial insurance contract (Michel-Kerjan, 2003; 2014).

Such uncertainty creates difficulties in pricing coverage. Empirical evidence shows that insurers will set premiums higher for events with ambiguous probabilities and uncertain losses than for well-specified risks—if they agree to insure at all. Underwriters of primary insurance companies and reinsurance firms were surveyed about the prices they would charge to insure a factory against property damage from a severe earthquake when probabilities and losses were

well specified, and when the probabilities and losses were ambiguous. The premiums the insurers charged for the ambiguous case were 1.43 to 1.77 times higher than if priced a precise risk (Kunreuther, Hogarth and Meszaros, 1993)<sup>1</sup>.

The few insurers who continued to provide terrorism coverage right after 9/11 charged extremely high premiums to protect themselves against a serious loss. For example, prior to 9/11, Chicago's O'Hare Airport had \$750 million of terrorism insurance coverage at an annual premium of \$125,000. After the terrorist attacks, insurers offered the airport only \$150 million of coverage at an annual premium of \$6.9 million. This new premium, if actuarially fair, implies the annual likelihood of a terrorist attack on O'Hare Airport to be approximately 1 in 22 (\$6.9 million/\$150 million), an extremely high probability. The airport was forced to purchase this policy since it could not operate without coverage (in nominal 2002 prices) (Jaffee and Russell, 2003).

The lack of availability of affordable terrorism insurance was problematic since many businesses are required to have this coverage as a condition for a mortgage and it must be included in workers' compensation insurance in most states. Businesses operating in the United States found it increasingly difficult to purchase commercial property insurance that included the risk of terrorism. As a result, real estate and commercial ventures were stalled because of an inability to obtain the requisite insurance coverage. After another large attack, only a small portion of the total losses would have been paid by insurers and their reinsurers. In this scenario, the government will likely be called upon to rescue unprotected firms, meaning the large majority of it will be paid by all of us as taxpayers.

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<sup>1</sup> A recent web-based experiment provided actuaries and underwriters in insurance companies in the United States with scenarios in which they seek advice and request probability forecasts from different groups of experts and then must determine what price to charge for coverage for flood damage and wind damage from hurricanes. The average premiums that insurers would charge was approximately 30 percent higher for coverage against either of these risks if the probability of damage was ambiguous rather than well-specified and if the experts were conflicted over their estimates. The data reveal that they would likely charge more in the case of conflict ambiguity (that is, experts disagree on point estimates) than imprecise ambiguity (that is, experts agree on a range of probability, recognizing that they cannot estimate the probability of the event precisely) (40).

## 2. Loss-Sharing Design Under TRIA

### 2.1. *The Passage of the Terrorism Risk Insurance Act (TRIA)*

These concerns led Congress to pass and the President to sign the Terrorism Risk Insurance Act (TRIA) at the end of 2002. TRIA is a public-private partnership by which the United States government provides a financial backstop to help the private insurance market provide financial protection against terrorism risk. TRIA established a risk-sharing mechanism between the insurance industry, the federal government and all commercial policyholders in the US for covering insured losses to enterprises from future terrorist attacks (US Congress, 2002). In return for federal protection against large losses and to ensure that terrorism coverage was available to commercial firms, TRIA requires all US primary insurance companies to offer coverage against terrorism risk on the same terms and conditions as other perils provided by their commercial insurance policies. Insurers are not restricted regarding the price of this coverage and firms are not required to purchase it unless mandated by state law, which is normally the case for workers' compensation insurance.

The Terrorism Risk Insurance Extension Act (P.L. 109-144) was passed in 2005 and modified in 2007 through the Terrorism Risk Insurance Program Reauthorization Act (P.L. 110-160). Congress failed to renew the program in December 2014 so it expired until it was modified and extended in January 2015 until December 31, 2020. Each of the renewals of TRIA increased the portion of the risk assumed by the insurance industry so that it now will bear the entire insured loss from attacks when total damage does not exceed \$60 billion, as we show in the next section.

### 2.2. *Current Risk Sharing Design*

Under TRIA's 2015 renewed design,<sup>2</sup> events certified as terrorism by the federal government and resulting in over a certain trigger in insured losses in TRIA-eligible lines of business (\$100 million in 2015 which is gradually increased up to \$200 million over time) would be shared as follows:

Commercial policyholders would be responsible for paying any losses within their standard insurance policy deductibles under TRIA; if these firms had declined to purchase

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<sup>2</sup> The text of the legislation is available at: <http://www.gpo.gov/fdsys/pkg/BILLS-114hr26enr/pdf/BILLS-114hr26enr.pdf>.



terrorism coverage for property and business losses they will be fully responsible for their losses from an attack. Commercial insurance companies would then provide coverage for all losses in excess of these TRIA deductibles, provided that total insurance industry losses did not exceed \$100 billion (often referred to as the TRIA “program cap”).

Insurers are responsible for covering losses from a TRIA deductible ( $D^*$ ) set equal to 20 percent of that company’s prior year’s direct earned premium (DEP) for the lines covered under the program, after which the federal government would then reinsure the commercial insurer’s terrorism losses.  $D^*$  has increased from significantly over time: from 1 percent in 2002, 7 percent in 2002 and 2003, 10 percent in 2004, 15 percent in 2005, 17.5 percent in 2006, to 20 percent since 2007 and has remained at that level for the 2015 renewal of TRIA. For large insurers, this TRIA deductible can be significant. Losses in excess of each insurer deductible would be shared between the insurance company and the federal government; federal share of compensation was set at 85 percent of insured losses that exceed insurer deductibles until January 1, 2016. Then the federal share is decreased by 1 percentage point per calendar year until it reaches 80 percent (Figure 1 shows the 80-20 loss sharing).

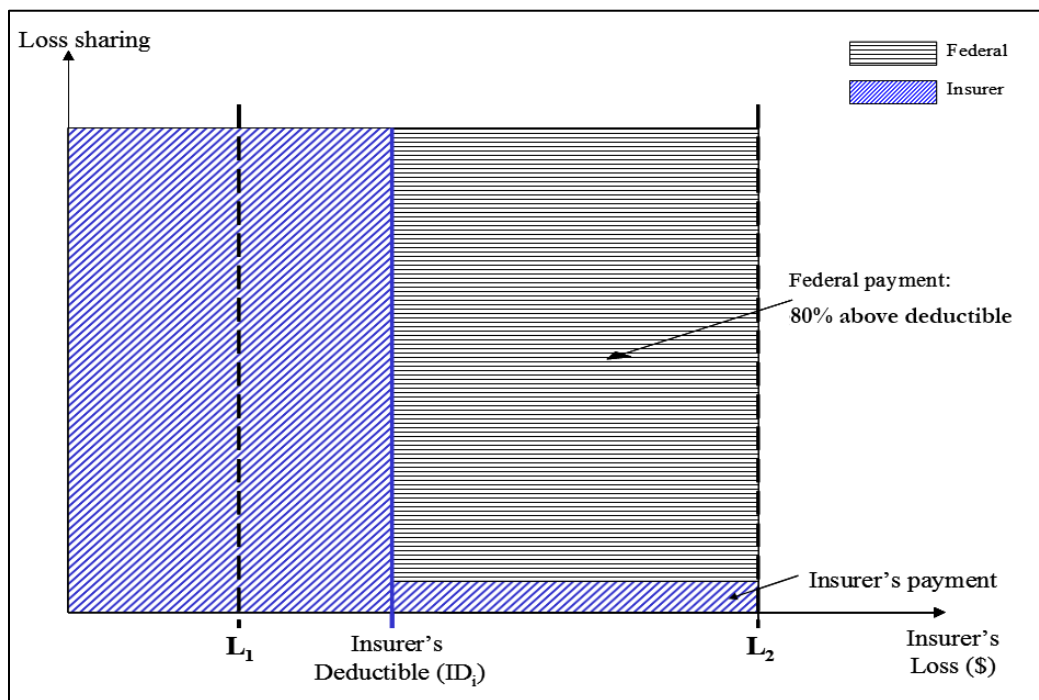
Should total insurance industry losses exceed \$100 billion, primary insurers are responsible for reimbursing policyholders only for their proportionate share of losses up to \$100 billion and Congress shall determine the procedure and source of any payments for the uninsured losses.

Figure 1 depicts the public-private loss sharing for a representative insurer covering terrorism for its commercial policyholders (either through workers’ compensation or property insurance) under the current TRIA arrangement when total insured losses are less than \$100 billion. If a terrorism loss incurred by an insurance company ( $i$ ) is less than its TRIA deductible amount ( $D_i$ ), as determined as a percentage of its prior year Direct Earned Premium (DEP) in TRIA-eligible lines, the insurer does not receive any reimbursement from the federal government. This situation is illustrated by an insured loss of  $L_1$  where the insurer’s payment is represented by the oblique lines on the left side of Figure 1.

When the insured loss from a certified terrorist attack is above the insurer’s deductible, as depicted by  $L_2$  in Figure 1, the insurer pays the entire claim and the federal government reimburses the insurer for 83 percent in 2017, 82 percent in 2018, 81 percent in 2019 and 80 percent of the losses above its deductible starting on January 1, 2020. We consider the 80 percent loss sharing in Figure 1 as an illustrative example. The horizontal lines on the right side of the figure represent the federal payment.  $D_i$  plays an important role in determining loss sharing

between insurers and the federal government and can amount to very large sums for many insurers. Should a terrorist attack occur this year, insurers will be responsible for losses equal to 20 percent of their DEP from last year.

**Figure 1. Loss Sharing under TRIA between an Insurer and the Federal Government**



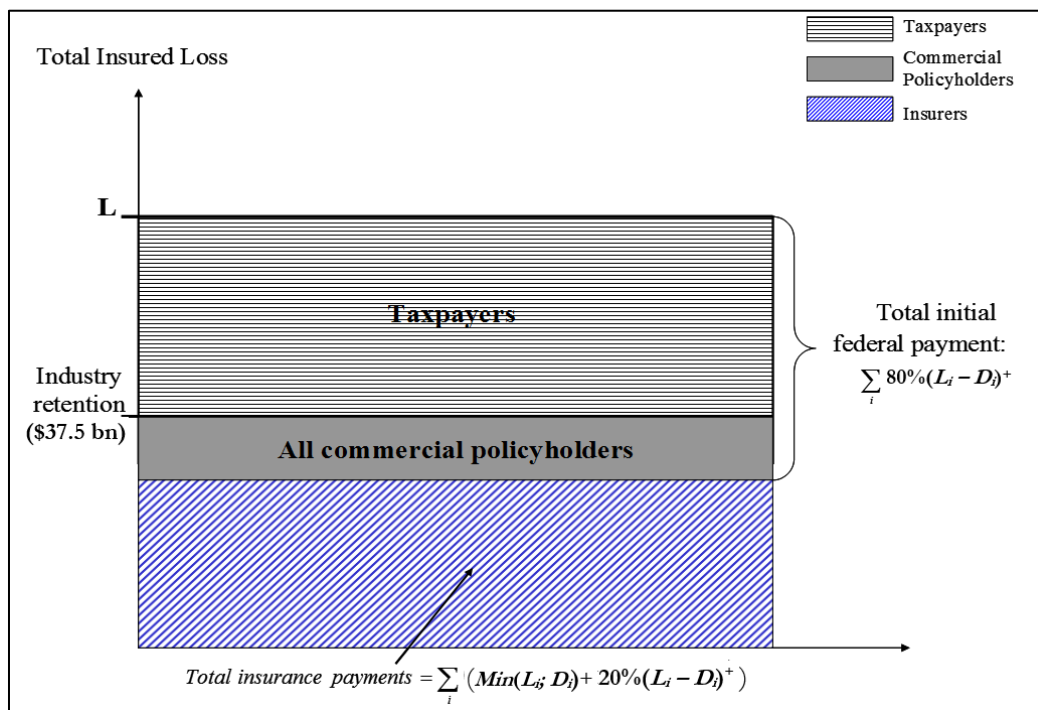
*Note:* the loss sharing between the federal government and an insurer was 85-15 percent in 2015, then 84-16 percent in 2016, 83-17 percent in 2017, 82-18 percent in 2018, 81-19 percent in 2019 and 80-20 percent of the losses above deductible starting on January 1, 2020.

The federal government recoups its payments between the total insurers’ outlays and a mandatory recoupment amount that will be levied by surcharges on all commercially insured policyholders (at a 140 percent rate). Should uncompensated insurer outlays across the insurance industry exceed the mandatory recoupment amount, the US Treasury has the option to collect some or all federal payments over time through a discretionary recoupment mechanism; see Figure 2).<sup>3</sup>

<sup>3</sup> This mandatory recoupment increases by \$2 billion a year starting in 2016 from the 2015 level of \$27.5 billion so it eventually becomes \$37.5 billion. We assume \$37.5 billion as the mandatory recoupment in our analysis. For terrorist acts occurring before 2018, all mandatory recoupment premiums must be collected by September 30, 2019. For attacks in 2018, 35 percent of amount is to be collected by September 30, 2019, and the rest by September 30, 2024. For acts on or after January 1, 2019, all of the mandatory recoupment premiums would be collected by September 30, 2024. For simplicity we assume no discount rate in our calculation.

If the entire insurance industry suffers terrorism losses on their US portfolio that requires the government to cover a portion of their claims, then these outlays shall be fully or partially recouped *ex post*, as described above. Insurers levy this surcharge against all commercial property and casualty policyholders, whether or not they had purchased terrorism insurance, and transfer the collected funds to the Treasury.

**Figure 2. Overall Loss Sharing under TRIA**



Note: Assuming here a \$37.5 billion market retention; see footnote 4 below.

Figure 2 depicts the repayment schedule between all the insurers whose policyholders suffer an insured terrorist attack (the area depicted by oblique lines), all commercial policyholders (solid area) and the taxpayers (area depicted by horizontal lines) after the federal government has reimbursed all insurers for their share of their claims payments above their individual TRIA deductible level. In the example considered here, since the total insured loss  $L$  for the entire insurance industry is greater than the industry retention (set at \$27.5 billion in 2015,

and increased by \$2 billion a year until it reaches \$37.5 billion<sup>4</sup>) but total losses retained by insurers within their deductibles and coinsurance requirements are below the market aggregate retention of \$37.5 billion (assuming as an example this is the threshold the year the attack occurs), a portion of the federal outlays are subject to the mandatory recoupment. Should the federal government elect to exercise its authority to levy a discretionary recoupment surcharge against commercial policyholders to fund federal outlays not covered by the mandatory recoupment mechanism, there would be a 1-for-1 reallocation of loss from taxpayers to commercial policyholders. For our analysis, we do not allocate losses to the discretionary recoupment mechanism as it reflects one of many alternatives by which the federal government could fund uncompensated federal outlays.

### **3. Market Penetration and Terrorism Insurance Cost**

#### **3.1. Market Penetration**

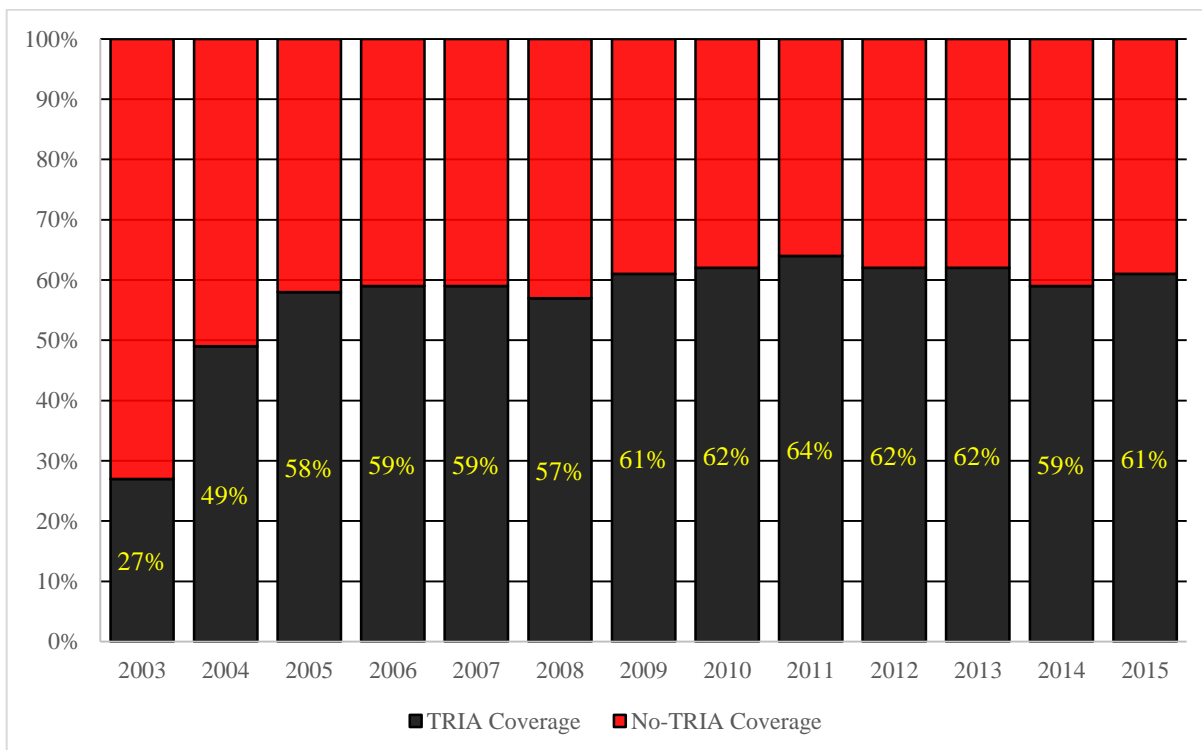
TRIA's most important success, in the absence of large-scale terrorist attacks on US soil since 9/11, was to significantly reduce and stabilize the price of terrorism insurance compared to premiums charged between 9/11 and the enactment of this legislation. Surveys undertaken on a regular basis since the inception of TRIA by Marsh and Aon, the two largest insurance brokers operating in the US, provide a good representation of the market for medium and large accounts.

Figure 3 below depicts the evolution of average TRIA-coverage penetration among 1,500 to 1,600 clients of Marsh over time (across industries, geographies and firm's size). The market penetration for these larger firms has remained somewhat stable at around 60 percent during the past 10 years.

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<sup>4</sup> The insurance marketplace aggregate retention amount was established at the lesser of \$27.5 billion, increasing annually by \$2 billion until it equals \$37.5 billion, and the aggregate amount of insured losses for the calendar year for all insurers. In the calendar year following the calendar year in which the marketplace retention amount equals \$37.5 billion, and beginning in calendar year 2020 it is revised to be the lesser of the annual average of the sum of insurer deductibles for all insurers participating in the Program for the prior three calendar years as such sum is determined by the Secretary of the Treasury by regulation.

Figure 3. TRIA Coverage Over the Period 2003–2015



Sources: Authors with data from Marsh.

The remaining 40 percent should not necessarily be interpreted as totally uninsured as firms can purchase standalone terrorism insurance coverage for all their US and foreign operations that is not dependent on TRIA. Firms can also be self-insured through the use of dedicated captives and/or structured debt (e.g., warrants, convertible and forgivable debt) and contingent capital (i.e., financing that is contingent on the occurrence of specified events). Moreover, a number of smaller companies may be insured without utilizing these larger insurance brokers.

### 3.2. Take-Up Rates Across Geographies and Industry Sectors

A higher percentage of companies in the Northeast (72 percent) purchased property terrorism insurance in 2015 than in any other region, likely attributable to the concentration of large metropolitan areas, including Washington, DC, and New York -- the perception that major cities may be at a higher risk of a terrorist attack, population density, and that the region was the

site of the 2001 terrorist attacks. The Midwest and South had the lowest take-up rates in 2015, at 57 percent and 54 percent, according to Marsh data.<sup>5</sup>

Terrorism insurance purchasing varies significantly by industry sector, too. According to Marsh, media companies purchased property terrorism insurance at a high rate (79 percent), followed by education (75 percent), hospitality and gaming (74 percent), health care organizations (73 percent), financial institutions (71 percent) and real estate (71 percent). Manufacturing (49 percent), chemicals (45 percent), and energy and mining (33 percent) were the three industry sectors with the lowest take-up rates.<sup>6</sup> Differences seem to be large in part due to some industries having exposure concentrations in central business districts and major metropolitan areas that are likely perceived as being at higher risk for terrorism (Marsh, 2016).

Until very recently, these were the best longitudinal market data available. There have been calls for a national data collection on the US terrorism insurance market by the federal government given that the terrorism insurance gap is an issue of importance for markets and national security (Michel-Kerjan, 2013). When TRIA was renewed in 2015, Congress requested the US Treasury to collaborate with the insurance industry so more granular data could be collected. In a report released in June 2016<sup>7</sup>, the US Treasury estimates that based on the data provided by insurers that volunteer to release their information, terrorism risk insurance penetration is around 80 percent across the country (based on the number of policies issued). Such a metric is useful for measuring the number of firms that are insured but it might also be biased or even skewed by less costly risks with lower total insured values (TIVs). Take-up rates measured by premiums or TIVs may more closely estimate the amount of insured business activity. Based on the data collected by the US Treasury the 2015 market penetration rate is

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<sup>5</sup> Geography is defined as the location of the headquarters of the firm. This is of course only a proxy since those firms have operations in many places around the country.

<sup>6</sup> Take up rate has remained relatively stable in industry sectors where take up rate is high. For instance, it was 82 percent in 2010 in media, and already above 70 percent in education, health care, financials and real estate. But take-up rate has somewhat declined in industry sectors where it is the lowest. For instance, it was 51 percent in energy and mining in 2010, versus 33 percent in 2015.

<sup>7</sup> The report is based on voluntary reporting by insurers for the first year (2005). Fifty-two insurer groups provided some or all of the requested information; they represent about \$85 billion in TRIP-eligible line direct earned premiums (DEP), or about 41 percent of the 2015 total DEP for terrorism risk insurance program's eligible lines. This group of insurers includes 11 of the 25 largest insurance groups (by total premiums in TRIP-eligible lines), and approximately 25 percent of insurers whose size would require submission of complete data in future years under Treasury's proposed rules released on April 1, 2016.

estimated to be lower, at about 70 percent when such alternative metrics are used (US Treasury, 2016). This means that on average firms purchase a lower quantity of coverage for terrorism risk than they do for other lines, even though this difference is not very large.

This confirms an earlier study of the US terrorism insurance market for large firms. Michel-Kerjan et al. (2015) compared the degree of coverage for terrorism insurance and property insurance, defined as the ratio of the limit on the terrorism (property) insurance policy the firm purchased (i.e., the maximum terrorism (property) claim payment it can receive from its insurers minus the deductible) to total insured value. They find the mean degree of coverage against terrorism risks to be 48 percent, and the mean degree of coverage for property to be about 55 percent.

### **3.3. Cost of Terrorism Risk Insurance**

The passage of TRIA quickly stabilized the market at a much lower cost to insured firms. By 2005 the median national cost for larger firms, all industries and geographies combined, was \$42 per million dollars of total insured value. Overall, the cost of TRIA terrorism insurance has continued to decrease in the years that followed.<sup>8</sup>

Pricing depends on the perceived likelihood of an attack market conditions and on the quantity of insurance purchased compared to the total insured value of a firm. Using data from Marsh Table 1 provides a more granular analysis to summarize the median cost of TRIA terrorism insurance by total insured value (TIV) (Table 1a) and also as a percentage of what a firm pays for its property coverage (Table 1b). This generally is in keeping with overall insurance pricing patterns: Larger companies typically purchase more insurance, which leads to lower average rates per dollar of coverage compared to rates for smaller companies.

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<sup>8</sup> International comparisons are also helpful, even though they should be taken with caution since programs and type of coverage differ from one country to another. Recent results are somewhat puzzling, though. For instance, Michel-Kerjan and Pedell (2007) analyze terrorism insurance costs of 2,600 large companies in the US and Germany that decided to purchase that coverage in 2006, and conclude that terrorism insurance prices (defined as premiums over quantity of insurance purchased) in Germany were then on average 2 to 4 times *higher* than in the US

**Table 1a. TRIA Terrorism Insurance Cost Per TIVs and Over Time  
(\$ Per \$ Million of Coverage)**

Total Insured Value (TIV)	2010	2011	2012	2013	2014	2015
> \$1 billion	\$21	\$21	\$19	\$18	\$18	\$15
\$500 - \$1 billion	\$23	\$19	\$20	\$16	\$18	\$20
\$100 million to \$500	\$27	\$27	\$25	\$23	\$25	\$25
< \$100 million	\$54	\$49	\$49	\$51	\$53	\$57

**Table 1b. TRIA Terrorism Insurance Cost as Percentage of Property Premium  
and Over Time**

Total Insured Value (TIV)	2010	2011	2012	2013	2014	2015
> \$1 billion	6%	5%	5%	5%	5%	4%
\$500 - \$1 billion	5%	4%	3%	5%	5%	5%
\$100 million to \$500	4%	4%	4%	4%	4%	5%
< \$100 million	4%	3%	4%	4%	4%	4%

Marsh reported, “Although this suggests that the cost of terrorism coverage generally remained the same in the various size classes, individual businesses may have experienced significant swings based on their property insurance program’s performance. For example, organizations with significant catastrophe (CAT) losses may have faced large increases in their overall property insurance program, but little change in their terrorism insurance pricing, resulting in a smaller percentage of their overall premium being attributed to terrorism coverage. Conversely, companies that had favorable loss histories in recent years may have experienced rate decreases in their overall programs while their terrorism insurance pricing remained constant or decreased, which may show in the analysis as an increase in terrorism pricing as a percentage, despite no overall increase in total costs” (Marsh, 2013).

### **3.4. Is Terrorism Insurance Affordable?**

Another criterion to evaluate a national disaster risk financing program is whether it is affordable. The market data leads us to conclude that indeed terrorism insurance quickly became affordable under the TRIA public-private partnership: Paying a relatively small extra premium for being insured against a federally declared terrorist attacks on US soil was attractive to many firms which translated into a relatively high market penetration. Moreover, the demand for this coverage is not only strong, as the data we just discussed about market penetration indicate, it is also fairly price inelastic. A recent study shows that terrorism insurance price elasticity is in the 0.1-0.2 range: a 10 percent increase in premiums will only decrease demand by 1 or 2 percent. As an element of comparison, the same study shows that a 10 percent increase in commercial property insurance will lead to a reduction of demand which is twice this size (Michel-Kerjan,



Raschky and Kunreuther, 2015). Comparing commercial demand for property and terrorism insurance, our findings suggest that both are rather price inelastic but that corporate demand for terrorism insurance is significantly more price inelastic than demand for property insurance.<sup>9</sup>

It is also worth mentioning that a number of insurers actually include terrorism insurance in their coverage at no cost. The aforementioned US Treasury report states that “approximately 23 percent of insurers” it collected data from “offered terrorism risk insurance at a disclosed \$0 premium charge. An insurer might offer terrorism risk coverage for a disclosed \$0 premium charge to ease administrative burdens or for other idiosyncratic reasons, and/or due to the lack of any cognizable terrorism risk presented in certain regions or under certain policies.”<sup>10</sup>

An open question as one analyzes the affordability of insurance under this TRIA program is how will the market react in the aftermath of another large attack triggering significant insured losses? Will capacity be significantly reduced and prices will go significantly higher than they currently are and, if so, for how long? The answers to these questions depend on the nature of the attack, its size and the market conditions when it occurs. For example, if there is excess capacity in the insurance market the premium increase may be relatively small; however, if the terrorist attack occurs after a series of costly natural disasters that have constrained capacity premiums might be significantly higher.

If the next terrorist attack were to occur in the distant future, insurers would have continued to collect premiums and may be in a position to cover the losses without a significant impact on their capacity. In its analysis, building on data collected by AM Best, the Treasury Department estimates that *insurers have collected about \$27.3 billion in terrorism insurance premiums in the US between 2003 and 2015 (corrected for inflation; 2016 prices)*.<sup>11</sup>

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<sup>9</sup> Depending on the estimation technique used for the analysis, the price elasticity for property coverage ranges from -0.43 to -0.82, while for corporate demand for terrorism coverage it ranges from -0.31 to -0.71.

<sup>10</sup> Data collected by the Treasury put the cost of terrorism insurance to about 2.6 percent of property premium for insurers that charge for that coverage. This percentage varies based on the TRIP-eligible lines of coverage, with the highest rates charged for excess workers' compensation insurance and aircraft insurance. Once policies are included for which insurers do not charge anything to cover terrorism for certain lines of business this percentage is lower at about 2 percent (US Treasury, 2016).

<sup>11</sup> As stated by the Treasury, “This amount may be understated because it is based in part upon charges as reported to A.M. Best, which does not rate every participating insurer, and presumably not every insurer completed the supplemental rating questionnaire in, given that A.M. Best has evaluated the vast majority of insurers that write TRIP-eligible insurance lines, the A.M. Best data likely provides a reasonable estimate of terrorism risk premium that was charged and collected during the 2004-2013 period. When adjusted for the missing years, the figure is premised upon the best information available.”

A related question is whether commercial firms will start putting pressure on their insurers to reduce the cost of terrorism even further absence of any new attack in the coming years. Suppose ten years from now that insurers in the United States have collected a total of \$50 billion in premiums since the inception of the TRIA program without any substantial claims. Would some firms, or some policymakers, raise questions that premiums are too high compared to the risk? This is a well known issue with low probability but extreme risks.

Another question to be discussed at the RFF-Wharton Risk Center workshop is whether disaster insurance programs link insurance with risk reduction. The TRIA program does not provide incentives for reducing risk as the legislation focused on the risk-sharing arrangement between insurers and the federal government, not on the demand side of the market. Terrorism is also more challenging than natural disaster risks in determining how firms can reduce their exposure to a large terrorist attack aside from increasing security and screening in its buildings. With respect to the flood risk, for instance, one can institute land-use regulations, well-enforced building codes and provide economic incentives for property owners to invest in loss reduction measures such as elevating the structure building or wet or dry flood proofing and for communities to building levees or dams. The other challenge with terrorism is that it is a dynamic threat: a terrorist organization can react to certain security measures in place at one facility by changing its mode of attack or attack in areas where security is lower. (Michel-Kerjan, 2003).

#### **4. Determining Terrorism Risk Costs: Methodology and Application to the Four Largest American Cities<sup>12</sup>**

Insurers are concerned about their exposure to terrorism losses given the deductible and coinsurance arrangement under TRIA that determines the cost-sharing arrangement with the federal government. For this reason and given the difficulty in estimating the likelihood of a terrorist attack, insurers often utilize scenarios to determine their maximum exposure in relation to their assets for a range of terrorist actions by location and mode of attack. Allocation of risk between policyholders, insurers and taxpayers under TRIA requires a detailed analysis of the impact of specific scenarios. To undertake this micro analysis we accessed market data from AM Best on 764 insurers doing business in the four states that we analyze here.

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<sup>12</sup> Part IV is based on Kunreuther, Michel-Kerjan, Lewis, Muir-Wood and Woo (2014).

#### **4.1. Methodology**

We adopt the following methodology for allocating losses from a specific scenario. First, we specify the nature of the terrorist attack and determine potential economic losses (including business interruption and workers' compensation) by simulating the attack in the downtown of our four focus cities using modeling capability from the modeling firm Risk Management Solutions. We then determine the proportion of losses assumed by each of the affected parties. While insurance companies use many different scenarios across multiple locations, we selected three possible attack scenarios to conduct our analysis (Kunreuther et al., 2014; Risk Management Solutions, 2013).

##### **Scenario A: 10-Ton (20,000 lb) Truck Bomb Attack**

In the 10-ton bomb scenario, a bomb made from conventional explosives is delivered by a truck or other vehicle and detonated as close to the target as possible. Ammonium Nitrate Fuel-Oil (ANFO) is the assumed explosive material, as this is a common commercial explosive. The raw materials for constructing this bomb are more readily available than other explosive materials, although access has been increasingly difficult since 9/11. Other high-explosive materials could be substituted with the same result, assuming equivalent yields. The pressure wave produced by the bomb around the detonation point is sufficient to cause structural and architectural damage as well as injuries and fatalities.

This scenario assumes the 10-ton bomb is detonated at street level in front of the target structure, close enough for the maximum blast pressure generated by the explosion to be exerted on the building structure. Blast effects of an explosion are in the form of a shock wave composed of a high-pressure shock front, which expands outward from the center of the detonation, with the pressure intensity decaying with distance and as a function of time. The magnitude and distribution of the shock wave pressures is a function of the following elements: explosive properties, location of the explosive relative to the structure and amplification of the pressure by its interaction with the ground and immediate surrounding buildings. Architectural damage is dominated by shattering glass in windows, and the resulting glass projectiles are the source of most injuries. Large pressure waves can also cause serious injuries, primarily to the ears and lungs.

Given its size, ambition and complexity, few historical precedents exist for a terrorist bomb of this size. In June 1996, Hezbollah attacked Khobar Towers, a US military accommodation complex in Dhahran, Saudi Arabia with a bomb estimated to be of comparable magnitude to 10 tons. This is the largest terrorist vehicle bomb that has ever been detonated. The

force of the explosion was so great it heavily damaged or destroyed six high rise apartment buildings and shattered windows in virtually every other structure in the compound, leaving a crater in the ground 85 feet wide and 35 feet deep. The blast was felt 20 miles away in Bahrain.

Overall, we find that a 10-ton truck bomb attack would cost \$26.6 billion in Los Angeles, \$28.3 billion in Houston, \$32.1 billion in New York City and \$36.6 billion in Chicago. The analysis reveals that property loss and business interruption range from \$19 billion in Houston to \$26.4 billion in Chicago. Workers' compensation losses range from \$6.7 billion in Los Angeles to \$12.7 billion in New York City (the difference due primarily to different worker density in these cities).

### **Scenario B: 1-Ton Sarin Chemical Agent Release Attack**

Sarin is the agent chosen for modeling a chemical attack based on technical and logistical requirements and terrorist interests. Like all nerve agents, sarin works by interfering with the mechanisms through which one's nerves communicate with one's bodily organs. Sarin is a liquid at ambient temperature. In vapor form, sarin is heavier than air and as a result will cling to floors, sink into basements, and gravitate towards low terrain. Sarin is also absorbed by the skin very rapidly.

The impact of such a chemical attack is affected by the time of occurrence, emergency response, and weather conditions, including wind speed and wind direction, and the heating, ventilation and air conditioning (HVAC) filtration systems in operation at affected locations. Victims who inhale large amounts soon lose consciousness, go into convulsions, and stop breathing. Inhalation of even low concentrations of the gas can be fatal (100 mg per cubic meter per minute will kill 50 percent of those exposed). If mass casualties occurred from a sarin gas attack, civil authority exclusion areas would be applied around the affected area and it would take time to clean up, investigate the scene of the crime and re-establish public confidence to return to the location. For this attack mode it is also assumed that there will be an "area of exclusion" for which there will be no physical damage, but there will be losses due to contingent business interruption (CBI) and business interruption (BI) losses associated with civil authority coverage provided in the underlying property policies. It could take several months for the full clean up to be completed and the area re-opened.

We determine the average property losses, workers' compensation losses and total losses dollar figures in the central business districts of Chicago, Houston, Los Angeles and New York for a representative 1-ton sarin attack as follows. Total losses in Chicago: \$17.1 billion (\$9.8bn for property losses and \$7.3bn for WC); total losses in Houston: \$9.2 billion (\$4.9bn for property

and \$7.3bn for WC); total losses for Los Angeles: \$11.8 billion (\$6.2bn for property and \$5.6bn for WC); total losses for New York City: \$25 billion (\$15.6bn for property and \$9.4bn for WC). The different building and worker density in New York and Chicago, versus Houston and Los Angeles, is the main driver of the difference in loss levels.

### **Scenario C: 1-Kiloton Nuclear Weapon Attack**

Detonation of a 1-kiloton nuclear weapon would have devastating consequences in an urban area. There are no known cases of a terrorist group getting close to obtaining, let alone using a nuclear device. However in 1998, an unsuccessful attempt by Al Qaeda to purchase uranium from black-market sources suggested an interest in the development of nuclear and radiological weapons. The nuclear bomb attack scenario considered here is a “*suitcase bomb*”-style nuclear device of 1-kiloton yield detonated in a city center. Although rarer than larger yield nuclear bombs, this size represents one that may be less difficult for terrorists to obtain or develop.<sup>13</sup>

Losses that result from any nuclear detonation are so severe that a low-end range of yield was selected as a representative attack. Damage agents include blast wave and intense heat; fires around the perimeter of the destroyed zone; radiation, and radioactive fallout that causes casualties and requires decontamination for many miles. Long-term health effects of radioactive fallout are not included in modeling workers’ compensation losses.

The impact of an attack is affected by the time of its occurrence, emergency response measures – especially urban fire suppression and medical treatment capability for very large numbers of injured – and weather conditions. Within the explosion impact region, the effects of radiation are not very significant because the bomb destroys much of the property that might be contaminated. Outside of the area affected by the explosion, there are radiation impacts due to fallout. Destruction from a nuclear device would come from several sources. The bomb will produce a pressure wave similar to that of a conventional bomb, although much larger in magnitude. A large amount of heat will also be generated, causing burns and fires. Finally, a plume of radioactive material will be generated, and dispersed by the wind.

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<sup>13</sup> Though referred to as a “*suitcase bomb*,” in reality it weighs hundreds of pounds and requires several people just to lift. Logistically, a nuclear attack of this type is extremely difficult to execute, requiring highly specialized technical skills, many operatives, years of planning, and significant financial resources.

The loss model uses different vulnerability functions based on construction class and building height. Business interruption losses are anticipated to be significant given the time needed to repair extensive physical damage, extra expense required for relocation, and reticence of employees to return to work. The loss estimates developed were validated against Hiroshima and Nagasaki nuclear bomb casualty studies, as well as benchmarked against published scenario studies by government agencies. We determine the average property losses, workers' compensation losses and total losses dollar figures in the central business districts of Chicago, Houston, Los Angeles and New York for a representative 1-kiloton nuclear attack as follows. Total losses in Houston: \$174.9 billion (\$99.7bn for property and business interruption—and \$74.2 for WC); total losses in Los Angeles: \$233.2 billion (\$163.3bn for property and \$69.9bn for WC); total losses in Chicago: \$342.3 billion (\$241.4bn for property and \$100.9bn for WC); the total losses in New York be the highest again with a staggering \$552.3 billion (\$392.7 billion for property and \$159.6bn for WC).

#### ***4.2. Public-Private Loss Sharing Under the New TRIA Legislation***

How would losses from such terrorist attacks be distributed across insurers, commercial policyholders and the federal government? This section examines this question under the three different terrorist attack scenarios described above with respect to location and magnitude of damage.

#### **Data and Methodology**

We utilized data on 764 insurers operating in at least one of the states in which the four cities are located to allocate losses from a terrorist attack among the insurance companies operating in each state today. Rating agency AM Best provided us with information on each insurer's direct earned premiums (DEP) for all TRIA lines, and also with their market share in the four states. These firms comprised virtually 100 percent of the terrorism insurance market placed with US licensed primary insurance carriers with respect to TRIA-line direct earned premiums at the end of 2012. Property insurance lines have been separated from workers' compensation (WC) lines. Actual losses from a terrorist attack are unlikely to be distributed among insurance companies exactly according to their market share in the affected state but this is an assumption we have to make for simplicity.

We assume a 50 percent take-up rate for terrorism insurance for the property lines, recognizing that the actual percentage may vary from one city to another as well as by the type of firm. Since terrorism cannot be excluded from workers' compensation insurance and must be

purchased by commercial enterprises, we assume a 100 percent take-up rate for terrorism-related workers' compensation losses. These assumptions apply to all the analyses undertaken below.

### **Analysis of Loss Distribution Across Key Stakeholders Varying the Location of the Attack and Size of the Loss**

We utilize projected damage to each of the four cities from a 10-ton truck bomb based on data discussed above to determine the distribution of losses among the non-insured, insured, all policyholders and the federal government. One could also undertake similar analyses using the other scenarios discussed in the previous section.

Table 2a examines how the losses associated with the 10-ton truck bomb would be shared among insurers, commercial policyholders and the federal government in these four cities.<sup>14</sup> For each city we determined the market share of the 764 insurers from data provided by AM Best, their individual deductible under TRIA (based on 2012 TRIA-line premiums collected) and the proportion of their insured losses covered by the federal government based on the loss sharing formula in TRIA 2015. We see that the insured losses from a 10-ton truck bomb in any of the four cities will be covered entirely by the insurers or their commercial policyholders with the federal government not responsible for any of the losses. (The federal government recoups the entire amount of its payments since the total insured loss is below the \$37.5 billion mandatory recoupment we use here for the analysis; as indicated earlier in the paper this industry retention depends on the year the attack would occur and market conditions.)

**Table 2a. Losses Due to a 10-Ton Truck Bomb**

<b>Location</b>	<b>Loss</b>	<b>Property</b>	<b>WC</b>	<b>Non-Insured</b>	<b>Total Insured</b>	<b>Insurers</b>	<b>Commercial Policyholders</b>	<b>Federal Taxpayers</b>
<b>Chicago</b>	\$36.59	\$26.39	\$10.21	\$13.19	\$23.40	\$21.25	\$3.01	\$0.00
<b>Houston</b>	\$28.29	\$19.02	\$9.27	\$9.51	\$18.78	\$15.22	\$4.98	\$0.00
<b>Los Angeles</b>	\$26.51	\$19.86	\$6.65	\$9.93	\$16.58	\$14.77	\$2.53	\$0.00
<b>New York</b>	\$32.07	\$19.38	\$12.69	\$9.69	\$22.38	\$16.74	\$7.90	\$0.00

*Note:* All numbers in \$ billion; we assume a 50 percent take-up rate on property lines, 100 percent on workers' compensation lines (WC) and a federal recoupment that applies only to the mandatory recoupment portion, not the discretionary portion for reasons explained above in the text. 80-20 percent Co-Share, 20 percent Deductible, \$37.5bn Retention; 140 percent recoupment rate against commercial policyholders.

<sup>14</sup> We assume that the federal government collects only the mandatory recoupment portion of the insured losses it pays up-front, and not the discretionary amount. This assumption is similar to the one made by the Congressional Budget Office (45) in its estimate of the impacts on different stakeholders in its analysis for the renewal of TRIA in 2007.

Table 2b then provides the results of the analysis now assuming that the total loss was fixed at \$25 billion, with \$15 billion in property damage and \$10 billion in workers' compensation (WC) for each of the four cities where the 10-ton truck bomb attack occurred. Of the \$25 billion total loss, \$17.5 billion was insured. Insurers in New York tend to be larger than those in Chicago and as a result have a higher deductible under TRIA. Therefore they will absorb a larger portion of the loss before assessing their commercial policyholders. For this \$25 billion loss scenario, there are no costs to the federal government in each of the four cities since losses are below the \$37.5 billion mandatory recoupment we assume here.

**Table 2b. Impact of \$25 Billion Loss Scenario in Different Cities**

Location	Loss	Property	WC	Non-Insured	Total Insured	Insurers	Commercial Policyholders	Federal Taxpayers
Chicago	\$25.00	\$15.00	\$10.00	\$7.50	\$17.50	\$16.28	\$1.71	\$0.00
Houston	\$25.00	\$15.00	\$10.00	\$7.50	\$17.50	\$13.92	\$5.01	\$0.00
Los Angeles	\$25.00	\$15.00	\$10.00	\$7.50	\$17.50	\$14.85	\$3.71	\$0.00
New York	\$25.00	\$15.00	\$10.00	\$7.50	\$17.50	\$13.60	\$5.46	\$0.00

*Note:* All numbers in \$ billion; we assume a 50 percent take-up rate on property lines, 100 percent on workers' compensation lines (WC) and a federal recoupment that applies only to the mandatory recoupment portion, not the discretionary portion for reasons explained above in the text. 80-20 percent Co-Share, 20 percent Deductible, \$37.5bn Retention; 140 percent recoupment rate against commercial policyholders.

Using the examples of possible terrorist attack scenarios specified in the previous section, we can analyze the entire spectrum of possible losses from zero to the \$100 billion using the same assumptions as above regarding terrorism insurance coverage with respect to property damage and workers' compensation (WC) losses. The amounts paid by the relevant stakeholders as a function of losses to New York City from terrorist attacks are depicted in Figure 4a.

The following key findings emerge from our analysis:

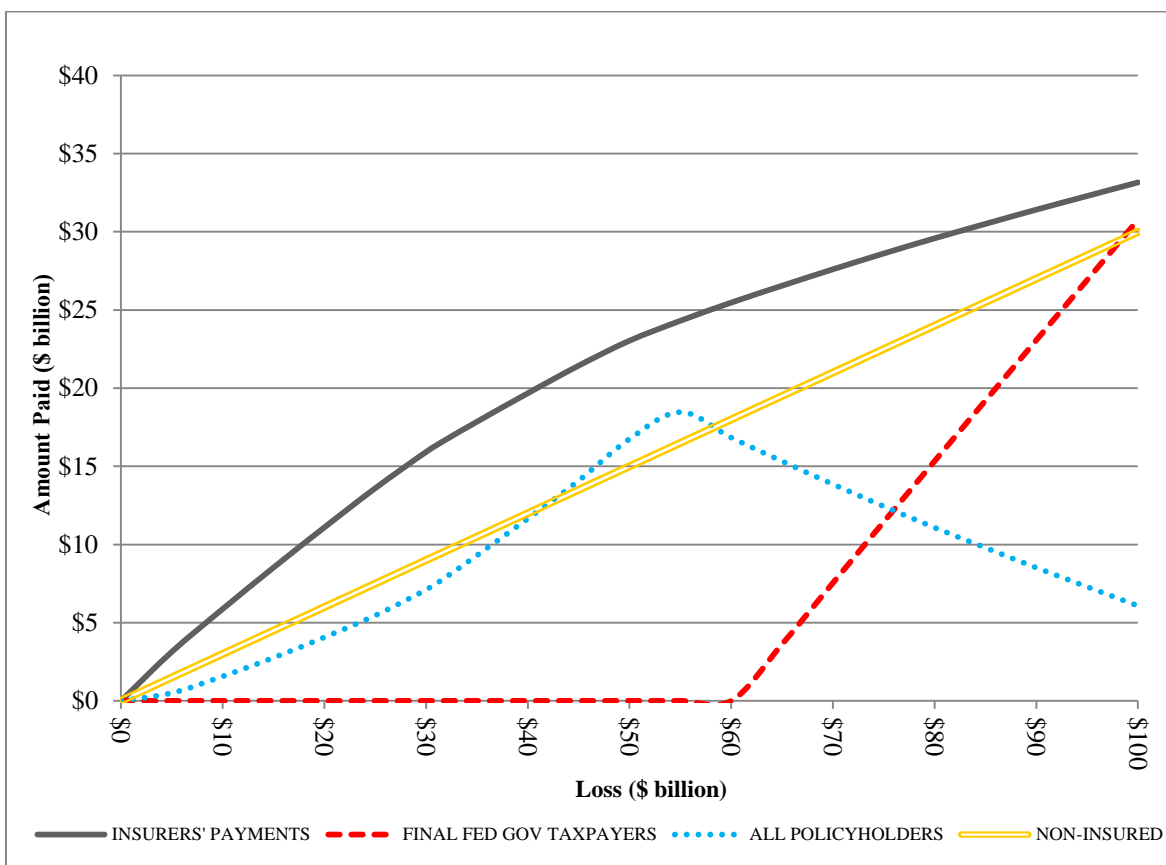
- Insurers will always pay more than any other stakeholder.
- The federal government will ultimately not be responsible for any payments under TRIA 2015 until the total insured and uninsured losses from a terrorist attack exceed \$60 billion. At this level of loss, insurers would pay \$25.5 billion, commercial policyholders \$16.85 billion; the remaining \$18 billion would be uninsured.
- When total insured and non-insured losses reach \$100 billion, insurers will ultimately be responsible for approximately \$33.15 billion in payments, taxpayers almost \$30.75 billion, the commercial policyholders over \$6.1 billion (through mandatory recoupment at a 140 percent rate); the remaining \$30 billion would be uninsured.



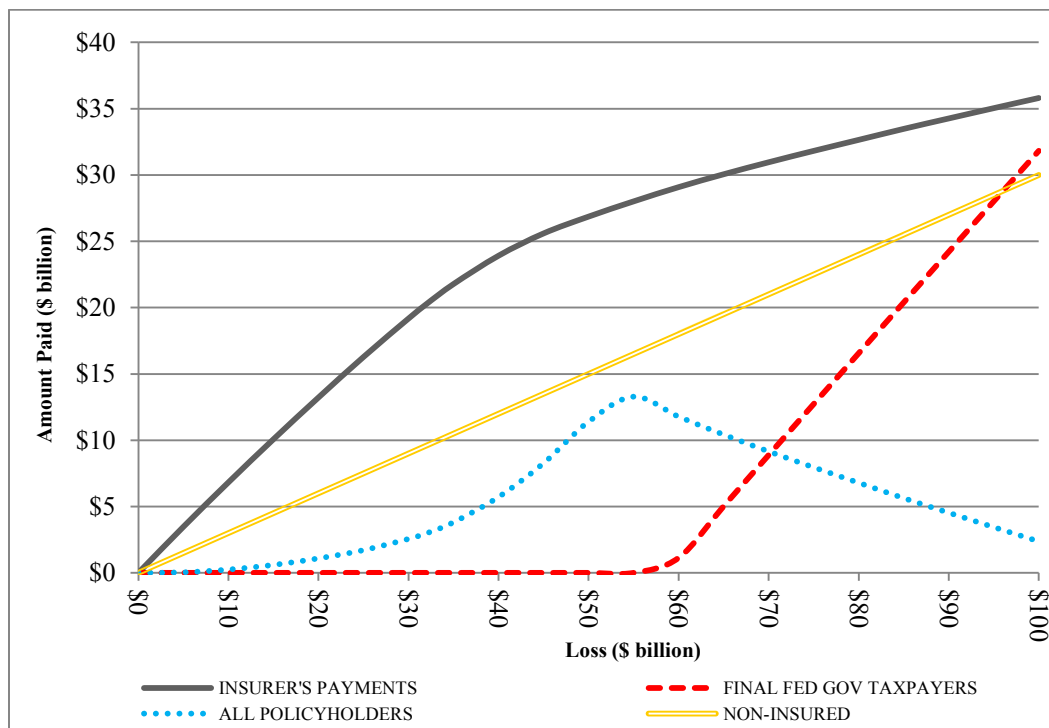
- Commercial policyholders would almost always pay some post disaster governmental recoupment in New York City. The maximum they would pay – \$18.5 billion – is reached when losses are \$55 billion.

We focused our discussion above on New York City. A similar analysis was conducted for Chicago, Houston and Los Angeles and results appear on Figures 4b, 4c and 4d.

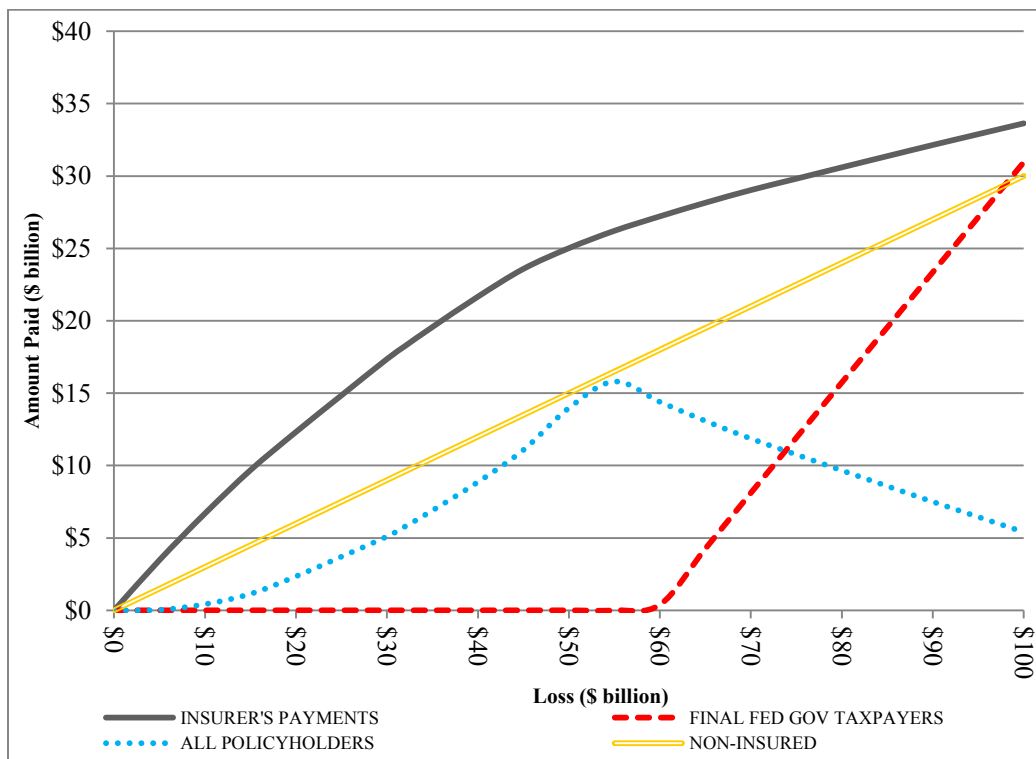
**Figure 4a. Amount Paid by Stakeholders for Different Loss Amounts from Terrorist Attacks in New York City under the 2015 TRIA Legislation**



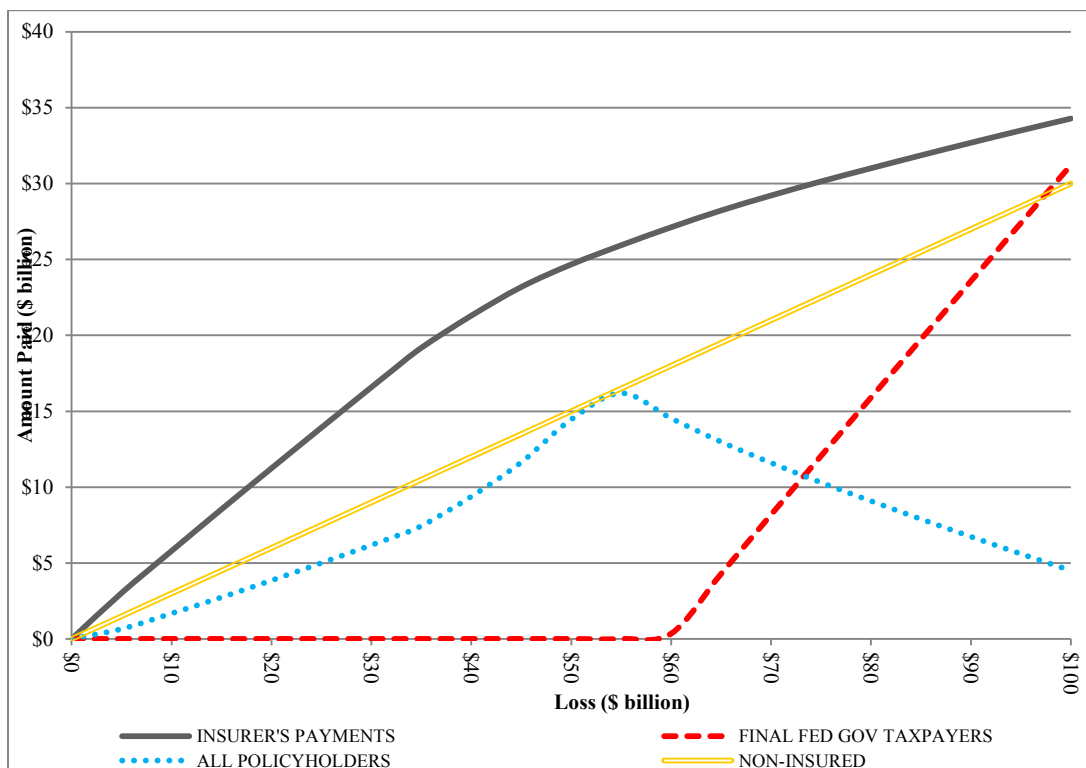
**Figure 4b. Amount Paid by Stakeholders for Different Losses from Terrorist Attacks in Chicago, IL, Under the 2015 TRIA Legislation**



**Figure 4c. Amount Paid by Stakeholders for Different Losses from Terrorist Attacks in Los Angeles, CA Under the 2015 TRIA Legislation**



**Figure 4d. Amount Paid by Stakeholders for Different Losses from Terrorist Attacks in Houston, TX, Under the 2015 TRIA Legislation**



### 5. Conclusions

Following the terrorist attacks of 9/11, insurers were reluctant to provide terrorism coverage because of the uncertainties associated with the risk and the frightening possibility of another attack leading to catastrophic losses. A public-private partnership, TRIA, was enacted to provide financial protection against future terrorist attacks in the United States.

Among all disaster insurance programs in which the government is involved, TRIA is rather unique. First it focuses only on commercial lines, not on homeowners. Second, it mandates insurers to offer that coverage to all their clients. Third, TRIA is not involved in price setting nor primary insurance (contrary to the NFIP or the crop insurance program, for instance). Third, it provides free up-front reinsurance to insurers, a somewhat unique position if one compares TRIA

to other terrorism insurance or reinsurance programs established internationally (See OECD, 2010; 2014; GAO, 2014; Michel-Kerjan, 2013)<sup>15</sup>.

Over time, the successive reforms of the terrorism risk insurance program have transferred more risks from the taxpayers to the private sector. While TRIA does not directly include private reinsurers in its design, reinsurers have played a more important role in recent years, covering a portion of the losses insurers will have ultimately to pay for should another attack occur (i.e. their deductible under TRIA and their portion of the risk above it). Of the 41 insurers that provided information to the US Treasury concerning reinsurance purchases (constituting a combined Program deductible figure of \$17.3 billion), 37 (or 90 percent) reported the purchase of a total of \$21 billion in reinsurance coverage for a single loss resulting from terrorism. (US Treasury, 2016).

Fifteen years after 9/11 it is surprising that financial protection against terrorism risk, which is so vital to our economy, remains largely understudied, compared to, say, natural disasters. The new data collection launched between the US Treasury and insurers is certainly an important step in that direction.

Overall, TRIA has worked well. It has stabilized a very disrupted market in the aftermath of 2001, making terrorism insurance widely available and affordable. Take up rates among enterprises, small and large, is rather high and premiums a few percentage point of what firms pay for their property insurance, even though cost and take up rate vary widely by size, industry, geography and line of business.

We provide a quantitative analysis of the terrorism loss-sharing under the federal TRIA program renewed in 2015 for three attack scenarios in four major cities in the United States. Under the new provisions of TRIA, for total losses from a terrorist attack below \$60 billion, if the federal government advances funds to insurers to assist them in paying claims, it will ultimately recoup this amount at a 140 percent rate against all commercial policyholders and thus will not have to incur any costs. In earlier versions of TRIA the government had to bear a portion

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<sup>15</sup> The Price-Anderson Nuclear Industries Indemnity Act (commonly called the Price-Anderson Act) is probably most similar to TRIA, although different in nature and much narrower. Established in 1957 and since renewed several times until 2026 it governs liability-related issues for all non-military nuclear facilities. The Act establishes a no fault insurance-type system in which the first approximately \$12.6 billion (as of 2011) is industry-funded as described in the Act; claims above the \$12.6 billion would be covered by a Congressional mandate to retroactively increase nuclear utility liability (somewhat similar to the recoupment process under TRIA) or would be covered by the federal government.

of the costs when the losses were \$25 billion or greater (Wharton Risk Center, 2005) so this has been, over time, a significant shift of the risk to the private sector.

An important factor that led to the passage of TRIA is the cost of capital the private sector would need to hold if it were responsible for paying all the insured losses from a terrorist attack. In particular, the prices charged must cover the costs of allocating risk capital to protect the insurer or reinsurer against claims payments (Doherty, 2000). Given the ambiguity associated with the terrorism risk, large amounts of risk capital are required to be held internally by the insurer or reinsurer. The resulting premium will thus be high relative to the best estimate of expected losses to maintain the insurer's credit rating (AM Best; 2013). Future studies on the costs of capital and their impact on insurance and reinsurance premiums for extreme events where the risk is uncertain and fat-tailed, such as terrorism, can provide insights in situations where public-private partnerships such as TRIA may be needed to enable insurers to provide coverage so that financial protection is widely available and affordable.

With the government providing free up-front protection against the truly catastrophic portion of losses from future terrorist attacks and in a position to recoup part of these against all commercial firms in the US (whether or not they are covered against terrorism), insurers have been able to reduce the amount of costly capital they need to hold. Evidence reveals that this strategy has worked. As a result, and without any new major terrorism insurance claims since 9/11, insurance is available at premiums that have led to significant demand for coverage (on average, at about 3 percent of the premium paid by firms for property insurance). Commercial take-up rates for terrorism insurance have more than doubled from 27 percent in 2003 to 60 percent in 2006, a level that has remained stable since (62 percent today) (Michel-Kerjan, Raschky and Kunreuther, 2015).

The present calculations of loss-sharing under TRIA do not include possible post-disaster relief from the federal government to uninsured firms that suffer losses from a future attack. However, based on the experience of 9/11 as well as the lessons learned from large-scale natural disasters, it is likely that the federal government will provide considerable assistance to uninsured victims (Kunreuther and Michel-Kerjan, 2011). As a reference point, post-disaster relief and special Congressional appropriations represented 80 percent of the cost of Hurricane Sandy in 2012 (Michel-Kerjan, 2013). But absent legislation on such an intervention, this aid will be ad hoc and hard to quantify ex ante (LaTourrette and Clancy, 2014).

Finally, what is insured or not under the current program is an important market and policy question to address. That TRIA focuses on commercial insured but does not cover

residents raises the question of the indemnification of individual victims of a terrorist attack (that is, beyond workers' compensation). The fact that terrorism insurance is relatively affordable in the United States also comes from the fact that two critical sources of truly devastating loss are typically not covered by insurers, thus not covered under the program. Think CBRN (chemical, biological, radiological and nuclear) attacks and cyber-attacks. CBRN is typically excluded from insurance policy in the US (except for workers' compensation), thus from the TRIA coverage; if cyber-terrorism insurance was sold as part of TRIA-eligible insurance lines it would be covered by TRIA too; but cyber-insurance is only starting to be sold so the coming years would tell whether insurers are comfortable insuring large-scale cyberattacks by terrorists for this line of business, and at what price. Those are not uninsurable since either or both are included in terrorism insurance programs in other OECD countries, resulting of course in higher premiums paid by insured firms in these countries.<sup>16</sup>

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<sup>16</sup> GAREAT in France and PoolRe in the United Kingdom.

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