Corporate Demand for Insurance: An Empirical Analysis of the U.S. Market for Catastrophe and Non-Catastrophe Risks

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Abstract

Despite a series of unprecedented disasters that have unfolded in the past decades, there has been little economic analysis about corporate demand for catastrophe insurance. Using a unique dataset of 1,808 large U.S. corporations, this study provides the first empirical analysis that compares corporate demand for standard property insurance and for catastrophe coverage (here, terrorism) using a demand-supply system equation. The main finding of this study is that corporate demand for catastrophe insurance is more price inelastic than for non-catastrophe insurance. This result differs from the existing findings on homeowners' demand for catastrophe insurance which has been shown to be price elastic. Further, larger companies are more likely to have some catastrophe coverage and a higher solvency ratio reduces demand for such coverage. Our results further suggest that free federal reinsurance under TRIA has led insurers to be less cautious about risk diversification in the case of terrorism risk than they are on the property side.

Keywords: Corporate Demand for Insurance; Economics of National Security; Terrorism

JEL classification: D21, D81, G22, H56

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1 Introduction

Today there are nearly 37 million small and large companies doing business in the United States. They employ directly or indirectly through suppliers abroad, several hundred million people. These corporations operate within a complex environment and face a large number of risks that can seriously challenge their future, or even lead to bankruptcy. A better understanding as to how these companies protect themselves against those risks is thus of prime importance.

Focusing on large corporations, this article investigates whether corporate demand for insurance differs with the nature of the risks that corporations face. One specific question this empirical paper infers in this context is whether large corporations treat the risk of catastrophic risks differently than non-catastrophic risks.[1] Somewhat surprisingly, these two questions have received little attention in empirical microeconomics.

In the past few years, there has been a growing interest in studying the economics of catastrophe risks and catastrophe risk financing, as illustrated by the publication of the 2007 Economic Report of the President prepared by the Council of Economic Advisors. For the first time ever, the CEA annual report devoted an entire chapter to the economics of catastrophe risk insurance (White House - Council of Economic Advisors 2007). As the report states, "insurance plays a vital role in America's economy by helping households and businesses manage risks. [...] Insuring economic losses arising from large-scale natural and manmade catastrophes such as earthquakes, hurricanes, and terrorist attacks poses special challenges for the insurance industry and for Federal and State governments." This growing interest in catastrophes should not come as a surprise if one considers the twenty-five most costly insured natural and man-made catastrophes in the world over the last 39 years (1970-2008). Indeed, 14 of them occurred since 2001, 13 of these in the United States. The terrorist attacks of September 11, 2001 (9/11 hereafter) were the most costly to insurance of all these catastrophes until Hurricane Katrina. These attacks inflicted insured losses of nearly $35 billion, nearly twice as much as those from Hurricane Andrew, the previous record. Furthermore, the claims from the 9/11 attacks were almost exclusively made by corporations located in or next to the World Trade Center (WTC).

[1] We know this to be the case for individuals. Many people tend to underinsure against catastrophe risks even though this is specifically the type of risk one might expect them to seek protection against. For instance, today only 12 percent of the population of California living in areas at high risk for earthquake has purchased quake insurance. Likewise, the Department of Housing and Urban Development (HUD) reported that 41 percent of homes damaged by the 2005 hurricanes were uninsured or underinsured, even after the four hurricanes that devastated Florida the previous year(U.S. Government Accountability Office (GAO) 2007). See Kunreuther, Ginsberg, Miller, Sagi, Slovic, Borkan & Katz (1978) for early work on this very question and Kunreuther, Meyer & Michel-Kerjan (forthcoming) for a review of the behavioral factors that contribute to these individual decisions.

A closer look at figures on terrorism reveals that the nature of this threat has radically changed over the past two decades. One of the main features of this transformation is that corporations are now much more likely to become targets for international terrorist organizations which seek to inflict mass casualties and economic disruption to Western countries. For instance, according to the U.S. Department of State, in 2000, 178 out of 206 U.S. targets attacked were businesses (over 80 percent); in 2001, 204 out of 228 (90 percent) (U.S. Department of State, 2004).[2]

Before 9/11, terrorism was included as an unnamed peril in most commercial insurance contracts in the United States. Quite surprisingly indeed, even after the first Al Qaeda attack against the World Trade Center in 1993, insurers had not excluded this risk from their policies-nor had they specifically priced it (Kunreuther & Michel-Kerjan 2004). The shock of 9/11 led insurers and reinsurers to stop covering this risk almost everywhere or, when they did, to charge a prohibitive price for it. In the United States, by early 2002, 45 states permitted insurance companies to exclude terrorism from their corporate policies,[3] leading to a call for some type of federal intervention (U.S. Congress 2002). A joint public-private program, TRIA (Terrorism Risk Insurance Act), was established at the end of 2002, thereby creating a new insurance market in the United States.[4] Several years have passed and the market is now mature enough that we can undertake microeconomic analyses based on a substantive data collection. In that context, this article investigates corporate demand for terrorism insurance and analyzes how decisions made by firms in this regard differ from their decisions on standard property coverage[5].

The paper is organized as follows. Section 2 provides an overview of studies on economics of national security, and corporate demand for insurance, the two fields to which this paper is contributing. Section 3 presents background information about the development of the U.S. terrorism insurance market pre- and post-September 11, 2001. It also discusses key

[2]CIA director, George Tenet, suggested this behavior in his prophetic unclassified testimony of February 7, 2001 (prior to 9/11) when he said: "As we have increased security around government and military facilities, terrorists are seeking out "softer" targets that provide opportunities for mass casualties." (Central Intelligence Agency (CIA) 2001). Such a soft target strategy has since been explicitly admitted by Khalid Sheikh Mohammed, the Al Qaeda chief of military operations, who was arrested in March 2003 (Woo 2004). NB: Such data are not publicly reported anymore after 2003.

[3]Workers' compensation insurance policies cover occupational injuries without regard to the peril that caused the injury

[4]Several European countries also created (France and Germany, for instance) or reorganized (U.K) their terrorism insurance market based on a risk-sharing arrangement between the private sector of insurance and the national government (Michel-Kerjan & Pedell 2005).

[5]This type of analysis is not easy because quite often one can access data only of those who have purchased coverage, but not those who decided not to buy insurance. This generally makes the determination of market penetration difficult, and the calculus of price elasticity somewhat biased (see Chapter 10 in Wharton Risk Center (2005) for an analysis of residential demand for hurricane risk coverage in the United States.). We have overcome this limitation here thanks to access to a complete set of data provided to us by Marsh.

features of the Terrorism Risk Insurance Act (TRIA) under which this market operates today. During the first few months after the passage of TRIA, less than 25 percent of large U.S. firms bought some type of terrorism insurance. We find that since that time, the market penetration has continuously increased until it reached a plateau in 2005 at about 60 percent for these large firms, where it remains today.

Section 4 describes the dataset, explains the empirical strategy, then presents and discusses the results of our econometric analysis. We perform a number of empirical estimations: We first look at the effect of corporate characteristics on the decision for terrorism insurance. Contrary to what one might have expected -that large companies are typically more diversified, have easier access to capital and therefore are less likely to buy insurance– we find that, other things being equal, large firms in our sample are more likely to buy terrorism insurance than smaller companies. We also find that firms who have purchased earthquake insurance, which is typically not required as a condition for a mortgage, are actually less likely to buy terrorism insurance. Another important result we derive from the analysis is that a higher solvency ratio (a proxy for how a company handles its long-term debt) reduces the demand for insurance significantly (by a factor of 0.23 in the case of terror coverage). The need for liquidity is more important than the solvency issue.

We then estimate and compare price elasticities of standard property and terrorism coverage using a demand-supply system of equations. We also test whether these elasticities vary by the size of a company. We find that corporate demand for terrorism insurance is more price-inelastic than demand for property coverage. The same 10 percent increase in price will reduce quantity of property coverage purchased on average by 2.92 percent where it will reduce the quantity of terrorism coverage by only 2.41 percent. The range of price elasticities is somewhat stable across firms of different sizes, even though demand is slightly more inelastic for the largest firms in our sample.

After undertaking this analysis we examine a possible "New York effect": Firms headquartered in the New York metropolitan area behave in a different way than those headquarters in other parts of the country. We find that price for terrorism insurance is actually two times higher in the New York metro area than it is in the rest of the country. Still, the price elasticity of the demand for terrorism insurance is about the same in the New York metro area as it is in the rest of the country (-0.249 versus -0.247). One explanation is that these companies see this location as being a more prominent target than the rest of the country, thus have a higher willingness to pay for terrorism insurance.

Section 5 concludes with some implications for federal intervention into catastrophe markets and policy implications for the U.S. terrorism insurance market specifically.

2 Related Literature

The analysis developed in this paper provides insights for two fields of research in economics: the economics of national security (how financial protection of commercial enterprises will help speed the recovery process in the aftermath of a terrorist attack), and corporate decision-making regarding insurance. We discuss them in turn now.

2.1 Economics of national security and government intervention in terrorism insurance markets

Not surprising, the field of economics of national and international security has been growing following the 9/11 attacks and the start of the wars in Afghanistan in 2001 and Iraq in 2003[6]. Looking specifically at terrorism risk, the literature in this field can be subdivided into three major strands.

The first one deals with the causes and origins of terrorism by investigating the nature of terrorism, the formation of terrorist movements, their behavior (e.g. Hoffman 1998, Stern, J. 2003, Sandler & Enders 2004), whether and, if so, how terrorism and economic factors such as poverty, education are related (e.g. Krueger & Maleckova 2003, Blomberg, Hess & Weerapana 2004, Enders, Sachsida & T. 2006, Mirza & Verdier 2008) as well as the possible effectiveness of counter-terrorism activities (e.g. Lapan & Sandler 1988, Lee 1988, Frey & Luechinger 2007, Sandler & Enders 2004).

The second area of research deals with the consequences of terrorism on society. For instance, several empirical studies in economics have been conducted on the effects of terrorism on a variety of indicators such as GDP (Tavares 2004), life satisfaction (e.g. Frey, Luechinger & Stutzer 2007), companies' stock value (Abadie & Gardeazabal 2003, Doherty, Lamm-Tennant & Starks 2003, Brown, Cummins, Lewis & Wei 2004), foreign direct investment (Enders et al. 2006), vacancy rate in business offices of large cities (Abadie & Dermisi 2010) or tourism activities (Drakos & Kutan 2003).

The third strand of literature, to which this paper contributes most, has its focus on financial protection against the consequences of terrorism attacks. Most of the papers published on this question so far are policy-oriented contributions, which examine the role of the public and private sectors in providing financial coverage against terrorism (Kunreuther & Michel-Kerjan 2004, Smetters 2005, Jaffee 2005, Jaffee & Russell 2005). Other contributions look more specifically at how risk is shared between different stakeholders under the current public-private TRIA program in the United States (U.S. Congress, Joint Economic Committee 2002, U.S. Department of Treasury 2005, Wharton Risk Center 2005, Kun-

[6]For instance, Martin Feldstein established the NBER Group on Economics of National Security in 2006.

reuther & Michel-Kerjan 2005, Kunreuther & Michel-Kerjan 2007), and under programs established in other countries (U.S. Government Accountability Office (GAO) 2005, Organization for Economic Cooperation and Development (OECD) 2005, Michel-Kerjan & Pedell 2005, Michel-Kerjan & Pedell 2006). Most contributions in the literature on terrorism insurance thus focus on the supply side of the market.

Quite surprisingly, the demand side has received only minor attention in the economic literature. Do more firms buy terrorism coverage today than just after TRIA was enacted at the end of 2002? How is the size of a company likely to affect its decision to buy terrorism insurance or not? What is the price of terrorism insurance today? How does the price vary by location and size of firm? What can we infer on how these firms perceive the likelihood to be victims of a terrorist attack? What is the price elasticity of the demand function? How does it vary by location and size of firms? How does the demand is affected by financial characteristics of the firm such as assets, solvency and currency ratios? This paper tries to shed some light on these issues.

In doing so, this paper also contributes to a better understanding of corporate decision-making regarding financial protection against catastrophic risk, using terrorism as an illustrative example of catastrophes potentially facing large firms. Here we stand at the crossroads with another important field in microeconomics, the analysis of firm behavior under risk and uncertainty.

2.2 Firm behavior under risk and uncertainty

The second field of literature this paper contributes to is the study of firms' behavior under risk and uncertainty. Here we are interested specifically in firms' decisions regarding insurance purchase. If corporations were perfectly risk-neutral agents and simply profit maximizers, insurance priced above actuarially fair rates should not be attractive to them. Still, firms, small and large, do purchase such insurance. This insurance puzzle has been extensively discussed in the economic theoretical literature in the past 25 years. Several possible explanations emerged.

One explanation is that corporations are required by law to buy some insurance (e.g. workers' compensation insurance is required in all states of the Union, except Texas). There might be also contractual obligations from a bank or bond covenant (Garven & MacMinn 1993). Aside from these requirements, a number of scholars have tried to develop a positive theory of corporate insurance demand. There might be some tax incentives since the tax code allows firms to deduct insurance premiums as business expenses (Main 1983)[7]. Mayers & Smith (1982) and MacMinn (1987) argue that insurance is just another form of

[7]The finance literature on corporate hedging also find evidence that firms hedge to reduce tax liabilities; see Nance, Smith & Smithson (1993)

financing by firms and that it helps avoid the transaction costs of bankruptcy. Indeed the probability of incurring these costs is lowered by shifting the firm's exposure risk to the insurance company. In the specific case of large companies though, which are typically owned by a large number of stockholders, the degree of diversification of the assets can be so high that there would be no need for insurance (Mayers & Smith 1982). If this is the case, then we should see larger companies being less likely to buy standard or terrorism coverage.

Still, another way to look at corporate behavior has been suggested by Greenwald & Stiglitz (1990) and Greenwald & Stiglitz (1993) who show how the introduction of the risk of a significant cost of bankruptcy and the existence of incentive systems within the firm could lead firm managers to act in the name of the company in a risk-averse manner. Such behavior might be particularly relevant in the case of terrorism. For instance, managers of large and very well known companies might be more likely to buy insurance than those of smaller firms if they believe they are more vulnerable to attack. That would be the case if they anticipate that terrorist organizations will view their corporation as an American symbol or trophy target. In the same vein, specific locations, such as the New York area where the two attacks perpetrated by international terrorist organizations on U.S. soil took place in 1993 and 2001 are legitimately viewed by many as a prime target; corporate demand there is likely to be higher than in the rest of the country. Furthermore, managers of these companies would not want to be singled out in the aftermath of a terrorist attack as not having protected their company against such a potentially catastrophic risk. If this prediction is correct, then we should see larger companies being more likely to buy some terrorism coverage.

Using the size of the company as a proxy for it being a trophy target and its capacity to self-insure and/or raise capital in the aftermath of a catastrophic loss, our data allow us to test which of these opposing effects is more relevant for larger companies' insurance decision. To our knowledge, no empirical study on corporate demand for property insurance has been published on the U.S. market due to the lack of available data. Regarding corporate demand for terrorism insurance in the U.S., Michel-Kerjan & Pedell (2006) provide the first study by comparing how much similar companies do pay for terrorism insurance in the U.S. versus Germany and the U.K., but their analysis is based on aggregate data so no econometric analysis were undertaken at a microeconomic level (we come back to some of these results in the discussion section).

The present paper extends their work by undertaking an econometric analysis of firm-level data. Marsh & McLennan, one of the largest insurance brokers, provided us with company-level data on their large clients headquartered in the U.S. in 2007 and the rating agency A.M.Best on insurers' characteristics. Before we discuss the data and econometric

analyses in section 4, the next section provides some background information on the evolution of the U.S. terrorism insurance market over time and the operation of TRIA.

3 Background on TRIA and Terrorism Insurance Demand

The 1993 bombing of the WTC killed 6 people and caused $725 million in insured damages. The Oklahoma City bombing of 1995, killed 168 people, but the largest losses were to federal property and employees, and were covered by the government. Before 9/11, insurance losses from terrorism were viewed as so improbable that the risk was not explicitly mentioned in any standard policy and hence the rate for providing such coverage to firms was never calculated. De facto terrorism was covered in most commercial insurance contracts. As Berkshire Chairman Warren Buffett said in his 2001 letter to shareholders: "we, and the rest of the industry, included coverage for terrorist acts in policies covering other risks, and received no additional premium for doing so."

Things radically changed in 2001. The terrorist attacks of September 11, 2001 killed more than 3,000 people[8] from over 90 countries and injured more than 2,250 others. The attacks also inflicted damage currently estimated at nearly $80 billion, about $32.5 billion of which (2001 prices) was covered by nearly 150 insurers and reinsurers worldwide (including $21 billion for damage and business interruption alone) (U.S. Department of the Treasury, Board of Governors of the Federal Reserve System, U.S. Securities and Exchange Commission, Commodity Futures Trading Commission 2006). Private reinsurers, who covered a majority of these losses, decided to exit this market, leaving insurers without protection. A few months after 9/11, insurers had excluded terrorism from their policies in most states. Commercial enterprises thus found themselves in a very difficult situation, with insurance capacity extremely limited and prices very high[9]. One year after 9/11, when national security had became the "number one" priority on the agenda of the United States and internationally, the country's commercial enterprises remained largely uninsured at home (Hale 2002). If another large-scale attack had occurred at that time,

[8]This number represents victims of the attacks in New York, Washington, DC, and Pennsylvania as well as among teams of those providing emergency service.

[9]Consider the case of insuring Chicago's O'Hare Airport. Prior to 9/11, the airport had $750 million of terrorist insurance coverage at an annual premium of $125,000 (an implicit probability of 1 in 4,300 if one disregards for simplicity additional administrative cost charged by the insurer). After the terrorist attacks insurers offered the airport only $150 million of coverage at an annual premium of $6.9 million (a revised implicit probability of 1 in 22; a 200-fold difference since the 9/11 attacks). The airport purchased this coverage and could not obtain any more (Jaffee & Russell 2005). Another example is the Golden Gate Park in San Francisco, which was unable to obtain terrorism coverage; moreover, even its non-terrorism coverage was reduced from $125 million to $25 million-and the premiums for this reduced amount of protection increased from $500,000 in 2001 to $1.1 million in 2002 (Smetters 2004)

the impact on the local economy could have been much more serious than it was on 9/11. The economic losses would not have been spread over a large number of insurers and reinsurers worldwide but, in the absence of massive government funding, sustained by the firms themselves. The lack of availability of terrorism insurance shortly after the 9/11 attacks led to a call from some private sector groups for federal intervention. For example, the U.S. Government Accountability Office reported in 2002 that the construction and real estate industries claimed that the lack of available terrorism coverage delayed or prevented several projects from going forward because of concerns by lenders or investors (U.S. General Accounting Office (GAO) 2002).

In response to such concerns, the Terrorism Risk Insurance Act of 2002 (TRIA) was passed by Congress and signed into law by President Bush on November 26, 2002[10]. This program was originally aimed at providing a three-year temporary measure to increase the availability of risk coverage, but the program has been renewed twice since. TRIA is now extended up to the end of 2014, but given the series of renewals in the past few years one might expect this program to be extended again in the future[11]. TRIA operation is somewhat complex and it is not the purpose of this paper to analyze it. Still, there are features of TRIA that will be important for this analysis and also for potential policy implications of our results. First, TRIA requires insurers to offer terrorism coverage to all their commercial clients (a legal "make available" requirement)[12]. These firms have the right to refuse this coverage unless it is mandated by state law, as in the case of workers' compensation lines in most states[13]. Second, loss sharing under TRIA is somewhat complex. The first layer is provided by insurers through a deductible. It is calculated as a percentage of the TRIA-line direct commercial property and casualty earned premiums of each insurer in the preceding year[14]. The second layer up to $100

[10]The complete version of the original Act can be downloaded at: http://www.treas.gov/offices/domestic-finance/financial-institution/terrorism-insurance/claims_process/program.shtml

[11]Many federal programs established in the past have actually benefited from quasi-systematic renewal since they were first established. That is true of the Price-Anderson Act first passed in 1957 to partially indemnify the nuclear industry against liability claims arising from nuclear incidents; the National Flood Insurance Program established in 1968 for covering against flood; and the California Earthquake Authority created in 1996 to provide insurance against earthquakes in that state.

[12]Residential coverage is not included in this program.

[13]Workers' compensation coverage is mandatory for a majority of employers in all states but Texas, where it is optional. Employers must either purchase insurance or qualify to self-insure. Workers' compensation laws do not permit employers or insurers to exclude coverage for worker injuries caused by terrorism.

[14]The percentage increases sharply over time: 7 percent in 2003, 10 percent in 2004, 15 percent in 2005, 17.5 percent in 2006 and 20 percent in 2007. As illustrative figures, a Morgan Stanley study estimates that AIG's 2004 deductible was $2.7 billion. Other insurers, such as Travelers, ACE, Chubb and Berkshire had lower 2004 deductibles: $928 million, 743 million, $600 million and $200 million, respectively (Morgan Stanley 2006). According to Wharton Risk Center (2005), deductibles would have more than doubled in real terms by 2008.

billion is the joint responsibility of the federal government and insurers. Specifically, the federal government is responsible for paying 85 percent[15] of each insurer's primary property-casualty losses during a given year above the applicable insurer deductible; the insurer covers only the remaining 15 percent.

The federal government does not receive any premium for providing this reinsurance coverage, but can recoup part of its payment post-attack against all commercial policyholders in the country. Hence, the insurance premium paid by a commercial firm for insurance coverage under TRIA today is much lower than it would be without the free up-front reinsurance provided by the federal government. This gives rise to important policy questions: What are the effects of this free reinsurance on insurers' behavior? Should the federal government continue to provide this type of free reinsurance (or should the market provide all or part of this reinsurance at a cost)?

So far, the main counter-argument against charging for this federal reinsurance (as is done in European countries such as France, France and the U.K.) has been that businesses in the United States would drop their terrorism coverage because they would not be able to sustain the resulting increase in price (which would happen if insurers are deprived of free federal reinsurance). Nevertheless, no one has provided empirical evidence to validate this assertion. Our results provide important insights to this debate.

4 Empirical Analysis

Our empirical analysis of the corporate demand for catastrophe insurance consists of three parts. On the demand side, we first examine the drivers of the decision to purchase coverage against terrorism., Among companies that have terrorism insurance, we analyze the determinants of the quantity of terrorism coverage purchased under TRIA. As a reference point, we compare these results with companies' decisions as to whether to purchase standard property insurance and how much such coverage they have. Second, we turn to the supply side and analyze some factors that can impact insurance pricing (e.g,. exposure, assets, liquidity, and rating). Finally, we combine demand and supply to determine demand elasticity and other economic measures. We also estimate regional differences between the New York metropolitan area and the rest of the country.

4.1 Data

The data for the demand side of the study was provided by Marsh on the property insurance contracts they brokered to their clients in 2007. Company identities are kept

[15]Before 2007, the federal government was responsible for paying 90 percent.

anonymous through the use of random ID numbers designed specifically for this study. Data was reported through an internal Internet form completed by brokers of the different Marsh offices in the United States. We assume that any broker or office idiosyncrasies were randomly distributed across the dataset.

The original data included 1,884 companies. We removed erroneous entries from the dataset, as well as a few companies that purchased stand-alone terrorism coverage only (coverage of all assets of the company worldwide, which is independent of TRIA and negotiated at a world level by the corporation). We also removed several companies with total insured value lower than $1 million. We were left with 1,808 companies, 1,064 of which had purchased some type of terrorism insurance in conjunction with their normal property insurance; that is a market penetration of 59 percent[16]. For 628 of these 1,064 companies we have observations for all relevant dependent and explanatory variables.

The data does not include exact information on the physical location of the company's assets. We used the address of the Marsh office which brokered their policy (typically in the same location as the headquarters of the company) as the proxy for location. Indeed, each individual contract covered multiple locations for a single company and we assume that the number of locations per company is randomly distributed across our data set. Marsh divided their offices into the nine major regions, each combining a number of states[17].

Firms in the dataset can be divided into 21 industry sectors[18]. Table 1 shows the distribution of companies within the full samples across these different industry sectors[19]. It also shows the number of companies with TRIA insurance. Table 2 shows the same data

[16]Market penetration/take-up rate is defined as the fraction of companies that have a terrorism insurance policy, and not the amount of assets insured against terrorism over the total amount of assets. This 59 percent is consistent with the evolution of market penetration in the past few years. Data for previous years show a significant and fairly continuous increase of the take-up rate, from 23 percent in the second quarter of 2003, 45 percent in 2004, 56 percent in 2005, and 60 percent in 2006.

[17]Central Midwest - Illinois, Indiana, Minnesota, Missouri, Wisconsin; Mid-Atlantic - District of Columbia, Maryland, Pennsylvania (Harrisburg, Philadelphia), Virginia; New York Metro - New Jersey (Morristown), New York (New York), Connecticut (Norwalk); Northeast - Connecticut, Massachusetts, Maine, New York (Rochester, Syracuse), Rhode Island; South Central - Louisiana, Oklahoma, Texas; Southeast - Alabama, Florida, Georgia, North Carolina, South Carolina, Tennessee, Virginia; Southwest - Arizona, California (Los Angeles, Newport Beach, and San Diego); Upper Midwest - Kentucky, Michigan, Ohio, Pennsylvania (Pittsburgh); West - Alaska, California (San Francisco, San Jose), Colorado, Hawaii, Oregon, Utah, Washington. –Note that California, New York, and Pennsylvania include offices that are in multiple regions. The specific locations are included in parentheses.

[18]Agriculture, Construction & Design Firms, Distribution, Education, Financial Institutions, Food & Beverages, Healthcare, Hospitality & Gaming, Manufacturing, Media, Mining, Pharmaceutical, Power & Utilities, Public Entities, Real Estate, Retail/Wholesale, Services, Technology, Telecomm and Transportation.

[19]It is interesting to observe how this take-up rate has evolved in recent years by specific industry sectors. Between 2003 and 2007, take-up rates in all sectors jumped from a 10 - 30 percent to a 50 - 80 percent range. Financial institutions, education, health care and real estate are the leading sectors in terms of take-up rate (in the 75-85 percent range today compared to 25-30 percent in 2003); manufac-

but for the New York metropolitan area only. As one can see from these two tables, both samples feature a similar distribution of companies across industries but, as expected, they differ in terms of market penetration of terrorism insurance (59 percent for the full sample, 73 percent for the New York Metro sample).

[INSERT TABLES 1 AND 2 ABOUT HERE]

The average size of companies in our sample is measured by assets that are covered under property insurance; that is the total insured value ("TIV" hereafter). The mean TIV in our sample is $1.75 billion (median of $2.95 billion) (see Table 3). We also have information for the full sample as to whether a company has some form of insurance against three types of natural hazards (wind/hurricane, earthquake, and flood). We converted information on natural hazard limits and deductibles into binary yes/no variables. 74 percent of companies in our sample have flood coverage (Table 3), 46 percent have wind coverage and 58 percent have earthquake coverage (not reported in Table 3). This is an interesting statistics in itself given that wind coverage is often required by banks to protect their mortgage. The largest proportion of firms in our sample have some type of quake insurance, which is typically not required.

[INSERT TABLE 3 ABOUT HERE]

The focus of the empirical analysis is on the subsample of companies that have terrorism coverage to estimate the quantity of insurance they purchased. Our dependent variable is a ratio between the maximum compensation they can receive from their insurers for terrorism (limit on the terrorism policy) and the total policy limit of the company (Cover TRIA). We construct the same variable for property insurance (Cover Property); Property TIV indicates the total value of all the assets covered under the insurance contract, which reflects the size of the company. For this part of the analysis we use information on the total premium paid by the company for terrorism insurance (Premium TRIA) and for property insurance (Premium Property). Statistics on these variables are reported in Table 4 and Table 5 (the whole sample and New York Metro only, respectively). We also report in these two tables the premium paid by these companies per $1,000 of coverage for property coverage and for terrorism coverage.

The third part of our analysis consists of estimating the coefficients of interest for a subsample of companies located in the New York Metro area and comparing them to the rest of the country. A quick glimpse at the data in Table 5 reveals that firms in this region are on average twice as large (measured by their TIV) and also that the average

turing, food & beverage, and retail, the lowest (nearly 50 percent today compared to 20-30 percent in 2003).

degree of property and terrorism coverage there (44.1 percent and 39.6 percent) is smaller than in the national sample (54.8 percent and 48.0 percent). Companies in the New York Metro area pay a larger premium for terrorism coverage (both in absolute value- $420,687- and per $1,000 of coverage, $1.36) compared to the national data ($111,963 and 59 cents, respectively). More surprisingly, we find this also to be the case for standard property coverage. On average, firms in the New York Metro area pay $2.28 million for property insurance and $6.15 per $1,000 of coverage (versus $1.24 million and $4.85 in our national sample, respectively). One reason for that might be related to the high number of financial service companies located in this area for which business interruption (included in the standard property coverage) could be particularly expensive[20].

[INSERT TABLES 4 AND 5 ABOUT HERE]

Insurance purchase decisions at the equilibrium result from decisions on both the demand and supply sides. In order to account for this demand-supply interaction we gathered additional data on insurance companies providing property and terrorism coverage to the companies in our sample in 2007. Financial data on insurance companies we used here were based on AM Best Insurance Reports - P/C US & Canada (Version 2008.1). In addition, AM Best provided us with the total premiums collected and the premiums collected for TRIA lines from 2002 to 2008 for these insurance companies. The supply variables (insurers) we use for the empirical analysis are: (1) total assets; (2) overall liquidity, and (3) AM Best rating (proxy for financial strength). Several other variables were created to analyze the supply side. We first determine the share that each company had in the insurer's portfolio (the more diversified an insurer is, the lower the share each one of its clients represent in its portfolio). We consider the ratio limit of the terrorism (property) policy by the sum of TRIA line (total) premiums collected by the insurer in 2006.

The supply and demand datasets were merged using a unique insurance company identifier. Due to missing or inexact information it was only possible to identify the insurance supplier for 421 of the total 628 companies in the subsample. The final sample comprehends of 15 different insurance suppliers. The descriptive statistics of the supply side data are presented in Table 6.

[INSERT TABLE 6 ABOUT HERE]

[20]We thank John Rand for his insight here

4.2 Empirical strategy

The empirical analysis starts with independent estimations of the demand and the supply side functions. To account for the simultaneity of the coverage decisions and pricing decisions we then perform a simultaneous-equations analysis.

4.2.1 Demand side

The empirical analysis of the demand side behavior is complicated by the bounded nature of the dependent variables (Cover TRIA and Cover Property) are always between 0 and 1 as well as the fact that many of our observations are concentrated at the upper boundary. Applying a standard OLS regression or an OLS regression with non-linear transformation of the explanatory variable does not guarantee that the predicted results lie within the range of the independent variable's interval. Papke & Wooldridge (1996) developed a quasi-maximum likelihood estimator (QMLE hereafter) to obtain robust results in that case and we use the same methodology here.

$$ln(coverage_{ij}) = \beta_0 + \beta_1 ln\,(TIV) + \beta_2 ln\left(\frac{premium_{ij}}{limit_{ij}}\right) + I_{ij} + R_{ij} + \epsilon_{ij} \qquad (1)$$

where, $(coverage_{ij})$ denotes for company i's degree of coverage for terrorism and property risk and $ln\,(TIV)$ is i's total insured value. $ln\left(\frac{premium_{ij}}{limit_{ij}}\right)$ is the premium for the terrorism or property policy purchased by company i from insurer j. I and R are industry and regions specific dummies; ϵ_{ij} is the error term with (ϵ_{ij}∼iid $(0,\sigma_\epsilon^2)$). β are to be estimated. We use the natural logarithm of the variables in order to attenuate the effects of the very large numbers.

4.2.2 Supply side

In order to determine the key drivers of the insurer's pricing decision, we estimate separately the following equation for property and terrorism insurance using OLS:

$$\begin{aligned} ln\left(\frac{premium_{ij}}{limit_{ij}}\right) =& \gamma_0 + \gamma_1 fraclimit_{ij} + \gamma_2 ln(limit_{ij}) + \gamma_3 ln(coverage) \\ &+ \gamma_4 ln(assets_j) + \gamma_5 Liquidity_j + I_{ij} + R_{ij} + u_{ij} \end{aligned} \qquad (2)$$

where, $fraclimit_{ij}$ is the share of company i's in insurer j's portfolio defined by the ratio limit on policy divided by the total amount of premiums (TRIA line or total premiums). *limit* reflects the absolute limit of the policy and coverage is the policy's degree of coverage (i.e. ratio limit over TIV in the case of property; terrorism limit over property limit in

case of terrorism). *assets* denotes for total assets of insurer j according to AM Best data and Liquidity is its overall liquidity. γ are parameters to be estimated and u_{ij} is the error term with (u_{ij}∼iid $(0,\sigma_u^2)$).
As an additional robustness check, we include AM Best's rating of the insurers. We construct dummies for each rating level and include them as additional regressors in equation (3). Unfortunately, this variable is only available for 283 out of the 441 observations.

4.2.3 Combining the demand and supply sides

We then apply a simultaneous equations model that recognizes the interaction between the customer's choice on the degree of coverage it purchase from the insurer and the insurance company's choice on the level of premium to charge. We therefore combine equations (1) and (2) and construct a system of equations. Thereby, we treat $coverage_{ij}$ and $ln\left(\frac{premium_{ij}}{limit_{ij}}\right)$ as endogenous and the other variables as exogenous. OLS would render inconsistent results because the endogenous variables are used as regressors in the respective other equation. We employ a three-stage least-square (3SLS) procedure instead to estimate the parameters of interest. The estimates are again performed for property and for terrorism insurance coverage.
A challenge inherent to the data we have is that our sample might not be random. The dataset we have received from Marsh contains a portfolio of 1,884 "large" companies. There could be a systematic bias in the decision which companies enter the portfolio of a given insurer. In addition, the decision on the quantity of insurance a company decides to purchase from the insurer is a decision made by each company and might be driven by unobserved characteristics we cannot control for. Therefore, the subsample of those companies that do have terrorism insurance might be a self-selected sample and not a random sample.
The solution to this problem is the extension to the sample-separation case generally characterized by two simultaneous equations systems corresponding to the two different regimes (company has terrorism coverage or not) and a selectivity criterion which determines the regime to which the observations belong. This procedure was suggested by Lee, Maddala & Trost (1980), which tackles these issues by reflecting the self-selection process in the first stage. We also assume that the probability of a company buying terrorism insurance has an influence on the degree of coverage in the second stage. To our knowledge, this approach is the only consistent estimator given the distribution of our company sample.
In the first stage we estimate a probit model where the dependent variable is a dichotomous indicator equal to 1 for companies that have a terrorism insurance policy and equal to 0 otherwise. The cumulative distribution function is g. We use the natural logarithm of

the total insured value of company i (an empirical proxy for the size of the company). The expectations on the sign of this size variable are ambiguous. On the one hand, as discussed above, larger companies are supposedly more able to diversify their risks. As a result they should be less likely to buy insurance than small firms. This suggests a negative sign. On the other hand, larger companies are a more visible (if not attractive) target for terrorist groups who seek to inflict major economic disruption and to impose fear on a large number of people (idea of trophy target we discussed earlier). Because of that, larger companies might be more likely to buy terrorism coverage and more likely to accept a higher cost of coverage as well. This suggests a positive sign. It is a priori not clear which one will be the most important effect.

The first stage specification also demands a variable that fulfills the exclusion criterion. We use a proxy for a company's attitude toward risks (measured here by degree of coverage for property) and specific attitude toward low probability-high-loss events (e.g. natural hazard insurance). We construct a dummy variable that switches to 1 if there is either information on the premium, deductible or limit in flood insurance indicating that the firm has protected itself against these hazards and equals 0 otherwise (no natural catastrophe insurance reported).

The predicted value from the first stage is then used to calculate the inverse Mills ratio[21]. This ratio measures the likelihood that a company has some terrorism coverage. Following the methodology developed in Lee et al. (1980) we estimate a reduced form equation of the pricing model and integrate the inverse Mills ratio. We then use the predicted values of this estimate to construct an instrument for premium/limit to be used in the final demand side estimate of the coverage. This demand side equation includes the exogenous regressors, the instrument as well as the inverse Mills ratio.

Differences in the demand for terrorism insurance and for property insurance as a function of company size might be explained either by the fact that terrorism can be viewed as a catastrophic risk by some managers in charge of buying insurance in those firms who want the company to be protected, some requirements by lenders, while other managers might simply think a terrorist attack will not happen to them. Unfortunately, there is no way we can determine how managers reacted to this risk without interviewing the relevant decision makers.

How price elasticity of the demand for property insurance differs from the elasticity of the demand for terrorism insurance is not necessarily obvious. Grace, Klein & Kleindorfer (2004) have shown for residential insurance that the demand for homeowners' insurance was much less price elastic than the demand for catastrophe risk insurance. This re-

[21]The inverse Mill's ratio is calculated by dividing the probability density function by the cumulative distribution function.

sult is somewhat puzzling since the house often represents a large portion of a family's wealth. One could think that individuals would be willing to pay more for insurance to protect them against true catastrophes that can destroy all their assets. But many don't. In the context of commercial insurance, no one has determined how price elasticity for catastrophe versus non-catastrophe (property) insurance differs.

4.3 Regression Results and Discussion

We first discuss the results from the quasi-maximum likelihood estimator (QMLE) estimates. Table 7 summarizes the results for the demand for terrorism insurance and for property insurance for the full sample; it also summarizes results for the New York Metro area alone and the subsample of all other regions combined except New York.

[INSERT TABLE 7 ABOUT HERE]

The coefficient of TIV is negative and highly significant, indicating that larger companies have on average a lower degree of coverage than smaller firms. Comparing the coefficients of the TIV shows that there are almost no differences in the effect of company size between terrorism and property insurance. In both cases, we find that among firms that have purchased terrorism coverage, larger companies tend to have a lower coverage of their asset (limit over TIV).This is in line with the theoretical literature. Doherty (2000) suggests that companies obtain insurance cover in order to access the risk-management expertise of the insurers as well. Larger companies are more likely to have some form of in-house risk-management and demand less of these "real-services" from the insurer. Larger companies also have better access to short term capital and might substitute market insurance with self-insurance (Hau 2004).

Results on price elasticity based on the demand side only are in the second row in Table 7. Comparing the estimates for terrorism insurance and for property insurance we can see that the demand for terrorism insurance is less price elastic (-0.191 versus -0.316). This means that a price increase of 10 percent will decrease the quantity of property insurance purchased by 3.16 percent but the quantity of terrorism insurance by only 1.91 percent (i.e. 65 percent more for property than for terrorism insurance). The theoretical model by Hau (2004) and the empirical results by Aunon-Nerin & Ehling (2008) suggest that companies with better access to the capital market have lower insurance coverage. We therefore include solvency ratio (a measure of how a company meets its long-term debt) and the current ratio (a measure of how a company meets its short-term debt) as additional regressors in our demand side estimates. Data on solvency ratio and current ratio are available for only 203 and 193 companies, respectively. The results presented in

Table 8 indicate that estimates are robust to the inclusion of these ratios (demand is more inelastic for terrorism coverage than it is for property coverage). Solvency ratio appears to have the substitutional effect as suggested by Aunon-Nerin & Ehling (2008), however the coefficient is only significant in the case of terrorism insurance. These results suggest that companies use their ability to self-insure as a substitute for catastrophe insurance but not for property insurance. Current ratio appears to have no impact on the demand for terrorism and property insurance.

[INSERT TABLE 8 ABOUT HERE]

We now turn our focus on the supply side and the determinants of insurers' pricing decision presented in Table 10.

[INSERT TABLE 9 ABOUT HERE]

Contract specific variables such as the policy limit and the degree of coverage are important determinants of premiums charged by the insurer. As shown in Table 9 (full sample) both variables have a positive sign and are highly significant. This indicates the insurance companies give discounts for larger limits in general as well as a higher degree of coverage. Both can be explained by decrease of some administrative costs (i.e. transaction costs related to evaluate the customer's exposure to a certain risk) with higher limits and degrees of coverage. A striking result is the different effect of the share of policy limit in the insurer's portfolio, FracLimit. This is our empirical proxy for the insurer's diversification effort. We find a positive and significant (at least at the 10 percent level) effect for property insurance and a negative and not-significant effect for terrorism insurance. This results allows two interpretations of the effect of federal intervention in the market for terrorism insurance: First, in contrast to the insurer's property portfolio, the TRIA line portfolio benefits from free re-insurance by the federal government under TRIA (above a certain deductible). This free federal reinsurance can lead insurers to care less about concentration of risks than they do for property since in that case they retain 100 percent of the losses (or have to pay for private reinsurance). Free federal re-insurance can crowd-out the insurers fulfillment of the main purpose of insurance: diversification of risks. Second, the obligation of insurers to offer terrorism insurance to every corporate customer (with a property insurance policy) reduces the insurer's options to make appropriate decisions regarding diversification in it's portfolio. This result has important policy implications we are going to discuss in more detail in the next section. As expected, assets and liquidity -which are proxies for the insurers' financial strength and capacity to meet their obligations- have a positive effect but appear to be significantly different from zero only in a few cases. We apply a number of robustness checks. First we include

AM Best's financial strength ration (Table 10). The results are robust. We also include a number of other liquidity measures as well as the insurer's organizational form (i.e. stock vs. mutual). Again the estimates stay robust, but the additional variables do not appear to have an effect on the pricing.

[INSERT TABLE 10 ABOUT HERE]

The New York Metro Effect - The second set of terrorism demand regressions focus on the comparison between the New York Metropolitan subsample and the rest of the country (see "New York" columns in Table 7). The decreasing effect of company size on terrorism insurance is slightly lower in New York than in other regions. As expected, given the highly perceived exposure to terrorism in this region, corporate demand for terrorism insurance is less elastic in New York than it is in all other regions (about half). Also, the difference in the price elasticity between terrorism and property insurance within the New York sample (153 percent) is larger than in the rest of the country (45 percent) (Table 6). Given that the average premium for terrorism insurance is about two times higher in New York Metro than in the rest of the country, these results indicate that corporations in this specific region are much more sensitive to terrorism risks and their demand for coverage is less responsive to small price changes . In contrast, the estimates for the supply side do not yield significant results (except for the coefficients of the coverage and the liquidity variables). The 65 companies in the New York subsample (where information on the insurer is available), purchased insurance from one of 13 companies, where about 85 percent of the contracts were bought from two insurers. We assume that this lack of supply-side variance explains the results we obtain for the pricing estimates for the New-York subsample.

Demand-Supply Analysis - In the next step of our analysis, we relax the assumption of the independence of the demand and the supply side equations and apply a simultaneous-equation analysis. The results are presented in Table 12. In general, the key results of the independent estimates hold. The price elasticity for terrorism insurance is still smaller than for property insurance, even though the difference decreases (except for the New York sub-sample; as we just discussed, these New York estimates should be interpreted with care though, due to the lack of variance in the supply side equation). We still find an indication that insurance companies apply a different diversification strategy incentives for terrorism and for property insurance (the coefficient of the variable fraclimit is significant and positive for the property but not for the terrorism insurance estimates).

[INSERT TABLE 11 ABOUT HERE]

In the last step, we control for sample selection. As shown in Table 12, the results are again robust. The selection variable Flood has a strong positive coefficient in the first

stage estimates. The coefficient of the inverse mills ratio is not significantly different from 0. This suggests that sample selection might not be a problem in our case.

[INSERT TABLE 12 ABOUT HERE]

Insurance demand and the size of companies - The first stage estimates in Table 12 also reveal that larger companies are more likely to have some coverage against terrorism (as well as some general property insurance), but the degree of coverage decreases with company size (again, both for terrorism and property insurance). This negative relationship between degree of coverage and company size can be explained by the fact that premiums are not actuarially fair. Premiums per unit coverage in higher layers tend to be disproportionately high for higher layers. In addition, premiums are subject to supply shocks over time although the risk (and thus an actuarially fair premium) stays the same. Unfortunately, our dataset includes only the total premium paid and has no separate information on the premium per unit coverage in different layers. Due to the data constraints, the creation of a panel-dataset and the analysis of premium variations over time are not possible. Controlling for supply side effects on pricing would further require information from the insurance companies which is not available.

Insurance premiums and implicit perceived probability-Before we turn to the policy implications of our results, we would like to briefly discuss terrorism pricing. One major difficulty in economics of security in general and terrorism insurance markets in particular is that it is almost impossible to provide a robust distribution of probability for terrorist attacks on U.S. soil. Given this difficulty, how can one determine the expected losses-and thus the "right" price? Is $592,000 in TRIA premium paid by a company to purchase $1 billion terror limit on its coverage an expensive deal, or a bargain? (Table 5). This amount increases to $1.36 million in premium for firms in the New York Metropolitan area with the same $1 billion terror limit(Table 6). Is it justified? It is hard to tell for sure. Maybe a better way to interpret these numbers is to look, as a reference point, at what the company pays for standard property insurance, for which one has a better handle on risk assessment. We find cost of insurance for standard property coverage to be nearly eight times higher than for the same quantity of terrorism coverage in the national sample. One possible reading of these results in Tables 5 and 6, assuming 2007 data remain the same today, is that given the current design of TRIA and market prices, firms in the United States see themselves as having a 1-in-206 chance to trigger their standard property limit this year (they pay $4.848 per $1,000 of property coverage), versus a 1-in-1690 chance to trigger their terrorism limit ($0.592 per $1,000 of terrorism coverage) (Table 5). When we look at New York Metro only (Table 6), this difference is reduced by half - the cost of insurance for standard property coverage is nearly four times higher than for the same

quantity of terrorism coverage. Using similar implicit probability reasoning, U.S. firms operating in the New York Metro area see themselves as having a 1-in-160 chance to trigger their standard property limit ($6.149 per $1,000 of coverage) versus a 1-in-730 chance to trigger their terrorism limit ($1.362 per $1,000 of terror coverage).

Another way to look at the price of TRIA coverage is to compare it with what firms with similar characteristics are paying in other countries. The data reveal that corporate terrorism insurance has become extremely inexpensive in the United States compared to what it is in Europe. In a companion study, we found that on average, large firms in the U.S. were paying two or three times less for terrorism insurance than what they were paying in Germany for the same amount of coverage. And even for financial institutions, which are typically located in places considered at higher risk, we found that in 2006, U.S. financial institutions were paying the same price as their German counterparts were paying in Germany (Michel-Kerjan & Pedell 2006). Unless one believes that the risk of large terrorist attacks has become similar or even much higher in Germany than it is in the U.S., which is quite unlikely, one should conclude that under current market conditions, terrorism insurance has become largely underpriced in the United States[22].

5 Conclusions, Policy Implications and Future Research

5.1 On corporate demand for insurance

Important contributions have been made in the past two decades that help explain decisions made by corporations as to how they decide to protect their assets against all sorts of risks they face, and the role that insurance can play in that regard. These are mainly theoretical contributions, however. Microeconomic analysis of demand for insurance is much more developed for individual decision than for corporations (Grace et al, 2004; Kunreuther and Michel-Kerjan, 2009). Part of the explanation for the lack of empirical work to test these theories has been that while there are large datasets available on the homeowners' insurance market (for instance, from the National Association of Insurance Commissioners), accessing data on a large number of corporations is difficult. Competition among firms, proprietary issues and anti-trust law make it often even more difficult for the research community to access a large enough data sample to undertake substantial microeconomic analysis on corporate insurance decision. Thanks to a unique cooperation with Marsh & McLennan, we have been able to provide the first analysis of U.S. corporate demand for insurance and compare firms' behavior for catastrophe and

[22]The alternative is that terrorism is simply overpriced in Germany. Nevertheless, data on the British and French terrorism insurance markets reveal that the cost of terrorism in these two countries is aligned with (if not even higher than) what it is in Germany (Michel-Kerjan & Pedell 2006).

non-catastrophe risks, using terrorism threat as an illustration. Looking specifically at over 1,800 large companies across regions and industry sectors that are headquartered in the United States, we conclude that larger companies are more likely to purchase terrorism coverage; however among those who have terrorism insurance, corporate behavior for standard property and terrorism coverage does not significantly differ with size. This might be the case because firms tend to purchase a limit for terrorism insurance close to what they have for standard property-we find that 80 percent of our sample does. Still, controlling for regional effects and industry sectors, we find that the demand functions have significant difference in price elasticity: demand for standard property is significantly more elastic than for terrorism insurance. This result is opposite to the seminal study by Grace et al. (2004) on homeowners, which finds that demand for property insurance is less price elastic (price elasticity of 0.4) than for catastrophe risk insurance (hurricanes; price elasticity of 1.9).

We also test for a possible "New York effect": given that prices for terrorism coverage are much higher in the New York Metro area than in the rest of the country, do we still see differences in price elasticity of demand for terrorism insurance? Looking at the demand side independently of the supply of insurance we find that firms exhibit a demand function for terrorism coverage in the rest of the country that is two times more price elastic than it is in the New York Metro region. That said, this difference changes when we account for both demand and supply (but maybe because of the peculiarities of our sample)

5.2 Policy implications for government intervention in market for catastrophes

In addition to contributing to the literature on corporate demand for insurance, these empirical results also provide input to the growing literature on economics of national security. After Al Qaeda's attacks on September 11, 2001, the insurance and reinsurance markets failed to provide adequate coverage to millions of firms operating in the United States and other OECD countries because terrorism became almost overnight uninsurable by the private sector alone. As in several European countries, the U.S. federal government intervened in the market to ensure firms had access to sufficient terrorism coverage and that coverage would be available at an affordable price. In the U.S., TRIA was passed in 2002 and has been renewed twice, until December 2014.

One important policy goal of TRIA was to make sure terrorism insurance would be accessible to many corporations that would need it. Data show that market penetration has significantly increased over the first few years of the implementation of TRIA to reach a plateau at about 60 percent. In that sense, federal intervention into this market has

reached its goal: a majority of the companies we studied have benefited from TRIA and bought coverage. Still, we find that four out of ten of these companies have decided not to buy that coverage. There might be several reasons for that. First, while our analysis shows that the demand for terrorism insurance is pretty inelastic, it also shows that smaller companies are more likely not to buy insurance. This might be because they think they are not at risk or because they have limited resources to spend on other insurance than the standard property coverage, or both. Second, a company that does not buy TRIA terrorism insurance is still effectively covered against terrorism for workers' compensation in all states but Texas and for fire following an attack in half the states. Also, current terrorism insurance policies typically do not cover against attacks using weapons of mass destruction (so-called CBRN; chemical, biological, radiological and nuclear), which are viewed by many as the main source of potential mega-catastrophe. So some companies might consider that the TRIA coverage is not such a great arrangement. Third, we show that companies with higher solvency ratio buy less terrorism insurance; these companies might decide that self-insurance is a more economically appealing proposal given their financial strength. Finally, given how federal government has intervened after recent disasters (rescuing the airlines after 9/11 and banks after the subprime crisis), some might simply expect the federal government to intervene after the next big disaster (although our data cannot validate this assumption).

Another important element of federal intervention in this terrorism insurance market is that TRIA requires insurers to offer the same limit on the coverage for terrorism risk as for standard property; firms could then decide to buy that quantity of insurance, less or more (if the insurer is willing). Our results show that the way the government designed this program had an important impact on firms' behavior. Indeed, 80 percent of the firms in our sample bought the same quantity of insurance for terrorism as they had for standard property coverage. This "anchoring" effect calls for more research.

Finally, as we discussed, under TRIA the government provides insurers with free federal reinsurance. Our results show that this led some insurers to give less attention to terrorism risk diversification then they probably would if they had to pay for this reinsurance from the private sector. Whether the government should continue to provide this free coverage to corporations or whether private insurers and reinsurers could re-enter this market by providing coverage for some layer currently covered by the government has been under debate since the inception of the program. It has been said that doing so would immediately increase the price of coverage firms would have to pay and result in a significant drop in coverage, thus making many companies more vulnerable economically. Our results do not support this statement; our determination of price elasticity indicates that for any extra 10 percent the firms in our sample would be asked to pay for terrorism,

they would decrease their coverage by only about 2.4 percent. There seems to be flexibility for policymakers to favor new market-based solutions.

The results of our analysis should be regarded as a starting point for future research in this field. Given the data constraints, we were able to study only a limited number of questions raised by the theoretical literature on corporate demand for insurance. For future work, it would be useful to access more detailed corporate information on liquidity, access to short term credit or decision structures within the company (including incentive systems in place) in order to provide a comparative analysis of how these other characteristics affect corporate demand for property and terrorism insurance. It would also be useful to extend our analysis to other catastrophic risks than terrorism, and also to countries with different institutional settings and different degrees of government involvement in commercial insurance markets, which might also influence how large companies operating there use insurance.

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Table 1: Distribution of Companies and Terrorism Insurance Across Industries - Full Sample

Industry	**Firms**	**in %**	**With terror insurance**	**in %**
Agriculture	11	0.61%	3	27.27%
Construction & Design	46	2.54%	23	50.00%
Distribution	35	1.94%	19	54.29%
Education	75	4.15%	55	73.33%
Financial Institutions	78	4.31%	56	71.79%
Food & Beverages	79	4.37%	40	50.63%
Healthcare	156	8.63%	115	73.72%
Hospitality & Gaming	84	4.65%	56	66.67%
Manufacturing	452	25.00%	199	44.03%
Media	46	2.54%	29	63.04%
Mining	18	1.00%	3	16.67%
Pharmaceutical	36	1.99%	20	55.56%
Power & Utilities	105	5.81%	69	65.71%
Public Entities	59	3.26%	35	59.32%
Real Estate	124	6.86%	97	78.23%
Retail & Wholesale	125	6.91%	70	56.00%
Services	120	6.64%	76	63.33%
Technology	68	3.76%	41	60.29%
Telecomm	27	1.49%	17	62.96%
Transportation	64	3.54%	41	64.06%
Total	**1,808**		**1,064**	

Table 2: Distribution of Companies and Terrorism Insurance Across Industries - New York Metropolitan Area

Industry	**Firms**	**in %**	**With terror insurance**	**in %**
Agriculture	0	–	0	–
Construction & Design	1	0.50%	1	100.00%
Distribution	2	0.90%	1	50.00%
Education	21	9.50%	20	95.00%
Financial Institutions	17	7.70%	15	88.00%
Food & Beverages	5	2.30%	4	80.00%
Healthcare	10	4.50%	10	100.00%
Hospitality & Gaming	9	4.10%	9	100.00%
Manufacturing	47	21.40%	23	49.00%
Media	13	5.90%	9	69.00%
Mining	5	2.30%	1	20.00%
Pharmaceutical	8	3.60%	4	50.00%
Power & Utilities	5	2.30%	4	80.00%
Public Entities	2	0.90%	2	100.00%
Real Estate	17	7.70%	15	88.00%
Retail & Wholesale	22	10.00%	14	64.00%
Services	21	9.50%	15	71.00%
Technology	7	3.20%	4	57.00%
Telecomm	3	1.40%	2	67.00%
Transportation	5	2.30%	3	60.00%
Total	**220**		**156**	

Table 3: Descriptive Statistics - Full sample

Obs.	**Variable**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Terrorism (Yes/No)	1,808	0.589	0.492	0.00	1.00
Property TIV ($ million)	1,808	1,750	5,780.00	1.03	93200.00
Wind Insurance (Yes/No)	1,808	0.462	0.499	0.00	1.00
Quake Insurance (Yes/No)	1,808	0.579	0.494	0.00	1.00
Flood Insurance (Yes/No)	1,808	0.740	0.439	0.00	1.00

Table 4: Descriptive Statistics - Companies with Terror Coverage - All Regions

Obs.	Variable	Mean	Std. Dev.	Min.	Max.
Cover Tria	628	0.480	0.376	0.002	1.000
Cover Property	628	0.548	0.365	0.008	1.000
Property TIV ($ million)	628	1,970	5,970	1.000	93,221
Premium TRIA ($)	628	111,963	400,815	21.00	5,877,503
Premium Property ($)	628	1,238,668	2,503,894	2,106	29,731,212
Premium per $ 1,000 ($) of TRIA insurance	628	0.592	1.645	0.001	22.195
Premium per $ 1,000 ($) of property coverage	628	4.848	7.973	0.290	99.948

Table 5: Descriptive Statistics - Companies with Terror Coverage - New York Metropolitan Area

Obs.	Variable	Mean	Std. Dev.	Min.	Max.
Cover Tria	92	0.396	0.368	0.003	1.000
Cover Property	92	0.441	0.369	0.009	1.000
Property TIV ($ million)	92	4,330	1,180	1,630	93,221
Premium TRIA ($)	92	420,687	917,863	1,255	5,877,503
Premium Property ($)	92	2,287,739	3,741,100	16,140	29,731,212
Premium per $ 1,000 of TRIA insurance ($)	92	1.362	2.393	0.0048	13.049
Premium per $ 1,000 of property coverage ($)	92	6.149	8.315	0.323	54.813

Table 6: Descriptive Statistics - Supply Side - Insurance Companies

Obs.	Variable	Mean	Std. Dev.	Min.	Max.
Terror Limit$_i$/TRIA Line Premiums$_j$	421	0.104	0.174	$5.29E{-}07$	0.991
Property Limit$_i$/ TotalPremiums$_j$	421	0.075	0.127	$4.26E{-}07$	0.934
Total Assets$_j$ ($million)	421	48,114.23	45,153.73	771.911	124,644.300
Overall liquidity$_j$	421	165.782	36.013	127.200	240.800

Table 7: Demand for Terrorism & Property Insurance - QMLE

	All regions		**New York**		**Other regions**	
	Terror	Property	Terror	Property	Terror	Property
$ln(TIV)$	−0.170***	−0.175***	−0.170***	−0.152***	−0.179***	−0.178***
	(0.012)	(0.008)	(0.035)	(0.022)	(0.013)	(0.009)
$ln\left(\frac{premium}{limit}\right)$	−0.191***	−0.316***	−0.100***	−0.253***	−0.220***	−0.320***
	(0.012)	(0.016)	(0.023)	(0.057)	(0.013)	(0.015)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	No	No	Yes	Yes
No. of obs.	628	628	92	92	536	536
Log Likelihood	-222.877	-209.577	-29.775	-29.591	-187.128	-177.609
Prob>χ^2	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is $ln(coverage)$. [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Robust standard errors are given in parenthesis.

Table 8: Demand for Terrorism & Property Insurance, Self-Insurance - QMLE - All Regions

	Terror	Property	Terror	Property
$ln(TIV)$	-0.110^{***}	-0.142^{***}	-0.110^{***}	-0.143^{***}
	(0.020)	(0.015)	(0.022)	(0.022)
$ln\left(\frac{premium}{limit}\right)$	-0.142^{***}	-0.280^{***}	-0.138^{***}	-0.286^{***}
	(0.016)	(0.016)	(0.016)	(0.028)
Solvency ratio	-0.235^{***}	-0.065		
	(0.074)	(0.075)		
Current ratio			0.008	0.000
			(0.012)	(0.012)
Industry FE[a]	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes
No. of obs.	203	203	193	193
Log Likelihood	-70.415	-71.586	-67.280	-67.963
Prob>χ^2	0.000	0.000	0.000	0.000

Notes: Dependent variable is $ln(coverage)$. [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Robust standard errors are given in parenthesis.

Table 9: Pricing for Terrorism & Property Insurance - OLS

	All regions		**New York**		**Other regions**	
	Terror	Property	Terror	Property	Terror	Property
$fraclimit$	−0.894	0.363∗	−2.561	−0.963	−0.787	0.486∗∗
	(0.783)	(0.178)	(1.865)	(1.140)	(0.840)	(0.198)
$ln(limit)$	−0.290∗∗	−0.313∗∗∗	0.118	−0.263	−0.332∗∗∗	−0.317∗∗∗
	(0.098)	(0.047)	(0.240)	(0.150)	(0.086)	(0.045)
$ln(coverage)$	−2.520∗∗∗	−2.019∗∗∗	−3.001∗∗∗	−2.222∗∗∗	−2.391∗∗∗	−2.006∗∗∗
	(0.189)	(0.073)	(0.637)	(0.265)	(0.268)	(0.096)
$ln(assets)$	0.026	0.132∗	0.118	−0.016	−0.084	0.158∗
	(0.159)	(0.063)	(0.438)	(0.093)	(0.117)	(0.079)
Liquidity	0.003	0.001	0.012∗	0.004∗∗	0.002	0.000
	(0.004)	(0.001)	(0.006)	(0.002)	(0.003)	(0.002)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	No	No	Yes	Yes
No. of obs.	441	441	65	65	376	376
R^2	0.506	0.606	0.623	0.662	0.501	0.703
Prob>F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Dependent variable is $ln\left(\frac{premium}{limit}\right)$. [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering on insurance company level.

Table 10: Pricing for Terrorism & Property Insurance, Financial Strength of Insurance Company - OLS - All Regions

	Terror	Property
$fraclimit$	−0.673	0.388***
	(0.707)	(0.097)
$ln(limit)$	−0.262	−0.354***
	(0.147)	(0.035)
$ln(coverage)$	−2.047***	−1.956***
	(0.207)	(0.105)
$ln(assets)$	−0.142	−0.037
	(0.292)	(0.048)
$Liquidity$	0.010	−0.003*
	(0.499)	(0.001)
Rating	Yes	Yes
Industry FE[a]	Yes	Yes
Region FE[b]	Yes	Yes
No. of obs.	441	441
R^2	0.506	0.606
Prob>F	0.000	0.000

Notes: Dependent variable is $ln\left(\frac{premium}{limit}\right)$. [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Standard errors are adjusted for clustering on insurance company level.

Table 11: Insurance Demand and Pricing for Terrorism & Property Insurance - System of Equations

	All regions				**New York**				**Other regions**			
	Terror		**Property**		**Terror**		**Property**		**Terror**		**Property**	
	Supply[c]	Demand[d]	Supply[c]	Demand[d]	Supply[c]	Demand[d]	Supply[c]	Demand[d]	Supply[c]	Demand[d]	Supply[c]	Demand[d]
$ln(TIV)$		−0.062***		−0.104***		−0.025		−0.102***		−0.072***		−0.107***
		(0.010)		(0.006)		(0.049)		(0.020)		(0.010)		(0.007)
$ln\left(\frac{premium}{limit}\right)$		−0.241***		−0.292***		−0.249***		−0.236***		−0.247***		−0.296***
		(0.014)		(0.012)		(0.067)		(0.038)		(0.015)		(0.013)
$fraclimit$	0.044		0.137*		−0.037		0.19		0.04		0.142*	
	(0.099)		(0.070)		(0.668)		(0.392)		(0.112)		(0.081)	
$ln(limit)$	−0.212***		−0.332***		−0.079		−0.359***		−0.240***		−0.339***	
	(0.039)		(0.024)		(0.154)		(0.090)		(0.039)		(0.025)	
$ln(coverage)$	−3.216***		−2.349***		−3.644***		−2.659***		−3.011***		−2.329***	
	(0.156)		(0.086)		(0.487)		(0.306)		(0.158)		(0.090)	
$ln(assets)$	0.001		0.013		0.008		0.018		−0.002		0.009	
	(0.010)		(0.011)		(0.050)		(0.034)		(0.013)		(0.013)	
$Liquidity$	0.000		0.000		0.000		−0.001		0.000		0.000	
	(0.000)		(0.000)		(0.000)		−0.002		(0.000)		(0.000)	
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
No. of obs.	441	441	441	441	65	65	65	65	376	376	376	376
R^2	0.576	0.490	0.672	0.713	0.626	0.408	0.627	0.764	0.584	0.527	0.681	0.717

Notes: [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. [c]Dependent variable is $ln\left(\frac{premium}{limit}\right)$. [d]Dependent variable is $ln(coverage)$. ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 12: Insurance Demand and Pricing for Terrorism & Property Insurance - Sample Selection

	$\mathbf{1}^{st}$ **stage**[e]	**Terror**		**Property**	
		Supply[c]	Demand[d]	Supply[c]	Demand[d]
$ln(TIV)$	0.051**	0.632***	−0.059***	0.574***	−0.101***
	(0.020)	(0.095)	(0.013)	(0.072)	(0.009)
$ln\left(\frac{premium}{limit}\right)$			−0.262***		−0.308***
			(0.016)		(0.013)
$fraclimit$		−0.605		0.453*	
		(0.591)		(0.253)	
$ln(limit)$		−0.738***		−0.867***	
		(0.089)		(0.073)	
$ln(coverage)$		−0.825***		−0.567***	
		(0.298)		(0.194)	
$ln(assets)$		−0.024		0.111***	
		(0.066)		(0.035)	
$Liquidity$		0.000		0.000	
		(0.002)		(0.000)	
$Flood$	0.307***				
$Insurance$	(0.083)				
λ		−0.616	−0.124	−0.125	0.005
		(0.575)	(0.168)	(0.317)	(0.119)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	Yes
No. of obs.	1,808	441	441	441	441
R^2		0.606		0.672	
Log Likelihood	-957.790				

Notes: [a]Agriculture is the omitted industry dummy. [b]Central Midwest is the omitted region dummy. [c]Dependent variable is $ln\left(\frac{premium}{limit}\right)$. [d]Dependent variable is $ln(coverage)$. [e]Dependent variable is *sample*, a dummy that switches to one if the company is in the sample of companies that have terrorism coverage and 0 otherwise (Probit). ***, **, * denote significance at the 1%, 5% and 10% level, respectively.