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Economics and Statistics**

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Corporate Demand for Insurance: An Empirical Analysis of the U.S. Market for Catastrophe and Non-Catastrophe Risks¹

Erwann Michel-Kerjan^{2,3}, Paul A. Raschky³ and Howard C. Kunreuther²

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Abstract

This paper tests some existing theories developed over the past 25 years on corporate demand for insurance. Using a unique dataset of 1,809 large U.S. corporations it provides the first empirical analysis that compares corporate demand for standard property insurance and for catastrophe coverage (here, terrorism).

We find that larger companies are more likely to have some catastrophe coverage. Corporate demand for catastrophe insurance is found to be more price inelastic than insurance for non-catastrophe risks. This result differs from the findings on individual demand for insurance.

The terrorism insurance premium per dollar of coverage is twice as high in the New York Metropolitan area than in the rest of the U.S. Yet the price elasticity of the demand for terrorism insurance is half in this area relative to the rest of the country.

JEL classification; D21 (Firm Behavior); D81 (Criteria for Decision-Making under Risk and Uncertainty); G22 (Insurance; Insurance Companies); H56 (National Security and War)

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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 decisions made by *large* corporations, this article investigates insurance as a natural means for financial protection. Here we are interested in 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 a truly catastrophe risk differently than non-catastrophe risk.⁴ 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, 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 most costly insured natural and man-made catastrophes in the world

⁴ 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. See Kunreuther (1978) for early work on this very question and Kunreuther, Meyer and Michel-Kerjan (forthcoming) for a review of the behavioral factors that contribute to these individual decisions. For instance, it might come as a surprise to some that 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 4 hurricanes that devastated Florida the previous year. (GAO, 2007).

over the last 38 years (1970-2007). Indeed, half of them occurred since 2001, nine of these ten in the United States.

The terrorist attacks of September 11, 2001 (9/11 hereafter) were the most devastating of all catastrophes until Hurricane Katrina occurred. These attacks inflicted insured losses of nearly \$35 billion, nearly twice as much as those from Hurricane Andrew, the previous world record holder. Furthermore, the claims from the 9/11 attacks were almost exclusively made by corporations located in or next to the World Trade Center (WTC).

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 US 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).⁵

In this 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.⁶

Undertaking this analysis today makes sense for at least two reasons. First, 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 and Michel-Kerjan, 2004).

Second, the shock of 9/11 led insurers and reinsurers to stop covering this risk almost everywhere or, when they did, 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,⁷ leading to a call for some type of federal intervention (U.S. Congress Joint Economic Committee, 2002). A joint public-private program, TRIA (Terrorism Risk Insurance Act), was established at the end of 2002, thereby creating a

⁵ 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”. (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.

⁶ 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 (2008) for an analysis of residential demand for hurricane risk coverage in the U.S.). We have overcome this limitation here thanks to access to a complete set of data provided to us by Marsh.

⁷ Workers’ compensation insurance policies cover occupational injuries without regard to the peril that caused the injury

new insurance market in the United States.⁸ Six years have passed and the market is now mature enough that we can undertake microeconomic analyses based on a substantive data collection.

Organization of the Paper and Key Findings

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 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 to reach 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. We then **estimate and compare price elasticities of standard property and terrorism coverage and also test whether these elasticities vary by the size of a company** We find that corporate demand for terrorism insurance is less price-elastic than demand for property coverage. The same 10 percent increase in price will reduce quantity of property coverage purchased on average by 1.99 percent where it would reduce the quantity of terrorism coverage by only 1.18 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 part 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 half in New York Metro of what it is in the rest of the country (-0.073 versus -0.130). 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.

⁸ Several European countries also created (France and Germany, for instance) or reorganized (e.g. U.K) their terrorism insurance market based on a risk-sharing arrangement between the private sector of insurance and the national government (Michel-Kerjan and Pedell, 2005).

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

2. RELATED LITERATURE

This 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 in the recovery process in the aftermath of a terrorist attack) and corporate decision-making regarding insurance.

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 and Iraq.⁹ Looking specifically at terrorism risk, the literature in this field can be subdivided into three major strands, the third of which this paper contributes to.

The first one deals with the causes and origins of terrorism by investigating the nature of terrorism CLARIFY , the formation of terrorist movements, their behavior (Hoffman, 1988, Stern, 2003, Sandler and Enders, 2004), whether and, if so, how terrorism and economic factors such as poverty, education are related (e.g. Krueger and Maleckova, 2003; Blomberg et al., 2004; Enders and Sandler, 2006; Mirza and Verdier, 2008) as well as the possible effectiveness of counter-terrorism activities (e.g. Lapan and Sandler, 1988; Lee, 1988; Frey and Luechinger, 2004; Sandler and 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 et al., 2007), companies' stock value (Abadie, 2003; Doherty et al., 2003; Brown et al., 2004), foreign direct investment (Enders et al., 2006), vacancy rate in business offices of large cities (Abadie and Dermisi, forthcoming) or tourism activities (Drakos and Kutan, 2003).

The third strand of literature, in which this paper fits, has its focus on financial protection against the consequences of terrorism attacks. Most of the papers published on this third question so far are policy-oriented contributions which examine the role of the public and private sectors in providing financial coverage against terrorism (Kunreuther and Michel-Kerjan, 2004; Smetters, 2004; Jaffee and Russell, 2005; Jaffee, 2005). Other contributions look more specifically at how risk is shared between different stakeholders

⁹ For instance, Martin Feldstein established the NBER Group on Economics of National Security in 2006.

under the current public-private TRIA program in the U.S. (U.S. Department of Treasury, 2005; Congressional Budget Office, 2005; Wharton Risk Center, 2005; Kunreuther and Michel-Kerjan, 2006; 2007), and under programs established in other countries (U.S. Government Accountability Office, 2005; OECD, 2005; Michel-Kerjan and Pedell, 2005, 2006). Most contributions in the literature on terrorism insurance thus focus on governmental intervention and/or the supply side of the market (i.e. the insurers).

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? How does size of a company is likely to affect its decision to buy or not to buy terrorism insurance? What's the price of terrorism insurance today? How does it vary by location and size of firm? What can we infer on how these firms perceived the likelihood to be victims of a terrorist attack? What's the price elasticity of the demand function? How does it vary by location and size of firms? 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 thus 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 fields of literature this paper contributes to is the study of firms' behavior under risk and uncertainty. In this study we are interested specifically in firms' decision regarding insurance purchase. If corporations were perfectly risk-neutral agents and simply profit maximizer, insurance priced above actuarially fair rates should not be attractive to them. Still, firms, small and large, do purchase such insurance.

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 but one, Texas). There might be also contractual obligations from a bank or bond covenant (Garven and 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)¹⁰. Mayers and Smith (1982) and MacMinn (1987) argue that insurance is just another form of financing by firms and that it helps avoid the transaction costs of bankruptcy¹¹. 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

¹⁰ The finance literature on corporate hedging also find evidence that firms hedge to reduce tax liabilities; see Nance, Smith and Smithson (1993).

¹¹ Doherty (2000) proposes an alternative view to examine corporate demand for property insurance. Property insurance can viewed as an alternative financing instrument before and after damage occurred. In the same vein, Hau (2006) argues that even a risk-neutral company might obtain property insurance as an alternative instrument to provide liquidity in the case of business interruptions and accompanied contract penalties.

stockholders, the degree of diversification of the assets can be so high that there would be no need for insurance (Mayers and 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 Grennwald and Stiglitz (1990, 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. Managers of these companies would not want to be singled out in the aftermath of a terrorist attack as not having covered 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.¹² Regarding corporate demand for terrorism insurance in the U.S., Michel-Kerjan and 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 over 1,809 of their large clients headquartered in the U.S. for the year 2007. 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

3.1. Terror insurance markets before and immediately after 9/11

¹² Yamori (1999), Hoyt and Khan (2000), Zo et al. (2003) and Regan and Hur (2007) provide some evidence but these analyzes all look at Asian markets (Japan, Taiwan, China and Korea). Further they all rely on insurance premiums as a proxy for the demand where we do measure the pure demand (actual quantity of insurance purchased) of the 1,809 firms in our sample.

The 1993 bombing of the WTC killed 6 people and caused \$725 million in insured damages. Prior to 9/11 the Oklahoma City bombing of 1995, which killed 168 people, had been the most damaging terrorist attack on domestic soil, but the largest losses were to federal property and employees, and were covered by the government. As a result 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 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 over 3,000 people¹³ 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 price) was covered by nearly 150 insurers and reinsurers worldwide (including \$21 billion for damage and business interruption alone) (U.S. Treasury et al., 2006). Private reinsurers, who covered a majority of these losses, decided to leave this market, leaving insurers without protection. A few months after 9/11 insurers had now 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.¹⁴ One year after 9/11, when national security had become the “number one” priority on the U.S. national and international agendas, the country’s commercial enterprises remained largely uninsured at home (Hale, 2002). If another large-scale attack had occurred at that time, the impact on the economy would have been much more serious than after 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 (GAO, formally General Accounting 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. GAO, 2002).

3.2. Terrorism insurance under TRIA

¹³ This number represents victims of the attacks in New York, Washington, DC, and Pennsylvania as well as among teams of those providing emergency service.

¹⁴ 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 only offered the airport \$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 and Russell, 2003). 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).

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, 2002.¹⁵ This program was originally aimed at providing a three-year temporary measure to increase the availability of risk coverage¹⁶, 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.¹⁷

TRIA operation can be 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 implication of our results. First, TRIA requires insurers to offer terrorism coverage to all their commercial clients (a legal “make available” requirement).¹⁸ 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.¹⁹ Second, loss sharing under TRIA is somewhat peculiar. The first layer is provided by insurers through a “deductible” they must assume. It is calculated as a percentage of the direct commercial property and casualty earned premiums of each insurer in the preceding year.²⁰ The second layer up to \$100 billion is the joint responsibility of the federal government and insurers. Specifically, the federal government is responsible for paying 85 percent²¹ of each insurer’s primary property-casualty losses during a given year above the applicable *insurer deductible*; the insurer covers 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 enterprises in the country. Hence, the insurance premiums 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 government program. An important policy question that has been debated in the past few years is whether the federal government should continue to provide this type of free reinsurance or whether the market should provide all or part of this reinsurance. So far the main counter-

¹⁵ 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

¹⁶ U.S. Congress (2002). *Terrorism Risk Insurance Act of 2002*. HR 3210. Washington, DC, November 26.

¹⁷ 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, of the National Flood Insurance Program established in 1968 for covering against flood, and of the California Earthquake Authority created in 1996 to provide insurance against earthquakes.

¹⁸ Residential coverage is not included in this program

¹⁹ Workers’ compensation coverage is mandatory for a large majority of employers in all states other than 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.

²⁰ 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, 2004). According to analysis we undertook as part of the Wharton Risk Center (2005) study, projections indicated that deductibles would have more than doubled in real terms by 2008.

²¹ Before 2007 it was 90 percent.

argument has been that any businesses in the U.S. would drop their terrorism coverage because they would not be able to sustain an increase in price (which would happen if insurers are deprived from free federal reinsurance). Nevertheless, no one has provided empirical evidence to validate this assertion. Our results shall provide important insights to this debate.

4. EMPIRICAL ANALYSIS

Our empirical analysis of the corporate demand for catastrophe insurance consists of two parts. We first examine the drivers of the decision to purchase coverage against terrorism. Second, 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. In addition, we try to estimate regional differences between the New York metropolitan area and the rest of the country.

4.1. Data and statistics summary

We accessed data from Marsh on the property insurance contracts they brokered to their clients in 2007. Company identities are kept 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 U.S. 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 percent²². For 628 of these 1,066 companies we have observations for all relevant dependent and explanatory variables.

The data does not include exact information on the physical location of all the company's assets but only the Marsh office which brokered their policy (typically in the same location that the headquarters of the company); we use this as the proxy for location. Indeed, each individual contract covered multiple locations for a single

²² 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. These data are 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.

company and we assume that the amount 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.²³

Firms in the dataset can be divided into 21 industry sectors.²⁴ Table 2 shows the distribution of companies within the full samples across these different industry sectors.²⁵ It also shows the number of companies with TRIA insurance. Table 3 shows the same data 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).

[INSERT TABLES 2 AND 3 ABOUT HERE]

In the first step of our econometric analysis we try to identify variables that have an effect on a company's decision to purchase terrorism insurance or not (Probit model). Therefore, we construct a dummy variable that simply indicates whether a company has some TRIA terrorism coverage or not, *Terrorism (Yes/No)*. In our full sample, about 59 percent of companies have terrorism coverage (see Table 2). 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 of the distribution is a TIV of \$1.75 billion (median of \$2.95 billion). 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. 46 percent of our samples have wind coverage, 58 percent have earthquake coverage and 74 percent have flood coverage. This is an interesting statistics in itself given that wind coverage is often required by banks to protect their mortgage. Still, a largest proportion of firms in our sample have some type of quake insurance, which is typically not required.

²³ 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.

²⁴ 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.

²⁵ Here also it is also 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); manufacturing, food and beverage, and retail, the lowest (nearly 50 percent today compared to 20-30 percent in 2003).

[INSERT TABLE 4 ABOUT HERE]

In the second part of the analysis we look at the specific subsample of companies that have terrorism coverage to estimate the quantity of insurance they purchased. We construct the ratio maximum compensation they can receive from their insurers for terrorism (limit on the policy) divided by 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 5 and Table 6 (the whole sample and New York Metro only, respectively). We also report in these two tables the premium paid by these companies per \$1000 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 6 reveals that firms in this region are on average twice as large (measured by their TIV) and also that the average 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, \$1.39) 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 pay \$2.2 million for property insurance and \$6.14 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 expensive²⁶.

[INSERT TABLES 5 AND 6 ABOUT HERE]

4.2. Empirical strategy

The empirical analysis is complicated by three major issues. First, there is 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 and Wooldridge

²⁶ We thank John Rand for his insight here.

(1995) developed a quasi-maximum likelihood estimator (QMLE hereafter) to obtain robust results in that case.

The functional form is as follows:

$$E(COVER_{ijr} | Z_{ijr}) = h(Z_{ijr} \gamma) \quad (1)$$

$COVER$ in (1) represents the degree of insurance coverage for terrorism and property insurance, Z is a vector of covariates, h is the cumulative distribution function (cdf) and γ is a $K \times 1$ vector of the coefficients to be estimated.

The parameters in equation (1) are estimated using the quasi-maximum likelihood estimated via the following Bernoulli log-likelihood function:

$$L(\gamma) = COVER_{ijr} \log[h(Z_{ijr} \gamma)] + (1 - COVER_{ijr}) \log[1 - h(Z_{ijr} \gamma)] \quad (2)$$

The second econometric issue derives from the fact 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. In addition, the decision *on the amount of coverage* 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. We apply a two stage approach based on the work by Heckman (1976) that has already been used by Zou et al. (2003) to estimate the corporate demand for property insurance of Chinese companies. Simply excluding the companies that do not have terrorism insurance would result in biased estimates.

In order to overcome these possible problems, we apply the Heckman methodology, which tackles these issues by reflecting the self-selection process in the first stage and also assumes that the probability of a company buying terrorism insurance has an influence on the degree of coverage in the second stage. This approach is the only consistent estimator given the distribution of our company sample.

In the first stage we apply a probit estimate with the following functional form:

$$P(Y_{ijr} = 1 | X_{ijr}) = g(LN(TIV_{ijr}), V_{ijr}) \quad (3)$$

The dependent variable is a dichotomous indicator equal to 1 for companies that have a terrorism insurance policy and equal to 0 otherwise. g is the cumulative distribution function.

$LN(TIV_{ijr})$ in equation (3) is the natural logarithm of the total insured value of company i in industry j and region r ; this variable serves as an empirical proxy for the

size of the company. We use the natural logarithm in order to attenuate the effects of the very large number. 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.

V_{ijr} is a vector including various empirical proxies 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). For the latter, a dummy variable has been constructed that switches to 1 if there is either information on the premium, deductible or limit in one of the natural hazard categories (wind/hurricane, earthquake and flood) indicating that the firm has protected itself against these hazards and equals 0 otherwise (no natural catastrophe insurance reported). This process has been repeated for each individual natural hazard in order to construct hazard-specific dummies as well. These hazard dummies serve as the selection variables in the first stage regression.

The predicted value \hat{Y}_{ijr} from the first stage is then used to calculate the inverse mills ratio λ^{27} . This ratio measures the likelihood that a company has some terrorism coverage. The traditional Heckman approach includes λ as an additional regressor in the second stage specification and applies OLS. Thus, the estimation function of the degree of coverage is conditioned on the selection function of the first stage.

$$COVER_{ijr} = \beta_1 + \beta_2 Z_{ijr} + \beta_3 \lambda + \varepsilon_{ijr} \quad (4)$$

COVER represents the degree of insurance coverage for terrorism and property insurance. It is calculated by dividing the limit of the TRIA policy by the company TIV and by dividing the limit of the property policy over TIV, respectively. Z is a vector of explanatory variables including, once again, the natural logarithm of the total insured value of the company, $LN(TIV)$, the natural logarithm of the ratio premium over limit, $LN(Premium/Limit)$, and a "New York Metro"-dummy that switches to 1 if the company is located in the New York Metro area and is 0 otherwise.

In contrast to the first stage probit-estimates, we expect company size to have a negative sign (given that they buy insurance, larger firms buy proportionally less coverage than small ones). This relates to the suggestions made in the literature discussed in section 2. Another reason is that it might be more difficult for large firms to find enough insurance capacity for very high layers of coverage or, in other words, the cost

²⁷ The inverse Mill's ratio is calculated by dividing the probability density function by the cumulative distribution function.

for that type of coverage might be seen as too high. The analysis of our data provides insights as to whether there is such a difference in insurance cost for different firm sizes.

The steps in the second stage of our econometric analysis are performed for terrorism insurance demand and property insurance demand separately. Controlling for the first-stage sample selection identifies the exact same sample of companies. This allows a direct comparison between the coefficients estimated in the terrorism insurance demand regression and in the property insurance demand one.

Differences in the demand for terrorism insurance and for property insurance as a function of company size might either be explained by the fact that terrorism is a catastrophic risk and some managers in charge of buying insurance in firms tend to overreact when others think simply it will not happen to them. There is no way we can determine how managers reacted to this risk without interviewing the relevant decision makers.

Differences in price can be related to two factors. First, terrorism insurance in the U.S. is subsidized by the federal government; furthermore six years after 9/11 without any attack on U.S. soil, the market has softened price has significantly decreased compared to where it was when TRIA was enacted in 2002. Our sample hence consists of large companies that face relatively “cheap” insurance compared to what it was after TRIA was passed. . Second, there might still be companies (or their managers) that want to be covered at all costs. Based on these arguments we expect the demand for property insurance to be more price elastic than the demand for terrorism insurance.

The final part of our empirical analysis tries to shed more light on the drivers that might explain differences in the price elasticity between terrorism and property insurance. Apart from the comparison between different types of insurance, we also make an attempt to compare corporate demand for insurance between different regions of the country. Given its history with terrorist events, we design a subsample that contains only companies with their headquarters in New York and compare the demand for property and terrorism insurance with all other regions. Given that the two attacks perpetrated by international terrorist organizations in the U.S. were in New York City, there is a general perception that the New York metropolitan area is at higher risk than any other part of the country. As pointed out above, New York is also the world’s leading financial center with a high concentration of firms and industries (and thus assets) that are very sensitive to the threats posed from terrorist attacks (idea of trophy target). For all these reasons, it is also important in our analysis to isolate a possible “New York effect” from other effects such as company size or industry. We expect the differences in price elasticities between terrorism and property insurance to be larger in New York than in the rest of the country.

The third econometric complication emerges from a potential endogeneous relationship between the premium and the degree of coverage. For example, we do not have any information about the negotiation process between the insurer and the insured; the premium and the degree of coverage might be influenced simultaneously by omitted variables. We try to circumvent this problem by applying an instrumental variable estimator. Our instruments for the insurance premium are dummy variables for each

insurance company. The premium offered by each supplier depends on insurance company specific effects such as the portfolio or the rating.

4.3 Regression results and discussion

National Sample---We first discuss the results from the quasi-maximum likelihood estimator (QMLE) estimates. Table 7 summarizes the results for the demand for terrorism insurance as well as property insurance for the full sample as well as the New York and the remaining regions subsamples.

[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 certainly the case because the cost of coverage is much higher for high limit. As illustrated in Figure 1, the cost of terrorism coverage increases with the total amount of coverage purchased but in a very different way below and above a \$1 billion limit. Below this threshold, the cost per \$1,000 of coverage is about the same for a 100 million dollar limit or a 1 billion dollar limit. But this cost increases sharply above 1 billion dollars as firms buy a higher limit. A company with a limit between 500 million dollars and one billion dollars pays on average \$0.3 per \$1,000 of coverage nationwide; but a company pays on average \$0.9 per \$1,000 if it buys a limit between 1 and 5 billion dollars; above 5 billion, the cost increases to \$1.8. This difference is even more important when we distinguish firms in the New York Metropolitan area from those in the rest of the country (see Figure 1). These differences in price certainly reflect both the limited capacity available to cover very large assets and the expensive cost of capital associated with covering those (for very high layers of coverage, the cost of capital alone can be several times the expected loss). For higher layers of coverage, the insurer is also more likely to suffer catastrophe loss in the case of large-scale attack, thus asking a higher marginal cost of coverage to protect against bankruptcy risk.

[INSERT FIGURE 1 ABOUT HERE]

Results on price elasticity are in the second row in Table 7. Comparing the estimates for terror 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 only by 1.91 percent (i.e. 65 percent more for property than for terrorism insurance).

The first robustness check consisted of the application of a Heckman-Sample selection model. The results for the full sample in Table 8 reveals that our results are robust even after controlling for possible sample selection bias. The signs and significance of both, the TIV and the premium variable are unchanged for the terrorism insurance estimates as well as the property insurance estimates. The size of the coefficients only changes marginally. In comparison to the QMLE estimates, the price elasticity of terrorism insurance is now -0.126 and for property insurance it is -0.209. The relative difference between the two coefficients stays unchanged (66 percent more for property than for terrorism insurance).

[INSERT TABLE 8 ABOUT HERE]

In the next step we applied an IV-estimator in order to control for a possible endogeneity bias. The results are summarized in Table 9. Once again, the estimates are robust and the sign, size and significance of the coefficients does not significantly change (relative catastrophe price elasticity is slightly higher- -74 percent--in comparison to the QMLE and the Heckman estimates).

[INSERT TABLE 9 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 (Tables 7, 8 and 9). The decreasing effect of company size on terrorism insurance is slightly larger in New York than in other regions.

As expected, the 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). 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 changes²⁸. These results stay robust for the Heckman and the IV-estimates (see Tables 8 and 9).

²⁸ It is important to keep in mind here that this is the price elasticity in a terrorism insurance market that has considerably softened in the past few years. According to a Marsh survey of over 1,600 client firms in the U.S., the median terrorism rate (ratio of terror premium to total insured value) fell from 0.0057 percent in

Table 10 provides a summary of the differences in price elasticity between terrorism and property insurance among different samples and estimators.

[INSERT TABLE 10 ABOUT HERE]

Insurance premiums and implicit perceived probability—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 impossibility, 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? (see Table 5). This amount increases to \$1.36 million in premium for firms with the same \$1 billion terror limit but in the New York Metropolitan area (Table 6). Is it justified? It is hard to tell for sure.

One way to interpret these numbers is to look as a reference point at what the company pays for standard property insurance. 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 U.S. see themselves as having a 1-in-206 chance to trigger their standard property limit this year (they pay \$4.848 per \$1000 of property coverage), versus a 1-in-1690 chance to trigger their terrorism limit (\$0.592 per \$1,000 of terror coverage) (Table 5)²⁹. 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

2004 to 0.0042 percent in 2005, indicating a decline of the average cost of terrorism coverage of over 25 percent (Marsh 2006). This trend continued in 2006 with a median rate decreased to 0.0038 percent.

²⁹ As prices convey information, one shall consider price insurers are charging corporations for terrorism insurance as an indicator of the associated implicit probability. We recognize that there are limitations to this exercise given that insurers should also include other elements in their pricing than the sole expected loss (administrative costs of managing the policies, marketing them and assessing claims as well as the cost of capital required to cover large firms). Moreover, under the current market conditions, a large part of the exposure is reinsured free of charge by the federal government. In other words, the cost that corporations are paying today is below what they would have to pay for the same coverage if this reinsurance were provided by the private reinsurance market. Still, we believe price contain information on risk belief.

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 and 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 U.S.³⁰.

SECTION 5. CONCLUSIONS, POLICY IMPLICATION AND FUTURE RESEARCH

5.1. *On corporate demand for insurance*

Important contributions have been made in the past two decades that helped better 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. Somewhat surprisingly these remain mainly theoretical contributions. Microeconomic analysis of demand for insurance is much more developed for individual decision than for corporations (Grace et al, 2003; Kunreuther and Michel-Kerjan, 2009). Part of the explanation for the lack of empirical work to test these theories has been that while there is large data available on the homeowners insurance market (for instance, from the National Association of Insurance Commissioners), data on a large number of corporations is difficult to access. Competition among firms 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 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 U.S., we conclude that larger companies are more likely to purchase terrorism coverage; still among those who have terrorism insurance, corporate behavior for standard property and terror 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 a different price elasticity: demand for standard property is significantly *more* elastic³¹. We also test for a possible New York Metropolitan 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? Our results show that to remain the case: 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.

³⁰ The alternative is that terrorism is simply overpriced in Germany. Still data on the British and French terrorism insurance markets reveal that the cost of terrorism in these two other countries is aligned with (if not even higher than) what it is in Germany (Michel-Kerjan and Pedell, 2006).

³¹ This result is opposite to the seminal study by Grace et al. (2003) on residents in New York, which finds that demand for property insurance is less price elastic than for catastrophe risks (hurricanes).

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 U.S. 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 assure firms had access to sufficient terrorism coverage and that coverage would be available at an affordable price. In the US, TRIA was passed in 2002 and was renewed twice since 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 4 out of 10 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 (it will not happen to us) 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-type 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. This terrorism coverage might not be a great arrangement for some of these companies. Third, 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 disasters (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 to). Our results show that the way the government designed this program had an important impact on firm's behavior. Indeed, 80 percent of the firm in our sample bought the same quantity of insurance for terrorism that 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. Whether the government should continue to provide this free service 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 up for

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 make the country more vulnerable economically.

Our results do not support this statement; our determination of price elasticity indicates that for any extra 10 percent firms would be asked to pay for terrorism they would decrease their coverage by only about 1 percent. Even for firms located in the New York Metropolitan area, which are likely to be impacted the most by a market-based reinsurance solution, this drop would be only of 0.79 percent for a 10 percent increase in price. There seems to be flexibility for policymakers to favor some market-based solutions here that has not been contemplated.

The results of our analysis should be regarded as a starting point for future research in this field. Given the data constraints, we were only able to deal with a limited number of issues raised by the theoretical literature on corporate demand for insurance. Apart from industry and location we were only able to estimate the effect of company size on demand for terrorism 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 degree of government involvement in insurance markets, which might also influence how large companies operating there use insurance.

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TABLE 1.**THE 10 MOST COSTLY TERRORIST ATTACKS IN TERMS OF INSURED PROPERTY LOSSES. 1970-2001**

| Insured property US\$ million, indexed to 2001 (excluding liability and life) | Event | Injured | Fatalities | Date | Location |
|---|--|---------|------------|-------------|-----------------------------|
| 907 | Bomb explodes near NatWest tower (City) | 54 | 1 | 24 Apr. 93 | UK (London) |
| 744 | Explosion of IRA car bomb near shopping mall | 228 | 0 | 15 Jun. 96 | UK (Manchester) |
| 725 | Bomb explodes in garage of World Trade Center | 1,000 | 6 | 26 Feb. 93 | USA (New York) |
| 671 | Bomb explodes in financial district | 91 | 3 | 10 Apr. 92 | UK (London) |
| 398 | Rebels destroy 3 airliners, 8 military aircraft and heavily damage 3 civilian aircraft | 15 | 20 | 24 Jul. 01 | Sri Lanka / Colombo Airport |
| 259 | IRA bomb attack in South Key Docklands | 100 | 2 | 09 Feb. 96 | UK (London) |
| 145 | Truck bomb attack on government building in Oklahoma City | 467 | 166 | 19 Apr. 95 | USA (Oklahoma City) |
| 138 | PanAm Boeing 747 crashes due to bomb | 0 | 270 | 21 Dec. 88 | UK (Lockerbie) |
| 127 | Hijacked Swissair DC-8, TWA Boeing 707 and BOAC VC-10 dynamited | 0 | 0 | 12 Sep.70 | Jordan (Zerqa) |
| 111 | Hijacked PanAm B-747 dynamited | 0 | 0 | 06 Sep 1970 | Egypt (Cairo) |

Sources: *Swiss Re (2002)*. Note: Starting in 1970 up to September 10, 2001.

TABLE 2: DISTRIBUTION OF COMPANIES ACROSS INDUSTRIES AND NUMBER OF COMPANIES WITH SOME TERRORISM INSURANCE – FULL SAMPLE OF 1808 COMPANIES

| Industry | Firms | Proportion | With terror insurance | Proportion |
|------------------------|--------------|------------|-----------------------|------------|
| 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 3: DISTRIBUTION OF COMPANIES ACROSS INDUSTRIES AND NUMBER OF COMPANIES WITH SOME TERRORISM INSURANCE – NEW YORK METROPOLITAN AREA ONLY – 220 COMPANIES

| Industry | Firms | Proportion | With terror insurance | Proportion |
|------------------------|------------|------------|-----------------------|------------|
| Agriculture | 0 | 0.0% | 0 | - |
| Construction & Design | 1 | 0.5% | 1 | 100% |
| Distribution | 2 | 0.9% | 1 | 50% |
| Education | 21 | 9.5% | 20 | 95% |
| Financial Institutions | 17 | 7.7% | 15 | 88% |
| Food & Beverages | 5 | 2.3% | 4 | 80% |
| Healthcare | 10 | 4.5% | 10 | 100% |
| Hospitality & Gaming | 9 | 4.1% | 9 | 100% |
| Manufacturing | 47 | 21.4% | 23 | 49% |
| Media | 13 | 5.9% | 9 | 69% |
| Mining | 5 | 2.3% | 1 | 20% |
| Pharmaceutical | 8 | 3.6% | 4 | 50% |
| Power & Utilities | 5 | 2.3% | 4 | 80% |
| Public Entities | 2 | 0.9% | 2 | 100% |
| Real Estate | 17 | 7.7% | 15 | 88% |
| Retail & Wholesale | 22 | 10.0% | 14 | 64% |
| Services | 21 | 9.5% | 15 | 71% |
| Technology | 7 | 3.2% | 4 | 57% |
| Telecomm | 3 | 1.4% | 2 | 67% |
| Transportation | 5 | 2.3% | 3 | 60% |
| Total | 220 | | 156 | |

TABLE 4. DESCRIPTIVE STATISTICS – FULL SAMPLE OF 1809 COMPANIES

| Variable | Obs | Mean | Std. Dev. | Min. | Max. |
|---------------------------|------------|-------------|------------------|-------------|-------------|
| Terrorism (Yes/No) | 1809 | 0.589 | 0.492 | 0 | 1 |
| Property TIV (\$ million) | 1808 | 1,750 | 5,780 | 1.03 | 93,200 |
| Wind Insurance (Yes/No) | 1809 | 0.462 | 0.499 | 0 | 1 |
| Quake Insurance (Yes/No) | 1809 | 0.579 | 0.494 | 0 | 1 |
| Flood Insurance (Yes/No) | 1809 | 0.740 | 0.439 | 0 | 1 |

TABLE 5. DESCRIPTIVE STATISTICS – COMPANIES WITH TRIA-TYPE COVERAGE – ALL REGIONS

| Variable | Obs | 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 | 93,221 |
| Premium TRIA (\$) | 628 | 111,963 | 400,815 | 21 | 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 | 7.76E-04 | 22.195 |
| Premium per \$1000 of property coverage (\$) | 628 | 4.848 | 7.973 | 0.290 | 99.948 |

TABLE 6. DESCRIPTIVE STATISTICS – COMPANIES WITH TRIA-TYPE COVERAGE – NEW YORK METRO ONLY

| Variable | Obs | Mean | Std. Dev. | Min. | Max. |
|--|------------|-------------|------------------|-------------|-------------|
| Cover Tria | 92 | 0.396 | 0.368 | 0.003 | 1 |
| Cover Property | 92 | 0.441 | 0.369 | 0.009 | 1 |
| 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 \$1000 of property coverage (\$) | 92 | 6.149 | 8.315 | 0.323 | 54.813 |

Figure 1: TRIA Premium per \$1,000 Limit for Different Limit Sizes (from 100 million dollars up to 5 billion dollars and above – Comparison Full Sample, New York Metro and other - Regions (Mean values in boxes)

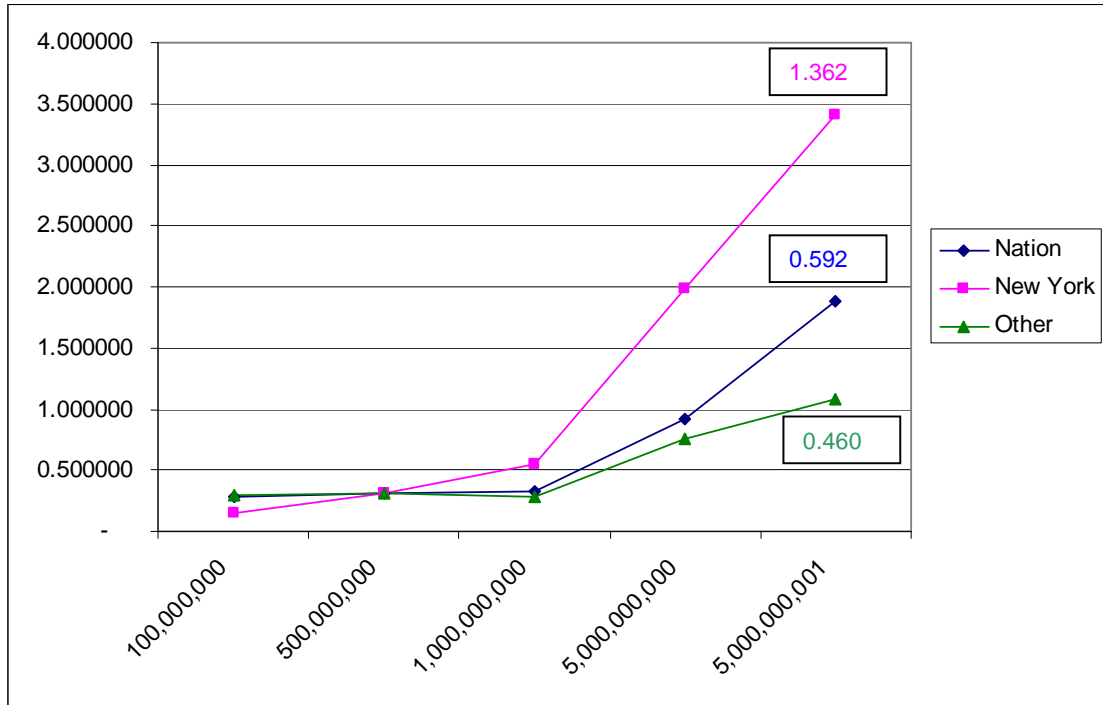


TABLE 7: INSURANCE DEMAND FOR TERRORISM & PROPERTY INSURANCE – QUASI-MAXIMUM LIKELIHOOD ESTIMATE (QMLE)

| | Full Sample | | New York | | Other Regions | |
|--------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Terror | Property | Terror | Property | Terror | Property |
| ln(TIV) | -0.170*** (0.012) | -0.175*** (0.008) | -0.170*** (0.035) | -0.152*** (0.022) | -0.179*** (0.013) | -0.178*** (0.009) |
| ln(Premium/Limit) | -0.191*** (0.012) | -0.316*** (0.016) | -0.100*** (0.023) | -0.253*** (0.057) | -0.220*** (0.013) | -0.320*** (0.015) |
| Industry FE ^a | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> |
| Region FE ^b | <i>Yes</i> | <i>Yes</i> | <i>No</i> | <i>No</i> | <i>Yes</i> | <i>Yes</i> |
| No. of obs. | 628 | 628 | 92 | 92 | 536 | 536 |
| Log Likelihood | -222.877 | -209.577 | -29.775 | -29.591 | -187.128 | -177.609 |

Notes: ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Robust standard errors are given in parenthesis.

^a Agriculture is the omitted industry dummy. ^b Central Midwest is the omitted region dummy.

TABLE 8: INSURANCE DEMAND FOR TERRORISM & PROPERTY INSURANCE – HECKMAN SAMPLE SELECTION

| | Full Sample | | | | New York | | | | Other Regions | | | |
|--------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Terrorism | | Property | | Terrorism | | Property | | Terrorism | | Property | |
| | 1 st stage | 2 nd stage | 1 st stage | 2 nd stage | 1 st stage | 2 nd stage | 1 st stage | 2 nd stage | 1 st stage | 2 nd stage | 1 st stage | 2 nd stage |
| ln(TIV) | 0.067** (0.027) | -0.105*** (0.009) | 0.069*** (0.026) | -0.100*** (0.008) | 0.074 (0.080) | -0.103*** (0.027) | 0.066 (0.080) | -0.086*** (0.025) | 0.070** (0.029) | -0.112*** (0.010) | 0.072** (0.029) | -0.102*** (0.009) |
| ln(Premium/Limit) | | -0.126*** (0.009) | | -0.209*** (0.010) | | -0.064** (0.027) | | -0.187*** (0.038) | | -0.139*** (0.009) | | -0.211*** (0.011) |
| Earthquake Insurance | -0.361** (0.154) | | -0.436** (0.182) | | 0.423 (0.434) | | 0.392 (0.387) | | -0.632*** (0.214) | | -0.665*** (0.216) | |
| Flood Insurance | 0.003 (0.189) | | 0.127 (0.186) | | 0.957 (0.582) | | 0.895 (0.552) | | 0.077 (0.221) | | 0.180 (0.214) | |
| Λ | | -0.102 (0.065) | | -0.104** (0.045) | | 0.232 (0.152) | | 0.318** (0.161) | | -0.109 (0.064) | | -0.073 (0.055) |
| Industry FE ^a | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> |
| Region FE ^b | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>No</i> | <i>No</i> | <i>No</i> | <i>No</i> | <i>No</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> |
| No. of obs. | 934 | 408 | 934 | 408 | 121 | 63 | 121 | 63 | 813 | 345 | 813 | 345 |
| Prob> χ^2 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 | | 0.000 |

Notes: ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Robust standard errors are given in parenthesis.

^a Agriculture is the omitted industry dummy. ^b Central Midwest is the omitted region dummy.

TABLE 9: INSURANCE DEMAND FOR TERRORISM & PROPERTY INSURANCE – IV-ESTIMATES

| | Full Sample | | New York | | Other Regions | |
|--------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Terror | Property | Terror | Property | Terror | Property |
| ln(TIV) | -0.104*** (0.007) | -0.107*** (0.005) | -0.110*** (0.027) | -0.075*** (0.017) | -0.108*** (0.007) | -0.110*** (0.006) |
| ln(Premium/Limit) | -0.123*** (0.010) | -0.214*** (0.016) | -0.086*** (0.027) | -0.284*** (0.036) | -0.129*** (0.011) | -0.208*** (0.012) |
| Industry FE ^a | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> | <i>Yes</i> |
| Region FE ^b | <i>Yes</i> | <i>Yes</i> | <i>No</i> | <i>No</i> | <i>Yes</i> | <i>Yes</i> |
| No. of obs. | 628 | 628 | 92 | 92 | 536 | 536 |
| Anderson LR-stat | 430.014*** | 442.493*** | 74.451*** | 40.238*** | 380.002*** | 407.613*** |
| Centered R ² | 0.604 | 0.708 | 0.584 | 0.654 | 0.624 | 0.705 |

Notes: ***, **, * denote significance at the 1%, 5% and 10% level, respectively. Robust standard errors are given in parenthesis. Insurance company fixed effects (e.g. dummies) are used as instruments for $\ln(\text{Premium/Limit})$.

^a Agriculture is the omitted industry dummy. ^b Central Midwest is the omitted region dummy.

TABLE 10: DIFFERENCES IN PRICE ELASTICITY OF CORPORATE DEMAND FOR INSURANCE FOR TERRORISM VERSUS PROPERTY INSURANCE AMONG DIFFERENT SAMPLES AND ESTIMATORS.

| Variable | Full | New York | Other regions |
|----------|-------|----------|---------------|
| QMLE | +65 % | +153 % | +45 % |
| Heckman | +66 % | +192 % | +52 % |
| IV | +74 % | +230 % | +61 % |

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

Abstract

This paper tests some existing theories developed over the past 25 years on corporate demand for insurance. Using a unique dataset of 1,809 large U.S. corporations it provides the first empirical analysis that compares corporate demand for standard property insurance and for catastrophe coverage (here, terrorism). We find that larger companies are more likely to have some catastrophe coverage. Corporate demand for catastrophe insurance is found to be more price inelastic than insurance for non-catastrophe risks. This result differs from the findings on individual demand for insurance. The terrorism insurance premium per dollar of coverage is twice as high in the New York Metropolitan area than in the rest of the U.S. Yet the price elasticity of the demand for terrorism insurance is half in this area relative to the rest of the country.

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