NBER WORKING PAPER SERIES

CORPORATE DEMAND FOR INSURANCE: NEW EVIDENCE FROM THE U.S. TERRORISM AND PROPERTY MARKETS

Erwann Michel-Kerjan
Paul Raschky
Howard Kunreuther

Working Paper 19532
http://www.nber.org/papers/w19532

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 2013

Financial support for this research was provided by Wharton's Managing and Financing Extreme Events project, DHS's Center of Excellence CREATE at the University of Southern California and Monash University. We thank George Akerlof, Neil Doherty, Marty Feldstein, Scott Harrington, Greg Nini, William Nordhaus, Jesse Shapiro, Terri Vaughan, and seminar participants at the American Economic Association annual meeting, National Bureau of Economic Research (NBER) Insurance Group, NBER Economics of National Security Group, University of Pennsylvania, University of Innsbruck, and the OECD high-level international conference on terrorism risk insurance markets for their comments and insightful discussions on an earlier version of this paper. We appreciated Marsh & McLennan sharing with us the data that were used for our analysis and are indebted to John Rand (formerly at Marsh) for many fruitful discussions on preliminary results. This article is forthcoming in the Journal of Risk and Insurance. The two journal referees provided excellent feedback on previous versions of the paper. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Corporate Demand for Insurance: New Evidence from the U.S. Terrorism and Property Markets
Erwann Michel-Kerjan, Paul Raschky, and Howard Kunreuther
NBER Working Paper No. 19532
October 2013
JEL No. G22,H56

ABSTRACT

Since the passage of the Terrorism Risk Insurance Act of 2002, corporate terrorism insurance is sold as a separate policy from commercial property coverage. In this paper, we determine whether companies differ in their demand for property and terrorism insurance. Using a unique dataset of insurance policies purchased by large U.S. firms, combined with financial information of the corporate clients and of the insurance provider, we apply a two-stage least squares (2SLS) approach to obtain consistent estimates of premium elasticity of corporate demand for property and terrorism coverage. Our findings suggest that both are rather price inelastic and that corporate demand for terrorism insurance is significantly more price inelastic than demand for property insurance. We further find a negative relation between the solvency ratios of both property and terrorism risk coverage, with a stronger effect on the latter, indicating that companies use their ability to self-insure as a substitute for market insurance. Our results are robust to the application of alternative estimators as well as changes in the econometric specifications.

Erwann Michel-Kerjan
The Wharton School
University of Pennsylvania
Center for Risk Management
3730 Walnut Street, 556 JMHH
Philadelphia, PA 19104-6340
erwannmk@wharton.upenn.edu

Paul Raschky
Department of Economics
Monash University
Australia
paul.raschky@monash.edu

Howard Kunreuther
Operations and Information Management
The Wharton School
University of Pennsylvania
3730 Walnut Street, 500 JMHH
Philadelphia, PA 19104-6366
and NBER
kunreuther@wharton.upenn.edu

1. Introduction

In the past 30 years we have witnessed a dramatic increase in the economic costs of natural and man-made disasters around the world, from $528 billion (1981-1990) to more than $1.2 trillion over the period 2001-2010. The years 2011 and 2012 triggered another $580 billion in losses (Munich Re, 2013). In the United States recent catastrophes have included terrorism (e.g., the 1993 WTC bombing; the September 11, 2001 attacks), wildfires, hurricanes, flooding (e.g., Hurricane Katrina in 2005; Ike in 2008; Irene in 2011, Sandy in 2012) and technological accidents (e.g., the 2003 blackout; the 2010 BP oil spill).

Individuals typically transfer the financial risks associated with such hazards either to primary insurers by purchasing coverage prior to a disaster and/or de facto to taxpayers if they receive post disaster government relief as many have in recent years. Firms have a variety of financial risk-transfer tools available to protect themselves against the economic consequences of negative outcomes (i.e., left-tail exposure).

Doherty (2000) and Hau (2004) posit that firms' principal risk associated with property damage is a lack of liquidity, which forces them to sell their most liquid assets at a lower than desired price. Catastrophes can also trigger significant business interruptions and prevent firms from fulfilling their contractual commitments. If the firm is unable to raise enough short-term capital to repair the damage, it faces the risk of bankruptcy.[2]

There are a number of potential sources of short-term capital that firms can access to replace damaged property and cover business interruptions. They can use cash reserves or increase debt by borrowing money at the market rate (self-insurance). Alternatively, they can obtain property insurance ex ante that covers potential damages (market insurance).

Corporate risk management aims at reducing the probability of such untoward events (Stulz 1996) and cash-flow variability when they occur (Froot, Scharfstein & Stein 1993). The literature has typically focused on the use of corporate derivatives as a hedge against negative outcomes. Leland (1998) has shown theoretically that the use of derivatives could have a direct effect on cash-flow and an indirect effect on negative (left-tail) outcomes. Smith & Stulz (1985) discuss the firm's use of a hedging strategy with off-balance-sheet instruments such as options and futures. Empirical work (e.g., Nance, Smith & Smithson 1993, Colquitt & Hoyt 1997, Gezcy, Minton & Schrand 1997, Graham & Rogers 2002) further suggests that derivatives are widely used by firms.

The problem with the application of derivative use to study corporate risk management, though, is that it is not clear a priori whether a firm hedges (left-tail outcomes) or speculates (right-tail outcomes) (e.g., Colquitt & Hoyt 1997[3], Hentschel & Kothari 2001, Allayannis & Ofek 2001). By focusing on insurance purchase instead, it is possible to quantify both the left-tail exposure (risks to which the firm is exposed)

[2] This is part of a larger discussion in recent years about the value of good corporate risk management and enterprise-wide risk management. For instance, Hoyt and Liebenberg (2011) found a positive relation between firm value (measured by its Tobin's Q) and the adoption of enterprise risk management (with a 20% premium).

[3] For instance, Colquitt and Hoyt (1997) provides an important empirical analysis of the degree to which 571 life insurers use futures and options for the purpose of hedging economic risk. In their study they are able to differentiate between hedgers and non-hedgers, based on the self-reported declaration of these insurers in their annual NAIC reporting. They show that the size of the insurer, its leverage and the degree of asset and liability duration mismatch all are positively related to the likelihood of the insurer of hedging its risks with futures and options.

and the hedging strategy a corporation adopts (insurance it buys to protect against those risks). Moreover, corporate insurance use for gains would require that the firm engage in fraudulent activities (we thus disregard the possibility that firms use insurance for speculating).

Since the 1980s there has been a growing literature analyzing why and when firms purchase 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, 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; Chen & PonArul, 1989; Hoyt & Khang, 2000). Mayers & 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 bankruptcy. Indeed the probability of incurring these costs is lowered by shifting the firm's exposure risk to the insurance company. Greenwald & Stiglitz (1990) and Greenwald & Stiglitz (1993) provide seminal theories that show how the risk of bankruptcy and the existence of incentive systems within the firm could lead managers to act in a risk-averse manner on behalf of the company, and thus purchase insurance coverage when a risk-neutral firm would not do so. This is also consistent with work in behavioral economics that postulates that managers in the risk management department of a firm might somewhat over-insure the firm as the precaution against being held responsible for large losses that might occur if the firm is underinsured (Borkan & Kunreuther 1979). Firms might also tend to focus on the consequences of an outcome (in particular, the risk of financial ruin) rather than the probability of occurrence of the catastrophic event. This can be particularly relevant in the case of terrorism we study here, since it is almost impossible to correctly assess probabilities of attacks (Kunreuther, Pauly & McMorrow, 2013).

Surprisingly, however, empirical evidence for these theories has been lacking for the past 20 years. Most likely, this is due to the difficulty for the research community to access detailed commercial insurance data for a large enough sample of firms. Firms are indeed often reluctant to share such data because of proprietary issues, regulatory requirements and anti-trust law. This certainly explains why only a handful of studies have been published on corporate demand for insurance in the finance literature to date (e.g., Core 1997, Yamori 1999, Hoyt & Khang 2000, Aunon-Nerin & Ehling 2008[4]).

Studying corporate demand for terrorism insurance is interesting for several reasons. First, terrorism presents a set of fairly peculiar characteristics for firms: the risk is difficult to quantify and is dynamic in nature since it depends on what action the terrorists may take in response to those undertaken by firms at risk. It is also not clear what physical mitigation measures firms should invest in that will really be effective at deterring terrorist attacks. For instance, a firm operating in the World Trade Center towers could not have done much to protect itself from commercial aircraft being crashed into the building on September 11, 2011 (9/11). Insurance against all potential types of attacks might therefore be a desirable risk management strategy. Many managers also consider terrorism risk as the ultimate low-probability high-consequence event over which they have almost no control: there have been three successful terrorist attacks on U.S. soil that led to large-scale devastating losses. In February 1993, Al Qaeda detonated a large truck bomb in the garage of the North Tower of the World Trade Center in New York. This event

[4] Mayers and Smith (1990) focus specifically on reinsurance purchases by U.S. property and liability insurers.

shut Tower 1 down for six weeks and Tower 2 for four weeks. While it did the entire building did not collapse (as the terrorists had planned), it killed six people and caused over $750 million in insured losses (Kunreuther and Michel-Kerjan 2004).[5] In April 1995, the Alfred Murrah Federal Building in downtown Oklahoma City was bombed by Timothy McVeigh. 168 people were killed and another 700 injured. The blast damaged 324 buildings within a sixteen-block radius. This attack caused about $650 million worth of damage. The federal government, who owned the building was self-insured against potential losses. This event demonstrated that the threat of terrorism could be domestic and that it did not take much sophistication to inflict massive losses. The Al Qaeda terrorist attacks on 9/11 resulted in over 3,000 deaths and a historic record high insured losses of $45 billion (2013 price)[6]—it was then the most costly event in the history of insurance, now second only to hurricane Katrina in 2005 in the U.S.

Before 9/11 commercial insurance contracts typically included terrorism as an unnamed peril and insurers did not charge for it. Following 9/11 and the passage of the 2002 Terrorism Risk Insurance Act (TRIA) firms have the option to purchase terrorism insurance coverage as a separate policy that can be added on to their property insurance. Insurers have to offer the same limits on a terrorism risk insurance policy as they do for property coverage but the client can decide to purchase a different limit.[7] One can thus measure corporate demand for terrorism insurance specifically and compare it with the demand for property coverage.[8] If the risk of bankruptcy and managers' self-interest is what partly triggers corporate interest in purchasing insurance to hedge left-tail outcomes, then corporate demand for terrorism insurance should be more price inelastic than for property coverage.[9] Past terrorist attacks have all been very costly and highly mediatized events. Risk-averse managers should thus see a large-scale terrorist attack against the firm as potentially more harmful to the company and to their reputation than other losses covered by property insurance. The Sarbanes-Oxley Act of 2002 also increased the liability of corporate directors, who in turn may be more willing to demand the purchase of terrorism insurance.

This paper benefits from a unique firm-level dataset we were able to access as part of a research partnership with Marsh & McLennan, a large insurance broker. We obtained data on complete insurance purchases by 1,808 large U.S. corporations headquartered across the country. The insurance purchased is for their U.S. operations only. These data contain information about the quantity of insurance purchased and the premiums paid by these firms for two lines of risk -- property and terrorism (demand side). We

[5] The Bishopsgate bombing of 24 April 1993 in the financial district of London, UK, cost over 1 billion British pounds worth of damage (OECD, 2005).

[6] All firms operating in the WTC were insured.

[7] Terrorism insurance under TRIA covers terrorist attacks perpetrated by U.S. citizens and foreigners alike. Policies typically exclude attacks using weapons of mass destruction (chemical, biological, radiological and nuclear), considered uninsurable by the market. A more detailed description of the U.S. terrorism insurance market can be found in Brown, Cummins, Lewis & Wei (2004) and Kunreuther & Michel-Kerjan (2004).

[8] Note that typical property insurance includes some coverage for hurricanes, floods and earthquakes. But because the coverage is bonded with many other types of risk the policy covers, one cannot specifically measure the demand for hurricane risk insurance alone, for instance. For residential insurance this can be done because flood and earthquake insurance is sold as separate policy. (See Browne and Hoyt 2000 on the demand for residential flood insurance, for instance.)

[9] More recent literature supports this view, suggesting that some of the variance in corporate performance can be attributed to discretionary behavior of individual managers (e.g., Adams, Almeida & Ferreira 2005, Bloom & Van Reenen 2010). Bertrand & Schoar (2003) provide compelling evidence that investment and financial decisions of firms depend on executives' fixed effects which affect risk-taking behavior, and that the extent of this influence is economically large.

also accessed a set of financial data from the ORBIS database, to control for the effects of companies' ability to self-insure.

A further strength of our analysis is that we also access insurance company-level data for insurers that covered these firms (supply side). Therefore, we know not only the quantity of insurance a given firm has purchased, at what cost, but also who provided that coverage. This is important methodologically because the econometric analysis of the corporate demand for insurance can be complicated by the inherent endogeneity problem associated with the relationship between premium and the degree of coverage. Indeed, corporate clients make a simultaneous decision on the premium and the degree of coverage. This can potentially create a problem of reversed causality and thus lead to erroneous analysis if one uses traditional econometrics. In this paper, we overcome this endogeneity problem by using insurer-specific variables as instrumental variables for insurance premium to identify the causal relationship between premium and insurance quantity.

Combining demand and supply data we can then empirically examine corporate demand for insurance. Our findings can be summarized as follows: (1) We find that a majority of firms in our sample (59%) do purchase terrorism insurance, demonstrating that this has become sizeable market. (2) Corporate demand for terrorism insurance and property insurance are found to be rather inelastic. For those firms that purchase terrorism insurance, the demand for that coverage is found to be *more* price inelastic than their demand for property coverage, as we hypothesized. Depending on the applied estimation technique used for the analysis, the price elasticity for property coverage ranges from -0.19 to -0.36, while the price elasticity of corporate demand for terrorism coverage ranges from -0.11 to -0.25. (3) There exists a substitutional relationship between a client's ability to self-insure (measured by the current and solvency ratios) and insurance use, but it is statistically significant only for solvency ratio and terrorism insurance coverage. In other words, a firm is more likely to purchase terrorism insurance when in greater danger of bankruptcy as measured by the solvency ratio. (4) Our findings confirm the proposition by Doherty (2000) that larger firms are more diversified and have developed internal risk management capacity, which results in their purchasing proportionally less coverage than smaller firms. Interestingly, the size of the estimated effect does not differ much between terrorism and property coverage suggesting that they make insurance-related decisions independent of coverage type. Our results are robust if we account for endogenous deductible choices in a 3SLS framework and account for distributional features of the dependent variable using Tobit or QMLE estimators. Further, they are not sensitive to changes in the choice of measures of company size and of financial strength. One possible interpretation of our results is that risk-averse managers are a driver for corporate demand for property insurance (e.g. Greenwald and Stiglitz 1990; 1993, and Mayers & Smith 1982; Kunreuther, Pauly & McMorrow, 2013). However, due to a lack of appropriate direct measures (e.g. percentage of shares held by managers) we are not able to test this hypothesis directly.

The paper is also timely since TRIA was renewed several times since 2002, most recently for seven years in 2007. Set to expire at the end of December 2014 unless renewed by Congress and the President, the paper proposes new knowledge on a market for which empirical analysis is lacking. The analysis should thus be of interest to policymakers and the corporate world alike.

The remaining sections of the paper are structured as follows. In Section 2, we present our data. Section 3 discusses our empirical strategy. The results of our analysis are discussed In Section 4 we discuss the results of our analysis and undertake a series of robustness checks. Section 5 concludes.

2. Data

The data used in this study are collected from three different sources: Marsh, ORBIS and A.M. Best. Data on property and terrorism insurance contracts was obtained from Marsh, which provided us with company-level insurance contract data on their clients headquartered in the United States in 2007. Contract details were reported through an intranet form completed by brokers from Marsh's offices in the United States. Company identities were kept anonymous through the use of random ID numbers designed specifically for this study. We assume that idiosyncrasies among brokers or offices were randomly distributed across the dataset. The original dataset included 1,884 companies. We have removed companies with total insured value lower than $1 million, which left us with 1,808 firms.

Assets for both lines of insurance coverage are exclusively located in the United States. And while the data does not include the exact locations of all of the companies' assets, we used the location of the Marsh office which brokered the policy (typically in the same location as the headquarters of the company) as the proxy for location when we undertake regional analyses. Given that each individual contract covered multiple locations for a single company, we assume that the number of locations per company is randomly distributed across our dataset. (Marsh divides their offices into nine major regions, each combining a number of states[10]). Firms in the dataset were divided into 20 industry sectors. Table 1 shows the distribution of companies within the full sample across these different industry sectors. Of the 1,808 companies, 1,064 had purchased terrorism insurance in conjunction with their normal property insurance. This implies a market penetration of 59% (Table 1).[11] The terrorism insurance take-up rate varies across industry sectors, ranging from a low 16.7% in mining to a high 78.2% in real estate. Of these 1,064 companies we have complete observations with information about the degree of coverage and the premium paid for both property *and* terrorism insurance for 628 of them.

[10] Central Midwest: Illinois, Indiana, Minnesota, Missouri, Wisconsin; Mid-Atlantic: District of Columbia, Maryland, Pennsylvania (Harrisburg, Philadelphia); New York Metro: Connecticut (Norwalk); New Jersey (Morristown), New York (New York City); Northeast: Connecticut, Maine, Massachusetts, 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, San Diego); Upper Midwest: Kentucky, Michigan, Ohio, Pennsylvania (Pittsburgh); West: Alaska, California (San Francisco, San Jose), Colorado, Hawaii, Oregon, Utah, Washington. (Note that California, Connecticut, New York, and Pennsylvania include offices that are in multiple regions. The specific locations are included in parentheses.)

[11] Market penetration/take-up rate is defined here as the percentage of companies that have a terrorism insurance policy, and not the amount of assets insured against terrorism over the total amount of assets.

Table 1: Distribution of Companies Across Industries and Terrorism Insurance Take-Up Rate – Full Sample

Industry	**Firms**	**Without terror insurance**	**%**
Agriculture	11	3	27.27%
Construction & Design	46	23	50.00%
Distribution	35	19	54.29%
Education	75	55	73.33%
Financial Institutions	78	56	71.79%
Food & Beverages	79	40	50.63%
Healthcare	156	115	73.72%
Hospitality & Gaming	84	56	66.67%
Manufacturing	452	199	44.03%
Media	46	29	63.04%
Mining	18	3	16.67%
Pharmaceutical	36	20	55.56%
Power & Utilities	105	69	65.71%
Public Entities	59	35	59.32%
Real Estate	124	97	78.23%
Retail & Wholesale	125	70	56.00%
Services	120	76	63.33%
Technology	68	41	60.29%
Telecomm	27	17	62.96%
Transportation	64	41	64.06%
Total	**1,808**	**1,064**	

The Marsh dataset contains both publicly traded and private companies. Standard sources of financial data, such as COMPUSTAT, however, contain information only for publicly listed companies. We therefore used the ORBIS database distributed by Bureau van Dijk that contains balance sheet information, profit and loss statements and a variety of financial ratios for over 19.2 million companies in the U.S. and Canada. We matched the ORBIS data with the Marsh dataset in those cases where an exact identification was possible and where both insurance and financial data were available. For a large number of companies in the Marsh dataset, exact matching with the ORBIS data was not possible. This reduced our final dataset to 193 companies for which we are able to estimate both the premium elasticity for both types of coverage and the effect of self-insurance. However, we are able to estimate premium elasticity and analyze the effect of size, industry and headquarter location on a sample of 628 firms, which we will use to supplement our findings on the 193 firms. The final sample in our study is similar in size to the studies by Hoyt & Khang (2000) (N=187) and by Aunon-Nerin & Ehling (2008) (N=183).

The average size of the companies in our final sample is measured by assets that are covered under property insurance; that is, the total insured value (TIV, hereafter).[12] This measurement contains tangible assets only, and no values associated with business interruptions or workers' compensation. The mean for the TIV variable in our final sample is $3.16 billion (median of $2.95 billion). Our dependent variable is the degree of coverage, *CoverTerror*, defined as the ratio of the quantity of terrorism insurance the firm purchased (i.e., the maximum terrorism claim payment the firm can receive from its insurer, minus the deductible) to TIV. We construct the variable for property insurance, *CoverProperty*, in a similar way. It is defined as the ratio of the quantity of property insurance the firm purchased (i.e., the maximum property claim payment the firm can receive from its insurer, minus the deductible) to TIV.

We find that the mean degree of coverage against terrorism, *CoverTerror*, is 0.350, and the mean degree of property coverage, *CoverProperty*, is 0.441. This indicates that, on average, firms that purchased terrorism insurance had a limit on their contract which represents 35% of the total insured value in the case of terrorism insurance, and 44% of the total insured value for property.

The premiums paid by the company for terrorism insurance and for property insurance are labeled $Premium_{Terror}$ and $Premium_{Property}$, respectively. We also calculate the premium paid by these companies per $1,000 of coverage and we measured it for both terrorism and property insurance (noted $Premium_{Terror}/Quantity_{Terror}$ and $Premium_{Property}/Quantity_{Property}$). On average, firms pay eight times more for property than they do for terrorism ($4.943 versus $0.628 per $1,000 of quantity of insurance purchased; i.e. coverage minus deductible.)[13] The correlation between property and terrorism insurance premium is 0.34.

In order to consider possible sample selection biases, Table 2 provides descriptive statistics for the original sample (upper panel), the subsample consisting of firms that have property and terror coverage (middle panel, N=628) and the final sample consisting of firms with both types of coverage, information about self-insurance capability of the insured and insurer specific information (lower panel, N=193). Comparing the descriptive statistics between the full sample and the sample of firms with both types of coverage (that is, the upper and middle panels), we do not find noticeable difference in the degree of coverage, firm size or premium. This makes us confident that a potential sample selection bias resulting from the constraint that the firms purchased both property and terrorism insurance will not be of concern.

If we compare the differences between the sample in the middle panel and the set of firms for which information on all controls are available (lower panel), we find that the degree of coverage for both property and terrorism is somewhat smaller in the final sample. Insurance premiums are again very similar. The only significant difference appears to be in the size of the firms (TIV). The final sample is composed of firms that are on average larger than the firms in the full sample and the subsample with both types of coverage. Comparing the maximum values between the three panels also suggests that this difference is not driven by an outlier in size (the maximum TIV in the final sample is $54 billion compared to $93 billion in the other two samples). The most likely explanation for this difference is that

[12] Note that we have information only about the total dollar value of insurance purchased by the firm and not the decomposition of assets under coverage (e.g., building, inventory, land, brand).

[13] We find that a firm with a $1.97 billion of insured value (which is the mean for our sample of 628 firms that purchased both property and terrorism insurance; Table 2) pays $1.16 million in premium per year for terrorism insurance.

on average larger firms are more likely to report (voluntarily) their financial and budget figures to ORBIS and therefore our final sample is composed of comparably larger firms.

As empirical proxies for a company's capability to borrow money in the short term (self-insurance capacity) we use 2005 values of the solvency and current ratios accounting for the company's ability to meet long-term and short-term debt, respectively (noted *SolvencyRatio* and *CurrentRatio*).[14]

To account for the demand-supply interaction that determines insurance purchase decisions (we discuss the rationale for this choice in the next section), we use a third source of data, that is supply-side data on the insurance companies providing property and terrorism coverage to all the firms in our sample in 2007 using annual A.M. Best Insurance Reports-P/C US & Canada (Version 2008.1). To proxy for the insurance company's marginal cost via its risk bearing capacity we use Liquidity and Operating Revenue. Liquidity is calculated by A.M. Best and gives the ratio of total admitted assets divided by total liabilities less conditional reserves, expressed as a percent. This ratio indicates a company's ability to cover net liabilities with total assets. Operating revenue is also a ratio calculated by A.M. Best and measures an insurer's overall operating profitability from underwriting and investment activity. The supply and demand datasets were then merged using the unique insurance company identifier. Based on available information for all these variables, it was possible to identify the full information on insurance supplier for 141 of the 193 large companies in the subsample. The final sample consists of data from 15 different insurance suppliers.

Table 2: Descriptive Statistics

Obs.	Variable	Mean	Std. Dev.	Min.	Max.
Full sample					
$Cover_{Property}$	1760	0.607	0.379	0.007	1.502
$Cover_{Terror}$	791	0.479	0.392	-0.002	1.409
TIV (\$ million)	1808	1,749.565	5,778.614	1.029	93,220.63
$Premium_{Property}/Quantity_{Property}$ (\$)	1809	5.678	10.596	0.000	133.334
$Premium_{Terror}/Quantity_{Terror}$ (\$)	684	0.566	1.603	0.076	22.195
Sample with property and terrorism cover					
$Cover_{Property}$	628	0.548	0.364	0.007	1.000
$Cover_{Terror}$	628	0.480	0.375	0.001	1.000
TIV (\$ million)	628	1,970.164	5,967.372	1.029	93,220.63
$Premium_{Property}/Quantity_{Property}$ (\$)	628	4.847	7.973	0.000	99.948
$Premium_{Terror}/Quantity_{Terror}$ (\$)	628	0.592	1.644	0.076	22.195
Sample with additional financial controls					
$Cover_{Property}$	193	0.441	0.335	0.008	1.000
$Cover_{Terror}$	193	0.350	0.330	0.002	1.000
TIV (\$ million)	193	3,159.872	7,341.933	3.000	54,094.860
$Premium_{Property}/Quantity_{Property}$ (\$)	193	4.943	8.853	0.360	99.948
$Premium_{Terror}/Quantity_{Terror}$ (\$)	193	0.628	1.388	0.082	10.162
Solvency Ratio	193	36.893	25.087	-60.420	95.210
Current Ratio	193	1.906	1.453	0.000	11.090
Operating Revenue	141	78.862	9.166	67.800	102.900
Liquidity	141	192.064	106.548	134.900	713.800

[14] The solvency ratio is calculated by adding the company's post-tax net profit and depreciation, and dividing the sum by the quantity of long-term and short-term liabilities; the resulting amount is expressed as a percentage. A high solvency ratio indicates a healthy company, while a low ratio indicates the opposite. A low solvency ratio further indicates likelihood of default. The current ratio is defined as current assets over current liabilities (often over the next twelve months). Both are available in the ORBIS database.

3. Empirical Approach

Based on our discussion above, we specify the following empirical demand function for each type of risk *c* (terrorism or property):

$$Cover_{ci} = \beta_0 + \beta_1 \ln(TIV_{ci}) + \beta_2 \ln(\frac{Premium_{ci}}{Quantity_{ci}}) + \beta_3 SolvencyRatio_i + \beta_4 CurrentRatio_i + I_i + R_i + \varepsilon_{ci} \quad (1)$$

where $Cover_{ci}$ denotes, for company *i*, its degree of coverage for risk type *c*. TIV is the total insured value of company *i* and *Premium/Quantity* is the cost of insurance (premium per $1,000 of quantity for the respective type of insurance). *I* and *R* are industry and region specific dummies; ε_{ci} is the error term and β are coefficients to be estimated.

Warner (1977) suggests that economies of scale reduce the bankruptcy costs of large firms. Doherty (2000) posits that corporate clients receive benefits from market insurance that go beyond the sole transfer of financial risk. Insurance companies provide their corporate clients with risk management expertise and often help them to develop appropriate risk management strategies. Larger corporate clients are more likely to produce some of these risk management services in-house (e.g., they maintain their own risk-management department) than smaller corporate clients. Therefore, it is reasonable to assume that smaller companies have a higher demand for the real service component that comes with an insurance policy. Hence, we expect β_1 to depict a negative sign for property coverage.

Whether this is also the case for terrorism insurance is not clear *a priori*. Indeed, terrorism has a set of characteristics that make it fairly different than risks covered under the property coverage. Terrorism threat is difficult to predict, and there is not as much data on claims and frequency as there is for fire or even natural hazards. As we discussed in the introduction, only a handful of terrorist attacks occurred on U.S. soil and were insured. As such, it is not clear whether insurers have the same level of service value in the case of terrorism as they have for property. Furthermore, larger firms might also be more likely to be targeted by terrorist organizations if those are perceived as "trophy" targets (Enders and Sandler, 2006); as such, larger firms might be more likely to purchase more terrorism coverage, relative to their total insurance value than smaller ones, all things being equal. The sign of β_1 for terrorism coverage is thus ambiguous, and ultimately a matter of empirical analysis.

The coefficient β_2 exhibits the price elasticity of demand. We expect β_2 to be negative and significant for both property and terrorism. We also expect to find β_2 to be higher for property than for terrorism; that is, to find the demand for terrorism insurance to be more price inelastic for reasons we explained in the introduction that review the literature and our hypotheses.

The marginal effects of a firm's access to short-term capital on its insurance demand is represented by coefficients β_3 (*SolvencyRatio*) and β_4 (*CurrentRatio*). A negative sign would indicate that self-insurance and market insurance are substitutes, while a positive sign indicates a complementary relationship. The correlation between *Solvency Ratio* and *Current Ratio* in our sample is 0.31. Excluding either one of the two ratios from the empirical demand function *(1)* does not change the results. We also include industry, I_i, and regions specific effects, R_i, to account for variations in demand between industries and geographic areas.

The analysis needs to overcome two econometric issues: The first one is related to the endogenous relationship between insurance coverage and premium, while the second one is associated with the distribution and bounded nature of the dependent variable. We discuss them in turn now.

First, there might be an endogenous relationship between the dependent variable $Cover_{ci}$ and the main explanatory variable, *Premium/Quantity*. Insurance companies and corporate clients negotiate an insurance package that consists of the insurance quantity and the premium. The client makes a simultaneous decision on the package (premium and quantity). Therefore, the observed data in our insurance dataset is basically a collection of equilibrium points on the supply and demand curve. A standard OLS estimator is not able to identify the demand relationship and therefore the price elasticity. Insurance premium is likely to be correlated with some other unobserved variable embodied in the error-term. The OLS estimates of β_2 will represent not only the effect of $Premium_c/Quantity_c$ on $Cover_c$ but also the effect of the unobserved variable, possibly yielding biased and inconsistent results.

One way to address this problem is the application of a two-stage least squares (2SLS) approach. In our case, this requires instruments that are good predictors with changes in the insurance premium (relevance) but are uncorrelated with the error-term in the demand equation (validity). In a demand-supply relationship we can use variables that affect the marginal cost of the supply of insurance.

The choice of instruments in this paper is based on Kleffner & Doherty (1996) who suggest a number of factors that determine insurers' ability to write corporate coverage. It typically depends on financial indicators that have an impact on the cost of risk bearing. We use *Liquidity* and *Operating Revenue* as proxies for the insurer's financial strength and risk-bearing capacity. The work by Kleffner & Doherty (1996) already shows that insurer's financial strengths are strong determinants of the level of insurance premium; therefore we are confident that these variables are relevant instruments in our case. In addition, we apply the Kleibergen-Paap test statistics, which provides further support for this claim (Table 3). Our identifying assumption is that the instruments are orthogonal to the error term in the second stage. Albeit not perfect,[15] we can evaluate our instruments' validity by applying statistical tests for over-identifying restrictions.

Our second strategy to deal with the endogeneity follows the approach of Aunon-Nerin & Ehling (2008) who apply a three-stage least-squares (3SLS) model to simultaneously estimate the limit and the deductible choice. In cases where the variance-covariance matrix is diagonal and each equation in the system is just-identified, 2SLS and 3SLS yield the same results. If we assume that all equations are correctly specified, 3SLS is asymptotically more efficient than the 2SLS procedure, but 2SLS is more robust. Assuming that our instruments are exogenous, the 2SLS estimates can be considered consistent. Instead of making assumptions about whether the equations in our system are correctly specified, we just present 3SLS estimates and compare them to the 2SLS estimates.

Applying a 3SLS estimator further allows us to simultaneously model the deductible choice. Second, we need to consider the bounded nature of the dependent variable ($Cover_{ci}$) which is always between 0 and 1 and the fact that our observations are concentrated at the upper boundary.

---

[15] Sargan and Hansen tests should only be interpreted as auxiliary support for theoretical validity. These test statistics for over-identifying restrictions basically tests for the equality of the instrumental variable (IV) estimates from each instrument. In a case where both instruments are correlated, they can be potentially endogenous for the same reasons and therefore IV estimates from the individual instruments will be similarly inconsistent.

Estimating equation (1) with OLS 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) present a quasi-maximum likelihood estimator (QMLE hereafter) to obtain unbiased estimates. We adopt the same methodology here. Still, to check whether our estimates are indeed sensitive to the estimator applied, we estimate equation (1) using QMLE and run the analysis for, Tobit and IV-Tobit as well.

4. Results

We commence the presentation of our results with the instrumental variable (IV)-estimates of our baseline specifications in Table 3. The lower panel of the table contains coefficient estimates of the first stage regression where we use the insurer's *Operating Revenue* and *Liquidity* as exogenous instruments for *Premium/Quantity*.[16] Both coefficients are statistically significant at the 1% level. A significant p-value for the Kleinbergen-Paap test is additional evidence that our instruments are strong and relevant. The instruments also pass the Hansen-J test for over-identifying restrictions. The second stage estimate on *Premium/Quantity* is negative and statistically significant at the 1% level.

The second stage results are presented in the upper panel of Table 3. The coefficient of TIV (total insured value) is negative and highly significant for both property and terrorism coverage, indicating again that larger companies have, on average, a lower degree of coverage than smaller firms (ratio quantity over TIV is lower), confirming the hypothesis discussed earlier. This might be due to higher geographical diversification of their assets. It could also be that smaller firms purchase insurance to access risk-management expertise of the insurers (Doherty 2000). In addition, larger companies also have better access to short-term capital and might substitute market insurance with self-insurance (Hau 2004).

Comparing the coefficients of the TIV shows that this effect of company size (larger companies have a lower degree of coverage than smaller firms) is similar between the two types of insurance coverage.

The price elasticity coefficients are negative and significant at the 1% level. All coefficient values are between 0 and -1, indicating that corporate demand for property and terrorism insurance is rather inelastic. In particular, a 10% increase in property premium leads to a 2.1% decrease in property coverage, while a 10% increase in terrorism premium leads to only a 1.3% decrease in terrorism coverage. To test whether the estimated coefficients of price elasticity systematically differ between each type of insurance we perform a Chow test. The Chow test is a standard t-test on the equality of coefficients for each type of coverage. In our main specification (including all control variables),[17] the Chow test yields a critical t-value of 22.91 and strongly rejects the null hypothesis of equality of coefficients.

---

[16] We regress individual level data (premium of one client) on more aggregate variables (Operating Revenue and Liquidity are on insurance company level and one insurance company supplies multiple firms in our sample). Moulton (1990) shows that in such a situation the estimated coefficients are consistent but the standard errors are biased downwards. To account for within-group correlation we adjust standard errors for within insurance company clustering. The results stay qualitatively the same if we do not adjust for within-group clustering.

[17] The results of the Chow-test are very similar for the other specifications.

This first set of 2SLS results thereby confirms our hypothesis that the demand for terrorism insurance is more price inelastic than the one for property. The coefficient for *SolvencyRatio* is negative and significant for both property and terrorism insurance, indicating some substitution effect between self-insurance and insurance purchased by these firms. But these coefficients are rather small. A 10% higher solvency ratio reduces demand for property coverage by 0.1% (significant at 5%) and for terrorism insurance by 0.3% (significant at 1%). Possibly, the variable for company size explains much of the variation related to a company's ability to generate money to cover property damages. Alternatively, many firms use bonds, and those contracts often require some insurance, as do some suppliers and customers. In addition, some might consider that a firm with a higher current ratio is still vulnerable to catastrophe risks (whether they are covered under property or require terrorism insurance) in a sense that a sudden and very large loss will make the willingness to purchase debt in the aftermath of a disaster difficult and costly; purchasing insurance ex ante would avoid this problem.

Several industry dummies yield a robust significant negative effect in the case of terrorism insurance; we found this effect for media, power and utilities, and services. But there is no significant industry effect for property insurance (except for media), which is somewhat surprising given that previous studies show that industry sector is an important determinant of corporate demand for property insurance (e.g., Hoyt & Khang 2000). It is very likely that the premium already picks up differences in exposure to property risks between industry types.

Regarding regional differences, we find that corporate demand for property insurance is higher in the New York Metro area (+9.7%). On average, corporate clients are located in closer proximity to each other there. Hazards to property such as a fire or a chemical spill are more likely to affect other companies located in the area. The demand for terrorism insurance is even higher in the New York Metro area (+20.6%), and remains higher for the Northeast and Mid-Atlantic regions. Compared to the other region dummies, these are very densely populated and urbanized areas. The events of 9/11 also showed that terrorist attacks in urban centers often affect multiple companies at once. In the case of New York there could be a "trophy target" effect in that terrorist organizations capable of inflicting a large-scale attack might be more likely to attack a city that represents so much of an American symbol. This was precisely the logic behind the 1993 and 2001 Al Qaeda's attacks.

Table 3: Demand for Property and Terrorism Insurance - Baseline Results

		IV		IV	
		Property	**Terror**	**Property**	**Terror**
ln (TIV)		-0.099***	-0.098***	-0.099***	-0.094***
		(0.014)	(0.026)	(0.014)	(0.024)
ln (Premium/Quality)		-0.213***	-0.127***	-0.219***	-0.138***
		(0.035)	(0.049)	(0.034)	(0.049)
Solvency Ratio				-0.001**	-0.003***
				(0.001)	(0.001)
Current Ratio				-0.005	0.009
				(0.012)	(0.012)
Industries[a]:					
	Construction	0.008	-0.130	-0.015	-0.166
		(0.172)	(0.133)	(0.181)	(0.150)
	Distribution	0.021	-0.058	-0.029	-0.143
		(0.172)	(0.195)	(0.159)	(0.163)
	Education	-0.072	-0.079	-0.097	-0.138
		(0.096)	(0.110)	(0.096)	(0.110)
	Financial Insitutions	-0.033	-0.033	-0.089	-0.138
		(0.123)	(0.108)	(0.121)	(0.107)
	Food & Beverages	0.182	0.091	0.141	0.037
		(0.131)	(0.159)	(0.137)	(0.178)
	Healthcare	-0.044	0.028	-0.091	-0.052
		(0.104)	(0.142)	(0.105)	(0.141)
	Hospitality	0.032	-0.062	0.006	-0.099
		(0.096)	(0.079)	(0.100)	(0.080)
	Manufacturing	0.051	-0.103	0.027	-0.148
		(0.091)	(0.121)	(0.091)	(0.119)
	Media	-0.199**	-0.109	-0.249***	-0.187***
		(0.086)	(0.085)	(0.089)	(0.089)
	Pharmaceutical	-0.036	-0.016	-0.073	-0.092
		(0.101)	(0.121)	(0.098)	(0.098)
	Power & Utilities	-0.061	-0.108	-0.103	-0.179**
		(0.095)	(0.089)	(0.095)	(0.087)
	Real Estate	-0.014	0.092	-0.069	-0.002
		(0.098)	(0.123)	(0.097)	(0.112)
	Retail/Wholesale	-0.106	-0.219*	-0.115	-0.250**
		(0.099)	(0.123)	(0.098)	(0.120)
	Services	-0.121	-0.167	-0.143	-0.212**
		(0.117)	(0.133)	(0.108)	(0.104)
	Technology	-0.047	-0.006	-0.052	-0.017
		(0.091)	(0.102)	(0.093)	(0.100)
	Telecomm	0.116	0.174	0.104	0.144
		(0.139)	(0.124)	(0.144)	(0.129)
Regions[b]:					
	Mid-Atlantic	0.051	0.134*	0.040	0.121**
		(0.059)	(0.071)	(0.053)	(0.059)
	New York Metro	0.092*	0.194***	0.097*	0.206***
		(0.053)	(0.074)	(0.052)	(0.076)
	Northeast	0.075	0.111*	0.080	0.120**
		(0.055)	(0.061)	(0.057)	(0.061)
	South Central	-0.002	-0.037	0.016	-0.067
		(0.147)	(0.090)	(0.179)	(0.127)
	Southeast	0.110	-0.012	0.106	-0.025
		(0.072)	(0.067)	(0.072)	(0.059)
	Southwest	0.031	-0.011	0.035	-0.004
		(0.079)	(0.072)	(0.076)	(0.064)
	Upper Midwest	-0.047	-0.061	-0.052	-0.079
		(0.056)	(0.075)	(0.055)	(0.073)
	West	0.025	0.029	0.015	0.015
		(0.052)	(0.056)	(0.050)	(0.059)
			1st Stage Results[c]		
Operating Revenue		0.042***	0.026***	0.050***	0.030***
		(0.005)	(0.001)	(0.008)	(0.013)
Liquidity		-0.002***	-0.002***	-0.003***	-0.003***
		(0.000)	(0.000)	(0.001)	(0.001)
Kleinbergen-Paap Test (p-value)		0.000	0.000	0.003	0.003
Hanson Test (p-value)		0.639	0.476	0.701	0.738
R^2		0.684	0.605	0.690	0.638
N		141	141	141	141

Notes: Dependent Variable Cover $_{cij}$. [a]Agriculture is the omitted industry dummy. Industry dummies for Mining, Public Entities, Services, and Transportation have been dropped because there are not enough firms from these industries in the final sample. [b]Central Midwest is the omitted region dummy. Robust standard errors in parenthesis. [c]Only the coefficients of the exogenous instruments are reported. Full sets of 1st stage results are available upon request. ***, **, * denotes significance at the 1%, 5% and 10% level, respectively.

Table 4 presents the results of the 3SLS approach. For each type of insurance coverage, we specify three equations which are then estimated simultaneously. The dependent variables are *Cover*, *Premium* and the natural log of the amount of deductible, *ln(Deductible)*. Again, we are using *Operating Revenue* and *Liquidity* as exogenous instruments for *Premium/Quantity*. For *ln(Deductible)* we are using the amount of deductible for flood insurance as an additional instrument. The estimated effect of company size (TIV) is -0.174 for property and -0.072 for terror coverage. Thereby, the estimated coefficients of TIV are very similar to those estimated using 2SLS in Table 3 (approx. 0.1).

The estimated price elasticity is -0.295 for property and -0.247 for terrorism insurance. Compared to the 2SLS estimates, these values are slightly larger, but still indicate a relatively inelastic demand. In addition, they also support our hypothesis that demand for terrorism insurance is more inelastic. The critical t-value of the Chow test is 15.36 and again rejects the null hypothesis of equality of the price elasticity parameters. With respect to the firms' self-insurance capabilities, we find a statistically significant effect of the solvency ratio on terror coverage but not on property coverage. However, again, the effect is very small. The 3SLS estimates reveal that the deductible choice has a systematic and positive effect on the quantity of insurance purchased of property insurance, which is in line with Aunon-Nerin & Ehling (2008). We do not find a statistically significant result on this relationship in the case of terrorism insurance. We also find a negative relation between solvency ratio and terrorism insurance coverage.

Table 4: Demand for Property and Terrorism Insurance - 3SLS-Estimates

	Property			**Terror**		
	Cover	*ln (Premium/ Quantity)*	*ln (Deductible)*	*Cover*	*ln (Premium/ Quantity)*	*ln (Deductible)*
ln (TIV)	-0.174***	0.254***	0.422***	-0.072*	0.467***	0.155
	(0.036)	(0.055)	(0.088)	(0.040)	(0.080)	(0.210)
ln (Premium/Quantity)	-0.295***		0.528**	-0.247***		0.815**
	(0.034)		(0.209)	(0.091)		(0.402)
ln (Deductible)	0.165***			0.064		
	(0.036)			(0.046)		
Solvency Ratio	-0.000	0.007**	-0.014**	-0.004***	-0.003	-0.007
	(0.002)	(0.003)	(0.005)	(0.001)	(0.004)	(0.006)
Current Ratio	-0.012	-0.030	0.035	-0.016	-0.096	0.095
	(0.023)	(0.067)	(0.096)	(0.026)	(0.098)	(0.133)
Operating Revenue		0.046***			0.024**	
		(0.009)			(0.011)	
Liquidity		-0.004***			-0.003***	
		(0.001)			(0.001)	
Flood			$8.83e^{-08}$***			$9.66e^{-08}$***
Deductible			(0.000)			(0.000)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	Yes	Yes

Notes: [a]Agriculture is the omitted industry dummy. Industry dummies for Mining, Public Entities, Services, and Transportation have been dropped because there are not enough firms from these industries in the final sample. [b]Central Midwest is the omitted region dummy. Standard errors in parenthesis are clustered on insurance company level. ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 5 provides the results of the QMLE to take into account the bounded nature of the dependent variable (*Cover*$_{ci}$). Tobit and IV-Tobit estimates are also provided. All numbers in the table are marginal effects, to allow comparability with the estimated coefficients in Tables 3 and 4.

For all three estimators, the effect of company size (measured as TIV) on the demand for property and terrorism insurance lies in a range between -0.085 and -0.151 and are thereby very similar to the estimated coefficients in from the 2SLS and 3SLS results.

Table 5: Demand for Property and Terrorism Insurance - QMLE, Tobit & IV-Tobit

	QMLE		Tobit		IV-Tobit	
	Property	Terror	Property	Terror	Property	Terror
ln (TIV)	-0.151***	-0.149***	-0.102***	-0.085***	-0.099***	-0.094***
	(0.019)	(0.020)	(0.010)	(0.014)	(0.014)	(0.024)
ln (Premium/Quantity)	-0.358***	-0.160***	-0.190***	-0.112***	-0.219***	-0.138***
	(0.034)	(0.019)	(0.017)	(0.013)	(0.035)	(0.049)
Solvency Ratio	-0.002*	-0.003***	-0.001	-0.002***	-0.001**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Current Ratio	0.002	0.019	-0.001	0.011	-0.005	0.009
	(0.014)	(0.014)	(0.010)	(0.012)	(0.012)	(0.012)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Dependent Variable: Cover $_{cij}$. N=193 [a]Agriculture is the omitted industry dummy. Industry dummies for Mining, Public Entities, Services, and Transportation have been dropped because there are not enough firms from these industries in the final sample. [b]Central Midwest is the omitted region dummy. Standard errors in parenthesis are clustered on insurance company level. ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Comparing the coefficients of *Premium/Quantity* for the QMLE, we find again that the demand for terrorism insurance is significantly less price elastic (-0.160) than the demand for property insurance (-0.358). A price increase of 10% will decrease the quantity of property insurance purchased by 3.58% and the quantity of terrorism insurance by only 1.60%. The Tobit and IV-Tobit yield similar results. Solvency ratio is again found to have a significantly negative effect, albeit fairly small.

Overall, the different econometric models yield a very coherent picture: corporate demand for property insurance is rather inelastic (in the range of -0.19 to -0.36, depending on the econometric specification we selected) and demand for terrorism risk insurance is even more price inelastic (-0.11 to -0.25). Based on the results from a Chow test, the differences in the estimated coefficients are found to be statistically significant. It might also be the case that terrorism insurance sold as an add-on policy covering only one type of hazard, combined with the intense visual media coverage of any successful attack, makes managers of the firm focus more on the negative consequences of an attack rather than its probability.

Moreover, firms purchasing both property coverage and terrorism coverage might consider the cost of terrorism coverage as being comparatively inexpensive relative to what they pay for property coverage. Finally, there might be a stronger willingness from the board of directors to support this purchase in the aftermath of the 2001 attacks and the passage of the Sarbanes-Oxley legislation in 2002.

These results on corporate insurance choices are important findings because they stand in contrast to individual insurance choices in controlled laboratory experiments (Ganderton, Brookshire, McKee, Stewart & Thurston 2000) and empirical studies on homeowners' insurance (e.g., Grace, Klein & Kleindorfer 2004, Kunreuther, Meyer & Michel-Kerjan 2013) which reveal that the majority of homeowners actually do not purchase catastrophe coverage, and that those who do exhibit a significantly higher price elasticity than what we find to be the case for corporations in our sample.

For instance, Grace et al. (2004) look at homeowners' insurance and distinguish demand for catastrophe risk (hurricane risk) and non-catastrophe risk insurance. They found a price elasticity coefficient equal to -1.9 for hurricane risk insurance and -0.4 for non-catastrophe risk. Prior studies of price elasticities of demand for residential flood insurance found to be in the range of −0.62 to −0.87 (Landry & Jahan-Parvar 2011) to -0.99 (Browne & Hoyt 2000), and as high as −1.55 to -4.48 for flood insurance policyholders who benefit from subsidized rates by the federal government (Landry & Jahan-Parvar 2011). As we discussed in the present study, there are numerous institutional arrangements that exist in the corporate world that do not apply to homeowners and that explain this difference. It is also interesting to see how our results on price elasticity compare to evidence in the literature for other fields. Elasticity of the demand for crop insurance for farmers was found to be in the -0.30 to -0.90 range (Garner & Kramer 1986; Goodwin 1993; Barnet & Skees 1995; Shaik et al. 2008). Price elasticity for auto insurance was found to be -0.56, for automobiles to be -1.20 and for dining out, -2.27 (Hoyt 1990). Gruber and Letteau (2004), which provides a comprehensive review of the literature on demand elasticity for health insurance, found the elasticity of firms' demand for health insurance spending to be -0.70.

We now turn to a series of robustness checks to test the sensitivity of our results with respect to alternative indicators of self-insurance capability and company size. Table 6 looks at the effect of four alternative measures of financial strength: *Net Income; Net Assets Turnover; Stock Turnover*; and *Liquidity Ratio*. We apply the same specifications for property and terrorism coverage as in Table 3, but replace *Solvency Ratio* and *Current Ratio*, with each of the four alternative measures, separately. The coefficient of *net income* (profit and loss ratio) depicts a negative sign for property and terrorism coverage, which is only statistically significant (at the 10% level) for property insurance. *Net Assets Turnover, Stock Turnover* and *Liquidity Ratio* all yield a negative coefficient. However, only the effect of stock turnover on property coverage is statistically significant. These four measures are mainly indicators of short-term financial strength. In combination with our main results, where only the solvency ratio has a statistically significant self-insurance effect, we interpret these results as an indication that it is mainly the ability to meet long-term obligations that matter for self-insurance considerations, rather than short-term financial strength. Our results on premium elasticity stay qualitatively and quantitatively the same.

In a further robustness check, we test whether our results change if we use alternative measures of company size. Our dependent variable *Cover* is the ratio of total limit over TIV. Therefore, the negative coefficient of TIV on the right-hand side of the equations could be the result of being in the denominator of the dependent variable. To check whether our results on the effect of company size on insurance demand hold, we replace TIV by alternative measures of company size in Table 7. Instead of TIV, we first use the log of sales, which also yields a negative coefficient which is significant at the 1% level. The second indicator of size, total number of employees, does not yield significant results. Finally, we include all three measures of size, sales, employees and TIV and we find that the coefficient is qualitatively and quantitatively very similar to our earlier estimates.

Table 6: Demand for Property & Terrorism Insurance - IV - Other Financial Indicators

	Property	**Terror**	**Property**	**Terror**	**Property**	**Terror**	**Property**	**Terror**
$ln(TIV)$	-0.098***	-0.092***	-0.096***	-0.081***	-0.076***	-0.099***	-0.097***	-0.089***
	(0.013)	(0.024)	(0.013)	(0.022)	(0.016)	(0.031)	(0.013)	(0.023)
$ln\left(\frac{Premium}{Quantity}\right)$	-0.210***	-0.135***	-0.224***	-0.153***	-0.235***	-0.117*	-0.218***	-0.138***
	(0.033)	(0.048)	(0.032)	(0.046)	(0.040)	(0.063)	(0.033)	(0.045)
Net Income (P/L)	-0.000*	-0.000						
	(0.000)	(0.000)						
Net Assets Turnover			-0.011	-0.005				
			(0.008)	(0.009)				
Stock Turnover					-0.001**	-0.001		
					(0.000)	(0.001)		
Liquidity Ratio							-0.000	-0.000
							(0.000)	(0.000)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Test (p-value)	0.000	0.001	0.000	0.001	0.000	0.033	0.000	0.001
Hansen Test (p-value)	0.687	0.899	0.533	0.783	0.563	0.934	0.646	0.997
N	145	145	136	136	100	100	139	139

Notes: Dependent Variable: $Cover_{cij}$. [a]Agriculture is the omitted industry dummy. Industry dummies for Mining, Public Entities, Services, and Transportation have been dropped because there are not enough firms from these industries in the final sample. [b]Central Midwest is the omitted region dummy. Standard errors in parenthesis are clustered on insurance company level. ***, **, * denote significance at the 1 %, 5 % and 10 %-level, respectively.

Table 7: Demand for Property & Terrorism Insurance - IV - Other Measures of Size

	Property	**Terror**	**Property**	**Terror**	**Property**	**Terror**
$ln\left(\frac{Premium}{Quantity}\right)$	-0.230***	-0.132**	-0.213***	-0.118**	-0.213***	-0.109**
	(0.046)	(0.052)	(0.049)	(0.056)	(0.037)	(0.043)
$ln(Sales)$	-0.039**	-0.051***			-0.007	-0.013
	(0.016)	(0.018)			(0.014)	(0.016)
Total Employees			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
$ln(TIV)$					-0.101***	-0.121***
					(0.018)	(0.022)
Industry FE[a]	Yes	Yes	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap Test (p-value)	0.000	0.006	0.000	0.013	0.000	0.002
Hansen Test (p-value)	0.935	0.539	0.782	0.325	0.457	0.847
N	64	64	64	64	64	64

Notes: Dependent Variable: $Cover_{cij}$. [a]Agriculture is the omitted industry dummy. Industry dummies for Mining, Public Entities, Services, and Transportation have been dropped because there are not enough firms from these industries in the final sample. [b]Central Midwest is the omitted region dummy. Standard errors in parenthesis are clustered on insurance company level. ***, **, * denote significance at the 1 %, 5 % and 10 %-level, respectively.

5. Conclusion

There have been important theoretical contributions during the past two decades that help explain decisions made by corporations as to how they should protect their assets against different types of left-tail outcomes. Although the empirical literature that focuses on derivative use to analyze corporate risk-management is consistent with theoretical predictions, it has a number of caveats. For example, hedging practices could be correlated with managerial quality and therefore lead to omitted variable bias. In addition, a firm's exposure to certain risks is very often difficult to quantify. Without an appropriate risk measurement, it will be hard to analyze whether firms use derivatives to hedge risks or simply to speculate. Aunon-Nerin & Ehling (2008) suggest that analyzing financial risk management via corporate insurance use can avoid these problems.

Using complementary dataset on the demand and supply sides, we are able to analyze some of the drivers of corporate demand for property coverage across industry sectors and for firms of different sizes for value they insured in the United States. In the aftermath of the September 11, 2001 terrorist attacks, the U.S. terrorism risk insurance market was modified with the passage of the Terrorism Risk Insurance Act of 2002 which excluded terrorism from typical property insurance and made it a distinctive policy firm can purchase from their insurance in addition to property coverage—that is, a distinctive market. This study benefited from access to the data for both lines of coverage, property and terrorism, further extending our understanding of how firms approach their insurance strategy.

We have explained why terrorism is different than other risks typically covered under property insurance (or perceived as such by firms) and as a result why managers would exhibit a demand for terrorism insurance that would be more price inelastic than for property insurance---a hypothesis that is confirmed by our findings across all our econometric specifications (2SLS, 3SLS, QMLE). Larger firms are found to purchase relatively less coverage, whether for property or for terrorism. This might be due to higher geographical diversification, more sophisticated in-house risk management expertise and easier access to short-term capital.

Our analysis has some limitations imposed by the data we were able to access. Because our sample contains many privately own firms, we were not able access all the data that are available for publically traded firms. However, when we performed similar analyses on the subsample of those firms, the results were not significantly altered. Another limitation relates to not knowing precisely how the assets under coverage are diversified geographically. To our knowledge, this information is not publically available, mainly because of commercial and national security concerns. For that reason and after discussing this issue with representatives from the industry, it was agreed that the location where the firms were headquartered provided a reasonably good proxy.

Moving this research agenda forward, it would be useful to access more detailed corporate information on liquidity, short-term credit or decision structures within the company (including incentive systems in place) to provide a comparative analysis of how these other characteristics affect corporate decisions for property and terrorism insurance. It would also be useful to extend the analysis provided here to extreme events other than terrorism (e.g., large technological accidents, natural disasters). This might be somewhat challenging, though, since those other hazards are typically part of the broader property coverage (at least up to some basic coverage limit); the main advantage of terrorism insurance from a research perspective is that today this coverage is sold to firms as a distinct policy. It would also be important to determine what role institutional settings play in corporate risk management in general, and for corporate insurance purchase strategy in particular, and how this strategy relates to firms' derivative use.

Our findings have important policy implications. TRIA requires insurers to offer terrorism risk insurance to their corporate clients, who can accept or refuse the coverage. The TRIA legislation was set as a temporary one in the aftermath of 9/11 and is set to expire at the end of 2014 unless renewed by Congress and the President. An important policy question as part of the debate that is taking place in Congress is how corporations think about terrorism threat and act upon it through their insurance decisions. What are some of the characteristics of the firms that purchase this coverage and those that do not? How does the demand for this coverage differ from other lines and how sensitive is it to price? This study sheds light on these questions and should thus be of interest, beyond the research community, to industry and policymakers as well.

In conclusion, corporate behavior is sensitive to market conditions and this might be particularly true in the case of terrorism. No major terrorist attack against commercial interests occurred in the United States since 2001. The April 2013 Boston Marathon attacks certainly increased concern about terrorism threat, again, but the market will be stressed significantly more should another attack of the size of 9/11 occurred in the near term. Given the rather inelastic demand we found here, it is likely that more firms would want to purchase that coverage even at significantly higher prices.

Finally, our results could have important implications for the broader hedging literature. We began this study by indicating why we thought that focusing on insurance might provide a better environment for understanding the corporate hedging decision. To our knowledge there is no empirical study that was able to document elasticity of the extent a risk exposure is hedged as option premiums change. Our findings might indicate that if firms' managers believe that oil price risk has a much greater possibility to cause bankruptcy than, say, currency risk, (and/or severally affect their reputation as having poor management skills), then this firm's option hedging strategy of oil price risk would be less driven by fluctuations in option premiums than it would be for currency risk.

References

Adams, R., Almeida, H. & Ferreira, D. (2005), 'Powerful CEOs and their Impact on Corporate Performance', Review of Financial Studies 18(4), 1403–1432.

Allayannis, G. & Ofek, E. (2001), 'Exchange rate exposure, hedging, and the use of foreign currency derivatives', Journal of International Money and Finance 20, 273–296.

Aunon-Nerin, D. & Ehling, P. (2008), 'Why Firms Purchase Property Insurance', Journal of Financial Economics 90, 298–312.

Barnett B. J. & Skees, J. R. (1995), 'Region and Crop Specific Models of the Demand for Federal Crop Insurance', Journal of Insurance Issues 18(2), 47-65.

Bertrand, M. & Schoar, A. (2003), 'Managing with Style: The Effect of Managers on Firm Policies', Quarterly Journal of Economics 118(4), 1169–1208.

Bloom, N. & Van Reenen, J. (2010), 'Why Do Management Practices Differ across Firms and Countries?', Journal of Economic Perspectives 24(1), 203–224.

Borkan, B. and H. Kunreuther (1979), 'Contingency Planning Against Low Probability Events', *Best's Review* 80.

Brown, J., Cummins, D., Lewis, C. & Wei, R. (2004), 'An Empirical Analysis of the Economic Impact of Federal Terrorism Reinsurance', Journal of Monetary Economics 51, 861–898.

Browne, M. J. and R. E. Hoyt (2000), 'The Demand for Flood Insurance: Empirical Evidence', Journal of Risk and Uncertainty 20(3), 291-306.

Chen, C. & PonArul, R. (1989), 'On the Tax Incentive for Corporate Insurance Purchase', Journal of Risk and Insurance 56, 307-311.

Colquitt, L.L., & Hoyt, R. E., (1997), 'Determinants of Corporate Hedging Behavior: Evidence from the Life Insurance Industry', Journal of Risk and Insurance 64(4), 649-671.

Core, J. (1997), 'On the Corporate Demand for Directors' and Officers' Insurance', Journal of Risk and Insurance 64(1), 63-87.

Doherty, N. A. (2000), Integrated Risk Management - Techniques and Strategies for Managing Corporate Risk, McGraw-Hill, New York.

Enders, W. & Sandler, T. (2006), The Political Economy of Terrorism, Cambridge University Press.

Froot, K., Scharfstein, D. & Stein, J. (1993), 'Risk management: Coordinating investment and financing policies', Journal of Finance 48, 1629–1658.

Ganderton, P. T., Brookshire, D. S., McKee, M., Stewart, S. & Thurston, H. (2000), 'Buying insurance for disaster-type risks: Experimental evidence', Journal of Risk and Uncertainty 20(3), 271–289.

Gardner, B. L., & Kramer, R. A. (1986), "Experience with Crop Insurance Programs in the United States." In: *Crop Insurance for Agricultural Development: Issues and Experience*, P. Hazzell, C. Pomareda, and A. Valdez (eds.), Baltimore: Johns Hopkins University Press, 195-222.

Garven, J. R. & MacMinn, R. D. (1993), 'The Underinvestment Problem, Bond Covenants, and Insurance', Journal of Risk and Insurance 60(4), 635–646.

Gezcy, C., Minton, B. & Schrand, C. (1997), ‘Why Firms Use Currency Derivatives’, Journal of Finance 52, 1323–1354.

Goodwin, B. K. (1993), ‘An Empirical Analysis of the Demand for Crop Insurance’, American Journal of Agricultural Economics 75, 425–34.

Grace, M. F., Klein, R. W. & Kleindorfer, P. R. (2004), ‘Homeowners Insurance with Bundled Catastrophe Coverage’, Journal of Risk and Insurance 71(3), 351–379.

Graham, J. & Rogers, D. (2002), ‘Do Firms Hedge in Response to Tax Incentives?’, Journal of Finance 57, 815–840.

Greenwald, B. & Stiglitz, J. E. (1990), ‘Asymmetric Information and the New Theory of the Firm: Financial Constraints and Risk Behavior’, American Economic Review 80, 160–165.

Greenwald, B. & Stiglitz, J. E. (1993), ‘Financial Market Imperfections and Business Cycles’, Quarterly Journal of Economics 108(1), 77–114.

Gruber, J., & Latteau. M. (2004), ’How Elastic Is the Firm’s Demand for Health Insurance?’, Journal of Public Economics 88, 1278-1293.

Han, L.-M. (1996), ‘Managerial Compensation and Corporate Demand for Insurance’, Journal of Risk and Insurance 63(3), 381–404.

Hentschel, L. & Kothari, S. (2001), ‘Are Corporations Reducing or Taking Risks with Derivatives?’, Journal of Financial and Quantitative Analysis 36, 93–118.

Hoyt, R. E. (1990), “The Effect of Insurance Fraud on the Economic System”, Journal of Insurance Regulation 8, 304-315.

Hoyt, R. E. & Khang, H. (2000), ‘On the Demand for Corporate Property Insurance’, Journal of Risk and Insurance 67(1), 91–107.

Hoyt, R. E. & Liebenberg, A. P. (2011), ‘The Value of Enterprise Risk Management’, Journal of Risk and Insurance, 78, 795–822.

Kleffner, A. E. & Doherty, N. A. (1996), ‘Costly Risk Bearing and the Supply of Catastrophic Insurance’, Journal of Risk and Insurance 63(4), 657–671.

Kunreuther, H. C., Meyer, R. & Michel-Kerjan, E. (2013), ‘Overcoming Decision Biases to Reduce Losses from Natural Catastrophes’, in E. Shafir, ed., ‘Behavioral Foundations of Public Policy’, Princeton University Press.

Kunreuther, H. C. & Michel-Kerjan, E. (2004), ‘Challenges for Terrorism Risk Insurance in the United States’, Journal of Economic Perspectives 18(4), 201–214.

Landry, C. E. & Jahan-Parvar, M. R. (2011), ‘Flood Insurance Coverage in the Coastal Zone’, Journal of Risk and Insurance 78, 361–388.

Leland, H. (1998), ‘Agency Costs, Risk Management, and Capital Structure’, Journal of Finance 53, 1213–1243.

MacMinn, R. D. (1987), ‘Insurance and Corporate Risk Management’, Journal of Risk and Insurance 24(4), 658–677.

Main, B. G. (1983), ‘Corporate Insurance Purchases and Taxes’, Journal of Risk and Insurance 20(2), 197–223.

Mayers, D. & Smith, C. W. (1982), ‘On the Corporate Demand for Insurance’, Journal of Business 55(2), 281–296.

Mayers, D. & C. W. Smith (1990), ‘On Corporate Demand for Insurance: Evidence from The Reinsurance Market’, Journal of Business, 63, 19-40.

Moulton, B. (1990), ‘An Illustration of a Pitfall in Estimating the Effects of Aggregate Variables on Micro Units’, Review of Economics and Statistics 72, 334–338.

Munich Re (2013), Topics Geo. Natural Catastrophes 2012, Report, Munich: Munich Re.

Nance, D., Smith, C. W. & Smithson, C. W. (1993), ‘On the Determinants of Corporate Hedging’, Journal of Finance 58, 267–284.

OECD (2005), Terrorism Risk Insurance in OECD Countries. Paris: Organization for Economic Cooperation and Development.

Papke, L. & Wooldridge, J. (1996), ‘Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rates’, Journal of Applied Econometrics 11(6), 619–632.

Shaik, S., Coble, K. Knight, T., Baquet, A. E. & Patrick, G. F. (2008), ‘Crop Revenue and Yield Insurance Demand: A Subjective Probability Approach’, Journal of Agricultural and Applied Economics 40(3), 757–766.

Smith, C. W. & Stulz, R. M. (1985), ‘The determinants of firms’ Hedging Policies’, Journal of Financial and Quantitative Analysis 20, 391–405.

Stulz, R. (1996), ‘Rethinking Risk Management’, Journal of Applied Corporate Finance 9, 8–24.

Warner, J. B. (1977), ‘Bankruptcy Costs: Some Evidence’, Journal of Finance 32, 337–347.

Yamori, N. (1999), ‘An Empirical Investigation of the Japanese Corporate Demand for Insurance’, Journal of Risk and Insurance 66, 239-252.