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Erwann O. Michel-Kerjan
Wharton School
University of Pennsylvania

Paul A. Raschky
Department of Economics
Monash University

Howard Kunreuther
Wharton School
University of Pennsylvania

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Risk Management and Decision Processes Center
The Wharton School, University of Pennsylvania
3730 Walnut Street, Jon Huntsman Hall, Suite 500
Philadelphia, PA, 19104
USA
Phone: 215-898-5688
Fax: 215-573-2130
http://opim.wharton.upenn.edu/risk/

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Erwann O. Michel-Kerjan† Paul A. Raschky ‡ Howard C. Kunreuther§

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ABSTRACT

Recent disasters and historical insurance payouts have triggered renewed interest in how firms manage their left-tail exposure. Using a unique dataset of fully described insurance policies purchased by large U.S. firms, we provide the first consistent estimates of premium elasticity of corporate demand for insurance for both catastrophe and non-catastrophe risks. We do so by combining this dataset with financial information of the corporate clients and of the insurer provider, and by applying an IV-approach to overcome the endogeneity problem. Corporate demand for insurance is found to be rather inelastic, and more so for catastrophe risks. Impact of solvency and current ratios are tested and we find a negative relation between the solvency ratio and catastrophe risk coverage.

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†The Wharton School, University of Pennsylvania

‡Department of Economics, Monash University

§The Wharton School, University of Pennsylvania and NBER.

1. Introduction

In recent years we have witnessed a dramatic increase in the economic cost from natural and man-made disasters around the world, from $528 billion (1981-1990) to more than $1.2 trillion over the period 2001-2010 (Munich Re 2011). In the United States over the past 10 years, catastrophes have included terrorism (e.g., the September 11, 2001 attacks), wildfires, hurricanes, flooding (e.g., Hurricane Katrina in 2005; Ike in 2008) and technological accidents (e.g., the 2003 blackout; the 2010 BP oil spill).

Individuals typically transfer the financial risks associated with these hazards either to primary insurers, or de facto to taxpayers if they receive post disaster government relief. Firms, in contrast, 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 would force 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.

There are a number of potential sources of short-term capital 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).

The finance literature has typically focused on the use of corporate derivatives as a hedge against negative outcomes. 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). Leland (1998) has shown theoretically that using derivatives could have a direct effect on cash-flow and an indirect effect on left-tail outcomes. Empirical work (e.g., Nance, Smith & Smithson 1993, Gezcy, Minton & Schrand 1997, Graham & Rogers 2002) further suggests that derivative use is often consistent with those theoretical predictions.

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., Hentschel & Kothari 2001, Allayannis & Ofek 2001). By focusing on insurance purchase instead, it is possible a priori to quantify both the left-tail exposure and the hedging strategy a corporation adopts. Moreover, corporate insurance use for gains would require that the firm engage in fraudulent activities (thus we can disregard the possibility that firms use insurance for speculating).

Since the 1990s there has been a growing theoretical literature analyzing why and when firms should purchase insurance. 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 (while a risk-neutral firm would not).

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. Most likely, the difficulty for the research community to access detailed commercial insurance data for a large enough sample of firms explains why only an handful of studies have been published on corporate demand for insurance in the finance literature (e.g., Hoyt & Khang 2000, Aunon-Nerin & Ehling 2008). These studies rely on survey data and lack information about key variables in the demand function (e.g., the level of insurance coverage) (Hoyt & Khang 2000). Furthermore, neither of them approaches the question of catastrophic events which are more likely to lead a firm to bankruptcy, and whether firms' insurance purchasing behavior differs for catastrophe risks versus non-catastrophe risks. If Greenwald and Stiglitz's theory applies, then firms' demand for catastrophe risk should be more price inelastic than for non-catastrophe risks, an hypothesis we would like to test here.

This paper fills this gap by introducing a unique firm-level dataset we were able to access as part of a research partnership with Marsh & McLennan, one of the world's largest insurance brokers. Through this collaboration, we obtained data on complete insurance purchases by 1,808 large U.S. corporations headquartered across the country. Those data contain information about the quantity of insurance those firms bought for two lines of risk - property and terrorism - *and* the insurance premiums that they paid for those coverages. On the demand-side data, we also accessed a set of financial data for those companies that we discuss in more detail later in the paper.

A further strength of our analysis is that we also access insurance company-level data for a portion of the insurers that covered these firms. 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 fact, the aforementioned literature does not adequately address this problem of endogeneity in the relationship between degree of coverage and premium; as a result, the two studies we cited above do not provide consistent and unbiased estimates of the premium elasticity.

In this paper, we use insurer-specific variables as instrumental variables for insurance premium to identify the causal relationship between premium and insurance quantity. To our knowledge, our analysis is the first attempt in the literature to overcome this endogeneity problem.

Combining demand and supply data we can then examine corporate demand for insurance empirically and test Greenwald and Stiglitz's theory. That is, if the risk of bankruptcy is what triggers corporate interest in purchasing insurance to hedge left-tail outcomes, then corporate insurance demand for catastrophe risk should be more price inelastic than for property coverage. That's because risk-averse managers should see a disaster as potentially much more harmful to the company.

Our findings can be summarized as follows: (1) We find that a majority of firms in our sample do purchase catastrophe risk insurance (59% of them). (2) Corporate demand for insurance against catastrophic and non-catastrophic risks is rather inelastic. Corporate demand for catastrophe coverage is found to be more price inelastic than the demand for non-catastrophe coverage. Specifically, we find that a 10% increase in price will reduce quantity of terrorism coverage by only 1.6% whereas it will reduce the quantity of property coverage by 3.6%. Our results provide supportive evidence for Greenwald and Stiglitz (1990; 1993). They also support Mayers & Smith (1982) and Han (1996), who reason that risk-averse managers have an incentive to purchase insurance to protect their interests and reputation. As disasters have recently become highly mediatized events, reputation is thus a critical element. Our findings show that managers might consider this important enough that their firms purchase some terrorism insurance coverage.[1] (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 catastrophe insurance coverage. (4) Our findings confirm the proposition by Doherty (2000) that larger firms are more diversified and have developed internal risk management capacity, which result in them purchasing proportionally less coverage than smaller firms. Interestingly, the size of the estimated effect does not differ much between catastrophe and

[1] 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.

non-catastrophe risk. (5) Finally, the analysis does not reveal significant differences in insurance demand between industries. However, there are regional differences. In particular, demand for both lines of risk appears to be higher in the Northeast U.S. and the New York Metro area.

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. Section 5 concludes.

2. Data

Our dataset uses variables from three different data sources: Marsh, ORBIS and A.M. Best. Data on property and terrorism[2] 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. Of the remaining 1,808 companies, 1,064 had purchased terrorism insurance in conjunction with their normal property insurance. This implies a market penetration of 59%.[3]

Of these 1,064 companies we have observations for 628 with information about the degree of coverage and the premium paid for both property and terrorism insurance. The data does not include exact information on the physical location of all of the companies' assets, so 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. 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.[4]) Firms in the dataset

[2]A more detailed description of the the U.S. terrorism insurance market can be found in Brown, Cummins, Lewis & Wei (2004) and Kunreuther & Michel-Kerjan (2004).

[3]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.

[4]**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, Penn-

were divided into 20 industry sectors. Table 1 shows the distribution of companies within the full sample across these different industry sectors. It also shows the number of companies which had purchased terrorism insurance.

[INSERT TABLE 1 ABOUT HERE]

The Marsh dataset contains both publicly traded and private companies. Standard sources of financial data, such as COMPUSTAT, however, only include information for publicly listed companies and providing financial data is often voluntarily for other companies.

We therefore used the ORBIS database distributed by Bureau van Dijk. ORBIS 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 (see Table 2). The final sample is similar in size to the study by Aunon-Nerin & Ehling (2008) (N=183).

[INSERT TABLE 2 ABOUT HERE]

The average size of the companies in our sample is measured by assets that are covered under property insurance; that is the total insured value (TIV hereafter). This measure contains tangible assets only, and no values associated with business interruptions or workers' compensation. The mean for the TIV variable in our sample is \$3.16 billion (median of \$2.95 billion). Our dependent variable is the degree of coverage, $Cover_{Terror}$, 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, $Cover_{Property}$, 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 catastrophe risks, $Cover_{Terror}$, is 0.350, and the mean degree of coverage against non-catastrophe risks, $Cover_{Property}$, is 0.441. This indicates that firms on average select a limit on their contract which represents 35% of the total insured value in the case of catastrophe insurance, and 44% of the total insured value for non-catastrophe coverage.

sylvania (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.)

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 $1,000 of coverage and we calculate this figure for both terrorism and property insurance ($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 coverage).

As empirical proxies for a company's capability to borrow money in the short term (self insurance capacity) we use the *Solvency Ratio* and the *Current Ratio* accounting for the company's ability to meet long-term and short-term debt, respectively.

To account for the demand-supply interaction that determines insurance purchase decisions, 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* (we discuss the rationale for this choice in the next section).

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.

3. Empirical Approach

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

$$\begin{aligned} Cover_{ci} = \beta_0 + \beta_1 \ln(TIV_i) + \beta_2 \ln\left(\frac{Premium_{ci}}{Quantity_{ci}}\right) \\ + \beta_3 Solvency\ Ratio_i + \beta_4 Current\ Ratio_i + I_i + R_i + \epsilon_{ci} \end{aligned} \quad (1)$$

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. In comparison to homeowners' insurance, these real services add extra value to an insurance contract. 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. The coefficient β_2 exhibits the price elasticity of demand. We expect β_2 to be negative and significant for both types of risk.

The marginal effects of a client's access to short-term capital on insurance demand is represented by coefficients β_3 (*Solvency Ratio*) and β_4 (*Current Ratio*). 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: First, the bounded nature of the dependent variable ($Cover_{ci}$) is always between 0 and 1; in addition, our observations are concentrated at the upper boundary. 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. To check whether our estimates are sensitive to the estimator applied, we also estimate equation (1) using OLS and Tobit.

Second, 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 (or QMLE and Tobit) 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, yielding biased and inconsistent results. One way to address this problem is the application of an IV-approach. In our case, this requires instruments that are associated with changes in the insurance premium but are uncorrelated with the error-term in the demand equation. 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 identify 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. IV is not feasible for QMLE which is the estimator of choice in our empirical strategy. However, it is available for Tobit. We therefore apply the standard IV and IV-Tobit models.

4. Results

The results of our OLS, Tobit and QMLE (marginal effects) estimates are presented in Table 3. The discussion below focuses on the QMLE estimates. The coefficient of *TIV* is negative and highly significant, indicating 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 (larger companies have a lower degree of coverage than smaller firms) is slightly smaller in the case of terrorism insurance, though (coefficient of -0.149 versus -0.151 in the case of property). This result might be counterintuitive given that terrorism risk can be considered more complex than standard risk. It is therefore more costly to generate information about the risk in-house, giving companies an additional incentive to purchase catastrophe insurance and the accompanied real services. One explanation could be that the insurer's risk management expertise is simply limited in the case of terrorism and the client does not get any additional benefits beyond comparable real services in the standard property case.

Comparing the coefficients of $Premium/Quantity$, we find that the demand for terrorism insurance is 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 difference in price elasticity is slightly smaller in the OLS and Tobit estimates). This result supports Greenwald & Stiglitz (1990) and Greenwald & Stiglitz (1993) who suggest that risk averse managers acting on behalf of a (risk neutral) firm can be an explanation why firms actually purchase insurance. Our findings show that managers might behave even more risk-averse in the case of catastrophe risk, which would be expected.

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 forthcoming) which reveal that the majority of individuals actually do not purchase catastrophe coverage, and that those who do exhibit a very elastic demand. Moreover, insurance demand for catastrophe risk by residents in exposed areas was actually found empirically to be much more price-elastic than for non-catastrophe risk (an opposite result to ours on corporate demand): Grace et al. (2004) found a -1.9 price elasticity coefficient for catastrophe risk and -0.4 for non-catastrophe risk.

A company's self-insurance capability appears to have only a minor impact on insurance demand. Only *Solvency Ratio* yields a statistically significant coefficient. However, the estimated coefficient is only significant at the 10% level using QMLE and not statistically different from zero once we use OLS or Tobit. *Solvency Ratio* seems to play only a small role in the company's decision on terrorism coverage. A 10% higher *Solvency Ratio* reduces demand for terrorism insurance by only 0.3%. One explanation of this finding is that the variable for company size already picks up much of the variation related to its ability to generate short-term money to cover property damages.

Alternatively, many firms use bonds, and those contracts often require some insurance, as do some suppliers and customers. Some might consider that a firm with a higher current ratio is still vulnerable to catastrophe risks in the 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 catastrophe insurance ex ante would avoid this problem. But this difficulty to raise debt might dissipate over time, so catastrophe insurance could become a substitute for long-term debt, as we show to be the case.

We further included industry and region dummies to examine whether the demand for property and terrorism insurance differs between industries or regions. Industry dummies do not yield robust significant results. 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 insurance demand is higher in the New York Metro area and the Northeast region. These differences exist both for property and terrorism insurance. Compared to the other region dummies, New York Metro and the Northeast represent very densely populated and urbanized areas. On average, corporate clients are located in closer proximity to each other in these two regions. Hazards to property such as a fire or a chemical spill are more likely to affect other companies located in the area. The events of 9/11 also showed that terrorist attacks in urban centers often affect multiple companies at once.

[INSERT TABLE 3 ABOUT HERE]

Table 4 presents the results of the IV-estimates. We use the insurer's *Operating Revenue* and *Liquidity* as instruments for *Premium/Quantity* in the first stage: 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.[5]

Both coefficients are statistically significant at the 1% level and pass the standard tests for over and underidentification. The second stage estimate on *Premium/Quantity* is negative and statistically significant at the 1% level. The difference in premium elasticity between property (-0.219) and terrorism (-0.138) still persists. The coefficient for *Solvency Ratio* in the case of terrorism insurance is literally the same as in the baseline results, while it is slightly smaller and significant at the 5% level for property insurance.

[INSERT TABLE 4 ABOUT HERE]

5. Concluding Remarks

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 finance literature that focuses on derivative use to analyze corporate risk-management is consistent with theoretical predictions, it has a number of caveats (Aunon-Nerin & Ehling 2008). For example, hedging practices could be correlated with managerial quality and therefore lead to omitted variable's bias. In addition, a firm's exposure to certain risks is very often difficult to quantify. Without an appropriate risk measurements, 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. However, only a few empirical papers attempt an analysis of the corporate demand for insurance, and

[5]The results stay qualitatively the same if we do not adjust for within-group clustering.

none of them properly address the endogeneity issue nor do they provide empirical analysis that compares corporate demand for insurance between different types of risks.

This paper provides first evidence that addresses these two elements.. We looked specifically at large companies across regions and industry sectors that are headquartered in the United States. We used terrorism threat as our catastrophe risk, and property as the non-catastrophe risk.

Overall, we find that corporate demand for insurance is rather inelastic. Comparing non-catastrophe and catastrophe risks, our results show that the corporate demand for catastrophe insurance is more inelastic than demand for property insurance. As discuss in the paper, these results support seminal theoretical work undertaken in the 1990s that the risk of bankruptcy and managers' risk aversion lead companies to purchase insurance. That managers in firms behave differently than residents living in hazard-prone areas who are often reluctant to purchase catastrophe risk and exhibit a very price elastic demand for that coverage when they do, is another important result from this study. One reason for the difference between how individuals behave as homeowners and as managers of a firm is that, in the latter case, they do not have to personally pay for that insurance; the company does. Moreover, should a disaster occur, managers might have their bonuses reduced or even be fired for not having purchased catastrophe coverage, but they do not personally bear the financial cost associated with purchasing it.

These findings should be regarded as a starting point for future research in the emerging field of catastrophe economics. 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 catastrophe and non-catastrophe risk insurance. It would also be useful to extend the analysis provided here to extreme events other than terrorism (e.g., technological accidents of large magnitude, natural disasters). It would also be important to estimate 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.

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

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

Table 2: Descriptive Statistics

Obs.	**Variable**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
$Cover_{Property}$	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	101.625
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

Table 3: Demand for Property & Terrorism Insurance

	OLS		Tobit		QMLE	
	Property	**Terror**	**Property**	**Terror**	**Property**	**Terror**
$ln(TIV)$	−0.102***	−0.085***	−0.102***	−0.085***	−0.151***	−0.149***
	(0.011)	(0.015)	(0.010)	(0.014)	(0.019)	(0.020)
$ln\left(\frac{Premium}{Quantity}\right)$	−0.190***	−0.112***	−0.190***	−0.112***	−0.358***	−0.160***
	(0.018)	(0.012)	(0.017)	(0.013)	(0.034)	(0.019)
Solvency Ratio	−0.001	−0.002***	−0.001	−0.002***	−0.002*	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Current Ratio	−0.001	0.011	−0.001	0.011	0.002	0.019
	(0.011)	(0.013)	(0.010)	(0.012)	(0.014)	(0.014)
Industries[a]*:*						
Construction	−0.131	0.028	−0.131	0.028	−0.013	−0.017
	(0.181)	(0.158)	(0.167)	(0.145)	(0.191)	(0.192)
Distribution	−0.181	−0.021	−0.181	−0.021	−0.196*	0.082
	(0.124)	(0.154)	(0.115)	(0.141)	(0.115)	(0.136)
Education	−0.139**	0.042	−0.139**	0.042	−0.112	0.132
	(0.058)	(0.073)	(0.054)	(0.068)	(0.136)	(0.144)
Financial Institutions	−0.205*	0.013	−0.205**	0.013	0.275	0.211
	(0.108)	(0.087)	(0.100)	(0.080)	(0.171)	(0.232)
Food & Beverages	0.085	0.150	0.085	0.150	−0.138	0.160
	(0.103)	(0.099)	(0.095)	(0.091)	(0.132)	(0.145)
Healthcare	−0.136**	0.042	−0.136**	0.042	0.026	0.087
	(0.063)	(0.077)	(0.058)	(0.071)	(0.152)	(0.044)
Hospitality & Gaming	−0.093	−0.014	−0.093	−0.014	0.053	−0.013
	(0.063)	(0.064)	(0.058)	(0.059)	(0.144)	(0.113)
Manufacturing	−0.075	−0.057	−0.075	−0.057	−0.206**	0.112
	(0.052)	(0.069)	(0.048)	(0.064)	(0.097)	(0.158)
Media	−0.235***	−0.029	−0.235***	−0.029	−0.208	−0.083
	(0.090)	(0.082)	(0.083)	(0.076)	(0.154)	(0.113)
Pharmaceutical	−0.142**	0.034	−0.142**	0.034	−0.095	0.312*
	(0.068)	(0.083)	(0.063)	(0.077)	(0.151)	(0.181)
Power & Utilities	−0.203***	−0.058	−0.203***	−0.058	−0.137	−0.088
	(0.065)	(0.065)	(0.060)	(0.060)	(0.139)	(0.105)
Real Estate	−0.098	0.050	−0.098	0.050	0.076	−0.025
	(0.074)	(0.092)	(0.068)	(0.085)	(0.175)	(0.125)
Retail & Wholesale	−0.228***	−0.105	−0.228***	−0.105*	−0.163	0.237*
	(0.060)	(0.068)	(0.055)	(0.062)	(0.112)	(0.130)
Technology	−0.104	0.151*	−0.104*	0.151**	−0.107	.091
	(0.066)	(0.079)	(0.060)	(0.073)	(0.130)	(0.157)
Telecomm	0.023	0.182*	0.023	0.182*	−0.062	0.367*
	(0.124)	(0.108)	(0.114)	(0.100)	(0.194)	(0.192)
Regions[b]*:*						
Mid-Atlantic	0.049	0.090	0.049	0.090	0.099	0.145
	(0.047)	(0.064)	(0.043)	(0.059)	(0.067)	(0.098)
New York Metro	0.102**	0.185***	0.102**	0.185***	0.143**	0.172**
	(0.049)	(0.061)	(0.045)	(0.056)	(0.071)	(0.081)
Northeast	0.115**	0.156***	0.115**	0.156***	0.120	0.138*
	(0.049)	(0.058)	(0.045)	(0.054)	(0.093)	(0.081)
South Central	0.025	−0.007	0.025	−0.007	−0.005	−0.032
	(0.088)	(0.086)	(0.081)	(0.079)	(0.163)	(0.121)
Southeast	0.093	0.055	0.093	0.055	0.168	−0.076
	(0.069)	(0.062)	(0.063)	(0.057)	(0.105)	(0.059)
Southwest	0.069	0.021	0.069	0.021	0.111	−0.012
	(0.075)	(0.065)	(0.069)	(0.060)	(0.102)	(0.079)
Upper Midwest	−0.022	−0.012	−0.022	−0.012	−0.048	−0.100
	(0.056)	(0.061)	(0.052)	(0.056)	(0.072)	(0.064)
West	0.057	−0.001	0.057	−0.001	0.057	−0.037
	(0.047)	(0.048)	(0.043)	(0.045)	(0.069)	(0.061)
Constant	1.522***	1.142***	1.522***	1.142***	3.908**	7.029***
	(0.285)	(0.360)	(0.263)	(0.332)	(1.872)	(2.103)
R^2	0.692	0.616				
AIC					1.085	1.084

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. Robust standard errors in parenthesis. ***, **, * denote significance at the 1 %, 5 % and 10 %-level, respectively.

Table 4: Demand for Property & Terrorism Insurance - IV-Estimates

	IV		IV-Tobit	
	Property	**Terror**	**Property**	**Terror**
$ln(TIV)$	−0.099***	−0.094***	−0.099***	−0.094***
	(0.014)	(0.024)	(0.014)	(0.024)
$ln\left(\frac{Premium}{Quantity}\right)$	−0.219***	−0.138***	−0.219***	−0.138***
	(0.034)	(0.049)	(0.035)	(0.049)
Solvency Ratio	−0.001**	−0.003***	−0.001**	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Current Ratio	−0.005	0.009	−0.005	0.009
	(0.012)	(0.012)	(0.012)	(0.012)
	1^{st} $stage^{a}$			
Operating Revenue	0.050***	0.030**		
	(0.008)	(0.013)		
Liquidity	−0.003***	−0.003***		
	(0.001)	(0.001)		
Industry FE[a]	Yes	Yes	Yes	Yes
Region FE[b]	Yes	Yes	Yes	Yes
Kleibergen-Paap Test (p-value)	0.003	0.003		
Hansen Test (p-value)	0.701	0.738		

Notes: Dependent Variable: $Cover_{cij}$. N=141. [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.