An Ex-Post Assessment Of Investor Response To Catastrophes

Abstract

A large body of research has documented negative abnormal stock returns for property-casualty insurance companies in the wake of major catastrophes. These studies often have concluded that investors expect claims from the disaster to outweigh any potential growth in demand or rates. We test the fundamental value predictions implied by these returns, examining the relationship between post-catastrophe returns and future financial outcomes for the insurers. We find no relationship between returns and any profit measures, which conflicts with many standard models of intrinsic value. We do, however, observe a positive relationship between post-catastrophe returns and growth in Total Assets. We conclude that this does reflect a non-standard assessment of firm value—investors were correct in predicting how the disaster will affect the firm's balance sheet, but not the firm's income statement. We discuss possible implications of these findings and develop a plan for further investigation.

1. Introduction

In the wake of a major natural disaster, investors set expectations regarding that event's impact on insurers and on the insurance industry as a whole. These expectations are reflected in stock returns for publicly traded insurers, and prior research has used event study analysis to investigate these returns. A vast majority of these studies have found that catastrophes are associated with negative stock returns for insurers, implying that investors are primarily concerned with an increase in claims. Relatively fewer studies have observed positive returns, which would indicate that investors expect insurers to ultimately benefit from the disaster via higher rates, increased demand for insurance, or loss control consulting opportunities. Whether those expectations were ultimately realized as a result of the disaster, however, remains an open question.

Prior studies have focused primarily on what pre-loss factors might influence post-loss insurer returns. These factors include exposure to the affected area or peril (Aiuppa et al., 1993; Blau et al., 2008; Hagendorff et al., 2015; Lamb, 1995; Shelor et al., 1992), lines of business (Doherty et al., 2003; Hagendorff et al., 2015; Yanase & Yasuda, 2010), loss reserves (Angbazo & Narayanan, 1996; Froot & O'Connell, 1999), financial strength ratings (Cummins & Lewis, 2003; Hagendorff et al., 2015), growth potential (Doherty et al., 2003; Hagendorff et al., 2015), competition (Hagendorff et al., 2015), and many others. Significant relationships between these factors and the generated returns implies that investors were rational in their response. In other words, prior research shows that investors considered how a disaster might affect an insurer's long-term financial condition before making their investment decision.

While there is evidence that investors considered the ex-ante position of insurers, were the investors ultimately correct in generating these returns ex-post? A stock's price reflects predictions of future financial outcomes–generally cash flows, profitability, and risk. In the immediate wake of a disaster, estimates of losses vary widely and investors react to insurers who quickly and accurately provide estimates of their losses (Doherty et al., 2003). Investors also appear to use recent catastrophe experience to determine their positions leading up to a new catastrophe (Blau et al., 2008).

This paper consists of two major contributions. First, we offer a comprehensive survey of the literature on insurer event studies surrounding catastrophes. No such survey currently exists, even though there are more than 25 peer-reviewed papers on such a topic. Many existing papers cite only the earliest or most recent catastrophe event studies, so this survey alone will provide value to academic research. Second, we investigate whether the returns generated by investors in the days and weeks following an event were ultimately justified by the insurer's later financial performance in the subsequent year.

We calculate the cumulative raw returns for insurance company stocks over three post-event windows: (0,1), (0,15), and (0,30) days. In contrast to most event studies, we do not derive abnormal returns by comparing actual returns to predicted returns. Actual (raw) returns reflect fundamental value, while abnormal returns reflect performance relative to the market—our assessment is with respect to fundamental value. We then examine the relationship between each of these post-event return windows and the insurer's financial results in the following year. This is clearly not a causal relationship, but it allows us to assess whether investor expectations about the catastrophe's impact on the firm were ultimately realized.

We find that, in contrast to prior event studies finding negative *abnormal* returns (i.e. post-event insurer returns compared to their normal performance relative to the market), *raw* returns for insurers are positive on average following catastrophe events. This implies that investors expect a disaster to have a positive effect on insurers' fundamental values. Returns over the (0,1) day window following a catastrophe are not related to any future financial outcomes, implying that "knee-jerk" investors either have incorrect expectations or are not considering the fundamental value of the insurer. Raw returns over the (0,15) and (0,30) day windows post-event are positively related to changes in Total Assets over the following year, indicating that these investors accurately predicted financial outcomes, at least with respect to the Balance Sheet. No return window, however, is significantly related to Net Income or Dividends.

Our findings have implications for the insurance industry and for stock market investors. The returns generated by days-long investors are not related to long-term financial outcomes, but those investors may be more focused on maintaining short-term gains. This possibility warrants further investigation. The accurate expectations by weeks- and month-long investors are consistent with efficient markets and rational expectations in the wake of major disasters. The null relationship with Net Income and Dividends may indicate that insurance company managers are "outsmarting the market" in how they respond to catastrophes, preventing the losses from affecting their profits as investors had expected. These results also indicate that traditional models of fundamental value may not be appropriate for insurance companies who have unique ebbs and flows in their income stream and who derive income from both underwriting results and investment returns. Future research may be dedicated to developing a firm valuation model that matches the unique operations of insurance companies.

The remaining paper is organized as follows. Section 2 reviews the prior research on catastrophe event studies and provides a short overview of stock valuation models. Section 3 describes the catastrophes and firms we study, while Section 4 outlines our methodology. We present our results in Section 5 and discuss them in Section 6. Finally, we review our plans for further analysis in Section 7.

2. Related Research

2.1. Event Studies

There is a substantial empirical literature investigating how stock prices respond to major disasters. Insurance companies have been a focus of many of the studies, but other industries, such as airlines and construction companies, also have been considered. Many of these studies calculate abnormal returns (ARs), where a security's actual returns over a particular event window are compared to its expected returns (calculated using pre-event data applied to the CAPM, the Fama-French Three Factor

Model, or a similar asset pricing model). These abnormal returns are often summed over a particular window to arrive at a cumulative abnormal return (CAR).[1] Abnormal returns are an excellent method of comparing pre-event expectations to post-event expectations, but do not reflect the effect of an event on the firm's intrinsic value, since the expected returns are calculated relative to other stocks.

Event studies focused on catastrophes and insurer stocks typically cite the seminal work of Shelor et al. (1992), Aiuppa et al. (1993), Lamb (1995), and Angbazo and Narayanan (1996). Shelor et al. (1992) found that abnormal returns for property-casualty (P&C) insurers were positive in the days following the 1989 Loma Prieta earthquake in California ($CAR_{0,1}$ = 1.72%, $CAR_{0,2}$ = 2.20%; CARs were positive for all days from 0 to 15). They hypothesized that this positive effect was because investors expected increased insurance demand to dominate expected claim payments, as many California residents did not have earthquake insurance. They did not find any relationship between returns and the insurer's earthquake exposure in California. Studying the same event, Aiuppa et al. (1993) found somewhat similar results ($CAR_{0,2}$ = 1.19% for earthquake insurers, $CAR_{0,2}$ = -0.20% for non-earthquake insurers). Lamb (1995), on the other hand, determined that P&C insurers experienced negative returns in the wake of Hurricane Andrew in 1992 ($CAR_{0,1}$ = -5.22% for insurers exposed to Andrew, $CAR_{0,1}$ = -1.33% for unexposed insurers). The $CAR_{0,1}$ return was negatively influenced by loss exposure in Florida or Louisiana.[2] Angbazo and Narayanan (1996) investigated abnormal returns surrounding Hurricane Andrew and a subsequent freeze of rates for American International Group on day +11. The authors found negative CARs for both the disaster ($CAR_{0,1}$=-1.88%) and the premium freeze ($CAR_{0,1}$ = -0.99%).

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[1] In discussing the results of these studies, we refer to the CAR window with a subscript. For an event occurring on day 0, $CAR_{-1,5}$ would be the sum of ARs from day -1 to day +5.

[2] In a replication of this study, Cummins & Lewis (2003) found similar but less significant CAR results after accounting for event-induced volatility. In their analysis, neither exposure nor insurer rating were significantly related to these returns.

They provided evidence that expectations of higher prices may have offset the negative effects of Andrew until the premium freeze.

The 9/11/2001 terrorist attacks ("WTC") were the focus of a number of interesting studies. Cummins & Lewis (2003) found that insurers experienced negative abnormal returns over the (0,4) day post-event window in response to claim expectations. Those losses, however, were recouped for financially strong insurers over the (5,30) day window as investors anticipated a "flight to quality" by insurance consumers. While not specifically focused on stock returns, research by Chen et al. (2008) is relevant to our empirical study. They investigated analyst revisions of earnings forecasts in the wake of WTC, finding that negative short-run (1-year) abnormal revisions reflected claim expectations while positive long-run (5-year) abnormal revisions reflected growth expectations.

Recent work has taken a novel approach to event studies. Blau et al. (2008) identified increases in short selling of insurer stocks several days *before* Hurricane Rita made landfall, 27 days after Hurricane Katrina generated negative returns for insurers. They interpreted this as evidence of adaptive learning by investors. Importantly with respect to our study, the short sellers did not account for each insurer's level of hurricane exposure, leading the authors to conclude that short sellers were "generally unsophisticated" about the factors affecting returns. Using a Dynamic Conditional Correlation Generalized Autoregressive Conditional Heteroskedasticity (DCC GARCH) model, Thomann (2013) established that catastrophes significantly increase volatility and decrease correlation of insurer stock returns, shifting beta and potentially biasing results reported in previous event studies. Ragin & Halek (2015) found that insurance brokers (rather than insurers) experienced positive abnormal returns following disasters, concluding that investors expect markets to harden and broker commissions to increase.

A comprehensive summary of catastrophe effects on insurer stock returns is provided in Appendix 1: Event Studies in Prior Literature. Each record catalogs the event(s) and firms studied and provides a short summary of results. We report hurricanes by name in the "Event(s)" column (omitting the word

"Hurricane"). Earthquakes are abbreviated as "EQ." To give some basis of comparison, we provide the $CAR_{0,1}$ return if possible. In many cases, this return is explicitly reported by the authors. In other cases, we calculated it from ARs listed in the results. We did not denote whether their results were statistically significant, as each paper may have used a different test to determine significance. Any main conclusions or notable results are also mentioned. This table does not include any studies focused on catastrophe effects on non-insurance stocks (airlines, real estate, construction. etc.) or non-catastrophe effects on insurer stocks (regulatory events, M&A, etc.).

2.2. Valuation Models

It cannot be certain that investors use any particular model in predicting the value of an insurer's stock price following a disaster. Rather than testing the predictions of a particular model, we generalize models to account for many different financial outcomes used in various valuation models. If we were to find null results in one particular model (i.e. investors were not correct in their ex-post response), our findings could only be interpreted as a failure of that model. Maintaining a broad focus on varied financial outcomes allows for more general results.

We focus primarily on the "income approach" to calculating firm value, where the stream of some future financial outcome, typically a cash flow, is discounted to present value (Hitchner, 2003).[3] These models take the financial outcome as a numerator and divide by some calculated discount rate k to arrive at present value. This fraction may be summed over n future periods (applying less weight to each future period):

$$PV = \sum_{i=1}^{n} \frac{CF_i}{(1+k)^i} \tag{1}$$

[3] We use the Hitchner text in describing the general form of valuation models. Formulas are taken directly from the text.

Such a form allows cash flows to vary indiscriminately in future periods (though the most immediate period carries the highest weight). In some cases, a constant growth rate g from period 1 is assumed:

$$PV = \frac{CF_1}{k - g} \tag{2}$$

Under these models, the value of the firm is directly related to cash flows and the growth rate and inversely related to the discount rate. Assuming that investors consider the firm's fundamental value in their investment decision, their assumptions and expectations with regards to these variables will affect their reservation price for the stock. If a catastrophe is expected to slow growth, reduce cash flows, or increase the discount rate (the required return), then the stock price will decrease. If a catastrophe is expected to increase growth, increase cash flows, or decrease the discount rate, then the stock price will increase.

In the current version of our study, we jointly examine financial outcomes and their growth rates by taking the percentage change in the financial outcome over the four quarters following the catastrophe. If investors correctly predict the impact of the catastrophe, these will be positively related to returns. Common financial outcomes include Net Income, Dividends, and Earnings per Share (EPS).[4] We consider these factors over both Generally Accepted Accounting Principles (GAAP, from public company filings of the studied insurers) and statutory accounting rules (from insurance company filings with insurance regulators). We also consider the change in Revenue due to prior research showing a "growth" effect of catastrophes. Balance sheet outcomes also may affect equity prices for

[4] Free Cash Flow (FCF) is another very common financial outcome. FCF begins with After-Tax Profits, adds Depreciation and Amortization, and then deducts Capital Expenditures and Working Capital. These additional factors are often relatively minor for insurance companies, so at this point, we do not calculate FCF as one of our financial outcomes of interest.

investors using the "asset approach" to valuation, so we investigate the relationship between returns and Total Assets (GAAP reporting) or Policyholder Surplus ("PHS," statutory reporting).

The discount rate k is the rate of return required in order to attract investors over the next-best investment. Perceived risk to the expected stream of outcomes increases the discount rate. This rate is often calculated using the capital asset pricing model (CAPM) or a related method. There is evidence that risk increases following major catastrophes—Cummins & Lewis (2003) found increases in insurer stock price volatility over the month following WTC and Hurricane Andrew, but not the Northridge Earthquake. In contrast, Thomann (2013), using a larger sample of events, found no consistent relationship between catastrophes and volatility (though he did find volatility increases for three individual events: WTC and Hurricanes Andrew and Frances). Investigating the long-term effect of catastrophes on the β of insurance companies is a top priority on our research agenda.

3. Data

3.1. Catastrophes

We begin by determining which catastrophe events to investigate, using the list of largest insured-loss natural disasters from the annual Swiss Re *Sigma* report.[5] Events must have occurred after 1996 to match our dataset of insurer financials. We require three characteristics of each event to be included in our dataset. First, the event must have a relatively distinct "event date."[6] Perils lasting for a long period of time may cause a gradual shift in investor sentiment, but this shift may also include many other events that occur over that period of time. Second, the event must not overlap directly with other

[5] We focus on natural disasters, so the 9/11/2001 terrorist attacks are not included in our analysis.

[6] An important consideration is that many of these events did not occur on a trading day or occurred late in the day after stock markets were closed. To address this, we create an event date which is the next full trading day following an event if it occurs during non-trading time.

events in the dataset, in order to avoid double-counting of returns. Finally, there must not be any non-catastrophe events occurring at the same time that would affect many insurers.[7]

There are two events that do not meet the first criterion of having a distinct event date. The summer 2012 drought in the U.S. Corn Belt is listed by Sigma as having an "event date" of July 15, 2012 (the peak of the drought), but the drought spanned March to November of 2012. The 2011 floods in Thailand also fail to meet this criteria–the flooding began in July and lasted through January 2012. We drop both of these events from our dataset.[8]

Several events had the same or nearly the same event date, failing the second criterion. Rather than drop potentially useful data, we merged the observations. We merged Winter Storm Martin (#39) into Winter Storm Lothar (#19) and Typhoon Songda (#32) into Hurricane Frances (#24). In merging these observations, we add the damage from each of the events together. We also apply any relevant descriptors to the remaining observation (e.g. Hurricane Frances is listed as both a U.S. event and a Japan event, since Typhoon Songda occurred in Japan).

Considering our third criterion, there was one event that occurred at the same time as an unrelated but significant event. Namely, Hurricane Ike (9/15/2008) struck land the day before the U.S. Federal Reserve's bailout of American International Group (AIG) was announced. As documented by Egginton et al. (2010), this event had a negative effect on AIG and a positive effect on AIG's competitors. Because of these confounding effects so close to the event date, we exclude Hurricane Ike from our event study.

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[7] Events that affect only one or a few insurers (such as earnings announcements) are less of a concern, since averaging will mitigate the influence of all but the largest outliers. We manually investigate the source of any large outliers (greater than 2σ from the mean) in our event study and drop those insurers from the event if the response appears to be due to another source. In our subsequent analysis, we control for major news events for each insurer that may affect financial outcomes.

[8] A number of shorter-term floods remain in the dataset. The event date for these floods is first full trading day after the floods began causing widespread business disruption or property damage based on news reports or similar .

Table 1: Catastrophes

Rank	Event	Location	Date	Insured Loss ($M, 2013)
1	Hurricane Katrina	US	8/29/05	80,373
3	Hurricane Sandy	US	10/24/12	36,890
10	New Zealand 2011 EQ	New Zealand	2/22/11	16,142
14	Hurricane Charley	US	8/16/04	10,313
17	Chilean EQ	Chile	3/1/10	8,876
19	Winter Storm Lothar	Europe	12/27/99	8,426
20	Alabama Tornadoes	US	4/25/11	7,856
22	Winter Storm Kyrill	Europe	1/18/07	7,112
25	Hurricane Irene	US	8/26/11	6,274
28	New Zealand 2010 EQ	New Zealand	9/3/10	5,548
29	Hurricane Georges	US	9/20/98	5,240
30	Tropical Storm Allison	US	6/5/01	4,925
33	Storms in US	US	5/5/03	4,216
34	Germany Floods	Europe	5/28/13	4,134
35	Hurricane Floyd	US	9/16/99	4,100
38	Germany Hail	Europe	7/27/13	3,838
40	Winter Storm Klaus	US	1/26/09	3,406

Source: Swiss Re *Sigma* (2014)

Our dependent variable is the change in quarterly financial outcome from $t = 0$ (the quarter of the event) to $t = 4$ (four quarters after the event). Given this quarterly data, we must consider only one catastrophe event per quarter, as allowing multiple events per quarter would double- or triple-count the following outcome. Thus, we only capture the first catastrophe event in each quarter. There were five quarterly periods with multiple events, and we drop all but the first events from the following list: 1999Q3 (Floyd and Typhoon Bart), 2004Q3 (Charley, Frances, Ivan, and Jeanne), 2005Q3 (Katrina, Rita, and Wilma), 2011Q1 (New Zealand EQ and Tohoku EQ), and 2011Q2 (Alabama Tornadoes and Missouri Tornadoes).[9]

[9] Hurricane Wilma actually occurred in Q4 of 2005, but it happened less than a month after Rita (the #12 largest disaster) and less than two months after Katrina (the #1 largest). We categorize it with the other Q3 disasters.

Our final data set of events includes seventeen catastrophes. There are three earthquakes, six hurricanes, three storms, three winter storms, one tropical storm, and one flood. Ten events occurred in the United States, while four happened in Europe, two happened in New Zealand, and one in Chile. Table 1 details the rank (based on insured loss), location, date, and size of each of the events in our dataset.

3.2. Firms

The insurance industry bears the most exposure to losses from these catastrophes, so we focus our investigation on publicly-traded property/casualty (PC) insurers and reinsurers. We specify that the firms must be traded on U.S. exchanges, as reporting and investor response may differ between countries. Insurers often have a number of subsidiaries writing different business lines, so we aggregate subsidiary firms to the group level to capture the overall risk of the entity.

We begin by examining financials provided by the National Association of Insurance Commissioners (NAIC). We are only interested in insurers who were exposed to property losses at the time of the event. We include in our analysis only firms who reported positive net premiums written (NPW) for homeowners, commercial multi-peril, earthquake, federal flood, crop, or fire and allied lines. We drop any insurers who are captive insurance companies or risk retention groups owned by public firms.

We then match those property insurance firms to stock return data from the Center of Research in Security Prices (CRSP) and GAAP financial statement data from Compustat. A number of insurers listed in the NAIC data are insurance operations of a non-insurance parent. For example, the construction equipment manufacturer Caterpillar, Inc. wholly owns an insurance company subsidiary which provides insurance to their dealerships and customers. Investors may react differently to such diversified firms, so we exclude any firms whose insurance assets comprise less than 5% of their total corporate assets. The final dataset includes 4,640 quarterly financial results from 76 publicly-traded insurers over the period. Insurers enter and exit the dataset via IPOs and acquisitions, so the number of insurers traded during each catastrophe event ranges from 44 to 65. There are 991 insurer-event observations, indicating that an average of 58 insurers were traded during each of the 17 studied events.

4. METHODOLOGY

We wish to determine whether post-catastrophe insurer stock returns are significantly related to future financial outcomes that would influence the firm's intrinsic value. Assuming that investors are responding to expected effects on the insurer, positive returns would be associated with increases in firm value (i.e. the catastrophe creates a growth effect in demand and/or rates, dominating claim payments) while negative returns would be associated with decreases in firm value (i.e. claim payments dominate any growth as a result of the disaster). We use the following general model to assess the relationship:

$$FinOutcome_{i,t>0} = \alpha + \beta_1 Return_{i,t=0} + \beta Controls + \epsilon \tag{3}$$

Where FinOutcome is the percentage change in the selected financial outcome from the quarter of the event ($t = 0$) to some future quarter ($t > 0$). This future time period must be long enough to include claim payments from the current event but short enough to exclude too many confounding events (such as other catastrophes, legislative changes, M&A activity, etc.). To determine an appropriate time period, we examine the percentage of homeowners insurance incurred losses paid in each year following an accident year. Between 1996 and 2014, an average of 70.4% of claims were paid by the end of the accident year and 91.7% of claims had been paid by the end of the following year. Taking this into account, we feel that examining financial outcomes four quarters following an event ($t = 4$) will sufficiently account for the impact of the disaster. We measure this by the year-over-year growth in the financial outcome to easily compare insurers of different sizes and exposure levels.[10] Summary statistics of growth rates (in percentage points) are provided in Table 2.

Table 2: Summary statistics for financial outcomes

	Mean	Median	Min	Max	SD	N
Net Income	-9.73	-2.94	-355.56	333.45	145.09	4,247
Dividends	10.90	5.70	-71.03	114.69	38.96	2,951
Assets	10.20	6.21	-10.95	59.64	16.52	4,247
Policyholder Surplus	8.23	6.25	-21.73	50.83	16.78	4,314
Underwriting Gain/Loss	-22.22	-23.49	-512.68	456.11	206.92	5,522

Summary statistics reported in percentage points (1.00 = 1%).

We examine three different return windows as our independent variable of interest and use calendar days to describe the return windows.[11] Similar to prior event studies, we sum each day's return in the window (though we calculate cumulative raw returns rather than cumulative abnormal returns). The "days-long" period of (0,1) days focuses on investors who respond to a catastrophe on the day of the event and one day after. This could be considered the "knee-jerk" response to the disaster, but still allows investors at least 24 hours to consider the impact of the event. The (0,1) day returns are reported in twelve prior studies. The "weeks-long" window of (0,15) days is a sufficient period for insurers to report their estimates of loss—Hagendorff et al. (2015) noted that loss estimates typically were announced 9-10 days after the catastrophe. Loss estimates are an important consideration for investors as determined by Doherty et al. (2003). The "month-long" (0,30) day window allows longer-term investors to fully consider the disaster's potential impact on the insurance market. According to

[10] We winsorize growth at the 5% level to account for outliers, which can be a problem when examining growth rates over small base amounts. For example, there are 80 observations where dividend growth is greater than 200%, and 333 observations where net income growth is greater than 200%. We also winsorize returns at the same level.

[11] We use calendar days to describe each return window because they are easier to reference: one day, two weeks, one month. We actually collect data based on the number of trading days—the (0,15) "calendar day" window is actually (0,10) trading days and may be as little as twelve or as many as seventeen calendar days. The (0,30) calendar day window is actually (0,20) trading days, which would represent approximately one calendar month.

Cummins & Lewis (2003), insurers may recoup their initial stock losses over the month following the event. If there is a subsequent catastrophe event during the window of interest, we exclude that observation window from our analysis. For example, Hurricane Floyd occurred on 9/16/1999 and was followed seven days later by Typhoon Bart. We keep the (0,1) return window for Hurricane Floyd, but drop the (0,15) and (0,30) windows since Typhoon Bart might have affected returns during those periods. Summary statistics for returns are provided in Table 3.

Table 3: Summary statistics for insurer returns

	Mean	Median	Min	Max	SD	N
Return (0,1)	0.48	0.19	-3.68	6.02	2.47	991
Return (0,15)	0.28	0.45	-10.20	9.72	4.93	944
Return (0,30)	-0.08	0.26	-14.87	12.32	6.88	701

Summary statistics reported in percentage points (1.00 = 1%).

In our analysis, we include a number of control variables that affect financial outcomes but are unlikely to affect the relatively short-run post-catastrophe returns. We include the insurer's expense ratio (the percentage of premiums dedicated to non-loss expenses), retention ratio (the percentage of premiums not ceded to a reinsurer), and investment yield at $t + 4$. High expense ratios may be associated with lower profitability but potentially higher revenue growth (as expenses may include the cost of acquiring new business). High retention ratios would increase the net impact of a disaster, while an insurer with low retention ratios would have more losses covered by reinsurance.[12] Investment returns would be positively associated with future financial outcomes if those returns were sustainable. We also include the natural logarithm of losses from any other catastrophes from the Swiss Re Sigma list that occurred between $t = 1$ and $t = 4$ as well as the natural logarithm of any acquisition costs the

[12] Retention ratios (or their reciprocal, reinsurance ratios) may be endogenous to returns, as investors may consider this effect on profitability. Reinsurance ratios were found by Angbazo and Narayanan (1996) to be insignificantly related to post-loss abnormal returns.

insurer incurred between $t = 1$ and $t = 4$. We include fixed effects for quarter and insurer and specify robust standard errors (which provides the same result as clustering standard errors by insurer).

5. RESULTS

We report the results of regressions based on Equation *(3)*, varying the financial outcome used as the dependent variable. Each table of results includes three columns of results representing the three return windows of interest: (0,1), (0,15), and (0,30). The first row in each table is the "Post-Cat Return," which is the coefficient on the respective return window in each column. We do not report coefficients for Acquisition Costs or Insured Loss, which are not often significant. While there are 991 insurer-event observations for returns, there are fewer observations in the regressions due to missing financial statement data.

We begin by reporting the regression using $\Delta NetIncome$ as the dependent variable in Table 4. It does not appear that post-catastrophe returns are significantly related to future Net Income. As expected, expense and retention ratios are negatively related to Net Income. Somewhat surprisingly, investment yields also appear to be negatively related to profits (though not significantly). This may be because insurers who experience high investment yields are less likely to sell those assets and realize capital gains.

Table 5 reports the relationships between post-catastrophe returns and $\Delta Dividends$. Similar to Net Income, it does not appear that returns are predictive of future Dividend growth. The number of observations is smaller in this model due to missing Dividend data. Overall, the model does seem to be somewhat more predictive than the model in Table 4 as evidenced by the R^2 statistic, though that may be a function of the missing data. Investment yields appear to be positively related to Dividends, perhaps indicating that dividends were growing across the market, increasing the value of the insurer's portfolio as well as of the insurer itself.

Table 4: The relationship between post-cat returns and future net income

Dependent Var: $\Delta NetIncome$	(0,1)	(0,15)	(0,30)
Post-Cat Return	3.448	0.766	-0.074
	(2.833)	(1.348)	(1.330)
Expense Ratio	-0.005	-0.005	-0.009*
	(0.005)	(0.006)	(0.004)
Retention Ratio	-0.221*	-0.212	-0.088
	(0.130)	(0.134)	(0.095)
Investment Yield	-0.071	-0.090	-0.013
	(0.068)	(0.082)	(0.133)
Log(Acquisition Costs$_{(t+1,\ldots,t+4)}$)	Yes	Yes	Yes
Log(Insured Loss$_{(t+1,\ldots,t+4)}$)	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes
R^2	0.06	0.06	0.07
N	786	780	545

Dependent variable is the percent change in Net Income between quarters t and $t+4$. Robust standard errors in parentheses. The symbols *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

We report the same model using $\Delta Assets$ as the dependent variable in Table 6. In contrast to the other models, the coefficient on post-catastrophe returns is significant—at the 10% level for the (0,15) return window and at the 5% level for the (0,30) return window. A 1% return over the (0,15) window is associated with a 0.24% increase in Total Assets between the quarter of the event and four quarters later, while a 1% return over the (0,30) window is associated with a 0.20% increase in Total Assets over the same period. The explanatory power of these models is relatively high.

Table 5: The relationship between post-cat returns and future dividends

Dependent Var: $\Delta Dividends$	(0,1)	(0,15)	(0,30)
Post-Cat Return	-0.341	-0.403	0.118
	(0.650)	(0.377)	(0.340)
Expense Ratio	-0.004**	-0.004**	-0.002
	(0.002)	(0.002)	(0.002)
Retention Ratio	-0.005	0.003	0.013
	(0.026)	(0.026)	(0.024)
Investment Yield	0.027	0.032*	0.050**
	(0.018)	(0.018)	(0.024)
Log(Acquisition Costs$_{(t+1,...,t+4)}$)	Yes	Yes	Yes
Log(Insured Loss$_{(t+1,...,t+4)}$)	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes
R^2	0.09	0.09	0.11
N	559	557	393

Dependent variable is the percent change in Dividends between quarters t and $t + 4$. Standard errors in parentheses, clustered by firm. The symbols *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

The Total Assets variable is the GAAP-reported Total Assets of the firm as catalogued in the Compustat database. Based on the results in Table 6, it is not clear exactly what component of Total Assets is being predicted by investors. We investigated the available components of Total Assets to find that only three had sufficient observations for further analysis—Cash and Short-Term Investments, Total Receivables, and Other Assets. We conducted the same regressions with these components as dependent variables (not reported) to find that Other Assets is the source of the significant results in Table 6. The coefficient on the (0,15) return window is 0.322 (significant at the 5% level) and is 0.188 for the (0,30) window (significant at the 1% level). Unfortunately, Compustat does not provide any higher level of detail—they list 77 items that make up Other Assets. We plan to collect quarterly data from the NAIC statutory filings to investigate exactly which financial outcome is associated with these post-catastrophe returns. This data provides a much finer level of detail on insurance company financials.

Table 6: The relationship between post-cat returns and future assets

Dependent Var: $\Delta Assets$	(0,1)	(0,15)	(0,30)
Post-Cat Return	-0.216	0.237*	0.199**
	(0.142)	(0.135)	(0.092)
Expense Ratio	-0.002*	-0.002*	-0.001
	(0.001)	(0.001)	(0.001)
Retention Ratio	0.002	0.003	-0.006
	(0.008)	(0.008)	(0.008)
Investment Yield	0.009*	0.007	0.001
	(0.005)	(0.006)	(0.007)
Log(Acquisition Costs$_{(t+1,\ldots,t+4)}$)	Yes	Yes	Yes
Log(Insured Loss$_{(t+1,\ldots,t+4)}$)	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
Insurer FE	Yes	Yes	Yes
R^2	0.14	0.15	0.20
N	786	780	545

Dependent variable is the percent change in Assets between quarters t and $t+4$. Standard errors in parentheses, clustered by firm. The symbols *, **, and *** denote statistical significance at the 0.10, 0.05, and 0.01 levels, respectively.

In addition to the dependent variables used Tables 4 through 6, we considered a number of other financial outcomes as dependent variables. These included Revenue, Earnings per Share, Underwriting Gain/Loss, and Policyholder Surplus. With $\Delta Revenue$ as the dependent variable, the coefficient on the (0,15) window was equal to 0.383 (significant at the 5% level). No other financial outcomes had significant coefficients for the return windows. The outcomes Underwriting Gain/Loss and Policyholder Surplus were collected from the NAIC on an annual basis, so are not comparable to the quarterly GAAP data. One of our next steps in this project is to collect and analyze quarterly NAIC data—we expect to complete this no later than April 2016.

We also considered alternative windows of change for the same financial outcomes. In addition to the year-over-year change (quarter t to $t+4$), we also examined the change from quarter t to quarters $t+1$, $t+2$, $t+3$, and $t+8$. The (0,15) and (0,30) return windows were positively and significantly related to $\Delta Assets$ in $t+2$ and $t+3$, similar to the $t+4$ window. This provides additional support for our results in Table 6, as there are fewer opportunities for confounding events to occur during these shorter windows. Examining the change over the $t+8$ window provided inconsistent coefficient signs, which we assume is due to many confounding events occurring over such a long time period.[13]

6. Conclusion

In this study, we first reviewed how investors in insurance companies have responded to major catastrophes. Prior literature has concluded that property-casualty insurance company stocks typically experienced negative abnormal returns in the wake of a disaster. Further, these returns are negatively related to exposure to the affected area. These trends indicate that investors expected increased claims to dominate any potential growth in demand or rates.

Stock prices ostensibly reflect the fundamental value of a company, with investors making a buy or sell decision based on whether they believe the current price accurately represents the true value. Models of intrinsic value typically discount future profits, dividends, or some similar financial outcome to present value. If investors are correct in assessing the impact of a disaster, future financial outcomes will be positively related to post-catastrophe returns.

In our analysis, we examine the relationship between post-catastrophe returns and future financial outcomes. We examine the (0,1), (0,15), and (0,30) day return windows following the disaster and match those returns to the change in financial outcomes between the quarter of the event t and four quarters in the future, $t+4$. Returns over the (0,1) day window do not have a significant relationship with any future financial outcome, indicating these investors are exhibiting a knee-jerk reaction to the catastrophe without considering the event's impact on the firm's value. The longer-period returns are

[13] Many different types of confounding events may be occurring during this period—catastrophes, M&A, regulatory actions, the financial crisis of 2008-2012, the dot-com bubble of 1997-2000, executive turnover, etc. It is virtually impossible to control for all possible events, so we essentially disregard the $t+8$ window as too long to be useful in this analysis. These events of course may also occur over the t+4 window, but there are fewer opportunities for this to occur.

not significantly related to year-over-year changes in Net Income, Dividends, Revenue, Earnings per Share, Underwriting Gain/Loss, and Policyholder Surplus. We do, however, find a positive relationship between the (0,15) and (0,30) day return windows and the percent change in Total Assets over t to $t+2$, $t+3$, and $t+4$. Further analysis shows that the "Other Assets" line item seems to be driving this relationship. We are currently in the process of collecting more refined, insurance-specific data to determine exactly what component of Other Assets is positively related to returns.

These results have three possible interpretations. First, it may be that investors are attempting to calculate fundamental value, but simply misestimate the ultimate impact of a catastrophe on an insurer's profits. Second, investors may be attempting to predict the behavior of naive investors rather than calculate the intrinsic value of the firm. Third, it may be that investors are correct about the isolated impact of a disaster but management is able to minimize the disaster's effect on the firm's financials (particularly the Income Statement). The positive relationship between returns and Total Assets indicates that fundamental value may be a consideration for some investors, but more detailed data is necessary to flesh out this relationship.

7. Agenda for Further Research

We have extensive plans to continue improving this research. First, we are in the process of collecting quarterly NAIC statutory financials to integrate those financials with our current results. The NAIC data is of relatively high quality and has a number of line items that are specific to insurance companies, such as Reinsurance Recoverable, Revenue by line of business, Loss Reserve Development, etc. We anticipate that these items will help to interpret the relationship between returns and Total Assets.

We also plan to collect a number of dependent variables outside of financial statement data. Examining longer-term returns (~1 year) would provide insight into how short-term investors predict long-term returns. We also plan to investigate the catastrophe's effect on stock beta and sigma in line with Thomann (2013) and Cummins & Lewis (2003), which would speak to the relevance of CAPM. The relationship between short-term returns, beta, and sigma would contribute significantly to our results. In addition, we may collect A.M. Best ratings to see if post-catastrophe returns have any relationship with changes in financial strength ratings.

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APPENDIX 1: EVENT STUDIES IN PRIOR LITERATURE

Author(s)/Year	Event(s)	Firms	Results	Conclusion/Notes
Aiuppa et al. (1993)	Loma Prieta EQ	Public U.S. insurers	$CAR_{1,3}$ = 0.91% EQ insurers $CAR_{1,10}$ = 2.80% EQ insurers CAR negative (not sig) for non-EQ insurers	Demand for EQ insurance expected to increase.
Aiuppa & Krueger (JII, 1995)	1994 LA EQ	Public U.S. insurers	$CAR_{0,1}$ = -0.76% EQ insurers $CAR_{0,1}$ = -0.96% non- EQ insurers $CAR_{0,9}$ = 0.51% EQ insurers $CAR_{0,9}$ = -3.07% non- EQ insurers	Demand for EQ coverage expected to increase, offsetting negative returns. Non- EQ insurers may have exposure to related claims but cannot benefit from increased demand.
Angbazo & Narayanan (1996)	Andrew, subsequent premium freeze	Public U.S. insurers	$CAR_{-1,1}$ = -1.97% surrounding Andrew $CAR_{-1,1}$ = -1.55% surrounding AIG premium freeze	Premium increases were expected to offset losses, tempering negative CAR. Exposure to affected areas not related to CAR. GLS method good for cross sectional correlation and small samples.
Blau et al. (2008)	Katrina and Rita	Public U.S. insurers	Short selling of insurer stocks was highest 3 trading days following Katrina and 3 trading days before Rita. Short selling not related to insurer exposure.	Investors learned to short after Katrina led to negative insurer returns.

Author(s)/Year	Event(s)	Firms	Results	Conclusion/Notes
Cagle (1996)	Hugo	Public U.S. insurers	$CAR_{-2,2}$ = -0.6% full sample $CAR_{-2,2}$ =-2.6% high exposure insurers $CAR_{-2,2}$ =1.4% low exposure insurers	Expected loss payments dominate expected premium/demand increases.
Cummins & Lewis (2003)	9/11, Andrew, Northridge EQ	Public U.S. insurers	$CAR_{0,1}$ = -4.65% $CAR_{0,4}$ = -9.56% $CAR_{5,30}$ = 7.80%	Sig increase in variance of ARs following Andrew and 9/11 but not Northridge. Highly rated insurers earned the long-term positive CAR (9/11 only).
Doherty et al. (2003)	9/11	Public U.S. insurers and brokers	No aggregate returns reported.	Early reporting of net losses positively associated with returns. Net loss amounts and pre-loss leverage negatively associated with returns.
Ewing et al. (2006)	Floyd	Public U.S. insurers	$CAR_{-8,1}$ = -2.17% for Floyd $CAR_{-8,1}$ = -2.72% for Andrew	Investors react to positive/negative information about approaching storm.
Gangopadhyay et al. (2010)	Katrina and Rita	Public U.S. insurers	$CAR_{-1,1}$ = -1.73% exposed to Katrina $CAR_{-1,1}$ = -1.26% unexposed to Katrina $CAR_{-1,1}$ = 2.73% exposed to Rita $CAR_{-1,1}$ = 1.19% unexposed to Rita	Investors generated negative returns earlier for Rita and corrected as storm approached.

Author(s)/Year	Event(s)	Firms	Results	Conclusion/Notes
Hagendorff et al. (2015)	19 major weather catastrophes in U.S., 1996-2010	Public U.S. insurers with HO exposure	$CAR_{-5,-1}$ = -0.19% $CAR_{0,1}$ = -0.28% $CAR_{0,5}$ = -0.67% $CAR_{0,20}$ = -1.39%	All US-based weather events, hurricanes less negative than other events. Post-Katrina events less negative than pre-Katrina. Use CAR0,15 as dependent var – PCS data shows that cats last 3-4 days and loss estimates announced 9-10 days post loss.
Kleidt et al. (2009)	25 largest events	148 Insurers	Investors in insurers are "not less rational" than other insurers, insurance stocks gradually adjust to new valuation	
Lamb (1995)	Andrew	Public U.S. insurers	$CAR_{0,1}$ = -5.22% exposed to Andrew $CAR_{0,1}$ = -1.33% unexposed to Andrew	CAR for exposed firms remains negative through 30 days post-event.
Lamb (1998)	Andrew and Hugo	Public U.S. insurers	$CAR_{0,1}$ = -5.22% exposed to Andrew $CAR_{0,1}$ = -1.33% unexposed to Andrew $CAR_{0,1}$ = -0.84% exposed to Hugo $CAR_{0,1}$ = -0.51% unexposed to Hugo	

Author(s)/Year	Event(s)	Firms	Results	Conclusion/Notes
Lamb & Kennedy (1997)	1994 LA Earthquake	Insurers		
Li (2013)	2005-2011 Australian disasters (storms, hail, cyclones, floods)	32 Australian firms in 7 industries	$CAR_{0,1}$ = -5.87% all firms $CAR_{0,5}$ = -24.23% all firms $CAR_{0,1}$ = 0.31% insurance firms $CAR_{0,5}$ = -8.64% insurance firms	Most industries with business exposure in affected area were negatively affected.
Marlett et al. (2000)	Revised estimates of damage from Northridge EQ	Insurers		
Ragin & Halek (2015)	43 largest events since 1970	Public U.S. brokers	$CAR_{0,1}$ = -0.03% all events (no WTC) $CAR_{0,1}$ = 0.51% Top 20 (no WTC) $CAR_{0,1}$ = 1.24% Top 10 (no WTC)	Investors expect prices to rise, increasing broker commissions.
Shelor et al. (1992)	Loma Prieta EQ	Public U.S. insurers	$CAR_{0,1}$ = 1.72% $CAR_{0,2}$ = 2.20%	Amount of EQ insurance written in CA not significantly related to returns.
Takao et al. (2013)	Tohoku EQ	5 public Japanese insurers	$CAR_{0,4}$ = -2.77% non-life insurers $CAR_{0,4}$ = 1.96% life insurers $CAR_{5,15}$ = 1.83% non-life insurers $CAR_{5,15}$ = -7.27% life insurers	Capital positively related to returns.
Thomann (2013)	10 largest	Public U.S. insurers	$CAR_{0,1}$ = -2.97% for 9/11 $CAR_{0,4}$ = -1.80% for 9/11	Catastrophe events increase insurer stock volatility and decrease beta. Beta increased following 9/11. Use of DCC-GARCH errors recommended.

Author(s)/Year	Event(s)	Firms	Results	Conclusion/Notes
Wang & Kutan (2013)	120 Japanese catastrophes and 100 U.S. catastrophes	US and Japanese stock markets and public insurers	$CAR_{0,3}$ = -0.84% US insurers after volcano $CAR_{0,4}$ = 1.49% Japanese insurers after tsunami $CAR_{0,4}$ = 0.30% Japanese insurers after EQ	
Wang & Corbett (2008)	9/11	Public U.S. insurers	$CAR_{0,1}$ = -6.20% P&C insurers $CAR_{0,1}$ = -1.96% Life/health insurers	Life/health recovered after first week, P&C did not recover during their sample (to day 19 post-event).
Yamori & Kobayashi (2002)	Hanshin Earthquake (1995)	13 public Japanese insurers	$CAR_{0,1}$ = -3.11% $CAR_{0,4}$ = -2.92% $CAR_{0,9}$ = -3.68%	Returns negatively related to fire exposure and beta, positively related to ROA.
Yanase & Yasuda (2010)	9/11	12 public Japanese insurers	$CAR_{0,1}$ = -2.78% high reinsurance received $CAR_{0,1}$ = -2.23% all P&C	Reinsurer TAISEI went bankrupt as a result of 9/11 claims, other reinsurers experienced negative returns as a result.
Yang et al. (2008)	61 Japanese catastrophes 1990-2000	Japanese stock market, insurers	No aggregate returns reported. No effect overall, negative for insurance industry, positive for construction industry.	Loss size negatively related to insurer returns.