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Capitalizing on Catastrophe: Short Selling Insurance Stocks Around Hurricanes Katrina and Rita

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Abstract

We develop several hypotheses regarding short-selling activity around Hurricanes Katrina and Rita. We find that abnormal short selling does not increase until 2 trading days after the landfall of Katrina and that short-selling activity is much more significant around Rita. We find a substantial increase in short-selling activity in the trading days prior to the landfall of Rita and relatively less short-selling activity in the trading days after landfall. There is little evidence that suggests that traders short insurance stocks with more potential exposure in the Gulf region than other insurance stocks in the days before landfall.

Introduction

The August 29 and September 24, 2005, hurricanes (Katrina and Rita, respectively) present an opportunity to analyze the ability of short sellers' attempt to capitalize on catastrophe. This article examines the behavior of short sellers around both hurricanes. Hurricane Rita (Rita) made landfall 27 days after the landfall of Hurricane Katrina (Katrina), both affecting the Gulf Coast region of the United States. The repeated nature of these disasters allows researchers to examine theories regarding information acquisition and learning.

There is a recent debate in the literature regarding the informativeness of short sellers. Some papers find consistency with the Diamond and Verrecchia (1987) hypothesis that short sellers are informed about the true value of stocks (e.g., Aitken et al., 1998; Christophe, Ferri, and Angel, 2004; Boehmer, Jones, and Zhang, 2008; and Diether, Lee, and Werner, in press), whereas others do not find evidence of the Diamond and Verrecchia (1987) hypothesis. Daske, Richardson, and Tuna (2005) do not find evidence

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of concentrated short selling during preannouncement periods of bad news events. Asquith, Pathak, and Ritter (2005) find that the evidence supporting the Diamond and Verrecchia (1987) hypothesis is driven by a few small firms. Previous researches (Ewing, Hein, and Kruse, 2006; Lamb, 1995, 1998) show that insurers' stock prices decline in the prelandfall period of hurricanes. The decrease in insurer's stock prices presents an opportunity to test the Diamond and Verrecchia hypothesis. If short sellers are able to predict negative price adjustments, then we expect short sellers to anticipate the price decline and sell short insurance stocks prior to the landfall of the hurricane. For further support of Diamond and Verrecchia, we would expect short sellers to be sophisticated about which stocks they short. Specifically, property–casualty insurance companies with more exposure in the Gulf Coast region will be fundamentally more affected by hurricanes than other insurance firms (e.g., Lamb, 1995, 1998). Therefore, we expect short-selling activity for these stocks to be greatest.

Theory regarding learning by investors can also be tested by examining short-selling behavior around Katrina and Rita. In general, we expect short sellers to learn from the effects of Katrina and subsequently capitalize on the potential stock price decline caused by Rita by executing more short-sale volume in the prelandfall period of Rita. Although several theoretical models explore information acquisition and learning, we attempt to determine whether the learning of short sellers between hurricanes is sophisticated or unsophisticated. Bayesian learning suggests that investors will update their behavior based on the realization of the economy via Bayes' rule. Within the framework of Katrina and Rita, if short sellers are Bayesian learners, they will be able to acquire information about the effect of the hurricanes on insurer's stock prices, and will further be able to determine which insurance stocks were most affected by Katrina before shorting stocks in the pre-Rita period.

Adaptive learning differs from Bayesian learning by suggesting that short sellers may imitate past successful behavior which may or may not be successful in the current period. Bayesian learning is complex and demands more of traders' rationality whereas adaptive learning demands less.[1] Learning models are generally tested in an experimental setting; however, the repeated nature of Katrina and Rita provides a unique opportunity to generalize Bayesian and adaptive learning in an attempt to test the level of sophistication short sellers use to acquire information about the stock price adjustment in the prehurricane period. We test to see if short sellers distinguish between stocks that face a higher likelihood of being affected by both Katrina and Rita. If short sellers are Bayesian, they will learn which stocks are more affected, or have more exposure in the affected region, and use the acquired information in determining which stocks to short prior to Rita. If short sellers are adaptive learners, we expect them to be less sophisticated in the stocks they choose to short in the prelandfall period of Rita. Consistency with the Diamond and Verrecchia (1987) hypothesis requires short

[1] Typically, the learning of traders occurs much faster than in the few weeks between the two hurricanes investigated. However, we attempt to apply a generalization of both Bayesian and adaptive learning to trading behavior around Katrina and Rita in attempt to test the sophistication of short-selling strategies. Within the framework of the 2005 Gulf Coast hurricanes, we argue that Bayesian learning will expect greater rationality and more sophistication in determining which stocks traders short, whereas adaptive learning requires less sophistication and rationality in determining which stocks to short.

selling to be more concentrated in stocks with greater regional exposure to Rita than to Katrina because investors can become more informed by learning about the effects of Katrina.

Consistent with Ewing, Hein, and Kruse (2006) and Lamb (1995, 1998), who find that stock prices decline prior to the landfall of Hurricanes Floyd and Andrew, respectively, we find that insurance stock prices begin declining in the week before landfall of Hurricane Katrina. Interestingly, we do not find significant short selling in the pre-Katrina period. Instead, we find significant abnormal short selling 3 trading days after the landfall of Katrina, consequently after prices have already reflected the expectations of damages. This finding contradicts our initial prediction that suggests short selling will significantly increase in the pre-Katrina landfall period.

As Rita approaches, we find a large price decrease beginning the week before landfall. Consistent with our expectation, we find abnormal short selling in the prelandfall period of Rita with the highest level of short-selling activity occurring on the day when prices begin to decrease. We argue that the difference in short seller's behavior between the two hurricanes is a result of learning about the effects of Katrina on stock prices and capitalizing on the effects of Rita by shorting insurance stocks in the prelandfall period.

We find that although short sellers learn from the effects of Katrina, they are not sophisticated in the stocks they choose to sell short in the prelandfall period for Rita. We find that prices of stocks with more exposure to Rita have a greater negative price adjustment in the prelandfall period. However, we do not find evidence of concentrated short selling of insurance stocks where the underlying insurers have more regional exposure in the Gulf Coast region. Further, we distinguish between insurers that write relatively more property–casualty business in the Gulf Coast region and insurers that write relatively less property–casualty business in the Gulf Coast region. We argue that property–casualty insurers will be more affected by a hurricane than other types of insurers. Although we find that property–casualty insurers in the Gulf Coast region have the largest stock price decreases, we do not find evidence of a significant difference in short-selling activity for the Gulf Coast region, property–casualty stocks and other insurance stocks in the prelandfall period for Rita.

Our interpretation of these findings is that short sellers acquire information adaptively. Routledge (1999) predicts that adaptive learners will experience success but will not allocate much of their resources on acquiring information. Though we do not find evidence of short sellers distinguishing between stocks that have more regional exposure to Rita, short sellers do appear to generally predict substantial stock price declines in the week prior to Rita's landfall.

PREVIOUS LITERATURE

A broad stream of literature regarding catastrophe risk faced by insurers discusses the ability of insurers to manage this risk as well as the effect of catastrophe risk on stock prices. Froot (1999) describes the market for catastrophic risk and argues that although self-insurance is inefficient, providing capital for catastrophic risk is costly. He argues that competition, innovation, and specialization can improve the efficiency of catastrophic risk management particularly through the use of cat bonds.

Other research (Niehaus and Mann, 1992; Froot, 2000) argues that increased use of derivatives may be able to lower the transactions costs of reinsurance and improve catastrophe risk management, whereas Golden, Wang, and Yang (2007) introduce the use of weather derivatives as a means for firms to hedge against weather-related risks. Additionally, Lewis and Murdock (1996) discuss ways that government regulation provides opportunity for intertemporal risk sharing through lower interest rates when natural disasters occur. Niehaus (2002) surveys the literature that addresses catastrophic risk sharing in an attempt to determine whether improved innovation in risk management techniques can still pay claims for a mega-catastrophe. Cummins, Doherty, and Lo (2002) analyze the ability of insurance companies to pay claims and present simulated evidence that even if insurance companies were to pay 90 percent of claims, there would still be billions of dollars in unpaid claims and a large number of insurance insolvencies. The 2005 hurricane season accounted for $52.7 billion in insured losses, nearly 93 percent of total insured losses for all of 2005 (Guidette, 2006), and provides an important view of the effect of catastrophe on insurance companies.

The effect of catastrophic events on insurance stock prices is investigated by Shelor, Anderson, and Cross (1990) and Aiuppa, Carney, and Krueger (1993). They examine the effect of the October 17, 1989, California earthquake on the stock price of property–liability insurers and suggest that earthquakes convey new information to the market, resulting in a significant positive market response to the earthquake. The findings indicate that investors' expectations of larger demands for insurance have the potential to offset the catastrophic losses. In a related article, Shelor, Anderson, and Cross (1992) examine the stock price of real-estate stocks around the 1989 California earthquake. In contrast to insurance stocks, the real-estate industry experienced significant negative returns in the affected region (San Francisco). The large negative returns indicate that investors viewed the earthquake as a signal of unfavorable future financial conditions in the real-estate market. This comparison raises an important question regarding investor's expectations of the insurance industry in response to an anticipated catastrophic event.

Lamb (1995, 1998) finds evidence of negative returns for property–casualty insurance stocks around Hurricane Andrew (1992). Insurers with more exposure in the affected region experienced larger stock price declines. In addition, Lamb suggests that the market is efficient in interpreting the information generated by Hurricane Andrew prior to landfall. Ewing, Hein, and Kruse (2006) examine the insurance market reactions to Hurricane Floyd (1999) while accounting for the hurricane's characteristics in the prelandfall period. These authors focus on whether or not the information provided by the hurricane's characteristics is valuable to financial markets. They suggest that insurance stock prices should be affected by the expectation of damages caused by the hurricane. Higher expected damages associated with a hurricane imply greater losses by insurers, consequently lowering stock prices.

In a separate stream of literature, Diamond and Verrecchia (1987) hypothesize that short-selling activity will predict negative returns. Senchack and Starks (1993) find evidence supporting the Diamond and Verrecchia hypothesis as they find that significant increases in short interest yield significant negative, albeit small, returns. Aitken et al. (1998) find significant negative returns immediately after short sales are executed

on the Australian Stock Exchange.[2] The authors find that, on average, the price adjustment occurs in the 15-minute interval after execution. Christophe, Ferri, and Angel (2004) find selectivity in the stocks that are shorted in the preearnings announcement period. They find that short-selling activity increases in the preannouncement period for stocks with negative earning announcements. Boehmer, Jones, and Zhang (2008) reject the hypothesis that short sellers are completely uninformed on the NYSE. After categorizing stocks in heavily shorted and lightly shorted groups, they find that heavily shorted stocks underperform the lightly shorted stocks. They find that institutional short sellers are more informed than individual short sellers, but in general they argue that short sellers are indeed informed. Recent articles argue that a further investigation of the Diamond and Verrecchia hypothesis is warranted. Daske, Richardson, and Tuna (2005) do not find an increase in concentrated short-selling activity for stocks with negative earnings announcements and instead find that short sellers do not distinguish between stocks with good and bad earnings announcements in the preannouncement period. Asquith, Pathak, and Ritter (2005) find that consistency with the Diamond and Verrecchia hypothesis is driven by a few small firms. Another natural investigation of the Diamond and Verrecchia hypothesis is to see whether or not short sellers predict the negative price movements during the prelandfall period of Katrina and Rita.

Previous research shows that prices of insurance stocks have a greater negative adjustment when the underlying insurer has more regional exposure to the catastrophe. Further tests regarding the informativeness of the short sellers can be applied by first examining whether or not short sellers are able to determine which insurance stocks will most likely be affected. Because Rita made landfall only 27 days after Katrina, further investigations regarding the ability of short sellers to acquire information are also available.

Grossman and Stiglitz (1980) provide the theoretical framework for the information acquisition of investors. Their model predicts that traders in a one-period economy can choose to allocate resources for a costly signal of a risky asset's terminal dividend. Other traders may not choose to acquire the signal and instead will make inferences about the signal from the market-clearing asset price. Bray and Kreps (1987) calculate utility maximizing demands in an attempt to specify prior beliefs about the price-signal relation so that traders can update their behavior via Bayes' rule. Learning has also been used as a partial explanation of excess volatility and the predictability of stock prices. Bulkley and Tonks (1989) examine excess volatility in U.K. stock prices and argue that part of the excess volatility of stock prices is attributed to revisions in investor's beliefs which intuitively affect the volatility of stocks. Timmerman (1993) finds evidence consistent with Bulkley and Tonks when examining dividend growth rates. The author finds that learning has a substantial impact on stock price dynamics, including predictability and volatility. Welch (1992) finds that learning around IPOs can lead to cascading and imitative behavior by traders. We find that when short sellers learn from the effect of Katrina on stock prices, price discovery in the prelandfall period for Rita occurs much faster than for Katrina, which may be a result of trading cascades in Rita's prelandfall period. Routledge (1999) builds on the intuition of Welch

[2] It is important to note that the Australian Stock Exchange reveals that a trade is a short sale upon execution.

(1992) and the Grossman and Stiglitz (1980) model, and conjectures that individuals that learn faster are more likely to be uninformed, which seems as a counter to the notion that sophisticated traders process more information. In the framework of Welch, faster learning is likely explained by higher imitative behavior and greater cascading. In these cases, Routledge suggests that information choice and inferences are determined by adaptive learning rather than optimization.

We next summarize our initial hypotheses developed from the previous research. First, we hypothesize that short sellers will anticipate the negative price adjustment prior to the landfall of Katrina and subsequently execute significant abnormal short-sale volume in the prelandfall period of Katrina. Second, we expect more abnormal short-selling activity to occur in the prelandfall period of Rita relative to Katrina because short sellers are able to learn from the effects of Katrina. Third, we posit that short sellers will be able to distinguish between stocks that will be more affected by Katrina; thus, we expect that short sellers will be able to determine which stocks have a greater regional exposure to Katrina. Finally, we expect short sellers to better distinguish between stocks with more regional exposure to Rita because of learning from the effect of Katrina.

RESEARCH DESIGN

Data

We use short-sale data that are made available by the NYSE in response to Securities and Exchange Commission (SEC) Regulation SHO. The trade data are obtained from the NYSE Trades and Quotes (TAQ) database. The stocks in the sample are NYSE-listed insurance companies. Using the SEC's EDGAR database, we examine 2005 second quarter filings and exclude stocks if revenue from insurance-type business is less than 50 percent of the total revenue. We also exclude stocks if they have a price less than $5 and if they are not traded every day in the sample time period (July 1, 2005, to September 30, 2005). The total number of stocks used in the analysis is 72.[3] We use the National Association of Insurance Commissioners (NAIC) database to determine insurance business by state. We separate the amount of business, both total business and property–casualty business, by Gulf states and non-Gulf states. The Gulf states are Alabama, Florida, Louisiana, Mississippi, and Texas. All other states are categorized as non-Gulf states.

Several hurricanes affected the United States in 2005; however, we limit our analysis to Katrina and Rita because these two hurricanes made landfall relatively close to each other and in the same geographical vicinity.[4] The repeated nature of the two hurricanes allows for better tests regarding the ability of short sellers to acquire and process information about which stocks will most likely be affected. As Ewing,

[3] We initially identified 125 insurance stocks listed on the NYSE.

[4] Hurricane Emily preceded Katrina in July 2005 but eventually made landfall in Northern Mexico after entering the Gulf of Mexico. Hurricane Wilma followed Rita, entering the Gulf of Mexico in October of 2005. After making landfall in the Yucatan Peninsula, the hurricane exited the Gulf of Mexico crossing Southern Florida. We do not include Emily or Wilma in our analysis because the hurricanes did not make landfall in the same vicinity as Katrina and Rita.

Hein, and Kruse (2006) document, investors expectations are revised as the hurricane approaches landfall. We notice that the exact time and place of landfall are not known with certainty by short sellers; however, as the storm approaches landfall, the level of uncertainty decreases. Therefore, our aim is to examine the short-selling activity of insurance stocks with more exposure in the entire Gulf Coast region (as opposed to a specific area in the Gulf Coast region) in a time period that allows the expectations of investors to affect stock prices around each event.

Methods

We use several measures of short-selling activity throughout the article. We use the amount of daily short volume for each stock as well as the daily number of short sales. In order to compensate for more actively traded stocks, we calculate two ratios. The short-volume ratio is calculated by dividing the daily short-sale volume by the daily total trade volume. The short-activity ratio is calculated by dividing the daily number of short sales by the daily number of total trades. We examine a 10-day time window around each event to allow the short sellers to obtain information and become more confident in the projection of the hurricanes' landfall. Table 1 presents descriptive statistics for the various measures of short selling for our sample of stocks. Panel A reports the descriptive statistics for the entire sample time period. Panel B gives the statistics for a 10-day window around the landfall of Katrina whereas Panel C presents the statistics for a 10-day window around the landfall of Rita. The 10-day window is defined as the 5 trading days before landfall and the 5 days after landfall. In both cases, the hurricanes occurred during nontrading hours. Katrina hit the Gulf Coast on Monday, August 29, 2005, at approximately 6:10 AM whereas Rita made landfall at approximately 2:30 AM on Saturday, September 24, 2005.[5]

According to research regarding the behavior of short sellers and stock price movements in response to an anticipated catastrophe, we expect short selling to increase around the hurricanes. Panels B and C of Table 1 provide tests of differences for the entire sample and the 10-day windows around Katrina and Rita. We find that the short-selling measures for the entire sample are larger than those around Katrina (significant for short-volume and the short-activity ratio) and significantly less than those around Rita (significant in all measures).

We use an event study method to test the effects of Katrina and Rita on short-selling activity. We standardize the short-selling measures in order to test the significance in short activity similar to previous research by calculating the following:[6]

$$Abnormal\ Measure = \frac{Measure_{i,t} - \overline{Measure_i}}{\sigma(Measure_i)}.$$

The abnormal short-selling measure is the difference between the short measure for stock i on day t and the mean of the short-selling measure across the sample time

[5] National Weather Service, 2005.

[6] See Lakonishok and Vermaelen (1986) and Koski and Scruggs (1998) for trading volume event effects.

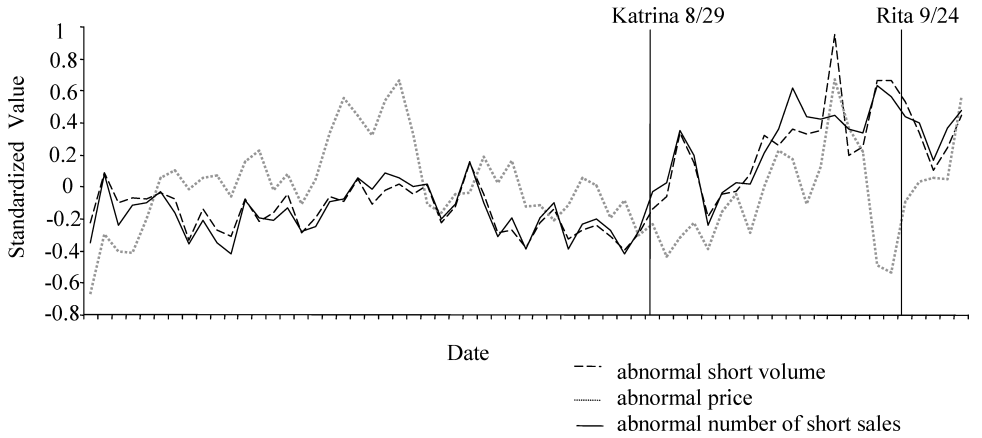
TABLE 1
Descriptive Statistics

	Short Volume	Number of Shorts	Short-Volume Ratio	Short-Activity Ratio
Panel A: Short Selling Descriptive Statistics for Entire Sample Period				
Mean	122,824.63	263.84	0.3094	0.3415
Standard deviation	168,493.16	242.60	0.0956	0.0977
Min	689.36	2.59	0.1079	0.1392
Max	1,072,244.44	1,111.84	0.5577	0.5682
N	72	72	72	72
Panel B: Short Selling Descriptive Statistics for 10-day Window Around Hurricane Katrina				
Mean	108,196.24	259.95	0.3097	0.3320
Standard deviation	151,868.80	266.47	0.1317	0.1318
Min	450.00	2.00	0.0978	0.1086
Max	914,470.00	1,000.40	0.7721	0.7123
N	72	72	72	72
Difference	17,393.00*	4.59	0.0029	0.0158**
t-statistic	(1.80)	(0.39)	(0.38)	(2.21)
Panel C: Short Selling Descriptive Statistics for 10-Day Window Around Hurricane Rita				
Mean	187,578.47	355.23	0.3368	0.3698
Standard deviation	325,212.13	331.82	0.1147	0.1153
Min	1016.67	2.83	0.1398	0.1512
Max	1,961,800.00	1,561.78	0.6210	0.6332
N	72	72	72	72
Difference	−75,577.00***	−83.36***	−0.0320***	−0.0350***
t-statistic	(−7.51)	(−6.74)	(−4.12)	(−4.71)

Notes: The table reports volume and activity measures for short selling of the sample of insurers trading on the NYSE between July and September 2005. The number of shorts and short volume is obtained from SEC Regulation SHO data. Total number of trades and volume is obtained from TAQ. The Short-Volume Ratio is calculated as short volume over total trading volume, and the Short-Activity Ratio is calculated as the number of shorts over the total number of trades. Panel A contains measures for July–September 2005. Panel B reports the statistics for the 5 days before and after Hurricane Katrina made landfall. The difference between the means in Panels A and B is reported. Panel C reports the statistics for the 5 days before and after Hurricane Rita made landfall with the difference between the means in Panels A and C. *t*-statistics are reported in parentheses.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

period. The difference is then divided by the standard deviation of the short-selling measure across the sample time period. The standardization allows for each measure on each day to be similarly distributed with a zero mean and a unit variance. A *t*-test distinguishes whether or not the standardized measure of short selling is significantly different from zero, which is the mean.

FIGURE 1
Short Selling and Prices Around Hurricanes Katrina and Rita



Note: The figure shows the time-series standardized values of short-sale activity and prices for july 1, 2005, to september 30, 2005, for the sample of 72 publicly traded insurance stocks. The variables are standardized to have a zero mean and unit variance.

Figure 1 shows the time series for the standardized daily short volume, daily number of short sales, and the daily prices, equally weighted by stock for the third quarter of 2005. The level of short selling for the entire period is driven by the high level of short selling during September. We see an increase in short-sale volume on September 1, 3 trading days after the landfall of Katrina. We find increasing short selling over the next few weeks prior to the landfall of Rita. Consistent with earlier research, we find that prices adjust downward beginning in the week prior to Katrina and continue adjusting downward until 2 days after landfall. We find an increase in short selling in the trading days before Rita's landfall. Although the upward trend in short selling in September may be partially explained by publicized damage reports from the aftermath of Katrina, we find increases in short-selling activity before the landfall of Rita, which we interpret as short sellers learning from the negative stock price effect of Katrina and responding by increasing the short selling of insurance stocks prior to Rita.

RESULTS

In Figure 1, we see that short volume does not increase until 3 trading days after the landfall of Katrina, which is contrary to our first prediction that short sellers anticipate damages resulting from the hurricane and execute prior to landfall. Further, Figure 1 shows that short-selling activity increases in the trading days prior to Rita's landfall which is consistent with our second prediction. We interpret this increase as short sellers learning from the effects of Katrina. Table 2 reports the differences between the means and medians of the volume and activity ratios around Katrina and Rita. We distinguish between prelandfall [−5 to −1] and postlandfall [+1 to +5]. Examining the means for the entire 10-day window, we find significantly more short selling

TABLE 2
Comparison of Means and Medians Between Hurricanes Katrina and Rita

	[−5 to +5]			[−5 to −1]			[+1 to +5]		
	Katrina	Rita	Difference	Katrina	Rita	Difference	Katrina	Rita	Difference
Volume ratio									
Mean	0.3097	0.3368	−0.0271*	0.3004	0.3371	−0.0367**	0.3165	0.3245	−0.0080
			(−1.70)			(−2.14)			(−0.73)
Median	0.2990	0.3216	−0.0227	0.2926	0.3387	−0.0461**	0.3018	0.3052	−0.0152
			(−1.25)			(−2.33)			(−1.60)
Activity ratio									
Mean	0.3320	0.3698	−0.0378***	0.3239	0.3774	−0.0535***	0.3390	0.3541	−0.0035**
			(−2.80)			(−3.51)			(−0.31)
Median	0.3266	0.3578	−0.0312**	0.3157	0.3807	−0.0650***	0.3276	0.3464	−0.0188**
			(−2.04)			(−3.95)			(−2.01)

Notes: For the entire sample of insurers, the table reports the difference in means and medians of the short-volume ratio and short-activity ratio for the 10-trading-day window around each hurricane making landfall, the 5-trading-day window before landfall and the 5-trading-day window immediately following landfall. *t*-statistics are reported for each difference.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

TABLE 3
Event Study of Short Selling Around Hurricanes Katrina and Rita

Event Time	Standardized Short Volume	Standardized Short Activity	Standardized Volume Ratio	Standardized Activity Ratio
Panel A: Short Selling Around Hurricane Katrina				
−5	0.0168	0.0972	0.1376	0.0163
−4	−0.0032	0.1087	0.1917	0.0126
−3	−0.1464	−0.0329	−0.0502	−0.1856
−2	0.3374	0.1180	−0.0656	−0.0657*
−1	0.0199	0.0898	0.1814	−0.0376
Landfall				
+1	0.3175	0.3683*	−0.0330	−0.0368
+2	0.7703*	0.06229**	0.3119*	0.1137
+3	1.6432**	0.9287***	0.1824	0.0651
+4	0.9653***	0.7633**	0.2890*	0.1340
+5	0.4971*	0.2853	0.4182	0.0615
Panel B: Short Selling Around Hurricane Rita				
−5	1.6021***	1.3950***	0.4603***	0.4360***
−4	1.1766***	1.0753***	0.3964**	0.3584**
−3	2.7932**	1.5924***	0.5277***	0.4902***
−2	4.5874**	1.7107***	0.1931	0.3941**
−1	3.7714*	1.6763***	0.4292**	0.3943**
Landfall				
+1	2.4869**	1.3491***	0.2212	−0.0146
+2	1.5974**	1.0705***	0.2773	0.1904
+3	1.4733***	1.2183***	0.4382**	0.3257**
+4	1.8907**	1.3269***	0.6360***	0.5858***
+5	0.7703*	0.6229**	0.3119*	0.1137

Notes: The table reports volume and activity measures for short selling of the sample of insurers for in event time. Panel A contains measures for Hurricane Katrina; Panel B contains measures for Hurricane Rita. The Short-Volume Ratio is calculated as short volume over total trading volume, and the Short-Activity Ratio is calculated as the number of shorts over the total number of trades. The standardization measures are calculated by taking the difference between the measure on each day and the mean of the measure across the sample period and dividing the difference by the standard deviation of the measure across the period.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

around Rita than around Katrina (the median difference for the short-volume ratio is not statistically significant).

Consistent with our hypothesis that short sellers learn from Katrina, we find that short selling (for the ratio measures in the prelandfall period [−5 to −1]) is significantly greater for Rita than for Katrina.

Table 3 reports the results of an event study using the standardized measures of short selling. We test for the significance in short-selling activity in the 10-day window

around the hurricanes. Similar to Figure 1, Panel A of Table 3 shows that relatively little short selling occurs in the prelandfall period for Katrina. That is, short sellers do not anticipate stock price declines in response to the potential damages caused by Katrina. Ewing, Hein, and Kruse (2006) document an important relation between the wind speed of hurricane and the effect on stock prices. We obtain from the weather service the category of Katrina on each day. From day $t-5$ to day $t-3$, Katrina was a tropical storm. Katrina was upgraded from a tropical storm to a hurricane on day $t-2$ and was upgraded again to a category 2 hurricane on day $t-1$. When examining the severity of the storms, short selling does not appear to be affected. This finding contradicts our initial expectation that short sellers will predict the negative price adjustment caused by the negative expectations from the hurricane. The postlandfall period for Katrina is important to note, as Katrina made landfall on a Monday morning, prior to the open of trading. One can argue that short sellers did not have the opportunity to trade prior to the landfall because of the weekend. We find that abnormal short selling does not increase on the first trading day after landfall (+1). Looking at the standardized short volume, we find significant short selling 3 trading days after landfall. Similarly, we find that the standardized number of short sales (standardized short activity) is greatest 3 trading days after landfall.[7] We find less significance in the standardized volume and activity ratios which may be due to an increase in normal trading activity of the stock, which is in the denominator of the ratios.

The results in Panel B are quite different. We find significant abnormal short selling around the landfall of Rita in both the standardized short volume and the standardized number of short sales. During the 3 trading days prior to landfall of Rita, [−3 to −1], we see the highest level of abnormal short-selling activity. For the ratio measures, we find high abnormal short-selling activity during the prelandfall period as well. Referring to Figure 1, we see that short selling is upward trending after Katrina, which may be a result of the shorting of insurance stocks as information regarding the damages is publicly disseminated in the days and weeks following Katrina. However, in the days before Rita, we see a significant increase in short selling which we interpret as short sellers anticipating the potential effects from Rita. We perform a similar investigation using the storm categories as before and find that on day $t-5$, Rita was classified as a tropical storm. On day $t-4$, Rita was upgraded to a category 2 hurricane, and from days $t-3$ to $t-1$, Rita was classified as a category 5 hurricane. It is difficult to determine whether the increase in short-selling activity is due to the increasing intensity of the storm or the increasing ability of meteorologists to predict its landing. However, the general results of the table support the notion that short sellers learn from Katrina and attempt to profit from the potential effect of Rita on the prices of insurance stocks.

[7] We recognize that short selling is upward trending for the time period, so we compare the means of the short-selling measures reported in Table 3 with the mean from the 20-day window prior to the 10-day window around each hurricane. The results are not reported, but we find that significant short selling occurs 2–3 trading days after Katrina and 3 trading days before Rita.

TABLE 4
Event Study of Short Selling for Hurricanes Katrina and Rita

	Katrina		Rita			
Event Time	Volume Ratio	Activity Ratio	Volume Ratio	Activity Ratio	Difference Volume Ratio	Difference Activity Ratio
−5	0.3010	0.3271	0.3466	0.3795	−0.0457	−0.0524**
					(−1.65)	(−2.25)
−4	0.3143	0.3294	0.3439	0.3725	−0.0296	−0.0431*
					(−1.11)	(−1.85)
−3	0.2753	0.3007	0.3412	0.3844	−0.0659***	−0.0837***
					(−2.84)	(−3.99)
−2	0.2791	0.2952	0.3134	0.3705	−0.0343	−0.0754***
					(−1.37)	(−3.32)
−1	0.3007	0.3211	0.3331	0.3727	−0.0324	−0.0516**
					(−1.29)	(−2.26)
Landfall						
+1	0.2855	0.3221	0.3102	0.3238	−0.0246	−0.0017
					(−1.00)	(−0.07)
+2	0.3297	0.3441	0.3195	0.3491	0.0102	−0.0050
					(0.32)	(−0.19)
+3	0.3075	0.3334	0.3458	0.3674	−0.0329	−0.0285
					(−1.16)	(−1.31)
+4	0.3271	0.3433	0.3602	0.3916	−0.0332	−0.0483*
					(−1.15)	(−1.81)
+5	0.3165	0.3217	0.3297	0.3441	−0.0132	−0.0225
					(−0.48)	(−1.20)

Notes: The table reports differences in volume and activity measures for short selling of the sample of insurers between Hurricanes Katrina and Rita in event time The Short-Volume Ratio is calculated as short volume over total trading volume, and the Short-Activity Ratio is calculated as the number of shorts over the total number of trades. *t*-statistics are reported for each difference.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

To further investigate our hypothesis that short sellers learn from the effect of Katrina, we present an event study using the raw ratios measured in Table 4. We calculate the equally weighted difference between Katrina's short-volume ratio and Rita's short-volume ratio for each day around the landfall of the respective hurricane. Likewise, we calculate the differences for the short-activity ratios between the two hurricanes. If short sellers learn from Katrina and attempt to profit from the effect of Rita, we expect the difference between the ratios of Katrina and Rita to be significant in the prelandfall and insignificant in the postlandfall. We find the short-selling ratios to be significantly greater in the prelandfall period of Rita than in the prelandfall period of Katrina, particularly when looking at the short-activity ratio (the difference between the short-volume ratio is only significant on day −3). We also find in the postevent period that there is no significance (except for the short-activity ratio on day +4).

These findings add to our argument that short sellers learn from Katrina and attempt to profit from the expected price decrease caused by Rita.

As there are other potential factors that influence the level of short selling, we use a multiple regression model to control for other variables. Specifically, we use the following model:

$$\begin{aligned} Ab\ Short\ Volume_{i,t} = {} & \beta_0 + \beta_1\ Price_{i,t}^{-1} + \beta_2 \ln(Volume_{i,t}) + \beta_3 \ln(Size_{i,t}) \\ & + \beta_4\ Volatility_{i,t} + \beta_5\ DAY_i + \beta_6\ PreKatrina_i \\ & + \beta_7\ PostKatrina_i + \beta_8\ PreRita_i + \beta_9\ PostRita_i + \varepsilon_{i,t}. \end{aligned} \quad (1)$$

The abnormal short volume for stock i on day t is regressed on the inverse of the price for stock i on day t, the natural log of daily volume, the natural log of daily capitalization, and volatility for stock i on day t. *DAY* is a discrete variable that is numbered 1–64 for each trading day in the time period and is included to control for the upward trend in short selling over time. In order to look at the effect of the pre- and postlandfall periods, we create four dummy variables. *PreKatrina* is equal to 1 for the days in the time window [−5 to −1] before the landfall of Katrina, whereas *PostKatrina* is equal to 1 for the window [+1 to +5] after the landfall of Katrina. Similarly, *PreRita* and *PostRita* are dummy variables capturing the effects of the prelandfall and postlandfall periods of Rita.

In order to test our first two hypotheses within a multiple regression framework we focus on the estimates of the dummy variables after controlling for other potential factors that influence the level of short selling. To test the first hypothesis we would expect the estimate for β_6 to be positive. The interpretation of a positive estimate for β_6 suggests that short sellers anticipate a negative price adjustment in Katrina's prelandfall period. To test our second hypothesis, we expect the estimate for β_8 to be positive and significantly larger than then estimate for β_6. This suggests that more short sellers anticipate the price adjustment in Rita's prelandfall period because of learning from the effects of Katrina. Table 5 reports the results from estimating Equation (1).[8] We find that price, volume, and volatility positively affect the level of abnormal short volume, whereas capitalization is negatively related to the level of short selling, and this result is consistent with other research (e.g., Boehmer, Jones, and Zhang, 2008). The variables of interest in the regression are the dummy variables. After controlling for other factors including the upward trend in short selling during the time period, the results are inconsistent with the hypothesis that short sellers anticipate the negative price adjustment in Katrina's prelandfall period. For the 5-day window before the landfall of Katrina, abnormal short volume is significantly less than other days not captured by dummy variables. Further, we find evidence supporting our second hypothesis that abnormal short volume is significantly greater for the 5-day window prior to the landfall of Rita. As shown in Figure 1, the upward trend

[8] The White (1980) test rejects the presence of conditional homoskedasticity; we therefore report the robust *t*-statistics.

TABLE 5
Regression of Abnormal Short Volume

	Standardized Short Volume	Standardized Short Volume	Standardized Short Volume
Intercept	0.6156***	0.6062***	0.6148***
	(2.81)	(2.73)	(2.80)
$Price^{-1}$	−2.8816***	−2.9554***	−2.8814***
	(−4.55)	(−4.63)	(−4.55)
ln(*Volume*)	0.2679***	0.2753***	0.2679***
	(16.45)	(16.81)	(16.47)
ln(*Size*)	−0.2728***	−0.2803***	−0.2728***
	(−12.78)	(−13.03)	(−12.78)
Volatility	0.0874***	0.0898***	0.0875***
	(7.43)	(7.64)	(7.46)
DAY	0.0069***	0.0080***	0.0072***
	(7.68)	(8.69)	(6.27)
PreKatrina	−0.2834***		−0.2940***
	(−7.28)		(−6.98)
PostKatrina		−0.0080*	−0.0909*
		(−1.83)	(−1.67)
PreRita	0.2036***		0.1873***
	(3.28)		(2.69)
PostRita		−0.0071	0.0089
		(−0.10)	(0.11)
R^2	0.1395	0.1306	0.1401

Notes: The table reports the results of a pooled OLS where the dependent variable is equal to abnormal short volume defined above. The model is given below:

$$\begin{aligned} Ab\ Short\ Volume_{i,t} = {} & \beta_0 + \beta_1\ Price_{i,t}^{-1} + \beta_2 \ln(\ Volume_{i,t}) + \beta_3 \ln(\ Size_{i,t}) + \beta_4\ Volatility_{i,t} \\ & + \beta_5\ DAY_i + \beta_6\ PreKatrina_i + \beta_7\ PostKatrina_i + \beta_8\ PreRita_i \\ & + \beta_9\ PostRita_i + \varepsilon_{i,t}. \end{aligned}$$

The independent variables are the inverse of the price of stock i on day t, the log of daily volume, the log of daily capitalization for, and the daily volatility for stock i which is measured as the standard deviation of the daily high price less the daily low price. *DAY* is a time trend variable numbered 1– 64 for the number of trading days in the time period. Further, *PreKatrina* and *PostKatrina* are dummy variables equal to unity for the 5-day window before and after landfall of Katrina, respectively. Similarly *PreRita* and *PostRita* are dummy variables equal to unity for the 5-day window before and after landfall of Rita. The robust *t*-statistics are reported in parentheses.

*Statistically significant at the 10% level.
**Statistically significant at the 5% level.
***Statistically significant at the 1% level.

in short selling after Katrina is likely short sellers trading on the lagged effects of Katrina. After controlling for the upward trend, we still find significant short selling prior to Rita suggesting that short sellers anticipate prices to be effected by Rita. When comparing the estimates for β_6 and β_8, we find that short-selling activity is

significantly greater in the prelandfall period of Rita than in the prelandfall period of Katrina.[9]

In summary, we find that although short sellers do not initially anticipate the price decline caused by the effects of Katrina, they predict the negative price adjustment in the prelandfall period of Rita, as shown in Figure 1. It is seen in the figure that the highest level of short-selling activity occurs on the day when prices begin to decrease in the prelandfall period of Rita, suggesting that some short sellers acquire information from the effects of Katrina and profitably trade on the information by predicting negative prelandfall price adjustments before Rita.

With evidence of potential learning by short sellers presented above, we next test our third and fourth hypotheses, which suggest that short sellers will be sophisticated about the stocks they short. In particular, we seek to find if short sellers distinguish between shorting insurance stocks where the underlying insurers write business in the Gulf states, particularly property–casualty business. Lamb (1995, 1998) presents evidence that the stock prices significantly decline for insurers with more exposure in the affected region; therefore, we expect short sellers to be sophisticated by determining which stocks will most likely be affected by the hurricanes. Using the NAIC database, we obtain premiums written in each state and divide the amount of premiums in the Gulf states by the total amount of premiums. We also calculate a percentage of property–casualty premiums relative to total premiums.[10] We categorize stocks to be Gulf state stocks if the calculated percentage is greater than the sample median.

Table 6 presents an event study around the two hurricanes. Again, we use the short-volume ratio and short-activity ratio as our measures of short-selling activity. However, we distinguish between insurers that write more Gulf state premiums and insurers that write more non-Gulf state premiums. We then calculate the equally weighted difference between the measures of short selling. We initially hypothesize that the short-selling ratios for stocks with more relative Gulf state premiums to be higher than stocks with less relative Gulf state premiums around the hurricanes. Panel A contains the results around Katrina whereas Panel B contains the results around Rita. The table shows the opposite of our expectation. That is, short sellers do not distinguish between Gulf state and non-Gulf state insurers. In fact, we find in Panel A, that after Katrina, non-Gulf state ratios are significantly higher than Gulf state ratios. In Panel B, we would expect that in the days preceding the landfall of Rita, short sellers would short the Gulf states stocks more than the non-Gulf state stocks.[11] We do not

[9] The t-statistic for the estimate of β_8 tests whether or not the estimate is significantly greater than zero. Since the estimate for β_6 is negative, we do not need to perform a t-test to see that there is significantly more short selling in the prelandfall period of Rita than in the prelandfall period of Katrina.

[10] We would prefer to concentrate on net premiums written (direct premiums written – reinsurance ceded). However, the amount of reinsurance ceded by state in order to calculate net premiums written in the Gulf states and the non-Gulf states is not available to us.

[11] Another examination of the categories of each hurricane is important to note in Table 6. The intensity of both storms increased as the hurricanes approached landfall; however, the evidence suggests that short sellers are unable to distinguish between Gulf and non-Gulf stocks, a result inconsistent with our expectation.

TABLE 6
Event Study of Short Selling Around Hurricanes Katrina and Rita for Gulf and Non-Gulf States

	Gulf States		Non-Gulf States			
Event Time	Volume Ratio	Activity Ratio	Volume Ratio	Activity Ratio	Difference Volume Ratio	Difference Activity Ratio
Panel A: Short Selling Around Katrina for Gulf and Non-Gulf States						
−5	0.3093	0.3112	0.2931	0.3422	−0.0160	0.0311
					(−0.36)	(0.75)
−4	0.3171	0.3117	0.3340	0.3250	−0.0050	−0.0090
					(−0.11)	(−0.20)
−3	0.2878	0.3010	0.2834	0.3005	−0.0240	−0.0049
					(−0.61)	(−0.01)
−2	0.2775	0.2806	0.2898	0.3003	0.0031	0.0106
					(0.08)	(0.29)
−1	0.2849	0.3058	0.3156	0.3355	0.0308	0.0297
					(0.76)	(0.77)
Landfall						
+1	0.2557	0.2828	0.3137	0.3592	0.0580	0.0764*
					(1.36)	(1.85)
+2	0.2999	0.3151	0.3579	0.3716	0.0560	0.0565
					(1.16)	(1.24)
+3	0.2559	0.2885	0.3549	0.3746	0.0991**	0.0861*
					(2.07)	(1.91)
+4	0.2814	0.2924	0.3703	0.3915	0.0889*	0.0991**
					(1.94)	(2.39)
+5	0.2975	0.2874	0.3345	0.3541	0.0370	0.0668*
					(0.84)	(1.81)
Panel B: Short Selling Around Rita for Gulf and Non-Gulf States						
−5	0.3393	0.3482	0.3536	0.4092	0.0143	0.0610
					(0.32)	(1.44)
−4	0.3179	0.3429	0.3685	0.4004	0.0506	0.0575
					(1.25)	(1.58)
−3	0.3170	0.3649	0.3641	0.4028	0.0471	0.0379
					(1.26)	(1.08)
−2	0.3256	0.3019	0.3835	0.3583	−0.0240	−0.0250
					(−0.57)	(−0.62)
−1	0.3303	0.3726	0.3357	0.3727	0.0054	0.0001
					(0.13)	(0.00)
Landfall						
+1	0.2999	0.3231	0.3199	0.3245	0.0200	0.0013
					(0.49)	(0.03)
+2	0.3301	0.3491	0.3094	0.3491	−0.0210	0.0001
					(−0.50)	(0.00)
+3	0.3467	0.3607	0.3450	0.3737	−0.0020	0.0129
					(−0.04)	(0.34)

(continued)

TABLE 6
(Continued)

Event Time	Gulf States Volume Ratio	Gulf States Activity Ratio	Non-Gulf States Volume Ratio	Non-Gulf States Activity Ratio	Difference Volume Ratio	Difference Activity Ratio
+4	0.3476	0.3715	0.3722	0.4107	0.0246	0.0393
					(0.51)	(0.83)
+5	0.2999	0.3579	0.3151	0.3716	0.0580	0.0565
					(1.16)	(1.24)

Notes: The table reports differences in volume and activity measures for short selling between insurers classified as Gulf state insurers and Non-Gulf state insurers in event time. Panel A contains measures for Hurricane Katrina; Panel B contains measures for Hurricane Rita. The Short-Volume Ratio is calculated as short volume over total trading volume, and the Short-Activity Ratio is calculated as the number of shorts over the total number of trades. An insurer is classified as a Gulf state insurer if its ratio of direct premiums written in the Gulf states to direct premiums written in all other states is above the median ratio among all insurers in the sample. *t*-statistics are reported for each difference.
*Statistically significant at the 10% level.
**Statistically significant at the 5% level.

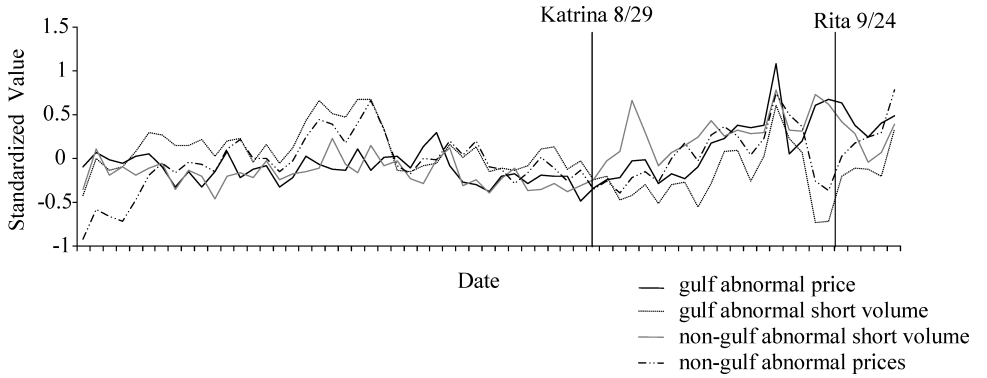
find evidence that short sellers distinguish between Gulf state and non-Gulf state stocks in the prelandfall period of Rita.

Figure 2 shows the time series for the standardized short volume and the standardized prices for both Gulf state and non-Gulf state stocks. We see that Gulf state stocks have a larger negative price adjustment than non-Gulf state stocks around Katrina but short sellers do not anticipate the price decrease in the prelandfall period. The significant increase in short-selling activity in the postlandfall period is for non-Gulf state stocks. The behavior of short sellers around Katrina is puzzling. We find little evidence supporting our conjecture that short sellers distinguish between Gulf state and non-Gulf state stocks, which is based on past theoretical and empirical research that suggests that short sellers are informed and sophisticated investors.

The prelandfall period for Rita is interesting. We find in the figure, that there is a significant increase in short volume for both Gulf state and non-Gulf state stocks in the prelandfall period. Subsequently, we see that prices adjust downward for both Gulf state and non-Gulf state stocks. It appears that short sellers anticipate the price declines as the short-selling activity is highest on the day when prices begin to decrease. Further, we see that when short sellers anticipate the declines, the price adjustment process occurs much faster in the prelandfall period. It is apparent in the figure that short sellers do not sufficiently distinguish between Gulf state and non-Gulf state stocks even though the price adjustment of the Gulf state stocks is greater than the price adjustment for the non-Gulf state stocks.

Next, we attempt to control for other potential factors that influence the level of short selling by using a similar regression as specified in Equation (1). We use pooled OLS to test our third and fourth hypotheses that posit that short sellers will be sophisticated in the stocks they choose to short in the prelandfall periods of Katrina and Rita. The

FIGURE 2
Short Selling and Prices for Gulf State and Non-Gulf State Insurers



Note: The figure shows the time series standardized values of short-sale activity and prices for July 1, 2005, to September 30, 2005, for the two subsamples. The Gulf state subsample consists of 36 stocks that have proportionately more business in the Gulf states, whereas the Non-Gulf subsample consists of 36 stocks that have proportionately less business in the Gulf states. The variables are standardized to have a zero mean and unit variance.

model is shown below:

$$\begin{aligned} \textit{Short Selling Measure}_{i,t} = {} & \beta_0 + \beta_1\, \textit{Price}_{i,t}^{-1} + \beta_2 \ln(\textit{Volume}_{i,t}) + \beta_3 \ln(\textit{Size}_{i,t}) \\ & + \beta_4\, \textit{Volatility}_{i,t} + \beta_5\, \textit{DAY}_i + \beta_6\, \textit{PreKatrina}_i + \beta_7\, \textit{PostKatrina}_i \\ & + \beta_8\, \textit{PreRita}_i + \beta_9\, \textit{PostRita}_i + \beta_{10}\, \textit{Gulf}_i + \beta_{11}\, \textit{Gulf}_i \times\ \textit{PreKat}_i \\ & + \beta_{12}\, \textit{Gulf}_i \times\ \textit{PostKatrina}_i + \beta_{13}\, \textit{Gulf}_i \times\ \textit{PreRita}_i \\ & + \beta_{14}\, \textit{Gulf}_i \times\ \textit{PostRita}_i + \varepsilon_{i,t}. \end{aligned} \tag{2}$$

The dependent variables are the abnormal short volume (same as in Equation (1)), the short-volume ratio, and the short-activity ratio. Because the ratio-dependent variables are constrained between 0 and 1, we use a Tobit model (unreported) in order to compensate for the censoring of the dependent variable.[12] Further, we do not regress the ratios on the natural log of volume because volume is already controlled for in the denominator of the dependent variable. The independent variables are the same as in Equation (1). *Gulf* is a dummy variable equal to unity if the percentage of business written in the Gulf Coast region relative to the total amount of business written in other states is greater than the sample median. The interaction terms compares the level of short selling of Gulf state stocks and non-Gulf state stocks around the landfall of the hurricane. For our third hypothesis to hold, we expect the estimate for β_{11} to be positive. A positive estimate for β_{11} suggests that short sellers distinguish between stocks that have more regional exposure and stocks that do not. For our fourth hypothesis to hold, we expect the estimate for β_{13} to be positive and significantly greater than the estimate for $\beta_{11,}$ which suggests that short sellers will

[12] The results are similar between the pooled OLS and the two-tailed Tobit; therefore, we only report the results from the pooled OLS model.

better distinguish between Gulf state insurers and non-Gulf state insurers in Rita's prelandfall period than in Katrina's prelandfall period because of learning from the effects of Katrina.

Table 7 reports the results from estimating Equation (2). We report the robust t-statistics as before. Similar to Table 5, we find that short selling is less for the 5-day time window prior to Katrina's landfall and higher for the 5-day time window prior to Rita's landfall after controlling for the upward trend in short activity. We do not find evidence that short sellers distinguish between insurers that write business in Gulf states around Katrina. In the 5-day window after Katrina, there is significantly less short selling in Gulf state stocks in all specifications. We also find that the estimates for β_{13} are negative and insignificant. Comparing the two estimates, we find, contrary to our prediction, that the estimate for β_{13} is less than the estimate for β_{11}. The results reported in Table 7 combined with the results from Table 6 and Figure 2 do not support our third and fourth hypotheses and instead suggest that short sellers are unsophisticated in choosing which stocks to short prior to the landfalls of Katrina and Rita.

To further test our third and fourth hypothesis, we look at the amount of property–casualty lines written in the Gulf states. As the hurricanes approach, the most widely affected insurers are likely to be the property–casualty insurers that write relatively more of their business in the Gulf Coast region.[13] The amount of incurred losses is likely to be higher for Gulf state property–casualty insurers than for any other insurers. Again, we calculate the percentage of Gulf state property–casualty premiums relative to non-Gulf state property–casualty premiums and similarly categorize stocks to be Gulf state property–casualty stocks as before. We anticipate that short sellers will distinguish between firms with more relative Gulf state property–casualty premiums and firms with less.

Table 8 reports the results of an event study around the landfall of Katrina (Panel A) and the landfall of Rita (Panel B). Similar to Table 6, we separate stocks by the amount of Gulf state and non-Gulf state business. However, in Table 8 we focus on firms that write the majority of their business in property–casualty lines. The ratio measures are reported along with the differences between the ratios for Gulf states and non-Gulf states. Consistent with Table 6, we do not find evidence that short sellers distinguish between insurers that write property–casualty business in Gulf states and insurers that do not. In the days prior to the landfall of Katrina (Panel A), we find that the ratios are greater for the Gulf state stocks than for the non-Gulf state stocks but the difference is not statistically significant. The results in Panel B are also consistent with Table 6.[14] In general, we do not find evidence that short sellers distinguish between the type of business written in the Gulf states.

[13] The state level data are the finest level data in which we can determine direct premiums written.

[14] Again, we note that as the intensity of the storm increase (as landfall approaches), we do not find that short sellers are able to distinguish between stocks that will be most affected by the hurricanes. It appears that short sellers are unsophisticated in their ability to determine which insurance stocks have the most property–casualty exposure in the Gulf.

TABLE 7
Regression of Short Selling Measures

	Standardized Short Volume			Volume Ratio			Activity Ratio		
Intercept	0.6149***	0.5979***	0.6045***	0.1239***	0.1210***	0.1238***	−0.0352	−0.0413	−0.0376
	(2.80)	(2.68)	(2.75)	(2.82)	(2.75)	(2.82)	(−0.85)	(−1.00)	(−0.91)
$Price^{-1}$	−2.8809***	−2.9552***	−2.8813***	0.2130	0.2118	0.2102	0.5764***	0.5766***	0.5747***
	(−4.54)	(−4.63)	(−4.55)	(1.44)	(1.43)	(1.42)	(3.89)	(3.89)	(3.88)
ln(*Volume*)	0.2679***	0.2746***	0.2673***						
	(16.44)	(16.79)	(16.45)						
ln(*Size*)	−0.2728***	−0.2797***	−0.2723***	0.0110***	0.0110***	0.0110***	0.0235***	0.0235***	0.0234***
	(−12.77)	(−13.04)	(−12.78)	(4.23)	(4.22)	(4.22)	(9.61)	(9.58)	(9.58)
Volatility	0.0874***	0.0896***	0.0872***	−0.0039*	−0.0039	−0.0039*	−0.0057***	−0.0057**	−0.0057***
	(7.43)	(7.61)	(7.42)	(−1.66)	(−1.63)	(−1.65)	(−2.66)	(−2.62)	(−2.65)
DAY	0.0069***	0.0079***	0.0072***	0.0006***	0.0006***	0.0005**	0.0006***	0.0007***	0.0006***
	(7.68)	(8.70)	(6.27)	(3.75)	(3.63)	(2.34)	(3.62)	(4.44)	(3.01)
PreKatrina	−0.2850***		−0.2865***	−0.0197		−0.0134	−0.0288**		−0.0266*
	(−5.31)		(−5.08)	(−1.28)		(−0.85)	(−1.97)		(−1.79)
PostKatrina		−0.0768	0.0807		0.0337**	0.0368**		0.0180	0.0200
		(1.03)	(1.04)		(2.05)	(2.18)		(1.19)	(1.29)
PreRita	0.2082**		0.2015**	0.0191		0.0281*	0.0277**		0.0294**
	(2.51)		(2.25)	(1.32)		(1.80)	(2.14)		(2.12)
PostRita		−0.0989	−0.0809		0.0152	0.0208		0.0013	0.0055
		(−1.12)	(−0.86)		(0.94)	(1.20)		(0.08)	(0.33)
Gulf	0.0011	0.0159	0.0201	−0.0107*	−0.0052	−0.0035	−0.0219***	−0.0168***	−0.0155**
	(0.004)	(0.54)	(0.61)	(−1.75)	(−0.86)	(−0.54)	(−3.75)	(−2.90)	(−2.41)
Gulf × *PreKatrina*	0.0032		−0.0158	0.0085		0.0013	0.0060		−0.0003
	(0.04)		(−0.20)	(0.43)		(0.07)	(0.32)		(−0.02)
Gulf × *PostKatrina*		−0.3441***	−0.3491***		−0.0669***	−0.0685***		−0.0636***	−0.0650***
		(−3.65)	(−3.67)		(−3.13)	(−3.18)		(−3.32)	(−3.35)

(continued)

TABLE 7
(Continued)

	Standardized Short Volume			Volume Ratio			Activity Ratio		
Gulf × *PreRita*	−0.0094		−0.0286	−0.0118		−0.0189	−0.0074		−0.0137
	(−0.08)		(−0.25)	(−0.61)		(−0.96)	(−0.42)		(−0.77)
Gulf × *PostRita*		0.1863	0.1822		−0.0071	−0.0088		−0.0027	−0.0040
		(1.43)	(1.39)		(−0.33)	(−0.40)		(−0.13)	(−0.19)
Adjusted R^2	0.1395	0.1334	0.1430	0.0133	0.0149	0.0149	0.0403	0.0400	0.0433

Notes: The table reports the results of a pooled OLS where the dependent variables are equal to abnormal short volume, the short-volume ratio and the short-activity ratio defined in the text. The model is given below:

$$\begin{aligned} \textit{Short Selling Measure}_{i,t} &= \beta_0 + \beta_1\, \textit{Price}_{i,t}^{-1} + \beta_2 \ln(\textit{Volume}_{i,t}) + \beta_3 \ln(\textit{Size}_{i,t}) + \beta_4\, \textit{Volatility}_{i,t} + \beta_5\, \textit{DAY}_i + \beta_6\, \textit{PreKatrina}_i + \beta_7\, \textit{PostKatrina}_i \\ &\quad + \beta_8\, \textit{PreRita}_i + \beta_9\, \textit{PostRita}_i + \beta_{10}\, \textit{Gulf}_i + \beta_{11}\, \textit{Gulf}_i \times\ \textit{PreKat}_i + \beta_{12}\, \textit{Gulf}_i \times \textit{PostKat}_i + \beta_{13}\, \textit{Gulf}_i \times \textit{PreRita}_i \\ &\quad + \beta_{14} \textit{Gulf}_i \times \textit{PostRita}_i + \varepsilon_{i,t}. \end{aligned}$$

The independent variables are the inverse of the price of stock i on day t, the log of daily volume, the log of daily capitalization for, and the daily volatility for stock i, which is measured as the standard deviation of the daily high price less the daily low price. *DAY* is a discrete variable numbered 1–64 for each trading day in the time period. Further, *PreKatrina* and *PostKatrina* are dummy variables equal to unity for the 5-day window before and after landfall of Katrina, respectively. Similarly *PreRita* and *PostRita* are dummy variables equal to unity for the 5-day window before and after landfall of Rita. *Gulf* is a dummy variable equal to unity if the percentage of business written in the Gulf states relative to the total amount of business written is greater than the median. The robust t-statistics are reported in parentheses.

*Statistically significant at the 10% level.

**Statistically significant at the 5% level.

***Statistically significant at the 1% level.

TABLE 8
Event Study of Short Selling Around Hurricanes Katrina and Rita for Property–Casualty Insurers in Gulf and Non-Gulf States

	Gulf States		Non-Gulf States			
Event Time	Volume Ratio	Activity Ratio	Volume Ratio	Activity Ratio	Difference Volume Ratio	Difference Activity Ratio
Panel A: Short Selling Around Katrina for P-C Insurers in Gulf and Non-Gulf States						
−5	0.3311	0.3417	0.2789	0.3207	−0.0520	−0.0210
					(−1.15)	(−0.51)
−4	0.3426	0.3487	0.2956	0.3197	−0.0470	−0.0290
					(−0.99)	(−0.67)
−3	0.2752	0.2958	0.2768	0.3083	0.0016	0.0125
					(0.04)	(0.29)
−2	0.2958	0.3082	0.2694	0.2884	−0.0260	−0.0200
					(−0.67)	(−0.53)
−1	0.3153	0.3245	0.2919	0.3221	−0.0230	−0.0020
					(−0.57)	(−0.06)
Landfall						
+1	0.2804	0.3061	0.2954	0.3413	0.0150	0.0353
					(0.34)	(0.82)
+2	0.3395	0.3357	0.3287	0.3604	−0.0110	0.0247
					(−0.22)	(0.54)
+3	0.2797	0.2996	0.3423	0.3745	0.0626	0.0749*
					(1.29)	(1.67)
+4	0.3390	0.3348	0.3246	0.3611	−0.0140	0.0263
					(−0.31)	(0.62)
+5	0.3037	0.3105	0.3193	0.3276	0.0156	0.0171
					(0.36)	(0.45)
Panel B: Short Selling Around Rita for P-C Insurers in Gulf and Non-Gulf States						
−5	0.3585	0.3737	0.3445	0.3950	−0.0140	0.0212
					(−0.32)	(0.50)
−4	0.3229	0.3535	0.3722	0.3987	0.0493	0.0452
					(1.22)	(1.24)
−3	0.3298	0.3515	0.3515	0.3690	0.0218	0.0294
					(0.57)	(0.82)
−2	0.3145	0.3723	0.3210	0.3791	0.0065	0.0068
					(0.16)	(0.17)
−1	0.3271	0.3797	0.3364	0.3639	0.0093	−0.0160
					(0.22)	(−0.43)
Landfall						
+1	0.3279	0.3404	0.2979	0.3129	−0.0300	−0.0270
					(−0.73)	(−0.71)
+2	0.3339	0.3548	0.3122	0.3500	−0.0220	−0.0050
					(−0.52)	(−0.12)
+3	0.3478	0.3645	0.3535	0.3804	0.0057	0.0159
					(0.15)	(0.43)

(continued)

TABLE 8
(Continued)

Event Time	Gulf States Volume Ratio	Gulf States Activity Ratio	Non-Gulf States Volume Ratio	Non-Gulf States Activity Ratio	Difference Volume Ratio	Difference Activity Ratio
+4	0.3877	0.3996	0.3436	0.3948	−0.0440	−0.0050
					(−0.93)	(−0.10)
+5	0.3395	0.3357	0.3287	0.3604	−0.0110	0.0247
					(−0.22)	(0.54)

Notes: The table reports differences in volume and activity measures for short selling between insurers classified as Gulf state insurers and Non-Gulf state insurers in event time, for insurers that only write insurance in property–casualty lines. Panel A contains measures for Hurricane Katrina; Panel B contains measures for Hurricane Rita. The Short-Volume Ratio is calculated as short volume over total trading volume, and the Short-Activity Ratio is calculated as the number of shorts over the total number of trades. An insurer is classified as a Gulf state insurer if its ratio of direct premiums written in the Gulf states to direct premiums written in all other states is above the median ratio among all insurers in the sample. *t*-statistics are reported for each difference.
*Statistically significant at the 10% level.

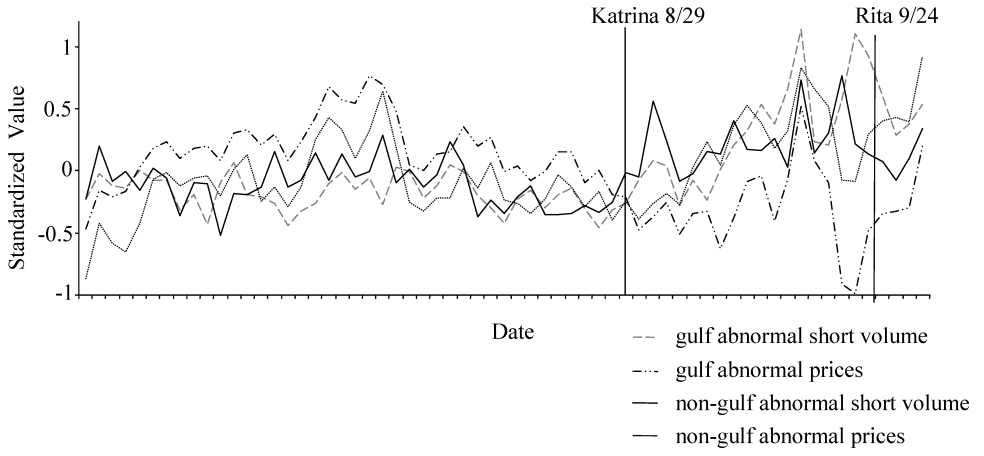
We find in Figure 3 that the price decrease for Gulf state property–casualty insurers is greatest around Katrina, yet we find insignificant short-selling activity in the prelandfall period. In the prelandfall period for Rita, it is apparent that prices for Gulf state property–casualty insurers are most affected. We do see evidence that short sellers anticipate the price adjustment, but consistent with the earlier tables, they do not sufficiently distinguish between Gulf and non-Gulf state property–casualty insurers.

Finally, we examine property–casualty insurers that write in the Gulf states. Similar to Equation (2), we estimate the following model using pooled OLS.

$$\begin{aligned} \textit{Short Selling Measure}_{j,t} = {} & \beta_0 + \beta_1 \textit{Price}_{j,t}^{-1} + \beta_2 \ln(\textit{Volume}_{j,t}) + \beta_3 \ln(\textit{Size}_{j,t}) \\ & + \beta_4 \textit{Volatility}_{j,t} + \beta_5 \textit{DAY}_i + \beta_6 \textit{PreKatrina}_j + \beta_7 \textit{PostKatrina}_j \\ & + \beta_8 \textit{PreRita}_j + \beta_9 \textit{PostRita}_j + \beta_{10} \textit{Gulf}_j + \beta_{11} \textit{Gulf}_j \times \textit{PreKat}_j \\ & + \beta_{12} \textit{Gulf}_j \times \textit{PostKat}_j + \beta_{13} \textit{Gulf}_j \times \textit{PreRita}_j \\ & + \beta_{14} \textit{Gulf}_j \times \textit{PostRita}_j + \varepsilon_{j,t}. \end{aligned} \tag{3}$$

The dependent and independent variables are the same as in Equation (2). However, the dependent variables for stock j in time t are for stocks where the underlying insurers write relatively more property–casualty business. That is, we only estimate Equation (3) for stocks that write more property–casualty business than the sample median. As before, we expect a positive estimate for β_{11}, which suggests that short sellers will determine which stocks have more regional exposure to Katrina in the prelandfall period. We expect that if short sellers learn from the affects of Katrina, then the estimate for β_{13} should be significantly positive and significantly greater than β_{11}.

FIGURE 3
Short Selling and Prices for Gulf and Non-Gulf Property-Casualty Insurers



Note: The figure shows the time series standardized values of short-sale activity and prices for July 1, 2005, to September 30, 2005, for the two subsamples. The Gulf state subsample consists of 36 stocks that have proportionately more *property–casualty* business in the Gulf states, whereas the Non-Gulf subsample consists of 36 stocks that have proportionately less *property–casualty* business in the Gulf states. The variables are standardized to have a zero mean and unit variance.

Table 9 reports the results from regressing Equation (3). We still find evidence that short sellers learn from Katrina, as short selling is greater in the 5-day time window before the landfall of Rita in all specifications after controlling for the upward trend in short selling. We find strong evidence against our expectation that short sellers distinguish between property–casualty insurers that write relatively more Gulf state business and property–casualty insurers that write relatively less Gulf state business. The interaction between the 5-day window before Katrina and the Gulf dummy variable is significantly negative in columns 1 and 3. We also find a significant negative estimate for the interaction of the 5-day window before Rita and the Gulf dummy in columns 1, 3, and 6. The estimate for β_{13} is more negative than the estimate for β_{11} in columns 1, 3, 4, and 6. There is little evidence that short sellers distinguish between insurers that write property–casualty business in the Gulf states and insurers that write in non-Gulf states. Further, we do not find evidence that short sellers become more sophisticated around Rita after learning from the effects of Katrina.

In summary, Tables 8 and 9 and Figure 3 are consistent with earlier tables and figures and suggest that short sellers may have learned from the effects of Katrina, but they do not distinguish between insurers that write (property–casualty) business in the Gulf Coast region and insurers that write other business elsewhere. The result supports the interpretation that the learning of short sellers from Katrina can be classified as adaptive rather than optimizing. Routledge (1999) suggests that adaptive learning is unsophisticated learning, or, in other words, learning that is imitative rather than optimizing. In the case of Hurricanes Katrina and Rita, we find that short sellers learn adaptively and attempt to profit on the affects of Rita by shorting insurance companies

TABLE 9
Regression of Property–Casualty Stocks

	Standardized Short Volume			Volume Ratio			Activity Ratio		
Intercept	0.9064**	0.9797**	0.8820**	−0.0913	−0.0921	−0.0956	−0.3030****	−0.3080***	−0.3064***
	(2.52)	(2.63)	(2.43)	(−1.19)	(−1.20)	(−1.25)	(−4.68)	(−4.74)	(−4.72)
$Price^{-1}$	−3.5089***	−3.6543***	−3.5008***	1.7298***	1.7318***	1.7276***	2.3868***	2.3883***	2.3859***
	(−3.27)	(−3.37)	(−3.27)	(8.86)	(8.90)	(8.93)	(13.16)	(13.13)	(13.21)
ln(*Volume*)	0.2200***	0.2312***	0.2190***						
	(11.83)	(11.92)	(11.79)						
ln(*Size*)	−0.2640***	−0.2774***	−0.2629***	0.0229***	0.0229***	0.0228***	0.0381***	0.0381***	0.0381***
	(−8.62)	(−8.75)	(−8.55)	(4.78)	(4.77)	(4.78)	(9.48)	(9.41)	(9.43)
Volatility	0.0465*	0.0493*	0.0463*	−0.0109***	−0.0109***	−0.0109***	−0.0061*	−0.0061*	−0.0061*
	(1.84)	(1.93)	(1.85)	(−2.84)	(−2.86)	(−2.87)	(−1.69)	(−1.68)	(−1.70)
DAY	0.0096***	0.0111***	0.0098***	0.0005*	0.0004	0.0002	0.0004*	0.0005**	0.0002
	(7.47)	(8.31)	(5.90)	(1.92)	(1.50)	(0.70)	(1.67)	(2.25)	(1.13)
PreKatrina	−0.0701		−0.0604	0.0173		0.0321	−0.0026		0.0035
	(−0.60)		(−0.50)	(0.54)		(0.98)	(−0.09)		(0.13)
PostKatrina		−0.0128	0.0749		0.0910**	0.1017***		0.0479*	0.0544*
		(−0.08)	(0.46)		(2.56)	(2.82)		(1.68)	(1.88)
PreRita	0.7883***		0.7941***	0.0404		0.0600**	0.0306		0.0380*
	(3.74)		(3.66)	(1.40)		(2.01)	(1.40)		(1.66)
PostRita		−0.0456	0.0749		0.0247	0.0383		−0.0036	0.0063
		(−0.29)	(0.46)		(0.69)	(1.04)		(−0.12)	(0.21)
Gulf	0.1538***	0.1004*	0.1893***	−0.0041	0.0002	0.0089	−0.0195**	−0.0151*	−0.0115
	(3.10)	(1.98)	(3.53)	(−0.42)	(0.02)	(0.89)	(−2.27)	(−1.80)	(−1.26)
Gulf × *PreKatrina*	−0.2777**		−0.3133**	−0.0249		−0.0379	−0.0141		−0.0220
	(−2.12)		(−2.36)	(−0.70)		(−1.07)	(−0.45)		(−0.71)
Gulf × *PostKatrina*		−0.2976*	−0.3906**		−0.1253	−0.1340***		−0.0946***	−0.0982***
		(−1.70)	(−2.23)		(−3.19)	(−3.39)		(−2.97)	(−3.06)

(continued)

TABLE 9
(Continued)

	Standardized Short Volume			Volume Ratio			Activity Ratio		
Gulf × *PreRita*	−0.6513***		−0.6879***	−0.0434		−0.0564*	−0.0081		−0.0161
	(−2.86)		(−3.01)	(−1.37)		(−1.76)	(−0.32)		(−0.63)
Gulf × *PostRita*		0.1106	0.0116		0.0036	−0.0052		0.0205	0.0170
		(0.60)	(0.06)		(0.09)	(−0.13)		(0.61)	(0.50)
Adjusted R^2	0.1593	0.1465	0.1656	0.0576	0.0641	0.0661	0.1109	0.1152	0.1175

Notes: The table reports the results of a pooled OLS where the dependent variables are equal to abnormal short volume, the short-volume ratio and the short-activity ratio defined in the text. The model is only estimated for the *j* stocks with the percentage of property–casualty business written relative to total business written greater than the sample median. The model is given below:

$$\begin{aligned} \textit{Short Selling Measure}_{j,t} = {} & \beta_0 + \beta_1 \textit{Price}_{j,t}^{-1} + \beta_2 \ln(\textit{Volume}_{j,t}) + \beta_3 \ln(\textit{Size}_{j,t}) + \beta_4 \textit{Volatility}_{j,t} + \beta_5 \textit{DAY}_i + \beta_6 \textit{PreKatrina}_j + \beta_7 \textit{PostKatrina}_j + \beta_8 \textit{PreRita}_j \\ & + \beta_9 \textit{PostRita}_j + \beta_{10} \textit{Gulf}_j + \beta_{11} \textit{Gulf}_j \times \textit{PreKat}_j + \beta_{12} \textit{Gulf}_j \times \textit{PostKat}_j + \beta_{13} \textit{Gulf}_j \times \textit{PreRita}_j + \beta_{14} \textit{Gulf}_j \times \textit{PostRita}_j + \varepsilon_{j,t}. \end{aligned}$$

The independent variables are the inverse of the price of stock *i* on day *t*, the log of daily volume, the log of daily capitalization for, and the daily volatility for stock *i*, which is measured as the standard deviation of the daily high price less the daily low price. *DAY* is a discrete variable numbered 1–64 for each trading day, and *PreKatrina* and *PostKatrina* are dummy variables equal to unity for the 5-day window before and after landfall of Katrina, respectively. Similarly *PreRita* and *PostRita* are dummy variables equal to unity for the 5-day window before and after landfall of Rita. *Gulf* is a dummy variable equal to unity if the percentage of business written in the Gulf states relative to the total amount of business written is greater than the median. The robust *t*-statistics are reported in parentheses.

*Statistically significant at the 10% level.

**Statistically significant at the 5% level.

***Statistically significant at the 1% level.

in general rather than distinguishing between insurers that will most likely be affected in terms of incurred losses.

CONCLUSION

The effect of catastrophe on insurer's stock prices is widely cited (Sprecher and Pearl, 1983; Davidson, Chandy, and Cross, 1987; Shelor, Anderson, and Cross, 1990; Aiuppa, Carney, and Krueger, 1993). In general, the empirical evidence suggests that insurers stock prices decline in response to the loss effect of hurricanes, particularly for insurers with more regional exposure (e.g., Lamb, 1995, 1998). There is also evidence that prior to landfall, stock prices begin to decline as the expectation of losses, due to the hurricane, is embedded into the price of the stock (e.g., Ewing, Hein, and Kruse, 2006). We find evidence, consistent with past research, that prices reflect the expectation of damages in the prelandfall period of Katrina and Rita as insurance stock prices begin to decline in the week prior to each hurricane.

In a separate stream of literature, Diamond and Verrecchia (1987) hypothesize that short sellers will predict negative returns. An interesting approach to testing the informativeness of short sellers is to examine their behavior around hurricanes, specifically, in the prelandfall period, prior to the decrease in insurer's stock prices. Further, the 2005 hurricane season provides an additional opportunity to investigate the learning behavior of short sellers, as Rita made landfall 27 days after Katrina in the same geographical vicinity of the United States. We argue that the level of sophistication of short sellers will increase from Katrina to Rita because of potential learning from the effects of Katrina. Because of learning, short sellers will be able to better determine which insurance stocks will most likely be affected by Rita because of the effects of Katrina. We test several hypotheses regarding the sophistication of short sellers of insurance stocks around Katrina and Rita. Contrary to our expectation, we do not find evidence that short selling of insurance stocks significantly increases in the days prior to the landfall of Katrina even though prices begin to decrease in the week prior to landfall. We do find evidence that short selling significantly increases 2 to 3 trading days after Katrina makes landfall.

Additionally, we find that the level of short selling significantly increases before the landfall of Rita. We report that short sellers predict the price decrease before Rita as short selling is highest on the day prices begin to decline in the prelandfall period. Our interpretation of these findings is that short sellers learn from Katrina and attempt to profit from stock price decreases as Rita approaches.

Further, we find that short sellers do not distinguish between insurance stocks that write property–casualty business in the Gulf states and insurance stocks that do not write in the Gulf states, nor do we find that their level of sophistication increases after getting an opportunity to learn from the earlier effects of Katrina. In the days prior to landfall, as the intensity of the storms increases, short sellers do not appear to distinguish between stocks that have the most Gulf Coast region exposure and stocks that do not. Consistent with the theoretical models regarding adaptive learning (e.g., Routledge, 1999), we find that short sellers are generally unsophisticated about which stocks will be most affected by the hurricanes due to regional exposure and type of business written by the underlying insurers. We suggest that short sellers around Katrina and Rita adaptively acquire information from Katrina and unsophisticatedly

attempt to profit on the potential of further insurance stock price declines as Rita approaches.

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