

**News Media as a Channel of Environmental Information Disclosure:
Evidence from an EGARCH Approach**

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Abstract

This paper incorporates EGARCH modeling in a financial event study relating firm value to negative environmental news. News media provide informal information channels unlike formal government disclosure programs. This paper improves on previous studies by using a larger sample than most studies, treating heteroskedasticity in the disturbance term with a hybrid method that allows EGARCH, and comparing stock market reactions across industries and event types. Both standard and hybrid methods reveal reductions in firms' stock market valuations by on average 1.2% in response to negative environmental events. Significant negative market reactions to environmental news arise for all industry groups and event types analyzed. Accidents and complaints yield 2.0% mean reductions in stock market value, versus later lawsuits and court decisions with 1.5% and 0.8% reductions respectively. Firms in traditional polluting industries are most affected. These stock market impacts suggest that informal environmental information channels may financially incentivize firms' self-regulation.

JEL codes: Q50; G14

Key words: environmental information disclosure; news media; event study; EGARCH; industry effects; event types.

1. Introduction

Policymakers have increasingly used information programs to help solve environmental problems caused by anthropogenic pollutants such as toxic chemicals and greenhouse gases. The use of information is an effort to decentralize environmental policy and to reduce the costs of conventional environmental regulation, which has mounted to \$26.6 million in 2005 [51]. One example of an information program is the U.S. EPA's Toxics Release Inventory (TRI) that provides mandated public access data collected from industrial and federal facilities. Another example is U.S. state-level mandatory disclosure of green power options. Under this rule, electricity utilities in some states are required to inform customers of options to purchase electricity generated from clean and renewable fuel resources. By design, information disclosure programs aim to create two kinds of benefits [16]: the direct benefits from disclosing the previously private information, and the indirect benefits from informing and mobilizing the communities surrounding firms' business operations, namely stakeholders (i.e., shareholders, consumers, suppliers, employees, etc.), so that firms have incentives to self-regulate their polluting behavior.

While tremendous research efforts have been engaged in evaluating the effectiveness and incentive mechanisms behind various mandatory environmental information programs [4, 12, 13, 24, 29, 31, 34, 35], much less attention has been paid to examining other information disclosure channels than those administered by government. News media, for example, serve as one of the information channels that may work in parallel with government administered information programs, in terms of getting stakeholders involved and providing external incentives to firms to change their environmental behavior. Moreover, news media differ from mandatory disclosure as a channel of information in at least two respects: first, media provide the general public with

easier access to pollution information, without having to be knowledgeable about how to access and analyze the data; second, once the information is treated as news by media, it can be followed up and updated more frequently than in mandatory programs. While mandatory programs are typically updated annually or monthly, environmental news can disseminate through newspapers, newswires, and websites on a continuous basis. However, relatively few studies have examined the effects of environmental news on firms' financial performance and environmental behavior.

A limited number of studies have assessed whether news media provide financial incentives for firms to self-regulate by testing stock market reactions to environmental news. With stock markets that work reasonably well to process new information and incorporate it into the stock price, it is possible to use a financial event study to analyze market reactions to firm-specific environmental events. This method allows researchers to analyze the immediate impact of events on firms' stock market performance; however, empirical work provides somewhat mixed evidence. On the one hand, a small group of studies found negative (positive) market reaction in response to negative (positive) environmental events. For example, Klassen and McLaughlin [30] found stock returns decrease if a firm experiences an environmental crisis (e.g., an oil spill or chemical leak) and increase if the firm receives an environmental award. Muoghalu *et al.* [43] found a negative reaction to announcements of lawsuits against firms violating the U.S. Resource Conservation and Recovery Act. Similarly, LaPlante and Lanoie [33] observed a negative market reaction to court settlements of environmental violations in Canada. Hamilton [24] found a negative response to the publication of poor figures in the U.S. Toxic Release Inventory. Along this line of investigation, Dasgupta *et al.* [11] reported the same sign of market reaction to environmental news in developing countries, Argentina, Chile, Mexico, and the Philippines.

Finally, Capelle-Blancard and Laguna [7] studied the market reaction to chemical disasters across the world and also found a significant negative market reaction.

On the other hand, though fewer in number, some other studies have found either neutral or negative (positive) stock market reaction to positive (negative) corporate environmental news. For example, Takeda and Tomozawa [47] found no overall market response to the annual release of environmental performance rankings published in Japanese newspapers during 1998-2005. However, companies that were upgraded in the annual ranking saw a significant decline in their stock prices and *vice versa*. The authors followed up this study by expanding the sample to cover 100 companies [48]. Again, they found no significant impact overall, but this time they found that all firms gained after the release of the ranking in the years 2003-2005 whether they were upgraded or downgraded. Prior to 2003 upgraded firms mostly lost value and downgraded firms gained. John and Rubin [28] also found no reaction to negative environmental events. Filbeck and Gorman [21] found consistently significant positive market outcomes in reaction to news of environmental awards, but did not find consistent significant outcomes for other types of environmental news.

Three issues arise in thinking about the inconsistencies in the empirical results. First, all the above studies use a standard OLS-based market model to conduct their event studies. While the OLS model assumes constant variance in disturbance, in reality heteroskedasticity in disturbances and volatility clustering are widely present in stock price data. It has been much debated which normal return model [6, 19, 20, 38] is more appropriate for predicting the mean and the variance of the return series. Yet the majority of the debate has been focused on the choice of the mean equation (i.e., possible candidates include the constant mean return model, market model, multifactor model, Capital Asset Pricing Model, etc.), whereas very little attention

has been paid to the variance equation. Questioning the validity of using OLS-based models in event studies, Yamaguchi [50] followed up on the work of Takeda and Tomozawa [47], by replacing their OLS model with an Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model. The author found that the relationship between the published environmental ranking and stock return became significantly positive. Along this line, a similar GARCH application had been used previously in testing stock market reaction to food recalls [49]. While one possible drawback of both Takeda and Tomozawa [47] and Yamaguchi [50] is that they used annual ranking data, which by nature may contain a lot of noise, the evidence from Yamaguchi [50] suggests that it is necessary to consider the biases that could be introduced by ignoring heteroskedasticity. In this study, we apply the EGARCH approach to data on actual environmental events rather than the annual rankings used by Yamaguchi [50] and compare the results of an OLS/EGARCH hybrid method with those of the standard method.

Second is the simple issue of sampling variability. Studies with larger sample sizes will tend to more accurately estimate the parameter or statistic of interest. Klassen and McLaughlin [30] used a sample of 22 events (16 firms). Takeda and Tomozawa [47] used a sample of 30 firms, although they covered a period of 8 annual data releases. Laplante and Lanoie [33] used a sample of 47 events. Capelle-Blancard and Laguna [7] used a sample of 64 events. Dasgupta *et al.* [11] used a sample of 87 negative and 39 positive events. Muoghalu *et al.* [43] used a sample of 128 suits filed and 74 settlement events. There is, therefore, a need for more and larger event studies. Our study has 388 environmental events, which is a relatively large sample in this field.

Third are problems of confounding events and sample construction. It is almost inevitable that some events in the sample will be “contaminated” with confounding effects from potentially influential events other than the event of interest during the event window. The main

method to control for confounding effects is to eliminate cases with confounding events [22]. McWilliams and Siegel [41] pointed out that some event studies do not properly eliminate or simply ignore confounding events, because eliminating all confounding effects may reduce the sample size too much. The authors showed that such a research design can bias the results and they suggest using shorter windows as the remedy to limit the number of confounding events. Their suggestion is partially based upon the Efficient Market Hypothesis (EMH), which states that information is incorporated into stock prices immediately. Accepting EMH implies that information is absorbed quickly, so the event window should be kept short. However, since 1970, EMH has been seriously challenged in the finance literature. On the basis of numerous empirical findings, many have come to believe that stock prices are at least partially predictable [2, 3, 8, 9, 20, 23, 25, 26, 28, 32, 36, 37, 45]. As the validity of EMH has become an issue of debate, using exceedingly short windows appears questionable. Long windows, however, require most events to be eliminated due to confounding effects. In this study we use a fairly long 5-day window. This length of window results in an acceptable 35% loss of events due to confounding effects, and seems plentiful to allow the market to adjust in response to news.

The present paper contributes to the literature by addressing the above issues. Ignoring these issues may conceal the nature of stock markets' reaction to corporate environmental events and compromise our understanding about the short-run incentive for firms to adopt environmental strategies. Our analysis extends prior studies related to the news media's function as a channel of environmental information in two directions. First, unlike previous papers using standard event study market models, we propose a novel hybrid method combining EGARCH with OLS, which will be explained in detail in the next section. Second, in order to generate a large sample and deal with confounding events, we collect environmental events (601 events of which 388 are free

of confounding effects) and stock returns data (79,540 observations) over a 25-year period from 1982-2007. To the best of our knowledge, the sample period is the most up-to-date and is longer than in any existing study.¹ Hence it provides a much more comprehensive picture of the stock market reaction to environmental news. Third, in addition to dividing the environmental events into four types (48 accidents, 69 complaints, 45 lawsuits, and 226 lawsuit settlements) and examining the reaction to each type of event, we examine market reactions in different industries (petroleum refining; chemicals; transportation equipment; electric, gas, and sanitary services; and others). These further analyses reveal how the event type and industry affect market reactions to environmental events.

The main finding of this paper is that the standard and hybrid method are consistent in finding negative market reactions to negative environmental events. Contrary to Yamaguchi [50], we find that the standard method is quite robust even with autoregressive conditional heteroskedasticity present. When examining different types of events and groups of industries, we find highly significant negative market reactions to environmental news in all types of events and industry groups analyzed. These result in 0.7% to 2.0% average reductions in firms' stock market valuations, depending on the type of event and the industry. Overall, the results suggest that environmental information released from an informal channel, like the news media, is associated with some combination of substantial costs to the firms and harmful publicity. Since stock market valuations often affect both firms' cost of new capital and managers' personal portfolio gains, this suggests that environmental news releases may provide substantial financial incentives for firms to self-regulate. Additionally, we create rankings of return reductions

¹ For example, the periods covered by various studies are as follows: Dasgupta *et al.* [11] 1990-1994, Klassen and McLaughlin [30] 1989-1990, Laplante and Lanoie [36] 1982-1991, Muoghalu *et al.* [47] 1977-1986, Hamilton [25] 1989, Capelle-Blancard and Laguna [7] 1990-2005, Takeda and Tomozawa [47, 48] and Yamaguchi [50] 1998-2005.

amongst different event types, and amongst different industries. Accidents and complaints are often the first news topics for environmental incidents and are associated with 2.0% estimated mean reductions in stock market value, whereas lawsuits are associated with 1.5% reductions and court rulings and fines with 0.8% reductions. Transportation equipment and petroleum refining firms experience mean reductions in value of near 2.0%, versus 1.6% in chemicals firms, 0.8% in electric, gas, and sanitary services firms, and 0.7% in other firms.

The rest of the paper is structured as follows. In the next section, we review the standard procedures of event studies, and then describe the hybrid method that allows for autoregressive conditional heteroskedasticity. In section three, we explain the sample construction and describe the data. Finally we present the results in section four, and concluding remarks in section five.

2. Method

Event studies originated in finance and accounting research to measure the impact of a corporate event on a firm's market valuation. Fama *et al.* [17] conducted a seminal study to examine the impact of stock splits and introduce the event study methodology in a form close to the standard method used today. In the following years, modifications were made to accommodate practical complications, such as the choice of normal return model [6], window size [40], and window clustering [10, 46]. In this section, we will review the standard event study method, and then introduce the hybrid method.

2.1. Standard Event Study Method

An event study begins with identifying the event day t_0 , which is the initial announcement day of the event of interest. This is followed by setting the event window (t_1, t_2) , over which a firm's stock return will be examined, and the estimation window (t_{1-L}, t_{1-1}) , over which the historical daily stock returns can be collected and the model parameters can be estimated. The

size of the event window is $t_2 - t_1$, and that of the estimation window is L . Figure 1 illustrates the time frame. If the event occurred on Day 0, the 5-day event window would be from Day -2 to Day 2, and the estimation period of 200 days would be from Day -202 to Day -3. The event study method is explained in detail in MacKinlay [38].

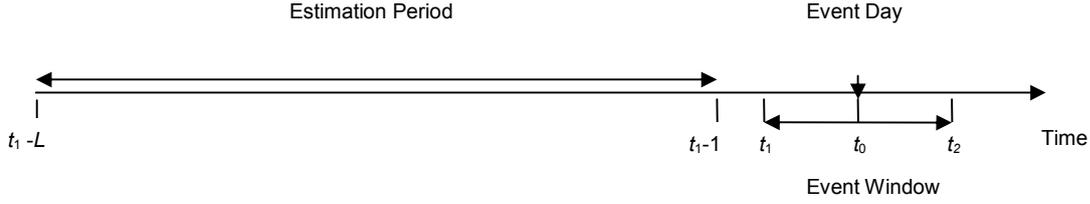


Figure 1. Time Frame for Event Study

The second step of the event study is to predict the normal return. Though there are many models to choose from, the most commonly used model is the market model [38]. The market model is essentially a linear regression model relating R_{it} , which is the return of any given firm i 's stock at time t , to R_{mt} , which is the return of the market portfolio at time t :

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_{\varepsilon_{it}}^2). \quad (1)$$

In Equation 1, ε_{it} is the error term, normally distributed with mean equal to 0 and variance equal to $\sigma_{\varepsilon_{it}}^2$. The parameters α_i and β_i can be estimated based on historical data within the estimation window. Then AR_{it} , the abnormal return or unexpected return due to the event, can be calculated for each day during the event window, by subtracting the fitted expected return for that day from the actual return in an out of sample manner:

$$AR_{it} = \varepsilon_{it} = R_{it} - \hat{\alpha}_i - \hat{\beta}_i R_{mt}. \quad (2)$$

The variance of AR_{it} is

$$\sigma^2(AR_{it}) = \sigma_{\varepsilon_{it}}^2 + \frac{1}{L} \left[1 + \frac{(R_{mt} - \hat{\mu}_m)^2}{\hat{\sigma}_m^2} \right], \quad (3)$$

where $\hat{\mu}_m$ and $\hat{\sigma}_m^2$ are the mean and variance of the market return index over the estimation period, respectively. The second term in Equation (3) represents variance due to sampling error, which also leads to serial correlation of the disturbance even though the true error should be independent. As L becomes large, the second term approaches zero, yielding the asymptotic estimator

$$\hat{\sigma}^2(AR_{it}) = \text{plim}_{L \rightarrow \infty} \sigma^2(AR_{it}) = \sigma_{\varepsilon_{it}}^2. \quad (4)$$

As the null hypothesis is that the environmental news events do not affect firms' stock returns (i.e., the abnormal returns during the event windows around environmental events are not significantly different from zero), we need to assess the abnormal returns across all firms in the sample. A two-step aggregation is taken to pool the estimates of AR_{it} as shown in Equations (5) and (6). First, the AR_{it} are aggregated within the event window to get $CAR(t_1, t_2)$, the cumulative abnormal return:

$$CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}. \quad (5)$$

Second, the $CAR(t_1, t_2)$ are averaged across firms to get $ACAR(t_1, t_2)$, the average cumulative abnormal return:

$$ACAR(t_1, t_2) = \frac{1}{N} \sum_{i=1}^N \sum_{t=t_1}^{t_2} AR_{it}. \quad (6)$$

It is assumed in the standard event study methodology that stock returns are jointly multivariate normal, and that they are independently and identically distributed (i.i.d.) through time. Therefore, AR_{it} is also i.i.d. with zero mean and variance equal to $\sigma_{\varepsilon_{it}}^2$. Assuming there is

no event clustering, which is the overlap of event windows across different firms, the distributional properties of $CAR(t_1, t_2)$ and $ACAR(t_1, t_2)$ can be obtained as

$$CAR(t_1, t_2) \sim N(0, \sum_{t=t_1}^{t_2} \sigma^2(AR_{it})), \text{ and} \quad (7)$$

$$ACAR(t_1, t_2) \sim N(0, \frac{1}{N^2} \sum_{i=1}^N \sum_{t=t_1}^{t_2} \sigma^2(AR_{it})). \quad (8)$$

Finally, following MacKinlay [38], the null hypothesis of no market response to environmental events can be tested by calculating the test statistic

$$\theta = \frac{ACAR(t_1, t_2)}{\text{var}(ACAR(t_1, t_2))^{\frac{1}{2}}} = \frac{\frac{1}{N} \sum_{i=1}^N \sum_{t=t_1}^{t_2} AR_{it}}{(\frac{1}{N^2} \sum_{i=1}^N \sum_{t=t_1}^{t_2} \sigma^2(AR_{it}))^{\frac{1}{2}}} \sim N(0,1). \quad (9)$$

2.2. Proposed Hybrid Method

This section presents an alternate event study method that considers the issues of autoregressive conditional heteroskedasticity. As revealed in Equation 9, the variance of $ACAR(t_1, t_2)$ is a critical component for calculating the test statistic; therefore, the accuracy of the variance forecast cannot be compromised. The potential biases caused by ignoring autoregressive heteroskedasticity have rarely been dealt with in the literature of event studies. However, volatility clustering has been studied extensively in the finance literature. To model volatility, a class of stochastic process models, the Autoregressive Conditional Heteroskedasticity (ARCH) family of models, was proposed beginning with Engle [14]. ARCH processes are defined as mean zero, serially uncorrelated processes with non-constant variances conditional on the past variances. Based on recent information on variance, a forecast of variance in the next period can be made. Formally, ARCH effects can be identified by the ARCH-LM test [14], which tests residuals from preliminary OLS for ARCH effects by regressing the squared

residuals on a constant and q lagged values of the squared residuals. Bollerslev [5] generalized the ARCH process to allow for past conditional variances in the current conditional variance equation. This new model is called the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model. As summarized by Engle [15], the typical GARCH (1, 1) model is presented in Equations (10) and (11):

$$R_{it} = \alpha_{i0} + \beta_{i0}R_{mt} + \varepsilon_{it}, \quad \varepsilon_{it} = \sqrt{h_{it}}v_{it}, \quad v_{it} \sim N(0,1), \quad \text{and} \quad (10)$$

$$h_{it} = \omega_i + \alpha_i\varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} = \omega_i + \alpha_i h_{i,t-1}v_{i,t-1}^2 + \beta_i h_{i,t-1}, \quad (11)$$

so that $\varepsilon_{it} \sim N(0, h_{it})$.

Equation (10) is the mean equation and Equation (11) is the variance equation. R_{mt} denotes the mean of the return series. The error term ε_{it} is equal to the product of its standard deviation and the Gaussian white noise v_{it} with zero mean and unit variance. Moreover, h_{it} is the variance of the residuals of the mean equation. After the term ‘‘GARCH,’’ the (1, 1) is a standard notation in which the first number refers to the number of autoregressive lags of h_{it} or ARCH terms, while the second number refers to the number of moving average lags of ε_{it}^2 , or GARCH terms, in Equation (11). α_i , β_i , and $\omega_i/(1-\alpha_i-\beta_i)$ are weights assigned to the long-run mean variance, the error between actual return and predicted return, and the estimated conditional variance in the past time period, respectively. Note that in order to keep the long-run variance and conditional variance nonnegative, $\alpha_i > 0$, $\beta_i > 0$, and $\omega_i > 0$ are required. In addition, $\alpha_i + \beta_i < 1$ has to be imposed to ensure long-run variance reversion behavior.

Exponential GARCH (EGARCH) represents an advance on standard GARCH. It is well-known that volatility tends to rise in response to bad news and to fall in response to good news.

Although GARCH elegantly captures the magnitude of volatility clustering, it is unable to reflect the sign of the rise and fall of volatility. The nonnegative limitation on the weights of the GARCH model also rules out the possibility that variance process can go up and down in an oscillatory manner. In response to these limitations, Nelson [44] proposed the Exponential GARCH (EGARCH) model. A simple EGARCH (1, 1) process is specified in Equations (12) and (13):

$$R_{it} = \alpha_{i0} + \beta_{i0}R_{it} + \varepsilon_{it}, \quad \varepsilon_{it} = \sqrt{h_{it}}v_{it}, \quad v_{it} \sim N(0,1), \quad \text{and} \quad (12)$$

$$\log(h_{it}) = \omega_i + \beta_{i1} \log(h_{it-1}) + \gamma_{i1} \frac{\varepsilon_{it-1}}{\sqrt{h_{it-1}}} + \alpha_{i1} \frac{|\varepsilon_{it-1}|}{\sqrt{h_{it-1}}} - \sqrt{2/\pi}, \quad (13)$$

so that $\varepsilon_{it} \sim N(0, h_{it})$. Logarithms are imposed on both sides of the variance equation to ensure that the conditional variances are positive. α_{i1} and γ_{i1} are estimated parameters of two zero-mean components constructed to accommodate the asymmetric relation between return and volatility change.

Given its flexibility in parameter estimation and its ability to treat information asymmetry, EGARCH fits perfectly the needs of this study. The steps that we take include:

1. Construct the stock return sample based on the environmental events. Using data from the estimation period, we conduct preliminary OLS regressions for stock return series of each event. Computing the ARCH-LM test (with $q = 1$) on residuals of OLS regressions allows us to identify the events with statistically significant ($p < .10$) autoregressive conditional heteroskedasticity in the disturbance. Events are then separated into two groups: events with ARCH effects and events without ARCH effects.

2. Use EGARCH to estimate AR_{it} and $\sigma^2(AR_{it})$ for events with statistically significant ARCH effects, or use the standard OLS-based market model to get the same estimates for other events.
3. Aggregate estimates from the EGARCH and standard market models to get $ACAR(t_1, t_2)$ and $Var(ACAR(t_1, t_2))$ for all events.
4. Test the null hypothesis that there is no market reaction.

Steps 1-4 constitute the proposed hybrid OLS/EGARCH method. Also, to check the robustness of the standard event study method, we

5. Apply the market model to all events and compare the result of the standard event study method with those of the hybrid method.

3. Data

We searched for negative environmental events involving publicly traded companies in U.S. markets using historical reports in Lexis-Nexis Academic from four major U.S. newspapers with large circulations – the New York Times, Wall Street Journal, Washington Post, and Los Angeles Times – over the period 1982-2007. Limiting the search to these four newspapers filters out very minor events reported only in local news. Major negative environmental events usually receive intensive media coverage, and reports are highly repetitive in different news sources. We used multiple search phrases designed to detect news about, for example, oil spills, gas leaks, chemical leaks, emission and discharge violations, and air, water, or waste pollution. Specifically, the search used was:

((oil ^ (spill | leak | pollution | fine | accuse | sue | suit)) | ((emission | discharge) ^ (violation | pollution | fine | accuse | sue | suit)) | ((chemical | gas) ^ (explosion | leak | spill | pollution | fine | accuse | sue | suit))) & (NYSE | AMEX).

Here, symbols | and & denote logical OR and AND respectively, and ^ denotes that terms to the left and right must be in the same sentence. This search appears to identify a large proportion, albeit not all, of major corporate environmental news events.

The intent was to cover all four types of negative environmental events that have been studied individually in the previous literature: accidents, complaints, lawsuits, and lawsuit settlements [11, 30, 33, 43]. Unlike some of the previous literature, we removed repeated references to the huge number of follow-up events of environmental accidents and complaints, as it is common to find in our sample that environmental litigation became decade-long battles. Only lawsuits filed and the resulting rulings or fines were retained.² After eliminating reports that are repetitive, involve positive statements or news, or involve companies that were not publicly listed on stock exchanges, the more than 30,000 citations identified in the search yielded 601 negative environmental events.³

Stock data, including the daily stock return for each firm with event(s) and the daily market return index, were obtained from the Center for Research in Securities Pricing (CRSP), the standard source for stock data research. In total, 205 days of stock price data are used for each

² Thus news about investigation, new evidence, appeals, and public opinions all were removed.

³ Some events in the sample include the following. On June 27, 1985, it was reported that “Smithfield Ltd. was fined 1.3 million by a federal judge for violating pollution regulation.” On January 5, 1988, a collapsed storage tank owned by Ashland Oil Company was reported to have spilled (the previous day) one million gallons of fuel oil into the Monongahela River near Pittsburgh. On July 21, 1994, it was reported that New York State environmental regulators had accused Consolidated Edison of polluting New York City waterways for seven years (the state had brought charges two years earlier but previously had not made them public). On July 31, 2003, residents and town officials in Endicott, NY, were reported as calling for “compensation for health care and depressed home prices” they ascribed to chemicals spilled by IBM.

event, with a five-day event period from $t_1 = t_0 - 2$ to $t_2 = t_0 + 2$ and a 200-day estimation period from $t_0 - 203$ to $t_0 - 3$. Events that lack sufficient daily stock data in CRSP to cover both the event window and the estimation window are eliminated from the sample.

A search for confounding events was conducted using the Wall Street Journal abstract within Lexis-Nexis Academic, to be able to eliminate confounding events that may have shifted investors' expectations of firms' future profitability.⁴ Examples of confounding events include substantial future contracts and the release of new products. This search period was extended from one day before the event window to one day after the event window, $t_0 - 3$ to $t_0 + 3$. After removing environmental events that coincided with potentially confounding events, we are left with 388 events involving 132 firms, representing a 35% reduction from the original sample. Window overlap for different events involving the same firm was also checked to ensure that there is no need to consider the covariance of abnormal returns when aggregating variances across events. There is no overlap found in the sample.

Table 1 contains descriptive statistics for daily stock returns in our sample and the market return index for the same days. The stock return sample that we construct contains 79,540 observations in total. This is obtained by multiplying 388, the number of events, by 205, the number of days with stock data. The mean of the individual stock returns is slightly higher than the market return index. Individual stock returns have a significantly higher standard deviation than the market return index, as should be expected since a weighted market return index fluctuates less than individual stock returns.

⁴ Searches for confounding effects were conducted by company name. All the news identified was considered a confounding event except when the news identified was a repetition, review, or analysis of an original event, or when the news identified was not really about the company of interest (for example, the name of the company could simply be mentioned in a comparison of quarterly profit).

Table 1. Descriptive Statistics for Stock Returns

Variable	N	mean	std dev	min	max
Stock return (daily)	79540	0.00057	0.0218	-0.357	0.462
Market return index (daily)	79540	0.00050	0.0099	-0.171	0.087

Figure 2 describes the relationship between the number of negative environmental events and the number of firms. Firms have up to 25 negative events during the sample period of 25 years. There are in total 132 firms in the sample, each of which has at least one event. The distribution is highly skew, with most firms having only one or a few events.

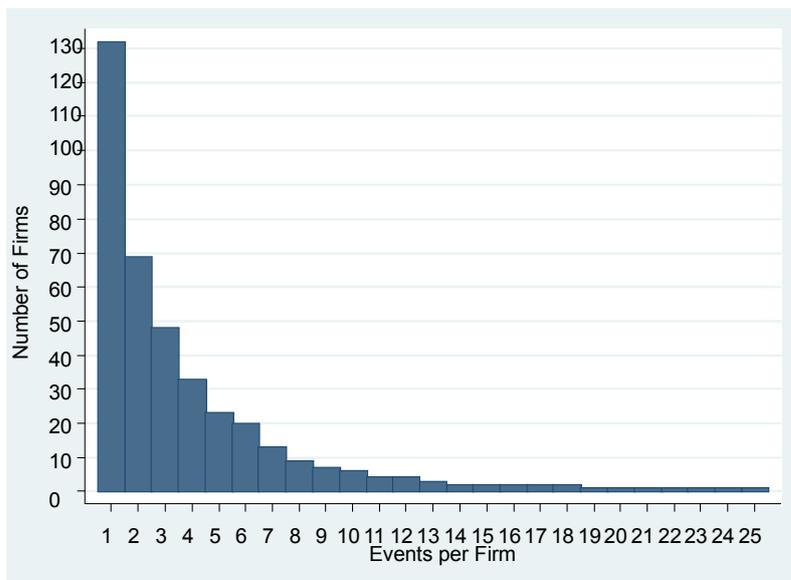


Figure 2. Number of Firms Having Specific Numbers of Events

In order to further investigate how firms are affected by different types of environmental events, we categorize the events into four types: 1) environmentally damaging accidents (e.g., a substantial oil spill, chemical leak, or explosion); 2) complaints expressed by citizens or government agencies about environmental problems; 3) environmental lawsuits brought by

citizens or government against corporations; and 4) fines or court rulings against a corporation (e.g., recalls for automobiles due to emission violations, a court order to clean up a dump site, or large fines for air or water violations). As shown in Figure 3, the sample contains 48 accidents (12% of events), 49 complaints (18%), 45 lawsuits (12%), and 226 court rulings or fines (58%). Court rulings and fines make up more than half of the sample, and together with lawsuits these comprise 70% of the total. This is not surprising because legal events generally receive more media coverage than environmental complaints or accidents.

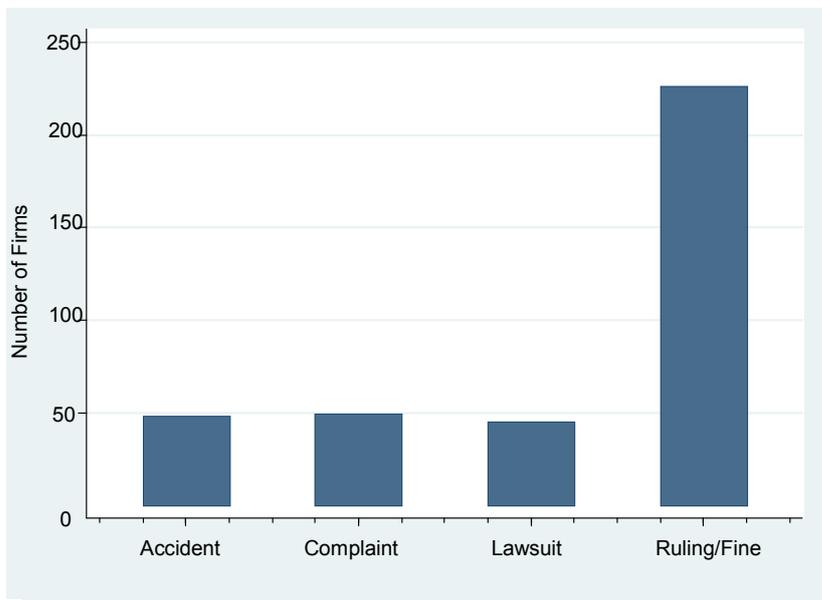


Figure 3. Event Types

In addition, we are interested in investigating to what degree firms in different industries are impacted by environmental events. Table 2 shows that out of 30 two-digit SIC industries within the sample, the four most representative industries – petroleum refining; chemicals; transportation equipment; and electric, gas, and sanitary services – comprise 63.4% of the sample. Not surprisingly the industries with the most environmental news are the traditional polluting

industries. These four industries are considered individually and the remaining industries are aggregated into an “others” category.

Table 2. Industry Distribution of Events

2-digit SIC	Description	Freq.	Percent
29	Petroleum Refining	71	18.3
28	Chemicals	59	15.2
37	Transportation Equipment	58	15.0
49	Electric, Gas, and Sanitary Services	58	15.0
33	Primary Metal Industries	21	5.4
20	Food and Kindred Products	20	5.2
36	Electronic and Other Electrical Equipment and Components	14	3.6
44	Water Transportation	13	3.4
13	Oil and Gas Extraction	11	2.8
35	Industrial and Commercial Machinery and Computer Equipment	10	2.6
38	Instruments; Photographic, Medical and Optical Goods	10	2.6
40	Railroad Transportation	7	1.8
24	Lumber and Wood Products	5	1.3
12	Coal Mining	4	1.0
26	Paper	4	1.0
79	Amusement and Recreation Services	4	1.0
53	General Merchandise Stores	3	0.8
67	Holding and Other Investment Offices	3	0.8
10	Metal Mining	2	0.5
48	Communications	2	0.5
51	Wholesale Trade-non-durable Goods	2	0.5
16	Heavy Construction	1	0.3
27	Printing, Publishing	1	0.3
30	Rubber and Plastics Products	1	0.3
32	Stone, Clay, Glass, and Concrete Products	1	0.3
34	Fabricated Metal Products	1	0.3
54	Food Stores	1	0.3
76	Miscellaneous Repair Services	1	0.3
Total		388	100.0

4. Empirical Results

4.1. Basic Results: Hybrid and Standard Event Study Method

ARCH-LM tests on OLS residuals reveal that of 388 negative environmental events, 130 events (34%) exhibit ARCH effects. Following the method described above, we divide the sample into ARCH events and non-ARCH events and compute the OLS/EGARCH model estimates, as well standard OLS model estimates, on the whole sample. The basic results are recorded in Table 3 to allow comparison.

Following negative environmental events, Table 3 reports highly significant stock return reductions, no matter which method is used. The magnitude of stock return reduction is indicated by ACARs of 1.25% from the standard method and a slightly lower 1.22% from the hybrid method, both accompanied by highly significant t -statistics (standard: -4.86, hybrid: -4.96). This difference in overall result comes from the different estimates of ARCH events. Using the standard method, the ACAR of ARCH events is -0.0136, versus -0.0127 using the hybrid method.

The t -statistics in the hybrid model estimated using the whole sample are a little bigger than those from the standard model. This can be interpreted as a piece of evidence that supports use of the OLS/EGARCH hybrid method over the simple OLS-based standard method. We also find that statistically significant and similar-sized return reductions exist in ARCH events and non-ARCH events. While the hybrid method might represent some potential gains in explanatory power because of the higher t -statistics, the comparison reveals that the standard method is quite robust even when autoregressive heteroskedasticity is present in one third of the sample.

Summarizing all the evidence found in this comparison, we conclude that the standard method and the hybrid method agree, both implying that negative environmental news disclosure through news media is associated with statistically significant and sizeable reductions in firms'

market valuations. Seemingly news media do function as a channel of environmental information disclosure that activates stock market reductions, potentially yielding a financial incentive for firms to self-regulate.

Table 3. Basic Results: OLS/EGARCH Hybrid Method and Standard Event Study Method

Method	Events	N of Events	ACAR	SE(ACAR)	t
Standard	All events	388	-0.0125	0.0026	-4.86***
	ARCH events	130	-0.0136	0.0048	-2.83**
OLS/EGARCH Hybrid	All Events	388	-0.0122	0.0024	-4.98***
	Non-ARCH events	258	-0.0119	0.0030	-3.95***
	ARCH events	130	-0.0127	0.0042	-3.04**

Note: The symbols ***, **, *, †, denote significance at levels 0.1%, 1%, 5% and 10% (two-tailed), respectively.

4.2. Additional Results: Event Type Effects and Industry Effects

In this section, we further investigate the event type effects and industry effects. Table 4 reports results by event type. The hybrid and standard methods are consistent in finding significant negative market reactions to all four types of events.

Given that we have calculated ACARs for each type of event, it is possible to rank the magnitude of return reduction induced by different types of events. To ascertain whether their mean cumulative abnormal returns, ACARs, are statistically distinguishable, we conduct two-sample *t*-tests for each pair of event types. Table 5 reports the *t*-test matrix using the ACARs from the hybrid method (very similar results arise from the standard method). All pairs of ACARs can easily be distinguished at the significance level $p < .01$ except for accidents and complaints, which have almost identical ACARs. Accidents and complaints have the strongest return reductions at -1.98% to -2.02%, followed by lawsuits at -1.53% and then court rulings and fines at -0.75%. The average return reduction, recall, is -1.22%. One way to interpret this ranking

is that the initial events rather than the follow-up events send the strongest negative information to investors because the information contained in the initial events is brand-new and has never been processed. It is this type of information that causes investors' expectation of firms' profitability to decline the most, yielding the greatest stock return reductions.

Table 4. Additional Results: Event Type Effects

Method	Event Type	N of Events	ACAR	SE(ACAR)	t
Standard	Accident	48	-0.0201	0.0079	-2.54*
	Complaint	69	-0.0204	0.0080	-2.54*
	Lawsuit	45	-0.0161	0.0090	-1.80†
	Ruling or fine	226	-0.0077	0.0027	-2.84**
	All events	388	-0.0125	0.0026	-4.86***
OLS/EGARCH Hybrid	Accident	48	-0.0202	0.0070	-2.88**
	Complaint	69	-0.0198	0.0080	-2.49*
	Lawsuit	45	-0.0153	0.0071	-2.17*
	Ruling or fine	226	-0.0075	0.0027	-2.75**
	All events	388	-0.0122	0.0024	-4.98***

Note: The symbols ***, **, *, †, denote significance at levels 0.1%, 1%, 5% and 10% (two-tailed), respectively.

Table 5. Two Sample T-Tests Comparing Hybrid-Method ACARs of Different Event Types

Method	Event Type	Accident	Complaint	Lawsuit
Hybrid	Complaint	-0.29		
	Lawsuit	-3.35**	-3.15**	
	Ruling or fine	-12.38***	-12.56***	-7.27***

Note: The symbols ***, **, *, †, denote significance at levels 0.1%, 1%, 5% and 10% (two-tailed), respectively.

Table 6 summarizes additional results concerning how firms in different industries are affected by negative environmental events. The table shows that environmental events in all industry groups are associated with statistically significant decreases in firms' stock returns. Breaking events into industry groups does not alter the basic results in Table 3.

Table 6. Additional Results: Industry Effects

Method	Industry	N of Events	ACAR	SE(ACAR)	t
Standard	Transportation Equipment	59	-0.0206	0.0079	-2.61*
	Petroleum Refining	58	-0.0194	0.0105	-1.84†
	Chemicals	58	-0.0154	0.0042	-3.62***
	Electric, Gas, and Sanitary	71	-0.0079	0.0042	-1.89†
	Others	142	-0.0073	0.0035	-2.08*
	Overall	388	-0.0125	0.0026	-4.86***
OLS/EGARCH Hybrid	Transportation Equipment	59	-0.0201	0.0078	-2.58*
	Petroleum Refining	58	-0.0189	0.0086	-2.22*
	Chemicals	58	-0.0155	0.0045	-3.46**
	Electric, Gas, and Sanitary	71	-0.0079	0.0040	-1.97†
	Others	142	-0.0069	0.0038	-1.81†
	Overall	388	-0.0122	0.0024	-4.98***

Note: The symbols ***, **, *, †, denote significance at levels 0.1%, 1%, 5% and 10% (two-tailed), respectively.

Table 7. Two Sample T-Tests Comparing Hybrid-Method ACARs of Different Industries

Method	Industry	Petro Refining	Chemicals	Trans Equipment	Electric, Gas
Hybrid	Chemicals	-2.7010**			
	Trans Equipment	0.7760	3.9154***		
	Electric, Gas	-9.0729***	-10.0940***	-10.9058***	
	Others	-10.3494***	-12.9280***	-12.4425***	-1.7792†

Note: The symbols ***, **, *, †, denote significance at levels 0.1%, 1%, 5% and 10% (two-tailed), respectively.

Next, we rank the magnitude of return reductions in each industry group. The two sample *t*-tests reported in Table 7 for the hybrid model indicate that ACARs of transportation equipment and petroleum refining are not significantly different from each other, while other pairs of ACARs are statistically distinguishable. Transportation equipment and petroleum refining have the strongest estimated return reductions in reaction to negative environmental events of -2.01% and -1.89% respectively, followed by chemicals at -1.55%, electric, gas, and sanitary services at -0.79%, and others at -0.69%.

The strongest responses come from industry groups with relatively few events in the sample (transportation equipment has 59 events, petroleum refining has 58 events, and chemicals has 58 events), while the weaker responses are from the industries with more events (electric, gas, and sanitary services has 71 events, and others has 142 events). This observation highlights the fact that a few small traditionally polluting industries such as transportation equipment, petroleum refining, and chemicals are among the industries most prone to the adverse impacts of negative environmental events.

5. Discussion and Future Research

5.1. Simple vs. Sophisticated Models

The results show that using our dataset the more sophisticated hybrid method actually provides quite similar results to the simple standard method. One reason for the lack of sensitivity to the hybrid method is that events with ARCH effects make up a relatively small fraction of the sample (34%). But this result also reflects a common modeling difficulty: we are uncertain whether the more sophisticated or the simple model works better in forecasting the return behavior.

This modeling difficulty has manifested in the previous debates over the choice of model for predicting the mean of normal stock returns. In reviewing the literature, we find in some cases the more sophisticated model can provide insights the simple model cannot [19, 20], whereas in other cases a simple model seems to work well in predicting the return behavior [6]. The comparison in this paper between the hybrid model and the simple market model can be considered an illustration of the second case: although the more sophisticated model represents a potential gain of explanatory power, it does not *guarantee* more explanatory power. For

applications in which the OLS model is a reasonable rough approximation, there is no guarantee that the efficiency advantage of EGARCH (which requires estimation of more parameters) will be realized in small samples. As the literature still offers no clear answer as to which is the better model to pursue (i.e., simple or sophisticated) in the econometric sense, more work needs to be done (possibly through simulation) comparing the performance of the hybrid and standard models.

5.2. Market Structure, Environmental Strategy, and Market Performance

The present paper investigates to what extent event type and industry characteristics impact firms' market reactions to environmental news. More variables than event type and industry characteristics might be hypothesized as influential factors. The industrial organization literature suggests a relationship among market structure, strategy choice, and market performance [1, 39]. The market power that a firm possesses may influence the extent to which environmental events can affect firms' future profitability; therefore, adding a measure of market structure as an independent variable in analyses of Cumulative Abnormal Return (CAR) could address how industry conditions affect firms' susceptibility to environmental news. This would also be useful when analyzing strategic choice of corporate environmental policies. There are many proxies of market power to choose from; however, as the scope of the individual firms' market power changes over time due in part to entry, exit, product and process innovation, and institutional changes (regulation, deregulation, etc.), no ideal measure is readily available. Measures of potential persistence of firms' profits may be particularly relevant [42]. In any case, it may be important to incorporate market structure into future studies of the consequences of information programs and incentives for firms to change behavior.

6. Conclusion

This paper examines how negative environmental news relates to firms' stock market returns. It improves on previous studies by using a longer sample period and larger sample, treating heteroskedasticity with a hybrid method that allows EGARCH, and analyzing how industry characteristics and event type affect market reactions to environmental events. The main finding is that the standard and hybrid method are consistent in finding negative market reactions to negative environmental events (standard: -1.22%, hybrid: -1.25%). In contrast to Yamaguchi [51], we find that the standard method is quite robust even with autoregressive conditional heteroskedasticity present. Overall, the results suggest that some combination of the direct costs of the events and the harmful publicity that results from the news media substantially harm firms' valuations, potentially providing a financial incentive for firms to self-regulate.

We further investigate the market reactions to environmental news in different groups of industries and with different types of events, and find highly significant negative market reactions in all groups of industries and in all types of events analyzed. Additionally, we create rankings that allow us to see to what degree firms are affected differently by different types of events, and to what degree firms in different industries are affected differently by environmental events. Accidents and complaints are associated with 2.0% reductions in mean stock market value, followed by lawsuits with 1.5% reductions and court rulings and fines with 0.8% reductions. Negative environmental news was associated with mean reductions in value of 2.0% and 1.9% in transportation equipment and petroleum refining firms respectively, 1.6% in chemicals firms, 0.8% in electric, gas, and sanitary services firms, and 0.7% in other firms.

References

- [1] J. S. Bain, *Barriers to New Competition*, Harvard University Press, Cambridge, MA, 1956.
- [2] R. Ball, Anomalies in relationships between securities' yields and yield-surrogates, *Journal of Financial Economics* 6 (1978) 103-126.
- [3] S. Basu, The relationship between earnings' yield, market value and the returns for NYSE common stocks: Further evidence, *Journal of Financial Economics* 12 (1983) 129-156.
- [4] L. S. Benneer and S. M. Olmstead, The impacts of the "right to know": Information disclosure and the violation of drinking water standards, *Journal of Environmental Economics and Management* 56 (2008) 117-130.
- [5] T. Bollerslev, Generalized autoregressive conditional heteroskedasticity, *Journal of Econometrics* 31 (1986) 307-327.
- [6] S. Brown and B. Warner, Using daily stock returns: The case of event studies, *Journal of Financial Economics* 14 (1985) 3-31.
- [7] G. Capelle-Blancard and M. A. Laguna, How does the stock market respond to chemical disasters? *Journal of Environmental Economics and Management*, Forthcoming (2009).
- [8] J. Y. Campbell and R. J. Shiller, Stock prices, earnings, and expected dividends, *Journal of Finance* 43 (1988) 661-676.
- [9] J. Y. Campbell and R. J. Shiller, Valuation ratios and the long-run stock market outlook. *Journal of Portfolio Management* 24 (1998) 11-26.

- [10] D. Collins, W. Dent, A comparison of alternative testing methodologies used in capital market research, *Journal of Accounting Research* 22 (1984) 48-95.
- [11] S. Dasgupta, B. Laplante, N. Mamingi, Pollution and capital markets in developing countries, *Journal of Environmental Economics and Management* 42 (2001) 310-335.
- [12] S. Dasgupta, J. H. Hong, B. Laplante, N. Mamingi, Disclosure of environmental violations and the stock market in the Republic of Korea, *Ecological Economics* 58 (2006) 759-777.
- [13] M. Delmas, M. Montes-Sancho, J. Shimshack, Information disclosure policies: evidence from the electricity industry, *Economic Inquiry*, Forthcoming (2009)
- [14] R. Engle, Autoregressive conditional heteroskedasticity with estimates variance of United Kingdom inflation, *Econometrica* 50 (1982) 987-1007.
- [15] R. Engle, GARCH 101: The use of ARCH/GARCH models in applied econometrics, *Journal of Economic Perspectives* 15 (2001) 157-168.
- [16] M. F. Evans, S. M. Gilpatric, L. R. Liu, Regulation with direct benefits of information disclosure and imperfect monitoring, *Journal of Environmental Economics and Management*. 57 (2009) 284-292.
- [17] E. Fama, L. Fisher, M. Jensen, R. Roll, The adjustment of stock prices to new information *International Economic Review* 10 (1969) 1-21.
- [18] E. Fama, K. French, Permanent and temporary components of stock prices, *Journal of Political Economy* 96 (1988) 246-73.

- [19] E. Fama, K. French, The cross-section of expected stock returns, *Journal of Finance* 47 (1992) 427-465.
- [20] E. Fama, K. French, Common risk factors in the returns on stocks and bonds, *Journal of Finance* 33 (1993) 3–56.
- [21] G. Filbeck and R. F. Gorman, The stock-price reaction to environmentally-related company news, *Journal of Business and Public Affairs* 29 (2004) 25-31.
- [22] G. Foster, Accounting policy decisions and capital market research, *Journal of Accounting and Economics*, 2 (1980) 29-62.
- [23] K. French, Stock returns and the weekend effect, *Journal of Financial Economics* 8 (1980) 55-69.
- [24] J. T. Hamilton, Pollution as news: media and stock market reactions to the Toxic Release Inventory data, *Journal of Environmental Economics Management* 28 (1995) 98–113.
- [25] R. A. Haugen, J. Lakonishok, The incredible January effect: The stock market's unsolved mystery, Dow Jones-Irwin, Homewood, IL, 1988.
- [26] G. Hawawini, D. B. Keim, On the predictability of common stock returns: Worldwide evidence, in “Handbooks in Operations Research & Management Science” (R. Jarrow, V. Maksimovic, W. Ziemba, Eds.), Volume 9, Elsevier Science, Amsterdam, (1995) 497–544.
- [27] K. Jones and P.H. Rubin, Effects of harmful environmental events on reputations of firms, *Advances in Financial Economics* 6 (2001) 161-182.

- [28] D. B. Keim, Size-related anomalies and stock return seasonality: Further empirical evidence, *Journal of Financial Economics* 12 (1983) 13-32.
- [29] M. Khanna, W. R. H. Quimio, D. Bojilova, Toxics release information: A policy tool for environmental protection, *Journal of Environmental Economics and Management* 36 (1998) 243-266.
- [30] R. Klassen, C. McLaughlin, The impact of environmental management on firm performance. *Management Science* 42 (1996) 1199-1214.
- [31] S. Konar, M. Cohen, Information as regulation: The effect of community right to know laws on toxic emissions, *Journal of Environmental Economics and Management* 32 (1997) 109-124.
- [32] J. Lakonishok, S. Smidt, Are seasonal anomalies real? A ninety-year perspective, *Review of Financial Studies* 1 (1988) 403-425.
- [33] B. Laplante, P. Lanoie, The market response to environmental incidents in Canada: A theoretical and empirical analysis, *Southern Economic Journal* 60 (1994) 657-672.
- [34] P. Lanoie, B. Laplante, M. Roy, Can capital markets create incentives for pollution control? *Ecological Economics* 26 (1998) 31-41.
- [35] J. Linn, The effect of cap-and-trade programs on firms' profits: Evidence from the nitrogen oxides budget trading program, *Journal of Environmental Economics and Management*, Forthcoming (2009).

- [36] A. W. Lo, A. C. MacKinlay, *A Non-Random Walk Down Wall Street*, Princeton University Press, Princeton, NJ, 1999.
- [37] A. W. Lo, H. Mamaysky, J. Wang, Foundations of technical analysis: Computational algorithms, statistical inference, and empirical implementation, *Journal of Finance* 55 (2000) 1705-1765.
- [38] A. MacKinlay, Event studies in economics and finance, *Journal of Economic Literature* 35 (1997) 13-39.
- [39] E. S. Mason, Price and production policies of large-scale enterprise, *American Economic Review* 29 (1939) 61-74.
- [40] M. McNichols, A. Dravid, Stock dividends, stock splits, and signaling, *Journal of Finance* 45 (1990) 857-879.
- [41] A. McWilliams, D. Siegel, Event studies in management research: Theoretical and empirical issues, *Academy of Management Journal* 40 (1997) 626-657.
- [42] D. Mueller, *Profits in the Long Run*, Cambridge University Press, New York, 1986.
- [43] M. I. Muoghalu, H. D. Robison, J. L. Glascock, Hazardous waste lawsuits, stockholder returns, and deterrence, *Southern Economic Journal* 7 (1990) 357-370.
- [44] D. B. Nelson, Conditional heteroskedasticity in asset returns: A new approach, *Econometrica* 59 (1991) 347-370.
- [45] J. Poterba, L. Summers, Mean reversion in stock returns: Evidence and implications, *Journal of Financial Economics* 22 (1988) 27-59.

- [46] K. Schipper, R. Thompson, The impact of merger-related relationships on the shareholders of acquiring firms, *Journal of Accounting Research* 21 (1983) 184-221.
- [47] F. Takeda, T. Tomozawa, An empirical study on stock price responses to the release of the environmental management ranking in Japan, *Economics Bulletin* 13 (2006) 1-4.
- [48] F. Takeda, T. Tomozawa, A change in market responses to the environmental management ranking in Japan, *Ecological Economics* 67 (2008) 465-472.
- [49] Z. Wang, V. Salin, N. H. Hooker, D. Leatham, Stock market reaction to food recalls: A GARCH application, *Applied Economics Letters* 9 (2002) 979-987.
- [50] K. Yamaguchi, Reexamination of stock price reaction to environmental performance: A GARCH application, *Ecological Economics* 56 (2007) 23-35.
- [51] U. S. Census Bureau. *Pollution Abatement Costs and Expenditures: 2005*, MA200 (05), U.S. Government Printing Office, Washington, DC, 2008.