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THE IMPACT OF POWER OUTAGES ON PUBLICLY TRADED UTILITIES

A Thesis in
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by
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Abstract

The objective of this thesis is to assess the impact of blackouts on the returns of publicly traded electric power utilities in the United States. I use data from the Department of Energy to select the 274 blackouts that affected at least 100,000 customers in the United States together with data from the Center for Research and Security Prices to gather information on daily share prices and returns. I found that on the whole, blackouts do not lead to a statistically significant change in returns of an electric power utility. However, when considering blackouts with long recovery periods and blackouts that affect more than one million people, utilities experience negative returns that last more than a month after the blackout occurred, possibly signaling investor pessimism about a utility's ability to recoup the cost of restoring power to affected customers.

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List of Symbols

DOE	Department of Energy
PUC	Public Utility Commission
ROR	Rate of Return
CRSP	Center for Research in Security Prices
SIC	Standard Industrial Classification
AR	Abnormal Return
CAR	Cumulative Abnormal Return
CAPM	Capital Asset Pricing Model

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Dedication

To my Family

Chapter 1

Introduction

The aim of this paper is to investigate investor reaction after customers of a publicly traded electric power utility experience a blackout. Blackouts of various sizes and effects are undesirable occurrences that plague the electric grid system leading to negative impacts on economic productivity and human lives. In the United States, over 800 power disturbances were documented by the Department of Energy (DOE) between the years 2000 and 2010 with annual costs to electricity consumers estimated at $79 billion[2]. One particular instance on August 14, 2003, the largest blackout in North American history affected roughly 50 million people throughout Northeastern and Midwestern United States and Ontario, Canada with many people losing power for almost four days[3]. A study conducted by the Anderson Economic Group estimated that the total impact of this blackout on US workers, consumers, and taxpayers resulted in a $6.4 Billion loss[4]. In addition, about 100 deaths were linked directly and indirectly to this blackout[5].

Despite considerable efforts by utilities and regulators to reduce the occurrence of blackouts, we must acknowledge that the present day electric grid system is a highly complex interconnection of many parts and system failures can not be completely avoided in such a complex system designed and operated by humans[6]. Because blackouts occur frequently and must be expected to occur, it is important to consider how investors react to news of these events. News regarding a blackout may have an impact on investors' perception about an electric power utility's future prospect. While investor perception cannot be directly observed, changes in the stock returns of electric power utilities after a blackout occurs can provide some insight into how investors interpret blackouts. For investors who bet their dollars on the future performance of a utility, a proper understanding of how a blackout is likely to affect the value of their investment is critical. On the other hand, executives of utility companies have a fiduciary responsibility to maximize shareholder wealth. This creates an incentive to understand how financial markets react to blackouts.

I consider, in this paper, a sample of blackouts occurring between years 2000 and 2010, and attempt to determine investor reaction and the financial impact of these events on the stock

Table 1.1. Five Largest Power Disturbances in North America, 2000-2009[1]

	Date	Location	MW	Customers	Primary Cause
1	14-Aug-2003	Eastern US, Canada	57,669	15,330,850	Cascading failure
2	18-September-2003	Southern US	10,067	2,590,000	Hurricane Isabel
3	23-October-2005	Southern US	10,000	3,200,000	Hurricane Wilma
4	29-August-2005	Southern US	9,652	1,091,057	Hurricane Katrina
5	4-December-2002	Southern US	7,200	1,140,000	Ice/wind/rain storm

market value of publicly traded electric power utilities. Is news of a blackout indeed a bad thing for utilities or do investors attribute blackouts to business risks that utilities must contend with possibly providing an opportunity to make more profits in the future? Relying on market efficiency[1], news about an event such as a blackout will be quickly incorporated into the price of a utility stock[7]. Events considered to be good news, for instance better than expected earnings, will invariably drive the share price up. Likewise, bad news will drive share price down. By checking for abnormal returns in the aftermath of a blackout, I attempt to shed light on investor reaction and perception of blackouts.

1.1 Literature Review

The event study method, over the last four decades, has been used extensively to detail the presence of abnormal returns around the dates of specific events. Fama et al[8], in the pioneering event study paper, discussed the informational content of stock splits and the speed of reaction of the market to publicly available information. They concluded that investors associated stock splits with substantial dividend increases leading them to re-evaluate the future expected income stream in a positive light, hence higher stock prices. Since then event studies have been used to study a diverse range of issues including the effects of regulation changes on insider trading[9][10], the effect of mergers on shareholder wealth[11], the informational content of corporate forecasts of earnings per share[12], investor reaction to a company's pollution track record[13], effects of corporate equity ownership on firm value[14], and the impact of the Fukushima nuclear accident in March 2011 on electric power utilities in Japan[15].

A considerable amount of research has been done using data on power outages in the United States. A study showed that blackouts follow a power-law probability density function indicating that blackouts occur more frequently than we may expect[16]. Another study by Carreras et al. used blackout data from 1984 to 1998 to develop a model for blackout mitigation. They argued that combining the higher societal costs of blackouts with their relatively high probability makes the risk of large blackouts comparable to the risk of small blackouts[17]. Simonoff et al., using blackout data from 1990-2004, studied the risk to the electricity grid associated with a terrorist attack. They created a model that can be used as inputs to estimate potential costs and risks of power disturbances[18].

[1] I rely on the semi-strong version of market efficiency which implies that information that is publicly available is incorporated quickly into the price of a stock.

While much consideration has been given to detailing the costs of blackouts to economic productivity, no specific work studies investor reaction to blackouts. This is surprising considering the number of blackouts that publicly traded electric power utilities suffer on a yearly basis. Joo et al[19] studied the impact of the aforementioned 2003 blackout on security values of electric power utilities and electrical equipment manufacturing firms. The results showed utilities suffered negative abnormal returns while electrical equipment manufacturers enjoyed positive abnormal returns. However, their research focuses narrowly on the 2003 blackout and no generalization can be made regarding trends in investor reaction to other blackouts.

This thesis contributes to existing literature by describing how investors in publicly traded utility companies have reacted to news of blackouts. While most research efforts quantify the economic losses incurred after blackouts, this study focuses on the effect of blackouts on shareholder wealth. By disaggregating blackouts into different categories based on cause, number of customers affected, and length of complete power restoration period, I attempt to delineate a comprehensive framework for understanding investor reaction to blackouts.

The rest of the thesis is organized into the four sections following the introduction

- Chapter 2 discusses competing hypotheses
- Chapter 3 describes the data sources used and the framework for evaluating the impact of blackouts on utility returns
- Chapter 4 discusses the results of the analysis
- Chapter 5 summarizes the findings and conclusions of the thesis

Chapter 2

Hypotheses Development

There is very little research on investor reaction to blackouts. One reason may the nature of utility shares. Companies in the utility industry have defensive stocks, meaning they produce goods which are not highly dependent on the health of the economy. In modern society, people generally need to consume some amount of electricity regardless of the prosperity of the economy. As a result, utilities are expected to provide constant dividends and stable earnings regardless of the overall health of the general stock market[20]. An investor must make a decision about the value of a stock partly based on beliefs and perception about the future performance of a firm. Theoretically, using a model that does not account for risk, an investor would value a stock as the expected value of its discounted future dividend stream.

$$V_i = \sum_t \frac{D_{i,t}}{(1+r)^t} \tag{2.1}$$

where
V_i = present value of stock i
$D_{i,t}$= expected dividend payments per share
r= cost of equity

Certain industry or firm specific events may lead investors to revise their perception of the future performance of a particular firm or all firms within a particular industry. To test the financial impact of blackouts on electric power utilities, I start with the premise that the effect of a blackout can be examined by the impact it has on the stock returns of electric power utilities. Assuming financial markets are informationally efficient, we must expect that investors will react to news in a manner that influences the changes, positive or negative, in stock returns. Firms that experience blackouts may experience changes in returns depending on how investors perceive the impact the blackout would have on future earnings.

In the aftermath of a blackout, utilities must restore power to their customers in order to earn revenue. The restoration process involves deploying technical crews to areas to fix problems and may also require more expensive efforts involving purchasing and installing new electrical equipment. The funds required to complete these tasks may be obtained from the affected utility's cash reserves and in some cases, short term loans may be required to supplement the cash reserves. In addition, utilities are not able to earn revenue from customers that have lost access to power. Recouping these costs is not necessarily a straight forward effort because utilities cannot directly pass such costs to consumers without going through a legal process to request a rate increase to cover costs of restoring power.

The framework of the electric power utility industry is affected by regulatory oversight under the jurisdiction of a Public Utility Commission(PUC), a state based body that regulates the rates and services of a public utility. The electric power industry has historically been regarded as a natural monopoly, meaning it is cheaper and more efficient for one firm to serve the entire market demand. Utilities face price regulation as a counter measure to monopoly pricing. A utility receives a monopoly service area and an opportunity to cover its costs while also earning a "fair and reasonable" return to encourage private investment. In exchange, the utility has an obligation to adequately meet customer demand[21]. The rates a utility is allowed to charge is determined through a legal hearing called a rate case. A utility is allowed to set prices such that

$$Revenue = expenses + r(RB) \tag{2.2}$$

where
r= Rate of Return (ROR)
RB= Rate Base

The rate base is the value of the property a utility uses to provide service. It may include cash, working capital, materials and supplies, accumulated deferred income taxes, contributions in aid of construction. A regulated utility must file a rate case in order to get a rate increase. Utilities make their arguments for a rate increase while also proposing the new rates and the dates the rates will go into effect. From equation 2.2, we see that given a certain ROR, an increase in the allowed rate base will lead to greater profits creating an incentive for regulated utilities to overcapitalize. This tendency is described as the Averch-Johnson effect[22]. The PUC is not obligated to accept a utility's rate increase request and cost dis-allowances have occurred in the past for different reasons[23].

Positive Returns Hypothesis: A utility may experience **positive abnormal returns** after a blackout if investors believe that regulators are likely to allow utilities to completely recoup blackout restoration costs and also to accumulate more capital in oder to avoid future blackouts. An increase in capital or rate base could allow the utility to become more profitable as argued by the Averch-Johnson effect. An informationally efficient market will mean investors belief about the success of the rate case will be impounded quickly into the stock prices of such utilities resulting in positive abnormal returns. An increase in the expected future cash flow will lead to a higher valuation of the stock according to equation 2.1

Negative Returns Hypothesis: On the other hand, **negative abnormal returns** may reflect investor pessimism about a utility's ability to recoup costs in the future. A utility is unlikely to recoup all the costs of power restoration if regulators argue successfully that the utility did not adequately prepare for and manage restoration efforts after a blackout. If investors, after a blackout, perceive that a utility will struggle to successfully convince regulators, they may expect a drop in the utility's future cash flow leading to negative abnormal returns

Chapter 3

Methodology

3.1 Power Outage Data

I gather data on every reported power outage documented by the U.S Department of Energy between January 2000 and December 2010. The DOE mandates that an impacted electric power utility report all electric emergency incidents and disturbances that occur in the utility's territory. Annual summaries of these events are made available to the public online on Form OE-417 through the Office of Electricity Delivery and Energy Reliability (OE). The data includes information on date and time the disturbance began, date and time power was restored, areas and number of customers affected, and amount of power lost.

There were a total of 844 reported power disturbances between January 2000 and December

Table 3.1. Selected Power Outages affecting at least one million people, 2000-2010[1]

	Utility	Date	Location	MW	Customers
1	Entergy	5/24/00	Texas	Unknown	2,000,000
2	Oklahoma Gas & Electric	1/30/02	Oklahoma	500	1,888,134
3	Pacific Gas& Electric	12/14/2002	California	180	1,500,000
4	Detroit Edison	8/14/2003	Southeastern Michigan	11,000	2,100,000
5	First Energy Corporation	8/14/2003	Northeast Ohio	7,000	1,203,000
6	Consolidated Edison	8/14/2003	NYC and Westchester County	11,202	3,125,350
7	Dominion-Virginia Power	9/18/2003	North Carolina & Northern Virginia	6,152	1,800,000
8	Florida Power & Light	8/13/2004	West Coast of Florida	1,400	1,200,000
9	Florida Power & Light	9/4/2004	West Coast of Florida	6000	2,775,093
10	Entergy	8/29/2005	Buras, Louisiana		1,100,000
11	Florida Power & Light	10/23/2005	South Florida	10,000	3,241,437
12	Pacific Gas& Electric	12/31/2005	California	800	1,667,316
13	Ameren Corporation	7/19/2006	Missouri & Illinois	1,500	1,500,000
14	Pacific Gas& Electric	7/22/2006	California	200	1,271,893
15	Pacific Gas& Electric	1/4/2008	Northern California	500	2,606,931
16	Center Point Energy	9/12/2008	Houston, Texas	8,087	2,142,678
17	Pacific Gas& Electric	1/18/2010	Northern California	290	1,700,000

2010 in the United States. I use the following criteria to specify the sample:

1. I consider only power outages that affected at least 100,000 customers. While this is an arbitrary selection, I assume that a loss of power to 100,000 customers or more is signicant.

2. I discarded cases that had no report of the number of customers affected. Although there is no reason to believe these cases affected zero customers, I had no reliable means to quantify the amount of affected customers so I dropped those cases from the sample.

3. This study deals with the stock returns of electric power utilities, therefore only publicly traded utilities are considered.

There were 129 reported cases that had missing information on the number of affected customers. Applying criteria 1 reduces the sample to 355 relevant blackouts. The second and third criteria reduces the sample to 282 blackouts. I dropped eight cases from the sample because these utilities became privately-owned entities and were no longer being actively traded on the day the blackouts occurred. Two outages involved Puget Sound Energy which was sold to foreign investors[24] and another six involved TXU electric delivery which became privately-owned through a leveraged buyout[25]. The final sample contains 274 reported blackouts representing 32.5% of all the reported blackouts that occurred between 2000-2010. After matching all the utilities to their respective holding companies, I end up with 43 firms in the sample.

Table 3.2. Descriptive Statistics of DOE power disturbance data

	Occurences
Total number of events	844
$\geq$ 100k customers	355
$\geq$ 100k customers & Public utilities	274

3.2 Securities Data

I obtain daily security data from a database compiled by the Center for Research in Security Prices (CRSP). CRSP, a part of the Booth School of Business at the University of Chicago, provides comprehensive data on historical stock market outcomes. I gather data on daily share prices, number of shares outstanding, daily returns, value weighted market returns from January 2, 1998 to February 28, 2011 for 43 companies. Some utilities included in the blackout report are subsidiaries of larger holding companies, hence, in those cases, I study the effect on the holding companies.

Return is the daily return of a firm's stock price measures the percentage change in value over a time period of one trading day. It takes into account the effects of splits and other capital actions. CRSP provides information on holding period return which includes dividends and other distributions.

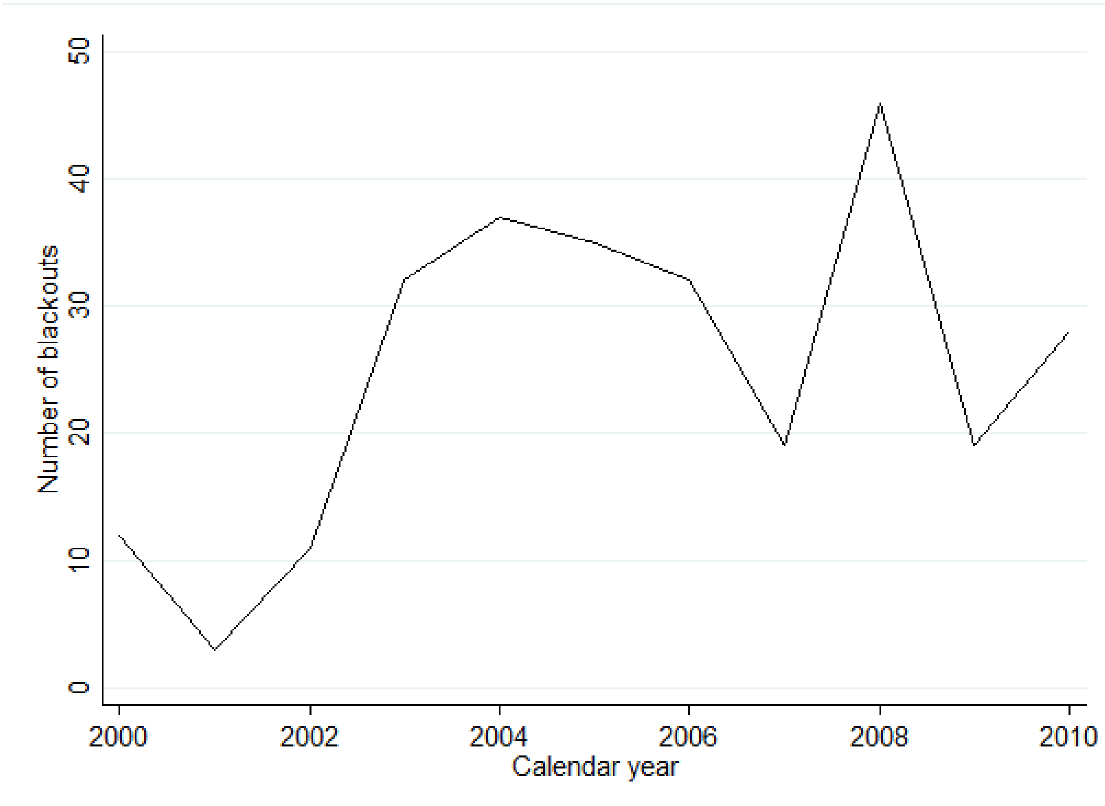

Figure 3.1. Sample blackouts over time

$$r_t = \frac{(p_t f_t + d_t) - p_{t-1}}{p_{t-1}}$$

where

p_t= Closing price at period t

p_{t-1}= Closing price at period t-1

f_t= split factor

d_t= dividends at period t

Since dividends and splits are relatively infrequent events, the return of a security on most days is simply calculated as the daily percentage change in the stock price.

$$r_t = \frac{p_t - p_{t-1}}{p_{t-1}}$$

Market Capitalization is the product of the share price and the number of outstanding shares.

$$price \times outstandingshares$$

Industry Return is the value-weighted average of all the stocks of electric power utilities. Utility stocks are classified by their standard industrial classification (SIC) codes: 4911 (electric services) and 4931 (electric & other services combined).

I create this return by weighting the average of all utility stocks by their respective market capital at the end of the previous trading period.

$$R_{Ind} = \frac{\sum MC_{i,t-1} r_{i,t}}{\sum MC_{i,t-1}} \tag{3.1}$$

where

R_{Ind} = Industry Return

$MC_{i,t-1}$ = Market Capitalization of the ith firm in the utility industry at period t-1

Portfolio Return I index utilities experiencing a blackout on the same day into a portfolio. Hence, a portfolio return is value weighted average return of all the stocks in the portfolio. It is estimated in a similar fashion to the market and industry returns.

$$R_p{}^{VW} = \frac{\sum MC_{i,t-1} r_{i,t}}{\sum MC_{i,t-1}} \tag{3.2}$$

Table 3.3. Financial Characteristics of Selected Firms

Variable	Mean	Std. Dev.	Min.	Max.
Share Price($)	37.55	18.19	3.49	126.07
Shares Outstanding(1000)	215,581	194,335	378	1,329,144
Daily Return(%)	0.041	0.0179	-49.47	62.96
Market Return(%)	0.0283	1.341	-8.98	11.50
Industry Return(%)	0.0308	0.0129	-8.28	13.8
Market Cap(1000$)	7,502,6312	7,516,810	12,947	60,116,115

3.3 Event Study Method

I use the event study method to study investor reaction to blackouts affecting publicly traded electric power utilities. As the name implies, an event study attempts to quantify the effect of an observed event on the stock returns of a firm or a group of firms[26]. Theoretically, the price of a stock is determined by the present value of expected future income streams. The expected future income of a company may be affected by a number of factors which may lead to investors revising the value of the company's stock.

Event studies are predicated on the premise of the semi-strong form of the efficient market hypothesis. The efficient market hypothesis argues that new publicly available information is quickly incorporated into share prices[8]. New information is expected to drive the security prices in a manner directed by the nature of the information, hence, any news that is detrimental, perceived or actual, to the future cash flows of the company will make investors pessimistic about the future. A downward revision of a utility's future cash flows will result in a decreased demand for its stock ultimately leading to a lower stock price as a result of investors selling their shares. For positive news, an upward revision can be expected. I attempt to determine, by using an event study, how investors react to blackouts. This process involves checking for abnormal returns (AR) which is the difference between the actual return and an estimated expected return in the absence of a blackout.

A model for estimating expected returns must be established in order to calculate the abnormal returns associated with a blackout. There are many model choices that can be used for this purpose and the popular options include the index model, market model, and the capital asset pricing model (CAPM)[1]. The **index model** is a simple approximation that assumes that over any period t, the return on the ith share will be equal to the market return. The abnormal return, AR_{it} is then estimated by subtracting the market return R_{mt} from the actual return, R_{it}

$$AR_{it} = R_{it} - R_{mt}$$

The **Capital Asset Pricing Model** gives the expected return on a share by adding a risk premium to the rate on a risk-free asset. It is expressed mathematically as

$$E(R_{it}) = R_{ft} + \beta_i[R_{mt} - R_{ft}] \tag{3.3}$$

where

R_{it} = return of ith stock
R_{ft} = return on a risk-free asset
β_i = beta of the ith stock
R_{mt} = market return

The abnormal returns are then calculated as

$$AR_{it} = R_{it} - E(R_{it})$$

The **Market Model** is a simple estimation of the CAPM, that in most cases performs suitably well or better than other models[27]. It indicates that the return on the ith security in period t is a function of the market return and a disturbance term specific to security i. An estimate of the disturbance term is the abnormal return of the security. The analysis that follows relies on the market model. Instead of using the individual return of securities as the dependent variable in the regression analysis, I create a value weighted portfolio return of securities that experience an event on the same day. There is evidence of cross-correlation of stock returns which renders the assumption of independent and identically distributed observations invalid, hence the central limit theorem essential for the inference testing invalid as well. This problem is solved by creating

[1] A more detailed explanation of the pros and cons of the different models is provided in Armitage (1995)

and using portfolio returns in place of individual stock returns[2].

$$R_{p,t} = \alpha_{p,t} + \beta_p R_{ind,t} + \epsilon_{p,t} \tag{3.4}$$

where

$R_{p,t}$= Return of portfolio p

α and β= regression coefficients

$R_{ind,t}$= Industry return

$\epsilon_{i,t}$= error term

I select a time period of 180 trading days before a blackout occurs to estimate the expected portfolio return based on the market model using ordinary least square (OLS) regression. This period, known as the estimation period, is used to determine the relationship between the returns of the portfolios in question and the industry return. The estimates for α and β are then used to predict the expected return given as

$$E[R_{p,t}] = \hat{\alpha} + \hat{\beta} R_{ind,t}$$

The abnormal returns[3] can then be calculated as the difference between the expected portfolio return and the actual portfolio return

$$AR_{p,t} = R_{p,t} - E[R_{p,t}] \tag{3.5}$$

I define day 0 as the day a blackout occurred. Day 1 represents the next trading day after a blackout occurred. For each portfolio of securities, the abnormal returns are calculated for each trading day after a blackout occurs by using equation 3.5. I also want to examine the cumulative abnormal returns (CAR) for each portfolio in different time periods after a blackout, hence, a cumulation procedure for each portfolio is given as

$$CAR = \sum_{t=1}^{T} AR_{p,t} \tag{3.6}$$

where

CAR=Cumulative abnormal return

T= the day of interest after the blackout

Significance Test

To check if the estimated abnormal returns are significant, I weight each portfolio's abnormal return by an estimate of its standard deviation $\hat{SD}_p$ calculated over the estimation period of 180

[2] There is no evidence that portfolio returns are cross-sectionally correlated, hence the i.i.d. assumption is not violated

[3] Abnormal returns of a portfolio can be simply interpreted as its deviation from its expected relationship from the average industry returns. Likewise, the cumulative abnormal return is the cumulative deviation.

days before the blackout occurs to give the portfolio standardized abnormal returns (SAR) . This calculation accounts for the volatility of a portfolio, thus preventing portfolios with high levels of variability from dominating the statistical tests. The SAR is given as

$$SAR_{pt} = \frac{AR_{pt}}{S\hat{D}_p} \tag{3.7}$$

I also estimate a cumulative standardized abnormal return (CSAR) in a similar fashion to equation 3.6

$$CSAR = \sum_{t=1}^{T} SAR_{p,t} \tag{3.8}$$

The estimated values for CSAR are only valuable for carrying out statistical tests. The actual values of interest are the estimated CARs, however, proper statistical testing requires checking if estimated CSAR values across portfolios are different from zero. The test statistic is esitmated as

$$t = \frac{CSAR}{\frac{s}{\sqrt{n}}} \tag{3.9}$$

Chapter 4

Results and Discussion

4.1 Average Effect

Figure 4.1 presents the ACARs of all the 208 portfolios in the sample for the period (1 to 60) i.e. from the 1st day after the blackout till the 60th day. The estimated values, more or less, increase after an initial drop in the first few days.

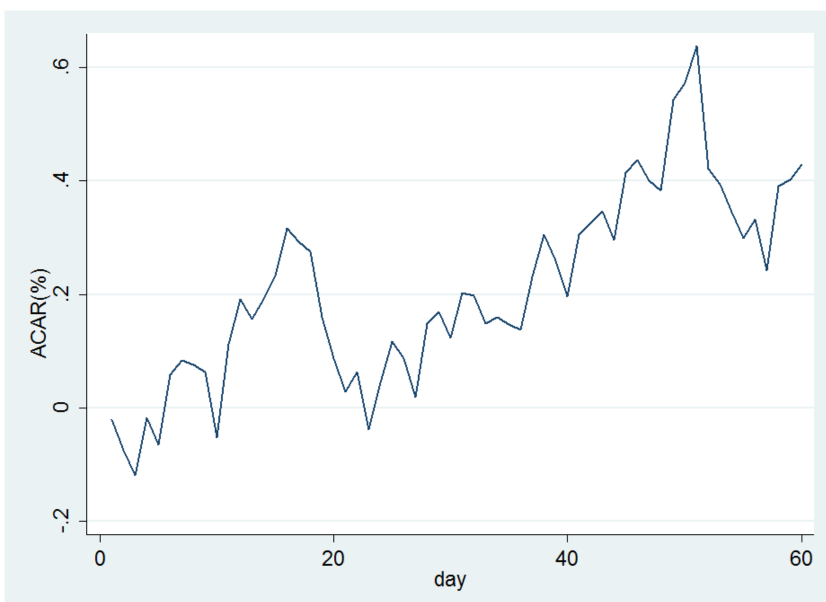

Figure 4.1. ACAR of all blackouts

Small negative abnormal returns in the first few days likely reflects utilities tapping into their cash reserves and in some cases using short term loans to pay for power restoration efforts. The depletion of a utility's cash reserves coupled with the loss of revenues as a result of being unable to serve customers would affect the short term cash flow of a utility and can lead to a drop in the present value of a utility's stock, hence negative abnormal returns. However, as more news and information filters in to the market, investors may decide that the financial effects of the blackouts are not too costly and utilities are well equipped to cover the costs leading to positive abnormal returns.

Most blackouts in this sample are relatively small with most blackouts affecting only a few hundred thousand people at a time and had an average recovery period of less than four days. Investors may interpret a short recovery period as a signal of a well prepared utility with enough resources to tackle blackouts. More importantly, quickly restoring power to customers ensures that utilities do not suffer long periods without revenue. The general upward progression of the ACARs in figure 4.1 is likely indicative of the fact that utilities are no longer spending cash in recovery efforts and are also able to earn revenue. Investors may interpret short blackout recovery periods with a well managed and efficient utility likely to successfully argue for a rate increase to recoup the costs of restoration efforts and the costs of new capacity essential to preventing future blackouts.

Table 4.1. Average effect of all blackouts

Day	**ACAR(%)**	**CSAR** (standard errors)	**% of negative** ACARs
1	-0.021	-0.000199	51.4
		(0.0595)	
2	-0.076	-0.064	51.4
		(0.0946)	
5	-0.066	-0.144	57.2
		(0.159)	
10	-0.053	-0.0522	51.4
		(0.263)	
15	0.23	0.234	48.1
		(0.310)	
20	0.086	0.0165	44.2
		(0.337)	
25	0.118	0.120	46.1
		(0.375)	
30	0.123	0.226	47.6
		(0.408)	

Significance:*10%, **5%, ***1%

The observed increases in abnormal returns, however, are all very small in magnitude with the maximum value of 0.6% occurring roughly 50 days later. Taken as a whole, the results in table 4.1 provide no conclusive evidence of utilities over performing after a blackout occurs. None of the estimated CARs in any of the time periods are statistically significant and the estimated value of 0.6% after 50 days is of very little economic significance.

4.2 Cause Based Effects

I divide the overall sample into three sub-samples based on blackout cause: natural disasters, non-extreme weather events, and other issues. I then check to see if investor reaction is sensitive to the cause of blackout.

Effects of Blackouts caused by Natural Disasters: Figure 4.2 shows the ACARs of the 58 portfolios in this sample. Besides a window of about ten days, the estimated values are generally negative possibly reflecting investor concern about blackouts caused by natural disasters. The negative ACARs are relatively small in magnitude with the largest negative value of roughly 0.5% occurring five and ten days after the blackout. CARs on day 5 and day 10 are borderline significant. Very little conclusion of investor reaction to natural disasters can be made from this result, though most of the estimated ACARs are negative, these values are small in magnitude (of very little economic significance) and are insignificantly different from zero.

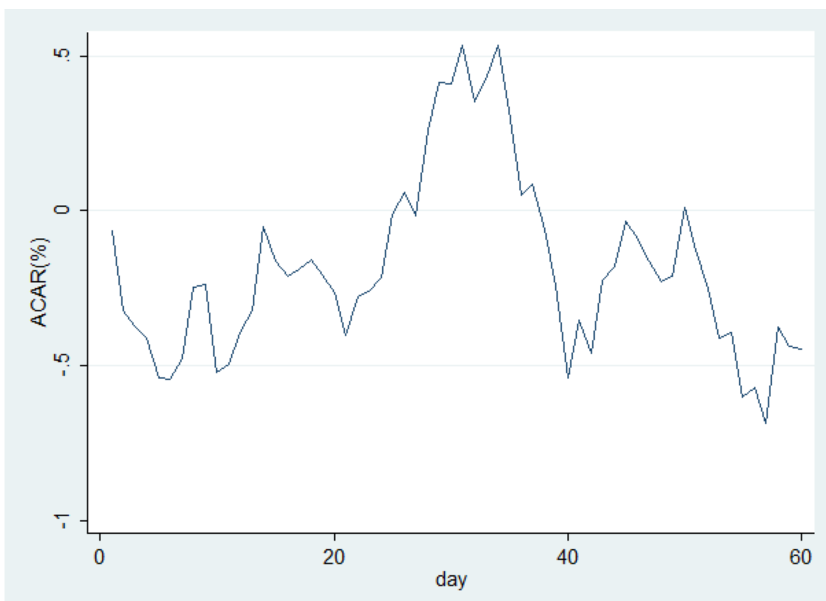

Figure 4.2. ACAR of Natural disaster based events

Long Recovery vs Short Recovery

I also check to see if investors react differently to blackout recovery periods.[1] Figure 4.3 compares ACARs of blackouts with long recovery periods to those with short recovery periods We see a steep drop in ACARs after day 10 which is likely caused by the longer than usual

[1] A long recovery period is longer than 10days while a short recovery period is less than 10days

Table 4.2. Average effect of blackouts caused by natural disasters

Day	ACAR(%)	CSAR (standard errors)	% of negative ACARs
1	-0.0656	-0.0359 (0.136)	55.2
2	-0.321	-0.317 (0.226)	58.6
5	-0.541	-0.581 (0.309)*	60.3
10	-0.524	-0.788 (0.424)*	58.6
15	-0.164	-0.345 (0.5422)	60.3
20	-0.266	-0.535 (0.567)	53.4
25	-0.0133	-0.169 (0.719)	50
30	0.411	0.139 (0.822)	46.5

Significance:*10%, **5%, ***1%

recovery times. By day 25, we observe an ACAR of -8.94%. News of customers not having electricity after such a long period is likely to disturb investors. Long recovery time periods may signal that a utility does not have the necessary resources to adequately restore power in a timely fashion. Utilities in this situation have probably depleted their cash reserves significantly in order to restore power. Investors may doubt the ability of utilities to recoup all the restoration costs hence leading to this significant drop. After day 23, the value of the ACARs begins to rebound likely reflecting that all power has been restored and utilities are once again able sell power to their customers.

However, we observe small positive ACARs for blackouts with short recovery periods. The results show that investors are not overly concerned with these types of blackouts because utilities are well prepared to handle them. The positive ACARs seem to agree with the idea that blackouts present an opportunity to earn more profits, however statistical significance is not significant in any of the time periods of interest.

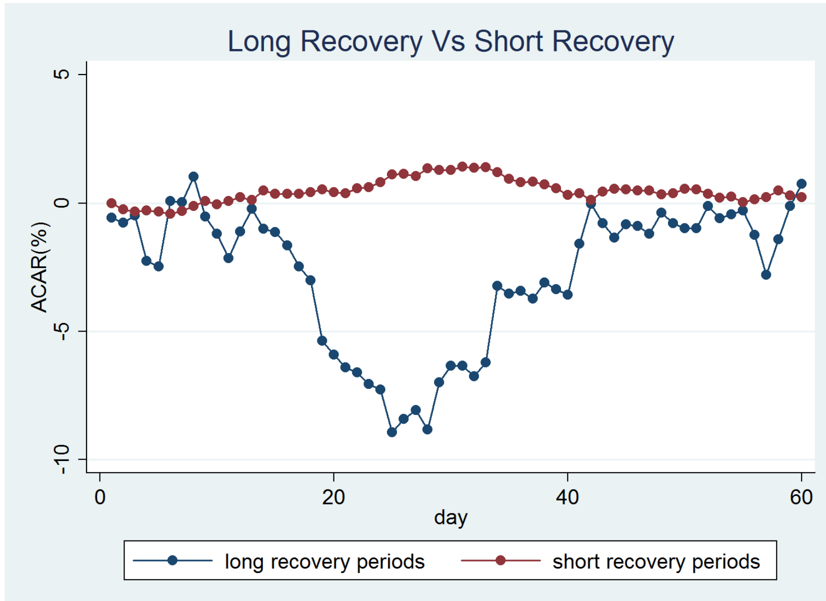

Figure 4.3. ACARs of Blackouts with long recovery and short recovery periods

Table 4.3. Average Effect of Blackouts with Long Recovery Periods

Day	**ACAR(%)**	**CSAR** (standard errors)	**% of negative** ACARs
1	-0.577	-0.469 (0.259)*	71.4
2	-0.758	-0.686 (0.539)	57.1
5	-2.47	-1.84 (1.12)*	71.4
10	-1.19	-0.296 (2.39)	57.1
15	-1.13	-0.42 (2.67)	57.1
20	-5.92	-4.89 (3.76)	85.7
25	-8.94	-7.07 (4.28)*	85.7
30	-6.33	-5.35 (3.17)*	71.4

Significance:*10%, **5%, ***1%

Effects of Non-Extreme Weather Induced events: Figure 4.4 shows small positive ACARs for blackouts caused by non-extreme weather events. These values are all statistically insignificant.

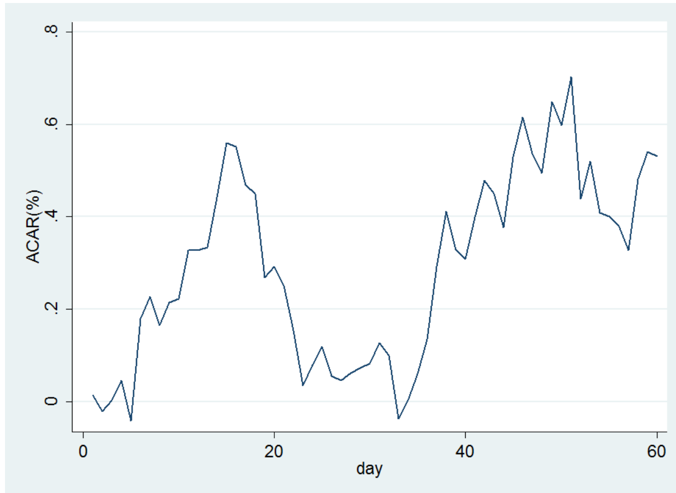

Figure 4.4. ACAR of Non-Extreme Weather Events

4.3 Customer Size Effect

I form two groups to see how investors react to the number of customers affected. Group 1 includes blackouts which affected less than one million customers while group 2 includes blackouts that affected more than one million customers. Figure 4.5 shows the ACARs of interest based on the number of customers affected. For blackouts affecting less than one million people, we notice that there are small positive but statistically insignificant abnormal returns. The observed ACARs show that investors do not view these types of blackouts as a negative factor when evaluating the future cash flow of utilities.

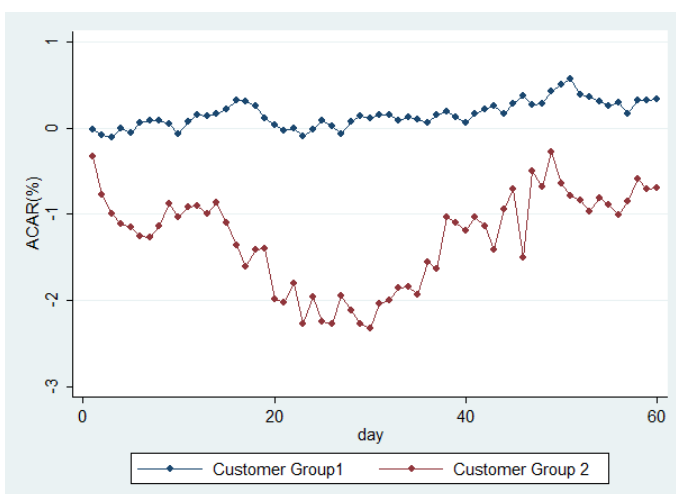

Figure 4.5. ACAR of blackouts based on number of customers affected

On the other hand, the results for group 2 (over one million customers) show negative ACARs through all the days of interest with statistical significance generally holding throughout. The average restoration period for this sub-sample is roughly 6 days, however the decline in ACARs still continues till the 30th day. In this case, investors probably are not pleased with utilities exposing so many of their customers to blackouts at the same time. Perhaps investors expect well managed utilities to have processes in place to prevent such large scale power outage.

Table 4.4. Average Effect of Blackouts affecting over 1million customers

Day	**ACAR(%)**	**CSAR** (standard errors)	**% of negative** ACARs
1	-0.333	-0.52	80.00
		(0.224)***	
2	-0.773	-1.335	60.00
		(0.621)***	
5	-1.156	-1.928	80.00
		(0.737)***	
10	-1.03	-2.23	73.33
		(1.26)*	
15	-1.11	-2.53	73.33
		(1.16)***	
20	-1.99	-3.42	73.33
		(1.69)**	
25	-2.24	-3.56	73.33
		(1.347)***	
30	-2.33	-3.449	73.33
		(1.343)***	

Significance:*10%, **5%, ***1%

Chapter 5

Conclusion

In this thesis, I investigated the reaction of investors to blackouts and the impact it has on stock market value of publicly traded electric power utilities. For the entire sample of blackouts, I observed small positive ACARs after a blackout with the maximum ACAR of 0.62% occurring 50 days after the blackout. This value is very small and of little economic significance. Hence, I cannot conclude blackouts signal to investors the possibility of future profits. Furthermore, none of the estimated Abnormal returns in any of the time windows were statistically significant. This is a reflection of the nature and distribution of most blackouts in this sample. More than 80% of the sample blackouts affect less than half a million customers and the average recovery period for all the events in this sample was 3 days. Because most of these events affect a smaller number of customers for short periods of times, the results show that investors are not concerned about negtive impacts to future cash flow.

I looked at other subsamples to get more clarity to investor reaction. The results for blackouts caused by non-extreme weather events and blackouts with short restoration periods are quite similar to the result I obtained from the overall sample. While most of the estimated ACARs were positive, they were small in magnitude and were not statistically significant. The same applied to the results from blackouts that affected less than one million customers. This further buttresses the earlier conclusion that investors are not overly concerned about the impact of cash flow caused by these types of blackouts. However, the results for blackouts with long recovery periods and blackouts affecting greater than a million people showed some interesting result. After 25 days, utilities that needed more than 10 days to restore power had suffered an average of -8.94%, significant at the 10% level. Investors may believe that utilities should be well prepared to restore power to customers after a blackout, and failure to do so may reflect investor doubt in managements ability to handle blackouts and also to successfully recoup their restoration costs in a rate case. I also observed negative ACARs for blackouts affecting more than a million customers with the lowest value of -2.5% occurring 23 days after the blackout. The average recovery period of this sample was under six days, however ACARs continued decreasing till day 23. Statistical significance generally holds for all the days of interest, proving that investors indeed view these types of events as a bad thing for a utility.

I conclude that investors expect utilities to be well equipped to handle most blackouts. However, blackouts affecting millions of customers or blackouts with long recovery periods force investors to revise the value of the affected utility's stock.

Appendix A

Descriptive Statistics

Table A.1. Descriptive Statistics

	portfolios	Avg.no. customers	Average Restoration Period
Complete sample	208	357303.9	3.18
Natural Disaster	59	451,120.6	4.59
Long Natural Disaster	7	747625.2	13.625
Short Natural Disaster	56	431,342.2	3.58
Non extreme weather	135	280912	2.98
Group 1	200	249363.6	3.02
Group 2	15	1,989,108	5.59

Table A.2. Natural Disaster Data

	Occurrences	Avg.no. customers	Avg Restoration days
Tornadoes	1	186000	3
Wild Fire	1	108000	23
Earthquake	2	200375	0.5
Lightning	5	283681.6	1.6
Tropical Storm	12	223184.8	2.1
Ice Storm	21	331572.1	5.2
Hurricanes	38	643547.4	5.24

Table A.3. Descriptive Statistics of Customer Groups

	portfolios	Avg.no. customers	min	max
Group 1	200	251,575.8	100,000	964,000
Group 2	15	1,971,450	1,100,000	3,241,437

Table A.4. Average Effect of Natural Disaster Blackouts with short Recovery Periods

Day	**ACAR(%)**	**CSAR**	**% of negative** ACARs
1	-0.0095	0.015 (0.148)	54.5
2	-0.247	-0.239 (0.236)	54.5
5	-0.341	-0.412 (0.296)	60.00
10	-0.059	-0.38 (0.454)	54.5
15	0.363	0.105 (0.570)	49.1
20	0.427	0.909 (0.831)	45.45
25	1.12	0.796 (0.654)	45.45
30	1.29	0.909 (0.831)	43.6

Significance:*10%, **5%, ***1%

Table A.5. Average Effect of Non-Extreme Weather Conditions

Day	**ACAR(%)**	**CSAR** (standard error)	**% of negative** ACARs
1	0.015	0.0278 (0.0689)	51.11
2	-0.0191	0.00406 (0.103)	51.11
5	-0.0592	-0.0622 (0.196)	57.78
10	0.257	0.409 (0.348)	48.89
15	0.573	0.551 (0.398)	46.67
20	0.272	0.284 (0.436)	43.7
25	0.08	0.09 (0.489)	48.1
30	0.0188	0.0799 (0.518)	48.89

Significance:*10%, **5%, ***1%

Table A.6. Average Effect of Blackouts on Customer Group 1

Day	**ACAR(%)**	**CSAR**	**% of negative** ACARs
1	-0.016	0.0255 (0.06)	49.75
2	-0.0776	-0.025 (0.095)	50.75
5	-0.0606	-0.087 (0.166)	56.28
10	-0.0747	0.0562 (0.269)	50.25
15	-0.213	0.339 (0.320)	47.24
20	0.0416	0.099 (0.353)	44.22
25	0.086	0.203 (0.403)	46.23
30	0.107	0.273 (0.436)	46.23

Significance:*10%, **5%, ***1%

Appendix B

Standard Error Bar Charts

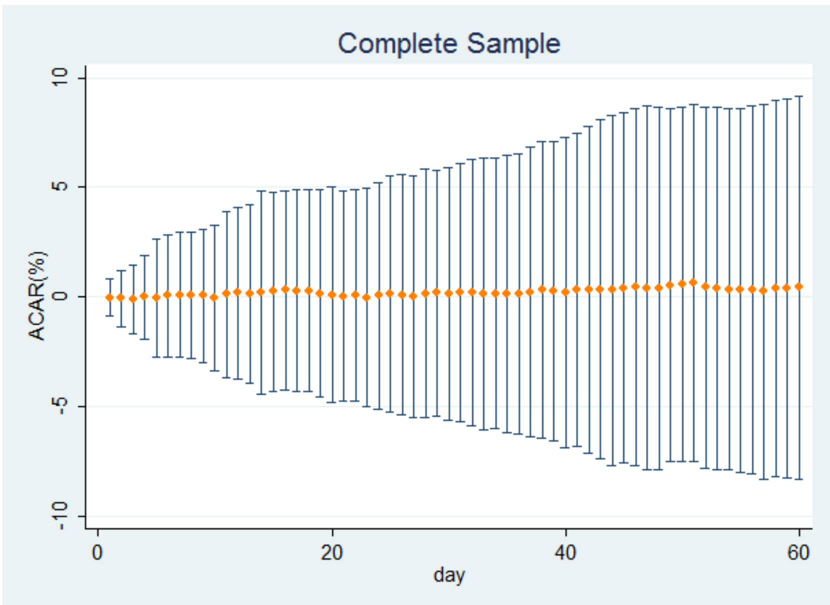

Figure B.1. Standard error plots for all blackouts

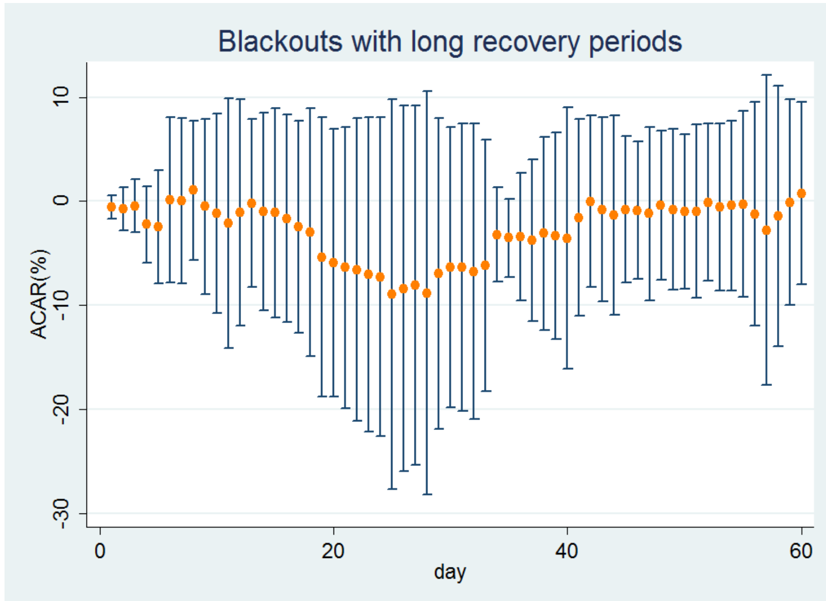

Figure B.2. Standard error plots for blackouts with long recovery periods

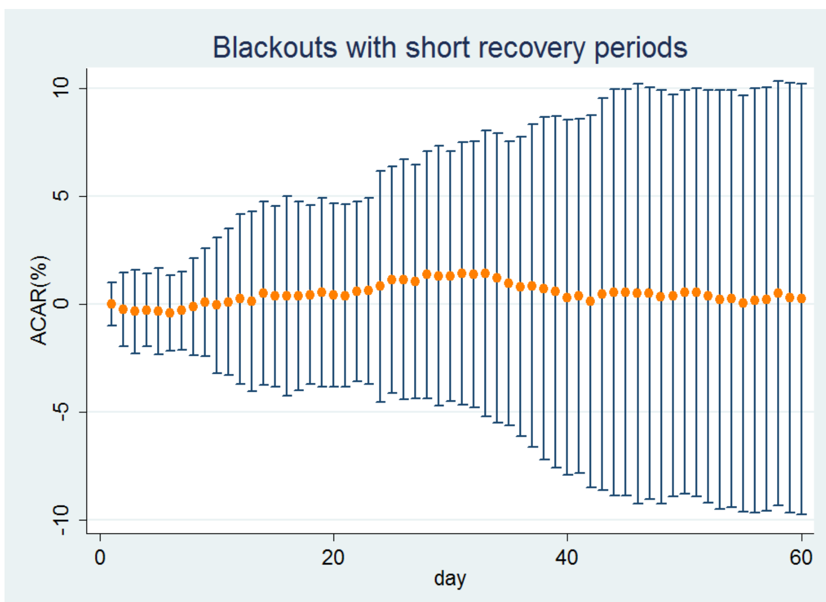

Figure B.3. Standard error plots for blackouts with short recovery periods

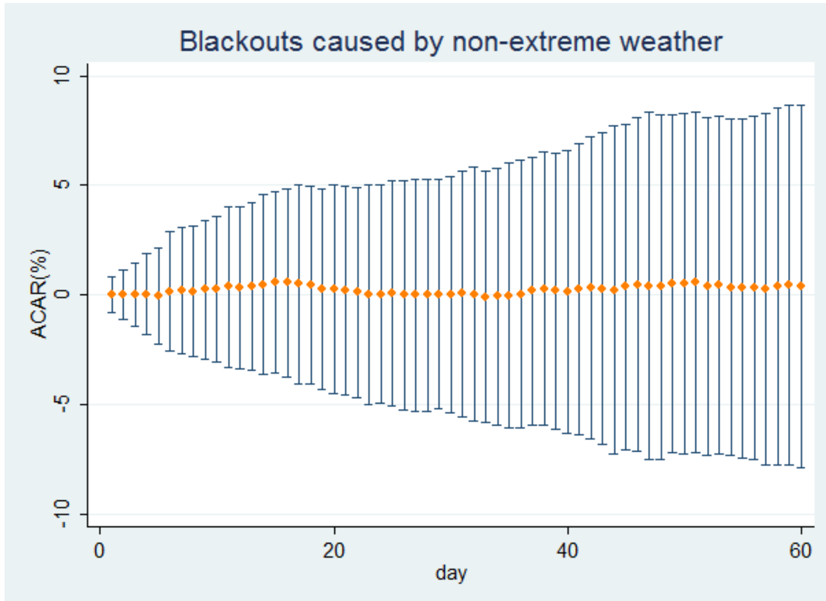

Figure B.4. Standard error plots for blackouts caused by non-extreme weather events

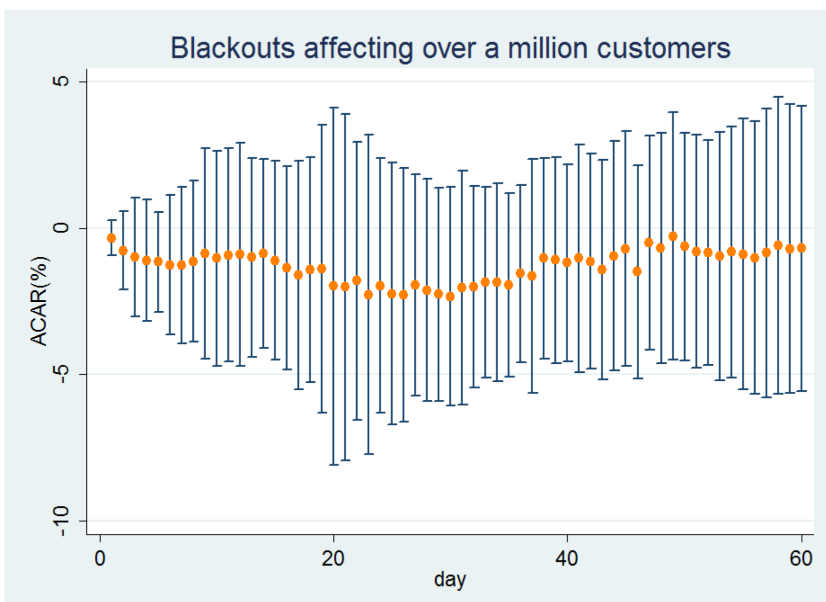

Figure B.5. Standard error plots for blackouts affecting over a million customers

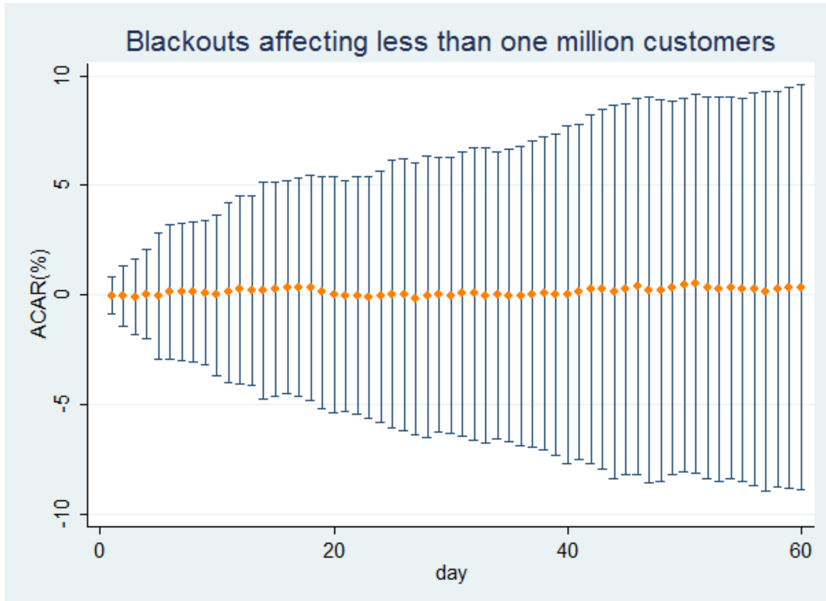

Figure B.6. Standard error plots for blackouts affecting less than one million customers

Bibliography

[1] "Information on Blackouts in North America," .
URL http://www.nerc.com/page.php?cid=5|66

[2] LaCommare, K. H. and J. H. Eto (2006) "Cost of Power Interruptions to Electricity Consumers in the United States (US)," **31**(4), pp. 1845–1855.

[3] (2004) *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, *Tech. rep.*, U.S.-Canada Power System Outage Task Force.

[4] Anderson, P. L. and I. K. Geckil (2003) "Northeast Blackout Likely to Reduce U.S. Earnings by $6.4 Billion," AEG Working Paper 2003-2.

[5] "Spike in deaths blamed on 2003 New York Blackout," .
URL http://www.reuters.com/article/2012/01/27/us-blackout-newyork-idUSTRE80Q07G20120127

[6] Apt, J., L. Lave, S. Talukdar, M. Morgan, and M. Ilic (2004) "Electrical Blackouts: A Systemic Problem," *Issues in Science and Technology*, **20**, pp. 55–61.

[7] Fama, E. F. (1965) "The Behavior of Stock-Market Prices," *The Journal of Business*, **38**(1), pp. 34–105.

[8] Fama, E. F., L. Fisher, M. C. Jensen, and R. Roll (1969) "The Adjustment of Stock Prices to New Information," *International Economic Review*, **10**(1), pp. 1–21.

[9] Jaffe, J. F. "The effect of regulation changes on insider trading," .

[10] ——— (1974) "Special Information and Insider Trading," *The Journal of Business*, **47**(3), pp. 410–428.

[11] Mandelker, G. (1974) "Risk and Return: The Case of Merging Firms," *Journal of Financial Economics*, **1**, pp. 303–335.

[12] Patell, J. M. (1976) "Corporate Forecasts of Earnings Per Share and Stock Price Behavior: Empirical Test," *Journal of Accounting Research*, **14**(2), pp. 246–276.

[13] Hamilton, J. T. (1995) "Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data," *Journal of Environmental Economics and Management*, **28**, pp. 98–113.

[14] Drees, F., M. Mietzner, and D. Schiereck (2013) "Effects of corporate equity ownership on firm value," *Review of Managerial Science*, **7**, pp. 277–308.

[15] Kawashima, S. and F. Takeda (2012) *The Effect of the Fukushima Nuclear Accident on Stock Prices of Electric Power Utilities*, *Tech. rep.*, University of Tokyo.

[16] Carreras, B. A., V. E. Lynch, I. Dobson, and D. E. Newman (2004) "Complex Dynamics of Blackouts in Power Transmission Systems," *Chaos*, **14**, pp. 643–653.

[17] Carreras, B. A., V. E. Lynch, D. Newman, and I. Dobson (2003) "Blackout Mitigation Assessment in Power Transmission Systems," in *Hawaii International Conference on System Science*, IEEE.

[18] Simonoff, J. S., C. E. Restrepo, and R. Zimmerman (2007) "Risk-Management and Risk-Analysis-Based Decision Tools for Attacks on Electric Power," *Risk Analysis*, **27**(3), pp. 547–570.

[19] Joo, S.-K., J.-C. Kim, and C.-C. Liu (2007) "Empirical Analysis of the Impact of 2003 Blackout on Security Values of U.S. Utilities and Electrical Equipment Manufacturing Firms," *IEEE Transactions on Power Systems*, **22**(3), pp. 1012–1018.

[20] "Defensive Stock," .
URL `http://www.investopedia.com/terms/d/defensivestock.asp#axzz27gd5FANL`

[21] Dahl, C. A. (2004) *International Energy Markets: Understanding Pricing, Policies and Profits*, Penn well Corporation.

[22] Averch, H. and L. L. Johnson (1962) "Behavior of the Firm Under Regulatory Constraint," *The American Economic Review*, **52**(5), pp. 1052–1069.

[23] Lyon, T. P. and J. W. Mayo (2005) "Regulatory opportunism and investment behavior: evidence from the U.S. electric utility industry," *RAND Journal of Economics*, **36**(3), pp. 628–644.

[24] "Puget Sound Energy sold to foreign investors," .
URL `http://www.thenewstribune.com/2008/12/31/581321/puget-sound-energy-sold-to-foreign.html`

[25] "TXU Corp. Announces Completion of Acquisition by investors Led by KKR and TPG," .
URL `http://media.kkr.com/media/media_releasedetail.cfm?ReleaseID=332996`

[26] Salinger, M. (1992) "Value Event Studies," *The Review of Economic and Statistics*, **74**, pp. 671–677.

[27] Armitage, S. (1995) "Event Study Methods and Evidence on their Performance," *Journal of Economic Surveys*, **8**(4), pp. 25–52.