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The Shareholder Value Effect of System Overloads: An Analysis of Investor Responses to the 2003 Blackout in the US

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ABSTRACT

This study investigates the stock price reaction of electric energy utility firms to the 2003 blackout in the Northeast of the USA and if the market was able to identify the responsible firm. Therefore, we employ event study methodology and select a sample of US-based electric energy utility firms. Although it took a commission almost 8 months to name the firm responsible for the blackout, investors punished FirstEnergy only two trading days after the blackout - and were right, as it later turned out. This study demonstrates this based on the analysis of abnormal stock returns and abnormal trading volumes. Our findings suggest that investors have extensive knowledge of electric energy utility firms' responsibility as they were able to identify the culprit. This, in turn, demonstrates that electric power utility firms should ensure a high-quality grid infrastructure to avoid these negative outcomes.

Keywords: Event Study, Blackout, System Overload, Market Efficiency
JEL Classifications: G1, Q40

1. INTRODUCTION

On 14 August 2003 shortly after 4 pm, a large part of the northeast of the USA experienced a major blackout. In total, the blackout left 50 million people without electricity for up to 2 days and contributed to at least 11 deaths, making it one of the most severe blackouts in US history. The blackout was a consequence of a series of human and system failures, including overgrown trees next to the high-voltage power line and bugged alarm systems at FirstEnergy Corporation (FirstEnergy), which did not inform the control room of the line damage (Minkel, 2008). The blackout itself, however, represented only the tip of the iceberg as the power system in the Northeast of the US has long been subject to inadequate transmission capacity and bottlenecks due to a limited number of high-voltage lines. This, in turn, fostered the emergence of the blackout as local generators tried to supply energy to areas in need which caused the lines to overload and to collapse, ultimately. Since the privatization and liberalization of the US electric energy system, there was limited interest in private utility firms to invest in new wires, new towers, and new transformers, which eventually fostered the occurrence of the system overload and the corresponding blackout (Antonsen et al., 2010; Firestone and Pérez-Peña, 2003; Xin, 2005). Yet, not everyone shared this opinion of relevance. Traders of Wall Street did not seem to expect lasting damage and trading to be normal and secured by backup generators (McGeehan and Schwartz, 2003). We want to test this claim and pose the following research question:

RQ1: Did the blackout trigger abnormal returns for electric power utility firms on the stock market?

Second, we want to analyze whether the stock market was able to identify the responsible firm for the blackout (system overload) which we cover in our second research question:

RQ2: Was the stock market able to identify the responsible firm (culprit)?

To this end, we employ event study methodology and analyze the abnormal stock returns and trading volumes associated with the blackout incident (MacKinlay, 1997).

Several scholars have examined the economic consequences of electricity blackouts. They found that electricity blackouts are generally associated with adverse effects on labor productivity of affected firms due to work interruptions (Falentina and Resosudarmo, 2019; Fisher-Vanden et al., 2012; Anderson et al., 2007; Nkosi and Dikgang, 2018; Yamashita et al., 2008), making them particularly costly in economic terms with regard to welfare losses.

To analyze the effects of blackouts on specific firms, scholars also employ event study methodology to examine respective stock price reactions (Yamashita et al., 2008). Previous empirical analyses on the stock price reaction to the 2003 blackout and blackouts in general by electric power utility firms already provided first evidence in that regard: Blumsack and Ositelu (2015) conducted a comprehensive analysis of 274 blackouts between 2000 and 2010 and further distinguished their sample of blackouts regarding their causes. For their overall sample, they report average abnormal stock losses for electric power utility firms shortly after the blackout, which is followed by an above-average stock recovery phase. For blackouts in consequence of a natural disaster, this stock recovery phase takes longer as damages caused by natural disasters are usually devastating and require large investments. Finally, they provide evidence that blackouts affecting more than one million customers imply stronger average abnormal stock losses than 'smaller' blackouts. Joo et al. (2007) specifically investigated the impact of the 2003 blackout on the stock returns of 36 electrical power suppliers and 22 electrical equipment suppliers in the US. They grouped their sample and came to the general conclusion that electric power utility firms suffered significant stock losses upon the blackout event while electric equipment firms benefited from it.

Our research directly builds on this finding; however, it takes a different angle on this incident. We specifically want to identify not only how the stocks of electric power utility firms reacted to the blackout event but also if the market was able to identify the culprit before the official commission report.

Based on the literature review, we hypothesize that the stock price of the responsible firm (culprit), FirstEnergy, reacts negatively to the electricity blackout incident while other electric power utility firms remain neglected by the stock market. Therefore, we formulate the following hypotheses:

H0: There are no abnormal stock reactions to the blackout by the responsible firm (culprit).

H1: There are abnormal stock reactions to the blackout by the responsible firm (culprit).

2. MATERIALS AND METHODS

In the course of the investigation, we first calculate the normal returns to be able to define abnormal returns and then test for normal distribution. In a further step, we analyze the trading volumes to detect potential abnormal changes in volumes due to the blackout.

We select the event study methodology to answer our research questions. This event study aims to test the information efficiency of the stock market. It should determine if and when there was a reaction to new information being the announcement of the blackout. This strongly relates to the assumption of market efficiency. For our investigation, however, we assume a semi-efficient market whereas the blackout represents a meaningful event: according to estimates, it caused damage in the billions (Minkel, 2008) and similar evidence for other events has been provided by prior literature (Maloney and Mulherin, 2003). Therefore, event studies provide the clearest evidence on the efficiency of stock markets (Fama, 1991).

The existence of multiple events raises the question, which of these events should be used as the underlying event for the analysis. Building on information efficiency, we suggest the first emergence of the blackout represents a suitable event for this purpose, i.e., August 14th, 2003. This brings the advantage that the blackout still represents an exogenous shock and, thus, allows us to avoid problems of endogeneity (Eckbo et al., 1990; Prabhala, 1997). Therewith, we address the issue of premature information leakage efficiently, which would not be possible in the case of ex-ante insider knowledge.

In the literature, it is common practice to define an event window more generously, usually at least the day of the event and the following day (MacKinlay, 1997). However, as the blackout was unexpected for that day, we examine the event day [0] and include two subsequent days [+1] [+2] to account for potential time lags in the reaction.

At this point, one could argue that by extending the time window, further price reactions in the following days can be included, or that the abnormal return is not measured at all because it is even further away in time. While this is correct, it would otherwise also lead to increasing parameter instability (MacKinlay, 1997). Furthermore, the sensitivity of our analysis decreases with the length of the event window; i.e., the application of different calculation methods does not usually cause significant differences in the results (Fama, 1991).

Another positive circumstance is the exact time of occurrence. By clearly defining the event window, the model becomes more robust and reduces the sensitivity of the results (Brown and Warner, 1985). By that, we reduce the probability of further events overlapping, and, thus, improve the measurement accuracy with the 3-day event window.

As an additional analysis to identify the responsible firm, we employ a peer group and expect a non-reaction of the share prices of uninvolved peers and a significant abnormal (negative) return of the responsible firm under the condition of well-informed markets.

We do not examine the days before the blackout as we assume a semi-efficient market (Dow and Gorton, 1993; French and Roll, 1986). As already outlined, the premature leakage of information can be ruled out since insiders could have considered a blackout due to grid overload as probable. However, this would still have been fraught with many uncertainties that clear instructions for action would not be given. We, therefore, assume that this event study builds on publicly available information that can be determined in terms of time and was triggered by an exogenous shock.

We select the firms for the comparative analysis according to several criteria. First, we examine FirstEnergy, as the commission report identified it as the culprit. Then, this blackout could be relevant for all electric power utility firms across the board. To analyze that, we select a comparison group from the LexisNexis database. We include the following firms in the analysis to test whether the market only sanctioned the responsible firm:

- American Electric Power Company
- Consolidated Edison Inc.
- Dominion Resources Inc.
- Duke Energy Corporation
- PPL Corporation
- Public Service Enterprise Group Inc.

To become a comparative firm, the following conditions must be met by them: (1) the firm's shares are traded on the New York Stock Exchange during the entire investigation period; (2) a clear commitment in the energy sector, especially in the supply of electricity; and (3) a clear commitment in the region of the blackout, meaning the Northeast of the US.

We apply the general event study framework by MacKinlay (1997). The first step in analyzing the effect of the blackout is to calculate the normal returns. In the second step, we compare them with the actual returns to calculate the abnormal returns. If their distribution deviates from the null hypothesis, we can conclude a significant effect in step three. This procedure is considered to be a clear indicator of significant events (Fama, 1991), especially in the short term, and will be applied to the 2003 blackout in the following.

The first decision in calculating the normal rate of return is that of the adequate model. Since our event window is only 3 days long, methodological subtleties have only a marginal influence on the overall result. Furthermore, the results do not differ significantly within the group of statistical methods (MacKinlay, 1997). We deliberately refrained from using an economic model such as the CAPM or the APT since their restrictive assumptions can lead to high sensitivity of the results (Fama and French, 1996) or have little further empirical value (Brown and Weinstein, 1985). We, therefore, ultimately decide in favor of the market model (MacKinlay, 1997):

$$E(R_{it})=\alpha_i+\beta_i R_{mt}+\varepsilon_{it} \quad (1)$$

where $E(R_{it})$ represents the expected stock return for i on day t, R_{mt} the market return on day t, β_i the beta factor (risk), and ε_{it} the disturbance term. We set the period for calculating the normal return (estimation window) at one year, ending 10 days before the blackout. This is necessary so that the effects of the event do not influence the period, for which it is intended to serve as a benchmark (MacKinlay, 1997), although similar publications sometimes only include an estimation window of 3 months (Maloney and Mulherin, 2003). By using a longer period, we have achieved a better explanation of the residual deviation for all firms. With an even larger extension of the observation period, the remaining deviation decreases again, so that the stock market year, which is also usual in literature, provided the highest explanatory values in our model (Table 1).

The source for the returns is the "*RI*" ("Total Return Index") of Thomson Reuters Datastream which includes standardized returns with adjustments for changes in equity and elimination of accounting effects. Furthermore, they exclude tax effects and brokerage fees. RI_t thus indicates a theoretical increase in the value of a share, whereby investors always use dividends to purchase new shares at the ex-post distribution price.

We collected daily stock data. This allows a more accurate measurement of abnormal returns and thus strengthens the validity of this study. However, due to the lack of smoothing, these data are much more volatile than monthly or weekly data.

We normalized these returns and calculated the mean to obtain the normal market. This is the return that can be expected for the days following the event, assuming the null hypothesis. If the deviations of the following days cannot be explained, the null hypothesis must be rejected, and the event had a significant impact on the actual returns.

We selected the S&P500 as the market index as it represents a standard market portfolio. A portfolio consisting only of firms in the energy sector would not fulfill this purpose since a large part of the firms contained in it are part of this study and thus the independence of the sample from the population would no longer be guaranteed (Brown and Warner, 1980).

3. RESULTS

3.1. The Abnormal Returns Due to the Blackout

Table 1 displays the findings of the market model and depicts the expected returns for all firms in our sample.

Table 1: Market model estimation

Firm	Alpha	Beta	Market returns (%)	Expected returns (%)	R^2 (%)	F-Test (P-value)	Std. errors
First energy	0.006	0.661	0.05	0.63	49.00	0.00	0.062
American electric power company	–0.168	0.846	0.05	–16.80	52.20	0.00	0.075
Consolidated Edison Inc.	–0.027	0.287	0.05	–2.70	38.70	0.00	0.033
Dominion resources Inc.	–0.002	0.888	0.05	–0.20	69.00	0.00	0.055
Duke energy corporation	0.038	0.155	0.05	3.80	45.50	0.00	0.016
PPL corporation	0.055	1.186	0.05	5.60	76.70	0.00	0.060
Public service Enterprise group Inc.	0.045	1.555	0.05	4.60	63.30	0.00	0.109

Table 1 displays the alpha and beta coefficients, market returns, expected returns, the R2, the P-values of the F-test, and the standard errors of the estimates for the market model estimation based on daily returns, respectively.

The period for measuring the abnormal return begins on the day of the blackout, 14 August 2003 [0], and ends after two further trading days [+1] and +2]. They are calculated as the difference between the actual and the expected returns:

$$AR_{it}=R_{it}-E(R_{it}) \quad (2)$$

where AR_{it} refers to the abnormal returns for i on day t. We performed this calculation for all firms and compared the results with the expected value of the return. The differences are the abnormal returns. We tested the abnormal returns for statistical significance using a t-test, which tests the probability that the differences between the realized returns and the expected returns are random. To overcome the over-rejection of the null hypothesis due to event-induced variance and cross-sectional correlation, we employ the t-statistic by Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). Table 2 displays the abnormal returns for our event windows:

At first sight, one can see that the reactions are not strong except for FirstEnergy. On top of that, the ARs for FirstEnergy are the only ones that are highly significant. With regard to our hypothesis, we can conclude that the market was indeed able to identify FirstEnergy as the firm responsible for the blackout and that only two trading days after the blackout took place. This was reflected in a heavy sellout by the investors of FirstEnergy.

As a means of a robustness check, we have employed the publication date of the commission report (2 March 2004) as the underlying date for a further event study and to test whether the publication of the report triggered any abnormal stock reactions at FirstEnergy (Federal Energy Regulatory Commission, 2004). In line with our hypothesis, we do not detect any abnormal stock reactions neither for FirstEnergy nor for any other electric power utility firm in our sample (untabulated). This robustness check comprehensively confirms our initial finding and demonstrates that the market has already discounted the stock of FirstEnergy two trading days after the blackout and, therefore, did not react with the final publication of the commission report.

3.2. The Abnormal Trading Volumes Due to the Blackout

A significant correlation between the blackout and the values traded can also be demonstrated using trading volumes. Analogous to the calculation of the normal returns, we choose a period of one year to determine the mean of the traded volumes. These were again compared with the realized volumes of the following two trading days. We report the findings in Table 3. The null hypothesis is that the event did not influence the trading volume. At least for FirstEnergy, Consolidated Edison, Duke Energy, and the PPL, we cannot reject the null hypothesis.

It should be noted, however, that the trading volumes, except for FirstEnergy and Consolidated Edison, show negative deviations from historical values, i.e., the innocent firms were traded less than expected. As seen in Table 3, the deviations remain in the range of approx. 50% to just over 100%. This is less than one standard deviation for the innocent firms. Besides, our estimate of the degrees of regression was relatively good, since the standard deviations are on a fairly low level.

With FirstEnergy, on the other hand, the situation is quite different: trading was on average 5 times as high as expected and the standard

Table 2: Abnormal returns

Firm	[0] (%)	t-test (P-value)	[+1] (%)	t-test (P-value)	[+2] (%)	t-test (P-value)
First Energy	–0.88	0.6117	–1.34	0.4377	–9.93***	0.000
American Electric Power Company	0.46	0.8774	–0.46	0.8759	–1.25	0.6738
Consolidated Edison Inc.	–0.72	0.5816	–0.47	0.7187	0.04	0.9780
Dominion Resources Inc.	–0.60	0.6547	0.14	0.9160	–0.72	0.5902
Duke Energy Corporation	–0.59	0.2986	0.49	0.3843	–0.65	0.2470
PPL Corporation	0.07	0.9648	0.08	0.9573	–0.81	0.5900
Public Service Enterprise Group Inc.	–0.30	0.8673	0.70	0.6985	–0.69	0.7038

Table 2 reports the event study findings for the blackout event. We include three event window specifications and report respective abnormal returns. Statistical significance is determined based on the t-statistic of Boehmer et al. (1991) adjusted by Kolari and Pynnönen (2010). The p-values of the t-tests are provided behind each abnormal return. ***, ** as well as * denote statistical significance at the 1, 5, and 10% levels, respectively

Table 3: Abnormal trading volumes

Firm	14.08.2003	15.08.2003	18.08.2003	Mean (12 months)	% of expected trading	t-test (P-value)	Std. deviation
First Energy	1,123.00	1,438.00	16,812.00	1,208.00	534.40%	0.417	7.420
American Electric Power Company	917.00	567.00	673.00	2,380.00	30.20%***	0.004	0.078
Consolidated Edison Inc.	699.00	1,031.00	1,174.00	892.00	108.50%	0.643	0.277
Dominion Resources Inc.	12.00	9.00	6.00	63.00	14.10%***	0.001	0.046
Duke Energy Corporation	10.00	6.00	15.00	14.00	76.00%	0.324	0.320
PPL Corporation	1,437.00	454.00	705.00	1,587.00	54.50%	0.136	0.323
Public Service Enterprise Group Inc.	646.00	836.00	807.00	1,148.00	66.40%**	0.023	0.091

Table 3 includes the respective trading volumes on each day of the event window and the mean volume of the last 12 months before the blackout Furthermore, it displays the ratio of actual volumes in comparison to expected volumes in percent, the standard deviations, and indicates the statistical significance of the abnormal trading volumes based on the p-values of a two-tailed t-test. ***, ** as well as * denote statistical significance at the 1, 5, and 10% levels, respectively.

deviation was 7 times as high, so we can assume that the trading volumes of FirstEnergy stocks are much less of a coincidence than the other significant three. On closer inspection, it is also remarkable that almost all of this abnormal trading took place on the second trading day after the blackout. Analogous to the explanation of the abnormal return, we can conclude that the price determination took three trading days in total.

We, therefore, state that the trading of FirstEnergy's stock was more heavily to its disadvantage. As expected, most of the innocent firms did not experience any extraordinary trading volume. Why, however, the other firms despite Consolidated Edison - American Electric Power Company, Dominion Resources Inc., Duke Energy Corporation, PPL Corporation, and Public Service Enterprise Group Inc. - were traded less than usual remains an open question. There remains an increased presumption of innocence: the traders were sure that these three had nothing to do with the blackout and deliberately wanted to smooth the trading.

4. DISCUSSION AND CONCLUSION

This study intends to answer the question of whether the blackout on August 14, 2003, had a significant, negative impact on the stock returns and trading volumes of the firm responsible for the blackout. The primary objective of this study is to investigate whether markets react efficiently to the blackout as new information and can identify the culprit.

The tendency is to affirm this. The stock market identified FirstEnergy and punished it as the culprit within three trading days. Our models for this purpose are reliable. It took the investigative commission almost 8 months to reach the same verdict so that one can speak of a relatively fast and efficient reaction of the stock market. On the other hand, we can affirm an 'acquittal' for innocent firms, which have largely been neglected by investors despite the severity of the blackout. This, in turn, provides robust evidence that investors specifically targeted FirstEnergy as the firm responsible for the blackout.

The observed trading volumes support our results: FirstEnergy's stocks were subject to heavy trading which was several times as often as "normally," while most other firms remain below their normal trading volume. This again speaks for the theory of the punishment for FirstEnergy and the explicit disregard of innocent firms.

Finally, the nature and processing of the information also argue in favor of our results since the US-American media did not start addressing issues at FirstEnergy until Sunday, speaking for a rational, macroeconomic price formation and a semi-efficient market (CNN, 2003).

By providing this evidence for efficient and informed markets, we clearly illustrate that neglecting necessary investments in the infrastructure and security systems for cost-saving can ultimately lead to the opposite and yield heavy stock losses. This finding is in line with extant research examining ecological (Bouzzine, 2021; Bouzzine and Lueg, 2020) and social issues (Bouzzine and Lueg, 2021) and provides evidence that excessive cost-saving might turn out value-destructive and unsustainable (Lueg et al. 2015). Then, the market's ability to identifying the culprit only two trading days after the blackout reveals that investors are well-informed about the state of the energy infrastructure and whose responsibility this is. Thus, we recommend that electric power utility firms ensure a high-quality infrastructure to avoid these negative outcomes.

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