



Unexpected tax refunds and capital market efficiency: Evidence from the German nuclear fuel tax

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ABSTRACT

We investigate the efficiency of capital markets in reacting to a ruling of the German Constitutional Court in 2017, which led to a large unexpected tax refund for the three German-based operators of nuclear power plants. Unlike events used by prior research, this unique firm-specific event allows us to assess both, the magnitude and speed of the market reaction. With regard to magnitude, we find that the tax refund is fully impounded into stock prices within a few trading days after the court ruling. When investigating the speed of the market reaction more granularly, we show that 63% to 82% of the entire abnormal returns of the event date are already realized within the first minute after the announcement of the court ruling and, moreover, that significant market reactions occur even within 5 to 15 s.

1. Introduction

On January 1, 2011, Germany introduced a nuclear fuel tax regime, which levied a tax of EUR 145 per gram of the nuclear fuels plutonium 239/241 and uranium 233/235 when used for the commercial generation of electric power. Due to a sunset provision, the tax regime automatically expired at the end of 2016. However, on June 7, 2017, the German Constitutional Court unexpectedly, and with retroactive effect, declared the entire legislation to be incompatible with the German Constitution (German Constitutional Court, 2017). In consequence, the three German-based operators of nuclear power plants (treated firms) became immediately entitled to a refund for all their nuclear fuel tax paid during the years 2011 to 2016, i.e., EUR 6.5 billion in total (including interest).

Our paper contributes to a large body of research on the efficiency of capital markets in reacting to major firm-specific events. Specifically, we investigate both the speed and magnitude of the market reaction. The former describes how much time is needed for the market to respond to information about the occurrence of an event. The latter describes the extent to which the observed change in market capitalization corresponds to the expected monetary impact of the event on the firm. In contrast to our study, in most of the prior literature, market efficiency has been evaluated solely in terms of the speed of market reaction. Ample evidence exists that capital markets react within minutes or even seconds to announcements of earnings, dividends (Patell and Wolfson, 1984) and equity issuance (Barclay and Litzenberger, 1988), block trades (Dann et al., 1976), court decisions (Katz et al.,

2017) as well as releases of analyst opinions (Busse and Green, 2002). In contrast, evidence on the magnitude of market reaction is scarce because, for most events, the monetary impact on the affected firms cannot be determined ex ante. Among the few to present empirical evidence on magnitude of market reaction are Carter and Simkins (2004) and Wang and Corbett (2008). They show that stocks of airline and insurance companies that were expected to face larger losses following the September 11th terrorist attacks show higher negative returns than the stocks of firms expected to face smaller losses. Similarly, Sakariyahu et al. (2023) show that negative stock returns following mass shootings in the U.S. vary across industries. Also considering magnitude of market reaction, Frank and Javagannathan (1998) show that on ex-dividend days stock prices drop by less than the respective dividend payouts even in the absence of capital gains and dividend taxes.

We contribute by adding a small piece to the puzzle investigating a unique firm-specific event where both the exact volume of the cash inflow (EUR 6.5 billion) and the exact timing of the cash inflow (immediately) are known. In addition, the 2017 ruling of the German Constitutional Court (2017RCC) exclusively affected the three treated firms, and had no impact on their future cash flows, as the nuclear fuel tax had already expired by the time of the 2017RCC. This allows us to exactly determine the monetary impact of the event. Moreover, value-relevant information in rulings of the German Constitutional Court can be straightforwardly assessed. Specifically, there are only three possible outcomes: legislation is upheld, legislation is abolished for

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future periods and legislation is abolished with retroactive effect; only the latter results in a tax refund. Therefore, the time for information processing is close to zero, and our setting enables us to very precisely measure the speed of market reaction. Finally, while the timing of announcement was known, the outcome of the 2017RCC was virtually unexpected, providing us with a clean exogenous shock.

Considering the magnitude of the effect, we find that the tax refund is fully impounded into stock prices within a few trading days. With regard to the speed of market reaction, we find that 63% to 82% of the event date's entire abnormal return (*AR*) is already realized after one minute; 100% of the event date's entire *AR* is realized after two to six minutes. The first significant market reactions even occur within 5 to 15 s, which is much shorter than the response time to court decisions shown by prior literature (e.g., Brooks et al., 2003).

2. Data and research design

On June 2, 2017, information became available that the 2017RCC would be announced on June 7, 2017. The announcement indeed occurred on June 7, 2017 (event date), at 9:32 a.m. (event time) on the website of the German Constitutional Court.¹ First reports about the outcome were issued by news agencies, e.g., *Bloomberg*, within one minute after announcement. Media reports followed one to two minutes later. The 2017RCC affected three treated firms, namely, RWE AG (RWE), E.ON SE (EON) and EnBW Energie Baden-Württemberg AG (EnBW).² We note that prior research tends to exclude EnBW (e.g., Ferstl et al., 2012), as EnBW has a free float of less than one percent. Hence, results on EnBW should be viewed with caution.

For our analysis on the magnitude of market reaction, we use daily data on stock price and market capitalization obtained from *Refinitiv Datastream* and *Worldscope*. Information on exact volumes of tax refunds for the individual treated firms are extracted from the 2017 annual reports; however, this information was already publicly available prior to the event date. First, we use these data to compute the expected market capitalization when fully impounding the tax refund; applying the Fama and French (2015) Five-Factor model (FF5)³ and compare it with the post-event actual market capitalization. Second, we use a standard event study design⁴ to assess the effects in *ARs* following the announcement of the 2017RCC. *ARs* are computed as the difference between raw returns (*RRs*) and estimated expected returns, according to, alternatively, FF5 and the one factor capital asset pricing model (CAPM)⁵ of the respective individual stock. We correspondingly compute portfolio abnormal returns (*PARs*) for an equal-weight portfolio of all three treated firms. Cumulative abnormal returns (*CARs*) and cumulative portfolio abnormal returns (*CPARs*) are computed as the sum of daily *ARs* and *PARs* over specified time periods.

For our analysis on the speed of market reaction, we use intraday data on stock price and trading volume obtained per minute and per

tick from *tickdatamarket*. We use data per minute to, again, compute *CARs* for RWE and EON.⁶ Similarly, using the data per tick for our most granular analysis, we compute cumulative raw returns (*CRRs*).⁷

3. Empirical results and discussion

3.1. Magnitude of market reaction

Fig. 1 shows expected and actual market capitalization for RWE,⁸ EON and EnBW, as well as the level of the European market factor ($R_m - R_f$) provided by French (2023).

For RWE, Fig. 1 shows a sharp increase in actual market capitalization within the first two days. However, the full tax refund is only impounded into stock prices after about 10 days. For EON, we observe that the full tax refund is impounded into stock prices within two days. We argue that this difference is driven by the (anticipated) future use of the tax refund. Specifically, RWE announced on June 23, 2017, that it would use a significant portion of the tax refund to pay a special dividend of EUR 1 per stock,⁹ whereas EON did not pay a special dividend. This supports the notion that investors prefer profit repatriation to dividend distribution.¹⁰ For EnBW, the tax refund is never fully impounded into stock prices. Specifically, after a sharp increase on the event date, the actual market capitalization remains at a constant level below the expected market capitalization. However, the results for EnBW must be viewed with caution, as EnBW has a free float of less than one percent. This supports the notion that a low free float reduces market efficiency due to a price discount for low market liquidity and potential agency problems caused by majority shareholders.

Event study results on *ARs* are presented in Table 1, with Columns (1) and (2) reporting results for the equal-weight portfolio of all treated firms and Columns (3) to (8) reporting results for each treated firm separately.¹¹

Table 1 shows significant *ARs* immediately on the event date that tend to increase further in the post-event period. Considering Column (1), the equal-weight portfolio reaches a maximum *CPAR* of 9.2% within two days [0;1], with a large portion of the *CPAR* of 6.8%, or a share of 73.9%, already being realized on the event date.

When considering Columns (3) to (8), we similarly observe significant *CARs* on the event date for each treated firm. While for stocks of RWE (Column (3)), significant *CARs* reach a maximum of 9.5% over the period of [0;2], EON (Column (5)) shows the highest significant *CAR* of 14.4% over the period [0;10]. For EnBW (Column (7)) a significant *CAR* is only realized on the event date, followed by declining *CARs*. For all treated firms *CARs* are economically larger after the event date [0;10] than before [-10;-1]. Results on CAPM are similar to results on FF5.

¹ The German Constitutional Court states 9:33 a.m. as the event time, which technically denotes announcement in the 33rd minute, and hence, any second between 9:32:00 and 9:32:59.

² The Swedish energy company Vattenfall AB was excluded from the analysis as it was only marginally affected by the 2017RCC: Throughout 2011 to 2016, Vattenfall owned only a minority share of 20% in one nuclear power plant operated by EON (Brokdorf).

³ To estimate the model, we rely on European factors provided by French (2023). The estimation period is set to 250 days and starts 20 days prior to the event date. The refund of the nuclear fuel tax was taxable as income. Hence, we use the average German business tax rate in 2017 of 29.8% to compute after-tax values. Alternatively, we use the 2017 and Q1-2017 effective tax rates of the respective firm. The alternative results are presented in Figure B.1 of the Online Appendix B.

⁴ We use the STATA package "eventstudy2" provided by Kaspereit (2022).

⁵ The estimation period amounts 250 days starting 20 days prior the event date. The event windows range from [-10;-1] days to [0;10] days around the event date.

⁶ For EnBW, intraday data were not available from *tickdatamarket*. The estimation period is three trading days starting the day prior the event date. The event window ranges from [-20;60] minutes around the event time. We exclude noncontinuous trading periods, such as auctions.

⁷ Note that due to the structure of tick data, i.e., with uneven time gaps between ticks, we must rely on *RRs* for this analysis.

⁸ The market capitalization of RWE includes both common and preferred stock, weighted by the share of equity.

⁹ Resulting in a total dividend payment of approximately EUR 615 million.

¹⁰ We also investigate the capital market reaction to the dividend announcement and find no significant *ARs* on or around the dividend-announcement date, indicating that dividend distribution of the tax refund was anticipated (Woolridge, 1982).

¹¹ For RWE, a portfolio of common and preferred stocks weighted by the share of equity is used. Results for each type of stock separately are presented in Table B.1 of the Online Appendix B.

Table 1
Cumulative (Portfolio) abnormal returns.

Event window	CPAR treated firms		CAR RWE		CAR EON		CAR EnBW	
	(1) FF5	(2) CAPM	(3) FF5	(4) CAPM	(5) FF5	(6) CAPM	(7) FF5	(8) CAPM
[-10; -1]	0.025	0.032	0.045	0.052	0.053	0.052	-0.023	-0.008
[-2; -1]	0.018	0.014	0.038	0.031	0.034	0.031	-0.017	-0.020
[-1; -1]	0.011	0.012	0.025	0.027	0.026	0.027	-0.017	-0.018
[0; 0]	0.068 ***	0.064 ***	0.059 **	0.051 **	0.060 ***	0.056 ***	0.085 **	0.083 **
[0; 1]	0.092 ***	0.083 ***	0.095 ***	0.079 **	0.105 ***	0.097 ***	0.077	0.073
[0; 2]	0.080 ***	0.071 ***	0.073 *	0.057	0.100 ***	0.094 ***	0.068	0.060
[0; 5]	0.087 ***	0.081 **	0.082	0.073	0.117 ***	0.113 **	0.060	0.056
[0; 10]	0.091 **	0.080 *	0.080	0.057	0.144 **	0.135 *	0.051	0.049

Notes: This table reports the CPARs for the equal-weight portfolio of treated firms and the CARs for RWE (common and preferred stock, value weighted by share of equity), EON and EnBW. The event windows range from [-10;-1] days to [0;10] days around the event date. The tax refund has been adjusted for tax payments by the 2017-average German business tax rate. ARs are estimated using the FF5 as well as the CAPM.

*** Denote significance at the 1%,
** Denote significance at the 5%,
* Denote significance at the 10%.

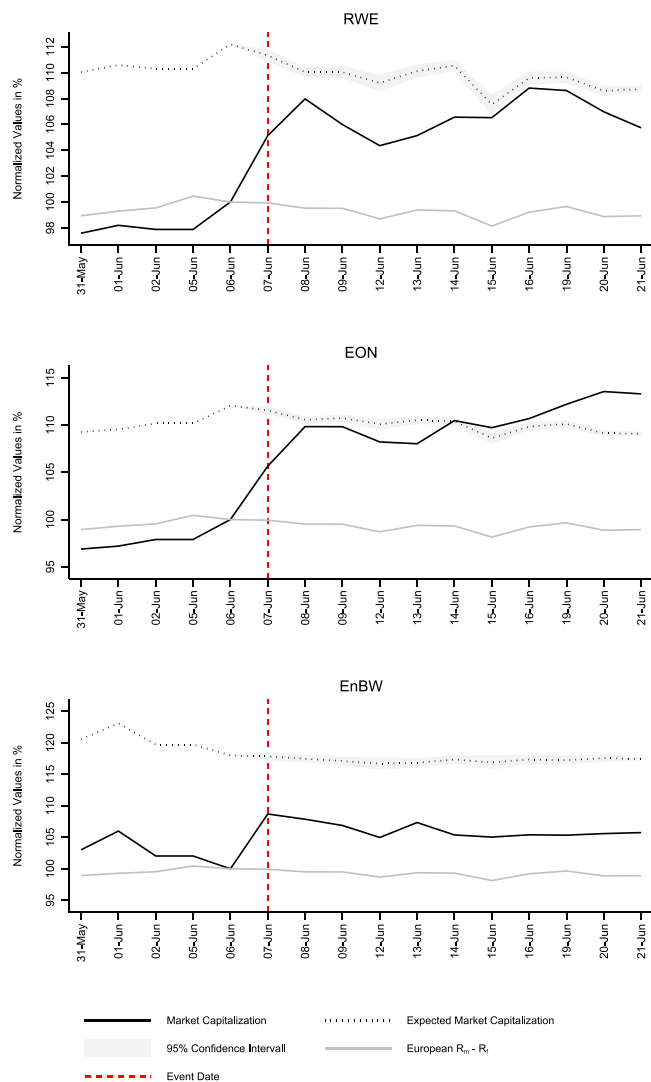


Fig. 1. Development of market capitalization.

Notes: This figure graphs the actual and expected (using FF5 when fully impounding the tax refund) market capitalization of RWE (common and preferred stocks), EON and EnBW, 5 days prior to the event date up to 10 days after the event date as well as the level of European $R_m - R_f$. All values are normalized to a base level of 100 on the day prior to the event date.

3.2. Speed of market reaction

The results for the intraday analysis on CARs in our minute data are reported in Panel A of Fig. 2. Panel B shows the trading volumes per minute around the event time.

For both, RWE and EON, Fig. 2 shows the largest effect within the first minute after the announcement, i.e., until 9:33 a.m. For RWE (EON), the entire daily CAR of the event date is already realized two minutes (six minutes) after the announcement. This increase in market capitalization is accompanied by an increase in trading volume. We note that the peak in trading volume for both treated firms occurs one to three minutes after the strongest increase in CARs. This finding is consistent with the trading pattern of large price movements being followed by large volume movements that has been described by prior research (Andreassen, 1988; Gallant et al., 1992).

For an even more granular analysis, Panel A of Fig. 3, presents CRRs per second as well as tick volumes per second using tick data. Panel B graphs the trading volumes per second.

Fig. 3 shows that strong increases in market capitalization for both RWE and EON already occur a few seconds after the announcement of the 2017RCC. Specifically, a considerable portion of the ARs of the first minute, as observed in Fig. 2, is realized within 15 s for RWE, and even within 5 s for EON. This is in line with prior literature for capital market reactions to releases of analyst opinions on television, with a realization time of approximately 15 s (Busse and Green, 2002). Again, the highest trading volume can be observed with a short delay to the strong increase in market capitalization. We also note that the tick volume increased prior to trading volume, indicating that a large portion of the market reaction was driven by low-volume trades. According to prior literature (Chordia et al., 2011; Weller, 2017), respective low-volume trades are likely to be associated with algorithmic trading of institutional investors. Also speaking to this interpretation, information on the event was published within the first minute by news agencies in an algorithm-accessible form. Accordingly, Fig. 3 provides indication that algorithmic trading contributes to market efficiency in a substantial manner.¹² Note that we only provide a conservative estimate on speed, as the event time is merely available as 9:32 a.m., and hence, actual announcement of the 2017RCC could have occurred even some seconds after 9:32:00. Overall, assuming that insider trading did not occur, our findings support the notion that the German capital market has a high market efficiency in reacting to firm-specific major events. Nonetheless, we recall that the 2017RCC is peculiar in that its announcement date, not its outcome, is known five days in advance and that economic assessment of the outcome is straightforward.

¹² Naturally, low-volume trades might be also attributed to retail investors. However, it appears unlikely that retail investors would be able to execute trades so quickly after the event.

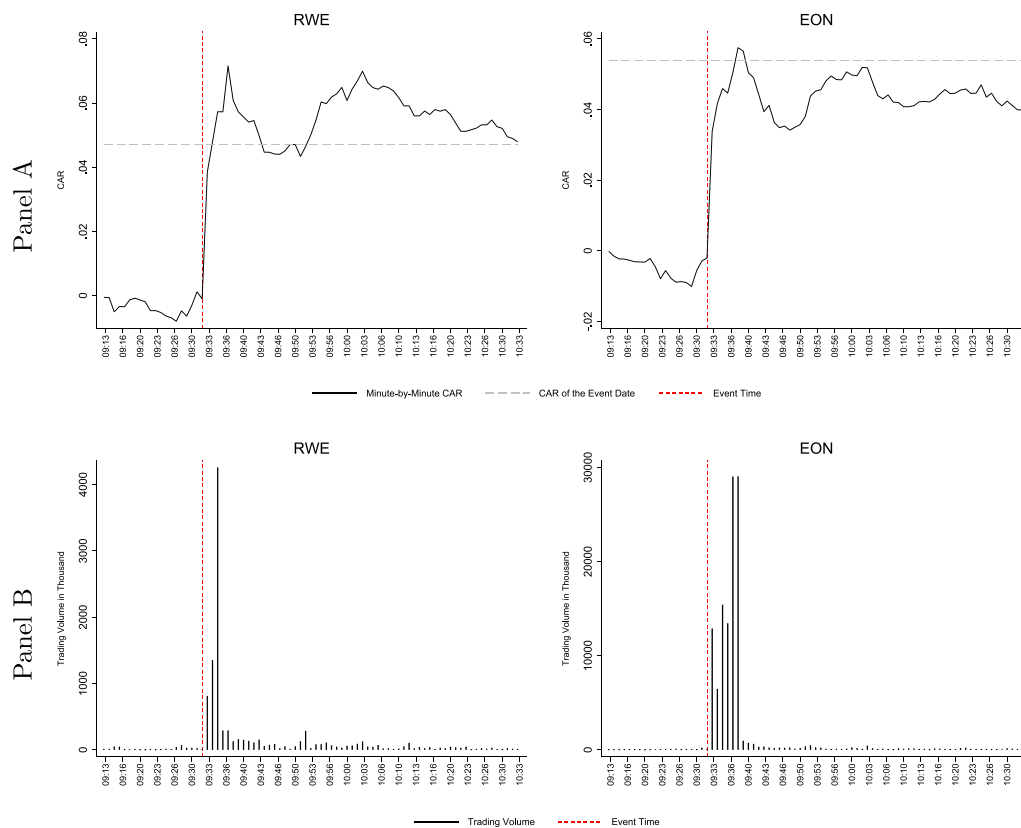


Fig. 2. Intraday analysis (minute data).
 Notes: Panel A of this figure shows minute-by-minute CARs (using CAPM with DAX30 as market return) of RWE and EON 20 min prior to the event time up to 60 min after the event time. Panel B shows the minute-by-minute trading volumes.

3.3. Pre-announcement effects

Our interpretation of results relies on the outcome of the 2017RCC being largely unexpected. To support this conjecture, we first note that Table 1 shows no significant ARs for the pre-event period $[-10;-1]$. Second, referring to Fig. 4, we note that of the seven preceding rulings by lower fiscal courts (four rulings), the Federal Fiscal Court (two rulings) and the European Court of Justice (one ruling), four were in favor of upholding the nuclear fuel tax, including the two rulings by the Federal Fiscal Court and the European Court of Justice. Third, according to the Constitutional Court’s principle of reliable budgetary planning, any substantial tax refund shall be cautiously weighed against its impact on Germany’s fiscal budget, as otherwise, unjustifiable burdens could be placed on future generations of taxpayers. In consequence, rulings of the German Constitutional Court on tax matters that would result in large tax refunds hardly ever lead to legislation being abolished with retroactive effect.¹³ The EUR 6.5 billion of tax refund resulting from the 2017RCC undoubtedly caused a substantial impact on Germany’s fiscal budget, and hence, it was widely expected that the 2017RCC would merely disallow similar legislation in the future, which would not have led to any tax refund. Fourth, our conjecture is supported by Davis et al.

¹³ To the best of our knowledge, there was only one prior ruling of the German Constitutional Court that resulted in a substantial tax refund; this tax refund still was considerably smaller than the tax refund resulting from the 2017RCC. Specifically, on March 9, 2004, the German Constitutional Court declared a tax on private capital gains unconstitutional and abolished the legislation with retroactive effect. This ruling resulted in a total tax refund of EUR 0.3 billion.

(2022) who show that the capital market also does not anticipate the outcome of rulings of the U.S. Supreme Court. Fifth, we use Google Trends Search to investigate search terms related to the nuclear fuel tax and find no notable increase in the pre-event period and an extreme increase on the event date.¹⁴ Finally, our conjecture is supported by our results themselves, because Fig. 1 shows that the exact value of the tax refund is impounded into stock prices within the event window for both RWE and EON. Given all these results, the expected value of a tax refund priced into stock prices prior to announcement of the 2017RCC is likely zero.

4. Robustness

We conduct multiple robustness tests. First, we use the disclosure of the announcement date of the 2017RCC (June 2, 2017) and the actual date of the judges’ decision (April 13, 2017) as placebo event dates. Second, we investigate ARs of other European power plant operators to control for sector-specific effects. Third, we apply different model specifications in computing ARs, i.e., global factors instead of European factors and different lengths of the estimation window (following Nerlinger and Utz, 2022). Fourth, we use on alternative models, instead of the FF5, for estimating market capitalization when fully impounding the tax refund, i.e., the Carhart (1997) Four-Factor model (FF4) and the Hou et al. (2019) q^5 model (q^5).¹⁵ All robustness tests support our main results. For more details, please refer to the Online Appendix A.

¹⁴ Results are presented in Figure B.2 of the Online Appendix B.
¹⁵ To estimate the model, we rely on US factors provided by Hou et al. (2023).

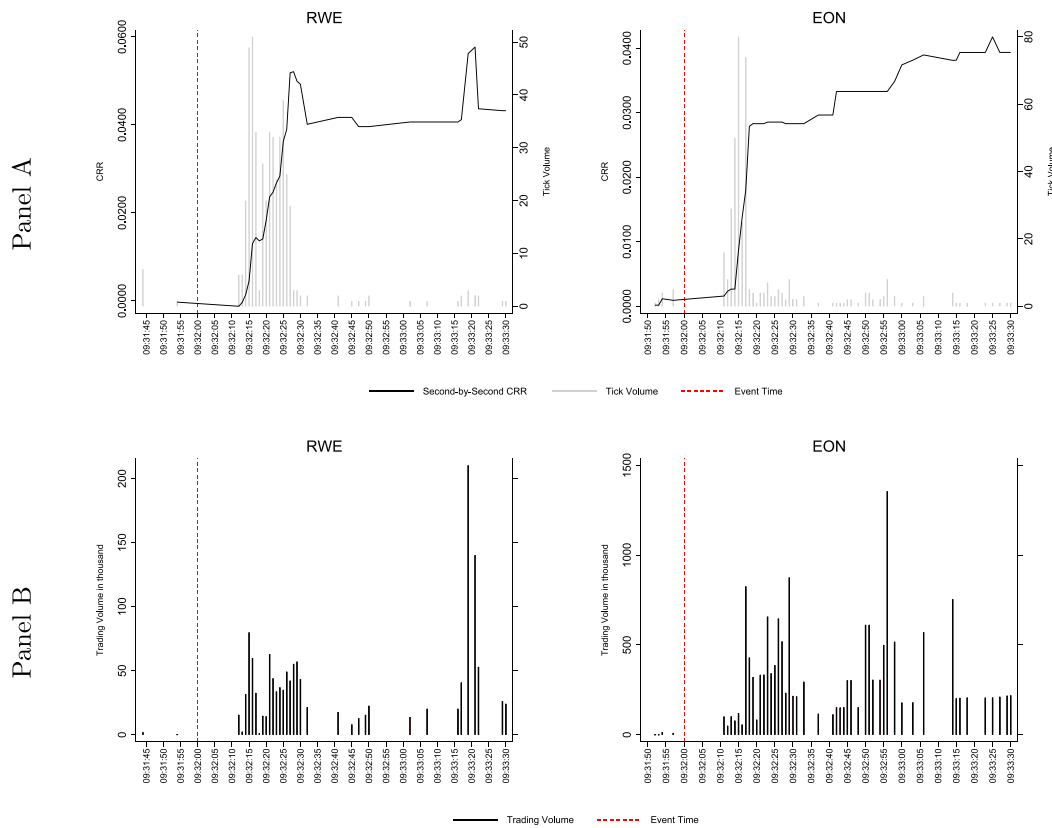


Fig. 3. Intraday analysis (tick data).

Notes: Panel A of this figure shows the second-by-second *CRRs* for RWE and EON from 30 s prior to the event time up to 90 s after the event time as well as the second-by-second tick volumes. Panel B shows the second-by-second trading volumes.

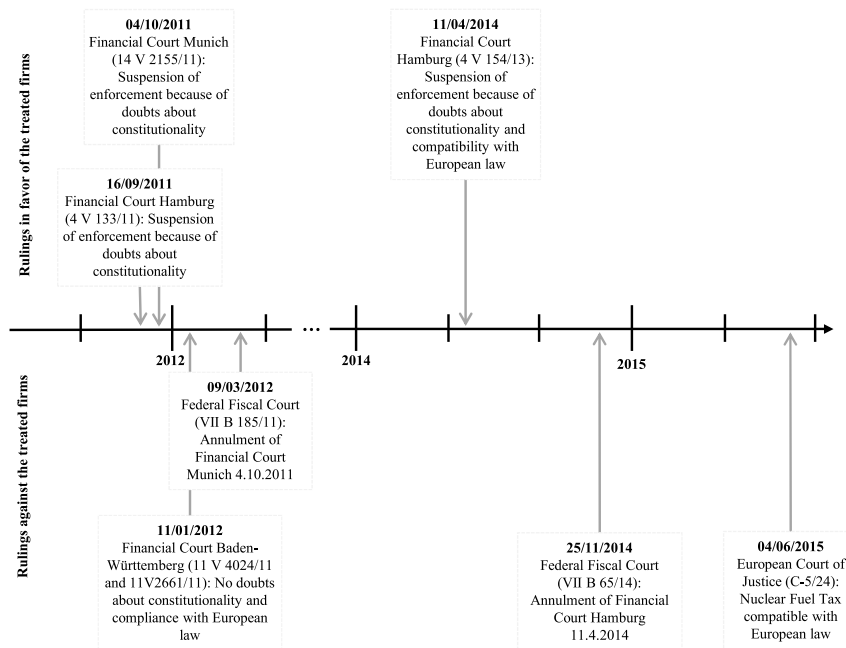


Fig. 4. Rulings preceding 2017RCC.

Notes: This figure shows relevant rulings preceding 2017RCC, clustered as in favor of or against the treated firms.

5. Conclusion

This paper adds to the scarce evidence on the efficiency of capital markets in reacting to major firm-specific events in terms of both the

magnitude and speed of market reaction. With regard to the magnitude of market reaction, we find that the exact tax refund is fully impounded into stock prices within two to 10 days after the event date. With regard to the speed of market reaction, we find that the entire abnormal

returns of the event date are already realized within two to five minutes, with significant reactions even occurring within the first five to 15 s. Overall, our findings are consistent with a high efficiency of capital markets.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.econlet.2024.111553>.

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