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Regulatory Carbon Risk: Evidence from the 2022 Reform of the EU Emissions Trading Scheme

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This paper examines the market reaction of 600 European stocks to the announcement of the reform of the European Emissions Trading Scheme (ETS). We find significant negative CARs over the week before the announcement, yet firm-level GHG emissions, environmental performance, and other firm-specific controls fail to explain these. In contrast, we confirm a positive market response over the week following the announcement. Firm-level emissions and environmental performance are both positively associated with post-agreement CARs. What seems counterintuitive at first glance can be explained by the disparities between both metrics. From an investor's perspective, better environmental performance represents lower risk exposure to environment-related risk, regardless of the absolute level of externalities.

Keywords: Carbon risk, climate policy, European emissions trading scheme, ETS, event study, energy policy, greenhouse gas emissions, pollution.

1. Introduction

European Union negotiators reached an agreement early Sunday morning, December 18, 2022, on reforming the European Emission Trading System (ETS), the world's largest carbon market and the EU's most important climate policy instrument (euractiv, 2022). The agreement requires sectors covered by the ETS to reduce their emissions by 62 percent below 2005 levels by 2030, a significant increase from the previous target of 43 percent. In addition to the more stringent emissions target, the previously free allowances for industries subject to an increased risk of carbon leakage, i. e., chemicals, cement, paper, and steel production, will be phased out from 2026 and abolished by 2034 (Pittel et al., 2022). In order to protect European industries, agreement was previously reached on the Carbon Border Adjustment Mechanism (CBAM), which is intended to protect European industry from unfair competition from abroad. Simultaneously, a second emissions trading system (ETS II) will be introduced for the sectors real estate and transport in 2027 (European Parliament, 2022).

The impact of green policy announcements (GPA) on financial markets has been widely discussed in the academic literature (e.g., Borghesi et al., 2022; Birindelli and Chiappini, 2021; Li et al., 2020; Pham et al., 2019; Ramiah et al., 2013, 2015; Zeng et al., 2021). Empirical evidence on market reactions to GPA differs in direction and magnitude, especially due to differences across sectors and industries (Ramiah et al., 2013, Birindelli and Chiappini, 2021). However, previous studies have mainly focused on country-level green policy announcements. Conversely, the ETS is an EU-level

GPA that simultaneously affects companies in all EU member states and beyond (European Commission, 2021).

Birindelli and Chiappini (2021) examine the impact of key climate policy events during 2013–2018 on firm value. All sectors were significantly affected by GPAs, with negative impacts outweighing positive ones. Borghesi et al. (2022) analyze investor reactions to GPAs in the largest European economies following the announcement of the EU Green Deal in 2019. Their results, based on the 100 largest stocks in Europe, yielded contrasting results. Market reactions are positive for both brown and green companies. On the one hand, they find that the sentiment-induced effect is more pronounced in green sectors; on the other hand, they find a dependence between the intensity of the market reaction and the volume of financial support announced.

A central rationale for our analysis is the carbon risk hypothesis (Bolton and Kacperzyk, 2021). Current literature debates whether carbon emissions are associated with stock returns (Aswani et al., 2023). A survey by Krueger et al. (2020) reveals that institutional investors consider carbon emissions a material risk factor. Stroebel and Wurgler (2021) find that regulatory risk is the most significant climate risk for companies and investors over the next five years. Bolton and Kacperczyk (2021) note that carbon emissions may pose a systemic risk factor if regulatory interventions to cut emissions apply uniformly to all emissions, i.e., "if a large federal carbon tax were to be introduced, this would be a systematic shock affecting all companies with significant emissions." We take the reformation of the ETS as a case study to conduct a natural experiment. While Bolton and Kacperzyk (2021) provide empirical evidence for the existence of a systematic carbon risk premium using unscaled emission data, Aswani et al. (2023) challenge those findings. Specifically, the authors argue that due to the substantial increase in vendor-estimated data, significant biases arise. Estimated emission data, unlike disclosed emission data, are mechanically correlated with company fundamentals. The results can therefore be interpreted as a link between revenues or firm fundamentals and stock returns rather than a robust link between carbon risk and stock returns. Drawing from the discussion in previous literature, we investigate whether non-scaled vendor-based emission data are associated with short-term, event-driven stock returns. In this way, we can support the carbon risk hypothesis while mitigating the bias created by the mechanical correlation of vendor-estimated issuance data with corporate fundamentals.

This paper examines the reaction of the European stock market to the announcement of the reform of ETS using event study methodology (Brown and Warner, 1985). We analyze the 600 companies listed in the EURO STOXX 600 at the time of the announcement. Thus, we capture roughly 90 % of the European market capitalization. We document a significant negative market reaction on the last trading day (Friday) before the announcement (Sunday), which is not related to any of the independent variables. Conversely, the overall net market reaction ex-post was positive but of modest magnitude. In addition, we show that greenhouse gas and carbon emissions,

as well as a firm's environmental performance, constitute significant determinants in explaining cross-sectional abnormal returns. We find that firms with high emissions respond positively to the announcement. Yet we also find that firms with better environmental performance benefit. These findings are in line with Borghesi et al. (2022). We conclude that the total level of actual GHG emissions as well as the aggregate information on the company's environmental-related risk exposure and environmental commitment, i.e., a company's Environmental Pillar Score (Borghesi et al., 2022; Birindelli and Chiappini, 2021), are an important determinant in cross-sectional abnormal returns following a GPA, although of a contrary sign.

The main contribution of our study to the literature is twofold. First, we show that investors consider both disclosed and estimated emission data when re-evaluating stock prices after a GPA. From the investor's perspective, it is imperative to identify what is actually being priced in addition to what is an appropriate measure of emissions. Significant inefficiencies can arise when the actual level of a company's carbon emissions differs substantially from the vendor-estimated emissions data and if the latter is priced by investors. Second, we highlight the importance of evaluating stock market reactions to GPA carefully. Our results depend significantly on the length of the event window employed, possibly due to the fact that investors anticipate the outcome of a GPA ex-ante.

The remainder of the paper is structured as follows. Section 2 illustrates the data and methodology. Section 3 presents the results. Section 4 concludes.

2. Data and Methodology

All equity-related data were retrieved from Refinitiv Eikon. Data on risk-free rates, market premia, and factor premia were taken from the Kenneth French Data Library (French, 2022). We include all stocks listed in the STOXX Europe 600 Index as of December 16, 2022. The index comprises 600 European stocks, covering large and medium-capitalized European companies. The classification of industries is based on the Thomson Reuters Business Classification Standard (TRBC). Returns are denoted in percentage throughout the study.

We apply standard event study methodology following Brown and Warner (1985). We compute cumulative abnormal returns $CAR_{i,[\tau_1;\tau_2]}$ as the difference between observed returns and estimated returns, formally quoted as:

$$CAR_{i,[\tau_1:\tau_2]} = \sum_{t=\tau_1}^{\tau_2} (r_{i,t} - E[r_{i,t} \mid (\Phi_t]) \tag{1}$$

where $r_{i,t}$ the observed return of stock i at day t and $E[r_{i,t} \mid (\Phi_t]$ the estimated return of stock i at day t. To estimate expected returns, we use the classical market model

(Sharpe, 1963). We use the MSCI World Index to represent the market portfolio. In addition, we apply the Capital Asset Pricing Model and the three-factor model of Fama-French (1993). We estimate stock parameters over a period of 250 trading days spanning [–260,–10] with respect to the event date.

The null hypothesis states that cumulative abnormal returns are not statistically different from 0 across the cross-section of stocks; H0: CAR = 0. The alternative hypothesis H1 states that cross-sectional mean (median) CARs are different from zero; H1: $CAR \neq 0$[1]. We test the hypothesis using a conventional t-test[2] as well as the non-parametric Wilcoxon signed-rank test (Wilcoxon, 1945).

Failing to reject the null hypothesis, however, does not imply the absence of market reactions. With regard to the economic consequences of the ETS reform, it is possible that individual companies or sectors have reacted positively or negatively and that market reactions eventually cancel out each other. Firms that do not have strong pricing power or offer products and services where demand is elastic may be more sensitive to the announcement of stricter environmental regulations (Ramiah et al., 2013; Clarkson et al., 2015). If firms or industries respond differently, cross-sectional effects may offset each other. Therefore, in the second step, we turn to the analysis of possible firm-level characteristics that could help explain the market reaction. The OLS regression model used for this purpose reads as follows:

$$CAR_{i,[\tau_1:\tau_2]} = \Upsilon_0 + \Upsilon_1{}' X_{i,} + \Upsilon_2{}' Z_i + \delta_k + \epsilon_i \quad (2)$$

where X_i constitutes a vector of company-specific environmental variables. The variables included are total greenhouse gas emissions at the company level, scope 2 carbon dioxide emissions, a company's Environmental Pillar Score, and a dummy variable indicating whether a company has environmental controversies. We employ the Environmental Pillar Score as an additional control variable alongside direct emissions, as it represents a company's exposure to environmental risk and, thus, the materiality of risk within an industry, as well as a company's ability to manage that risk (Borghesi et al., 2022). The variables in vector Z_i include additional control variables. We control for standard predictors, such as the book-to-market ratio, leverage ratio, and the size of a company proxied by market capitalization, derived one day prior to the announcement. δ_k denotes k industry fixed effects.

1 Previous literature suggests that the sign of the market reaction is ambiguous, which is why we refrain from specifying the expected sign in the hypothesis.

2 As a robustness check, we also calculate skewness corrected t-statistics according to Hall (1992). The level of significance remains virtually unchanged.

Table 1: Descriptive statistics. Emission data are denoted in kilotons, market capitalization (size) in million USD.

	N	Mean	Median	SD	1. Quartile	3. Quartile	P (T-Test)	P (Wilcoxon)
Descriptive statistics of CARs based on the market model.								
[–1,4]	600	–0,028	–0,040	3,574	–2,264	1,885	[0,8476]	[0,4944]
[-1,1]	600	–0,978	–0,899	3,119	–2,730	0,741	[0,0000]	[0,0000]
[-3,3]	600	0,780	0,742	2,630	–0,600	2,083	[0,0000]	[0,0000]
Pre-event Week	600	–1,501	–1,459	3,172	–3,066	0,218	[0,0000]	[0,0000]
Post-event Week	600	0,872	0,843	2,832	–0,654	2,352	[0,0000]	[0,0000]
Descriptive statistics of CARs based on the CAPM								
[-1,4]	600	0,036	–0,019	3,572	–2,199	1,913	[0,8053]	[0,8105]
[-1,1]	600	–0,879	–0,805	3,116	–2,666	0,855	[0,0000]	[0,0000]
[-3,3]	600	0,706	0,671	2,631	–0,670	2,011	[0,0000]	[0,0000]
Pre-event Week	600	–1,388	–1,341	3,172	–2,982	0,319	[0,0000]	[0,0000]
Post-event Week	600	0,821	0,787	2,829	–0,705	2,301	[0,0000]	[0,0000]
Descriptive statistics of CARs based on the Fama-French Model (3F)								
[-1,4]	600	–0,532	–0,584	3,240	–2,297	1,082	[0,0001]	[0,0000]
[-1,1]	600	–1,278	–1,278	2,864	–2,864	0,255	[0,0000]	[0,0000]
[-3,3]	600	0,363	0,311	2,433	–0,908	1,619	[0,0003]	[0,0000]
Pre-event Week	600	–1,778	–1,669	3,197	–3,286	–0,099	[0,0000]	[0,0000]
Post-event Week	600	0,549	0,431	2,670	–0,883	1,899	[0,0000]	[0,0000]
Descriptive statistics of independent firm-level variables								
CO2_T	574	2748	93	11571	13	512		
CO2_S2	553	417	34	1614	6	194		
EPS	596	68,486	73,216	21,333	55,270	85,511		
EC	596	0,060	0,000	0,238	0,000	0,000		
Size	600	41910	12334	115466	4954	36215		
B2M	600	3,559	0,951	8,050	0,430	2,160		
Lev	600	12,381	4,364	30,487	2,961	7,646		

3. Results

The following section presents our results. Table 1 shows descriptive statistics of the cumulative abnormal returns over different time windows and descriptive statistics on the control variables used. Table 2 exhibits the correlation matrix of independent variables.

Table 2: Correlation Matrix

	Size	Lev	B2M	CO2_T	CO2_S2	EPS
Lev	–0,047					
B2M	–0,057	0,109				
CO2_T	0,038	–0,050	–0,028			
CO2_S2	0,045	–0,061	–0,055	0,571		
EPS	0,109	–0,181	0,226	0,124	0,113	
EC	0,073	–0,006	0,114	0,160	0,217	0,142

On Sunday, December 18, 2022, the concluded negotiations on the reform of the ETS were initially announced. As this day is not a trading day, December 19 is considered the event day. Abnormal returns derived over the week before the agreement are significantly negative. Interestingly, 75 % of all stocks in our sample have a CAR of close to zero or less. In the week following the agreement, the picture reverses. Returns are positive and significant on average. The quartiles prove that the effect is robust for most European stocks; thus, the results are not driven by a few outliers.

An important determinant of negative pre-agreement returns appears to be the Friday before the weekend of the announcement. Positive reactions are determined to a significant extent by the days in the week following the announcement, suggesting that the market reacts cautiously to positive information and needs time to digest the economic implications of the agreement. This pattern is consistent with the view of risk-averse investors and the uncertain information hypothesis of Brown et al. (1988). Cautious negative reactions as a form of risk premium are uniformly observed ex-ante for most stocks, while investors seem to pay more attention to company-specific variables when evaluating positive information ex-post. Nonetheless, we conclude that the ETS reform announcement was overall positively received by investors, on average. This may be interpreted as a kind of relief among investors who may have previously anticipated stricter environmental regulations. The CARs based on the CAPM hardly differ from CARs obtained from the market model based on the MSCI World Index. In contrast, significant differences emerge when examining results based on the Fama-French three-factor model. Market reactions in the previous week are more pronounced, while market reactions in the week after the announcement are weaker. This finding underscores the undirected, cautious market reactions before the announcement, whereas firm-specific variables explain the positive reactions after the announcement.

In the following, we will further analyze the drivers of positive returns in greater detail. The results of the OLS regressions are shown in Table 3.

Table 3: Results of OLS regressions of post-event CARs on firm-level variables. All models include industry-fixed effects. Standard errors are clustered at the industry level, and the respective t-statistics are given in square brackets. *, **, and *** denote statistical significance at the 10-, 5-, and 1 % levels, respectively.

	(1)		(2)		(3)		(4)		(5)		(6)	
CO2_T	0,170 **	[1,963]	0,172 *	[1,917]					0,150	[1,578]	0,142	[1,522]
EPS					0,014 **	[1,977]	0,014 *	[1,908]	0,005	[0,542]	0,009	[1,016]
EC	-0,178	[-0,272]	-0,427	[-0,647]	-0,030	[-0,048]	-0,255	[-0,391]	-0,197	[-0,293]	-0,448	[-0,663]
B2M			0,040 **	[2,363]			0,043 **	[2,495]			0,036 *	[1,952]
Lev			-0,010 *	[-1,745]			-0,008 *	[-1,847]			-0,010 *	[-1,669]
Size			-0,391 ***	[-3,676]			-0,358 ***	[-3,744]			-0,417 ***	[-4,053]
Intercept	1,254	[0,823]	11,339 ***	[4,667]	2,883 ***	[4,043]	12,099 ***	[5,423]	1,206	[0,792]	11,784 ***	[5,011]
Adj. R^2	0,243		0,280		0,257		0,290		0,242		0,282	
N	574		574		596		596		574		574	

The results reveal a positive and statistically significant relationship between a firm's GHG emissions and cumulative abnormal returns over the week following the announcement. The coefficient can be interpreted as follows. A one percent increase in GHG emissions results in a 0.170 basis point increase in cumulative abnormal returns. The effect remains constant and significant even after including alternative control variables, which also show a significant impact.

The inclusion of a company's environmental performance also provides enlightening evidence. The coefficient of the Environmental Pillar Score has the same sign as the coefficient of greenhouse gas emissions, which implies that not only companies with high GHG emissions have responded positively but also those companies that are exposed to lower environmental risks despite their high emission levels, i. e., that manage these risks better than their industry peers. However, the coefficients are no longer statistically significant when both variables are included in the regression model. As expected, the coefficient of environmental controversies is overall negative yet statistically insignificant in all models. However, the direction of the coefficient supports the environmental-related risk hypothesis.

Table 4 shows results based on Scope 2 carbon dioxide emissions.

Table 4: Results of OLS regressions of post-event CARs on firm-level variables. All models include industry-fixed effects. Standard errors are clustered at the industry level, and the respective t-statistics are given in square brackets. *, **, and *** denote statistical significance at the 10-, 5-, and 1 % levels, respectively.

	(1)		(2)		(3)		(4)	
CO2_S2	0,146 **	[2,348]	0,153 ***	[2,614]	0,132 **	[2,022]	0,138 **	[2,282]
EPS					0,005	[0,608]	0,009	[1,035]
EC	-0,326	[-0,460]	-0,612	[-0,851]	-0,347	[-0,479]	-0,626	[-0,855]
B2M			0,044 ***	[2,652]			0,039 **	[2,130]
Lev			-0,010 *	[-1,692]			-0,010	[-1,605]
Size			-0,380 ***	[-3,739]			-0,408 ***	[-4,084]
Intercept	2,300 **	[2,540]	12,043 ***	[4,991]	2,075 **	[2,116]	12,302 ***	[5,249]
Adj. R^2	0,244		0,281		0,244		0,282	
N	553		553		553		553	

This measure may provide a more accurate picture of regulatory carbon risk than total greenhouse gas emissions, including other greenhouse gases such as methane. The correlation coefficient of both variables in the present sample is 0.57 (see Table 2). It is worth noting that, despite the comparatively low correlation, the regression coefficient of scope 2 emissions is of similar magnitude as in the previously presented results. The results from the last models highlight the dominance of GHG emissions as a driver of abnormal returns in response to the agreement on the ETS reform.

Given the substantial negative returns in the week before the event, it is questionable what information investors were anticipating ex-ante, and hence, whether firm-level variables also explain negative pre-event reactions. We, therefore, repeat the results of the OLS regressions for the week before the official announcement. The variables of interest are insignificant. Accordingly, the results suggest that the market has priced a substantial yet homogenous risk premium as compensation for bearing uncertainty associated with the negotiations. The findings are presented in Table 5.

Table 5: Results of OLS regressions of pre-event CARs on firm-level variables. All models include industry-fixed effects. Standard errors are clustered at the industry level, and the respective t-statistics are given in square brackets. *, **, and *** denote statistical significance at the 10-, 5-, and 1 % levels, respectively.

	(1)		(2)		(3)		(4)		(5)		(6)	
CO2_T	0,052	[0,457]	0,114	[0,917]					0,077	[0,708]	0,114	[0,966]
EPS					-0,002	[-0,175]	0,003	[0,294]	-0,006	[-0,611]	0,000	[0,005]
EC	-0,236	[-0,262]	-0,280	[-0,310]	-0,308	[-0,355]	-0,333	[-0,380]	-0,213	[-0,239]	-0,280	[-0,310]
B2M			-0,012	[-0,793]			-0,004	[-0,286]			-0,012	[-0,696]
Lev			0,001	[0,150]			-0,003	[-0,700]			0,001	[0,150]
Size			-0,398 ***	[-2,946]			-0,359 ***	[-2,696]			-0,398 ***	[-2,718]
Intercept	-2.899	[-1,538]	6,205 **	[2,195]	-1,839 *	[-1,832]	6,917 **	[2,338]	-2.838	[-1,486]	6,208 **	[2,141]
Adj. R^2	0,185		0,204		0,197		0,212		0,184		0,202	
N	574		574		596		596		574		574	

We also replicate the results from Table 3 for the week before the agreement. The inclusion of scope 2 carbon dioxide emissions also shows no significant impact on the cumulative abnormal returns, and the coefficients are statistically indistinguishable from zero. The results are available from the authors on request.

As a final robustness test, we replicate all OLS regressions with the CAPM or Fama-French adjusted cumulative abnormal returns. The former results are virtually identical in expression and significance compared to the results based on the market model. In contrast, the results based on Fama-French adjusted cumulative returns show no significant impact of either GHG emissions or environmental performance, which accentuates the correlation of emission data with firm fundamentals and hence incumbent risk premia, as discussed in Aswani et al. (2023).

4. Conclusion

Our study provides revealing insights into market reactions following the announcement of the sweeping reform of the European Emissions Trading Scheme (ETS). Market-wide CARs are negative over the week before the announcement, yet firm-level control variables are insignificant. This finding suggests that investors priced a significant risk premium as compensation for policy uncertainty. Conversely, we find positive CARs in the week following the announcement, which are significantly positively related to firm-level GHG emissions. Thus, our results confirm the empirical evidence in Borghesi et al. (2022). Moreover, we also find a positive relationship between cumulative abnormal returns and a firm's environmental performance. What may seem counterintuitive at first can be explained by the information content of the two measures. While absolute greenhouse gas emissions pose a measure of the externalities caused by the respective company and thus exposure to regulatory carbon risk (Bolton and Kacperzyk, 2021), the Environmental Pillar Score represents a company's ability to manage carbon- and environment-related risks (Borghesi et al., 2022). Companies' share prices reacted positively to the announcement, especially if investors considered the environmental risks low and well-managed despite high levels of GHG and carbon emissions. Regarding data, investors seem to consider both vendor-estimated and disclosed emissions data.

Our study also offers important implications for academics and future research. When analyzing market reactions to GPAs, it is essential to consider expected reactions before the event to assess the net effect. Investors may have priced in significant risk premia prior to the event which compensate for policy uncertainty. The unwinding of these risk premia may then lead to irregular positive market reactions ex-post. The results from our study depend significantly on the choice of the event window. The results of aggregated analyses, as in Borghesi et al. (2022) and Ramiah et al. (2013), should therefore be interpreted with caution. Individual case analyses are imperative and justified to control for idiosyncratic effects such as variations in investors' ex-ante expectations and associated uncertainty.

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Zusammenfassung

In diesem Beitrag wird die Marktreaktion von 600 europäischen Aktien auf die Ankündigung der Neugestaltung des europäischen Emissionshandelssystems (Emissions Trading Scheme; ETS) untersucht. Wir beobachten signifikant negative kumulierte abnormale Renditen in der Woche vor der Ankündigung, die sich jedoch nicht mit den unternehmensspezifischen Treibhausgasemissionen, der Umweltleistung (approximiert durch den Environmental Pillar Score des ESG Ratings eines Unternehmens) und anderen unternehmensspezifischen Faktoren erklären lassen. Demgegenüber bestätigen wir eine positive Marktreaktion in der Woche nach der Ankündigung. Sowohl die Emissionen auf Unternehmensebene als auch die Umweltleistung stehen in einem positiven Zusammenhang mit den kumulierten abnormalen Renditen nach der Ankündigung. Was auf den ersten Blick kontraintuitiv erscheint, lässt sich mit den Unterschieden zwischen den beiden Messgrößen erklären. Aus Sicht der

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Anleger bedeutet eine bessere Umweltleistung ein geringeres Risiko in Bezug auf umweltbezogene Risiken, unabhängig von der tatsächlichen Höhe der Emissionen. Die Ergebnisse liefern empirische Belege dafür, dass Treibhausgasemissionen eine wichtige Determinante für die Preisbildung nach einer bedeutenden umweltpolitischen Ankündigung sind, und stützen damit die „Carbon Risk Hypothesis“.

Schlagworte: Kohlenstoffrisiko, Umweltpolitik, Klimapolitik, Europäisches Emissionshandelssystem, Ereignisstudie, Treibhausgasemissionen