Investigating the Impact of the EU Emissions Trading System on the Corporate Sector in Selected European Countries

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Abstract

The EU ETS is the first and largest carbon market successfully implemented in practice. Considering the relevance and importance of this system in combating climate change, this paper investigates its impact on the corporate sector in the EU by selecting companies from the four largest emitter countries, Germany, France, Poland, and Italy. This paper uses the GMM estimator to investigate the possible impact of free allowances, surrendered allowances, and verified emissions on stock prices and the EV/EBITDA ratio. Free allowances (FA) negatively affect stock prices and EV/EBITDA ratios in France and Germany, while in Italy, they are linked to a positive impact on the EV/EBITDA ratio. Surrendered allowances are associated with negative effects on both stock prices and the EV/EBITDA ratio in Poland and Germany, while in Italy, they negatively impact stock prices but positively influence the EV/EBITDA ratio. In France, they exhibit a positive effect on both indicators. Verified emissions (VE) positively influence both stock prices and the EV/EBITDA ratio in Poland and Germany, while in France, they have a negative effect on both indicators, and in Italy, and they are associated with a positive impact on stock prices but a negative effect on the EV/EBITDA ratio. While this paper faces certain limitations, these results are useful and important, indicating how the EU ETS system may affect financial performance and market sentiment in listed companies that are part of the EU ETS.

Keywords: Climate Change, EU ETS, EV/EBITDA ratio, Stock Prices, Carbon Allowances, Emissions

Introduction

Climate change has been one of the most unique challenges in recent years. Concern about climate change and its broader consequences has resulted in several international initiatives to address it.

The Montreal Protocol of 1987 is the first international agreement of the United Nations that has been ratified and signed by 197 countries. This agreement was supposed to help reduce the emissions that increase global warming, that is, for the protection of the ozone layer. The protocol is characterized as a successful initiative since, according to the Scientific Assessment of Ozone Depletion (2022), with the actions taken so far, the substances that deplete the ozone layer have been reduced, and thus, a global warming of about 0.5-1 ° C is avoided.

The first international agreement that directly addresses climate change is the United Nations Framework Convention on Climate Change (UNFCCC), which has been ratified by 198 countries. The main goal of this convention, defined by Article 2, is to stabilize the greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992). This convention resulted in the Kyoto Protocol and the Paris Agreement. The Kyoto Protocol was adopted in 1997 and officially entered into force in 2005. This protocol is the first legally binding agreement. By the agreed objectives, the protocol aimed to control emissions under the convention. The main reason for the ineffectiveness of this initiative is that it does not address the carbon footprint, but rather the carbon consumption, and also allows states to avoid reducing emissions by having very few enforcement mechanisms (Helm, 2012).

Unlike the Kyoto Protocol, the Paris Agreement is considered the most important international agreement that requires the signatory countries to take concrete actions according to their characteristics, to limit emissions. With the adoption of the Paris Agreement in 2015, the goal of limiting the average global temperature below 2°C, or about 1.5°C above pre-industrial levels, was accepted (Rogelj et al., 2016). The international community continues to largely support the Paris Agreement and agrees on CO_2 emission reduction targets and timelines for achieving net zero emissions (Hoegh-Guldberg et al, 2018).

Since carbon dioxide (CO_2) emissions are the primary driver of global climate change (see Ritchie & Roser, 2020), in 2005, the European Commission (EC) implemented a carbon pricing mechanism called the European Union Emissions Trading System (EU ETS). It is a "cap and trade" scheme for limiting the total amount of emissions that can be emitted. This market operates in all EU countries plus Iceland, Liechtenstein, and Norway, covering around 40 percent of the EU's emissions (including CO_2, N2O, and PFCs emissions) in several sectors, including the manufacturing industry, aviation, and power sector (European Commission, 2022). Within the cap, companies receive free or buy emission allowances. In case companies need more allowances, they go to the market and buy from those companies that have excess allowances. Theoretically, this means that the companies that buy allowances are still carbon-intensive and have not reduced their emissions, unlike those companies that sell allowances and have managed to reduce their emissions. Buying and selling allowances on a net basis in the economy should not make a difference in terms of emissions, as excess emissions are netted by the reduced emissions. However, this may not be the case since there are also free allowances that are distributed to certain sectors that have the greatest risk of moving their production outside the EU (so-called carbon leakage). Free allowances are mostly granted to sectors related to industrial production or heating because those have the highest risk of carbon leakage to other countries with more flexible legislation.

Unlike the other initiatives, the EU ETS can be considered the first and largest carbon market that has been successfully implemented in practice. In line with international initiatives, the European Union increased its ambitions to reduce greenhouse gas emissions by at least 62 percent by 2030 compared to 2005 levels or to be climate neutral by 2050. Accordingly, substantial

changes in the corporate decision-making process are expected. The reduction of emissions implies changing the working operations and processes, which will consequently have an impact on the corporate results and performance. It is also expected that the capital market will redirect funds to finance companies with a sustainable business perspective and environmentally responsible behavior.

Taking into account the relevance and importance of the EU ETS, it is crucial to investigate the impact of the EU ETS on the capital market. Confirming that there is a significant impact would indicate that the capital market makes a distinction between companies that successfully reduce emissions and companies that fail to reduce or even increase them. This would further mean that the capital market can be used as a successful tool to decarbonize the economy. To achieve the research objective, this paper utilizes data from two main sources: (1) the EU ETS system, which includes information on free allowances, surrendered allowances and verified emissions, and (2) the capital market, encompassing data on average share prices weighted by volume and the ratio of a company's enterprise value (EV) to its earnings before interest, taxes, depreciation, and amortization (EBITDA). The analysis focuses on companies from Germany, Poland, France, and Italy, as these countries are among the largest carbon emitters in the EU (Eurostat, 2023). This paper uses the generalized method of moments (GMM estimator) to investigate the relationships between the variables.

1. Literature review

1.1. Development of the EU ETS

The development of the EU ETS is divided into four phases. The first phase, from 2005 to 2007, was more of an ‘experimental’ period in which the market was established. This phase covered emissions from selected industries, including energy-intensive and manufacturing industries. According to the directive 2003/87/EC, the member states had to prepare a national plan and determine the quantity of allowances that would be distributed. Due to the determination of the required quantity of allowances on a national basis, which were also granted free of charge in this pilot phase, more allowances than emissions were found on the market. During this period, the price of allowances showed high volatility, ranging from 5 to 30 euros. The system crashed in April 2006 after the realized emissions from 2005 were made public, showing that the market was generally dysfunctional because there were excess allowances (Hintermann, 2010). In this phase, the price signal was significantly affected by excess allowances, and the emissions reduction targets were not ambitious enough.

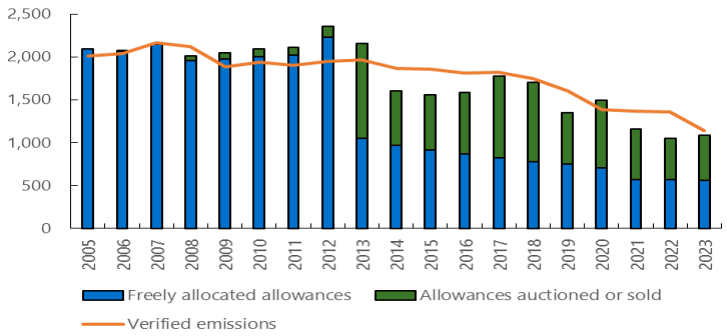
In the second phase (2008-2012), the number of allowances was to be significantly adjusted downward (about 6.5 percent lower than the 2005 level) and set more ambitious targets. However, due to slower economic activity due to the recession, improved energy efficiency, reduced use of coal due to lower gas prices, and greater use of renewable energy sources, emissions reductions were greater than expected (EU-15 emissions were 6.9 percent below the baseline year under the Kyoto Protocol) (EEA, 2010). This led to the re-presence of a large surplus of allowances in the market again pushing the price down. At this stage, the European Commission introduced the Market Stability Reserve (MRS) to absorb excess allowances and correct the price signal (Nissen et al., 2022).

In 2009, the EC adopted a new Directive 2009/29/EC for the third phase (2013-2020) and the emission limit was significantly reduced to at least 20 percent below 1990 levels, that is, the

directive provided for a 21 percent reduction in the number of allowances that would be distributed by 2020, compared to 2005 levels. The number of allowances was supposed to decrease by an annual linear factor of about 1.74 percent. At this stage, the allocation method changed from free distribution of allowances to auction allocation. Due to the greater risk of certain sectors for "carbon leakage", i.e. the transfer of production capacities outside the Union to countries with more flexible legislation, part of the allowances remained available for free distribution. The free distribution was planned to decrease every year by equal amounts, that is to achieve complete phase out of the free distribution by 2027. At the end of the second phase, i.e. in 2012, the aviation sector, as one of the fastest-growing sources of emissions, was included in the EU scheme. According to this, about 88 percent of the total quantity of allowances was to be allocated through auction at the volume defined by the 2005 scheme, or according to the average amount from 2005 to 2007 (whichever volume is higher), 10 percent of the total amount of allowances was to be auctioned for the sake of solidarity and growth, and 2 percent of the total amount of allowances to be auctioned to the Member States that by 2005 had reduced emissions to at least 20 percent below their emissions in the base year that applied to them under the Kyoto Protocol (this covered only 9 member states[1]). For the aviation sector, the annual permit cap target for the third phase was initially divided into 82 percent free allocation, 15 percent auctions, and 3 percent special reserves for fast-growing operators.

At the beginning of the fourth phase (2021-2030), the European Commission set a more ambitious target of climate neutrality by 2050, aiming for at least a 55 percent net reduction in emissions by 2030 compared to 1990 levels, or a 61 percent reduction in emissions compared to 2005 levels. The annual cap decrease was set to 2.2 percent, but the overall coverage changed due to Brexit. As part of the legal revisions made for this phase, the cap on emissions was tightened further to 62% by 2030, the free-allocated emissions were set to be phased out in several sectors, the CBAM was envisaged to be fully implemented from 2026, the coverage was expected to expand to maritime shipping, a new ETS scheme covering buildings, road transport, and other sectors is expected to be implemented from 2027 or 2028, and there will be a straightened commitment to use ETS revenues to address distributional effects and spur innovation.

Figure 1 Emissions and allowances in the EU ETS system 2005-2023



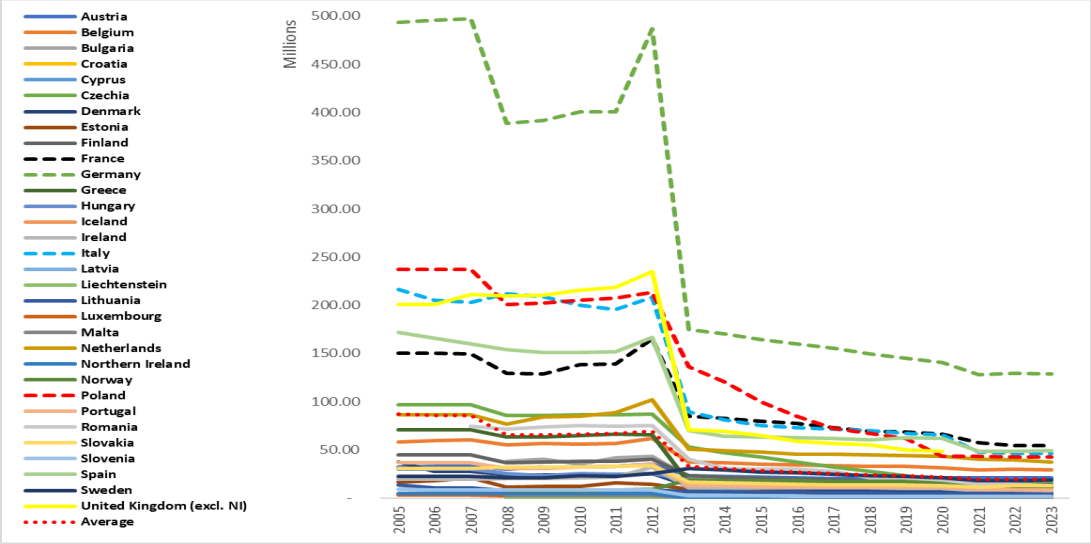
Source: European Environment Agency (EEA); Chart created by the authors

[1] Germany, England, France, Italy, Spain, Netherlands, Belgium, Sweden and Austria

During these four phases, the EU ETS significantly modified and improved. Bayer and Aklin (2020) found that the EU Emissions Trading System (EU ETS) led to substantial reductions in emissions between 2008 and 2016, compared to a scenario without carbon markets—amounting to nearly half of the reductions EU countries had pledged under the Kyoto Protocol. According to Nissen et al. (2022) from 2005 to 2021, the EU ETS showed satisfactory results in reducing emissions due to the decarbonization trend, i.e., reduced use of coal and lignite for electricity production and increased use of renewable sources. Colmer et al. (2024) suggest that the EU ETS contributed to global emissions reductions—meeting both necessary and sufficient conditions for effective climate change mitigation. Additionally, some authors (see Hagendorn et al., 2024) find that enhancing the environmental performance of the EU manufacturing sector is possible through reduced free allowances and rising ETS prices—especially when supported by increased investment—without significantly undermining competitiveness.

Figure 1 shows the trends in allowances and verified emissions from 2005 to 2023. Verified emissions decreased by about 43 percent, which is mainly a result of several factors, namely the decarbonization trend itself, reduced use of coal for electricity generation, and increased use of renewable sources.

Figure 2 Free allocated allowances per country



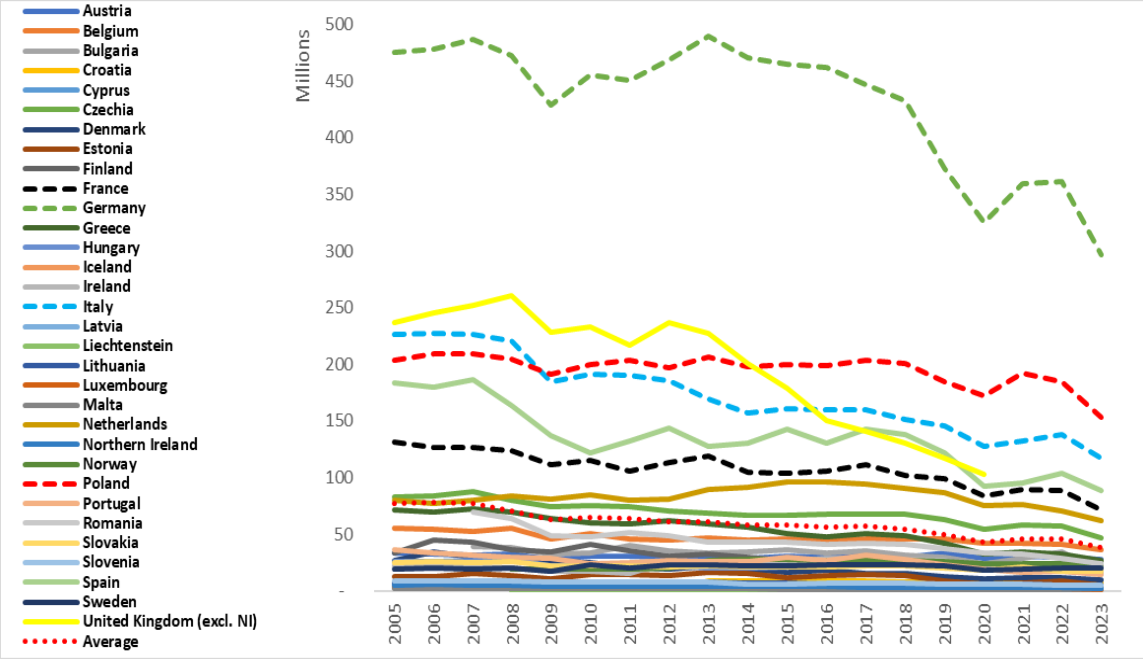
Source: European Environment Agency (EEA); Chart created by the authors

The chart also shows the trend in free and auctioned allowances. In the first pilot phase, only free allowances were allocated. However, a significant amount of allowances acquired through auction or sales appeared in 2013, during the third phase, when the allocation method switched from free distribution to auction allocation. Free allowances recorded a significant decline in 2013 and have been on a downward trend since then. In 2021, there is a decrease in emissions and allowances, which could be due to changes in the coverage of installations, i.e. starting from 2021 the United Kingdom (UK) is not included in the system. In accordance with the Protocol on Ireland/Northern Ireland to the EU-UK Withdrawal Agreement and the EU-UK Trade and Cooperation Agreement, electricity generation installations in Northern Ireland and flights to the UK remain under the EU ETS system (European Commission, 2022). The decrease

in emissions and allowances during this period is also due to the Covid pandemic and the energy crisis, i.e. the reduced economic activity and, accordingly, the lower industrial production.

Figure number 2 illustrates that, from the perspective of EU ETS member countries, there has been a significant decline in the free allocation of allowances starting from the third phase, compared to the levels in 2005. Among the countries with the largest number of free allocations, significantly above the average, are Germany, the United Kingdom, Poland, Italy, France, the Netherlands, Spain, Austria and Belgium. Although in the analyzed period these countries have a significant decrease in these allowances, they are still significantly above the average.

Figure 3 Verified emissions per country



Source: European Environment Agency (EEA); Chart created by the authors

Most of these countries also have significantly higher verified emissions than the average. As shown in Figure 3, Germany, the United Kingdom, Poland, Italy, France, the Netherlands, Spain, and the Czech Republic all have verified emissions above the average. Among these, Germany stands out with the highest number of free allowances and verified emissions, accounting for approximately 23% and 26%, respectively.

1.2. The impact of EU ETS on the corporate sector

According to the literature review, the impact of the EU Emissions Trading Scheme (EU ETS) varies broadly across different economies, sectors, and companies. Some companies have successfully passed carbon pricing costs to customers, preserving profitability, while others face increased costs and reduced competitiveness. Additionally, although green projects are often viewed as riskier due to their reliance on new technologies and typically lower rates of return (Sachs et al., 2019), some researchers argue that innovation in green financing and investment can

yield higher returns as a result of these higher risks (Ozili, 2022). Due to the varying perspectives on this issue, it is essential to conduct a thorough analysis of the existing literature and compare findings on the impact of the EU ETS on corporate sector performance and capital markets.

Millischer et al. (2022) analyzed over 300 European companies in the period from 2013 to 2021 and identified a significant negative relationship between carbon prices and stock returns, demonstrating that companies with higher costs for carbon allowances experienced weaker share performance during rising carbon prices. A similar conclusion was drawn by Bushnell et al. (2013), who found that a decline in carbon allowance prices adversely affected stock returns from the EUROSTOXX index, particularly in carbon and energy-intensive industries. Kovachevska Stefanova and Jovanovski (2024), analyzed 38 German companies and found that free allowances negatively impact stock prices due to future costs and regulatory changes. They also found that free allowances negatively affect ROA but positively impact dividends. According to Bolton et al. (2023), daily increases in carbon prices tend to lower stock prices for firms with emissions allowance shortfalls, while increasing stock prices for those with greater allowance coverage.

Conversely, some researchers argue that the EU ETS has minimal or negligible effects on corporate performance. Marin et al. (2017) found that companies were able to pass costs onto consumers and enhance labor productivity, mitigating any negative impacts from the EU ETS. Qiu et al. (2023) provided evidence of no long-term connection between carbon and stock markets, although a short-term positive correlation emerged, likely intensified by the COVID-19 crisis. Additionally, Anger & Oberndorfer (2008) concluded that the EU ETS did not significantly affect corporate revenues or employment in Germany. Demailly & Quirion (2008) noted that the effects on production and profitability were minor, particularly for the iron and steel sectors, with profitability, measured by EBITDA, largely dependent on the amount of free allowances allocated.

Several studies have highlighted a positive influence of EU allowances on stock prices and corporate performance. Milic & Stjernberg (2023) reported that free allowances positively impacted stock returns. Smale et al. (2006) analyzed the effects of CO_2 emissions trading on firm profits and market prices, finding substantial positive changes in EBITDA for energy-intensive sectors, although market share changes were modest for most industries except in steel, cement, and aluminum. Oestreich & Tsiakas (2012) revealed that German companies receiving free allowances in the early years of the EU ETS outperformed those that did not, attributing this to higher cash flows and returns linked to carbon risk. This could be explained by (1) the higher cash flows due to the free allocation of carbon emission allowances, and (2) higher returns due to the exposure to the higher carbon risk.

Further investigations, such as those by Dechezleprêtre et al. (2022) found that the EU ETS reduced emissions by 10% between 2005 and 2012 across several European countries, while boosting revenues and fixed assets without negatively affecting profits or employment in 31 ETS-regulated nations. Da Silva et al. (2016) confirmed a long-term positive impact of EUA price changes on the Spanish power industry's stock market returns. In another study, Da Silva et al. (2015) noted positive impacts on stock returns in the electricity, cement, and oil sectors, while the iron and steel sectors experienced negative impacts. García et al. (2020) provided evidence of a long-run positive effect from EU allowance prices on the stock market in six countries, including Austria, France, Germany, Italy, the Netherlands, and Spain. Finally, Benz and Trück (2009) suggested that a rise in EUA prices would lead to an increase in company value.

These studies provide a comprehensive overview of the EU ETS's impacts, highlighting both challenges and opportunities for companies and investors. To better understand the relationship between the EU ETS and corporate performance, this paper investigates the impact of

free, surrendered allowances, and verified emissions on the capital market for companies in Germany, Poland, Italy, and France, which have the highest CO_2 emissions from fossil fuel combustion for energy use in the EU (Eurostat, 2023). The paper examines the effects of these factors on stock prices and the EV/EBITDA ratio, shedding light on their influence on financial performance.

2. Methodology and dataset

This paper selected the four EU member states with the highest CO_2 emissions, Germany, Poland, Italy, and France. According to Eurostat (2023), Germany alone accounts for one-quarter of the EU's total CO_2 emissions from fossil fuel combustion for energy use, Italy and Poland each around 12.4%, and France 10.7%. The panel data samples consist of 50 German companies, 25 Italian companies, 29 Polish companies, and 46 French companies, between 2005 and 2021. The selection of the companies depends solely on the availability of data.

This paper examines several key variables related to the EU ETS and the capital markets across four countries. The first variable, 'verified emissions,' refers to the emissions reported in the annual emissions report, which must be verified by an accredited verifier by March 31st. The second variable is 'free allowances,' is the number of allowances that remain available for free distribution, despite the transition to auctioning system. Surrendered allowances refer to the allowances that companies must submit to cover their verified emissions. This data is sourced from the authors of Millischer et al. (2022). Additionally, this study includes average share prices weighted by volume and the EV/EBITDA ratio, which compares a company's enterprise value (EV) to its earnings before interest, taxes, depreciation, and amortization (EBITDA), sourced by Thomson Reuters.

The statistical description of all data is presented in Table 1.

Table 1 Statistical description

Variable	Obs.	Mean	Std.Dev	Min	Max
Poland					
Stock Price	493	1.43	3.18	(5.79)	35.69
EV/EBITDA	493	6.54	13.91	-	198.20
Free Allowances	493	3,446,844.49	9,951,405.08	-	75,261,300.00
Surrendered Allowances	493	5,195,829.83	13,151,014.61	-	73,671,916.00
Verified Emissions	493	5,196,696.75	13,148,941.84	-	73,671,916.00
Italy					
Stock Price	425	1.40	1.20	-	8.13
EV/EBITDA	425	25.66	269.77	(12.80)	5,042.65
Free Allowances	425	3,164,050.10	10,884,709.78	-	91,263,517.00
Surrendered Allowances	425	5,025,093.20	14,804,658.84	-	121,947,490.00
Verified Emissions	425	5,033,265.98	14,695,332.73	-	107,622,674.00
France					
Stock Price	782	1.50	9.64	(197.57)	155.09
EV/EBITDA	782	8.22	15.40	(165.20)	338.25
Free Allowances	782	1,928,553.26	6,435,092.17	-	47,629,993.00
Surrendered Allowances	782	2,714,633.62	8,224,211.55	-	75,446,973.00
Verified Emissions	782	2,720,699.23	8,111,793.13	-	55,328,383.00
Germany					
Stock Price	815	2.21	2.96	(6.83)	68.92
EV/EBITDA	815	20.23	263.39	(4.11)	7,348.96
Free Allowances	815	3,029,190.76	11,707,279.40	-	132,841,880.00
Surrendered Allowances	815	4,699,488.69	17,898,836.42	-	139,397,465.00
Verified Emissions	815	4,699,557.79	17,885,782.47	-	138,546,315.00

(Source: Authors' calculation)

The equations are calculated for each country separately. From the dataset, it can be concluded that:

1. The panel datasets analyzed have a short time dimension (T=17 years) and a larger company dimension (Germany N=50; France N=46, Italy N=25, Poland N=29, depending on the country). As proposed by Arellano and Bond (1991), and Arellano and Bover (1995), when T is shorter than N, the generalized method of moments (GMM estimator) can be used;

The empirical equation is as follows:

$Y_{it} = \alpha Y_{it-1} + \beta X_{it} + \omega_i + \mu_{it}$, where

Y_{it} is the dependent variable or EV/EBITDA and stock price, for the first and second equations respectfully, Y_{it-1} is its lagged value. α is the autoregressive (persistence) parameter, X_{it} is the endogenous regressor, or in our case verified emissions and free allowances. ω_i is the fixed-effect error term, and μ_{it} is the disturbance term.

2. There are time-invariant company characteristics (fixed effects) such as demographics or type of activities, which may be correlated with the explanatory variables. According to Mileva (2007), the fixed effects are contained in the error term in the equation, which consists of the unobserved company-specific effects and the observation-specific errors. To resolve this issue, the GMM estimator adds the first differences of the regressors, removing the fixed company-specific effect since it does not vary with time.

The difference GMM uses first-differences and transforms the equation into:

$\Delta Y_{it} = \alpha \Delta Y_{it-1} + \Delta \beta X_{it} + \Delta \mu_{it}$.

The validity of the GMM estimator is tested by applying (1) the Sargan test of overidentification and (2) the Arellano and Bond test for second-order serial correlation. The Sargan test tests an over-identifying restriction in the statistical model. The joint null hypothesis states that the instruments are valid and uncorrelated with the error term. The Arellano – Bond test for autocorrelation that is estimated in this analysis has a null hypothesis that assumes no autocorrelation and it is applied to the differenced residuals. According to Mileva (2007), the test for AR (2) in the first difference is more important because it will detect an autocorrelation in the levels.

3. Results and Interpretations

Table 2 shows the results from cointegration tests. Using the Pedroni Residual Cointegration Test in EViews, several test statistics are provided, including the Panel PP-Statistic and Panel ADF-Statistic, both used in the context of panel cointegration tests. The null hypothesis for both tests is that there is no cointegration among the variables. Rejecting the null hypothesis suggests that the variables share a long-term equilibrium relationship, which is crucial for further econometric modelling.

The results for Poland, Italy and Germany indicate strong evidence of cointegration among variables. For France, there is a cointegration relationship with stock prices, but not with the EV/EBITDA ratio.

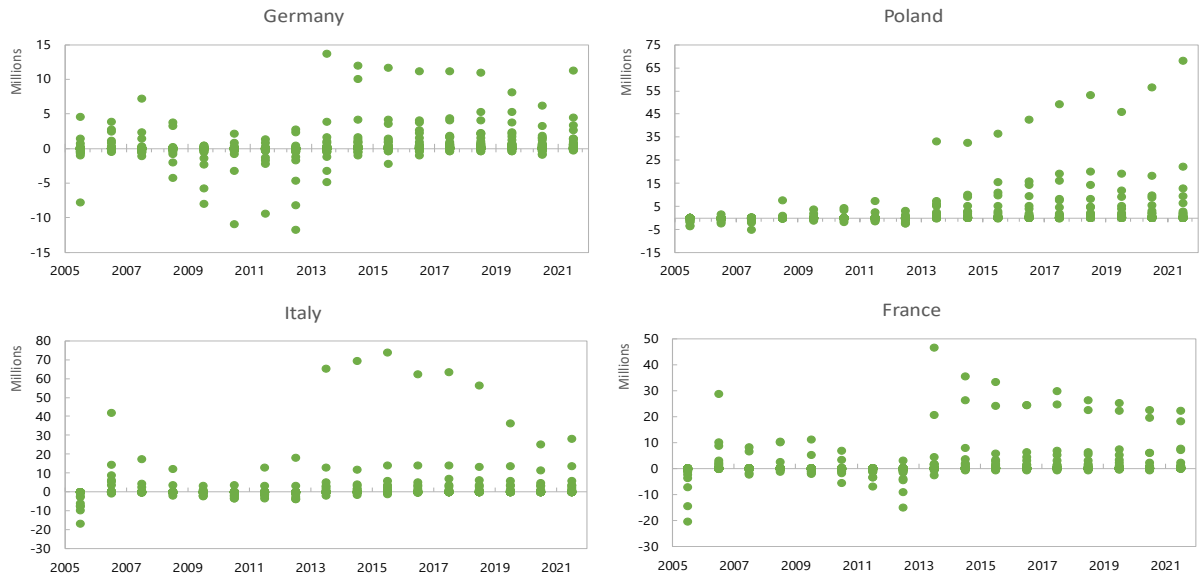
Table 2 Cointegration Test Results

	Cointegration with Stock Prices				Cointegration with EV/EVEB			
	Unweighted		Weighted		Unweighted		Weighted	
Poland	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Panel PP-Statistic	(16.456)	0.000	(7.793)	0.000	(36.237)	0.000	(16.849)	0.000
Panel ADF-Statistic	(5.918)	0.000	(4.146)	0.000	(7.767)	0.000	(6.729)	0.000
Italy								
Panel PP-Statistic	(8.078)	0.000	(9.265)	0.000	(14.605)	0.000	(13.239)	0.000
Panel ADF-Statistic	(8.996)	0.000	(2.480)	0.007	(5.215)	0.000	(5.652)	0.000
France								
Panel PP-Statistic	(21.235)	0.000	(14.731)	0.000	0.173	0.569	(22.410)	0.000
Panel ADF-Statistic	(5.679)	0.000	(6.215)	0.000	2.853	0.998	(8.332)	0.000
Germany								
Panel PP-Statistic	(36.066)	0.000	(16.124)	0.000	(5.086)	0.000	(23.172)	0.000
Panel ADF-Statistic	(5.964)	0.000	(7.059)	0.000	(6.395)	0.000	(9.063)	0.000

(Source: Authors' calculations)

The estimation results are shown in Table 3. The results vary significantly across countries, reflecting differences in market perceptions, levels of economic carbonization, and the characteristics of sectors and companies.

Figure 4 Net Allowance Position



(Source: Authors' calculation)

Free allowances (FA) have varied impacts across different countries. In France and Germany free allowances have negative impact on both stock prices and EV/EBITDA ratio. These relationships suggest that the majority of investors perceive companies receiving more free allowances as lacking incentives to reduce emissions. However, since the EU ETS policy

anticipates a gradual reduction in free allowances over time, this creates a risk of increased future costs, either for reducing emissions or for purchasing allowances on the market. This tightening of policy could also explain the decrease in the EV/EBITDA ratio, as investors may lower company valuations in anticipation of these future costs. In Italy free allowances increase the EV/EBITDA ratio, while having no significant impact on the stock prices. Since free allowances reduce operating costs, it increases the EBITDA and/or increase enterprise value, which leads to a higher EV/EBITDA ratio. In Poland free allowances do not have significant impact on both, stock prices and the EV/EBITDA ratio.

Surrendered allowances (SA) have mixed impact on stock prices and the EV/EBITDA ratio among the selected countries. To easier interpret these results, figure 4 presents the net allowance position of companies in the selected countries, calculated using the company-level data available to this paper. A higher net allowance position indicates that a company surrendered more allowances than it received for free, meaning the remaining allowances had to be purchased—resulting in higher costs. Conversely, a negative net position implies that the company received more free allowances than needed, leading to excess allowances in the portfolio.

Figure 5 Company-Level Verified Emissions per Country 2005-2021

(Source: Authors' calculations)

It can be observed that in all four countries, the net position has been positive in recent years for most of the countries, indicating that companies have predominantly purchased allowances. In Poland, there is a clear upward trend, while in Germany, although there are fluctuations, the overall direction compared to previous phases of the system is generally positive. In both countries, the number of surrendered allowances negatively impacts the stock prices and the EV/EBTDA ratio. This relationship may stem from the rising costs of acquiring allowances,

particularly when companies hold more purchased than freely allocated allowances, or from negative market sentiment, due to higher carbonization of the companies.

In Italy, surrendered allowances contribute to declining stock prices but simultaneously boost the EV/EBITDA ratio, indicating unfavorable market sentiment while enterprise value grows at a quicker pace than EBITDA. In France, SA has a positive impact on both stock prices and the EV/EBITDA ratio, suggesting stronger stock performance and higher enterprise value than EBITDA.

Verified emissions are usually associated with higher risks which may lead to lower stock prices, which is the case in France, however in Germany, Poland and Italy the relationship is positive indicating that this may reflect higher output which can boost market sentiments or valuations. Figure 5 illustrates trends in verified emissions among companies in selected countries, with the most pronounced downward trends observed among the outliers (most carbon intensive companies).

Table 3 - Differenced panel GMM Arellano-Bond estimations

Country	**Coeff.**	**Std.**	**Prob.**	**Country**	**Coeff.**	**Std.**		**Prob.**
Poland				*Poland*				
Stock Price (-1)	(0.315)	0.003	0.000	EV/EVEB (-1)	(0.436)	0.000	(7,730.853)	0.000
Free Allowances	0.012	0.012	0.325	Free Allowances	(0.264)	0.142	(1.854)	0.074
Surrendered Allowances	(1.363)	0.193	0.000	Surrendered Allowances	(5.028)	0.254	(19.820)	0.000
Verified Emissions	1.420	0.213	0.000	Verified Emissions	4.717	0.316	14.941	0.000
J-Statistics	*25.242*		*0.449*	*J-Statistics*	*29.602*			*0.284*
Arellano-Bond Serial Correlation Test AR(2)			**0.290**	**Arellano-Bond Serial Correlation Test AR(2)**				**0.983**
Italy				*Italy*				
Stock Price (-1)	(0.327)	0.001	0.000	EV/EVEB (-1)	(0.548)	0.000	(24,223.242)	0.000
Free Allowances	0.003	0.003	0.357	Free Allowances	9.357	0.018	517.261	0.000
Surrendered Allowances	(0.087)	0.008	0.000	Surrendered Allowances	3.940	0.062	63.189	0.000
Verified Emissions	0.070	0.008	0.000	Verified Emissions	(62.930)	0.233	(269.697)	0.000
J-Statistics	*22.384*		*0.378*	*J-Statistics*	*22.475*			*0.373*
Arellano-Bond Serial Correlation Test AR(2)			**0.850**	**Arellano-Bond Serial Correlation Test AR(2)**				**0.581**
France				*France*				
Stock Price (-1)	(0.457)	0.001	0.000	EV/EVEB (-1)	(0.354)	0.001	(323.857)	0.000
Free Allowances	(0.220)	0.005	0.000	Free Allowances	(0.000)	0.000	(12.597)	0.000
Surrendered Allowances	0.786	0.005	0.000	Surrendered Allowances	0.000	0.000	17.042	0.000
Verified Emissions	0.492	0.024	0.000	Verified Emissions	(0.000)	0.000	(12.948)	0.000
J-Statistics	*43.568*		*0.423*	*J-Statistics*	*39.463*			*0.583*
Arellano-Bond Serial Correlation Test AR(2)			**0.109**	**Arellano-Bond Serial Correlation Test AR(2)**				**0.014**
Germany				*Germany*				
Stock Price (-1)	(0.109)	0.001	0.000	EV/EVEB (-1)	(0.511)	0.000	(278,468.102)	0.000
Free Allowances	(0.013)	0.001	0.000	Free Allowances	(12.469)	0.018	(685.928)	0.000
Surrendered Allowances	(0.030)	0.003	0.000	Surrendered Allowances	(714.477)	0.326	(2,189.305)	0.000
Verified Emissions	0.077	0.006	0.000	Verified Emissions	724.770	0.324	2,235.867	0.000
J-Statistics	*46.928*		*0.393*	*J-Statistics*	*48.245*			*0.382*
Arellano-Bond Serial Correlation Test AR(2)			**0.491**	**Arellano-Bond Serial Correlation Test AR(2)**				**0.557**

(Source: Authors' calculations)

In Poland and Germany, VE positively and significantly influence both stock prices and the EV/EBITDA ratio, contrasting with the effects of free and surrendered allowances. This may be attributed to the value placed on transparency and the adherence to regulations of the EU ETS. In Italy, verified emissions (VE) positively influence stock prices but negatively impact the EV/EBITDA ratio. This reflects positive market sentiment, as investors may value transparency.

However, the purchase of allowances to cover emissions weighs on profitability. In France, VE negatively impacts both stock prices and the EV/EBITDA ratio, possibly due to market sentiment regarding inefficient decarbonization efforts and increased costs.

The Prob(J-Statistic) or the p-value of the Sargan test, is higher than 0.05 in all countries and shows that we cannot reject the null hypothesis that the instruments are valid at any conventional significance level. In other words, these results do not provide evidence against the validity of the selected instruments. The p-value for the Arellano – Bond test for serial correlation AR(2), which is applied to the differenced residuals to remove the unobserved and perfectly autocorrelated, is greater than 0.05 in all countries, except France. This shows that the instruments are appropriate or that there is no phenomenon of serial correlation for residuals in the selected countries, with the exception of France.

While the Sargan test suggests that the instruments are valid, the Arellano-Bond test for AR(2) shows a p-value below 0.05, which suggests that the model may suffer from second-order serial correlation, which can lead to biased results. To address this, we re-estimated the model for France by including year dummy variables to control for unobserved time-specific effects that could be driving autocorrelation. After this adjustment, the AR(2) p-value rose well above 0.05, confirming that the residuals no longer exhibit problematic autocorrelation and that the instrument set is now likely valid. Some years may have involved systematic shocks or common external factors that affected most firms in the panel.

Table 4 Re-estimated model for France

Variable	*Coefficient*	*Std. Error*	*Prob.*
EV/EVEB (-1)	(0.267)	0.010	0.000
Free Allowances	0.299	0.105	0.007
Surrendered Allowances	(0.177)	0.138	0.208
Verified Emissions	2.483	0.806	0.004
2008	(1.901)	0.332	0.000
2009	5.522	0.241	0.000
2010	(1.961)	0.275	0.000
2011	(1.665)	0.295	0.000
2012	1.681	0.218	0.000
2013	0.548	0.171	0.002
2014	0.543	0.201	0.010
2015	0.860	0.239	0.001
2016	(1.856)	0.493	0.000
2017	(0.501)	0.581	0.393
2018	(0.654)	0.943	0.491
2019	1.073	1.128	0.347
2020	0.084	0.396	0.833
2021	(0.354)	4.520	0.938
J-Statistics	*28.278*		*0.450*
Arellano-Bond Serial Correlation Test AR(2)			**0.987**

(Source: Authors' calculations)

The results differ across countries due to the country-specific characteristics and due to the sample of companies, which is heterogeneous and consists of companies from different industries. The primary limitation of this paper lies in the sample of companies— it does not encompass all firms from the selected countries that contribute to carbon emissions. Additionally, the absence of industry-specific segmentation may significantly influence the results. For future research, it would be beneficial to broaden the sample to include more countries, incorporate industry-level analysis, and consider additional relevant variables to enhance the robustness of the findings.

4. Conclusion

Climate change has been one of the most unique challenges in recent years which resulted in many international initiatives and protocols. Among the most important initiatives is the EU ETS as the first and largest carbon market which is successfully implemented in practice. Considering the relevance and importance of this system in combating climate change, this paper investigates its impact on the stock market in the EU by selecting companies from the four largest emitter countries, Germany, France, Poland, and Italy.

This paper uses the differentiated generalized method of moments (GMM estimator) to investigate the possible impact of free and surrendered allowances, and verified emissions on stock prices and the EV/EBITDA ratio. These relationships could highlight the complex interplay between regulatory compliance, operational efficiency, financial performance and market sentiment across the selected companies and countries.

The overall findings indicate that the EU ETS affects both the corporate sector and capital markets, with its effects varying across different countries. Negative impact of free allowances on both stock prices and the EV/EBITDA ratio suggests that investors perceive companies receiving more free allowances as lacking incentives to reduce emissions and lower company valuations in anticipation of future costs, which is the case in Germany and France. In some countries, such Poland, free allowances does not have significant impact, while in Italy it only positively affects the EV/EBITDA ratio, reflecting lower operational costs.

Surrendered allowances (SA) have mixed impact on stock prices and the EV/EBITDA ratio among the selected countries. In Germany and Poland, the surrendered allowances negatively impacts stock prices and the EV/EBITDA ratio, which reflects negative market sentiment toward companies with higher amounts of surrendered allowances and higher operational costs, especially if the purchased allowances have higher share in the portfolio. In Italy, surrendered allowances contribute to declining stock prices but simultaneously boost the EV/EBITDA ratio, indicating unfavorable market sentiment while enterprise value grows at a quicker pace than EBITDA. In France, SA has a positive impact on both stock prices and the EV/EBITDA ratio, suggesting stronger stock performance and higher enterprise value than EBITDA.

Verified emissions are usually associated with higher risks which may lead to lower stock prices and enterprise valuation, which is the case in France, however in Germany, Poland and Italy the relationship is positive indicating that this may reflect higher output which can boost market sentiments or valuations. Similarly, the impact on EV/EBITDA is positive in both Poland and Germany and negative in France and Italy.

This paper has some limitations related to the selected sample of companies since (1) not all companies that participate in carbon emissions are covered, and (2) there is no disaggregation of data by industries which can significantly change the results. Regarding future related research,

it is suggested to expand the sample to other countries, to break down the data by industry, and to include other variables.

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