Original article

Journal of High School Science

Examining shared characteristics of noncompliant companies in a Cap-and-Trade system

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Submitted: July 25, 2023, Revised: version 1, August 29, 2023
Accepted: September 7, 2023

Abstract

Climate change poses an ever-increasing threat to our world, and addressing greenhouse gas (GHG) emissions is critical to mitigating its impact. Cap-and-trade systems have emerged as a key mechanism to incentivize emission reduction by allowing parties to trade carbon credits. Despite the potential benefits of these systems, some companies fail to comply with emission reduction targets, leading to inefficiencies in achieving carbon neutrality. This study explores the shared characteristics of noncompliant companies in a cap-and-trade system to identify patterns and improve compliance rates. For the scope of this study, the focus was on the European Union Emissions Trading System (EU ETS), the world's first and largest international cap-and-trade program, and a descriptive analysis approach was utilized. Data was collected from the EU ETS operators registry and financial records from the Orbis database. Three key characteristics were investigated: firm size, financial performance (measured by EBITDA margin), and industry sector. A total of 38 noncompliant and 38 compliant companies were analyzed. The findings revealed that noncompliant firms tend to be smaller in size and financially strained, indicating that financial health plays a significant role in compliance behavior. While the analysis of industry sectors did not provide clear conclusions due to the specific nature of the classifications, it suggests that more comprehensive industry groupings may yield stronger associations. These results have important implications for environmental policy and cap-and-trade system design. By identifying characteristics associated with noncompliance, policymakers can better target enforcement efforts and develop tailored strategies to improve overall compliance rates. Enhancing compliance will lead to greater efficiency in cap-and-trade systems, accelerating progress towards carbon neutrality and climate change mitigation.

Keywords

Cap-and-Trade, Noncompliance, Carbon credits, Emissions trading system, Climate change mitigation, Environmental policy, Compliance behavior, EBITDA, Carbon neutrality, Emission reduction

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Introduction

In this ever-changing and hyper-connected world, therein lies an unwavering, daunting challenge that has yet to be quelled: climate change. According to the United States Environmental Protection Agency (EPA), from 1990 to 2015, emissions of carbon dioxide, which accounted for about three-fourths of total emissions, increased by 51 percent. The pace of global warming has accelerated to an impermissible level, with historical measurements showing that the current global atmospheric concentrations of carbon dioxide are entirely unprecedented compared with the past 800,000 years, even after accounting for natural fluctuations (4). To address the levels of greenhouse gas (GHG) emissions, a more recent opportunity was unlocked by the combination of the United Nations Framework Convention on Climate Change (1992), the Kyoto Protocol (1997), and Article 6 of the 2015 Paris Climate Agreement, signed by 196 countries (16). They introduced and established the implementation of trade-focused carbon markets and allowed countries and firms to cooperate to achieve emission reduction targets. This had incentivized countries and companies to achieve net zero emissions by enabling parties to trade carbon credits (26). One key mechanism that was born out of these agreements is cap-and-trade. In a cap-and-trade system, participating parties are issued pollution permits—essentially allowances for the capped amount of emissions they may create under a given period. If polluters exceed their set amount of credits, they can buy permits from other parties that have excess carbon credits. (as shown in Figure 1). Each year, the cap for each participating firm or country decreases, ensuring that true GHG removal occurs and our society is making genuine progress. Thus, an emissions trading system (ETS) had unfolded where economic incentive was strategically juxtaposed with GHG reduction and the path to carbon neutrality.

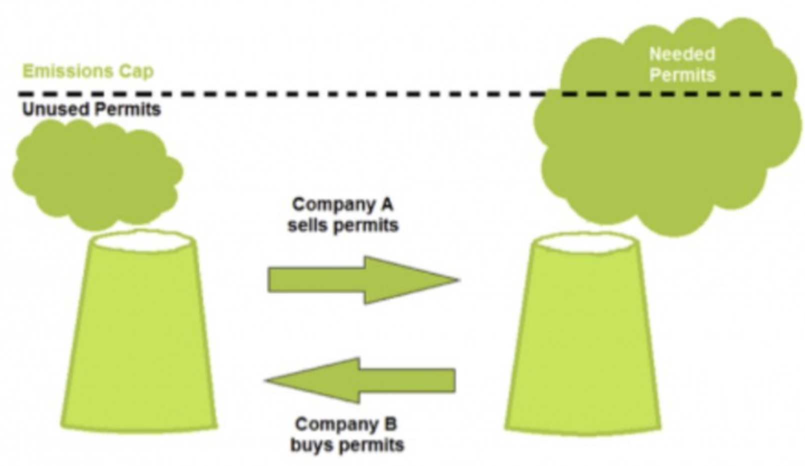

Figure 1. If companies emit less than the cap, they are permitted to sell the excess carbon permits to companies that are polluting more. The company polluting less will profit from this transaction. The figure was adapted from Energy Royd, 2013.

As of the beginning of 2022, there had been 26 operating ETS stationed around the world, whereas, in 2011, only 7 operating ETS had existed (25). The largest and most renowned are China's ETS (launched in 2021), The European Union's ETS (launched in 2005), South Korea's ETS (launched in 2015), the United Kingdom ETS (launched in 2021), and the USA - California Cap-and-trade Program (launched in 2012). Cap-and-trade is the future and provides hope for the future of our climate. Carbon trading could facilitate the removal of 50% more emissions (about 5 gigatons of carbon dioxide per year by 2030 (22). With the increasing popularity of these carbon mechanisms, growing from just 7 ETS initiatives in 2011 to the currently existing 26 (25), the global economy has now shifted and must perfect cap-and-trade as a tool to transition to a net-zero world.

Literature Review

Beginning with foundational knowledge for my exploration of cap-and-trade systems, the first ongoing discussion in the literature is the existence of noncompliant companies. There had been numerous studies, specifically focusing on compliance in a cap-and-trade program. Aakre and Hovi defined compliance in cap-and-trade as correctly measuring and reporting emissions and meeting emission reduction or limitation targets (2010). Compliance is an objective determination that doesn't rely on data on a firm's environmental behavior but is a mere artifact of program participation and adherence to the rules (14). As cap-and-trade programs have been instituted into practice, economists and policymakers have realized that some companies may not comply with such rules (1). Aakre and Hovi then address 4 ways a firm may be noncompliant with the system. A participant might fail to correctly measure and report its emissions, a participant might oversell their permits, a participant might underbuy permits, and finally, after a participant has been deemed noncompliant (for any of the violations mentioned), the noncompliant participant might fail to comply with their punishment. Boswall & Lee (2002) put the concept of noncompliance more simply: "those who emit more than their total allocated allowance, including their initial allowance and any purchased allowances they may have, are heavily penalized by the government.". To put this into context, looking at a recent case study will make the phenomenon more concrete. In the first quarter of 2021, TESLA made $518 million off of selling carbon credits. In a quarter with a pretax income of $533 million, it is clear that the sales of the credits accounted for almost the entirety of Tesla's profit for this quarter (20). Why may this be? Because the automaker produces only electric vehicles, they make a substantial profit selling their excess credits to companies who are short of their credits as they have most if not all of their carbon credits remaining. High-polluting firms benefit from purchasing credits to avoid costly punishment by the government, but nevertheless, noncompliance exists.

There are several reasons why this noncompliance is worth studying. Several studies have examined how the phenomenon of noncompliance affects the overall efficiency of a cap-and-trade program. Malik (1990) examined the consequences of noncompliance in a transferable discharge permit market (TDP), one that is comparable to the more modern cap-and-trade system. He found that when firms were noncompliant, TDP markets did not fully retain their efficiency. His simulation results showed that when firms were perfectly compliant, the markets minimized the cost of achieving a certain emissions abatement level because it equated marginal profits across firms. However, when firms were noncompliant, it was more difficult to equate marginal profits across firms, hence this cost optimization did not apply. Therefore, he concluded that TDP markets may not be efficient when firms are noncompliant. Keeler (1991) elaborated upon Malik's findings, emphasizing the need for robust compliance enforcement and penalties to preserve efficiency. However, the underlying characteristics of noncompliance behavior in firms remain largely unexplored in the literature. If noncompliance poses potential implications on the efficiency of cap-and-trade programs, it is imperative to investigate the factors associated with this behavior.

Currently, the body of literature attributes noncompliance as being system-based rather than based on the individual firm. Murphy and Stranlund (2006) recognize a link between a compliance enforcement system's potency and its compliance rates. Aakre and Hovi (2010) agree that compliance is traced back to how the program addresses participation and penalties. Yang et al. (2021) highlight that a higher noncompliance penalty is one of the most effective methods for increasing overall system compliance. The pattern between each of these scholars' conclusions is that they trace the root of the issue back to the cap-and-trade system itself. However, based on March and Olsen's (1989) logic of social choice, participants, whether it be countries or firms, are motivated by two factors when making decisions pertaining to compliance: self-interest and social norms. Self-interest is defined as "the economic and environmental effects entailed by such decisions for that actor" and social norms are regarded as countries/firms "should participate in and comply with the provisions of institutions that provide a public good regardless of whether doing so is in their self-interest" (13). Because society's norm surrounding ETS is that companies should comply to advance the world towards a carbon-neutral society rid of climate change, but noncompliant companies disregard these norms, the factor of self-interest must be focused on. Aakre and Hovi (2010) agree and acknowledge that the motivating force of these factors truly varies from case to case, as it cannot be generalized for all firms. Thus, regardless of the system itself, it is vital to focus on individual firms and evaluate their personal compliance behavior. There remains a significant research gap in identifying characteristics of noncompliance on a firm-by-firm basis and drawing parallels between the noncompliant firms to explore potential similarities. If the system is the only thing looked at as a cause, the individual noncompliant firms, who should also be faulted, are disregarded.

The aforementioned studies use game theoretic approaches, derive optimal amounts of noncompliance, and focus on the importance of compliance enforcement, but there is a clear gap in this area of study. Prior researchers recognize that noncompliance behavior is an issue and should be adequately addressed in carbon policymaking (19), as well as the fact that noncompliant firms should be severely penalized (2). They even note that it is interesting to understand the noncompliance behavior of individual firms and the consequences of such behavior on operational decisions (27). However, till date, no research appears to have been performed to synthesize shared characteristics among noncompliant firms operating in a cap-and-trade program, so as to maximize compliance, increase the efficiency of the system, and in turn amplify the progress toward net zero carbon emissions.

A nuanced approach was taken in this study to examine the factors associated with noncompliance in cap-and-trade programs. The hypothesis posited is that noncompliant firms will have shared characteristics regarding firm size, financial performance, and industry sector. Justification of these hypotheses is included in the methodology section. This led to the central question of this research: Do firm size, financial performance, and industry sector affect a firm's compliance behavior in the EU's cap-and-trade system? To explore this question, instances of noncompliance were identified and data from financial archives was synthesized to draw similarities among the noncompliant firms. By pinpointing characteristics that are generally associated with noncompliance, policies can shift to account for those factors, increasing the overall compliance rate for cap-and-trade, therefore the efficacy of the system in its entirety, and thus aiding the world in establishing more sustainable business and industry.

Methods

The approach for this study used a descriptive analysis. The intention was purely to test if a relationship existed between a firm's compliance behavior and the three characteristics: firm size, financial performance, and industry sector, and not the strength of that relationship. Thus, a descriptive analysis was aligned to fit the inquiry rather than a correlational analysis. According to Scribbr, descriptive research is an "appropriate choice when the research aim is to identify characteristics, frequencies, trends, and categories." Unlike other experimental approaches, the researcher does not manipulate any of the variables (18). This was precisely the intention of this study, thus a descriptive analysis was perfectly tailored to the characteristics of this inquiry as specific patterns among noncompliant firms in cap-and-trade were being tested to see if they existed, not to attempt to explain them or derive the strength of their correlations.

Furthermore, a secondary statistical analysis was the best choice for this particular study because financial indicators in companies were considered, so examining financial and compliance data was the ideal way to obtain verified and impartial results. A survey or experimental method would not be tailored to address the nuances of this topic of inquiry as concrete quantitative data was needed to look at the system on a firm-by-firm basis.

This study was hypothesis-driven, allowing for the refinement of the characteristics focused on in the EU ETS. A study that guided the exploration of the topic was conducted by Vazquez-Brust and Plaza Ubeda in 2021. They had focused on shared characteristics among firms that go beyond compliance with environmental regulations. Vazquez-Brust and Plaza Ubeda had hypothesized that "firms with beyond compliance will be associated with positive drivers, incentives stimulating development of capabilities and availability of good quality environmental technologies." From their governing hypotheses, the first two hypotheses of this study were created but focused on the opposite end of the spectrum: noncompliant firms. The hypotheses were as follows: noncompliant firms are likely to be smaller and noncompliant firms are likely financially strained. To add to the set of hypotheses, an extra, original one was included: a firm's compliance behavior will depend on which industry sector it is classified as. The reasoning for this was that it was expected that firms operating in real estate or management consulting emitted less CO2 than one that was oil mining. Therefore, this study tested three hypotheses: 1) Noncompliant firms are likely to be smaller firms, 2) Noncompliant firms are likely financially strained, and 3) Noncompliant firms are likely to operate in a similar industry. To address these particular hypotheses, exclusively the private company database, Orbis, was utilized. It had long been a universally trusted resource with access to reliable and current data and had won the DataManagement Award in 2018 named "Best Entity Data Solution" (23), so accurate and up-to-date findings were ensured. On Orbis, a plethora of financial records and data were found on all the private international companies needed for this study, so the next step was deciding which financial markers were aligned with each of the hypotheses. Data collection was split into each of my three hypotheses and statistics were chosen to address each one. For firm size, firm revenue in the past year and the number of employees each company had were chosen as indicators. Firm revenue is an efficient marker of firm size as Fortune 500 ranks the largest 500 companies in the world using revenue as an indicator (6). The secondary measure looked at for firm size was the number of employees a company has, but since this may vary due to the industry the company operates in, it tends to be a weaker measure of firm size. However, for this analysis, both values were considered. For the next characteristic, financial performance, Earnings Before Interest, Taxes, Depreciation, and Amortization margin. (EBITDA margin (%)) was chosen as an indicator. This is also known as a company's profitability ratio and is a widely used metric that strips out expenses that may obscure how a company is truly performing, allowing easy comparison of the financial performance between companies (7). Lastly, for industry sector, the predetermined classifications provided by the EU ETS operators registry were used to remain consistent and retain accuracy in analyzing the sectors the firms operated in.

Locating and Utilizing Compliance Data

The first step was to identify noncompliant firms. This section of the methodology was modeled off of a 2019 study by Jo, who also synthesized data from the EU ETS. The data was publicly accessible and provided by the European Union Transaction Log (EUTL). Data from the 2021 compliance cycle was examined to ensure data analysis was still relevant and applicable. The EU ETS was chosen, as it was the world's first international ETS (started in 2005) and is often turned to for its experience(10) It regulates the emissions of around 11,000 companies (15), so there would likely be more data on noncompliant firms. According to Jo, on the Excel spreadsheets of compliance data, "...there are five possible compliance codes installations can be given: A, when the number of allowances and permits surrendered by the deadline (30 April) is greater than or equal to verified emissions, B, when the number of allowances and permits surrendered by the deadline is lower than verified emissions, C, when verified emissions were not entered until the deadline, D, when competent authority corrected verified emissions after the deadline and decided that the installation is not in compliance, and E, when competent authority corrected verified emissions after the deadline and decided that the installation is in compliance" (2019). Just as Jo did, companies marked with a compliance code of a "B" or a "D" were considered noncompliant for this study. Companies marked with a code of B or D, indicating noncompliance, were flagged, and they were moved into a separate Excel spreadsheet for further analysis. As the next phase of data collection was entered, companies with incomplete or outdated data were edited out to ensure results could be as accurate as possible. Outdated data was classified as anything earlier than 2020 to remain consistent with the focus of the study. To draw similarities from noncompliant companies from the 2021 emissions cycle, the financial data must have also been reported in 2020 or 2021. It was also ensured that all data came from the same platform, Orbis, to avoid any inconsistencies in numbers and records. As the intention was to find shared characteristics of noncompliant firms in a cap-and-trade system, it was also pivotal to investigate a sample size of compliant companies for precedent and comparison when analyzing results. Therefore, of the remaining firms participating in the 2021 EU ETS cycle, each of the companies marked with a compliance code of A (meaning they were compliant) was imputed into a random name picker. An equal sample size of compliant companies was then generated for analysis, ensuring each of these also had complete and recent financial statistics. Both data sets (noncompliant and compliant) and all of their data points are formatted into charts included in Appendix A and Appendix B, respectively.

Data analysis

To align with the goal of the inquiry and the descriptive approach, solely descriptive statistics such as median, range, quartiles, and scatter plot graphs were used. Again, this study only aimed to evaluate if this relationship existed, not to uncover an explanation for these relationships or quantify the relationships by any means.

Results and Discussion

Preliminary Analyses

After removing the firms falling under the category of incomplete or outdated data, there were 38 noncompliant companies in the 2021 EU ETS available for further examination, along with an equal sample size of compliant companies. All three factors were analyzed, and firms were categorized into noncompliant and compliant. The analysis was then divided into the three specific characteristics sought in relation to the hypotheses: firm size, financial performance, and industry sector.

Section 1: Firm Size

As mentioned earlier in the methods section, firm size was assessed in two distinct methods. First, the 2021 revenue of the company was examined, alongside considering the number of employees of the company for additional insights into the management structure and company size. Figures 2 and 3 display the range, median, and quartiles for the revenue of the noncompliant dataset and the compliant dataset.

Range	3.79M - 561M
Median	27.15M
Quartiles	Q1: 10.1M, Q2: 27.15M, Q3: 60.4M

Figure 2. Revenue for Noncompliant set

Range	26M - 11.6B
Median	391.5M
Quartiles	Q1: 235M, Q2: 391.5M, Q3: 807M

Figure 3. Revenue for Compliant set

As evidenced by the data, the offenders/noncompliant set scores lower in range, median, and each of the three quartiles. The median of the 38 compliant companies in Figure 2, 391.5M vs. the 27.15M median for the 38 noncompliant companies suggests that there is a correlation between revenue and compliance behavior.

In terms of the number of employees, there were 4 companies lacking data on the number of employees in the noncompliant data set and 3 companies lacking data on the number of employees in the compliant data set. However, these firms were not removed from the list as number of employees is a secondary way of assessing the size of a company. The primary way is found through examining revenue, so the incomplete data sets wouldn't skew results. The range, median, and quartiles for the noncompliant and compliant data sets are below in Figures 4 and 5.

Range	18 - 1348
Median	117
Quartiles	Q1: 57, Q2: 117, Q3: 216

Figure 4. Number of employees for Noncompliant set

Range	3 - 35,200
Median	458
Quartiles	Q1: 323, Q2: 458, Q3: 866

Figure 5. Number of employees for Compliant set

While the number of employees is likely a weaker way to classify firm size than revenue is, the statistics still consistently support hypothesis A, displaying that the compliant firms tend to have a larger management team which may be related to larger firm size. Comparing the quartiles of the noncompliant set to the compliant set indicates that the 25th, 50th, and 75th percentile are all significantly smaller for the noncompliant companies in relation to those that are compliant.

Section 2: Financial Performance

To assess financial performance, data was located for each of the 38 compliant and noncompliant firms on the EBITDA margin. The range, median, and quartiles for each data set can be found in Figures 6 and 7.

Range	-68.2 - 55.4
Median	-2.3
Quartiles	Q1: -22.0, Q2: -2.3, Q3: 5.8

Figure 6. EBITDA margin (%) for Noncompliant set

Range	0.83 - 56.99
Median	11.23
Quartiles	Q1: 7.23, Q2: 11.23, Q3: 20.68

Figure 7. EBITDA margin (%) for Compliant set

The comparison of the median of the data sets provides a clear perspective on the trend, with the median in Figure 6 of the noncompliant firms being -2.3%, with the median in Figure 7 of the compliant firms being 11.23%. It is important to recognize that a negative EBITDA margin indicates that a company is losing money, meaning that a large portion of the noncompliant set is under major financial strain. Furthermore, examining the range provides valuable insights, as the lowest EBITDA margin in the compliant set is 0.83. Even the minimum doesn't dip below zero, implying that every company in the compliant set is profitable to some extent. However, it is important to acknowledge that there was an outlier in the noncompliant set which has an EBITDA margin of 55.4%. If that outlier was removed, the maximum value in the noncompliant set would be 17.7%. Figures 8 and 9 further solidify this by providing a visual distribution of the EBITDA margins, using the same range (from -80% to 80%) to thoroughly demonstrate the contrast. These results suggest that firms under financial strain are more unlikely to comply with their emissions cap.

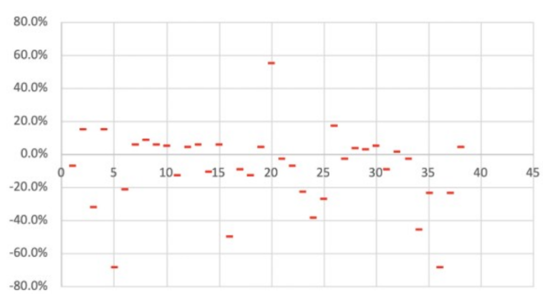

Figure 8. EBITDA margin (%) for Noncompliant set

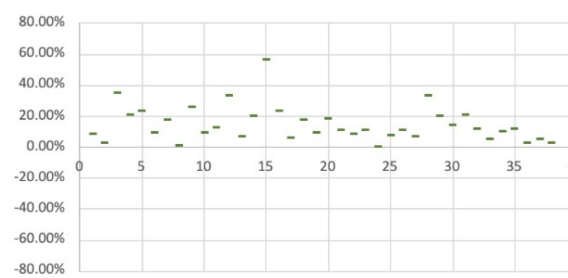

Figure 9. EBITDA margin (%) for Compliant set

Section 3: Industry Sector

For the industry sector, the provided categories from the EU ETS operators registry were used. The sectors in which each company was classified were then tallied. The list of original sectors can be found in Appendix C. Common themes within the industry classifications were identified and condensed to generate the outcomes presented in Figure 10.

Aircraft Operator	Ratio - 1:0	100.00%
Manufacturing of Glassware and Ceramics	Ratio - 7:3	70.00%
Combustion of Fuels	Ratio - 17:18	48.57%
Production of pulp, paper, and cardboard	Ratio - 8:4	66.67%
Production of chemicals, minerals, and metals	Ratio - 4:11	36.36%
Installation/Production of cement	Ratio - 1:1	50.00%
Other (Unknown)	Ratio - 0:1	0.00%

Figure 10: Heat Map of Industry Sectors Compliance Behavior

In the heat map, greener means more compliant, redder means less compliant, and the ratios are listed to demonstrate the sample size of each industry in the format of (# of noncompliant firms: # of compliant firms). Common themes were synthesized for brevity. For instance, the combination of production of non-ferrous metals, production of ferrous metals, production of pig iron & steel, production of nitric acid, production of bulk chemicals, and refining of mineral oil resulted in a comprehensive category termed production of chemicals, minerals, and metals. Within this industry sector, there were 4 noncompliant firms and 11 compliant firms, stating this industry sector held only a 36.36% chance of noncompliance and was primarily compliant. Similarly, the grouping of manufacturing of glassware and manufacturing of ceramics led to the category manufacturing of glassware and ceramics, which exhibited a 70% noncompliance rate, with 7 noncompliant and 3 compliant companies in that sector. As evident in the heatmap, numerous sectors identified approached the 50% mark for both noncompliance and compliance, represented by a yellowish shade.

Conclusion

The results address the initial research question: Do firm size, financial performance, and industry sector affect a firm's compliance behavior in a cap-and-trade system? The findings upheld ⅔ of my hypotheses and were consistent with the predictions of Vazquez-Brust and Plaza Ubeda. The findings supported that noncompliant firms tend to be smaller companies and financially strained. However, deducing a clear conclusion from the industry sector section of the analysis was difficult because each sector provided by the EU ETS would be classified as a similar NAICS code. NAICS codes are standard classifications for industries widely used in statistical agencies and the economy. Using more general industries such as these would likely yield more direct conclusions as most of the companies looked at in this study would fall under the overarching industries of manufacturing and utilities.

As an extension, a recent news headline from the New York Times directly supports these findings. Recently, the state of California announced an expected budget deficit in early 2023, When Governor Newsom declared this deficit, he immediately vowed not to dip into the state's $37 billion in reserves, but instead called for reduced funding for climate change initiatives (11). This emphasizes the finding that when companies are financially strained, they do not allocate funds to efforts or progressive climate policies. Furthermore, this news headline broadens the implications of this research by suggesting that these conclusions may not just apply to firms, but to the public sector as well. That such backpedling should occur in California is especially surprising given its notoriously ambitious climate and sustainability targets.

In the context of the broader field of environmental economics, this paper suggests that the system may not necessarily be the only issue. As this issue was examined on a firm-by-firm basis and similarities among noncompliant firms were gathered, the hope is that one could address the systemic issues right from the start. To do so, the aforementioned conclusions would be utilized to identify companies that are at a higher risk of noncompliance and to create policies targeting and monitoring those firms. By focusing resources on these high-risk firms, enforcement agencies can increase efficiency in deterring noncompliance. When compliance is improved, this will increase the efficacy of cap-and-trade systems in their entirety, as discussed in accordance with Malik and Keeler in the literature review. Increasing the effectiveness of cap-and-trade systems will allow reliance on these mechanisms as a constructive resource to combat GHG emissions and confront the climate challenge at the business level.

Furthermore, it is imperative to consider the process of establishing emissions caps. Although the responsibility for this rests with the government, a collaborative approach must be taken, involving engagement of companies as stakeholders in the decision-making process. Assuming that the government consults with companies across various industries and scales, granting noncompliant companies a voice becomes paramount so that their considerations and struggles are taken into account in establishing the right cap. It is essential to avoid a scenario where only compliant firms are represented, potentially resulting in unattainable caps for noncompliant entities. As long as the caps are not determined through a voting system, it is not crucial to have equal representation among compliant and noncompliant firms, but it is important to ensure adequate representation from both categories of firms to improve compliance rates.

One potential innovative suggestion for instituting emissions caps involves setting them inversely proportional to a firm's EBITDA. Thus, a more profitable company would have a lower cap, conversely, it would be easier for a firm to be compliant if they are not as profitable, because they would have a higher cap. While critics of this approach may argue that it implies that emission mitigation is optional, and only suited for a wealthy company, this may actually help unprofitable firms survive to the point where they will become compliant. The higher cap could allow them to sell some carbon credits, become more profitable, and thus improve their compliance behavior. After all, for financially strained companies, survival takes precedence, with sustainability becoming a focus once profitability is gained.

Another alternative approach involves calibrating pollution limits based on the energy consumption required per production unit. By considering the energy efficiency of a company's production process, emissions caps could accommodate variations in energy-intensive sectors. While, in theory, this approach could optimize emissions reduction efforts, its practical implementation requires further investigation. Each product category would require a benchmark—consider, for instance, energy data for diverse automobile types like small cars, mid-size cars, trucks, SUVs, and more. Such benchmarks could only be compared to similar products from similar firms, as all companies are not created equal. Comparing the energy requirements for manufacturing glassware against those for automobiles, for instance, would not be equitable due to the substantial differences in production processes.

Limitations

Inherently, this study has several limitations. Since it represented a purely quantitative analysis using and synthesizing raw financial data, it disregarded other qualitative factors that may play into a firm's compliance behavior, and which may be observed through means such as interviews and surveys with the management of those particular companies. Additionally, the study was limited to 76 companies in total (38 compliant and 38 noncompliant) which may not provide an accurate depiction of a cap-and-trade system that may include thousands of firms. Specific firms were also edited out because of partially incomplete or outdated data to ensure that the validity of the study wasn't compromised. However, that may have skewed results or omitted valuable data. Also, interconnectedness or existing relationships between the three characteristics identified – colinearity - were not accounted for, thus there is uncertainty regarding whether one characteristic, such as firm size, is correlated with EBITDA margin. Finally, the cap-and-trade system does not account for emissions beyond atmospheric pollutants, such as wastewater released into the public water supply or solid waste directed towards landfills or incinerators. Thus, these methods may act as a loophole and may falsify compliance data and behavior; a company can use them to bypass the emissions cap.

Directions for Future Research

The findings provide clear directions for future research in the field. Results from this study indicate that the system of cap-and-trade itself may not be the only challenge, but in fact, similarities among noncompliant firms exist. However, only 3 factors were explored: firm size, financial performance, and industry sector---but there are a plethora of other characteristics that can be investigated in future research such as management, business risk, and carbon intensity, among other critical factors. Future researchers may want to quantify these relationships by testing the strength of their correlations, as the goal of this study was only to identify if these relationships existed. Lastly, future research may want to build on the conclusions in this paper by using them as hypotheses on another cap-and-trade system other than the EU ETS. This would supplement and reinforce the validity of this research.

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Appendix A. Noncompliant Companies and Data

1	Installation Name	Compliance Code	Revenue	# of Employees	EBITDA margin	Code from EU ETS
2	Air Belgium	B	159M	368	-6.8%	Aircraft Operator
3	Keramika Burgas	B	10.9M	117	15.9%	Manufacture of Ceramics
4	Rubin JSC	B	23.2M	498	-31.3%	Manufacture of Glass
5	SVILOCELL EAD	B	68.4M	524	15.6%	Production of Pulp
6	BRIKEL EAD	B	70.5M	1,348	-68.2%	Combustion of Fuels
7	TPP VARNA EAD	B	60.4M	240	-20.7%	Combustion of Fuels
8	Velpa 91 AD	B	9.08M	220	6.2%	Production of paper or cardboard
9	Cerámica del Nalón	B	18.8M	72	8.9%	Manufacture of ceramics
10	Cerámicas Nomdedeu, S.A.	B	11.2M	53	6.2%	Manufacture of ceramics
11	Comercial e Industrial Aries S.A.	B	12.6M	54	5.8%	Production of lime, or calcination of dolomite/magnesite
12	ENEACER S.L.	B	18M	60	-12.6%	Manufacture of ceramics
13	Firtec, S.A.	B	29.3M	74	4.8%	Combustion of fuels
14	Grabisa tintes y acabados,	B	10.1M	57	6.2%	Combustion of fuels
15	Iberboard Mill, S.L.	B	36.2M	144	-9.7%	Production of paper or cardboard
16	Reckitt Benckiser, Granollers SL	B	82.3M	102	6.4%	Combustion of fuels
17	Zumos Palma, S.L.U.	B	24.1M	117	-49.3%	Combustion of fuels
18	ALTEO GARDANNE	B	251M	468	-8.8%	Production of primary aluminium
19	DURALEX INTERNATIONA	B	39.5M	n/a	-12.0%	Manufacture of glass
20	FREGATA HYGIENE	B	31.7M	46	5.2%	Combustion of fuels
21	GLOBAL SWITCH (PARIS)	B	60.5M	26	55.4%	Combustion of fuels
22	Wizpaper	B	30.8M	n/a	-1.9%	Production of paper or cardboard
23	ISD Kokszoló Kft.	B	127M	n/a	-6.7%	Production of coke
24	ISD POWER Kft. Erőmű	B	121M	n/a	-22.0%	Combustion of fuels
25	CALCISERNIA S.P.A.	B	5.27M	18	-37.7%	Installations for the production of cement clinker in rotary kilns or lime in rotary kilns or in other furnaces
26	CARTIERA SUL LIRI S.P.A.	B	3.96M	33	-26.3%	Production of paper or cardboard
27	Corning Pharmaceutical Gla	B	51.8M	131	17.7%	Manufacture of glass
28	Distillerie G. Di Lorenzo s.r.l	B	7.19M	35	-2.4%	Combustion of fuels
29	Essity Italia SpA	B	561M	899	4.5%	Production of paper or cardboard
30	Industria Cartaria Tivoli S.r.l	B	58.2M	73	3.4%	Production of paper or cardboard
31	SOCIETA' CHIMICA BUSSI S.P.A	B	54.8M	121	5.7%	Combustion of fuels
32	Vafos Pulp AS	B	20.7M	55	-8.5%	Production of pulp
33	Energetyka Cieszyńska Sp. z o.o	B	8.38M	112	1.8%	Combustion of fuels
34	MEGATEM EC-LUBLIN Sp.	B	25M	147	-2.2%	Combustion of fuels
35	CENTRALA ELECTRICA DE TE	B	35.9M	171	-45.4%	Combustion of fuels
36	SC SERVICII COMUNALE	B	6.38M	148	-22.7%	Combustion of fuels
37	SC Uzina de Agent Termic	B	6.58M	137	-67.9%	Combustion of fuels
38	SC Viromet SA	B	3.79M	216	-23.0%	Production of bulk chemicals
39	UZINA TERMOELECTRICA PRO	B	4.75M	84	4.7%	Combustion of fuels

Appendix B. Compliant Companies and Data

1	Installation Name	Compliance Code	Revenue	# of Employees	EBITDA Margin	Code from EU ETS
2	Laakirchen Papier AG	A	412000000	458	8.95%	Production of paper or cardboard
3	Montanwerke Brixlegg AG	A	1510000000	323	2.83%	Production or processing of non-ferrous metals
4	Smurfit Kappa Nettingsdorf	A	352000000	360	35.08%	Production of paper or cardboard
5	Vertellus Specialties Austria	A	177000000	3	21.02%	Production of bulk chemicals
6	Zellstoff Pols	A	411000000	512	23.92%	Production of pulp
7	Akzo Nobel Ghlin	A	11600000000	35,200	9.97%	Combustion of fuels
8	Alco Bio Fuel	A	320000000	50	18.05%	Combustion of fuels
9	Aurubis Olen	A	3860000000	627	1.37%	Production or processing of non-ferrous metals
10	Biowanze	A	372000000	128	26.30%	Combustion of fuels
11	Oleon	A	1010000000	1,008	9.61%	Combustion of fuels
12	Norbord	A	114000000	123	13.05%	Combustion of fuels
13	Provital	A	26000000	83	33.71%	Combustion of fuels
14	Taminco	A	559000000	412	7.23%	Combustion of fuels
15	VPK Paper	A	296000000	294	20.68%	Production of paper or cardboard
16	Devnya Cement	A	130000000	214	56.99%	Production of cement clinker
17	LUKOIL Neftochim Borgas AD	A	772000000	1,309	23.65%	Refining of mineral oil
18	Sofia Med	A	807000000	635	6.17%	Production or processing of non-ferrous metals
19	Zagorka AD	A	72400000	422	18.21%	Combustion of fuels
20	Borsodchem MCHZ	A	252000000	n/a	9.49%	Production of nitric acid
21	CS CABOT, spol. s r.o.	A	215000000	n/a	18.69%	Other activity opted-in pursuant to Article 24 of Directive 2003/87/EC
22	Nexen Tire Europe	A	411000000	n/a	11.22%	Combustion of fuels
23	Aiala Vidrio SA	A	101000000	350	8.46%	Manufacture of glass
24	Tameh Czech	A	235000000	330	11.21%	Combustion of fuels
25	VÍTKOVICE STEEL, a.s.	A	969000000	866	0.83%	Production of pig iron or steel
26	NUFRI S.A.T.	A	310000000	1,074	8.23%	Combustion of fuels
27	Cheminova A/S	A	558000000	590	11.24%	Combustion of fuels
28	Harboes Bryggeri A/S	A	203000000	504	7.19%	Combustion of fuels
29	Novozymes A/S	A	2370000000	6,781	33.91%	Combustion of fuels
30	Alier SA	A	171000000	200	19.99%	Combustion of fuels
31	Acerinox, S.A.	A	7650000000	8,150	14.77%	Production of pig iron or steel
32	Baldocer SA	A	237000000	596	21.32%	Manufacture of ceramics
33	Compacglass SL	A	318000000	565	12.21%	Manufacture of ceramics
34	Covestro SL	A	418000000	326	5.28%	Production of bulk chemicals
35	Ercros SA	A	1140000000	1,336	10.59%	Combustion installations with a rated thermal input exceeding 20 MW
36	Font Salem SL	A	420000000	477	12.42%	Combustion of fuels
37	Nervacero, S.A.	A	440000000	332	3.33%	Production of pig iron or steel
38	Roldan SA	A	340000000	416	5.31%	Production or processing of ferrous metals
39	Seat SA	A	10800000000	14,689	2.84%	Combustion of fuels

Appendix C. List of Original Industry Sectors

1	Aircraft Operator
2	Manufacture of Ceramics
3	Manufacture of Glass
4	Production of Pulp
5	Combustion of Fuels
6	Production of paper or cardboard
7	Production of lime, or calcination of dolomite/magnesite
8	Production of primary aluminium
9	Production of coke fuel
10	Installations for the production of cement clinker in rotary kilns or lime in rotary kilns or in other furnaces
11	Production of bulk chemicals
12	Cement clinker
13	Refining of mineral oil
14	Production of nitric acid
15	Other activity opted-in pursuant to Article 24 of Directive 2003/87/EC
16	Production of metals
17	Combustion installations with a rated thermal input exceeding 20 MW