Masters' thesis

The influence of board characteristics on the relationship between carbon emissions and firm value

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Abstract

Both carbon emissions and board characteristics affect firm value. The relationship between carbon emissions and firm value could be affected by an interaction between board characteristics and carbon emissions, as the influence of carbon emissions on firm value could depend on the sustainability measures that are taken by the board of a company. The interaction between carbon emissions and board characteristics could display the effectiveness of the sustainability measures and therefore influence the relationship between carbon emissions and firm value. This has been tested with panel data of European listed companies over the period 2014-2018. The results only support the interaction absolute carbon emissions and the presence of a sustainability committee in a model with a market based firm value. Other interactions are not supported. Although there is no strong evidence, the results could give new insights and create new opportunities for further research.

Keywords

Carbon emissions, firm value, board characteristics, board size, board tenure, CEO duality, sustainability committee, gender diversity, independent directors

1. Introduction

In a time where the climate crisis is a worldwide important issue, many companies feel the urge to become more environmentally sustainable and limit their carbon emissions. Research shows that an increase of corporate financial performance can come from exceeding a minimum level of carbon emissions reduction (Lewandowski, 2017). Busch and Lewandowski (2018) found that carbon emissions vary inversely with financial performance. This indicates that good carbon performance is positively related to superior financial performance. This might be important information for companies, as it can stimulate them to further reduce their carbon emissions. The board of a company helps to set the general goals of a company (Chen, 2019) and, therefore, is of importance regarding measures that are taken to reduce carbon emissions. To gain more insight in the relationship between carbon emissions and firm value, this study will also focus on board characteristics, as this might influence this relationship.

A range of studies have shown that board characteristics influence firm performance, firm value, and carbon emissions. Martín and Herrero (2020) found that the existence of a corporate social responsibility (CSR) committee and gender diversity within a board have a positive association with the environmental performance of a firm. Orazalin (2020) found that the presence of a sustainability committee improves the effectiveness of CSR strategies and that firms with effective CSR strategies show better environmental performance. Hidayat and Utama (2016) have shown that the proportion of independent directors can increase firm performance. The findings of the research of Saona, Muro, San Martín and Cid (2020) confirmed the benefits of a good board of directors, which includes a balanced gender diversity, is large in size, and has sufficient independent directors. There is thus a strong indication that board characteristics have an influence on both firm value and carbon emissions. In prior studies (Hassan & Romilly, 2018; García-Sánchez & Martínez-Ferrero, 2019; Alsaifi, Elnahass, & Salama, 2020; Amran, Lee, & Devi, 2014) regarding the relationship between carbon emissions and firm value, sometimes a number of board characteristics are included as control variables. Ultimately the board decides on the corporate governance within a company and thus has a major influence on the focus within a company. The focus that is maintained can be influenced by the personal experiences and background of the board members (García-Sánchez & Martínez-Ferrero, 2019). An example of the focus of a board on improving sustainability, is the presence of a sustainability committee. The presence shows a commitment towards sustainable development and the willingness to invest. Furthermore, it shows that the board is willing to invest in the long-term. The long-term perspective that the board maintains also shows a commitment to sustainable growth, which will show in the firm value (Martín & Herrero, 2020; Orazalin, 2020). It shows that the willingness of the board to maintain a long-term perspective influences both carbon emission reduction and firm value. Therefore, this study will focus on the board characteristics that influence both carbon emissions and firm value. This study will look into the interaction effect between a number of board characteristics and carbon emissions. Board characteristics that influence both carbon emissions and firm value, might, combined with carbon emissions, indicate the effectives of the board characteristics on carbon emissions. The effect of carbon emissions on firm value might depend on the board characteristics. This could ultimately be shown in the relationship between carbon emissions and firm value. This leads to the following research question “What is the influence of board characteristics on the relationship between carbon emissions and firm value?”.

The scope of existing research will be broadened by studying the influence of board characteristics on the relationship between carbon emissions and firm value. There is research regarding the relationship between board characteristics and firm value and between board characteristics and carbon emissions. However, there is no research on the strengthening or weakening effect that board characteristics might have on the relationship between carbon emissions and firm value.

The practical relevance of this study is twofold and can firstly be found in a challenge companies face on a large scale; the reduction of carbon emissions. While the reduction of carbon emissions can be an objective within a company, it is important for companies to gain profits as that is the tool for survival. With those profits is it possible to create a strong, enduring, and valuable company and also provide the possibility to make sustainable investments. It can be helpful for companies to know the influence of board characteristics on the relationship between carbon emissions and firm value. The second practical relevance of this study can be found in the implications for society. Society is diverse and this is not always reflected in the board of a company. Two of the board characteristics that will be discussed in this study are gender diversity in the board and board tenure. Knowing the implications of a more gender diverse board can help companies to become more diverse in gender. Board tenure might also encourage companies to be more diverse in age.

The dataset consists of 4,294 firm-year observations from listed European companies in the years 2014-2018. The dependent variable is firm value and the independent variables are carbon emissions and board characteristics. The board characteristics that are included are board size, CEO duality, gender diversity on the board, the proportion of independent directors, CEO tenure, and the presence of sustainability committee. The results only support the interaction between absolute carbon emissions and the presence of a sustainability committee in a model with a market based firm value. Other interactions are not supported. This could imply that the influence of board characteristics is smaller than expected or that the effect of board characteristics is different or more complicated than predicted in this study.

The thesis will continue with a literature review which leads to an hypothesis development. After that, the research design and the data will be presented. The following section will present the results and an analysis of the those results. The thesis will end with a discussion and conclusion.

2. Literature review and hypothesis development

2.1 The influence of carbon emissions on firm value

Sustainability is an intensely discussed topic worldwide and can be a major theme within a company. There can be many reasons for companies to become more sustainable. The foundation for this can, for example, be found in revenue enhancement, cost reduction as a result of the efficient use of resources and risk management (Siegrist, Bowman, Mervine, & Southam, 2020). Due to investor pressure, executive compensation, and decision-making criteria that are bound to financial reporting systems, often a short-term perspective is adopted in decision-making (Siegrist, Bowman, Mervine, & Southam, 2020). Stakeholders also have a big influence on the perspective that is maintained. This can be explained by stakeholder theory, which suggests that organizational strategies can potentially be influenced by stakeholders (Brulhart, Gherra, & Quelin, 2019). It is always important to keep the influence of stakeholders in mind. Especially with a topic as sustainability, in which a long-term perspective can be necessary. Sustainability can entail more than only the carbon emissions management of a company. Companies that improve their environmental performance can benefit from competitive advantages, new green markets, and efficiency improvements (Lewandowski, 2017; Shrivastava & Hart, 1995). Efficiency improvements can include reductions in production materials, improvements in processes, and operational costs related to the use of resources and energy (Busch & Lewandowski, 2018). Recycling, the collection of waste products, an efficient use of resources, and closing the material loops should become a priority when improving the sustainability performance (Brulhart, Gherra, & Quelin, 2019). Reducing the resources used in production can be seen in the carbon emissions of a company and will eventually also reduce the costs of a company in the long-term. An improved environmental performance can also improve the economic performance of a firm through a higher productivity and an increase in demand (Nishitani, Kaneko, Komatsu, & Fujii, 2014). Environmental innovations and regulations can reduce unnecessary spending when simplifying designs, eliminate costly materials and reduce unnecessary packaging (Porter & Linde, 1995). Hassan and Romiliy (2018) have concluded that good environmental performance and good economic performance are associated with each other.

Although there are many forms to measure the sustainability performance of a company, the focus of this research is on the carbon emissions of a company. This measurement is not additionally influenced by other (social) measures and looks solely at the environmental impact. There is a range of studies that have found a relation between carbon emissions and firm value (or measurements that could directly increase firm value, like firm performance). When a company has a superior carbon performance, according to Lewandowski (2017) it pays to be environmentally sustainable in terms of corporate financial performance. A minimum level of carbon performance reduction has to be achieved to benefit from these investments. In another study Busch and Lewandowski (2018) found that carbon emissions vary inversely with financial performance. Busch and Hoffmann (2011) found that corporate environmental reduction performance pays off and they found an inverse relationship between corporate environmental performance and corporate financial performance. According to the research of Hassan and Romilly (2018), lower emissions are strongly associated with better economic performance. However, it is an one-way causation that leads from emissions and environmental disclosure to economic performance. The research by Brulhart, Gherra and Quelin (2019) shows that the environmental proactivity of companies has a positive impact on profitability.

Previous studies have shown a negative relationship between carbon emissions and firm value. Carbon emissions can be lowered by investing in carbon emission lowering solutions as solar panels, insulating buildings and electric cars. The company can benefit from these investments for a long time. Limiting the use of resources in production is also a way to limit costs and reduce carbon emissions. Besides limiting the carbon emissions, investing in carbon emission lowering solutions and limiting the use of resources, are both ways to limit costs in the long-term. This money can be invested in the company and help it grow. Therefore, this study expects the following hypothesis:
H1 There is a negative relationship between carbon emissions and firm value.

2.2 Board characteristics and their influence on carbon emissions and firm value

The company's board helps to set the general goals of a company (Chen, 2019). The large influence of the board makes that it could be possible that the board has a strengthening or weakening effect on the relationship between carbon emissions and firm value. Especially since previous studies (elaborated upon in the next paragraphs) have shown the influence that board characteristics have on both carbon emissions and firm value. Besides the board as a whole, the CEO and higher management teams also have a major influence in a company. It is explained by the upper echelon theory that the personal background characteristics, values and attributes of the CEO and the higher management teams affect managerial decisions. The resource dependency theory argues that the environment of the firm influences behaviour (García-Sánchez & Martínez-Ferrero, 2019). Combining the upper echelon theory and the resource dependency theory, it also explains that decisions (including those regarding sustainability) are influenced by CEO characteristics, values and attributes (García-Sánchez & Martínez-Ferrero, 2019). *"Firm-level corporate governance features directly impact firm value and are powerful instruments to improve firm performance*" (Saona, Muro, Martín, & Cid, 2020, p. 24). Good environmental management and environmental ethics of a company affect the competitive strategy and show a higher firm performance (Han, Lin, Wang, Wang, & Jiang, 2019; Lannelongue, Gonzalez-Benito, & Gonzalez-Benito, 2015).

The board, the CEO, and the higher management teams thus can have a large influence on the company and eventually the value of the firm. As discussed, it is expected that carbon emissions and firm value have a negative relationship (Busch & Lewandowski, 2018). This research will show whether there is an interaction effect between carbon emissions and board characteristics that affects the relationship between carbon emissions and firm value. Due to the reasons behind the theory that board characteristics influence firm value, the interaction effect might exist. Here it can be illustrated as follows, both a low carbon emission and a board that maintains a long-term perspective in their decisions could lead to a high firm value. A long-term perspective is also a trait that can lower carbon emissions. The low carbon emission and the long-term perspective can strengthen each other, as the long-term perspective can maintain the low carbon emission. Otherwise, the low carbon emission can indicate carbon emission management which originates from a long-term perspective. When combining the board characteristic and the carbon emissions into an interaction effect, it could be possible that it affects the relationship between carbon emissions and firm value. Therefore, the research question is "What is the influence of board characteristics on the relationship between carbon emissions and firm value?". Next, the various board characteristics and their specific interaction with carbon emissions will be discussed. These board characteristics are chosen because previous studies have shown their relationship with firm value and their connection with carbon emissions. The studies that have shown this relationship are mentioned throughout the following paragraphs.

Gender diversity in the board of directors

De Silva and Pownall found that, whilst begin socially minded, educated women put the greatest value on sustainability (Silva & Pownall, 2014). This is shown by gender diversity within a board of directors being positively associated with the environmental performance of a firm (Martín & Herrero, 2020). Sustainable environmental initiatives are promoted by women through their talent, educational background, and experience (Martín & Herrero, 2020). Greater gender diversity in a board can improve decisions making (Martín & Herrero, 2020). Women are more cautious in their financial decisions and are more risk averse (Saona, Muro, Martín, & Cid, 2020). Gender diversity in the board could increase the ability of providing a better oversight of the disclosure of a firm and the financial reporting. This could ultimately lead to improvement of the value of the firm. Diversity could also improve the quality of the discussions within the board (Saona, Muro, Martín, & Cid, 2020) possibly leading to better and more fundamental outcomes. Earnings management is found to have a negative relationship with the presence of female directors and it is suggested that there is a positive relationship between the proportion of female directors and firm value (Saona, Muro, Martín, & Cid, 2020). It has also been highlighted that diverse groups are more innovative (Saona, Muro, Martín, & Cid, 2020). However, it has also been suggested that diversity can also be double-edged, as it can drive or hinder strategic change. This drive or hinder can be contributed to the power of the female directors or the firm performance (Triana, Miller, & Trzebiatowski, 2014).

The long-term perspective, improvement of decision making, innovativeness, and the risk aversity of a gender diverse board all allow for a higher firm value. It are the characteristics of women that can improve both firm value and carbon emission reduction. A balanced board can make more fundamental decisions which allow for better performances. When board gender diversity and carbon emissions are combined this could influence the relationship between carbon emissions and firm value, because the effect of the carbon emissions on firm value can depend on the sustainability measures taken by the board. Combining carbon emissions and gender diversity could weaken the relationship between carbon emissions and firm value, depending on the level of carbon emissions and gender diversity. Therefore, this study expects the following hypothesis:

H2a The relationship between carbon emissions and firm value will be weakened through gender diversity in the board of directors.

Board size

The board size of a company could influence the effectiveness of it. Bigger boards could allow for more diversity and they are more difficult to manipulate. Smaller boards could make decisions in a more active, efficient and timelier way, which can be translated to better results. (Saona, Muro, Martín, & Cid, 2020). The diversity that could come with a larger board size, could lead to the benefits that can be reached by having a higher proportion of women in the board of directors. Not only the specific benefits brought to the board by women are a benefit of a larger board. It also includes more board member with their own speciality, experience, and expertise on specific issues, as sustainability. This gives access to resource networks and important information and offers better advise (Villiers, Naiker, & Staden, 2011).

While the positive side of a small board is the effectiveness, the larger board comes with benefits. The knowledge and experience of board members allow for more grounded discussions and decisions. This accounts for both decisions regarding carbon emission reduction and firm value. The effect of carbon emissions on firm value could be influenced by an interaction effect between carbon emissions and firm value as this relationship can depend on the experience and knowledge of a large board. The carbon emissions combined with the effects of the board could indicate the effectiveness of the sustainability measures and therefore influence the relationship between carbon emissions and firm value. Firm value might not only depend on the level of carbon emissions, but the (effectiveness of the) sustainability measures could be of influence. The sustainability measures are taken by the board and influenced by the knowledge and experience of it. Therefore, this study expects the following hypothesis: **H2b** The relationship between carbon emissions and firm value will be weakened by increasing the size of the board of directors.

Proportion of independent directors

According to Saona et al. (2020), in line with agency theory it is suggested that a greater proportion of independent directors will be able to monitor better. This could prevent any self-interested actions by managers at the expense of the owners. Less self-interested actions can also lead to increased profit and greater returns for the shareholders. A greater efficiency is also implied by a greater degree of board independence through the supervisory role. This could lead to fewer conflict and ultimately increase the value of the company. (Saona, Muro, Martín, & Cid, 2020). The interests of minority shareholders are protected by independent board members. The return on assets is increased by the proportion of independent directors (Hidayat & Utama, 2016). Also with environmental decisions that are made, independent directors might prevent short-term decisions, and look at the long-term, which in the end benefits most.

Independent directors gain valuable knowledge and experience from external experiences. They have been exposed to a range of issues, including strategic, performance, governance, and environmental issues. It is likely that they have more resources and a more critical opinion related to these issues through experience (Villiers, Naiker, & Staden, 2011).

The board can benefit from the monitoring, knowledge and experience from the independent board members. They can be valuable for both carbon emission reduction and firm value. The long-term perspective, which is in line with monitoring, is valuable for carbon emission reduction. The effectiveness of the sustainability measures that are taken combined with the carbon emissions in an interaction effect, could influence the relationship between carbon emissions and firm value. The effectiveness of the carbon emission reduction could depend on the effectiveness of the long-term measures taken by the board. This could be shown through an interaction effect. Therefore, this study expects the following hypothesis: **H2c** The relationship between carbon emissions and firm value will be weakened through the proportion of independent directors in the board of directors.

CEO duality: CEO also serves as the chair of the board of directors

When the CEO also serves as chair of the board of directors, this could cause problems from the agency perspective, leading to higher agency costs (Martín & Herrero, 2020). The agency problems include information asymmetry between the board and the CEO, excessive managerial compensation and other unfavourable outcomes for shareholders (Villiers, Naiker, & Staden, 2011). Short-term objectives might be chosen over long-term objectives as the CEO can dominate the agenda (Martín & Herrero, 2020). This is at the expense of strategic investments, which could include investments with long payback periods, like environmental investments (Villiers, Naiker, & Staden, 2011). CEO duality is not expected to have a positive impact on either carbon emissions and firm value. An interaction effect between carbon emissions and CEO duality could indicate the ineffectiveness of the sustainability measures that are taken. The effectiveness of the relationship between carbon emissions and firm value can depend on the sustainability measures taken by the board. As it is not expected that a board that is chaired by the CEO takes effective, long-term measures, an interaction effect between carbon emissions and CEO duality might indicate this. Therefore, this study expects the following hypothesis: **H2d** The relationship between carbon emissions and firm value will be strengthened because of CEO duality.

Tenure: the number of years the directors have fulfilled

Legitimacy theory explains that a senior board member could be more experienced and respected. In the process of performance improvement, CEOs with a longer tenure might have a greater insight. (Sánchez, Bolívar, & Hernández, 2017). Longer tenure can be regarded as organizational knowledge and internal social capital represented by familiarity of the processes of a firm. Tenure can also provide better access to resources and better advice (Villiers, Naiker, & Staden, 2011). The experience, knowledge, resources, and internal social capital allow for more grounded discussions and decisions. This could account for both carbon emissions as firm value. The valuable input that can be brought into sustainability measures. The effectiveness of the relationship between carbon emissions and firm value can depend on measures that are taken by the board. An interaction effect between carbon emissions and tenure could account for the effectiveness of the sustainability measures that are taken and therefore influence the relationship between carbon emissions and firm value. Therefore, this study expects the following hypothesis: **H2e** The relationship between carbon emissions and firm value will be weakened by the CEO tenure.

Sustainability committee

The presence of a sustainability committee is positively associated with the environmental performance of a firm. It also shows the commitment of a company to sustainable development. (Martín & Herrero, 2020). This commitment includes the willingness to invest and ultimately gain from the savings made by investing. The effectiveness of CSR strategies is also improved with the presence of a sustainability committee. When a firm has an effective CSR strategy, they show better environmental performance. The positive relationship between board sustainability committees and corporate environmental performance could even be explained by the effectiveness of this CSR strategy (Orazalin, 2020). The presence of a sustainability committee can positively influence firm value by showing the long-term perspective of the board and a commitment to sustainable growth (Martín & Herrero, 2020). The board might choose long-term investments over short-term profits and shows the willingness to invest for the future. The board might also take more effective sustainability measures. The relationship carbon emissions and firm value might depend on the effectiveness of the measures that are created by such a sustainability committee. The effectiveness could be shown by an interaction effect between carbon emissions and the presence of a sustainability committee. Therefore, this study expects the following hypothesis: **H2f** The relationship between carbon emissions and firm value will be weakened by the presence of a sustainability committee.

3. Research design and data

3.1 Sample and data

The quantitative research method applied in this study fits within the mainstream perspective of accounting research. The panel data used for the quantitative research has been found in Eikon and tested in Stata. The data used will consist of European listed companies and will cover the last five years of which information is fully available, which are 2014-2018. A five year period is chosen to gain a better insight through more firm-year observations and to control for changes within companies and the results of those changes within a company, but meanwhile be able to look at a large amount of companies. Over the years, more and more companies voluntarily disclose information about carbon emissions and board characteristics. The most information is disclosed in the most recent years. The five year scope is chosen, as this gives the opportunity to test more complete data of a large amount of companies. A larger amount of companies can be (almost) completely included in five years opposed from ten years. Although the data is still unbalanced, more complete data allows for a more precise testing opposed to a more unbalanced dataset. The choice for European companies is based on cultural differences around the world with the expectation that European cultures are relatively similar. There is a possibility that cultures could influence characteristics of people (and how these are perceived by others). By focussing on board characteristics in this study, this could have an influence. This is partly ruled out by including countries as a control variable and partly by focussing on one continent. It is a custom in Europe to use a two tier system, which can be different in other continents, for example North-America. Finally, previous studies have mainly focussed on global or US-based samples (Alsaifi, Elnahass, & Salama, 2020). Focussing on Europe would differentiate within the research topic.

The initial data sample consisted of 1159 companies (a total of 5795 firm-year-observations). These are European listed companies with information available for the variables that are used in this study in the time period 2014 – 2018. There were some unknown datapoints and to solve this for testing, the unknown datapoints have been deleted. The unknown datapoints could mostly be found within the dependent and independent variables, the control variables were mostly known. As it is important for hypotheses testing that the variables in the hypotheses are known, it has been chosen to delete the unknown datapoints. It was also often the case that multiple variables from one company in one year were unknown, which makes that adjusting these variables would not improve the dataset. The unknown datapoints indicated that the company had not completely released voluntary data (for that year). The resulting dataset consists of a total of 4294 firm-year-observations.

3.2 Research variables

This paragraph will discuss the dependent, independent and control variables that are used in this study. All variables are retrieved from Thomson Reuters Eikon.

3.2.1 Dependent variables

The dependent variable of the study is firm value. Bush and Lewandowski (2018) have shown in their research that market-based measures of financial performance are more positively related to carbon performance than accounting-based measures. However, carbon performance is significantly positively related to both measures. Therefore, this study will measure firm value with both a market-based measure, as well as an accounting-based measure. The accounting-based measure for firm value will be return on equity. Return on equity is measured as ((net income – bottom line – preferred dividend requirement) / average of last year's and current year's common equity) * 100 (Thomson Reuters Eikon, n.d.(h)). The market-based measure for firm-value will be the market value as measured by the share price multiplied by the number of ordinary shares in issue (Thomson Reuters Eikon, n.d.(f)).

3.2.2 Independent variables

The independent variables of the research will be the carbon emissions of the company and board characteristics. Carbon emissions will be measured in absolute and relative terms. The absolute quantity will be the total carbon dioxide and carbon dioxide equivalents emissions in tonnes (Thomson Reuters Eikon, n.d.(d)). The relative quantity will be the total C02 and C02 equivalents emissions in ton divided by the net sales or revenue (Thomson Reuters Eikon, n.d.(e)). As board characteristics will be included: board size (total number of board members at the end of the fiscal year (Thomson Reuters Eikon, n.d.(a))), CEO duality (the CEO also serves as chair of the board (Thomson Reuters Eikon, n.d.(b))), gender diversity on the board of directors, proportion of independent board members, tenure (the average number of years each board member has been on the board (Thomson Reuters Eikon, n.d.(c))), and the presence of a sustainability committee.

3.2.3 Control variables

The following control variables will be included: total assets as representative for firm size, debt ratio (measured as the total debt as a percentage of the total capital (Thomson Reuters Eikon, n.d.(g))), risk (measured as the beta), industry (to control for industries that are more or less carbon intensive), country, and year (Amran, Lee, & Devi, 2014; García-Sánchez & Martínez-Ferrero, 2019; Martín & Herrero, 2020; Alsaifi, Elnahass, & Salama, 2020; Hidayat & Utama, 2016; Lewandowski, 2017; Hassan & Romilly, 2018).

3.3 Research design

The following main empirical model will be used to test the hypotheses:

$FV_{it} = \beta_0 + \beta_1\ CE_{it} + \beta_2\ BS_{it} + \beta_3\ CEOD_{it} + \beta_4\ GEN_{it} + \beta_5\ INDD_{it} + \beta_6\ TEN_{it} + \beta_7\ SUSTC_{it} + \beta_8\ BS*CE_{it} + \beta_9\ CEOD*CE_{it} + \beta_{10}\ GEN*CE_{it} + \beta_{11}\ INDD*CE_{it} + \beta_{12}\ TEN*CE_{it} + \beta_{13}\ SUSTC*CE_{it} + \beta_{14}\ TA_{it} + \beta_{15}\ DR_{it} + \beta_{16}\ RISK_{it} + \beta_{17}\ IND_{it} + \beta_{18}\ CNT_{it} + \beta_{19}\ YEAR_{it} + \beta_{18}\ COMP_{it} + \varepsilon_{it}$

In which

FV is the value of the firm
CE is the carbon emissions of the firm
BS is board size
CEOD is CEO duality
GEN is the gender diversity on the board
INDD is the proportion of independent directors
TEN is CEO tenure
SUSTC is the presence of a sustainability committee
TA is total assets
DR is the debt ratio
RISK is the risk measured by beta
IND is the industry
CNT is the country
COMP is the company
β_0 is the intercept
i is the entity indicator
t is the period indicator
ε is the error term

The model will also be tested with lagged variables, as some independent variables can cause change in the firm value in the following year. This is further discussed in chapter 4. The variables are all presented in the tabulated overview in table 1. Table 2 presents an overview of the companies per year and per country.

Abbreviation	Definition	Measurement
FV	Firm value	Measured in both a market based and an accounting based value
FVMB	Market based firm value	Share price multiplied by the number of ordinary shares in issue
FVAB	Accounting based firm value	Return on equity
CE	Carbon emissions	Measured in both an absolute and relative value
CEA	Absolute carbon emissions	The total carbon dioxide and carbon dioxide equivalents emissions in tonnes
CER	Relative carbon emissions	The total C02 and C02 equivalents emissions in ton divided by the net sales or revenue
BS	Board size	Total number of board members at the end of the fiscal year
CEOD	CEO duality	Dummy variable: the CEO also serves as chair of the board
GEN	Gender diversity	The percentage of women in the board
INDD	Independent directors	The proportion of independent board members
TEN	Tenure	The average number of years each board member has been on the board
SUSTC	Environmental committee	Dummy variable: the presence of a sustainability committee
TA	Total assets	((net income – bottom line – preferred dividend requirement) / average of last year's and current year's common equity) * 100
DR	Debt ratio	The total debt as a percentage of the total capital
RISK	Risk	Beta
IND	Industry	The industry in which the company is categorised
CNT	Country	The country in which the company is situated
YEAR	Year	The years 2014-2018
COMP	Company	

Table 1 – Summary definition of variables

COUNTRY / YEAR	2014	2015	2016	2017	2018
AUSTRIA	9	10	12	14	15
BELGIUM	12	23	23	25	29
SWITZERLAND	37	51	53	56	57
CZECH REPUBLIC	1	3	2	3	4
GERMANY	54	68	78	92	101
DENMARK	16	22	22	24	26
SPAIN	37	38	41	44	45
FINLAND	21	20	21	23	24
FRANCE	76	84	89	102	95
UNITED KINGDOM	237	308	321	351	337
GREECE	8	10	11	11	7
HUNGARY	3	4	4	4	4
IRELAND	4	7	8	7	8
ITALY	26	32	37	49	52
NETHERLANDS	25	28	29	34	37
NORWAY	14	21	21	25	26
POLAND	9	27	27	27	26
PORTUGAL	4	6	7	8	8
SWEDEN	31	46	53	58	58
TURKEY	13	17	18	21	18

Table 2 - Overview companies per year and country

4. Results and analysis

4.1 Summary and correlation

Before testing the model, the data has been prepared. The continuous variables have been winsorized at the first and 99th percentile to exclude the most extreme outliers. With winsorizing, the data in the chosen percentiles is replaced with the nearest value. The winsorized data is used in testing the model. Table 3 presents a summary of the data after winsorizing. Continuing, the most notable values from Table 3 will be discussed.

All variables have 4,294 observations, which indicates that there are no missing variables in the data. CEO duality and environmental committee are both dummy variables, which is also shown by the minimum (0) and maximum (1) values. CEO duality is 1 when the CEO serves also as chair of the board and 0 when the CEO does not serve as the chair of the board. It has a mean of 0.19, which indicates that more companies do not have the CEO as chair of the board, than boards that do have the CEO as chair of the board. Environmental committee is 1 when an environmental committee is present in a company and 0 when there is no environmental committee present. The mean is 0.55, which indicates that more companies do have an environmental committee than companies that do not. Gender diversity, independent directors and debt ratio are all ratios and therefore the values are between 0 and 100. The mean for gender diversity is 25% and the maximum 55%. 25% indicates that in the average board 25% of the board members is female. The boards with the highest gender diversity are almost equally divided between men and women. Independent directors ranges from 0% to 100%, with a mean of 57%. The presence of independent directors can be described as diverse between companies. Debt ratio has a range from 0% to 92.4%. 0% is a notable low value, especially for a listed company. However, it can be possible that a company does not have any debt. Both carbon emission values have a minimum value of 0, which indicates that there are companies that are carbon neutral.

Variable	Obs	Mean	Std. Dev.	Min	Max
FVAB	4,294	12.13486	19.43034	-70.16	90.6
FVMB	4,294	9,618,982	16830.93	94.07	100480.3
CEA	4,294	2122994	7942043	0	5.83e+07
CER	4,294	.0001858	.0005125	0	.0036043
BS	4,294	10.49558	3.784906	4	21
CEOD	4,294	.1949231	.3961877	0	1
GEN	4,294	25.17413	12.53163	0	54.55
INDD	4,294	57.20903	24.0922	0	100
TEN	4,294	6.135.422	2.631802	1.45	14.69
SUSTC	4,294	.545878	.4979487	0	1
TA	4,294	4.34e+07	1.37e+08	216347	9.49e+08
DR	4,294	37.61845	23.63611	0	92.4
RISK	4,294	.9305815	.4836327	-.26	2.3437

Table 3 - Summary (winsorized data)

See table 1 for a tabulated overview of the definition and operationalization of the variables

After winsorizing, the data has also been checked for multicollinearity. The correlation matrix can be found in table 4 and shows no high correlation values between independent variables. Table 5 presents the VIF scores. As the VIF scores are all low, it is assumed that there is no multicollinearity present.

	FVMB	FVAB	CEA	CER	BS	CEOD	GEN	INDD	TEN	SUSTC	TA	DR	RISK
FVMB	1.000												
FVAB	0.1005	1.000											
CEA	0.2852	-0.0699	1.000										
CER	-0.0190	-0.1121	0.5993	1.000									
BS	0.3525	-0.0395	0.1774	0.0559	1.000								
CEOD	0.0765	0.0056	0.0486	0.0022	0.1729	1.000							
GEN	0.1826	0.0519	0.0382	-0.0248	0.1638	0.0651	1.000						
INDD	0.1667	0.0409	0.0833	0.0383	-0.1845	-0.1139	0.1804	1.000					
TEN	0.0634	0.0879	-0.0409	-0.0390	0.0819	0.2243	-0.0614	-0.0933	1.000				
SUSTC	0.2412	0.0067	0.1367	0.1307	0.2475	0.1383	0.1302	0.0337	0.0298	1.000			
TA	0.4878	-0.0681	0.0697	-0.0546	0.2963	-0.0138	0.1209	0.0779	-0.0590	0.1364	1.000		
DR	0.1283	-0.1168	0.0503	0.0365	0.2606	0.0401	0.0756	-0.0165	-0.1020	0.1032	0.2967	1.000	
RISK	0.0836	-0.1302	0.0888	0.0896	0.1634	0.0021	0.0090	0.0295	-0.0325	0.1240	0.2494	0.1798	1.000

Table 4 - Correlation Matrix

See table 1 for a tabulated overview of the definition and operationalization of the variables

Independent variable / dependent variable	FVMB	FVMB	FVAB	FVAB
CEA	1.06		1.06	
CER		1.04		1.04
BS	1.35	1.32	1.35	1.32
CEOD	1.11	1.11	1.11	1.11
GEN	1.10	1.10	1.10	1.10
INDD	1.14	1.12	1.14	1.12
TEN	1.09	1.09	1.09	1.09
SUSTC	1.11	1.12	1.11	1.12
TA	1.23	1.25	1.23	1.25
DR	1.16	1.17	1.16	1.17
RISK	1.10	1.10	1.10	1.10
Mean VIF	1.15	1.14	1.15	1.14

Table 5 - VIF scores

See table 1 for a tabulated overview of the definition and operationalization of the variables

4.2 Regressions

After preparing the data, as described in the previous paragraph, the data was tested. As explained in paragraph 3.3, there are four variations on the model. Firm value is measured in both a market based value and an accounting based value. Carbon emission is measured in an absolute and a relative value. The tests have been performed with and without the interactions. The data has first been tested by a pooled OLS regression, a Fixed Effects Model and a Random Effects Model. The Hausman test has been performed to find the best fit between the Fixed Effects Model and the Random Effects Model. The Hausman test is significant when the p-value is smaller than 0.05, which indicates that the fixed effects model should be used. When the p-value is larger than 0.05, the test is no longer significant and the random effects model should be used. This test has been executed when a Fixed Effects Model or a Random Effects Model is presented, only the model that is fitting according to the Hausman test is included in this study. After these tests, the data has been tested including lags. The board characteristics, carbon emissions and their interaction effect has been lagged with one year. This is because some time might have passed before the effects of the board characteristics and carbon emissions affect firm value.

Every one of the described tests is presented in all four variations in appendix 1. Tables 6 and 7 present only the best fitting models. In some cases a pooled OLS regression was chosen over a Fixed Effects Model or a Random Effects model, as they did not improve the fit of the pooled OLS regression. A pooled OLS regression is preferred then, as the data is not customized to a model. Table 6 presents the models including the absolute carbon emissions and table 7 presents the models including the relative carbon emissions. Both tables present the model including interactions, excluding interactions, and the best fitting regression with lags. Next, the hypotheses and their significance will be discussed.

	Random Effects FVMB	Pooled OLS FVAB	Fixed Effects FVMB	Pooled OLS FVAB	Fixed Effects FVMB incl. lags	Fixed Effects FVAB incl. lags
CEA	0.000330***	-9.02e-08	0.000329**	-0.000000159	-0.000373* ^	-0.00000281*** ^
	(9.54)	(-1.94)	(2.62)	(-0.58)	(-2.14)	(-3.54)
BS	346.9***	-0.0686	250.3***	-0.0535	236.3*** ^	-0.772** ^
	(7.31)	(-0.60)	(4.83)	(-0.45)	(3.65)	(-2.63)
CEOD	-76.79	0.548	-42.65	0.706	-242.4 ^	3.411* ^
	(-0.26)	(0.62)	(-0.14)	(0.77)	(-0.64)	(2.00)
GEN	11.75	0.114***	6.689	0.107***	-4.945 ^	-0.158** ^
	(1.34)	(3.83)	(0.74)	(3.52)	(-0.44)	(-3.09)
INDD	4.647	0.0346*	-4.566	0.0360*	8.225 ^	-0.0230 ^
	(0.71)	(2.30)	(-0.65)	(2.31)	(0.91)	(-0.56)
TEN	164.3**	0.502***	134.3*	0.502***	78.07 ^	-1.040** ^
	(3.03)	(3.90)	(2.31)	(3.84)	(1.03)	(-3.04)
SUSTC	642.7*	0.903	296.9	0.770	200.9 ^	-0.160 ^
	(2.57)	(1.29)	(1.13)	(1.07)	(0.62)	(-0.11)
*CEA*BS*			0.00000156	-1.91e-09	-0.000000331 ^	4.40e-08 ^
			(0.28)	(-0.16)	(-0.04)	(1.22)
*CEA*CEOD*			-0.0000954	-7.60e-08	0.000183 ^	0.000000824 ^
			(-1.14)	(-0.76)	(0.81)	(0.80)
*CEA*GEN*			0.000000492	4.05e-09	-7.21e-08 ^	1.07e-08 ^
			(0.47)	(1.19)	(-0.05)	(1.67)
*CEA*INDD*			-0.00000176*	-5.46e-10	0.000000568 ^	-1.52e-10 ^
			(-2.34)	(-0.28)	(0.55)	(-0.03)
*CEA*TEN*			-0.0000126	-2.12e-09	0.000000117 ^	8.19e-08* ^
			(-1.76)	(-0.11)	(0.01)	(1.99)
*CEA*SUSTC*			0.000122**	5.62e-08	0.000470*** ^	-0.000000220 ^
			(3.12)	(0.59)	(7.43)	(-0.76)
TA	0.0000470***	-4.72e-09	0.0000280***	-4.82e-09	0.0000223***	-2.61e-08
	(16.56)	(-1.78)	(6.60)	(-1.81)	(4.15)	(-1.07)
DR	-16.34*	-0.0501**	-18.95**	-0.0498**	-20.97*	-0.549***
	(-2.49)	(-2.93)	(-2.83)	(-2.90)	(-2.53)	(-14.56)
RISK	89.94	-1.622*	48.40	-1.573*	104.8	3.963**
	(0.45)	(-2.25)	(0.24)	(-2.18)	(0.37)	(3.05)
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES		YES		
Company		YES		YES		
Country	YES	YES		YES		
Constant	-912354.7***	181.9	-986195.1***	196.0	-1042704.7***	-1289.7*
	(-11.26)	(0.45)	(-12.39)	(0.48)	(-9.40)	(-2.56)
Observations	4294	4294	4294	4294	3216	3216
Adjusted R-squared	0.5658****	0.247	-0.200	0.247	-0.310	-0.253
Hausman	1.0000		0.0000		0.0000	0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 6 - Regressions Absolute Carbon Emissions

	Fixed Effects FVMB	Pooled OLS FVAB	Fixed Effects FVMB	Pooled OLS FVAB	Fixed Effects FVMB incl. langs	OLS FVAB incl. lags
CER	-1088755.8*	-3091.3***	1311527.4	-1763.8	-109101.7 ^	2917.8 ^
	(-2.34)	(-4.05)	(1.14)	(-0.62)	(-0.08)	(0.90)
BS	252.4***	-0.0761	270.4***	-0.0832	237.0*** ^	-0.0574 ^
	(5.11)	(-0.67)	(5.11)	(-0.70)	(3.59)	(-0.41)
CEOD	-81.04	0.599	220.6	0.701	2.985 ^	1.256 ^
	(-0.27)	(0.68)	(0.71)	(0.75)	(0.01)	(1.15)
GEN	6.978	0.117***	10.96	0.125***	-6.327 ^	0.0889* ^
	(0.79)	(3.93)	(1.18)	(4.01)	(-0.54)	(2.44)
INDD	-8.624	0.0343*	-6.057	0.0295	8.182 ^	0.0242 ^
	(-1.26)	(2.29)	(-0.84)	(1.88)	(0.88)	(1.31)
TEN	123.4*	0.513***	113.6	0.531***	97.87 ^	0.467** ^
	(2.19)	(3.99)	(1.89)	(3.99)	(1.24)	(3.01)
SUSTC	494.5	0.984	602.4*	1.397	909.5** ^	1.893* ^
	(1.94)	(1.41)	(2.21)	(1.89)	(2.67)	(2.20)
*CER*BS*			-82332.0	46.17	-66964.8 ^	-138.5 ^
			(-1.28)	(0.29)	(-0.81)	(-0.80)
*CER*CEOD*			-3137710.9**	-265.8	-2291700.6 ^	-633.7 ^
			(-3.15)	(-0.17)	(-1.43)	(-0.35)
*CER*GEN*			-29174.5	-45.63	-16798.5 ^	-58.13 ^
			(-1.90)	(-1.04)	(-0.90)	(-1.17)
*CER*INDD*			-5243.1	27.17	6160.6 ^	1.158 ^
			(-0.58)	(1.01)	(0.47)	(0.04)
*CER*TEN*			56304.3	-122.5	46518.4 ^	-178.8 ^
			(0.65)	(-0.50)	(0.46)	(-0.64)
*CER*SUSTC*			-688839.5	-2209.1	-312557.3 ^	-3377.5* ^
			(-1.33)	(-1.74)	(-0.47)	(-2.26)
TA	0.0000301***	-5.31e-09*	0.0000301***	-5.49e-09*	0.0000228***	-5.63e-09
	(7.07)	(-2.01)	(7.07)	(-2.07)	(4.20)	(-1.88)
DR	-19.95**	-0.0482**	-20.06**	-0.0488**	-21.52*	-0.0481*
	(-2.96)	(-2.83)	(-2.98)	(-2.86)	(-2.56)	(-2.41)
RISK	25.72	-1.496*	40.16	-1.507*	230.5	-0.674
	(0.13)	(-2.08)	(0.20)	(-2.09)	(0.80)	(-0.74)
Year	YES	YES	YES	YES	YES	YES
Industry		YES		YES		YES
Company		YES		YES		YES
Country		YES		YES		YES
Constant	-958471.9***	197.8	-959731.5***	185.3	-1096481.3***	-141.9
	(-11.98)	(0.49)	(-11.98)	(0.46)	(-9.75)	(-0.24)
Observations	4294	4294	4294	4294	3216	3216
Adjusted R-squared	-0.217	0.250	-0.212	0.250	-0.344	0.249
Hausman	0.0000		0.0000		0.0377	

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 7 - Regressions Relative Carbon Emissions

4.2.1 Hypothesis 1

The relationship between carbon emissions and firm value is not the same in the different models. Relative carbon emissions more often show a negative relationship with firm value, which is only significant in the regressions without interactions. The relationship absolute carbon emissions and firm value also more often show a negative relationship with firm value, which is significant in both models with lags. A significant positive relationship is shown in the Random Effect Model (excluding interactions) with the market based firm value and the Fixed Effects Model with the market based firm value. The models do not show a significant positive or negative relationship for firm value with both relative and absolute carbon emissions.

Although not both significant, the accounting based firm value shows a negative relationship with both the absolute and relative carbon emissions in the Pooled OLS model including and excluding the interactions. The market based firm value shows a negative relationship in the Fixed Effects Model including lags with both the absolute and relative carbon emissions. The Fixed Effects Model with the market based firm value shows a positive relationship with both the absolute and relative carbon emissions. Although the coefficients are not significant for both the relative as the absolute carbon emissions, this could tell something about the relationship between firm value and carbon emissions.

The coefficients show that there is a relationship between carbon emissions and firm value, yet not always significant and not always in the same direction. The hypothesis, H1, is therefore not supported by the results, as the results are too diverse, even the significant results.

4.2.2 Hypothesis 2

There are only a few interactions that are significant. The models with the absolute carbon emissions show three significant interactions. The interaction independent directors and absolute carbon emissions is significant in the Fixed Effects Model with the market based firm value. The interaction sustainability committee and absolute carbon emissions is significant in both the Fixed Effects Model with the market based firm value excluding and including lags. The models with the relative carbon emissions shows two significant interactions. The interaction CEO duality and relative carbon emissions is significant in the Fixed Effects Model with the market based firm value. The interaction sustainability committee and relative carbon emissions is significant in the Pooled OLS Model including lags with the accounting based firm value.

Notable is that in the models with significant interactions the relationship carbon emissions and firm value has changed. The relationship carbon emissions and firm value, however, does not change consistently. The Fixed Effects Model with the market based firm value and the Pooled OLS regression with the accounting based firm value including lags (both relative carbon emissions) both include a significant interaction and show a positive relationship between carbon emissions and firm value, although not significant. The other models with relative carbon emissions all show a negative relationship between carbon emissions and firm value. When including significant interactions, the models with the absolute carbon emissions do change less drastically opposed to the models with the relative carbon emissions, however the relationship absolute carbon emissions and the market based firm value is significant in the Fixed Effects Models both including and excluding lags. Although the relationship carbon emissions and firm value does change opposed to the models excluding the interactions, when significant interactions are included, the interactions do not change the relationship in a consistent and similar way. Also, the interactions that are significant do not show a pattern in which model they are significant. Therefore, the results do not support hypotheses H2c and H2d. The results do support H2f enough to accept the hypotheses under specific circumstances, as the interaction absolute carbon emissions and the presence of a sustainability committee is significant in the models with the market based firm value. There is no other pattern shown by the interaction carbon emissions and the presence of a sustainability committee and therefore hypotheses H2f is not fully supported by the results.

The interactions board size and carbon emissions, gender diversity and carbon emissions, and tenure and carbon emissions are not significant in any of the models. Therefore, the results do not support hypotheses H2a, H2b, and H2e.

5. Discussion and conclusion

Both carbon emissions and board characteristics influence firm value. However, it could be possible that an interaction between board characteristics and carbon emissions could influence the relationship between carbon emissions and firm value. This is because board characteristics can also influence carbon emissions and a combination of a board characteristic that could lower carbon emissions and a low carbon emission could indicate the effectiveness of the board characteristics, which could influence the relationship between carbon emissions and firm value. The stronger the measurements that are taken by the board, as a result of the board characteristics in combination with the desired carbon emissions, the more it might influence the relationship carbon emissions and firm value. This has led to the research question “What is the influence of board characteristics on the relationship between carbon emissions and firm value?”. This has been tested with a model in which firm value is measured in both an accounting based and market based value. Carbon emissions has been measured in both a relative and absolute value. This has been done to gain a deeper understanding of the relationship and to see if a different measurement gives a different result.

After testing there has been concluded that hypotheses H1, H2a, H2b, H2c, H2d, and H2e are not supported by the results. Hypothesis H2f is only supported by the results for the interaction absolute carbon emissions and the presence of a sustainability committee in the models with the market based firm value. The interaction carbon emissions and the presence of a sustainability committee does not show a pattern within the models that could explain a condition under which the hypothesis could be fully supported. Not accepting the hypotheses does not mean that the interactions do not have an effect at al. The fit of the models does not worsen, nor improve when the interactions are added. When including lags, the coefficients even become larger.

Implications of the results are that the influence of board characteristics is smaller than expected. It could also be possible that the effect is different than predicted in this study. For example a delayed effect of the board characteristics on carbon emissions. Also, not all previous studies have been conducted solely in Europe, therefore, it could be possible that the effect in another continent is different, due to cultural reasons. Furthermore, personal characteristics are not taken into account. A graduate from an university that focusses on sustainability could be more influential than a graduate from an university that does not focus on sustainability. A limitation regarding the interpretation of the results is the extensiveness of the data testing. Measuring both firm value and carbon emissions in two different variables could give a deeper understanding about the conditions in which the hypotheses are supported, but it complicates drawing a decisive conclusion about the results and therefore limits a clear interpretation. The recommendation for future research is further research regarding the role of a sustainability committee in a company as a driver for carbon emission reduction. The partly support of hypothesis H2f could indicate that a sustainability committee increasingly affects the relationship between absolute carbon emissions and the market value of a company. This requires further research in the role of a sustainability committee and influence of a sustainability committee in the decision making process of a company.

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Appendix

Appendix 1 – Regression overview

FVMB	OLS	Random Effects	OLS	Fixed Effects
CEA	0.000575***	0.000330***	-0.000451**	0.000329**
	(18.98)	(9.54)	(-2.58)	(2.62)
BS	984.3***	346.9***	1096.4***	250.3***
	(13.29)	(7.31)	(14.45)	(4.83)
CEOD	-58.39	-76.79	196.0	-42.65
	(-0.10)	(-0.26)	(0.33)	(-0.14)
GEN	85.65***	11.75	67.12***	6.689
	(4.41)	(1.34)	(3.44)	(0.74)
INDD	125.9***	4.647	105.4***	-4.566
	(12.80)	(0.71)	(10.54)	(-0.65)
TEN	470.1***	164.3**	420.4***	134.3*
	(5.60)	(3.03)	(5.01)	(2.31)
SUSTC	1557.8***	642.7*	1425.2**	296.9
	(3.41)	(2.57)	(3.07)	(1.13)
*CEA*BS*			-0.00000411	0.00000156
			(-0.53)	(0.28)
*CEA*CEOD*			-0.0000834	-0.0000954
			(-1.30)	(-1.14)
*CEA*GEN*			0.0000116***	0.000000492
			(5.34)	(0.47)
*CEA*INDD*			0.00000840***	-0.00000176*
			(6.78)	(-2.34)
*CEA*TEN*			0.0000337**	-0.0000126
			(2.63)	(-1.76)
*CEA*SUSTC*			0.0000607	0.000122**
			(0.99)	(3.12)
TA	0.0000551***	0.0000470***	0.0000547***	0.0000280***
	(31.80)	(16.56)	(32.02)	(6.60)
DR	-5.957	-16.34*	-2.391	-18.95**
	(-0.53)	(-2.49)	(-0.22)	(-2.83)
RISK	-877.9	89.94	-784.1	48.40
	(-1.87)	(0.45)	(-1.69)	(0.24)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	
COMPANY	YES		YES	
COUNTRY	YES	YES	YES	
Constant	-29693.3	-912354.7***	1952.5	-986195.1***
	(-0.11)	(-11.26)	(0.01)	(-12.39)
Observations	4294	4294	4294	4294
Adjusted R-squared	0.573	0.5658****	0.586	-0.200
Hausman		1.0000		0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 8 - Model Market Based Firm Value and Absolute CO2

FVMB	OLS	Fixed Effects	OLS	Fixed Effects
CEA	0.000563*** ^	0.000123** ^	-0.000634** ^	-0.000373* ^
	(15.84)	(2.74)	(-3.00)	(-2.14)
BS	981.0*** ^	233.3*** ^	1113.1*** ^	236.3*** ^
	(10.94)	(3.77)	(12.18)	(3.65)
CEOD	-58.12 ^	-160.9 ^	337.3 ^	-242.4 ^
	(-0.08)	(-0.43)	(0.48)	(-0.64)
GEN	94.53*** ^	-9.020 ^	72.68** ^	-4.945 ^
	(4.01)	(-0.82)	(3.07)	(-0.44)
INDD	145.6*** ^	8.869 ^	119.6*** ^	8.225 ^
	(12.11)	(1.00)	(9.81)	(0.91)
TEN	481.5*** ^	94.85 ^	424.3*** ^	78.07 ^
	(4.74)	(1.29)	(4.19)	(1.03)
SUSTC	1651.7** ^	902.2** ^	1494.0** ^	200.9 ^
	(3.00)	(2.86)	(2.68)	(0.62)
CEA*BS			-0.00000161 ^	-0.000000331 ^
			(-0.18)	(-0.04)
CEA*CEOD			-0.000121 ^	0.000183 ^
			(-1.58)	(0.81)
CEA*GEN			0.0000138*** ^	-7.21e-08 ^
			(5.26)	(-0.05)
CEA*INDD			0.0000101*** ^	0.000000568 ^
			(7.08)	(0.55)
CEA*TEN			0.0000302* ^	0.000000117 ^
			(2.00)	(0.01)
CEA*SUSTC			0.0000777 ^	0.000470*** ^
			(1.05)	(7.43)
TA	0.0000551***	0.0000218***	0.0000546***	0.0000223***
	(27.17)	(4.02)	(27.38)	(4.15)
DR	-13.43	-21.34*	-8.798	-20.97*
	(-0.99)	(-2.55)	(-0.66)	(-2.53)
RISK	-605.0	262.6	-287.7	104.8
	(-0.98)	(0.91)	(-0.48)	(0.37)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	
COMPANY	YES		YES	
COUNTRY	YES		YES	
Constant	-61813.4	-1105854.5***	-50969.5	-1042704.7***
	(-0.16)	(-9.89)	(-0.13)	(-9.40)
Observations	3216	3216	3216	3216
Adjusted R-squared	0.577	-0.341	0.593	-0.310
Hausman		0.0000		0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 9 - Model Market Based Firm Value and Absolute CO2 including lags

FVMB	OLS	Fixed Effects	OLS	Fixed Effects
CER	-1942963.9***	-1088755.8*	916811.1	1311527.4
	(-3.73)	(-2.34)	(0.47)	(1.14)
BS	1037.5***	252.4***	1137.2***	270.4***
	(13.44)	(5.11)	(14.00)	(5.11)
CEOD	702.6	-81.04	400.7	220.6
	(1.17)	(-0.27)	(0.63)	(0.71)
GEN	86.19***	6.978	78.36***	10.96
	(4.26)	(0.79)	(3.71)	(1.18)
INDD	136.8***	-8.624	132.7***	-6.057
	(13.35)	(-1.26)	(12.47)	(-0.84)
TEN	458.0***	123.4*	499.4***	113.6
	(5.23)	(2.19)	(5.52)	(1.89)
SUSTC	2005.2***	494.5	1942.0***	602.4*
	(4.21)	(1.94)	(3.86)	(2.21)
CER*BS			-370341.8***	-82332.0
			(-3.48)	(-1.28)
CER*CEOD			1465421.2	-3137710.9**
			(1.35)	(-3.15)
CER*GEN			33888.8	-29174.5
			(1.14)	(-1.90)
CER*INDD			16614.8	-5243.1
			(0.91)	(-0.58)
CER*TEN			-234501.5	56304.3
			(-1.41)	(0.65)
CER*SUSTC			175139.7	-688839.5
			(0.20)	(-1.33)
TA	0.0000576***	0.0000301***	0.0000573***	0.0000301***
	(31.98)	(7.07)	(31.82)	(7.07)
DR	-15.72	-19.95**	-14.85	-20.06**
	(-1.35)	(-2.96)	(-1.28)	(-2.98)
RISK	-323.2	25.72	-450.4	40.16
	(-0.66)	(0.13)	(-0.92)	(0.20)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	
COMPANY	YES		YES	
COUNTRY	YES		YES	
Constant	70012.0	-958471.9***	78717.4	-959731.5***
	(0.25)	(-11.98)	(0.29)	(-11.98)
Observations	4294	4294	4294	4294
Adjusted R-squared	0.535	-0.217	0.538	-0.212
Hausman		0.0000		0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 10 - Model Market Based Firm Value and Relative CO2

FVMB	OLS	Fixed Effects	OLS	Fixed Effects
CER	-2217685.6*** ^	-910984.1 ^	-281883.2 ^	-109101.7 ^
	(-3.62)	(-1.63)	(-0.12)	(-0.08)
BS	1011.1*** ^	220.3*** ^	1120.3*** ^	237.0*** ^
	(10.85)	(3.56)	(11.42)	(3.59)
CEOD	643.7 ^	-153.5 ^	268.7 ^	2.985 ^
	(0.89)	(-0.41)	(0.35)	(0.01)
GEN	91.56*** ^	-8.985 ^	83.89** ^	-6.327 ^
	(3.73)	(-0.81)	(3.28)	(-0.54)
INDD	155.3*** ^	9.038 ^	148.1*** ^	8.182 ^
	(12.43)	(1.02)	(11.41)	(0.88)
TEN	475.1*** ^	101.5 ^	533.1*** ^	97.87 ^
	(4.50)	(1.38)	(4.88)	(1.24)
SUSTC	2157.1*** ^	882.8** ^	2094.7*** ^	909.5** ^
	(3.76)	(2.79)	(3.46)	(2.67)
*CER*BS*			-363563.1** ^	-66964.8 ^
			(-2.97)	(-0.81)
*CER*CEOD*			1737666.3 ^	-2291700.6 ^
			(1.38)	(-1.43)
*CER*GEN*			38156.1 ^	-16798.5 ^
			(1.09)	(-0.90)
*CER*INDD*			37130.5 ^	6160.6 ^
			(1.66)	(0.47)
*CER*TEN*			-319102.8 ^	46518.4 ^
			(-1.63)	(0.46)
*CER*SUSTC*			198481.5 ^	-312557.3 ^
			(0.19)	(-0.47)
TA	0.0000576***	0.0000227***	0.0000573***	0.0000228***
	(27.38)	(4.18)	(27.24)	(4.20)
DR	-20.69	-20.99*	-19.72	-21.52*
	(-1.47)	(-2.50)	(-1.40)	(-2.56)
RISK	147.1	223.4	26.96	230.5
	(0.23)	(0.78)	(0.04)	(0.80)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	
COMPANY	YES		YES	
COUNTRY	YES		YES	
Constant	67344.4	20494.8	29330.6	-1096481.3***
	(0.16)	(0.05)	(0.07)	(-9.75)
Observations	3216	3216	3216	3216
Adjusted R-squared	0.545	0.542	0.545	-0.344
Hausman		0.0000		0.0377

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 11 - Model Market Based Firm Value and Relative CO2 including lags

FVAB	OLS	Fixed Effects	OLS	Fixed Effects
CEA	-9.02e-08	-0.000000657***	-0.000000159	-0.00000189**
	(-1.94)	(-3.50)	(-0.58)	(-3.16)
BS	-0.0686	-0.229	-0.0535	-0.372
	(-0.60)	(-0.98)	(-0.45)	(-1.51)
CEOD	0.548	-0.544	0.706	-0.351
	(0.62)	(-0.39)	(0.77)	(-0.25)
GEN	0.114***	0.0762	0.107***	0.0662
	(3.83)	(1.83)	(3.52)	(1.55)
INDD	0.0346*	0.0467	0.0360*	0.0445
	(2.30)	(1.45)	(2.31)	(1.33)
TEN	0.502***	-0.0560	0.502***	-0.287
	(3.90)	(-0.21)	(3.84)	(-1.04)
SUSTC	0.903	0.245	0.770	0.359
	(1.29)	(0.20)	(1.07)	(0.29)
CEA*BS			-1.91e-09	5.20e-08
			(-0.16)	(1.94)
CEA*CEOD			-7.60e-08	-1.73e-08
			(-0.76)	(-0.04)
CEA*GEN			4.05e-09	4.98e-09
			(1.19)	(1.00)
CEA*INDD			-5.46e-10	-2.06e-10
			(-0.28)	(-0.06)
CEA*TEN			-2.12e-09	0.000000104**
			(-0.11)	(3.05)
CEA*SUSTC			5.62e-08	-0.000000100
			(0.59)	(-0.54)
TA	-4.72e-09	-2.64e-08	-4.82e-09	-2.67e-08
	(-1.78)	(-1.31)	(-1.81)	(-1.33)
DR	-0.0501**	-0.439***	-0.0498**	-0.440***
	(-2.93)	(-13.79)	(-2.90)	(-13.83)
RISK	-1.622*	1.560	-1.573*	1.595
	(-2.25)	(1.63)	(-2.18)	(1.66)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	
COMPANY	YES		YES	
COUNTRY	YES		YES	
Constant	181.9	237.5	196.0	226.7
	(0.45)	(0.63)	(0.48)	(0.60)
Observations	4294	4294	4294	4294
Adjusted R-squared	0.247	-0.250	0.247	-0.248
Hausman		0.0000		0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 12 - Model Accounting Based Firm Value and Absolute CO2

FVAB	OLS	Fixed Effects	OLS	Fixed Effects
CEA	-0.000000171** ^	-0.00000179*** ^	4.19e-08 ^	-0.00000281*** ^
	(-3.27)	(-8.90)	(0.13)	(-3.54)
BS	-0.0849 ^	-0.656* ^	-0.0319 ^	-0.772** ^
	(-0.64)	(-2.35)	(-0.23)	(-2.63)
CEOD	1.084 ^	3.671* ^	1.119 ^	3.411* ^
	(1.05)	(2.19)	(1.05)	(2.00)
GEN	0.0788* ^	-0.135** ^	0.0632 ^	-0.158** ^
	(2.26)	(-2.72)	(1.78)	(-3.09)
INDD	0.0278 ^	-0.0202 ^	0.0311 ^	-0.0230 ^
	(1.56)	(-0.50)	(1.69)	(-0.56)
TEN	0.418** ^	-0.817* ^	0.451** ^	-1.040** ^
	(2.79)	(-2.47)	(2.96)	(-3.04)
SUSTC	1.234 ^	-0.448 ^	1.042 ^	-0.160 ^
	(1.52)	(-0.32)	(1.24)	(-0.11)
CEA*BS			-1.48e-08 ^	4.40e-08 ^
			(-1.09)	(1.22)
CEA*CEOD			1.87e-08 ^	0.000000824 ^
			(0.16)	(0.80)
CEA*GEN			6.36e-09 ^	1.07e-08 ^
			(1.62)	(1.67)
CEA*INDD			-1.15e-09 ^	-1.52e-10 ^
			(-0.54)	(-0.03)
CEA*TEN			-3.63e-08 ^	8.19e-08* ^
			(-1.60)	(1.99)
CEA*SUSTC			7.93e-08 ^	-0.000000220 ^
			(0.72)	(-0.76)
TA	-4.16e-09	-2.51e-08	-4.65e-09	-2.61e-08
	(-1.39)	(-1.03)	(-1.55)	(-1.07)
DR	-0.0492*	-0.549***	-0.0462*	-0.549***
	(-2.46)	(-14.60)	(-2.30)	(-14.56)
RISK	-0.692	3.843**	-0.527	3.963**
	(-0.76)	(2.97)	(-0.58)	(3.05)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	
COMPANY	YES		YES	
COUNTRY	YES		YES	
Constant	-56.03	-1246.0*	-55.78	-1289.7*
	(-0.10)	(-2.48)	(-0.10)	(-2.56)
Observations	3216	3216	3216	3216
Adjusted R-squared	0.247	-0.255	0.248	-0.253
Hausman		0.0000		0.0000

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 13 - Model Accounting Based Firm Value and Absolute CO2 including lags

FVAB	OLS	Fixed Effects	OLS	Random Effects
CER	-3091.3***	-4000.2	-1763.8	-101.0
	(-4.05)	(-1.82)	(-0.62)	(-0.03)
BS	-0.0761	-0.214	-0.0832	-0.0617
	(-0.67)	(-0.92)	(-0.70)	(-0.39)
CEOD	0.599	-0.489	0.701	0.121
	(0.68)	(-0.35)	(0.75)	(0.11)
GEN	0.117***	0.0767	0.125***	0.0990**
	(3.93)	(1.84)	(4.01)	(2.76)
INDD	0.0343*	0.0467	0.0295	0.0422*
	(2.29)	(1.45)	(1.88)	(1.98)
TEN	0.513***	-0.0718	0.531***	0.221
	(3.99)	(-0.27)	(3.99)	(1.24)
SUSTC	0.984	0.230	1.397	1.042
	(1.41)	(0.19)	(1.89)	(1.10)
*CER*BS*			46.17	-186.2
			(0.29)	(-0.92)
*CER*CEOD*			-265.8	2004.3
			(-0.17)	(0.84)
*CER*GEN*			-45.63	-29.37
			(-1.04)	(-0.54)
*CER*INDD*			27.17	7.483
			(1.01)	(0.23)
*CER*TEN*			-122.5	38.23
			(-0.50)	(0.13)
*CER*SUSTC*			-2209.1	-2457.0
			(-1.74)	(-1.46)
TA	-5.31e-09*	-3.17e-08	-5.49e-09*	-5.67e-09
	(-2.01)	(-1.58)	(-2.07)	(-1.28)
DR	-0.0482**	-0.431***	-0.0488**	-0.204***
	(-2.83)	(-13.53)	(-2.86)	(-9.19)
RISK	-1.496*	1.675	-1.507*	0.257
	(-2.08)	(1.75)	(-2.09)	(0.32)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	YES
COMPANY	YES		YES	
COUNTRY	YES		YES	YES
Constant	197.8	166.9	185.3	178.3
	(0.49)	(0.44)	(0.46)	(0.50)
Observations	4294	4294	4294	4294
Adjusted R-squared	0.250	-0.254	0.250	0.2899
Hausman		0.0368		0.3162

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 14 - Model Accounting Based Firm Value and Relative CO2

FVAB	**OLS**	**Fixed Effects**	**OLS**	**Random Effects**
CER	-3358.9*** ^	-663.8 ^	2917.8 ^	7680.6 ^
	(-3.87)	(-0.26)	(0.90)	(1.82)
BS	-0.0963 ^	-0.509 ^	-0.0574 ^	-0.0955 ^
	(-0.73)	(-1.80)	(-0.41)	(-0.52)
CEOD	1.041 ^	3.607* ^	1.256 ^	3.198* ^
	(1.01)	(2.11)	(1.15)	(2.39)
GEN	0.0820* ^	-0.133** ^	0.0889* ^	-0.00948 ^
	(2.36)	(-2.64)	(2.44)	(-0.22)
INDD	0.0259 ^	-0.0224 ^	0.0242 ^	0.0288 ^
	(1.46)	(-0.55)	(1.31)	(1.14)
TEN	0.435** ^	-0.883** ^	0.467** ^	-0.0364 ^
	(2.90)	(-2.63)	(3.01)	(-0.18)
SUSTC	1.283 ^	-0.397 ^	1.893* ^	1.439 ^
	(1.58)	(-0.27)	(2.20)	(1.31)
*CER*BS*			-138.5 ^	-349.9 ^
			(-0.80)	(-1.53)
*CER*CEOD*			-633.7 ^	-362.9 ^
			(-0.35)	(-0.13)
*CER*GEN*			-58.13 ^	-35.30 ^
			(-1.17)	(-0.57)
*CER*INDD*			1.158 ^	-39.85 ^
			(0.04)	(-0.98)
*CER*TEN*			-178.8 ^	-43.79 ^
			(-0.64)	(-0.13)
*CER*SUSTC*			-3377.5* ^	-5266.4** ^
			(-2.26)	(-2.66)
TA	-5.18e-09	-3.78e-08	-5.63e-09	-4.28e-09
	(-1.74)	(-1.52)	(-1.88)	(-0.87)
DR	-0.0469*	-0.559***	-0.0481*	-0.250***
	(-2.35)	(-14.61)	(-2.41)	(-9.58)
RISK	-0.555	4.193**	-0.674	2.054*
	(-0.61)	(3.18)	(-0.74)	(1.97)
YEAR	YES	YES	YES	YES
INDUSTRY	YES		YES	YES
COMPANY	YES		YES	
COUNTRY	YES		YES	YES
Constant	-95.36	-1504.0**	-141.9	-780.7
	(-0.16)	(-2.94)	(-0.24)	(-1.62)
Observations	3216	3216	3216	3216
Adjusted R-squared	0.248	-0.300	0.249	0.2939****
Hausman		0.0009		0.5271

*t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001 **** overall R-squared ^one lag (t-1)*
see table 1 for a tabulated overview of the definition and operationalization of the variables

Table 15 - Model Accounting Based Firm Value and Relative CO2 including lags