**Master's thesis**

# The moderating role of board characteristics in the relationship between carbon emission performance and firm value


Student: Peter Keppels

Student number: s4490908

Supervisor: Dr. Daniel Reimsbach


Master's program: Economics

Track: Accounting and Control

Date: 18/10/2021

## Abstract:

Reducing carbon emissions has been on the minds of stakeholders since the start of the millennium, which has prompted firms to respond. To contribute to this debate, this thesis tests the relationship between carbon emission performance and firm value. Additionally, this research will test the potential moderating effects of board characteristics on this relationship. The panel data research will use a dataset consisting of 4,271 firms over the period 2015 – 2020. The results show a significant relationship between carbon emission performance and firm when adding lags or, in some cases, with interaction variables. A strengthening effect has been found with board independence. However, surprisingly, a weakening effect has been found with board diversity and board size. The weakening effects of these two variables reject the assumptions of previous research. Therefore, the results can lead to new empirical research on the moderating effects of board characteristics.

**Keywords:** carbon emission performance, firm value, board diversity, board independence, environmental committee, CEO duality, board size

# Table of contents

# 1. Introduction

Since the start of the millennium, improving the levels of greenhouse gases has grown as an important goal for many stakeholders, like investors, regulators, standard-setters, and action groups. The Kyoto-protocol has set a binding goal to reduce greenhouse gases, enhanced by other agreements like the Paris climate agreements of 2015. Carbon dioxide is an essential driver of climate change. According to the Environmental Protection Agency (EPA), 81% of U.S. greenhouse gases consist of carbon dioxide (EPA, 2021). Current studies show that having a good carbon emission performance has a significant positive effect on firm value (f.i. Brouwers et al., 2018; Chapple et al., 2013; Busch & Hoffmann, 2011). It seems that firms benefit from actively handling their carbon emissions, which gets compensated by an increase in firm value. This should stimulate firms to increase their carbon emission performance and get ahead of their lacking competitors. One potentially important factor in increasing carbon emission performance are the characteristics of the firm's board (f.i. De Villiers et al., 2011; Haque, 2017; Velte et al., 2020).

In recent years it has become apparent that board characteristics can moderate the relationship between firm performance and carbon emission performance. The systematic review of Velte et al. (2020) shows the plethora of relationships and variables which influence these performance indicators. Board characteristics, argued in this thesis, can influence this relationship when looking through a stakeholder theory and upper echelons theory lens. Individual board members and the board itself are responsible for setting long-term strategic goals, which both influence firm value and carbon emissions. In general, it can be argued that board characteristics can determine the implementation and execution of sustainable strategies and, therefore, can influence environmental performance (Garcia Martin & Herrero, 2020). The moderating effect can be tested by adding them to the model as interaction variables. The interaction variable shows the change of one variable, while the other has a value of zero. This should show a strengthening or weakening effect on the relationship between carbon emission performance and firm value.

The moderating role can be argued as follows: a high carbon emission performance and a board with a long-term strategic view could lead to a high firm value. A long-term strategic view can also lead to a higher carbon emission performance. Therefore, the long-term strategic view and the high carbon emission performance can strengthen each other, as the long-term view will maintain the high carbon emission performance. Looking at it from the other side, a high carbon emission performance could indicate that the firm has a board that focuses on a long-term strategic view. Ergo, combining carbon emission performance and the board characteristics into an interaction variable could show that there is an influence on the relationship between carbon emission performance and firm value.

The following board characteristics will be explored: board diversity, board independence, board size, CEO duality, and the presence of an environmental committee. The characteristics are picked based on stakeholder theory or upper echelons theory. This is elaborated in chapter 2. To test the moderating effects of board characteristics, the following research question has been formulated:

*To what extent do board characteristics moderate the relationship between carbon emission performance and firm value?*

This paper will test multiple hypotheses formulated in chapter 2 to answer this research question, namely the relation between carbon emission performance and firm value itself to set the baseline of the research and to compare the results with the literature. Secondly, the board characteristics will be added as a moderating variable to show if they have a significant moderating effect on the strength or direction of the beforementioned relationship.

The hypotheses will be tested empirically on a regression model over a period of time. To capture a change within a firm, it is beneficial to look at certain firms over time. Panel data is the most suitable method to look at a dataset over time. Panel data increases the number of data points, increases the degrees of freedom, and reduces the collinearity among explanatory variables (Hsiao, 2014). The data set consists of firms in Europe and the U.S. within the time frame of 2015 - 2020. The data is retrieved from the Eikon (Datastream) database. The total data set consists of 1,738 firms, which in total have 7,448 observations. The dependent variable firm value is measured in Tobin's Q, and the independent variables are carbon emission performance and board characteristics. Board characteristics are added as interaction variables to test if they have a strengthening or weakening effect on the relationship between carbon emission performance and firm value.

This research adds to the existing literature by looking at the moderating effect of board characteristics on the relationship between carbon emission performance and firm value. Previous research mainly looked at their direct influence on carbon emission performance, while looking at it through a moderating lens can give new insights. This research shows that it is beneficial to have a good carbon emission performance to boost firm value, encouraging firms to adopt a proactive stance towards combatting their carbon emissions. Furthermore, the results can influence firms to change their board compositions or characteristics, as this can improve their firm value and stakeholder satisfaction. Also, improving their carbon emissions will combat the climate change problems, as $CO_2$ is currently 81% of all greenhouse gasses (EPA, 2021). This would mean that society could benefit from this research when firms adopt better carbon emission initiatives through changes in board composition.

The structure of the thesis will be as follows. Chapter two will give an overview of the relevant literature to build the hypotheses, which are included in chapter two. Chapter three will describe the research method and the data used for the research. Chapter four will present the results, on which chapter five will give the conclusion and discussion.

# 2. Literature review

This chapter gives an overview of the relevant literature. First, there will be a summary of the relationship between carbon emission performance and firm value. Secondly, the relationship of board characteristics on carbon emission performance and firm value will be discussed. Subsequently, the potential moderating effect of the board characteristics is formulated. Finally, based on these literature studies, two hypotheses will be formulated.

## 2.1 Carbon emission performance and firm value

A growing body of literature shows the significant relationship between carbon emission performance and a firm's market performance. These studies can be divided into those looking at mandatory and voluntary approaches of firms having to report their carbon emissions within the country or region they operate (Brouwers et al., 2018). According to Wahba (2008), the distinction is between the implicit costs of stakeholders in the voluntary setting and the direct costs by legislators in the mandatory setting. The relationship between carbon emission performance and firm value generally holds better when looking at firm value-based measures (f.i. Tobin's Q) compared to accounting based-measures (f.i. return on asset) (Brouwers et al., 2018).

Studies find that in both settings there is a positive relationship between carbon emission performance and firm value. Carbon emission performance is defined as the firm's total carbon emissions divided by its total sales, also known as carbon emissions intensity (Velte et al., 2020). Busch and Hoffmann (2011) have created a theoretical framework based on the empirical results to explain the positive relationship. Firstly, they argue that investing in efficient ecological ventures should lead to operational cost savings by better use of raw materials and energy. Secondly, they state that pressure from stakeholders can lead to better financial performance because an effective relationship with stakeholders can lead to marketplace success and, therefore, financial success.

Additionally, other factors that significantly influence the relationship are proposed in the literature. For instance, a firm's reputation is increased by achieving a well-performing environmental performance. Also, by having a good carbon emission standard and therefore mitigating environmental costs, a firm can mitigate risks and prevent future environmental fees. Lower risks are valued as more valuable (Brouwers et al., 2018). When a firm's actions are visible to the public, like reducing its carbon emission output, its reputation may increase (Jones, 1995). Carbon emission performance is based on the ratio of carbon emissions per total annual sales; therefore, it considers how efficient a firm is with its carbon emissions when compared to firms in the same industry. The research of Chapple, Clarkson, and Gold (2013) further supports this claim by arguing that a good environmental performance prevents substantial financial risks by avoiding regulatory intervention and reputational impacts. Nishitani and Kobubu (2011) argue this is the result of shareholders valuing the superior environmental results of a firm, therefore increasing the stock price.

Looking through the lens of the resource perspective, firms going beyond the compliance level of carbon emissions to redesign products and technologies to prevent future environmental problems are following a proactive strategy. Firms can achieve a competitive advantage by considering the wishes of the stakeholders, thereby creating goodwill (Buysse & Verbeke, 2003). In addition to this, Dixon-Fowler et al. (2013) state that developing environmental-related capabilities will lead to a more efficient way of using natural resources. These capabilities lead to a direct reduction of costs related to the production of these goods and higher profitability.

Having a poor carbon emission performance may be a short-term advantage, according to Misani and Pogutz (2015), as it gives a firm the opportunity to invest and innovate to increase its production processes. On the other hand, if the firm is not able to offset these costs to the customer, then it can be beneficial to not improve the performance. Delmas et al. (2015) suggest that offsetting the costs of reducing carbon emissions in the short run is complex and would lead to a short-term decrease of return on assets. In the long run, however, the firm would benefit from the decrease by receiving a premium on their stocks from investors. It shows that managers of the firm are willing and capable of reducing their outputs of carbon emission while staying competitive within the market. Investing in a pro-active environmental strategy would therefore lead to a better firm value in the long run.

Misani and Pogutz (2015) state that it depends on the initial performance level if a firm benefits from increasing its carbon emission performance. The relationship is non-linear, i.e., U-shaped, due to the different outcomes per initial level of carbon emission performance. According to their research, a firm achieves the highest financial performance with an intermediate carbon performance. The low performing firms have to invest much money to subsequently not increase their carbon performance much, meaning stakeholders will not notice the performance change. Stakeholders start to notice at the intermediate level, and thereby investment starts to pay off. The costs of increasing the carbon performance at the higher levels start receiving marginally fewer rewards on the financial level.

There are also other reasons firms are gaining firm value for increasing their carbon emission performance. Stakeholders value performance and therefore accept a premium from high-performing firms (Busch & Hoffmann, 2011). Orsato (2006) suggests that when firms invest in carbon emission performance, it promotes product differentiation and creates new markets, and adds value to their existing products. This makes the investments in carbon emission performance a long-term strategy and not only a cost.

Concluding from the literature, a positive relationship between carbon emission performance and firm value is expected. Therefore, the following hypothesis is formulated:

*Hypothesis 1: Carbon emission performance has a positive effect on firm value.*

## 2.2 The role of board characteristics

Available literature suggests that board characteristics potentially play a moderating role in the relationship between carbon emission performance and firm value. There are a few theories that support this claim. Firstly, firms must consider social and environmental goals as stakeholders nowadays do not only focus on financial targets. This assumption fits within the framework of stakeholder theory. Stakeholder theory states that the effective management of important stakeholders will lead to marketplace success and better financial performance (Delmas et al., 2015). Thus, one of the main goals of the board of directors is to manage stakeholders' expectations.

Secondly, the board of directors and the directors individually have a significant influence on the firm's strategy and resulting from that firm value. According to a meta-analysis of both Guerrero-Villegas et al. (2018) and Velte et al. (2020), governance parameters affect carbon emission performance and should be included in carbon research. This is supported by the upper echelons theory (Hambrick, 2007), which argues that directors' decision-making is based on their experiences, knowledge, and values. Therefore, a more diverse board will have more tools to make informed strategic decisions. This would lead to an improved firm value and carbon emission performance, as both benefits from long-term strategic thinking.

The moderating role can be argued as follows: a high carbon emission performance and a board with a long-term strategic view could lead to a high firm value. A long-term strategic view can also lead to a higher carbon emission performance. Therefore, the long-term strategic view and the high carbon emission performance can strengthen each other, as the long-term view will maintain the high carbon emission performance. At the same time, a high carbon emission performance could indicate that the firm has a board that focuses on a long-term strategic view. Ergo, combining carbon emission performance and the board characteristics into an interaction variable could show that there is an influence on the relationship between carbon emission performance and firm value.

In order to address the research question, this study looks at five board characteristics that have a shown relationship with both carbon emission performance and firm value. The characteristics are prevalent in current CSR research and have a significant effect on the beforementioned variables, which is summarized in multiple meta-analyses (f.i. Busch & Lewandowski, 2018; Velte et al., 2020).

### 2.2.1 Board diversity

Gender diversity is a widely debated topic, especially concerning social and environmental issues. Female board members are somewhat more aligned with the needs of the public and, therefore, should have a positive effect on CSR (Jaffee & Hyde,2000). The bulk of literature suggests that having women on the board should lead to a more open view on environmental problems, and they are more likely to act on these problems (Post et al., 2011). As a caveat, it is suggested that these effects only hold if there are enough women on the board, as described by critical mass theory (Kramer et al., 2006). The critical mass theory suggests that minorities in groups are ignored when they have only one or two members in the group.

A couple of studies show the direct relationship between gender diversity and carbon emission performance. Haque (2017) found, in a U.K. setting, that gender diversity does improve carbon reduction initiatives but does not directly impact the reduction of carbon emissions. The study shows that there is a more considerable willingness to start environmentally friendly initiatives with more female board members, but this did not translate to a lower carbon emission output. It suggests that a board, even with a high percentage of female members, will still focus on financial goals. However, Garci Martín and Herrero (2020) did find a significant positive effect of board gender diversity on carbon emission performance. They state this is because this is consistent with the idea of women bringing their background, talent, and experience to the company, which is more in line with environmental objectives.

More generally, the effect of board diversity on environmental performance has been researched as well. For example, in a French setting, Burkhardt, Nguyen, and Poincelot (2020) have found that firms with a higher proportion of women in board positions are associated with greater environmental performance. They credit this to the gender socialization theory, which states that women are more associated with care for the environment. Furthermore, the firms with more female board members had a higher environmental performance score, which gives strength to the claim. This relation has been further researched and found to be significantly positive by Galia, Zenou, and Inham (2015), Cordeiro et al. (2020), Lu and Herremans (2019), and more.

A diverse board, according to previous research, has a positive effect on the effectiveness, know-how, and performance of the board, which creates the expectation from stakeholders that long-term goals like carbon emissions will be met. If firms with a high level of board diversity turn out to have a low carbon emission performance, it is expected that they are punished harder for this in their firm value. If firms with a high level of board diversity meet the expectation of a high carbon emission performance, they will most likely be rewarded more in firm value than firms with a lower level of board diversity. To sum up, it is most likely expected that gender diversity will strengthen the relationship between carbon emission performance and firm value. Therefore, the following hypothesis has been formulated:

*Hypothesis 2a: Gender diversity will have a strengthening effect on the positive relationship between carbon emission performance and firm value.*

### 2.2.2 Board independence

Independent board members are members who do not have a material relationship with the firm itself and are not part of the day-to-day operations of the firm. They are more likely to look at the long-term issues rather than the short-term because they are less directly impacted by the negative short-term results. Long-term goals are often costly and, therefore, will hamper short-term financial results. The outside directors are more likely to demand environmental reports, auditing reports and may recommend setting up specialized committees (Post et al., 2011). They also have no direct relationship with the managers and are therefore better suited at monitoring and controlling them.

Following the principles of agency theory, independent board members are more likely to perform effective monitoring within a firm, which in turn increases the efficiency and performance of the firm. Independent board members are not directly involved with day-to-day operations, therefore, are less influenced by actors trying to benefit themselves from the firm (Haque, 2017). They are more likely to report opportunistic behavior and wrongdoings, provide more objective feedback, and provide more objective monitoring for outside stakeholders (Liao et al., 2015). According to Haque (2017), the independent board member has two essential roles for carbon emission performance: keeping the firm in line with its long-term carbon emission goals and prevent and combat opportunistic CSR engagements of poorly performing executives.

Tauringana and Chithambo (2015) suggest that internal managers might not be sufficiently compensated to develop green targets and therefore need to be steered in the right direction by board members. Independent board members can use their rich and diverse background to implement these targets, but they do generally have less know-how about the specific industry and situation of the firm

(Post et al., 2011). In addition, internal processes are often hard to identify and verify for outside sources, like shareholders, and should therefore be monitored by board members. One such internal process is the symbolic carbon initiatives from poor-performing managers. These projects look good from the outside but are merely for show to appease stakeholder pressure to keep their jobs (Cordeiro & Sarkis, 2008).

Decisions about carbon emissions are taken by the board and are indirectly influenced by the knowledge and experience of the board members. The general findings of previous research are that independent board members add value to the firm by using their diverse backgrounds and expertise to facilitate long-term goals. Their independence from the firm also makes them better at monitoring the internal processes and making sure that the stakeholders are heard, which improves the firm's value. Therefore, firms with a high amount of independent board members and a high carbon emission performance will be rewarded more by investors than firms with a lower amount of lower board members with the same carbon emission performance. At the same time, if they perform relatively worse with their carbon emission performance, investors will get punished harder because they expect that an independent board should lead to better results. To sum up, a board with more independent board members will strengthen the relationship between carbon emission performance and firm value. These members will make sure the long-term financial and environmental goals will be met. Therefore, the following hypothesis has been formulated:

*Hypothesis 2b: Independent board members will have a strengthening effect on the positive relationship between carbon emission performance and firm value.*

### 2.2.3 Environmental committee

Literature shows that having a committee with board members dedicated to environmental problems helps the firm to ensure there is better quality and depth of information on potential issues within the firm. The environmental committee commits a firm to plan, implement and review sustainability policies systematically. It helps with implementing a corporate sustainability strategy and by increasing the relationship with various stakeholders. The committee members have more experience and know-how about the problem; therefore, they are more specialized in dealing with the core of the problems (Ayuzo, 2007).

Research shows that environmental committees are more likely to be proactive on corporate environmental risks and respond faster to stakeholders' demands (Peters & Romi, 2014). They also found in their study that the presence of an environmental committee has a positive effect on carbon emission performance. They argue that this follows the legitimacy theory because having a dedicated committee shows commitment and gives a direct contact to the environmental stakeholders. Biswas et al. (2018) and Dixon-Fowler et al. (2017) also found that firms with an environmental committee tend to perform better on social and environmental scores.

The study of Eccles, Ioannou, and Serafeim (2014) finds that firms which voluntarily implement social and environmental goals in their organization are also more likely to create environmental committees. These firms are more likely to have a better understanding of the wishes of the stakeholders and are more likely to have a longer-term focus. These firms outperform their competition both on financial and non-financial terms, as they have a better understanding of how to improve their long-term results. The committee has a long-term perspective, foregoing short-term profits to create a healthy firm in the future (Biswas et al., 2018).

Having a dedicated committee focused on CSR-related problems will increase the board's effectiveness in focusing on the environmental problems. It gives the firm an effective way of dealing with the wishes of the stakeholders and, at the same time maintaining a healthy financial organization. The financial and environmental results of the committee depend on if the committee is able to influence the strategy of the firm, therefore it is not a given that the committee will succeed. The expectation from investors will be that the presence of a CSR committee will lead to a better carbon emission performance. It is expected that a firm with a high carbon emission performance and CSR committee will be rewarded by investors with a higher firm value because their expectations are met. Vice versa, if their carbon emission performance is worse than expected, they will get punished harder than firms without a CSR committee. Therefore, the following hypothesis has been formulated:

*Hypothesis 2c: The existence of an environmental committee will have a strengthening effect on the positive relationship between carbon emission performance and firm value.*

### 2.2.4 Board size

The size of the board of directors influences its effectiveness and performance, but the relationship with environmental performance is unclear (Garcia Martin & Herrero, 2020). De Villiers et al. (2011) argue that large boards lead to a bigger access to information and a greater diversity of views and know-how, which translates into carbon reduction initiatives. They say that larger boards will facilitate more funds, which would allow for more investments into more costly and uncertain investments. Having a bigger board will give a firm more opportunities to have experienced directors to help with improving the environmental performance (Booth & Deli, 1996).

On the other hand, some studies show board size does not give any advantages and might even be a disadvantage. For example, Boone et al. (2007) found that it was primarily contingent on a combination of firm-specific and managerial characteristics. Which they argue would mean that changes in board size have no effect on the effectiveness of the board because this is caused by other characteristics of the firm. They also argue that large boards have a challenging time reaching agreements and suffer from the problems associated with free riders. Another problem is the opportunistic behavior of board members, who only work to better themselves, who are less likely noticed due to the high amount of board members (Boone et al., 2007).

There is empirical evidence supporting both the benefit of smaller and larger board of directors. The knowledge and experience of larger boards can lead a firm to have a better long-term view. The effects of carbon emissions are, for the most part, focused on a long-term view and would therefore benefit from a large board. Nevertheless, a large board could have problems coming to a decisive conclusion as the majority has to agree, and unwilling directors could work against long-term goals as they want their short-term financial gains. The smaller boards can have better communication and achieve conclusions faster. For this research, it is assumed that the benefits of a large board outweigh the drawbacks. A firm with a large board is expected to have a higher carbon emission performance and will be rewarded by investors when they meet this expectation. On the other hand, having a low carbon emission performance and a large board will get punished by investors, as they expected that their performance would be high. Therefore, the following hypothesis has been formulated:

*Hypothesis 2d: Board size will have a strengthening effect on the positive relationship between carbon emission performance and firm value.*

### 2.2.5 CEO duality

The CEO of a firm can also hold a position within the board of directors. Following agency theory, De Villiers et al. (2010) state that CEOs usually focus on short-term goals due to short-term financial incentives. The short-term focus can potentially negatively influence the long-term goals of the firm, like environmental investments.  This is supported by the research of De Velliers et al. (2010), in which the dual role of the CEO is linked with agency theory problems and unfavorable outcomes for shareholders. The dual role of the CEO places too much power in the hands of one person and creates information asymmetry between the CEO and the other board members (Boyd, 1994).

In the context of stakeholder theory, CEO duality will lead to a lower level of disclosure because external directors are less subjected to pressure from shareholders compared to internal directors. Hence, when the line between CEO and board is blurred, the line between management and control also becomes blurred. This can lead to the board focusing on other goals than those preferred by stakeholders because the CEO will put the focus on short-term gains (Prado-Lorenzo & Garcia-Sanchez, 2010).

It seems that the dual of the CEO will lead to a more significant focus on the short-term financial goals of the firm instead of the long-term goals like reducing carbon emissions. De Villiers et al. (2010) also state that separating the CEO and the board will lessen the tension between them and will make it easier for board members to focus on the long term. Therefore, the expectation of investors is that if there is CEO duality, it will lead to worse long-term strategic results. Investors already factor in the dual role of the CEO. Therefore a high carbon emission performance will not be fully rewarded, compared to a firm without a dual of the CEO. If a firm is performing badly on its carbon emission performance and has a CEO with a dual role, it will be punished harsher by investors as their expectations are met. Therefore, the following hypothesis has been formulated:

*Hypothesis 2e: CEO duality will have a weakening effect on the positive relationship between carbon emission performance and firm value.*

# 3. Research method

## 3.1 Data sample

To test the hypotheses formulated in the previous chapter, panel data research is most suitable. Panel data research gives the researcher the ability to look at a set of firms over a period of time (Hsiao, 2014). The most used models of panel data research are fixed effects models and random-effects models. The choice between the fixed and random effects model has been made by using the Hausman test. The results, shown in appendix 1 and 4, of the Hausman tests show that the fixed effects model is most suitable for the research. A pooled OLS model has also been included in the appendixes to test if the assumptions also hold when not taking the time factor into consideration. The pooled OLS model will not be used for this part of the analysis because the time-element of the fixed effects model is significant according to the F-test, see appendices 2 and 5.

The data used in this research consists of European and U.S. firms in the period 2015 – 2020 and is retrieved from the database Eikon. The firms are pulled from the Asset4 dataset, which consists of data regarding firms' environmental, social, and governance performance. The reason both European and U.S. firms have been added is to add to the external validity by having more companies to research. Country controls will be added to control for potential cultural and economic differences between the two continents. Additionally, the U.S. will be excluded during a robustness check to test if there is a significant difference. The years 2015 – 2020 have been chosen because they have sufficient observations, which should give a good representation. Not enough firms before 2015 did report on their carbon emissions and board characteristics to make it worthwhile for testing.

The initial data set consisted of 2008 – 2020, with 4,271 firms and 55,523 firm-year observations, many of which have missing variables. Carbon emissions were lacking in observations for the first years of the dataset; therefore, only 2015 - 2020 have been chosen, as there will be at least 1,000 companies per year. Unknown datapoints have been deleted, and extreme values of continuous variables have been winsorized at the 1st and 99th percentile. The data set consists of 1738 firms, with in total 7,448 firm-year observations. Table 1 summarizes the observations per country and year.

| | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| **COUNTRY** | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Total |
| | | | | | | | |
| **AUSTRIA** | 8 | 10 | 12 | 13 | 13 | 8 | 64 |
| **BELGIUM** | 15 | 14 | 15 | 17 | 20 | 12 | 93 |
| **SWITSERLAND** | 35 | 37 | 41 | 41 | 43 | 35 | 232 |
| **CZECH REPUBLIC** | 0 | 0 | 1 | 1 | 3 | 0 | 5 |
| **GERMANY** | 52 | 62 | 68 | 67 | 66 | 38 | 353 |
| **DENMARK** | 17 | 19 | 19 | 22 | 24 | 21 | 122 |
| **SPAIN** | 36 | 39 | 42 | 44 | 46 | 27 | 234 |
| **FINLAND** | 20 | 20 | 23 | 25 | 24 | 16 | 128 |
| **FRANCE** | 69 | 81 | 95 | 92 | 91 | 48 | 476 |
| **GREAT BRITAIN** | 283 | 296 | 311 | 314 | 302 | 218 | 1,724 |
| **GREECE** | 10 | 10 | 11 | 11 | 12 | 0 | 54 |
| **HUNGARY** | 3 | 3 | 3 | 3 | 3 | 1 | 16 |
| **IRELAND** | 5 | 6 | 5 | 6 | 7 | 7 | 36 |
| **ITALY** | 30 | 36 | 45 | 51 | 51 | 20 | 233 |
| **NETHERLANDS** | 23 | 26 | 30 | 31 | 29 | 26 | 165 |
| **NORWAY** | 14 | 17 | 20 | 21 | 23 | 19 | 114 |
| **POLAND** | 5 | 6 | 6 | 10 | 13 | 3 | 43 |
| **PORTUGAL** | 5 | 6 | 6 | 6 | 6 | 4 | 33 |
| **SWEDEN** | 33 | 38 | 45 | 48 | 50 | 41 | 255 |
| **TURKEY** | 16 | 16 | 18 | 19 | 20 | 1 | 90 |
| **U.S.** | 398 | 452 | 536 | 616 | 706 | 270 | 2,978 |
| | | | | | | | |
| **TOTAL** | 1,077 | 1,194 | 1,352 | 1,458 | 1,552 | 815 | 7,448 |

*Table 1 Summary of observations per country and year*

## 3.2 Variable definitions

### 3.2.1 Dependent variable

The dependent variable of the research is firm value, measured as Tobin's Q. Tobin's Q has been used in previous research and has been described as a ratio that is able to capture long-term effects on profitability (Lee et al., 2015; Misami & Pogutz, 2015; Brouwers et al., 2018; and Delmas et al., 2015). A market-based measure has been chosen instead of an accounting-based measure because the meta-analysis of Velte et al. (2020) showed that only market-based measures have a significant relationship with carbon emissions. A simplified formula of Tobin's Q is used (Misani & Pogutz, 2015):

$$Tobin's\ Q = Equity\ market\ value\ /\ Equity\ book\ value$$

The ratio essentially shows the firm's efficiency in using its assets, as a ratio higher than 1 indicates a firm is overvalued or undervalued with a ratio lower than 1. Tobin's Q can be used as a long-term indicator, which reflects intangible measures of performance like investor confidence and reputation; ergo, it is an indication for future performance. (Delmas et al., 2015).

### 3.2.2 Independent variable

The independent variables are carbon emission performance and the board characteristics described in the previous chapter. Carbon emission performance will be calculated by dividing the total scope 1 & 2 carbon emissions by the total sales, which has been used in previous research (f.i. Kim et al., 2015; Misani & Pogutz, 2015; Brouwers et al., 2018). The moderating variables, which are the interaction variables between carbon emission performance and the board characteristics, are measured based on variables used in previous research.

The board characteristics will be calculated as follows: board independence is the percentage of independent board members; board diversity is the percentage of female board members; board size is the number of board members; the presence of an environmental committee is a dummy variable which is 1 if there is a CSR committee and 0 otherwise; and CEO duality is a dummy variable which is 1 if the CEO is also a member of the board and 0 otherwise. The measurements are summarized in table 2.

### 3.2.3 Control variables

Control variables are added to the regression to increase the model's explanatory power and decrease the influence of confounding and extraneous variables. The control variables are selected based on previous research of firm value and, more specifically, Tobin's Q.

The first control variable which will be added is firm size, which will be measured by the total assets of the firm. This will account for the differences in firm size within the dataset, which has a negative effect on Tobin's Q (King & Lenox, 2002). The second control variable is debt ratio, which will be measured by the total debt divided by the total assets of the firm. This also has a negative relationship with Tobin's Q, as investors dislike the high leverage (Rajan & Zingalas, 1995). The third control variable is firm growth, which will be measured by the annual sales growth of the firm, which accounts for variation of production per year. This has a positive relationship with Tobin's Q as investors prefer firms that show growth. Other research also suggests that R&D expenditure significantly influences firm value, f.i. Chauvin and Hirschey (1993), but there are not enough observations available in the dataset to include this variable. Delmas et al. (2005) suggest using the natural logarithm to avoid the skewed distribution; therefore it will also be used in this research with firm size and debt ratio. However, sales growth was negative in many cases, accordingly it will not be adjusted to a logarithmic variable as this is impossible.

There will also be a control variable for country, industry, and year to avoid biases when using a Pooled OLS model, otherwise when using a fixed-effects model only a year control variable will be used as country and industry are already accounted for with this type of model. Table 2 shows an overview of the variables.

| Variable | Abbreviation | Definition | Eikon abbreviation* |
|---|---|---|---|
| **Dependent variable** | | | |
| *Tobin's Q* | FV | (Equity market value) / (Equity book value) | WC08001+WC03351 / WC03501+WC03351 |
| **Independent variables** | | | |
| *Carbon emission* | CE | Total scope 1 & 2 carbon emissions | ENERDP023 |
| *Carbon emission performance* | CEP | (Total scope 1 & 2 carbon emissions) / (Total revenues) | ENERDP023 / WC01001 |
| *Board independence* | BIND | (Independent board members) / (Board size) | CGBSO07V |
| *Board diversity* | BDIV | (Female board members) / (Board size) | CGBSO03V |
| *Environmental committee* | ENV | Dummy variable: presence of environmental committee | CGVSDP005 |
| *Board size* | BSIZE | Total members of board | CGBSDP060 |
| *CEO duality* | CEOD | Dummy variable: the CEO also serves as member of the board | CGBSDP061 |
| **Control variables** | | | |
| *Firm size* | FSIZE | Total Assets, logarithmic | WC02999 |
| *Debt ratio* | DR | Debts / Assets, logarithmic | WC03255 / WC02999 |
| *Firm growth* | FGROW | Annual change in sales | WC08631 |
| *Country controls* | COUNT | To prevent a bias, country controls are added by using a dummy variable, i.country | |
| *Industry controls* | IND | To prevent a bias, industry controls are added by using a dummy variable, i.industry | |
| *Year controls* | YEAR | To prevent a bias, year controls are added by using a dummy variable, i.year | |

*Table 2 Summary of definitions of variables.*

** All variables are collected from the Eikon (Datastream) database.*

## 3.3 Empirical model

To test hypothesis 1, whether carbon emission performance has a negative effect on firm value, the following model for a fixed-effects model has been constructed:

$$Firm\,Value_{it} = \alpha + \beta_1 Carbon\,Emission\,Performance\,(CEP)_{it} + \beta_2 Firm\,Size_{it} + \beta_3 Debt\,Ratio_{it} + \beta_4 Firm\,Growth_{it} + \beta_5 Year\,control_{it} + \epsilon_{it}$$

To test hypothesis 2, the board characteristics will be added as interaction variables to the model. The five board characteristics will also be tested individually due to the high correlation between the interaction variables. The best fit of the results will be chosen in chapter 4.

$$Firm\ \ Value_{it} = \alpha + \beta_1 Carbon\,Emission\,Performance\,(CEP)_{it} + \beta_2 CEP_{it} * Board\,Independence_{it} + \beta_3 CEP_{it} * Board\,Diversity_{it} + \beta_4 CEP_{it} * Environmental\,Committee_{it} + \beta_5 CEP_{it} * Board\,Size_{it} + \beta_6 CEP_{it} * \beta_7 CEO\,Duality_{it} + \beta_8 Firm\,Size_{it} + \beta_9 Debt\,Ratio_{it} + \beta_{10} Firm\,Growth_{it} + \beta_{11} Year\,control_{it} + \epsilon_{it}$$

# 4. Results

## 4.1 Descriptive statistics

Table 3 summarizes the descriptive statistics of the independent, dependent, and control variables. To adjust for outliers, the continuous variables have been winsorized at the 1st and 99th percentile, as is typical (Lewandowski, 2017). This changes the outliers to the nearest value available, reducing extreme values from the dataset.

All variables have 7,448 observations after cleaning up the data. Carbon emissions show that there are no companies without any carbon emissions. There are still significant differences in carbon emissions between companies after winsorizing when looking at the standard deviation. CSR committee and CEO duality are dummy variables, with a value of 1 if they are present or otherwise 0. The data shows that companies are more likely to have a CSR committee and a CEO with a dual role by looking at the mean. This may be skewed because this information will be excluded from the dataset when companies do not report this fact. Board diversity and board independence are both ratios between 0 and 100. Board diversity shows that some companies have zero female board members and there are no companies with an entire female board, the maximum is 71. The board independence variable shows that on average, there are 69% independent board members, but the range is 0 – 100, meaning that there are fully independent boards and entirely dependent boards. Board size shows the number of board members in a company, ranging from 1 to 30, with a mean of 10. A median and mean of 10 and a standard deviation of 3 shows that probably most companies have around 7 – 13 board members. Notable of the control variables is the minimum value of the debt ratio of 0, meaning there are companies without any debt.

| Variable | Observations | Mean | SD | Min | Median | Max |
|---|---:|---:|---:|---:|---:|---:|
| FV | 7,448 | 1.8 | 1.240 | .72 | 1.4 | 7.9 |
| CE | 7,448 | 2683846.3 | $8.65e^{6}$ | 0 | 143115 | $6.0e^{7}$ |
| CEP | 7,448 | 0.3 | 0.900 | 0 | .037 | 13 |
| BIND | 7,448 | 69.0 | 22.093 | 0 | 75 | 100 |
| BDIV | 7,448 | 26.2 | 11.723 | 0 | 25 | 71 |
| ENV | 7,448 | 0.7 | 0.436 | 0 | 1 | 1 |
| BSIZE | 7,448 | 10.5 | 3.138 | 1 | 10 | 30 |
| CEOD | 7,448 | 0.8 | 0.409 | 0 | 1 | 1 |
| DR | 7,448 | 0.2 | 0.138 | 0 | .24 | 1.3 |
| FSIZE | 7,448 | 15.9 | 1.694 | 13 | 16 | 21 |
| FGROW | 7,448 | 6.1 | 18.940 | -43 | 4 | 103 |

*Table 3 Summary of winsorized variables*

The data has been tested for multicollinearity, which would mean that there is a correlation between the independent variables. The results of a correlation matrix are shown in table 4, in which the correlation between the independent, dependent, and control variables can be found. A correlation higher than 0.70 is generally considered strong, and therefore the model should be adjusted for it (Moore, 2003). This rule of thumb has not been reached; therefore, no investigation is necessary. Furthermore, a VIF score can be checked to know if there is multicollinearity present. A variable with a score below 5 indicates that there is no or only moderate variance and is generally considered safe to use. The variables do not exceed the thresholds of correlation and multicollinearity, see table 4 and 5; therefore they can be used in the research. However, it is expected that the interaction variables will have a high correlation between them because they share the carbon emission performance variable. To correct for this, the models will also be tested with the interaction variables separately. Meaning there will be six regressions for hypothesis 2.

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) FV | 1.000 | | | | | | | | | |
| (2) CEP | -0.141 | 1.000 | | | | | | | | |
| (3) BIND | 0.078 | 0.063 | 1.000 | | | | | | | |
| (4) BDIV | 0.022 | -0.088 | 0.027 | 1.000 | | | | | | |
| (5) ENV | -0.036 | 0.025 | 0.032 | 0.124 | 1.000 | | | | | |
| (6) BSIZE | -0.100 | 0.007 | -0.135 | 0.132 | 0.226 | 1.000 | | | | |
| (7) CEOD | 0.075 | 0.033 | 0.076 | -0.141 | -0.015 | 0.048 | 1.000 | | | |
| (8) DR | -0.023 | 0.139 | 0.097 | -0.039 | 0.080 | 0.025 | 0.100 | 1.000 | | |
| (9) FSIZE | -0.232 | 0.013 | 0.167 | 0.158 | 0.278 | 0.525 | -0.001 | 0.045 | 1.000 | |
| 10)FGROW | 0.104 | -0.027 | -0.036 | -0.099 | -0.075 | -0.070 | 0.017 | -0.055 | -0.054 | 1.000 |

*Table 4 Correlation matrix*

| Variables | VIF |
|---|---|
| FV | 1.57 |
| CEP | 1.03 |
| BIND | 1.13 |
| BDIV | 1.08 |
| ENV | 1.11 |
| BSIZE | 1.52 |
| CEOD | 1.04 |
| DR | 1.05 |
| FSIZE | 1.57 |
| FGROW | 1.02 |
| Mean | 1.17 |

*Table 5 VIF scores*

## 4.2 Test of hypotheses

As described in chapter three, two models will be tested to analyze the hypotheses. First, the relationship between carbon emission performance and firm value will be tested. Secondly, the moderating effects of the board characteristics will be added to the regression to test if they influence the relationship.

The first model has been tested with and without the control variables with three different regressions types: the pooled OLS regression, the fixed-effects model, and the random-effects model. The Hausman test will be used to determine which model is applicable for this research, which will be displayed within the tables showing the regressions. An F-test will be performed to determine if a pooled OLS model is preferred to the time-sensitive model.

### 4.2.1. Hypothesis 1

The expectation from the literature study is, as described in chapter 2.1., that there is a positive relationship between carbon emission performance and firm value. First, the Hausman test was conducted to know if the random-effects model or fixed-effects model had to be used. The result of the Hausman test is significant, therefore the fixed-effects model was selected. The F-test has been used and shows a significant result, indicating that the pooled OLS model cannot be used. A robust standard error based on the unique firm code has been added to the fixed effects model to adjust for heteroskedasticity. Model 1.1 shows the results of the original model. Additionally, the board characteristics were added to model 1.2 as additional control variables.

The results of the regressions are shown in table 6, where models 1.1 and 1.2 both show an insignificant positive relationship between carbon emission performance and firm value. This is remarkable, as the relationship has been extensively researched and is therefore expected to be significant. The board characteristics as extra control variables do not add to the significance of the relationship, and they also have no significant relationship with firm value. The three control variables all have a significant relationship with firm value, as expected.

However, important to note, adding the interaction variables of hypothesis 2 to the regression, there is a significant ($p = 0.068$) and positive relationship between carbon emission performance and firm value, as shown in table 7. Therefore, based on the results of model 1, hypothesis 1 is rejected. However, when considering model 2, there is some evidence that hypothesis 1 is supported.

| | 1.1 | 1.2 |
|---|---|---|
| | FV | FV |
| CEP | 0.00698 | 0.00710 |
| | (0.0128) | (0.0130) |
| DR | -0.625* | -0.624* |
| | (0.288) | (0.288) |
| FSIZE | -0.407*** | -0.409*** |
| | (0.0577) | (0.0583) |
| FGROW | 0.00230*** | 0.00231*** |
| | (0.000383) | (0.000384) |
| BIND | | 0.000480 |
| | | (0.000923) |
| BDIV | | -0.000130 |
| | | (0.00147) |
| ENV | | -0.0420 |
| | | (0.0309) |
| BSIZE | | 0.00547 |
| | | (0.00523) |
| CEOD | | 0.0388 |
| | | (0.0326) |
| Year | Yes | Yes |
| Industry | No | No |
| Company | No | No |
| Country | No | No |
| Constant | 8.425*** | 8.367*** |
| | (0.900) | (0.908) |
| Observations | 7448 | 7448 |
| $R^2$ | 0.073 | 0.074 |
| *Hausman* | 0.0000 | 0.0000 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Table 6 Fixed effects model, including robustness check, to support hypothesis 1.*

### 4.2.2. Hypothesis 2

The five hypotheses of hypothesis 2 test if board characteristics have a moderating effect on the relationship between carbon emission performance and firm value. An interaction variable between carbon emission performance and the board characteristics has been added to the model to test these hypotheses. As was stated in chapter 4.1, the interactions have been tested both together and individually to account for the high correlation between the interaction variables. The interpretation of the interaction variable is as follows: the coefficient represents the value for a situation in which the other variable has the value zero. For example, in the case of CEP * BIND, it is the coefficient for board independence when carbon emission performance is zero. The result of the Hausman test was significant, indicating that the fixed effects model must be used over the random-effects model. The F-test result is also significant, see appendix 5, which indicates that the fixed-effects should be used over the pooled OLS model. A robustness variable is included within the fixed effects model to adjust for heteroskedasticity by including the clustering of firms. Appendix 4 shows the results of the fixed effects model with the combined interaction variables and the individual variables. As the R-squared does not change drastically with testing the variables separately and the results do not differ, the model with them combined will be used for the results.

The regression results of interest are the interaction variables shown in table 7. For this research, a five percent significance level is taken into consideration when looking at the results. Two interaction variables meet this significance level, namely board diversity (CEP * BDIV, $p = 0.045$) and board size (CEP * BSIZE, $p = 0.022$). Surprisingly, both variables show a negative coefficient which is against the expectations. This means they both have a weakening effect on the relationship between carbon emission performance and firm value. These results are also found when the interaction variables are tested individually (respectively, $p = 0.05$ and $p = 0.033$), as shown in appendix 4, which gives extra confidence to the findings. The other three interaction variables do not show a significant effect on the relationship between carbon emission performance and firm value.

As stated before, carbon emission performance has a significant positive relationship with firm value, even though this was not found in model 1. Additionally, a significant positive relationship is also found in individual models of board diversity and board size, shown in appendix 4.

Based on the results, hypotheses 2a and 2d are rejected based on the different significant outcomes than expected. Both 2a and 2d expected a strengthening effect, but both ended up being weakening. The other hypotheses are rejected because there is no significant moderating variable found in the results.

| | 2.1 |
|---|---|
| | FV |
| CEP | 0.0706$^{+}$ |
| | (0.0387) |
| CEP * BIND | 0.000418 |
| | (0.000506) |
| CEP * BDIV | -0.00136$^{*}$ |
| | (0.000680) |
| CEP * ENV | 0.00304 |
| | (0.0140) |
| CEP * BSIZE | -0.00507$^{*}$ |
| | (0.00220) |
| CEP * CEOD | -0.0147 |
| | (0.0153) |
| BIND | 0.000375 |
| | (0.000999) |
| BDIV | 0.000208 |
| | (0.00156) |
| ENV | -0.0421 |
| | (0.0335) |
| BSIZE | 0.00724 |
| | (0.00560) |
| CEOD | 0.0447 |
| | (0.0347) |
| DR | -0.627$^{*}$ |
| | (0.289) |
| FSIZE | -0.410$^{***}$ |
| | (0.0584) |
| FGROW | 0.00232$^{***}$ |
| | (0.000384) |
| Year | Yes |
| Industry | No |
| Company | No |
| Country | No |
| Constant | 8.363$^{***}$ |
| | (0.909) |
| Observations | 7448 |
| $R^2$ | 0.075 |
| *Hausman* | 0.0000 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Table 7 Fixed effects model, including robustness variables, for hypothesis 2*

## 4.3 Robustness checks

To test the validity of the results, three robustness checks will be conducted. The robustness checks are based on previous research and check if the results hold when some assumptions of the model are changed. The same correlation and variance checks to find the appropriate model as paragraph 4.2 have been conducted and have been added as appendixes. The best-fitting models are shown in the tables provided in the paragraphs. The results of the tests show that the fixed-effects model fits best, therefore, it will be used for all three robustness checks.

### 4.3.1 Carbon emissions

The first robustness check will use carbon emissions instead of carbon emission performance as an independent variable. This also means the interaction variable will use carbon emissions. Available literature shows that a reduction in carbon emissions enhances the firm value, and failing to do so will be punished by the market (f.i. Nishitani & Kokubu, 2012; Lee et al., 2015; Delmas et al., 2015; Wang & Gao, 2014). The best-fitting results of both models are shown in table 8 and appendixes 6, 7, and 8.

Model 3.1 tests the first hypothesis without the interaction variables and finds an insignificant negative relationship between carbon emissions and firm value. The first hypothesis is supported but not strongly significant ($p < 0.10$) by model 3.3, which is the model which only includes the environmental committee interaction variable. It is in accordance with the expected relationship, but there is not enough evidence to support the claim that carbon emissions are negatively related to firm value. Model 3.2 tests the second hypothesis, but the results do not support any of the potential moderating effects of board characteristics on the relationship between carbon emissions and firm value. Therefore, no claims of hypothesis 2 are supported by the carbon emission data.

### 4.3.2 Excluding the U.S.

The second robustness check will exclude the U.S. firms from the dataset to check if the continent has a significant effect on the results. The U.S. firms represent around 40% of the dataset. Therefore it should be ensured that the results are not driven only by the U.S. firms. The dataset is decreased from 7.448 to 4.470.

Like the original model, the results of model 4.1 do not find a significant relationship between carbon emission performance and firm value. However, one of the models (4.3, CEP * BSIZE) used for hypotheses 2 does find a moderately significant positive relationship ($p < 0.05$) between carbon emission performance and firm value. Again, this corresponds with the results of the original model. Hypothesis 1 is, therefore, only moderately supported by the results of this robustness check.

The only interaction variable with a significant coefficient is board size (CEP * BSIZE, $p < 0.01$). The moderating effect is weakening, which supports the main analysis results, which also found a negative significant moderating effect of board size on the relationship between carbon emission performance and firm value. This is further confirmed by the results of the individual model, model 4.3, which also shows a significant negative moderating effect of board size. The other interaction variables are all insignificant and therefore do not support the hypotheses of hypothesis 2. Therefore, only hypothesis 2d is supported by the data without the U.S..

### 4.3.3 Lagged variables

The third robustness check adds lags of one year to the independent variables; carbon emission performance and the board characteristics. It could be possible that effects of carbon emission performance and board characteristics need a year to influence firm value. In general, strategic decisions made by board members should take some time before affecting the day-to-day operations. Also, initiatives and improvements of carbon emission performance might take some time before being noticed by stakeholders. The dataset of the lagged variables is decreased from 7.448 to 5.641.

Model 5.1 shows a significant positive relationship between carbon emission performance and firm value. Model 5.1 is the only model designed for hypothesis 1 which supports the claim directly, without the help of the interaction variables. Also, two of the individual interaction models (5.3; CEP * BDIV and 5.4; CEP * ENV) from hypothesis 2 show a significant positive relationship. Therefore, based on the results of the lagged variables model, hypothesis 1 is supported.

Surprisingly, model 5.2 does not yield many significant moderating effects of board independence. Board independence (CEP * BIND) is the only significant interaction variable ($p < 0.05$), which is strengthening. This is also found in the individual model, see appendix 14. This is the expected effect according to hypothesis 2a. This result was not found during the original model. The other moderating variables are all insignificant. Therefore, the hypotheses, other than H1 and H2a, are rejected based on the results of the lagged variables approach.

| Variables | 3.1<br>FV | 3.2<br>FV | 3.3<br>FV |
|---|---|---|---|
| CE | -3.13e-09 | 6.03e-10 | -4.20e-09$^{+}$ |
| | (2.27e-09) | (5.87e-09) | (2.44e-09) |
| CE * BIND | | -1.91e-11 | |
| | | (4.38e-11) | |
| CE * BDIV | | -4.03e-11 | |
| | | (5.52e-11) | |
| CE * ENV | | 1.60e-09 | 1.57e-09 |
| | | (1.17e-09) | (1.16e-09) |
| CE * BSIZE | | -8.11e-11 | |
| | | (2.67e-10) | |
| CE * CEOD | | -2.01e-09 | |
| | | (3.35e-09) | |
| BIND | | 0.000517 | |
| | | (0.000973) | |
| BDIV | | -0.0000178 | |
| | | (0.00154) | |
| ENV | | -0.0452 | -0.0460 |
| | | (0.0327) | (0.0327) |
| BSIZE | | 0.00562 | |
| | | (0.00575) | |
| CEOD | | 0.0439 | |
| | | (0.0336) | |
| DR | -0.628$^{*}$ | -0.626* | -0.625* |
| | (0.288) | (0.288) | (0.288) |
| FSIZE | -0.405$^{***}$ | -0.408*** | -0.403*** |
| | (0.0579) | (0.0587) | (0.0582) |
| FGROW | 0.00229$^{***}$ | 0.00230*** | 0.00229*** |
| | (0.000380) | (0.000382) | (0.000380) |
| Constant | 8.405$^{***}$ | 8.351*** | 8.402*** |
| | (0.902) | (0.912) | (0.905) |
| Year | Yes | Yes | Yes |
| Industry | No | No | No |
| Company | No | No | No |
| Country | No | No | No |
| Observations | 7448 | 7448 | 7448 |
| $R^2$ | 0.074 | 0.075 | 0.074 |
| *Hausman* | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Table 8 Results of regression for carbon emissions robustness check*

| Variables | 4.1<br>FV | 4.2<br>FV | 4.3<br>FV |
|---|---|---|---|
| CEP | 0.00276 | 0.0435 | 0.0792$^{*}$ |
| | (0.0112) | (0.0443) | (0.0309) |
| CEP * BIND | | 0.000959 | |
| | | (0.000658) | |
| CEP * BDIV | | 0.0000393 | |
| | | (0.00108) | |
| CEP * ENV | | -0.0219 | |
| | | (0.0189) | |
| CEP * BSIZE | | -0.00848$^{**}$ | -0.00830$^{**}$ |
| | | (0.00297) | (0.00315) |
| CEP * CEOD | | -0.0154 | |
| | | (0.0169) | |
| BIND | | -0.000675 | |
| | | (0.00101) | |
| BDIV | | -0.000458 | |
| | | (0.00185) | |
| ENV | | -0.0139 | |
| | | (0.0420) | |
| BSIZE | | 0.0109$^{+}$ | 0.0113$^{+}$ |
| | | (0.00596) | (0.00595) |
| CEOD | | 0.0485 | |
| | | (0.0379) | |
| DR | -1.041$^{***}$ | -1.048$^{***}$ | -1.050$^{***}$ |
| | (0.261) | (0.261) | (0.261) |
| FSIZE | -0.332$^{***}$ | -0.339$^{***}$ | -0.340$^{***}$ |
| | (0.0641) | (0.0648) | (0.0646) |
| FGROW | 0.00193$^{***}$ | 0.00192$^{***}$ | 0.00193$^{***}$ |
| | (0.000439) | (0.000440) | (0.000437) |
| Constant | 7.166$^{***}$ | 7.193$^{***}$ | 7.169$^{***}$ |
| | -1.001 | -1.004 | -1.003 |
| Year | Yes | Yes | Yes |
| Industry | No | No | No |
| Company | No | No | No |
| Country | No | No | No |
| Observations | 4470 | 4470 | 4470 |
| $R^2$ | 0.095 | 0.097 | 0.096 |
| *Hausman* | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Table 9 Results of regression Europe only robustness check*

| | 5.1 | 5.2 | 5.3 | 5.4 |
|---|---|---|---|---|
| | FV | FV | FV | FV |
| CEP_lag | 0.0275* | -0.0375 | 0.0566* | 0.0370** |
| | (0.0119) | (0.0504) | (0.0263) | (0.0130) |
| CEP_lag*BIND_lag | | 0.00126* | | |
| | | (0.000632) | | |
| CEP_lag*BDIV_lag | | -0.00126 | -0.00107 | |
| | | (0.000869) | (0.000808) | |
| CEP_lag*ENV_lag | | -0.0200 | | -0.0176 |
| | | (0.0160) | | (0.0150) |
| CEP_lag*BSIZE_lag | | 0.00176 | | |
| | | (0.00357) | | |
| CEP_lag*CEOD_lag | | 0.0124 | | |
| | | (0.0164) | | |
| BIND_lag | | 0.000335 | | |
| | | (0.000992) | | |
| BDIV_lag | | -0.000935 | -0.000905 | |
| | | (0.00149) | (0.00149) | |
| ENV_lag | | 0.00434 | | 0.00285 |
| | | (0.0381) | | (0.0377) |
| BSIZE_lag | | -0.00215 | | |
| | | (0.00559) | | |
| CEOD_lag | | 0.0113 | | |
| | | (0.0342) | | |
| DR | -0.871*** | -0.885*** | -0.873*** | -0.873*** |
| | (0.262) | (0.263) | (0.263) | (0.263) |
| FSIZE | -0.430*** | -0.429*** | -0.430*** | -0.430*** |
| | (0.0692) | (0.0696) | (0.0694) | (0.0692) |
| FGROW | 0.00175*** | 0.00172*** | 0.00172*** | 0.00175*** |
| | (0.000402) | (0.000406) | (0.000404) | (0.000402) |
| Constant | 8.839*** | 8.830*** | 8.866*** | 8.843*** |
| | -1.092 | -1.093 | -1.093 | -1.092 |
| Year | Yes | Yes | Yes | Yes |
| Industry | No | No | No | No |
| Company | No | No | No | No |
| Country | No | No | No | No |
| Observations | 5641 | 5641 | 5641 | 5641 |
| $R^2$ | 0.090 | 0.091 | 0.090 | 0.090 |
| *Hausman* | 0.000 | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses
$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Table 10 Results of regression for lagged variables robustness check*

# 5. Discussion and conclusion

Over the past years, there has been increasing pressure on firms to focus on environmental issues, making carbon emission performance a pressing concern. Previous research has shown that firms get punished by underperforming on their carbon emission performance. This research aims to look at this positive relationship between carbon emission performance and firm value. This research also included board characteristics as moderating variables to test any potential role on the beforementioned relationship. Board characteristics can weaken or strengthen the relationship. Therefore, it could show a moderating effect between specific board characteristics and carbon emission performance and firm value. This would give firms ways to improve their performance in ways that are currently underdeveloped. The assumptions base themselves on stakeholder theory and upper echelons theory, stating that members of the board influence long-term strategic thinking and can therefore influence the relationship between carbon emission performance and firm value.

The results for hypothesis 1, whether the relationship between carbon emission performance and firm value is positive, only moderately support this claim. The model used for hypothesis 1 does not find a significant relationship, but a significant positive relationship is found when adding the moderating variables of hypothesis 2. The performed robustness checks did also find the relationship to be significantly positive. Model 5.1 shows a significant relationship by adding lags to the independent variables, indicating that they might have a delayed reaction on firm value. Four other models during the robustness check, 3.3, 4.3, 5.3, and 5.4, also show a moderately significant relationship. All these models only include one of the interaction variables. This implies a need for more research on the topic, as the currently used variables are not sufficient to find a solid positive significant relationship between carbon emission performance and firm value.

The main research question, whether board characteristics moderate the relationship between carbon emission performance and firm value, is tested with hypotheses 2a through 2e. The results of the original models and the robustness checks show no significant moderating effect of environmental committees and CEO duality. Therefore, hypotheses 2c and 2e are rejected. The results of the lagged variables robustness check, model 5.2, support the claim of hypothesis 2a—namely, the strengthening moderating effect of board independence, which was expected from the literature. Board diversity has a weakening moderating effect according to model 2.1, thereby rejecting hypothesis 2b because it is the opposite effect as expected. Finally, board size has a weakening moderating effect according to models 2.1, 4.2, and 4.3, thereby rejecting hypothesis 2d, which expected a strengthening effect.

The results found for hypotheses 2a-e lead to some implications, which are interesting for future research. First of all, the strengthening moderating effect of board independence indicates that having an independent board leads to better financial and environmental performance. Firms should therefore look to hire more independent board members instead of using board members affiliated with the firm. Secondly, not finding a significant moderating effect for environmental committees and CEO duality could indicate that not all board characteristics are relevant for the researched relationship, meaning firms do not have to focus on these characteristics. Thirdly, the counterintuitive results for the moderating effects of board diversity and board size also lead to some implications. Current literature argues that they both should strengthen the relationship, as they both lead to a better long-term strategic view of the firm, leading to a better firm and carbon performance. These two interactions need more research to make sense.

The limitations of the study could also explain the limited results of this research. Not all firms report on their carbon emissions and board characteristics, therefore excluding many firms. Also, the R-squared of the models are relatively low, indicating that variables are missing to explain the entire relationship. Using interaction variables is also difficult to interpret because the researcher has to set one of the used variables as value zero. Picking the correct variable to set to zero and then interpret it can lead to nit-picking of results. This research only uses carbon emissions to measure greenhouse gases, whilst many different types of gases influence the environment. These other gases are reported less, therefore it is hard to get an appropriate sample size to test them.

This research adds to the existing literature by looking at the moderating effect of board characteristics on the relationship between carbon emission performance and firm value. Previous research mainly looked at their direct influence on carbon emission performance, while looking at it through a moderating lens can give new insights. This research shows that it is beneficial to have a good carbon emission performance to boost firm value, encouraging firms to combat their carbon emissions proactively. Furthermore, the results can influence firms to change their board compositions or characteristics, as this can improve their firm value and carbon emission performance, and ultimately stakeholder satisfaction. Also, improving their carbon emissions will combat the climate change problems, as $CO_2$ is currently 81% of all greenhouse gasses (EPA, 2021). This would mean that society could benefit from this research when firms adopt better carbon emission initiatives through changes in board composition.

## References

Alsaifi, K., Elnahass, M., & Salama, A. (2020). Carbon disclosure and financial performance: U.K. environmental policy. *Business Strategy and the Environment*, *29*(2), 711-726.

Ayuso, S., Rodríguez, M. A., García-Castro, R., & Ariño, M. A. (2014). Maximizing stakeholders' interests: An empirical analysis of the stakeholder approach to corporate governance. *Business & society*, *53*(3), 414-439.

Biswas, P. K., Mansi, M., & Pandey, R. (2018). Board composition, sustainability committee and corporate social and environmental performance in Australia. *Pacific Accounting Review*.

Boone, A. L., Field, L. C., Karpoff, J. M., & Raheja, C. G. (2007). The determinants of corporate board size and composition: An empirical analysis. *Journal of financial Economics*, *85*(1), 66-101.

Booth, J. R., & Deli, D. N. (1996). Factors affecting the number of outside directorships held by CEOs. *Journal of Financial Economics*, *40*(1), 81-104.

Boyd, B. K. (1994). Board control and CEO compensation. *Strategic management journal*, *15*(5), 335-344.

Brouwers, R., Schoubben, F., & Van Hulle, C. (2018). The influence of carbon cost pass through on the link between carbon emission and corporate financial performance in the context of the European Union Emission Trading Scheme. *Business Strategy and the Environment*, *27*(8), 1422-1436.

Burkhardt, K., Nguyen, P., & Poincelot, E. (2020). Agents of change: Women in top management and corporate environmental performance. *Corporate Social Responsibility and Environmental Management*, *27*(4), 1591-1604.

Busch, T., & Hoffmann, V. H. (2011). How hot is your bottom line? Linking carbon and financial performance. *Business & Society*, *50*(2), 233-265.

Busch, T., & Lewandowski, S. (2018). Corporate carbon and financial performance: A meta-analysis. *Journal of Industrial Ecology*, *22*(4), 745-759.

Buysse, K., & Verbeke, A. (2003). Proactive environmental strategies: A stakeholder management perspective. *Strategic management journal*, *24*(5), 453-470.

Callan, S. J., & Thomas, J. M. (2014). Relating CEO compensation to social performance and financial performance: Does the measure of compensation matter?. *Corporate Social Responsibility and Environmental Management*, *21*(4), 202-227.

Chapple, L., Clarkson, P. M., & Gold, D. L. (2013). The cost of carbon: Capital market effects of the proposed emission trading scheme (ETS). *Abacus*, *49*(1), 1-33.

Chauvin, K. W., & Hirschey, M. (1993). Advertising, R&D expenditures and the market value of the firm. *Financial management*, 128-140.

Cook, R. D., & Weisberg, S. (1982). Residuals and influence in regression. New York: Chapman and Hall.

Cordeiro, J. J., & Sarkis, J. (2008). Does explicit contracting effectively link CEO compensation to environmental performance?. *Business Strategy and the Environment*, *17*(5), 304-317.

Cordeiro, J. J., Profumo, G., & Tutore, I. (2020). Board gender diversity and corporate environmental performance: The moderating role of family and dual-class majority ownership structures. *Business Strategy and the Environment*, *29*(3), 1127-1144.

Cucari, N., Esposito de Falco, S., & Orlando, B. (2018). Diversity of board of directors and environmental social governance: Evidence from Italian listed companies. *Corporate Social Responsibility and Environmental Management*, *25*(3), 250-266.

Deckop, J. R., Merriman, K. K., & Gupta, S. (2006). The effects of CEO pay structure on corporate social performance. *Journal of Management*, *32*(3), 329-342.

Delmas, M. A., Nairn-Birch, N., & Lim, J. (2015). Dynamics of environmental and financial performance: The case of greenhouse gas emissions. *Organization & Environment*, *28*(4), 374-393.

De Villiers, C., Naiker, V., & Van Staden, C. J. (2011). The effect of board characteristics on firm environmental performance. *Journal of Management*, *37*(6), 1636-1663.

Dixon-Fowler, H. R., Ellstrand, A. E., & Johnson, J. L. (2017). The role of board environmental committees in corporate environmental performance. *Journal of Business Ethics*, *140*(3), 423-438.

Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science*, *60*(11), 2835-2857.

EPA (2021). Greenhouse Gas Emissions - Overview of Greenhouse Gases. Accessed on March 23, 2021: https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Galia, F., Zenou, E., & Ingham, M. (2015). Board composition and environmental innovation: does gender diversity matter?. *International Journal of Entrepreneurship and Small Business*, *24*(1), 117-141.

García Martín, C. J., & Herrero, B. (2020). Do board characteristics affect environmental performance? A study of E.U. firms. *Corporate Social Responsibility and Environmental Management*, *27*(1), 74-94.

Guerrero-Villegas, J., Pérez-Calero, L., Hurtado-González, J. M., & Giráldez-Puig, P. (2018). Board attributes and corporate social responsibility disclosure: A meta-analysis. *Sustainability*, *10*(12), 4808.

Hambrick, D. C. (2007). Upper echelons theory: An update.

Haque, F. (2017). The effects of board characteristics and sustainable compensation policy on carbon performance of U.K. firms. *The British Accounting Review*, *49*(3), 347-364.

Hsiao, C. (2014). *Analysis of panel data* (No. 54). Cambridge university press.

Jones, T. M. (1995). Instrumental stakeholder theory: A synthesis of ethics and economics. *Academy of management review*, *20*(2), 404-437.

Jung, J., Herbohn, K., & Clarkson, P. (2018). Carbon risk, carbon risk awareness and the cost of debt financing. *Journal of Business Ethics*, *150*(4), 1151-1171.

Kılıç, M., & Kuzey, C. (2019). The effect of corporate governance on carbon emission disclosures. *International Journal of Climate Change Strategies and Management*.

King, A., & Lenox, M. (2002). Exploring the locus of profitable pollution reduction. *Management Science*, *48*(2), 289-299.

Kramer, V. W., Konrad, A. M., Erkut, S., & Hooper, M. J. (2006). *Critical mass on corporate boards: Why three or more women enhance governance* (pp. 2-4). Wellesley, MA: Wellesley Centers for Women.

Kuo, L., & Chen, V. Y. J. (2013). Is environmental disclosure an effective strategy on establishment of environmental legitimacy for organization?. Management Decision.

Lee, K., & Lee, H. (2019). How does CSR activity affect sustainable growth and value of corporations? Evidence from Korea. *Sustainability*, *11*(2), 508.

Lewandowski, S. (2017). Corporate carbon and financial performance: The role of emission reductions. *Business Strategy and the Environment*, *26*(8), 1196-1211.

Liao, L., Luo, L., & Tang, Q. (2015). Gender diversity, board independence, environmental committee and greenhouse gas disclosure. *The British Accounting Review*, *47*(4), 409-424.

Lu, J., & Herremans, I. M. (2019). Board gender diversity and environmental performance: An industries perspective. *Business Strategy and the Environment*, *28*(7), 1449-1464.

Misani, N., & Pogutz, S. (2015). Unraveling the effects of environmental outcomes and processes on financial performance: A non-linear approach. *Ecological economics*, *109*, 150-160.

Moore, D. S. (2003). *The basic practice of statistics* (3rd ed.). W.H. Freeman.

Nishitani, K., & Kokubu, K. (2012). Why does the reduction of greenhouse gas emissions enhance firm value? The case of Japanese manufacturing firms. *Business Strategy and the Environment*, *21*(8), 517-529.

Orazalin, N. (2020). Do board sustainability committees contribute to corporate environmental and social performance? The mediating role of corporate social responsibility strategy. *Business Strategy and the Environment*, *29*(1), 140-153.

Orsato, R. J. (2006). Competitive environmental strategies: when does it pay to be green?. *California management review*, *48*(2), 127-143.

Peters, G. F., & Romi, A. M. (2014). Does the voluntary adoption of corporate governance mechanisms improve environmental risk disclosures? Evidence from greenhouse gas emission accounting. *Journal of Business Ethics*, *125*(4), 637-666.

Post, C., Rahman, N., & Rubow, E. (2011). Green governance: Boards of directors' composition and environmental corporate social responsibility. *Business & Society*, *50*(1), 189-223.

Prado-Lorenzo, J. M., & Garcia-Sanchez, I. M. (2010). The role of the board of directors in disseminating relevant information on greenhouse gases. *Journal of business ethics*, *97*(3), 391-424.

Rajan, R. G., & Zingales, L. (1995). What do we know about capital structure? Some evidence from international data. *The journal of Finance*, *50*(5), 1421-1460.

Tauringana, V., & Chithambo, L. (2015). The effect of DEFRA guidance on greenhouse gas disclosure. The British Accounting Review, 47(4), 425-444.

Wahba, H. (2008). Does the market value corporate environmental responsibility? An empirical examination. *Corporate Social Responsibility and Environmental Management*, *15*(2), 89-99.

Wang, L., Li, S., & Gao, S. (2014). Do greenhouse gas emissions affect financial performance?–an empirical examination of Australian public firms. *Business Strategy and the Environment*, *23*(8), 505-519.

# Appendix

| | Pooled OLS | Pooled OLS | Fixed Effects | Fixed Effects |
|---|---|---|---|---|
| | tobinsq | tobinsq | tobinsq | tobinsq |
| co2perf | -0.113*** | -0.109*** | 0.00698 | 0.00710 |
| | (0.0184) | (0.0189) | (0.0128) | (0.0130) |
| log_debtratio | -0.168 | -0.131 | -0.625* | -0.624* |
| | (0.280) | (0.275) | (0.288) | (0.288) |
| log_totalassets | -0.144*** | -0.191*** | -0.407*** | -0.409*** |
| | (0.0196) | (0.0235) | (0.0577) | (0.0583) |
| sales_growth | 0.00570*** | 0.00648*** | 0.00230*** | 0.00231*** |
| | (0.00112) | (0.00111) | (0.000383) | (0.000384) |
| boardindependence | | 0.00160 | | 0.000480 |
| | | (0.00138) | | (0.000923) |
| female | | 0.0115*** | | -0.000130 |
| | | (0.00257) | | (0.00147) |
| csrcommittee | | 0.0844 | | -0.0420 |
| | | (0.0566) | | (0.0309) |
| boardsize | | 0.0212* | | 0.00547 |
| | | (0.00865) | | (0.00523) |
| ceoduality | | 0.174* | | 0.0388 |
| | | (0.0736) | | (0.0326) |
| Year | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | | |
| Company | Yes | Yes | | |
| Country | Yes | Yes | | |
| Constant | 3.133*** | 3.054*** | 8.425*** | 8.367*** |
| | (0.538) | (0.702) | (0.900) | (0.908) |
| Observations | 7448 | 7448 | 7448 | 7448 |
| $R^2$ | 0.261 | 0.273 | 0.073 | 0.074 |
| *Hausman* | | | 0.0000 | 0.0000 |

Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

*Appendix 1 Regressions for hypothesis 1*

```
Fixed-effects (within) regression               Number of obs     =      7,448
Group variable: isin                            Number of groups  =      1,738

R-sq:                                           Obs per group:
     within  = 0.0735                                         min =          1
     between = 0.0582                                         avg =        4.3
     overall = 0.0583                                         max =          6

                                                F(9,1737)         =      44.18
corr(u_i, Xb)  = -0.3342                        Prob > F          =     0.0000

                               (Std. Err. adjusted for 1,738 clusters in isin)
------------------------------------------------------------------------------
             |               Robust
     tobinsq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     co2perf |   .0069755   .0127695     0.55   0.585    -.0180698    .0320207
log_debtratio|  -.6250579    .288105    -2.17   0.030    -1.190127   -.0599888
log_totalassets| -.4071858  .0576631    -7.06   0.000    -.5202822   -.2940895
sales_growth |   .0023018   .0003825     6.02   0.000     .0015515     .003052
             |
        year |
       2016  |  -.0041768   .0127689    -0.33   0.744    -.0292208    .0208673
       2017  |   .0755282   .0169032     4.47   0.000     .0423754    .1086811
       2018  |  -.0902214   .0192826    -4.68   0.000     -.128041   -.0524018
       2019  |   .0840097   .0227335     3.70   0.000     .0394217    .1285977
       2020  |   .1661773   .0312174     5.32   0.000     .1049497    .2274049
             |
       _cons |   8.425312   .8996769     9.36   0.000     6.660748    10.18988
-------------+----------------------------------------------------------------
     sigma_u |  1.2531814
     sigma_e |  .40694544
         rho |   .9046094   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

*Appendix 2 STATA results of fixed effects model for hypothesis 1*

| | Pooled OLS tobinsq | Pooled OLS tobinsq | Pooled OLS tobinsq | Pooled OLS tobinsq | Pooled OLS tobinsq | Pooled OLS tobinsq |
|---|---|---|---|---|---|---|
| co2perf | -0.106 | -0.112$^{+}$ | -0.0946$^{**}$ | -0.102$^{***}$ | -0.163$^{***}$ | -0.0884$^{*}$ |
| | (0.0709) | (0.0576) | (0.0300) | (0.0262) | (0.0450) | (0.0361) |
| int_co2perfboardind | 0.000263 | -0.0000274 | | | | |
| | (0.000784) | (0.000713) | | | | |
| int_co2perffemale | -0.00109 | | -0.000644 | | | |
| | (0.00120) | | (0.00110) | | | |
| int_co2perfcsrcomm | -0.0274 | | | -0.0158 | | |
| | (0.0329) | | | (0.0294) | | |
| int_co2perfboardsize | 0.00580 | | | | 0.00495 | |
| | (0.00374) | | | | (0.00335) | |
| int_co2perfceodual | -0.0480 | | | | | -0.0295 |
| | (0.0443) | | | | | (0.0377) |
| boardindependence | 0.00155 | 0.00188 | | | | |
| | (0.00144) | (0.00138) | | | | |
| female | 0.0119$^{***}$ | | 0.0123$^{***}$ | | | |
| | (0.00277) | | (0.00276) | | | |
| csrcommittee | 0.0932 | | | 0.114$^{+}$ | | |
| | (0.0612) | | | (0.0606) | | |
| boardsize | 0.0189$^{*}$ | | | | 0.0215$^{*}$ | |
| | (0.00913) | | | | (0.00912) | |
| ceoduality | 0.189$^{*}$ | | | | | 0.188$^{*}$ |
| | (0.0767) | | | | | (0.0742) |
| log_debtratio | -0.127 | -0.178 | -0.135 | -0.176 | -0.149 | -0.161 |
| | (0.275) | (0.279) | (0.278) | (0.278) | (0.280) | (0.280) |
| log_totalassets | -0.191$^{***}$ | -0.147$^{***}$ | -0.159$^{***}$ | -0.155$^{***}$ | -0.164$^{***}$ | -0.148$^{***}$ |
| | (0.0235) | (0.0199) | (0.0204) | (0.0206) | (0.0221) | (0.0199) |
| sales_growth | 0.00645$^{***}$ | 0.00575$^{***}$ | 0.00623$^{***}$ | 0.00580$^{***}$ | 0.00581$^{***}$ | 0.00573$^{***}$ |
| | (0.00111) | (0.00112) | (0.00111) | (0.00112) | (0.00111) | (0.00111) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Company | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 3.054$^{***}$ | 3.067$^{***}$ | 2.898$^{***}$ | 3.264$^{***}$ | 3.151$^{***}$ | 3.220$^{***}$ |
| | (0.713) | (0.562) | (0.652) | (0.547) | (0.519) | (0.593) |
| Observations | 7448 | 7448 | 7448 | 7448 | 7448 | 7448 |
| $R^2$ | 0.274 | 0.262 | 0.269 | 0.262 | 0.263 | 0.262 |

Standard errors in parentheses. $^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 3 Pooled OLS regressions for hypothesis 2*

| | Fixed Effects | Fixed Effects | Fixed Effects | Fixed Effects | Fixed Effects | Fixed Effects |
|---|---|---|---|---|---|---|
| | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq |
| co2perf | 0.0706$^{+}$ | -0.000627 | 0.0407$^{+}$ | 0.00993 | 0.0505$^{+}$ | 0.0131 |
| | (0.0387) | (0.0338) | (0.0230) | (0.0143) | (0.0260) | (0.0147) |
| int_co2perfboardind | 0.000418 | 0.000115 | | | | |
| | (0.000506) | (0.000470) | | | | |
| int_co2perffemale | -0.00136$^{*}$ | | -0.00131$^{+}$ | | | |
| | (0.000680) | | (0.000668) | | | |
| int_co2perfcsrcomm | 0.00304 | | | -0.00625 | | |
| | (0.0140) | | | (0.0128) | | |
| int_co2perfboardsize | -0.00507$^{*}$ | | | | -0.00468$^{*}$ | |
| | (0.00220) | | | | (0.00219) | |
| int_co2perfceodual | -0.0147 | | | | | -0.00839 |
| | (0.0153) | | | | | (0.0150) |
| boardindependence | 0.000375 | 0.000388 | | | | |
| | (0.000999) | (0.00100) | | | | |
| female | 0.000208 | | 0.000269 | | | |
| | (0.00156) | | (0.00155) | | | |
| csrcommittee | -0.0421 | | | -0.0404 | | |
| | (0.0335) | | | (0.0333) | | |
| boardsize | 0.00724 | | | | 0.00749 | |
| | (0.00560) | | | | (0.00558) | |
| ceoduality | 0.0447 | | | | | 0.0452 |
| | (0.0347) | | | | | (0.0345) |
| log_debtratio | -0.627$^{*}$ | -0.626$^{*}$ | -0.626$^{*}$ | -0.622$^{*}$ | -0.626$^{*}$ | -0.624$^{*}$ |
| | (0.289) | (0.288) | (0.288) | (0.288) | (0.288) | (0.288) |
| log_totalassets | -0.410$^{***}$ | -0.407$^{***}$ | -0.409$^{***}$ | -0.405$^{***}$ | -0.412$^{***}$ | -0.407$^{***}$ |
| | (0.0584) | (0.0577) | (0.0578) | (0.0579) | (0.0581) | (0.0577) |
| sales_growth | 0.00232$^{***}$ | 0.00231$^{***}$ | 0.00231$^{***}$ | 0.00230$^{***}$ | 0.00231$^{***}$ | 0.00230$^{***}$ |
| | (0.000384) | (0.000382) | (0.000386) | (0.000382) | (0.000382) | (0.000383) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | | | | | | |
| Company | | | | | | |
| Country | | | | | | |
| Constant | 8.363$^{***}$ | 8.393$^{***}$ | 8.441$^{***}$ | 8.418$^{***}$ | 8.425$^{***}$ | 8.391$^{***}$ |
| | (0.909) | (0.900) | (0.901) | (0.903) | (0.902) | (0.902) |
| Observations | 7448 | 7448 | 7448 | 7448 | 7448 | 7448 |
| $R^2$ | 0.075 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |
| *Hausman* | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 4 Fixed effects model regressions for hypothesis 2*

```
Fixed-effects (within) regression               Number of obs     =      7,448
Group variable: isin                            Number of groups  =      1,738

R-sq:                                           Obs per group:
     within  = 0.0749                                         min =          1
     between = 0.0597                                         avg =        4.3
     overall = 0.0597                                         max =          6

                                                F(19,1737)        =      21.61
corr(u_i, Xb)  = -0.3316                        Prob > F          =     0.0000

                                (Std. Err. adjusted for 1,738 clusters in isin)
------------------------------------------------------------------------------
                     |               Robust
             tobinsq |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------------+--------------------------------------------------------
             co2perf |   .0705588   .0386784     1.82   0.068    -.0053023    .1464199
 int_co2perfboardind |   .0004182   .0005059     0.83   0.409     -.000574    .0014104
   int_co2perffemale |  -.0013634   .0006802    -2.00   0.045    -.0026975   -.0000292
  int_co2perfcsrcomm |   .0030373     .01398     0.22   0.828    -.0243821    .0304567
int_co2perfboardsize |  -.0050674   .0022032    -2.30   0.022    -.0093887   -.0007461
  int_co2perfceodual |  -.0146505   .0152684    -0.96   0.337    -.0445969     .015296
   boardindependence |   .0003754   .0009992     0.38   0.707    -.0015843    .0023352
              female |   .0002077   .0015614     0.13   0.894    -.0028548    .0032702
        csrcommittee |  -.0420763   .0334724    -1.26   0.209    -.1077268    .0235742
           boardsize |   .0072424   .0055975     1.29   0.196    -.0037362    .0182211
         ceoduality |    .044679   .0346962     1.29   0.198    -.0233718    .1127297
       log_debtratio |  -.6267027   .2887702    -2.17   0.030    -1.193077   -.0603289
     log_totalassets |  -.4103837   .0584284    -7.02   0.000     -.524981   -.2957864
        sales_growth |   .0023168   .0003843     6.03   0.000     .0015631    .0030705
                     |
                year |
               2016  |  -.0045184   .0128921    -0.35   0.726     -.029804    .0207673
               2017  |    .075878   .0177926     4.26   0.000     .0409807    .1107752
               2018  |  -.0881629   .0210097    -4.20   0.000    -.1293698   -.0469559
               2019  |   .0899249   .0264962     3.39   0.001     .0379571    .1418927
               2020  |   .1747632   .0357886     4.88   0.000     .1045699    .2449564
                     |
               _cons |   8.362877   .9089383     9.20   0.000     6.580148    10.14561
---------------------+--------------------------------------------------------
             sigma_u |  1.2514053
             sigma_e |   .4069958
                 rho |  .90434294   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

*Appendix 5 STATA result for hypothesis 2*

| | Pooled OLS | FE |
|---|---|---|
| | FV | FV |
| CE | 2.55e-10 | -3.13e-09 |
| | (2.14e-09) | (2.27e-09) |
| DR | -0.218 | -0.628* |
| | (0.281) | (0.288) |
| FSIZE | -0.144*** | -0.405*** |
| | (0.0214) | (0.0579) |
| FGROW | 0.00572*** | 0.00229*** |
| | (0.00112) | (0.000380) |
| Constant | 3.159*** | 8.405*** |
| | (0.554) | (0.902) |
| Year | Yes | Yes |
| Industry | Yes | |
| Company | Yes | |
| Country | Yes | |
| Observations | 7448 | 7448 |
| $R^2$ | 0.256 | 0.074 |
| *AIC* | 22216.2 | 5770.5 |
| *BIC* | 22492.8 | 5832.7 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 6 Robustness check carbon emission for hypothesis 1*

| | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq |
|---|---|---|---|---|---|---|
| Cotwee | 1.40e-09 | 8.49e-09$^{+}$ | -2.94e-09 | -4.63e-09 | -2.52e-10 | 2.16e-09 |
| | (1.09e-08) | (4.58e-09) | (3.48e-09) | (3.09e-09) | (6.48e-09) | (3.88e-09) |
| int_cotweeboardind | -8.34e-11 | -1.07e-10$^{+}$ | | | | |
| | (6.64e-11) | (5.70e-11) | | | | |
| int_cotweefemale | 7.13e-11 | | 1.38e-10 | | | |
| | (1.14e-10) | | (1.07e-10) | | | |
| int_cotweecsrcomm | 5.08e-09$^{+}$ | | | 5.68e-09$^{*}$ | | |
| | (2.68e-09) | | | (2.76e-09) | | |
| int_cotweeboardsize | -4.37e-11 | | | | 4.34e-11 | |
| | (4.73e-10) | | | | (4.36e-10) | |
| int_cotweeceodual | -8.76e-11 | | | | | -2.23e-09 |
| | (3.37e-09) | | | | | (3.88e-09) |
| boardindependence | 0.00162 | 0.00197 | | | | |
| | (0.00144) | (0.00139) | | | | |
| female | 0.0117$^{***}$ | | 0.0120$^{***}$ | | | |
| | (0.00269) | | (0.00267) | | | |
| csrcommittee | 0.0769 | | | 0.101$^{+}$ | | |
| | (0.0592) | | | (0.0592) | | |
| boardsize | 0.0209$^{*}$ | | | | 0.0234$^{*}$ | |
| | (0.00934) | | | | (0.00933) | |
| ceoduality | 0.178$^{*}$ | | | | | 0.188$^{*}$ |
| | (0.0761) | | | | | (0.0739) |
| log_debtratio | -0.168 | -0.225 | -0.175 | -0.220 | -0.204 | -0.208 |
| | (0.277) | (0.280) | (0.279) | (0.279) | (0.281) | (0.281) |
| log_totalassets | -0.192$^{***}$ | -0.147$^{***}$ | -0.159$^{***}$ | -0.155$^{***}$ | -0.165$^{***}$ | -0.147$^{***}$ |
| | (0.0253) | (0.0216) | (0.0221) | (0.0223) | (0.0240) | (0.0217) |
| sales_growth | 0.00653$^{***}$ | 0.00577$^{***}$ | 0.00627$^{***}$ | 0.00584$^{***}$ | 0.00584$^{***}$ | 0.00577$^{***}$ |
| | (0.00112) | (0.00112) | (0.00112) | (0.00112) | (0.00112) | (0.00112) |
| Constant | 3.090$^{***}$ | 3.087$^{***}$ | 2.949$^{***}$ | 3.290$^{***}$ | 3.167$^{***}$ | 3.248$^{***}$ |
| | (0.719) | (0.578) | (0.662) | (0.563) | (0.533) | (0.607) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Company | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 7448 | 7448 | 7448 | 7448 | 7448 | 7448 |
| $R^2$ | 0.269 | 0.257 | 0.265 | 0.258 | 0.258 | 0.258 |
| *AIC* | 22099.1 | 22210.7 | 22128.8 | 22206.1 | 22200.2 | 22207.3 |
| *BIC* | 22424.2 | 22494.3 | 22412.4 | 22496.6 | 22483.8 | 22497.8 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 7 Robustness check carbon emission for hypothesis 2, pooled OLS*

| | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq |
|---|---|---|---|---|---|---|
| Cotwee | 6.03e-10 | -2.26e-09 | -2.31e-09 | -4.20e-09$^{+}$ | -2.03e-09 | -1.62e-09 |
| | (5.87e-09) | (3.85e-09) | (2.62e-09) | (2.44e-09) | (3.91e-09) | (3.18e-09) |
| int_cotweeboardind | -1.91e-11 | -1.18e-11 | | | | |
| | (4.38e-11) | (4.33e-11) | | | | |
| int_cotweefemale | -4.03e-11 | | -4.17e-11 | | | |
| | (5.52e-11) | | (5.74e-11) | | | |
| int_cotweecsrcomm | 1.60e-09 | | | 1.57e-09 | | |
| | (1.17e-09) | | | (1.16e-09) | | |
| int_cotweeboardsize | -8.11e-11 | | | | -7.30e-11 | |
| | (2.67e-10) | | | | (2.45e-10) | |
| int_cotweeceodual | -2.01e-09 | | | | | -2.10e-09 |
| | (3.35e-09) | | | | | (3.20e-09) |
| boardindependence | 0.000517 | 0.000456 | | | | |
| | (0.000973) | (0.000976) | | | | |
| female | - 0.0000178 | | 0.0000415 | | | |
| | (0.00154) | | (0.00153) | | | |
| csrcommittee | -0.0452 | | | -0.0460 | | |
| | (0.0327) | | | (0.0327) | | |
| boardsize | 0.00562 | | | | 0.00590 | |
| | (0.00575) | | | | (0.00574) | |
| ceoduality | 0.0439 | | | | | 0.0469 |
| | (0.0336) | | | | | (0.0334) |
| log_debtratio | -0.626$^{*}$ | -0.629$^{*}$ | -0.628$^{*}$ | -0.625$^{*}$ | -0.627$^{*}$ | -0.627$^{*}$ |
| | (0.288) | (0.288) | (0.288) | (0.288) | (0.289) | (0.288) |
| log_totalassets | -0.408$^{***}$ | -0.405$^{***}$ | -0.406$^{***}$ | -0.403$^{***}$ | -0.410$^{***}$ | -0.405$^{***}$ |
| | (0.0587) | (0.0579) | (0.0580) | (0.0582) | (0.0585) | (0.0580) |
| sales_growth | 0.00230$^{***}$ | 0.00230$^{***}$ | 0.00229$^{***}$ | 0.00229$^{***}$ | 0.00229$^{***}$ | 0.00229$^{***}$ |
| | (0.000382) | (0.000380) | (0.000384) | (0.000380) | (0.000379) | (0.000380) |
| Constant | 8.351$^{***}$ | 8.370$^{***}$ | 8.411$^{***}$ | 8.402$^{***}$ | 8.420$^{***}$ | 8.371$^{***}$ |
| | (0.912) | (0.903) | (0.903) | (0.905) | (0.904) | (0.904) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | | | | | | |
| Company | | | | | | |
| Country | | | | | | |
| Observations | 7448 | 7448 | 7448 | 7448 | 7448 | 7448 |
| $R^2$ | 0.075 | 0.074 | 0.074 | 0.074 | 0.074 | 0.074 |
| *AIC* | 5778.5 | 5774.1 | 5774.3 | 5770.0 | 5772.8 | 5773.0 |
| *BIC* | 5896.1 | 5850.2 | 5850.3 | 5846.1 | 5848.8 | 5849.1 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 8 Robustness check carbon emission for hypothesis 2, fixed effects model*

| | -1 | -2 |
|---|---|---|
| | tobinsq | tobinsq |
| co2perf | -0.123*** | 0.00276 |
| | (0.0337) | (0.0112) |
| log_debtratio | -0.737* | -1.041*** |
| | (0.287) | (0.261) |
| log_totalassets | -0.161*** | -0.332*** |
| | (0.0223) | (0.0641) |
| sales_growth | 0.00300*** | 0.00193*** |
| | (0.000757) | (0.000439) |
| Constant | 4.170*** | 7.166*** |
| | (0.376) | -1.001 |
| Year | Yes | Yes |
| Industry | Yes | |
| Company | Yes | |
| Country | Yes | |
| Observations | 4470 | 4470 |
| $R^2$ | 0.290 | 0.095 |
| *AIC* | 12022.6 | 2488.5 |
| *BIC* | 12266.0 | 2546.1 |

Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

*Appendix 9 Robustness check only Europe for hypothesis 1*

| | -1 | -2 | -3 | -4 | -5 | -6 |
|---|---|---|---|---|---|---|
| | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq |
| co2perf | -0.172 | -0.154$^{+}$ | -0.144$^{*}$ | -0.0980$^{+}$ | -0.171$^{*}$ | -0.115$^{+}$ |
| | (0.119) | (0.0826) | (0.0611) | (0.0588) | (0.0687) | (0.0599) |
| int_co2perfboardind | 0.000419 | 0.000501 | | | | |
| | (0.00125) | (0.00115) | | | | |
| int_co2perffemale | 0.000787 | | 0.000860 | | | |
| | (0.00229) | | (0.00193) | | | |
| int_co2perfcsrcomm | -0.0608 | | | -0.0360 | | |
| | (0.0699) | | | (0.0658) | | |
| int_co2perfboardsize | 0.00470 | | | | 0.00432 | |
| | (0.00412) | | | | (0.00391) | |
| int_co2perfceodual | -0.00831 | | | | | -0.0136 |
| | (0.0638) | | | | | (0.0641) |
| boardindependence | 0.00155 | 0.00139 | | | | |
| | (0.00158) | (0.00147) | | | | |
| female | 0.0102$^{**}$ | | 0.0104$^{***}$ | | | |
| | (0.00319) | | (0.00315) | | | |
| csrcommittee | 0.0431 | | | 0.0599 | | |
| | (0.0754) | | | (0.0731) | | |
| boardsize | 0.00899 | | | | 0.00902 | |
| | (0.00918) | | | | (0.00890) | |
| ceoduality | 0.174$^{*}$ | | | | | 0.160$^{*}$ |
| | (0.0863) | | | | | (0.0815) |
| log_debtratio | -0.725$^{*}$ | -0.751$^{**}$ | -0.735$^{**}$ | -0.738$^{*}$ | -0.722$^{*}$ | -0.730$^{*}$ |
| | (0.283) | (0.286) | (0.283) | (0.287) | (0.287) | (0.287) |
| log_totalassets | -0.193$^{***}$ | -0.164$^{***}$ | -0.173$^{***}$ | -0.166$^{***}$ | -0.170$^{***}$ | -0.166$^{***}$ |
| | (0.0261) | (0.0226) | (0.0231) | (0.0229) | (0.0247) | (0.0227) |
| sales_growth | 0.00359$^{***}$ | 0.00300$^{***}$ | 0.00345$^{***}$ | 0.00303$^{***}$ | 0.00305$^{***}$ | 0.00307$^{***}$ |
| | (0.000744) | (0.000758) | (0.000748) | (0.000759) | (0.000754) | (0.000751) |
| Constant | 4.190$^{***}$ | 4.116$^{***}$ | 4.157$^{***}$ | 4.199$^{***}$ | 4.187$^{***}$ | 4.221$^{***}$ |
| | (0.376) | (0.381) | (0.369) | (0.375) | (0.377) | (0.379) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Company | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4470 | 4470 | 4470 | 4470 | 4470 | 4470 |
| $R^2$ | 0.302 | 0.290 | 0.298 | 0.290 | 0.290 | 0.291 |
| *AIC* | 11963.8 | 12022.0 | 11970.8 | 12023.7 | 12021.9 | 12015.7 |
| *BIC* | 12271.2 | 12278.2 | 12227.0 | 12279.9 | 12278.1 | 12271.9 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 10 Robustness check only Europe for hypothesis 2, pooled OLS*

| | -1 | -2 | -3 | -4 | -5 | -6 |
|---|---|---|---|---|---|---|
| | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq | tobinsq |
| co2perf | 0.0435 | -0.0251 | -0.00470 | 0.0143 | 0.0792$^{*}$ | 0.0118 |
| | (0.0443) | (0.0351) | (0.0283) | (0.0127) | (0.0309) | (0.0112) |
| int_co2perfboardind | 0.000959 | 0.000473 | | | | |
| | (0.000658) | (0.000507) | | | | |
| int_co2perffemale | 0.0000393 | | 0.000277 | | | |
| | (0.00108) | | (0.000906) | | | |
| int_co2perfcsrcomm | -0.0219 | | | -0.0245 | | |
| | (0.0189) | | | (0.0172) | | |
| int_co2perfboardsize | -0.00848$^{**}$ | | | | -0.00830$^{**}$ | |
| | (0.00297) | | | | (0.00315) | |
| int_co2perfceodual | -0.0154 | | | | | -0.0149 |
| | (0.0169) | | | | | (0.0130) |
| boardindependence | -0.000675 | -0.000728 | | | | |
| | (0.00101) | (0.00101) | | | | |
| female | -0.000458 | | -0.000570 | | | |
| | (0.00185) | | (0.00185) | | | |
| csrcommittee | -0.0139 | | | -0.0170 | | |
| | (0.0420) | | | (0.0419) | | |
| boardsize | 0.0109$^{+}$ | | | | 0.0113$^{+}$ | |
| | (0.00596) | | | | (0.00595) | |
| ceoduality | 0.0485 | | | | | 0.0566 |
| | (0.0379) | | | | | (0.0372) |
| log_debtratio | -1.048$^{***}$ | -1.043$^{***}$ | -1.041$^{***}$ | -1.035$^{***}$ | -1.050$^{***}$ | -1.040$^{***}$ |
| | (0.261) | (0.261) | (0.261) | (0.262) | (0.261) | (0.261) |
| log_totalassets | -0.339$^{***}$ | -0.332$^{***}$ | -0.332$^{***}$ | -0.332$^{***}$ | -0.340$^{***}$ | -0.332$^{***}$ |
| | (0.0648) | (0.0641) | (0.0641) | (0.0643) | (0.0646) | (0.0641) |
| sales_growth | 0.00192$^{***}$ | 0.00192$^{***}$ | 0.00192$^{***}$ | 0.00193$^{***}$ | 0.00193$^{***}$ | 0.00194$^{***}$ |
| | (0.000440) | (0.000439) | (0.000444) | (0.000439) | (0.000437) | (0.000439) |
| Constant | 7.193$^{***}$ | 7.212$^{***}$ | 7.176$^{***}$ | 7.176$^{***}$ | 7.169$^{***}$ | 7.133$^{***}$ |
| | -1.004 | (0.998) | -1.002 | -1.004 | -1.003 | -1.003 |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4470 | 4470 | 4470 | 4470 | 4470 | 4470 |
| $R^2$ | 0.097 | 0.095 | 0.095 | 0.095 | 0.096 | 0.095 |
| *AIC* | 2496.3 | 2491.5 | 2492.1 | 2490.7 | 2485.1 | 2490.3 |
| *BIC* | 2618.0 | 2561.9 | 2562.6 | 2561.2 | 2555.6 | 2560.8 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 11 Robustness check only Europe for hypothesis 2, fixed effects model*

| | Pooled F.V. | F.E. F.V. |
|---|---|---|
| CER_lag | -0.116*** | 0.0275* |
| | (0.0185) | (0.0119) |
| DR | -0.0580 | -0.871*** |
| | (0.327) | (0.262) |
| FSIZE | -0.142*** | -0.430*** |
| | (0.0212) | (0.0692) |
| FGROW | 0.00652*** | 0.00175*** |
| | (0.00131) | (0.000402) |
| Constant | 3.241*** | 8.839*** |
| | (0.616) | -1.092 |
| Year | Yes | Yes |
| Industry | Yes | |
| Company | Yes | |
| Country | Yes | |
| Observations | 5641 | 5641 |
| $R^2$ | 0.262 | 0.090 |
| *AIC* | 16810.2 | 2954.3 |
| *BIC* | 17062.5 | 3007.4 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 12 Robustness check lagged variables for hypothesis 1*

| | F.V. | F.V. | F.V. | F.V. | F.V. | FV |
|---|---|---|---|---|---|---|
| CER_lagged | -0.137$^{+}$ | -0.131$^{*}$ | -0.0986$^{**}$ | -0.101$^{***}$ | -0.169$^{***}$ | -0.0996$^{**}$ |
| | (0.0772) | (0.0634) | (0.0305) | (0.0235) | (0.0425) | (0.0365) |
| CER*BIND_lag | 0.000516 | 0.000188 | | | | |
| | (0.000909) | (0.000786) | | | | |
| CER*BDIV_lag | -0.00112 | | -0.000663 | | | |
| | (0.00132) | | (0.00114) | | | |
| CER*ENV_lag | -0.0390 | | | -0.0230 | | |
| | (0.0351) | | | (0.0291) | | |
| CER*BSIZE_lag | 0.00640$^{+}$ | | | | 0.00505 | |
| | (0.00361) | | | | (0.00311) | |
| CER*CEOD_lag | -0.0386 | | | | | -0.0197 |
| | (0.0465) | | | | | (0.0385) |
| BIND_lag | 0.00108 | 0.00146 | | | | |
| | (0.00160) | (0.00153) | | | | |
| BDIV_lag | 0.0117$^{***}$ | | 0.0121$^{***}$ | | | |
| | (0.00307) | | (0.00305) | | | |
| ENV_lag | 0.129$^{+}$ | | | 0.151$^{*}$ | | |
| | (0.0660) | | | (0.0649) | | |
| BSIZE_lag | 0.0195$^{*}$ | | | | 0.0231$^{*}$ | |
| | (0.00946) | | | | (0.00951) | |
| CEOD_lag | 0.138 | | | | | 0.137$^{+}$ |
| | (0.0850) | | | | | (0.0815) |
| DR | -0.0331 | -0.0666 | -0.0421 | -0.0704 | -0.0375 | -0.0498 |
| | (0.322) | (0.327) | (0.325) | (0.325) | (0.326) | (0.327) |
| FSIZE | -0.192$^{***}$ | -0.145$^{***}$ | -0.157$^{***}$ | -0.157$^{***}$ | -0.163$^{***}$ | -0.145$^{***}$ |
| | (0.0251) | (0.0214) | (0.0221) | (0.0222) | (0.0236) | (0.0215) |
| FGROW | 0.00728$^{***}$ | 0.00655$^{***}$ | 0.00697$^{***}$ | 0.00664$^{***}$ | 0.00676$^{***}$ | 0.00653$^{***}$ |
| | (0.00131) | (0.00131) | (0.00131) | (0.00132) | (0.00131) | (0.00131) |
| Constant | 3.258$^{***}$ | 3.230$^{***}$ | 3.073$^{***}$ | 3.410$^{***}$ | 3.272$^{***}$ | 3.262$^{***}$ |
| | (0.722) | (0.657) | (0.688) | (0.625) | (0.611) | (0.617) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Company | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 5641 | 5641 | 5641 | 5641 | 5641 | 5641 |
| $R^2$ | 0.275 | 0.262 | 0.270 | 0.264 | 0.264 | 0.263 |
| *AIC* | 16731.7 | 16811.2 | 16751.3 | 16796.8 | 16796.7 | 16809.3 |
| *BIC* | 17050.3 | 17076.7 | 17016.8 | 17062.3 | 17062.2 | 17074.9 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 13 Robustness check lagged variables for hypothesis 2, pooled OLS*

| | (1) FV | -2 F.V. | -3 F.V. | -4 F.V. | -5 F.V. | -6 F.V. |
|---|---|---|---|---|---|---|
| CER_lagged | -0.0375 | -0.0421 | 0.0566* | 0.0370** | 0.0185 | 0.0120 |
| | (0.0504) | (0.0425) | (0.0263) | (0.0130) | (0.0336) | (0.0188) |
| CER*BIND_lag | 0.00126* | 0.00103+ | | | | |
| | (0.000632) | (0.000621) | | | | |
| CER*BDIV_lag | -0.00126 | | -0.00107 | | | |
| | (0.000869) | | (0.000808) | | | |
| CER*ENV_lag | -0.0200 | | | -0.0176 | | |
| | (0.0160) | | | (0.0150) | | |
| CER*BSIZE_lag | 0.00176 | | | | 0.000977 | |
| | (0.00357) | | | | (0.00430) | |
| CER*CEOD_lag | 0.0124 | | | | | 0.0213 |
| | (0.0164) | | | | | (0.0185) |
| BIND_lag | 0.000335 | 0.000224 | | | | |
| | (0.000992) | (0.000998) | | | | |
| BDIV_lag | -0.000935 | | -0.000905 | | | |
| | (0.00149) | | (0.00149) | | | |
| ENV_lag | 0.00434 | | | 0.00285 | | |
| | (0.0381) | | | (0.0377) | | |
| BSIZE_lag | -0.00215 | | | | -0.00183 | |
| | (0.00559) | | | | (0.00562) | |
| CEOD_lag | 0.0113 | | | | | 0.0103 |
| | (0.0342) | | | | | (0.0340) |
| DR | -0.885*** | -0.877*** | -0.873*** | -0.873*** | -0.871*** | -0.873*** |
| | (0.263) | (0.262) | (0.263) | (0.263) | (0.263) | (0.263) |
| FSIZE | -0.429*** | -0.429*** | -0.430*** | -0.430*** | -0.429*** | -0.430*** |
| | (0.0696) | (0.0691) | (0.0694) | (0.0692) | (0.0696) | (0.0692) |
| FGROW | 0.00172*** | 0.00175*** | 0.00172*** | 0.00175*** | 0.00175*** | 0.00176*** |
| | (0.000406) | (0.000403) | (0.000404) | (0.000402) | (0.000404) | (0.000402) |
| Constant | 8.830*** | 8.812*** | 8.866*** | 8.843*** | 8.845*** | 8.827*** |
| | -1.093 | -1.094 | -1.093 | -1.092 | -1.088 | -1.093 |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | | | | | | |
| Company | | | | | | |
| Country | | | | | | |
| Observations | 5641 | 5641 | 5641 | 5641 | 5641 | 5641 |
| $R^2$ | 0.091 | 0.090 | 0.090 | 0.090 | 0.090 | 0.090 |
| *AIC* | 2967.6 | 2956.2 | 2955.9 | 2957.6 | 2958.1 | 2957.6 |
| *BIC* | 3087.1 | 3022.6 | 3022.2 | 3024.0 | 3024.5 | 3023.9 |

Standard errors in parentheses

$^{+}$ $p < 0.10$, $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

*Appendix 14 Robustness check lagged variables for hypothesis 2, fixed effects model*