The moderating role of culture in the relationship between carbon emissions and firm value

A Master's Thesis in Economics, specialisation Accounting & Control

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Abstract

This research examines the moderating effect of culture on the relationship between carbon emissions and firm value, using carbon emissions data, firm data, and cultural data from 2011-2018. Based on a sample of 1,101 firms from 41 countries, additional support is provided for the previously researched negative relationship between carbon emissions and firm value. This finding is consistent with the argument that capital markets impose a penalty for firms' carbon emissions. Only three of the six cultural dimensions have significant moderating effects when firm value is measured as the market value of common equity. However, all cultural dimensions except the masculinity-femininity dimension have significant moderating effects with ROA as measure of firm value. Additionally, with Tobin's Q, only the long-term orientation dimension has a significant moderating effect. Thus, with market value and Tobin's Q, the negative relationship between carbon emissions and firm value is quite robust against cultural differences. Nevertheless, this research is the first to find significant evidence for moderating effects of the power distance index, individualistic-collectivistic dimension, masculinity-femininity dimension, and the indulgence-restraint dimension on the relationship between carbon emissions and firm value. However, further research is needed to examine these moderating effects in other settings.

Keywords: Carbon emissions, carbon intensity, firm value, market value, national culture, Hofstede

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1. Introduction

Institutional investors and other stakeholders are increasingly interested in climate-change risk. (PricewaterhouseCoopers, 2012). Climate change means that severe weather events like droughts, flooding, and storms may occur more often, which can directly affect society and the economy. In this way, climate-change risks are also impacting investors. Younger investors want to invest their money with sustainability in mind (CNBC, 2020). This millennial generation is mostly interested in impact investing since nearly 90% of this generation sets it as the first investment criteria (CNBC, 2019).

In addition to the increasing interest of investors in climate-change risks and sustainable investments, the global economy is also shifting towards a low-carbon model with the Paris Agreement fuelling this pressure further. So, firms from all over the world are under increasing pressure to cut their carbon emissions (KPMG, 2017), because carbon dioxide regulations and policies impact the firm's financial performance and cost of capital (Dobler, Lajili, & Zéghal, 2014). Due to these regulations and policies, firms with a bad track record on ESG issues could receive fines in the future, so investors might want to avoid those firms (CNBC, 2020). Finally, firms may lose their reputation because investors negatively assess their response to climate change.

Climate change is driven by multiple factors. One of the large climate change drivers are greenhouse gases, which heat the atmosphere (EPA, 2020). The major greenhouse gas emitted through human activities is carbon dioxide or, in other words, CO_2. In 2017, almost 82 percent of all U.S. greenhouse gas emissions from human activities consisted of CO_2 (EPA, 2020).

Given the importance of carbon dioxide as a climate change driver, much research has been done on the effect of carbon emissions on firm value, market value, and firm performance. Matsumura, Prakash, and Vera-Munoz (2014) argue that carbon emissions have significant market-value implications if capital markets think that the amount of carbon emissions is measured reliably and if capital markets think it is relevant for valuation. They found a negative effect of carbon emissions on firm value for S&P 500 firms, and argue that markets impose a penalty for carbon emissions of firms. Lee, Min, and Yook (2015) also found that carbon emissions decrease firm value for Japanese manufacturing firms. While Matsumura et al. (2014) and Lee et al. (2015) focused on a U.S. setting and Japanese setting respectively, Choi & Luo (2020) focused on a global setting. They also found a negative relationship between carbon emissions and corporate financial performance. So, most research found a negative effect of carbon emissions on firm value, market value and firm performance (Matsumura et al., 2014; Lee et al., 2015; Fujii, Iwata, Kaneko, & Managi, 2013; Gallego-Álvarez, Segura, & Martínez-Ferrero, 2015; Busch & Hoffmann, 2011; Choi & Luo, 2020).

Therefore, other studies increasingly examine factors that could influence the relationship between carbon emissions and firm value. Previous research on environmental practices of firms mostly focused on formal institutions, but it placed little attention on informal institutions such as national culture (Moon, 2004; Campbell, 2007; Chih, Chih, & Chen, 2010). Therefore, this research aims to explore the moderating effect of culture on the relationship between carbon emissions and firm value. Culture could have a moderating effect on the relationship between carbon emissions and firm value in multiple ways. For instance, Luo & Tang (2016) argue that culture impacts managerial attitudes and philosophies about environmental protection. Thus, culture affects the willingness and extent to which managers recognize the need for emissions control. Furthermore, culture affects the way different stakeholders think about climate issues and the conservation of nature. Consumers from countries with cultural characteristics that care about society could punish firms with high carbon emissions by buying fewer products. Likewise, capital markets in different countries can incorporate carbon emissions into firm valuation to varying degrees.

However, culture is a broad concept. Hofstede (1980) has distinguished six cultural dimensions to explain cultural differences between countries: power distance, individualism-collectivism, masculinity-femininity, uncertainty avoidance, long-term orientation-short-term orientation, and indulgence-restraint. Although other studies have controlled for country differences, the explicit role of culture in terms of all cultural dimensions of Hofstede (1980) has not been investigated. Therefore, this research will use the six cultural dimensions of Hofstede (1980) to examine the moderating role of culture on the relationship between carbon emissions and firm value. Since, for example, the Netherlands and Germany have scores of 67 and 83 for the long-term orientation dimension, while the U.S. has a score of 26, it might be interesting to study these differences (Hofstede Insights, 2020). Therefore, the research question of this paper is:

"What is the moderating effect of culture on the relationship between carbon emissions and firm value?

To answer the research question, panel data regression analyses will be performed. This is the most suitable method for this research because multiple firms can be analysed over time (Hsiao, 2006). The sample consists of 1,101 firms located in 41 countries, and the data consists of carbon data, cultural characteristics, firm-level characteristics, industry-level characteristics collected from 2011 till 2018. Following prior research, firm value will be measured as the market value of common equity (Matsumura et al., 2014). Carbon emissions will be measured as carbon intensity, because it is more common in previous research to use a scaled variable to measure carbon emissions, instead of total carbon emissions (Misani & Pogutz, 2015; Ganda & Milondzo, 2018; Busch & Hoffmann, 2011; Rokhmawati, Sathye, & Sathye, 2015; Fujii et al., 2013; Lee et al., 2015). The data will be retrieved from Thomson Reuters Eikon's Datastream, ASSET4, and Worldscope databases. Each cultural dimension represents an index ranging from 1-100, and the data will be retrieved from Hofstede Insights (2020). Control variables include firm size, leverage, growth rate, and capital intensity, and will be retrieved from Worldscope. There will also be controlled for industry-level and year characteristics, by including industry and year fixed effects.

As robustness checks for firm value, Tobin's Q and ROA will be used. Tobin's Q measures the market response to a firm's decisions, while ROA captures the internal performance of the firm on the balance sheet (Misani & Pogutz, 2015). Additionally, the independent variables will be lagged 1 year behind the market value of common equity to increase confidence in the direction of the relationship (Delmas, Nairn-Birch, & Lim, 2015).

This research finds a negative relationship between carbon emissions and firm value, which is consistent with previous findings (Matsumura et al., 2014; Lee et al., 2015; Fujii et al., 2013; Gallego-Álvarez et al., 2015; Busch & Hoffmann, 2011; Choi & Luo, 2020). However, the results concerning the moderating effect of culture are less clear. Concerning the developed hypotheses, only H2a and H2d are partially supported, and H2e is supported with both the main model and robustness checks. Furthermore, there is no overall significant evidence that culture has a moderating effect on the relationship between carbon emissions and market value because only for three of the six cultural dimensions small significant effects were found. However, with ROA as measure of firm value, significant moderating effects were found for five of the six cultural dimensions. Therefore, there is significant evidence that culture has a moderating effect on the relationship between carbon emissions and ROA.

Overall, the findings of this research indicate that the negative relationship between carbon emissions and firm value measured as market value of common equity or Tobin's Q is quite robust against cultural differences. A possible explanation might be that all stakeholders see carbon performance as highly relevant non-financial information, where they see more carbon emissions as negative because of the increasing threat of climate change and associated interest of society in climate change. Although stakeholders in certain countries might consider carbon emissions as less important due to cultural differences, this difference might be so small that it does not significantly influences the relationship between carbon emissions and firm value.

This paper extends the research on the effect of carbon emissions on firm value by examining the moderating role of culture. The scientific relevance of this research is that it fills the knowledge gap of the role that the cultural dimensions of Hofstede (1980) play in the relationship between carbon emissions and firm value. It adds to the limited empirical research on the moderating effect of culture by extending Choi & Luo (2020), who focus exclusively on the uncertainty avoidance index and long-term orientation versus short-term orientation dimension. Furthermore, most of the previous research only study certain countries (Matsumura et al., 2014; Ganda & Milondzo, 2018; Lee et al., 2015; Rokhmawati et al., 2015; Fujii et al., 2013), while this study examines a global sample. The scope is therefore extended, thereby increasing external validity.

This research also has societal relevance, since investors, regulators, standard-setters and other stakeholders are increasingly concerned about climate-change risk and carbon emission levels. At the moment, US GAAP and IFRS do not mandate carbon-related information (Choi & Luo, 2020), although the negative influence of carbon emissions on firm value is widely acknowledged. Therefore, investors and other stakeholders need to have reliable and relevant carbon-related information, and standard setters should thus think about mandating carbon-related information.

Furthermore, this research has practical relevance in terms of managerial implications, because evidence is provided for the negative firm-value effects of carbon emissions. Managers can use this information to make important decisions about the cost-benefit trade-offs of resource allocation to reduce carbon emissions (Thaler & Sunstein, 2009). Furthermore, if certain cultural characteristics of a country are associated with a stronger negative effect of carbon emissions on firm value, management of firms that are headquartered in these countries, will have to consider the financial consequences regarding their carbon management strategies (Choi & Luo, 2020).

This paper proceeds as follows. In section 2, the relevant literature is reviewed, and the hypotheses are formulated. In section 3, the research design with the sample, data, methodology, and variables is explained. Section 4 provides the results and robustness checks. Finally, section 5 provides a conclusion and discussion of this research.

2. Theoretical background

2.1 The relationship between carbon emissions and firm value

There has been a long debate about the relationship between corporate financial performance and corporate environmental performance over the last decades (Lee et al., 2015). On the one hand, there is earlier research that adopts the traditional view. This branch of research states that firms incur additional costs if they respond to environmental challenges and this reduces firm value and profits. On the other hand, there is the revisionist view, which states that “a firm can improve its economic performance by exploiting environmental opportunities as a first mover” (Lee et al., 2015, p. 3).

However, corporate environmental performance is a broad concept, because it includes a large range of corporate behavior concerning its processes, commitments, outputs, and resources. Therefore, different aspects of corporate environmental performance may have different implications for financial performance. This indicates that it is important to focus on specific elements of corporate environmental performance, such as the amount of carbon emissions (Lee et al., 2015).

Carbon emissions are an important element of corporate environmental performance because carbon dioxide is an essential climate change driver, so potential and actual harm are related to carbon emissions (Lee et al., 2015). Furthermore, stakeholders consider carbon performance as highly relevant, non-financial information (Eccles, Serafeim, & Krzus, 2011). Since shareholder value maximization is one of the strategic objectives of firms (Jensen, 2002), it is important to investigate whether stock markets include the firms’ amount of carbon emissions in their valuation (Hua, Gregory, & Whittaker, 2018). As an illustration, there is evidence that when analysts and investors make investment recommendations and decisions, they take into account the improvement in environmental risk factors (Heinkel, Kraus, & Zechner, 2001; Mackey, Mackey, & Barney, 2007). Higher environmental performance should be viewed as successful environmental risk management because firms mitigate their risk of litigation when they make strategic investments that reduce carbon emissions (Sharfman & Fernando, 2008).

Therefore, much research is done on the effect of carbon emissions on firm value and firm performance. Matsumura et al. (2014) draw on value relevance research as a theoretical framework to determine whether investors use information about the amount of carbon emissions for firm valuation. They argue that carbon emissions have significant market-value implications if a capital market assumes that the amount of carbon emissions is measured reliably and if it is assumed to be relevant for valuation. Furthermore, Matsumura et al. (2014) draw on natural-resource-based theory, which states that the key capabilities and resources of firms affect their ability to maintain their competitive advantage (Hart, 1995). Consistent with this view, they argue that firms that do not invest in alternatives to reduce carbon emissions tend to lower the market-value expectations of investors in comparison with firms that integrate climate change risk into their strategy. The results of their research show a negative effect of carbon emissions on firm value for S&P 500 firms between 2006 and 2008, and they argue that markets impose a penalty for carbon emissions of firms.

Similarly, Lee et al. (2015) also found that carbon emissions decreased the value of Japanese manufacturing firms studied between 2003 and 2010. Furthermore, Fujii et al. (2013) also conducted an empirical analysis of Japanese manufacturing firms and found a significant, positive relationship between environmental performance measured as the amount of carbon emissions and financial performance measured as profitability. This positive relationship implies that environmental performance is high when the amount of carbon emissions is low.

While Matsumura et al. (2014), Lee et al. (2015) and Fujii et al. (2013) focused on a U.S. setting and Japanese setting respectively, others focused on an international setting (Gallego-Álvarez et al., 2015; Choi & Luo, 2020; Busch & Hoffmann, 2011). First of all, Gallego-Álvarez et al. (2015) found that a reduction in carbon emissions led to higher financial performance. Furthermore, Busch and Hoffmann (2011) found that firms with lower carbon intensity can generate a "carbon premium" when using Tobin's q as a measure for financial performance. However, for return on equity and return on assets as measures of financial performance, no significant results were found. Lastly, Choi and Luo (2020) state that firms with a high amount of carbon emissions might have to change their production process to reduce carbon emissions or might be subject to additional fines and taxes imposed by the government in the future. Rooted in value-relevance theory and instrumental stakeholder theory, they argue that the capital market tends to penalize firms with a high amount of carbon emissions more than other firms, which leads to high liabilities and future cash outflows because meeting the expectations of stakeholders to reduce their carbon emissions is costly (Choi & Luo, 2020). They also found a negative relationship between carbon emissions and firm value for Global 500 firms.

By contrast, some studies show positive relationships or mixed results (Rokhmawati et al., 2015; Ganda & Milondzo, 2018). Rokhmawati et al. (2015) use instrumental stakeholder theory to explain the relationship between carbon emissions and firm performance. They argue that carbon emissions positively affect firm performance when there are ineffective environmental regulations and little pressure of stakeholders. Using a sample of Indonesian firms, their hypothesis is supported. This implies that Indonesian firms incur low penalties for increasing their carbon emissions and lack financial incentives to reduce carbon emissions (Rokhmawati et al., 2015). In contrast to Rokhmawati et al. (2015), Ganda and Milondzo (2018) show evidence of a negative relationship between carbon emissions and corporate financial performance for South African firms. However, they also found positive effects when distinguishing between clean and polluting industries and direct and indirect emissions. Thus, their results are mixed.

Although previous studies mostly assume a linear relationship between carbon emissions and firm value, some research assumes a non-linear relationship. To illustrate, Misani and Pogutz (2015) argue that firms with high carbon emissions can outperform competitors who invest in reducing their carbon emissions because they only face reputation or legitimacy losses, which will likely be lower than costly investments to reduce the emissions. However, they found that carbon-intensive firms get the highest financial performance when their carbon emission is intermediate. Thus, instead of a linear relationship, they found a U-shaped relationship between carbon emissions and firm performance.

To summarize, most research reports a negative relationship between carbon emissions and firm value (Matsumura et al., 2014; Lee et al., 2015; Fujii et al., 2013; Gallego-Álvarez et al., 2015; Busch & Hoffmann, 2011; Choi & Luo, 2020). In line with Matsumura et al. (2014) and Choi and Luo (2020), this research argues that stakeholders pressure firms to reduce their carbon emissions, and that capital markets tend to penalize firms with a high amount of carbon emissions more than other firms, due to high future liabilities and cash outflows. Therefore, also consistent with previous findings, the following hypothesis is suggested:

Hypothesis 1: Carbon emissions have a negative effect on firm value.

2.2 The moderating role of culture on the relationship between carbon emissions and firm value

A moderator is a quantitative or qualitative variable that influences the strength and/or the direction of the relationship between a dependent and independent variable (Baron & Kenny, 1986). Culture can be a moderator in the relationship between carbon emissions and firm value. It is defined as “the collective programming of the mind that distinguishes the members of one group or category of people from others” (Hofstede, 2011, 3). Various levels of culture, such as personal, national, and organizational culture, exist (Hofstede, 2001). So, it is a very broad concept. However, this study focuses on national culture.

National culture shapes the attitudes and perceptions of people, and in this way influences how people utilize their environments and natural resources (Park, Russell, & Lee, 2007). Thus, it can be reasonably suspected that the ability and will to protect the environment are influenced by sociocultural factors within a country. Environmentally responsible behavior can be perceived very differently across countries due to cultural differences because culture impacts normative ethical views of what is morally correct behavior (Cohen & Nelson, 1994). Furthermore, others observe a significant cross-cultural variability in the attitudes of people to nature and its conservation (Kellert, 1996).

As for the corporate setting, culture impacts managerial attitudes and philosophies about environmental protection (Luo & Tang, 2016). Thus, culture affects the willingness and extent to which managers recognize the need for emissions control. Additionally, how different stakeholders think about climate issues and conservation of nature also depends on culture prescriptions. Stakeholders from different societies react differently to irresponsible behavior such as high amounts of carbon emissions by firms (Williams & Zinkin, 2008). Capital markets in different countries can, therefore, incorporate carbon emissions into firm valuation to varying degrees.

Besides, stakeholders from certain countries might punish firms with high carbon emissions more than stakeholders from another country. Here, punishment could, for example, mean that consumers buy fewer products from the irresponsible behaving firm. This can lower firm performance and in turn negatively impact firm value. Conversely, firms with a low amount of carbon emissions could also attract stakeholders with high interests in sustainability.

Thus, there are several ways in which culture could play a moderating role in the relationship between carbon emissions and firm performance. Therefore, this research questions whether culture has a moderating effect on the relationship between carbon emissions and firm value. To further decompose culture, the cultural dimensions of Hofstede (1980) will be used. Hofstede (1980) has distinguished six cultural dimensions to explain cultural differences between countries: power distance index, uncertainty avoidance index, individualism-collectivism, masculinity-femininity, long-term orientation-short-term orientation, and indulgence-restraint. These dimensions will be explained in the following subparagraphs, and hypotheses for each dimension will be developed.

2.2.1 Power distance

The power distance index reflects the propensity with which the less powerful members of societies view power inequality as legitimate (Hofstede, 1991). Powerless members of high power distance societies accept that power is more concentrated as a fact of life (Park et al., 2007).

Regarding the environment, societies scoring high on this dimension are likely to display greater tolerance for environmental or social injustices and accept more power inequality than societies with low power distance (Park et al., 2007; Williams & Zinkin, 2008). Therefore, it is assumed that firms located in high power distance societies implement little environmental management practices and are less concerned about social responsibilities (Calza, Cannavale, & Tutore, 2016; Ioannou & Serafeim, 2012; Ringov & Zollo, 2007). Furthermore, consumers of societies scoring high on the power distance dimension may accept externalities generated by firms in their larger scale function. Besides, members of those societies are accustomed to hierarchical distinctions and thus may put less pressure on firms to be egalitarian towards the social nexus of the environment (Petruzzella, Salvi, & Giakoumelou, 2017). As a consequence, shareholders may place less value on the amount of carbon emissions when valuing the company.

Furthermore, in high power distance societies corporate scandals tend to be covered up rather than being publicly known (Hofstede & Hofstede, 2005). Therefore, Williams and Zinkin (2008) argue that stakeholders in high power distance societies are less likely to punish firms that behave irresponsibly than stakeholders in societies with low power distance. For low power distance societies, it is expected that stakeholders are more likely to punish firms without waiting for 'permission'. (Williams & Zinkin, 2008). Based on the previous arguments, the following hypothesis is suggested:

Hypothesis 2a: The negative effect of carbon emissions on firm value is weaker for firms headquartered in high power distance countries than for firms headquartered in low power distance countries.

2.2.2 Uncertainty avoidance

The uncertainty avoidance index reflects the extent to which members of a particular society feel uncomfortable about ambiguity and uncertainty. Societies scoring high on the uncertainty avoidance dimension are likely to have more laws and regulations because they put greater effort into trying to reduce risks (Park et al., 2007). Since environmental impacts are associated with uncertainties, there are also strict rules and regulations to protect the environment in these societies. So, firms in high uncertainty avoidance societies have to commit to stricter regulations and rules. Therefore, firms in countries scoring high on this dimension are expected to emphasize environmental sustainability more than firms in countries scoring low on the uncertainty avoidance index (Thanetsunthorn, 2015).

Likewise, Luo and Tang (2016) found that firms are more likely to voluntarily disclose carbon information when they are operating in high uncertainty avoidance countries. Moreover, Choi and Luo (2020) argue that firms in high uncertainty avoidance countries are more pressured to proactively manage carbon emissions to avoid uncertain cash outflows related to future changes in carbon taxes or environmental regulations. So, Choi and Luo (2020) expected that the value-decreasing effect of carbon emissions is smaller for firms operating in high uncertainty avoidance countries, and their empirical results confirmed their expectations.

However, other aspects than voluntary disclosure of carbon information and proactively managing carbon emissions, such as stakeholders in high uncertainty avoidance societies who disapprove of ambiguous and uncertain situations, could also influence the moderating role of uncertainty avoidance. Since environmental impacts are associated with uncertainties, shareholders may attach more value to the amount of carbon emissions when valuing a company than shareholders in low uncertainty avoidance societies. Likewise, consumers in high uncertainty avoidance societies could punish firms for their high amounts of carbon emissions more than consumers in low uncertainty avoidance societies. This suggests a stronger negative effect of carbon emissions on firm value for firms operating in high uncertainty avoidance countries than for firms operating in low uncertainty avoidance countries Therefore, the following hypothesis is suggested:

Hypothesis 2b: The negative effect of carbon emissions on firm value is stronger for firms headquartered in high uncertainty avoidance countries than for firms headquartered in low uncertainty avoidance countries.

2.2.3 Individualism versus collectivism

This dimension communicates the extent to which members of societies care for themselves and their close relatives. In high individualistic societies, members are likely to value self-reliance and care for the well-being of the individual over the group interest. These members tend to put shareholders ahead of other stakeholders (Williams & Zinkin, 2008). By way of contrast, people tend to emphasize collaboration and sacrifice personal interest for group benefits in low individualistic societies (Hofstede & Hofstede, 2005). Therefore, firms located in individualistic countries are less likely to care about environmental issues, because they care more about their benefits than about the group interest.

This is also shown by Petruzzella et al. (2017), who states that employees in individualistic societies show less ethically oriented behavior compared to employees in collectivistic societies. Therefore, firms in individualistic countries pay less attention to the impact they have on the environment. Consequently, it can be argued that stakeholders in individualistic societies consider carbon emissions as less important and less harmful than stakeholders in collectivistic societies.

However, Williams and Zinkin (2008) argue that stakeholders in individualistic societies tend to punish the irresponsible behavior of firms more without waiting for peer group approval. In collectivistic societies, stakeholders such as consumers tend to look to social institutions or the government to act.

Nevertheless, since stakeholders in individualistic societies care for individual well-being more than the group interest, this study takes the position that these stakeholders consider carbon emissions to be less important and harmful. Therefore, the following hypothesis is suggested:

Hypothesis 2c: The negative effect of carbon emissions on firm value is weaker for firms headquartered in individualistic countries than for firms headquartered in collectivistic countries.

2.2.4 Masculinity versus femininity

Masculine societies are likely to be egocentric and more concerned about economic status and power, while feminine societies place more emphasis on social goals like the physical environment, relationships, and helping others (Van der Laan Smith, Adhikari, & Tondkar, 2005). Additionally, feminine societies are likely to place more weight on the quality of life than on wealth, recognitions and ego-boosting, while masculine societies tend to emphasize material success and achievement, even at the sacrifice of the well-being of others (Hofstede, 1980; Park et al., 2007). The quality of life greatly depends on the natural environment's quality. Since carbon emissions cause global warming and thus unstable climates, they decrease the quality of life. Therefore, firms in masculine countries are expected to perform less environmental practices than firms in feminine countries, as they may put shareholders ahead of other stakeholders.

By way of contrast, firms in feminine countries are likely to care more about the effects their activities have on the environment because managers do not see the pursuit of economic opportunities but the preservation of the environment as one of their highest priorities, and they are likely to be relationship-oriented and value environmental protection in general (Luo & Tang, 2016; Hofstede, 2001). Since stakeholders in feminine countries tend to care more about the quality of life, shareholders in feminine countries might consider carbon emissions as more important than shareholders in masculine countries, thereby affecting the relationship between carbon emissions and firm value more. Conversely, it can be argued that shareholders in masculine countries consider carbon emissions as less important, thereby affecting the relationship between carbon emissions and firm value less. Therefore, the following hypothesis is suggested:

Hypothesis 2d: The negative effect of carbon emissions on firm value is weaker for firms headquartered in masculine countries than for firms headquartered in feminine countries.

2.2.5 Long-term orientation versus short-term orientation

The long-term orientation versus the short-term orientation dimension describes the time horizon of societies. It reflects the extent to which members of societies focus on the future consequences certain actions have (Tsai, Huang, & Chen, 2019). Short-term oriented societies are more concerned with the past and present, and respect tradition, while long-term oriented countries are likely to be more concerned with the future and have the capacity for adaptation (Hofstede & Minkov, 2010). Furthermore, members of long-term oriented countries are more open to adapting improvements proposed by practices in other cultures, and they are more likely to have increased savings which allow funds for investments (Petruzzella et al., 2017). So, they may be more able to invest in sustainable practices. Besides, investments in sustainable practices usually pay off in the future. So, firms operating in long-term oriented countries may see more need for investing in sustainable practices than firms operating in short-term oriented countries.

In long-term oriented countries, there tends to be more institutional pressure to establish long-term carbon strategies (Choi & Luo, 2020). In this case, managers will be more rewarded for investing in forward-looking carbon management through high compliance with long-term institutional pressures. Moreover, since managers will be rewarded they will provide more carbon-related information to stakeholders (Luo & Tang, 2016). Choi and Luo (2020) predicted that the negative effect of carbon emissions on firm value would be weaker in long-term oriented countries, because corporate executives and stakeholders are highly aware of the importance of future-oriented strategies, and the results support their hypothesis. So, the following hypothesis is suggested:

Hypothesis 2e: The negative effect of carbon emissions on firm value is weaker for firms headquartered in countries representing long-term oriented societies than for firms headquartered in countries representing short-term oriented societies.

2.2.6 Indulgence versus restraint

The indulgence versus restraint dimension is closely related to the long-term orientation dimension (Petruzzella et al., 2017). Restrained societies see the value in restraining someone's desires and withholding pleasures to bring them more in line with societal norms, while indulgent societies value the satisfaction of desires and human needs (Hofstede & Minkov, 2010). So, indulgent societies are likely to focus more on individual well-being and happiness, while this is less important in restrained societies. Members of an indulgent society tend to focus less on norms and order, while members of a restrained society experience more norms and formal control (Petruzzella et al., 2017).

Therefore, firms operating in indulgent countries will adopt less strict environmental commitment than firms operating in restrained countries. Consequently, it can also be argued that stakeholders in indulgent societies consider carbon emissions to be less important than stakeholders in restrained societies. Hence, shareholders might place less value on the amount of carbon emissions when valuing a firm, and consumers might punish high amounts of carbon emissions less. Therefore, the following hypothesis is suggested:

Hypothesis 2f: The negative effect of carbon emissions on firm value is weaker for firms headquartered in countries representing indulgent societies than for firms headquartered in countries representing restrained societies.

3. Research design

3.1 Sample and data

The sample consists of 1,101 publicly listed firms located worldwide because selecting worldwide firms, instead of focusing on a particular continent, increases the amount of firms in the sample, thereby increasing the external validity of this research. Furthermore, since most research only looked at particular countries or continents, it is relevant to examine cultural differences within a global sample. Table 1 provides the industry composition of the sample firms. 72.2% of the firms (795) are active in the industrial sector. The utility sector has the second-largest share with 9.5% (105 firms). The other sectors have relatively similar shares. In other research (Choi & Luo, 2020;) the industrial sector also has the most observations. However, compared to other research, the industry sector represents quite a large number of firms in this research.

The sample period is 2011-2018. 2011 has been chosen as the starting period for two reasons.

First, a lot of data on carbon emissions is missing before 2011. Second, the global financial crisis that started in 2008 raised investment risk, uncertainty, and slowed economic growth. This event negatively influenced firm value during 2008-2010 (Lee et al., 2015). Finally, 2018 has been chosen as the final year because for 2019 not enough data was available. As can be seen in Table 3, the amount of firm-year observations is 8,808 over the 2011-2018 period. Thus, the panel is strongly balanced since the amount of firm-year observations is equal for every year. As can be seen in Tables 2 and 3, the majority of the observations are from Japan, which constitutes 17.71% of the sample, followed by the United States with 16.26%. The United Kingdom is also well represented in the sample with 13.44% and 1184 observations. Other countries are less represented but still account for 52.59%.

The data is extracted from the databases Thomson Reuters Datastream and Hofstede Insights (2020). Thomson Reuters Datastream is the most comprehensive financial time series database worldwide.[1] Within Thomson Reuters Datastream, the sub-databases ASSET4 and Worldscope have been used. ASSET4 provides relevant, objective, and systematic environmental, social, and governance information (Thomson Reuters, 2013). Worldscope is the premier source of detailed financial statement data on public firms worldwide for the financial industry (Thomson Reuters, 2015). All the environmental data has been retrieved from ASSET4 and the financial data from Worldscope. Additionally, Hofstede Insights (2020) has been used for retrieving the cultural variables on the dimensions of national culture. To give each firm the correct scores for each cultural dimension, ISIN country codes are used. All variables are measured in US dollars.

Table 1

Industry composition of sample firms by General Industry classification

Industry	Freq.	Percent	Cum.
Industrial	795	72.21	72.21
Utility	105	9.54	81.74
Transportation	50	4.54	86.29
Bank/Savings & Loan	58	5.27	91.55
Insurance	41	3.72	95.28
Other Financial	52	4.72	100.00
Total	1,101	100.00	

[1] For more information see http://solutions.refinitiv.com/datastream-macroeconomic-analysis

Table 2

Country distribution of sample firms

Country	Freq.	Percent	Cum.
Austria	6	0.54	0.54
Australia	48	4.36	4.90
Belgium	12	1.09	5.99
Brazil	19	1.73	7.72
Canada	39	3.54	11.26
Switzerland	29	2.63	13.90
China	1	0.09	13.99
Colombia	4	0.36	14.35
Germany	39	3.54	17.89
Denmark	14	1.27	19.16
Spain	24	2.18	21.34
Finland	20	1.82	23.16
France	51	4.63	27.79
United Kingdom	148	13.44	41.24
Greece	3	0.27	41.51
Hong Kong	11	1.00	42.51
Hungary	2	0.18	42.69
Indonesia	2	0.18	42.87
Ireland	9	0.82	43.69
India	17	1.54	45.23
Italy	13	1.18	46.41
Japan	195	17.71	64.12
Republic of Korea	26	2.36	66.49
Luxembourg	2	0.18	66.67
Mexico	5	0.45	67.12
Malaysia	5	0.45	67.57
Netherlands	19	1.73	69.30
Norway	12	1.09	70.39
New Zealand	3	0.27	70.66
Philippines	4	0.36	71.03
Poland	6	0.54	71.57
Portugal	5	0.45	72.03
Russian Federation	4	0.36	72.39
Saudi Arabia	1	0.09	72.48
Sweden	28	2.54	75.02
Singapore	12	1.09	76.11
Thailand	8	0.73	76.84
Turkey	5	0.45	77.29
Taiwan	29	2.63	79.93
United States	179	16.26	96.19
South Africa	42	3.81	100.00
Total	1,101	100.00	

Table 3

Tabulation of firm-year observations per country per year

	Year								
Country	2011	2012	2013	2014	2015	2016	2017	2018	Total
Austria	6	6	6	6	6	6	6	6	48
Australia	48	48	48	48	48	48	48	48	384
Belgium	12	12	12	12	12	12	12	12	96
Brazil	19	19	19	19	19	19	19	19	152
Canada	39	39	39	39	39	39	39	39	312
Switzerland	29	29	29	29	29	29	29	29	232
China	1	1	1	1	1	1	1	1	8
Colombia	4	4	4	4	4	4	4	4	32
Germany	39	39	39	39	39	39	39	39	312
Denmark	14	14	14	14	14	14	14	14	112
Spain	24	24	24	24	24	24	24	24	192
Finland	20	20	20	20	20	20	20	20	160
France	51	51	51	51	51	51	51	51	408
United Kingdom	148	148	148	148	148	148	148	148	1184
Greece	3	3	3	3	3	3	3	3	24
Hong Kong	11	11	11	11	11	11	11	11	88
Hungary	2	2	2	2	2	2	2	2	16
Indonesia	2	2	2	2	2	2	2	2	16
Ireland	9	9	9	9	9	9	9	9	72
India	17	17	17	17	17	17	17	17	136
Italy	13	13	13	13	13	13	13	13	104
Japan	195	195	195	195	195	195	195	195	1560
Republic of Korea	26	26	26	26	26	26	26	26	208
Luxembourg	2	2	2	2	2	2	2	2	16
Mexico	5	5	5	5	5	5	5	5	40
Malaysia	5	5	5	5	5	5	5	5	40
Netherlands	19	19	19	19	19	19	19	19	152
Norway	12	12	12	12	12	12	12	12	96
New Zealand	3	3	3	3	3	3	3	3	24
Philippines	4	4	4	4	4	4	4	4	32
Poland	6	6	6	6	6	6	6	6	48
Portugal	5	5	5	5	5	5	5	5	40
Russian Federation	4	4	4	4	4	4	4	4	32
Saudi Arabia	1	1	1	1	1	1	1	1	8
Sweden	28	28	28	28	28	28	28	28	224
Singapore	12	12	12	12	12	12	12	12	96
Thailand	8	8	8	8	8	8	8	8	64
Turkey	5	5	5	5	5	5	5	5	40
Taiwan	29	29	29	29	29	29	29	29	232
United States	179	179	179	179	179	179	179	179	1432
South Africa	42	42	42	42	42	42	42	42	336
Total	1,101	1,101	1,101	1,101	1,101	1,101	1,101	1,101	8,808

3.2 Variables

3.2.1 Dependent variables

In this research, firm value will be used as the dependent variable and is measured as the market value of common equity, which is calculated as the share price multiplied by the number of ordinary shares in issue (Matsumura et al., 2014; Choi & Luo, 2020). However, after plotting the histogram (Figure A1) of the market value of common equity, it became clear that normality cannot be assumed.

Therefore, the natural logarithm of market value is included. As can be seen in Figure A2, normality can be assumed.

Most of the research on carbon emissions and firm value/firm performance use either accounting variables or market variables as dependent variables (Misani & Pogutz, 2015; Gallego-Álvarez et al., 2015; Fujii et al., 2013; Lee et al., 2015; Rokhmawati et al., 2015; Matsumura et al., 2014; Choi & Luo, 2020). Therefore, Tobin's Q and ROA will be used as robustness checks for firm value. Tobin's Q is calculated by the market value of equity plus the book value of liabilities divided by the book value of assets (Lee et al., 2015). It measures the market response to firm's decisions, while ROA, which is calculated as EBIT divided by total assets times 100, captures the internal performance of the firm on the balance sheet (Misani & Pogutz, 2015; Gallego-Álvarez et al., 2015; Fujii et al., 2013; Rokhmawati et al., 2015).

3.2.2 Independent variables

The first independent variable is carbon intensity, because it is more common in previous research to use a scaled variable to measure carbon emissions, instead of total carbon emissions (Misani & Pogutz, 2015; Ganda & Milondzo, 2018; Busch & Hoffmann, 2011; Rokhmawati et al., 2015; Lee et al., 2015; Fujii et al., 2013; Choi & Luo, 2020). Carbon intensity is calculated as total carbon emissions divided by sales (Misani & Pogutz, 2015; Ganda & Milondzo, 2018; Busch & Hoffmann, 2011; Rokhmawati et al., 2015). However, after checking the histogram (Figure A3) it became clear that carbon intensity is not normally distributed. Therefore, the natural logarithm of carbon intensity is included. As can be seen in Figure A4, normality can be assumed.

Total carbon emissions includes Scope 1 (direct) and Scope 2 (indirect) emissions. Scope 1 emissions are direct emissions from sources that are owned or controlled by the company, while Scope 2 emissions are indirect emissions resulting from consumption or purchased electricity, heat or steam which occur at the facility where heat, electricity or steam is generated. Previous studies also focused on both scopes (e.g., Busch & Hoffmann, 2011; Misani & Pogutz, 2015).[2] Scope 3 includes emissions from contractor-owned vehicles, employee business travel (by rail or air), waste disposal, and outsourced activities. However, Scope 3 emissions are excluded because there is little data available.

To examine the moderating role of culture on the relationship between carbon emissions and firm value, culture will be included as the second independent variable. Table A1 in the Appendix provides the scores of the cultural dimensions per country. The six cultural dimensions represent an index ranging from 1 to 100. Then, interaction terms will be constructed to measure the moderating effect of the cultural dimensions separately. To create the interaction terms, the cultural dimensions and carbon intensity variables are centered. Positive coefficients are expected for all interaction terms

[2] Some studies (Misani & Pogutz, 2015; Ganda & Milondzo, 2018; Matsumura et al., 2014) measured the effect of the scopes on firm value separately, so the intention was to include it as a robustness check. However, this reduced the sample size so it was excluded.

except the uncertainty avoidance index because this means that the negative effect of carbon emissions on firm value is weaker for firms operating in high power distance countries, individualistic countries, masculine countries, long-term oriented countries, and indulgent countries. A negative coefficient is expected for the uncertainty avoidance interaction term, which means that the negative effect of carbon emissions on firm value is stronger for firms operating in countries scoring high on the uncertainty avoidance index.

3.2.3 Control variables

Several control variables are included in the models. These are firm size, leverage, capital intensity, and growth rate. They are retrieved from Thomson Reuters Datastream sub-database Worldscope. The first control variable is firm size, which is measured as the natural logarithm of the total assets of the firm (see Figures A5 and A6 for the distribution of firm size). Previous research has shown that firm size influences firm responses to environmental issues (Misani & Pogutz, 2015; Busch & Hoffmann, 2011; Rokhmawati et al., 2015). Large firms' legitimacy and reputation are influenced by media attention. Therefore, large firms demonstrate more socially responsible behavior than small firms (Busch & Hoffmann, 2011). Thus, a positive coefficient is predicted.

Another control variable is leverage, which can be seen as a proxy for firm risk because it measures the extent to which the assets of a firm are financed by debt (Rokhmawati et al., 2015). It is calculated as total debts divided by total assets (Misani & Pogutz, 2015; Busch & Hoffmann, 2011; Rokhmawati et al., 2015). Higher firm risk could negatively influence the market value of the firm (Rokhmawati et al., 2015; Busch & Hoffmann, 2011). Therefore, a negative coefficient is predicted.

Capital intensity is also controlled for. It is the amount of money invested to receive one dollar of output (Rokhmawati et al., 2015; Ganda & Milondzo, 2018), and it is calculated as total assets divided by sales (Russo & Fouts, 1997). Since both Rokhmawati et al. (2015) and Ganda and Milondzo (2018) found negative coefficients, a negative coefficient is predicted here as well.

Following previous research, growth rate is also included as a control variable, which is calculated as the firm's annual change in sales (Gallego-Álvarez et al., 2015). Firms with high growth potential are likely to generate high cash flows in the future (Purwohandoko, 2017). This could positively affect firm value and therefore, a positive coefficient is predicted.[3]

Finally, there is controlled for industry-level characteristics and year characteristics, to prevent biased results due to these factors (e.g., Busch & Hoffmann, 2011). Detailed variable definitions are provided in Table 4.

[3] Additionally, Misani & Pogutz (2015) state that R&D intensity could influence the relation between environmental performance and financial performance, the intention was therefore to add R&D intensity as a control variable. However, little data was available, so R&D intensity was excluded.

Table 4

Definitions of variables

Variable	Definition	Source
Dependent variable		
Market value$_{i,t}$	The natural logarithm of the share price multiplied by the number of ordinary shares in issue for firm i at time t (market value is displayed in millions of units of USD). Additionally, Tobin's Q, which is calculated as the market value of equity plus the market value of liabilities, divided by the book value of equity plus the book value of liabilities for firm i at time t, is used as a robustness check. Furthermore, ROA, which is measured as (net income – bottom line + ((interest expense on debt-interest capitalized) * (1-tax rate))) / average of last year's and current year's total assets * 100 for firm i at time t, is also used as a robustness check.	Datastream, Worldscope
Independent variables		
CO2 intensity$_{i,t}$	The natural logarithm of total carbon emissions divided by total sales in US dollars.	ASSET4
Power distance index$_i$	An index ranging from 1-100, representing the propensity with which the less powerful members of societies view power inequality as legitimate.	Hofstede Insights
Uncertainty avoidance index$_i$	An index ranging from 1-100, representing the extent to which members of a society feel uncomfortable about ambiguity and uncertainty.	Hofstede Insights
Individualism$_i$	An index ranging from 1-100, representing the extent to which members of societies care for themselves and their close relatives.	Hofstede Insights
Masculinity$_i$	An index ranging from 1-100, representing the degree to which members of a society will be driven by competition, achievement, and success.	Hofstede Insights
Long-term orientation$_i$	An index ranging from 1-100, representing the extent to which members of a society focus on the future consequences certain actions have.	Hofstede Insights
Indulgence$_i$	An index ranging from 1-100, representing the extent to which members of a society value the satisfaction of desires and human needs instead of controlling their desires.	Hofstede Insights
Control variables		
Leverage$_{i,t}$	Total debt divided by total assets, * 100 for firm i at time t.	Worldscope
Firm size$_{i,t}$	The natural logarithm of the firm's i total assets at time t.	Worldscope
Capital intensity$_{i,t}$	Total assets divided by total revenues for firm i at time t.	Worldscope
Growth rate$_{i,t}$	The current year's net sales or revenues divided by last year's total net sales or revenues - 1, *100 for firm i at time t.	Worldscope
Industry controls	Industry controls are added by using a dummy variable (i.industry), to prevent that the industry of the firm will bias the results.	
Year controls	Year controls are added by using a dummy variable (i.year), to prevent that a specific year of the sample period will bias the results.	

3.3 Methodology

This research strives to measure the moderating effect of culture on the relationship between carbon emissions and firm value. Therefore, panel data regression analyses will be performed to test the different hypotheses. Panel data regression analysis is the most suitable method for this topic because it allows us to analyse different entities over a longer period. Furthermore, panel data analysis has a large benefit because it often can avoid omitted variable problems which would cause bias in cross-sectional research (Studenmund, 2017).

However, a distinction has to be made because there are two types of panel data regression models: fixed-effects and random-effects models. To decide which model should be used, a Hausman test, which is a test for model misspecification, can be performed (Hausman, 1978). H0 is that the random-effects model should be used, and Ha is that the fixed-effects model should be used. If the p-value is less than 0.05, H0 must be rejected, and the fixed-effects model should be used. Likewise, if the p-value is above 0.05, the random-effects model should be used. In this way, the most suitable model can be chosen. Tables A2-A8 provide the outcomes of the Hausman tests.[4] All p-values are less than 0.05, except for H2c (0.145). Thus, a random-effects model should be used for H2c, and for the other hypotheses fixed-effects models should be used.

However, explanatory variables that do not vary over time within each entity, but vary across entities such as the cultural dimensions used in this research, cannot be used with the fixed-effects model because they would create perfect multicollinearity (Studenmund, 2017). Therefore, a choice must be made between the random-effects model or the pooled OLS regression model. The Breusch-Pagan Lagrange Multiplier test (Breusch & Pagan, 1980) is used to decide which model best fits the data. H0 is that variances across entities are zero and that the pooled OLS regression model should be used. If the p-value is less than 0.05, H0 must be rejected, and the random-effects model should be used. As can be seen in Tables A9-A15 in the Appendix, all p-values for the 7 regressions are less than 0.05. Therefore, random-effects models will be used.[5]

To examine how the different cultural dimensions influence the relationship between carbon emissions and firm value, equation (1) is estimated,

$$\begin{aligned} Firm\ value_{it} = {} & \beta_0 + \beta_1 CO2\ emissions_{it} + \beta_2 Culture_{it} + \beta_3 Culture * CO2\ emissions_{it} + \\ & \beta_4 Leverage_{it} + \beta_5 Firm\ size_{it} + \beta_6 Capital\ intensity_{it} + \beta_7 Growth\ rate_{it} + \\ & Industry\ Controls + Year\ Controls + \varepsilon_{it} \end{aligned} \tag{1}$$

Where *Firm value* is the natural logarithm of the market value of common equity, *LNMV*, Tobin's Q, *TOBINQ*, or return on assets, *ROA*. *Culture* consists of the six cultural dimensions *Power distance*

[4] The Hausman test has also been used for the baseline regression and the robustness checks, but they are not included in the Appendix for parsimony.

[5] The Breusch-Pagan Lagrange Multiplier test has also been used for the baseline regression and the robustness checks, but they are not included in the Appendix for parsimony.

index, *Individualism*, *Masculinity*, *Uncertainty avoidance index*, *Long-term orientation*, and *Indulgence*. *CO2 emissions* is the natural logarithm of CO2 intensity, *LNCO2INT*, and *i* and *t* denote firm and year.

4. Results

4.1 Testing of underlying assumptions

Before the hypotheses can be tested, several tests must be performed to check the assumptions underlying the regressions, because correlation, multicollinearity, autocorrelation, and heteroskedasticity violate these assumptions.

4.1.1 Correlation matrix

First, the correlation between the different variables used in the regressions is analysed. A correlation higher than 0.5 or lower than -0.5 can be considered moderate (Moore, Notz & Flinger, 2013). Table 5 provides the Pearson correlation matrix. The correlation between the natural logarithm of firm size and the natural logarithm of market value is positive and significant (0.764; $p < 0.05$). This indicates that if the firm size is higher, market value is also higher, which is quite logical because large firms usually have more assets. Furthermore, various cultural dimensions, such as individuality, long-term orientation, and indulgence are relatively highly correlated with each other. However, this is not a problem because they are not used in the same regression. Additionally, the correlation between return on assets and Tobin's Q is also positive and significant (0.650; $p < 0.05$), but as they are also used in different regressions, this is also not a problem.

Table 5

Pearson correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Natural logarithm of market value	1.000													
(2) Tobin's Q	0.252*	1.000												
(3) Return on assets	0.217*	**0.650***	1.000											
(4) Natural logarithm of firm size	**0.764***	-0.232*	-0.198*	1.000										
(5) Growth rate	-0.001	0.099*	0.229*	-0.065*	1.000									
(6) Capital intensity	0.118*	-0.230*	-0.190*	0.461*	-0.055*	1.000								
(7) Leverage	-0.037*	-0.024*	-0.096*	0.027*	-0.040*	-0.007	1.000							
(8) Natural logarithm of CO2 intensity	-0.148*	-0.140*	-0.058*	-0.207*	-0.018	-0.276*	0.253*	1.000						
(9) Power distance index	0.008	-0.119*	-0.043*	0.067*	0.054*	-0.022*	0.021	0.086*	1.000					
(10) Individuality	0.107*	0.179*	0.087*	0.001	-0.030*	0.037*	0.044*	-0.063*	**-0.684***	1.000				
(11) Masculinity	-0.024*	-0.112*	-0.092*	0.007	-0.011	-0.049*	-0.064*	0.048*	0.106*	-0.088*	1.000			
(12) Uncertainty avoidance index	-0.020	-0.233*	-0.193*	0.116*	-0.023*	-0.060*	-0.018	-0.030*	0.514*	**-0.554***	0.406*	1.000		
(13) Long-term orientation	-0.105*	-0.218*	-0.137*	0.009	-0.033*	-0.052*	-0.092*	-0.058*	0.330*	**-0.627***	0.356*	**0.616***	1.000	
(14) Indulgence	0.001	0.221*	0.133*	-0.117*	-0.001	0.016	0.050*	-0.054*	**-0.626***	**0.704***	-0.266*	**-0.634***	**-0.673***	1.000

*Note: * indicates significance at 5% level. A moderate association (or stronger) between variables (larger than 0.5 or smaller than -0.5) has been bolded.*

4.1.2 Multicollinearity

Multicollinearity emerges when 2 or more independent variables are imperfectly linearly related (Studenmund, 2017). Although there is no indication of multicollinearity according to the correlation between the independent variables, the Variance inflation factor (VIF) is still used to detect possible multicollinearity. However, as can be seen in Table A16 in the Appendix, all VIFs are below 5, which indicates there is no evidence for multicollinearity (Studenmund, 2017).

4.1.3 Heteroskedasticity

Heteroskedasticity violates the assumption that the observations of the error term are drawn from a distribution that has a constant variance (Studenmund, 2017). In addition to choosing between a random-effects model or pooled OLS regression model, the Breusch-Pagan test can also be used as a test for heteroskedasticity and will be used here as well. H0 indicates that there is homoskedasticity, which means there is constant variance, and Ha indicates heteroskedasticity. As can be seen in Tables A9-A15 in the Appendix, the p-values are below 0.05, so H0 can be rejected. This means there has to be controlled for heteroskedasticity. Heteroskedasticity-corrected standard errors are a powerful remedy (Studenmund, 2017), which are also known as robust standard errors. The analysis will thus use robust standard errors.

4.1.4 Autocorrelation

The last test that is performed is the Wooldridge test for autocorrelation. H0 is that there is no autocorrelation. When there is autocorrelation, the observations of the error term are correlated and the errors of the model follow a pattern (Studenmund, 2017). As can be seen in Tables A17-A23 in the Appendix, all p-values are below 0.05, so H0 can be rejected.[6] This implies that there has to be controlled for autocorrelation. Since the models suffer from both heteroskedasticity and autocorrelation, robust standard errors can be created through clustering by firm (Hoechle, 2007).

4.2 Descriptive statistics

Table 6 provides the summary statistics for the variables used in the regression analyses. The mean of the market value is 20.62 billion USD. CO2 intensity has a mean of 0.6. Regarding the cultural dimensions, the sample firms are, on average, relatively more individualistic than collectivistic, masculine than feminine, long-term oriented than short-term oriented, indulgent, and prefer avoiding uncertainty. The power distance dimension has a mean of 47, indicating that the sample firms are headquartered in countries where, on average, the less powerful members of the society expect and accept less that power is distributed unequally. Looking at the minimum and maximum values of the variables, some extreme values may be influential cases. As a check, Cook's distance values are calculated for all observations. Cases are considered influential when Cook's distance is larger than 4

[6] The Wooldridge test for autocorrelation has also been used for the baseline regression and the robustness checks, but the results are not reported for parsimony.

divided by 8808 observations (Cook, 1977). This results in a critical value of approximately 0.00045413, and 448 influential cases which are approximately 5% of the total observations. Therefore, all continuous variables are winsorized at the 1st and 99th percentiles. As can be seen in Table 7, the values of the winsorized variables have a lower minimum and maximum.

Table 6

Summary statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Market value	8808	20615.37	40556.7	5.52	869000
Tobin's Q	8808	1.581	.984	.282	12.766
Return on assets	8808	5.474	6.934	-68.21	97.06
CO2 intensity	8808	.6	5.667	0	231.121
Power distance index	8808	47.062	14.285	11	100
Individuality	8808	66.009	23.114	13	91
Masculinity	8808	61.053	21.823	5	95
Uncertainty avoidance index	8808	60.237	22.879	8	100
Long-term orientation	8808	55.089	24.65	13	100
Indulgence	8808	56.333	14.743	17	97
Firm size	8808	67100000	223000000	183000	2880000000
Growth rate	8808	5.799	15.798	-87.13	295.56
Leverage	8808	25.556	15.914	0	116.54
Capital intensity	8808	4.059	11.248	.206	394.756

Note: Market value is in millions.

Table 7

Summary statistics after winsorizing at the 1st and 99th percentiles

Variable	Obs	Mean	Std.Dev.	Min	Max
Market value	8808	19730.3	33114.04	247.55	233000
Tobin's Q	8808	1.566	.886	.59	6.212
Return on assets	8808	5.496	6.039	-22.45	28.59
CO2 intensity	8808	.398	.985	.001	6.906
Power distance index	8808	47.062	14.285	11	100
Individuality	8808	66.009	23.114	13	91
Masculinity	8808	61.053	21.823	5	95
Uncertainty avoidance index	8808	60.237	22.879	8	100
Long-term orientation	8808	55.089	24.65	13	100
Indulgence	8808	56.333	14.743	17	97
Firm size	8808	58200000	150000000	527000	1090000000
Growth rate	8808	5.524	12.629	-37.27	73.33
Leverage	8808	25.435	15.488	0	72.76
Capital intensity	8808	3.753	6.506	.335	39.539

Note: Market value is in millions.

4.3 Test of hypotheses

This section provides the results of the regression analyses. Table 8 provides the results of the models with market value as the dependent variable. Overall, the R-squared of the different models is approximately 0.71, which is quite high. This means that the estimated regression equations fit the sample data quite well (Studenmund, 2017).

Model 1 is used to test H1, which predicts the effect of carbon emissions on firm value. As can be seen in Table 8, CO2 intensity is highly significant with a p-value smaller than 0.001 and it has a negative coefficient as predicted. This means that if CO2 intensity increases with 1, market value will decrease with -0.0712. Therefore, the results provide support for H1, indicating that carbon emissions have a negative effect on firm value. Furthermore, as predicted, firm size has a positive significant coefficient (0.783), which means that if the firm size rises with 1, the market value will rise with 0.783. Leverage also has a significant but negative coefficient (-0.0138), which was also predicted. This means that higher leverage has a negative influence on the market value of the firm. Capital intensity also has a significant negative effect (-0.0254). Lastly, growth rate has an insignificant coefficient, so there is no indication that it influences market value.

Before the moderating effects of culture are explored, a baseline regression with all cultural dimensions as control variables has been performed. Model 2 provides the results of this regression. The initial relationship between carbon emissions and firm value does not change with the cultural dimensions as control variables. *CO2INT* still has a negative significant coefficient (-0.0753) and the control variables also have the same signs as in model 1. *PDI* has a positive significant coefficient (0.00537), which indicates that being headquartered in countries scoring high on the power distance index dimension increases firm value, although the effect is very small economically. *UAI* and *LTO* have negative significant coefficients, which indicates that being headquartered in countries scoring high on the uncertainty avoidance index and the long-term versus short-term orientation dimension lowers firm value. However, *MAS*, *IDV,* and *IVR* do not influence firm value because they are not significant.

Hypothesis 2a predicted a weaker negative relationship between carbon emissions and firm value in high power distance countries, so a positive coefficient for the interaction term *PDI*CO2INT* is expected. Model 3 provides the results of this regression. As can be seen in Table 8, the interaction term *PDI*CO2INT* is positive but insignificant. Therefore, H2a is not supported. However, *PDI* has a significant negative coefficient (-0.00518), which indicates that the higher the power distance index is where the firm is headquartered, the lower the market value of the firm is. Furthermore, carbon emissions still have a significant negative effect on market value (-0.0709).

Hypothesis 2b predicted a stronger negative relationship between carbon emissions and firm value in high uncertainty avoidance countries. Model 4 provides the results of the regression. The interaction term *UAI*CO2INT* is positive and significant (0.000977). Although its magnitude is very small, evidence for a weaker negative relationship between carbon emissions and firm value in high uncertainty avoidance countries instead of a stronger negative relationship is found. Therefore, H2b is also not supported. *UAI* has a significant negative coefficient (-0.00845), which indicates that firms headquartered in high uncertainty avoidance countries have a lower market value. Again, the initial relationship between carbon emissions and firm value is negative.

Hypothesis 2c predicted a weaker negative relationship between carbon emissions and firm value in individualistic countries. Model 5 provides the results of this regression. The interaction term *IDV*CO2INT* has a negative but insignificant coefficient (-0.000522). Therefore, H2c is also not supported. Again, CO2 intensity has a significant negative coefficient (-0.0699). *IDV* has a positive and significant coefficient (0.00690), indicating that the more individualistic the country is where the firm is headquartered, the higher the market value of the firm is.

Hypothesis 2d predicted a weaker negative relationship between carbon emissions and firm value in masculine countries. Model 6 provides the results of the regression. The interaction term *MAS*CO2INT* is positive and significant (0.000998), indicating that it positively affects the relationship between carbon emissions and firm value. Therefore, H2d is supported, although its magnitude and thus its effect are very small economically. However, *MAS* has a significant negative coefficient (-0.00328). This indicates that the more masculine the country where a firm is headquartered is, the lower the market value of the firm will be. *CO2INT* again has a negative and significant coefficient (-0.0662).

Hypothesis 2e predicted a weaker negative relationship between carbon emissions and firm value in long-term oriented countries. Model 7 provides the results of the corresponding regression. The interaction term *LTO*CO2INT* has a positive and significant coefficient (0.00162). This indicates that the negative relationship between carbon emissions and firm value is weaker for firms headquartered in long-term oriented countries. Therefore, H2e is supported. However, *LTO* has a significant negative coefficient (-0.00882). Thus, this indicates that long-term orientation has a negative effect on firm value. Also in this model, *CO2INT* has a negative effect on firm value.

Hypothesis 2f predicted a weaker negative relationship between carbon emissions and firm value in indulgent countries. Model 8 provides the results of the regression. The interaction term *IVR*CO2INT* has a negative but insignificant coefficient (-0.00120). Therefore, there is no support for H2e. *IVR* has a significant positive coefficient (0.0115), indicating that being headquartered in indulgent counties has a positive effect on firm value. Additionally, the initial relationship between carbon emissions and firm value is still negative.

Lastly, the control variables *SIZE, LEV,* and *CAPINT* are in models 1-8 significant and have the predicted coefficients, which are positive, negative, and negative respectively. Growth rate has a positive but insignificant coefficient in all models.

Table 8

Market value, carbon intensity, and the moderating role of culture

	(1) Ln (MV)	(2) Ln (MV)	(3) Ln (MV)	(4) Ln (MV)	(5) Ln (MV)	(6) Ln (MV)	(7) Ln (MV)	(8) Ln (MV)
Ln (CO2INT)	-0.0712^{***}	-0.0753^{***}	-0.0709^{***}	-0.0706^{***}	-0.0699^{***}	-0.0662^{***}	-0.0742^{***}	-0.0698^{***}
	(0.0115)	(0.0113)	(0.0116)	(0.0111)	(0.0114)	(0.0115)	(0.0112)	(0.0115)
Ln (SIZE)	0.783^{***}	0.798^{***}	0.787^{***}	0.800^{***}	0.785^{***}	0.787^{***}	0.793^{***}	0.796^{***}
	(0.0223)	(0.0218)	(0.0222)	(0.0217)	(0.0218)	(0.0221)	(0.0215)	(0.0220)
LEV	-0.0138^{***}	-0.0139^{***}	-0.0138^{***}	-0.0137^{***}	-0.0138^{***}	-0.0138^{***}	-0.0140^{***}	-0.0139^{***}
	(0.00117)	(0.00115)	(0.00116)	(0.00115)	(0.00116)	(0.00117)	(0.00115)	(0.00116)
GROWTH	0.000538	0.000472	0.000550	0.000481	0.000563	0.000532	0.000496	0.000525
	(0.000385)	(0.000384)	(0.000385)	(0.000384)	(0.000384)	(0.000384)	(0.000382)	(0.000385)
CAPINT	-0.0254^{***}	-0.0261^{***}	-0.0258^{***}	-0.0266^{***}	-0.0257^{***}	-0.0258^{***}	-0.0247^{***}	-0.0256^{***}
	(0.00496)	(0.00493)	(0.00494)	(0.00493)	(0.00490)	(0.00497)	(0.00483)	(0.00491)
PDI		0.00537^{**}	-0.00518^{***}					
		(0.00203)	(0.00150)					
UAI		-0.00543^{***}		-0.00845^{***}				
		(0.00122)		(0.000814)				
IDV		0.00211			0.00690^{***}			
		(0.00151)			(0.000860)			
MAS		0.000779				-0.00328^{***}		
		(0.000996)				(0.000855)		
LTO		-0.00498^{***}					-0.00882^{***}	
		(0.00135)					(0.000747)	
IVR		0.00146						0.0115^{***}
		(0.00225)						(0.00140)
PDI*CO2INT			0.000671					
			(0.000568)					
UAI*CO2INT				0.000977^{*}				
				(0.000433)				
IDV*CO2INT					-0.000522			
					(0.000489)			
MAS*CO2INT						0.000998^{*}		
						(0.000444)		
LTO*CO2INT							0.00162^{***}	
							(0.000451)	
IVR*CO2INT								-0.00120
								(0.000653)
_Constant	-3.494^{***}	-3.640^{***}	-3.301^{***}	-3.238^{***}	-3.972^{***}	-3.336^{***}	-3.147^{***}	-4.341^{***}
	(0.357)	(0.443)	(0.353)	(0.345)	(0.355)	(0.356)	(0.343)	(0.382)
Observations	8808	8808	8808	8808	8808	8808	8808	8808
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Overall) R-squared	0.7111	0.7432	0.7157	0.7346	0.7259	0.7139	0.7371	0.7295

Robust standard errors are in parentheses. Note: MV = Market value, CO2INT = CO2 intensity, SIZE = Firm size, LEV = Leverage, GROWTH = Growth rate, CAPINT = Capital intensity, PDI = Power distance index, UAI = Uncertainty avoidance index, IDV = Individuality, MAS = Masculinity, LTO = Long-term orientation, and IVR = Indulgence. All continuous variables are winsorized at the 1st and 99th percentiles. * *$p < 0.05$,* ** *$p < 0.01$,* *** *$p < 0.001$.*

4.4 Robustness checks

As mentioned in Chapter 3, ROA and Tobin's Q are used instead of market value as robustness checks. Additionally, the independent variables will be lagged 1 year behind the dependent variable market value of common equity as a robustness check to increase confidence in the direction of the relationship (Delmas et al., 2015; Misani & Pogutz, 2015).

Table 9 provides the models with ROA as the dependent variable. In general, *CO2INT* has a significant negative effect on ROA in all models. Notably, *CO2INT* has a larger magnitude with ROA as the dependent variable than with market value as the dependent variable in all models. Furthermore, the overall fit of the estimated models has decreased drastically, with R-squared ranging from 0.1219 to 0.1588.

Model 1 is used to measure the effect of carbon emissions on firm value. *CO2INT* has a significant negative coefficient (-0.504), indicating that carbon emissions negatively influence ROA. Therefore, H1 is supported. Furthermore, *LEV* and *CAPINT* have significant and negative coefficients (-0.128 and -0.0810), which corresponds with the predictions. Additionally, the growth rate is now also significant and positive (0.0728), which was also predicted. However, in contrast to the models with market value as the dependent variable, firm size has a significant negative coefficient in all the models with *ROA* as the dependent variable, which indicates that the larger the firm is, the lower the ROA of the firm is.

Model 2 provides the results of the effect of carbon emissions on ROA with the cultural dimensions as controls. As with the market value of common equity as measure of firm value, the initial relationship between carbon emissions and firm value does not change. Furthermore, *PDI*, *UAI*, and *LTO* are again significant and have the same signs as in model 2 of Table 8.

Models 3-8 provide the results regarding the moderating role of culture. Notably, the interaction terms *PDI*CO2INT*, *UAI*CO2INT*, *IDV*CO2INT*, *LTO*CO2INT,* and *IVR*CO2INT* are significant with ROA as the dependent variable. The power distance index interaction term *PDI*CO2INT* has a significant positive coefficient (0.0122). This indicates that the negative relationship between carbon emissions and firm value is weakened for firms headquartered in high power distance countries. Therefore, H2a is supported.

The uncertainty avoidance interaction term *UAI*CO2INT* also has a significant positive coefficient (0.00719), which indicates that the negative relationship between carbon emissions and firm value is weakened by higher uncertainty avoidance. Thus, firms that are headquartered in countries with high uncertainty avoidance, experience a less negative effect of carbon emissions on firm value. However, this is not in line with H2b, which predicted that the negative effect of carbon emissions on firm value is stronger for firms in high uncertainty avoidance countries than for firms in low uncertainty avoidance countries.

*IDV*CO2INT* has a significant negative coefficient (-0.0108). This indicates that the negative relationship between carbon emissions and firm value is strengthened for firms headquartered in individualistic countries. However, this is also not in line with H2c, which predicted that the negative effect of carbon emissions on firm value is weaker for firms headquartered in individualistic countries than for firms headquartered in collectivistic countries.

The long-term orientation interaction term *LTO*CO2INT* has a significant positive coefficient (0.00981). This indicates that firms headquartered in long-term oriented countries experience a smaller negative effect of carbon emissions on firm value, although its magnitude is very small. Therefore, H2e is supported.

*IVR*CO2INT* has a significant negative coefficient (-0.0161), which indicates that the negative relationship between carbon emissions and firm value is strengthened for firms headquartered in indulgent countries. However, this is also not in line with H2f, which predicted that the negative effect of carbon emissions on firm value is weaker for firms headquartered in countries representing indulgent societies than for firms headquartered in countries representing restrained societies.

Lastly, the cultural dimensions *IDV* (0.0293), *MAS* (-0.0301), *UAI* (-0.0494), *LTO* (-0.0457) and *IVR* (0.0608) have significant coefficients. This indicates that the more individualistic and indulgent the country where a firm is headquartered is, the higher the ROA of the firm is. Furthermore, the results indicate that the more masculine, uncertainty avoidant, and long-term oriented the country where a firm is headquartered is, the lower the ROA of the firm is.

Table 9

ROA, carbon intensity, and the moderating role of culture

	(1) ROA	(2) ROA	(3) ROA	(4) ROA	(5) ROA	(6) ROA	(7) ROA	(8) ROA
Ln (CO2INT)	-0.504^{***}	-0.546^{***}	-0.510^{***}	-0.501^{***}	-0.497^{***}	-0.470^{***}	-0.528^{***}	-0.489^{***}
	(0.0828)	(0.0840)	(0.0849)	(0.0798)	(0.0843)	(0.0815)	(0.0811)	(0.0825)
Ln (SIZE)	-0.396^{**}	-0.279^{*}	-0.381^{**}	-0.275^{*}	-0.401^{**}	-0.357^{**}	-0.341^{**}	-0.315^{*}
	(0.129)	(0.125)	(0.129)	(0.125)	(0.128)	(0.128)	(0.127)	(0.128)
LEV	-0.128^{***}	-0.128^{***}	-0.128^{***}	-0.126^{***}	-0.129^{***}	-0.130^{***}	-0.131^{***}	-0.129^{***}
	(0.0108)	(0.0105)	(0.0107)	(0.0105)	(0.0106)	(0.0107)	(0.0106)	(0.0106)
GROWTH	0.0728^{***}	0.0720^{***}	0.0730^{***}	0.0725^{***}	0.0733^{***}	0.0727^{***}	0.0725^{***}	0.0729^{***}
	(0.00541)	(0.00541)	(0.00541)	(0.00542)	(0.00542)	(0.00541)	(0.00541)	(0.00541)
CAPINT	-0.0810^{*}	-0.0852^{*}	-0.0852^{*}	-0.0904^{*}	-0.0819^{*}	-0.0841^{*}	-0.0685	-0.0773^{*}
	(0.0384)	(0.0380)	(0.0383)	(0.0381)	(0.0383)	(0.0382)	(0.0385)	(0.0383)
PDI		0.0394^{**}	-0.0176					
		(0.0152)	(0.0108)					
UAI		-0.0398^{***}		-0.0494^{***}				
		(0.00842)		(0.00540)				
IDV		-0.00110			0.0293^{***}			
		(0.00976)			(0.00588)			
MAS		-0.00629				-0.0301^{***}		
		(0.00691)				(0.00597)		
LTO		-0.0217^{*}					-0.0457^{***}	
		(0.00924)					(0.00502)	
IVR		0.0157						0.0608^{***}
		(0.0155)						(0.00913)
PDI*CO2INT			0.0122^{**}					
			(0.00416)					
UAI*CO2INT				0.00791^{**}				
				(0.00266)				
IDV*CO2INT					-0.0108^{***}			
					(0.00297)			
MAS*CO2INT						0.00588		
						(0.00309)		
LTO*CO2INT							0.00981^{***}	
							(0.00248)	
IVR*CO2INT								-0.0161^{***}
								(0.00393)
_Constant	14.35^{***}	13.76^{***}	14.92^{***}	15.45^{***}	12.52^{***}	15.72^{***}	16.06^{***}	9.688^{***}
	(2.076)	(2.672)	(2.077)	(2.045)	(2.091)	(2.113)	(2.072)	(2.142)
Observations	8808	8808	8808	8808	8808	8808	8808	8808
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Overall) R-squared	0.1219	0.1668	0.1296	0.1588	0.1384	0.1331	0.1545	0.1468

Robust standard errors are in parentheses. Note: ROA = Return on assets, CO2INT = CO2 intensity, SIZE = Firm size, LEV = Leverage, GROWTH = Growth rate, CAPINT = Capital intensity, PDI = Power distance index, UAI = Uncertainty avoidance index, IDV = Individuality, MAS = Masculinity, LTO = Long-term orientation, and IVR = Indulgence. All continuous variables are winsorized at the 1st and 99th percentiles. * *$p < 0.05$,* ** *$p < 0.01$,* *** *$p < 0.001$.*

Table 10 provides the models with *TOBINQ* as the dependent variable. Notably, *CO2INT* again has a significant negative effect on firm value, but the magnitude (-0.103) is smaller than with *ROA* as the measure of firm value but higher than with the market value of common equity as the measure of firm value. Furthermore, the overall fit of the estimated models has decreased a lot, with R-squared ranging from 0.1382 to 0.2148.

Notably, after adding the cultural dimensions as control variables to model 1, only *UAI* (-0.00548) and *LTO* (-0.00463) are significant. So, being headquartered in high uncertainty avoidance and long-term oriented countries negatively influences Tobin's Q. This is in contrast to the models with *MV* and *ROA* as dependent variables, where *PDI* was also significant.

Regarding H2a-H2e, none of the interaction terms except *LTO*CO2INT* is significant at the 5% significance level. This indicates that only the long-term orientation cultural dimension plays a moderating role in the relationship between carbon emissions and firm value. *LTO*CO2INT* has a positive coefficient (0.00116), which indicates that the negative effect of carbon emissions on firm value is weaker for firms headquartered in long-term oriented countries, although the effect is very small. Therefore, H2e is supported, but H2a-H2d and H2f are not supported.

However, although the coefficients are very small, all cultural dimensions have a significant effect on firm value. *IDV* (0.00734) and *IVR* (0.0120) have positive coefficients, which indicates that being headquartered in an individualistic or indulgent country has a positive effect on firm value. Opposite, *PDI* (-0.00617), *MAS* (-0.00444), *UAI* (-0.00907) and *LTO* (-0.00901) have a negative coefficient, which indicates that being headquartered in a masculine, uncertainty avoidant, long-term oriented country and a country scoring high on the power distance index, lowers firm value.

All control variables are significant, and *LEV, CAPINT,* and *GROWTH* have the predicted signs in all models. However, *SIZE* has a negative coefficient in all models, which is not as predicted. This indicates that firm size negatively influences firm value when it is measured as Tobin's Q.

Table 10

Tobin's Q, carbon intensity, and the moderating role of culture

	(1) TOBINQ	(2) TOBINQ	(3) TOBINQ	(4) TOBINQ	(5) TOBINQ	(6) TOBINQ	(7) TOBINQ	(8) TOBINQ
Ln (CO2INT)	-0.103^{***}	-0.107^{***}	-0.102^{***}	-0.104^{***}	-0.102^{***}	-0.101^{***}	-0.107^{***}	-0.102^{***}
	(0.0131)	(0.0131)	(0.0134)	(0.0126)	(0.0132)	(0.0130)	(0.0126)	(0.0131)
Ln (SIZE)	-0.172^{***}	-0.157^{***}	-0.168^{***}	-0.154^{***}	-0.170^{***}	-0.168^{***}	-0.162^{***}	-0.158^{***}
	(0.0279)	(0.0269)	(0.0277)	(0.0269)	(0.0272)	(0.0276)	(0.0267)	(0.0273)
LEV	-0.00337^{*}	-0.00351^{*}	-0.00337^{*}	-0.00337^{*}	-0.00344^{*}	-0.00344^{*}	-0.00360^{*}	-0.00350^{*}
	(0.00143)	(0.00141)	(0.00142)	(0.00142)	(0.00141)	(0.00143)	(0.00141)	(0.00142)
GROWTH	0.00317^{***}	0.00311^{***}	0.00318^{***}	0.00312^{***}	0.00319^{***}	0.00316^{***}	0.00313^{***}	0.00316^{***}
	(0.000450)	(0.000450)	(0.000450)	(0.000450)	(0.000450)	(0.000450)	(0.000449)	(0.000450)
CAPINT	-0.0137^{***}	-0.0141^{***}	-0.0140^{***}	-0.0148^{***}	-0.0138^{***}	-0.0139^{***}	-0.0130^{***}	-0.0137^{***}
	(0.00348)	(0.00351)	(0.00349)	(0.00355)	(0.00349)	(0.00349)	(0.00349)	(0.00350)
PDI		0.00454	-0.00617^{**}					
		(0.00285)	(0.00203)					
UAI		-0.00548^{***}		-0.00907^{***}				
		(0.00156)		(0.000993)				
IDV		0.00251			0.00734^{***}			
		(0.00157)			(0.000996)			
MAS		-0.000255				-0.00444^{***}		
		(0.00110)				(0.00104)		
LTO		-0.00463^{**}					-0.00901^{***}	
		(0.00152)					(0.000894)	
IVR		0.00103						0.0120^{***}
		(0.00304)						(0.00169)
PDI*CO2INT			0.000518					
			(0.000541)					
UAI*CO2INT				0.000222				
				(0.000391)				
IDV*CO2INT					-0.000460			
					(0.000411)			
MAS*CO2INT						0.000220		
						(0.000483)		
LTO*CO2INT							0.00116^{*}	
							(0.000466)	
IVR*CO2INT								-0.000846
								(0.000624)
_Constant	4.133^{***}	4.056^{***}	4.362^{***}	4.403^{***}	3.622^{***}	4.356^{***}	4.474^{***}	3.243^{***}
	(0.441)	(0.542)	(0.431)	(0.422)	(0.444)	(0.441)	(0.424)	(0.462)
Observations	8808	8808	8808	8808	8808	8808	8808	8808
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Overall) R-squared	0.1382	0.2148	0.1507	0.1970	0.1746	0.1511	0.2009	0.1815

Robust standard errors are in parentheses. Note: TOBINQ = Tobin's Q, CO2INT = CO2 intensity, SIZE = Firm size, LEV = Leverage, GROWTH = Growth rate, CAPINT = Capital intensity, PDI = Power distance index, UAI = Uncertainty avoidance index, IDV = Individuality, MAS = Masculinity, LTO = Long-term orientation, and IVR = Indulgence. All continuous variables are winsorized at the 1st and 99th percentiles. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

As a last robustness check, the independent variables are lagged 1 year behind firm value to increase confidence in the direction of the relationship (Delmas, Nairn-Birch, and Lim, 2015). As can be seen in Table 11, although the magnitude of *CO2INT* has decreased, the initial relationship between carbon emissions and firm value is still negative and significant. This increases confidence in the negative direction of the relationship between carbon emissions and firm value.

Notably, only the interaction terms *IDV*CO2INT*, *LTO*CO2INT,* and *IVR*CO2INT* are significant at the 5% significance level in models 3-8. *IDV*CO2INT* and *IVR*CO2INT* have negative coefficients (-0.000732 and -0.00120), while *LTO*CO2INT* has a positive coefficient (0.000750). Thus, only H2e is supported, but these significant effects are very small economically. These findings are contrary to the results in Table 8, where *UAI*CO2INT*, *MAS*CO2INT,* and *LTO*CO2INT* have significant positive coefficients. Therefore, confidence in the sign of the coefficient is only increased for *LTO*CO2INT*. In addition, compared to the non-lagged model 2, IDV has a significant positive coefficient (0.00337; $p < 0.05$). Concerning the control variables, the only difference is that *GROWTH* now also has a significant positive coefficient, compared to the non-lagged models in Table 8.

Table 11

Market value (t+1), carbon intensity, and the moderating role of culture

	(1) Ln (MV) (t+1)	(2) Ln (MV) (t+1)	(3) Ln (MV) (t+1)	(4) Ln (MV) (t+1)	(5) Ln (MV) (t+1)	(6) Ln (MV) (t+1)	(7) Ln (MV) (t+1)	(8) Ln (MV) (t+1)
Ln (CO2INT)	-0.0519***	-0.0607***	-0.0506***	-0.0540***	-0.0488***	-0.0509***	-0.0602***	-0.0495***
	(0.00960)	(0.00967)	(0.00973)	(0.00937)	(0.00954)	(0.00966)	(0.00934)	(0.00942)
Ln (SIZE)	0.691***	0.709***	0.697***	0.715***	0.695***	0.695***	0.707***	0.710***
	(0.0149)	(0.0145)	(0.0150)	(0.0145)	(0.0146)	(0.0149)	(0.0143)	(0.0148)
LEV	-0.0123***	-0.0126***	-0.0123***	-0.0122***	-0.0126***	-0.0125***	-0.0129***	-0.0127***
	(0.00123)	(0.00117)	(0.00122)	(0.00120)	(0.00121)	(0.00122)	(0.00119)	(0.00120)
GROWTH	0.00425***	0.00411***	0.00431***	0.00417***	0.00436***	0.00423***	0.00414***	0.00427***
	(0.000722)	(0.000721)	(0.000722)	(0.000722)	(0.000719)	(0.000722)	(0.000722)	(0.000722)
CAPINT	-0.0243***	-0.0252***	-0.0253***	-0.0268***	-0.0252***	-0.0246***	-0.0231***	-0.0242***
	(0.00538)	(0.00533)	(0.00541)	(0.00538)	(0.00536)	(0.00537)	(0.00535)	(0.00540)
PDI		0.00535**	-0.00481***					
		(0.00191)	(0.00142)					
UAI		-0.00432***		-0.00761***				
		(0.00113)		(0.000765)				
IDV		0.00337*			0.00697***			
		(0.00135)			(0.000810)			
MAS		0.000418				-0.00334***		
		(0.000921)				(0.000791)		
LTO		-0.00497***					-0.00832***	
		(0.00124)					(0.000695)	
IVR		-0.000156						0.0104***
		(0.00209)						(0.00130)
PDI*CO2INT			0.000939					
			(0.000500)					
UAI*CO2INT				0.000484				
				(0.000361)				
IDV*CO2INT					-0.000732*			
					(0.000338)			
MAS*CO2INT						-0.000181		
						(0.000392)		
LTO*CO2INT							0.000750*	
							(0.000319)	
IVR*CO2INT								-0.00120*
								(0.000506)
_Constant	-2.226***	-2.470***	-2.080***	-2.131***	-2.726***	-2.069***	-2.010***	-3.090***
	(0.236)	(0.337)	(0.234)	(0.230)	(0.242)	(0.239)	(0.229)	(0.260)
Observations	8807	8807	8807	8807	8807	8807	8807	8807
Industry controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Robust standard errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
(Overall) R-squared	0.5654	0.5935	0.5697	0.5847	0.5802	0.5685	0.5897	0.5802

Robust standard errors are in parentheses. Note: MV = Market value, CO2INT = CO2 intensity, SIZE = Firm size, LEV = Leverage, GROWTH = Growth rate, CAPINT = Capital intensity, PDI = Power distance index, UAI = Uncertainty avoidance index, IDV = Individuality, MAS = Masculinity, LTO = Long-term orientation, and IVR = Indulgence. All continuous variables are winsorized at the 1st and 99th percentiles. * *$p < 0.05$,* ** *$p < 0.01$,* *** *$p < 0.001$.*

5. Discussion and conclusion

The relationship between carbon emissions and firm value has been extensively investigated in previous research, generally finding a negative relationship. This research contributes to the academic literature by striving to gain insight in the moderating effect of culture on the relationship between carbon emissions and firm value, by answering the following research question: "*What is the moderating effect of culture on the relationship between carbon emissions and firm value?*"

First, using panel data regression analysis and a sample of 1,101 firms from 41 countries, a negative relationship between carbon emissions and firm value was predicted and found. By measuring carbon emissions as carbon intensity and firm value as the market value of common equity, if carbon intensity increases with 1, market value decreases with 0.0712. This negative effect was also found when using ROA and Tobin's Q as measures of firm value. This research, therefore, provides additional support for the extensively researched negative relationship between carbon emissions and firm value.

However, the main goal of this research was to examine the moderating effect of culture. So, to further decompose culture, the cultural dimensions of Hofstede (1980) were used to examine this moderating effect. For each cultural dimension hypotheses were developed, which resulted in six additional hypotheses. All cultural dimensions except the uncertainty avoidance index were predicted to weaken the negative relationship between carbon emissions and firm value. However, only for the uncertainty avoidance index, masculinity-femininity, and long-term versus short-term orientation dimensions significant positive interaction terms were found with the market value of common equity as the dependent variable. This provides evidence that these dimensions weaken the relationship between carbon emissions and firm value, although the effects are very small economically.

Furthermore, this means that the uncertainty avoidance index weakens the relationship instead of strengthening. This finding is not in line with the hypothesis of this research, but it is in line with the findings of Choi & Luo (2020). They argued from a managerial perspective, by stating that firms operating in high uncertainty avoidant countries are more pressured to proactively manage carbon emissions to avoid uncertain cash outflows related to future changes in carbon taxes or environmental regulations. So, Choi and Luo (2020) argued that the value-decreasing effect of carbon emissions is smaller for firms operating in high uncertainty avoidance countries than in low uncertainty avoidance countries.

However, this research stated that there may be more factors influencing the moderating role of culture. Rooted in value-relevance theory, this research argued that shareholders in high uncertainty avoidance countries may attach more value to the amount of carbon emissions when valuing a company than shareholders in low uncertainty avoidance countries, but this does not seem to be correct. To summarize, this research only found significant effects for three of the six cultural dimensions, so no overall significant moderating effect of culture on the relationship between carbon emissions and the market value of common equity was found.

Several robustness checks were performed to ensure consistency and reliability of the results. First, two robustness checks were performed with ROA and Tobin's Q as different measures of firm value. Tobin's Q measures the market response to the firm's decisions, while ROA captures the internal performance of the firm on the balance sheet (Misani & Pogutz, 2015). So, Tobin's Q is more like the market value of common equity. First, using Tobin's Q as a measure of firm value only a small significant positive effect for the long-term orientation versus short-term orientation dimension was found. This is in line with the results of the analysis with the market value of common equity as the dependent variable and with H2e, but the uncertainty avoidance index and masculinity-femininity dimension are no longer significant.

However, with ROA as the dependent variable, for all cultural dimensions except the masculinity-femininity dimension, significant moderating effects were found. On the one hand, the power distance index and long-term orientation versus short-term orientation dimension weaken the negative relationship between carbon emissions and firm value as predicted. On the other hand, however, the individualistic-collectivistic dimension and the indulgence-restraint dimension make the negative association between carbon emissions and firm value even more negative. This indicates that firms headquartered in individualistic and indulgent countries experience a stronger negative effect of carbon emissions on firm value. Furthermore, the uncertainty avoidance index also weakens the negative relationship between carbon emissions and firm value, which was also not predicted. Thus, these findings are not in line with the hypotheses of this research, and therefore support is only provided for H2a and H2e.

To summarize, with the market value of common equity and Tobin's Q as measures of firm value, culture seems to play a very small role in the relationship between carbon emissions and firm value. However, with ROA as a measure of firm value, culture has a general moderating effect although the effects of the several cultural dimensions are quite small economically. A reason that the negative relationship between carbon emissions and firm value seems to be quite robust against cultural differences can be that all stakeholders see carbon performance as highly relevant non-financial information, where they see more carbon emissions as negative because of the increasing threat of climate change and associated interest of society in climate change. Although stakeholders in certain countries might consider carbon emissions as less important due to cultural differences, this difference might be so small that it does not significantly influences the relationship between carbon emissions and firm value. The findings that more cultural dimensions have significant moderating effects on the relationship between carbon emissions and firm value with ROA as a measure of firm value, may be explained by the fact that culture has a stronger effect on managerial behavior than on shareholders' view on carbon emissions. This effect on managerial behavior may imply that managers put less effort and allocate fewer resources to reduce their carbon emissions.

In addition to the robustness checks with other measures of firm value, the independent variables were lagged 1 year behind the dependent variable market value of common equity as a last robustness check. The results of this robustness check increase confidence in the negative direction of the relationship between carbon emissions and firm value, because the negative effect of carbon emissions on firm value is still significant and negative. However, confidence in the effect on the relationship between carbon emissions and firm value was only increased for *LTO*CO2INT*, as no additional support was found with the lagged models for the other significant cultural dimensions in the non-lagged models.

To summarize, the results do not provide support for a general moderating effect of culture on the relationship between carbon emissions and market value, but they do provide evidence for a general moderating effect of culture on the relationship between carbon emissions and firm value measured as ROA. Furthermore, this research is the first to find significant evidence for moderating roles of the power distance dimension, individualistic-collectivistic dimension, masculinity-femininity dimension, and the indulgence-restraint dimension in the relationship between carbon emissions and firm value.

The results of this research should be seen in light of some limitations. First, 2006 till 2010 and 2018 were omitted from the sample because many observations were missing. This resulted in a smaller sample, while a bigger sample indicates that the sample firms are a good representation of all global firms. However, the sample size still consists of 1,101 firms and is thus not very small, so the sample still relatively well represents all firms worldwide.

Second, the sample might suffer from self-selection bias. At the moment, carbon information is not mandated by US GAAP and IFRS (Choi & Luo, 2020). Since firms are likely to hide information that might have a negative effect on their firm value, some firms with high carbon emissions may choose not to disclose their carbon emissions. In this way, the sample might suffer from self-selection bias. Therefore, further research should take this into account.

Third, this research only looks at relatively large, publicly-listed firms. Therefore, the results of this research cannot be generalized to smaller firms without caution. Further research is needed to examine the relationship between carbon emissions and firm value, and the moderating effect of culture within smaller firms.

Finally, this research used carbon intensity as a measure of carbon emissions. However, changes in the carbon intensity of a firm might be caused by a change in sales instead of an increase or decrease in the amount of carbon emissions. Therefore, future research should evaluate the reasons behind changes in the carbon intensity of a firm and how these changes relate to firm value (Lewandowski, 2017).

This study has several implications. First, US GAAP and IFRS currently do not mandate carbon-related information (Choi & Luo, 2020), although the negative influence of carbon emissions on firm value is widely acknowledged and supported by this research. Therefore, investors and other stakeholders need to have reliable and relevant carbon-related information, and standard setters should thus think about mandating carbon-related information. Furthermore, this research also has practical relevance in terms of managerial implications, because evidence provided for the negative firm-value effects of carbon emissions. Managers can use this information to make important decisions about the cost-benefit trade-offs of resource allocation to reduce carbon emissions (Thaler & Sunstein, 2009). Additionally, if certain cultural characteristics of a country are associated with a stronger negative effect of carbon emissions on firm value, management of firms that are headquartered in these countries, will have to consider the financial consequences regarding their carbon management strategies (Choi & Luo, 2020).

To conclude, the findings of this research provide preliminary evidence of a moderating effect of culture on the relationship between carbon emissions and firm value. However, further research is needed to examine this moderating effect in other settings. Since this research only examined the cultural dimensions separately, future research could explore multiple cultural dimensions in one model, and see how the cultural dimensions influence each other and whether there is an underlying main factor influencing the cultural dimensions.

Bibliography

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies, 47*(1), 239-253.

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

Calza, F., Cannavale, C., & Tutore, I. (2016). The important effects of national culture on the environmental proactivity of firms. *Journal of Management Development, 35*(8), 1011-1030.

Campbell, J. L. (2007). Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility. *Academy of Management Review, 32*, 946-967.

Chih, H. L., Chih, H. H., & Chen, T. Y. (2010). On the determinants of corporate social responsibility: International evidence on the financial industry. *Journal of Business Ethics, 93*, 115-135.

Choi, B., & Luo, L. (2020). Does the market value greenhouse gas emissions? Evidence from multi-country firm data. *The British Accounting Review*. Advance online publication. https://doi.org/10.1016/j.bar.2020.100909

CNBC. (2019). Climate change investing catches on with millennials who believe it's pressing – and profitable. Retrieved March 30, 2020, from https://www.cnbc.com/2019/12/31/climate-change-investing-catches-on-with-millennials.html

CNBC. (2020). Amid climate crisis, investors are starting to put their money towards a sustainable future. Retrieved 30 March, 2020, from https://www.cnbc.com/2020/01/24/climate-crisis-investors-putting-money-towards-sustainable-future.html

Cook, R. D. (1977). Detection of influential observations in linear regression. *Technometrics, 19*(1), 15-18.

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.

Dobler, M., Lajili, K., & Zéghal, D. (2014). Environmental performance, environmental risk and risk management. *Business Strategy and the Environment, 23*(1), 1-17.

Eccles, R. G., Serafeim, G., & Krzus, M. P. (2011). Market interest in nonfinancial information. *Journal of Applied Corporate Finance, 23*(4), 113-127.

EPA. (2020). Greenhouse gas emissions - Overview of greenhouse gases. Retrieved March 30, 2020, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Fujii, H., Iwata, K., Kaneko, S., & Managi, S. (2013). Corporate environmental and economic performance of Japanese manufacturing firms: Empirical study for sustainable development. *Business Strategy and the Environment, 22*(3), 187-201.

Gallego-Álvarez, I., Segura, L., & Martínez-Ferrero, J. (2015). Carbon emission reduction: the impact on the financial and operational performance of international companies. *Journal of Cleaner Production, 103*, 149-159.

Ganda, F., & Milondzo, K. S. (2018). The impact of carbon emissions on corporate financial performance: Evidence from the South African firms. *Sustainability 10*(7), 2398.

Hart, S. L. (1995). A natural-resource-based view of the firm. *The Academy of Management Review, 20*(4), 986-1014.

Hausman, J. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251-1271.

Heinkel, R., Kraus, A., & Zechner, J. (2001). The effect of green investment on corporate behavior. *Journal of Financial and Quantitative Analysis, 36*(4), 431-449.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence. *The Stata Journal*, *7*(3), 281-312.

Hofstede Insights. (2020). Compare countries. Retrieved March 30, 2020, from https://www.hofstede-insights.com/product/compare-countries/

Hofstede, G. (1980). *Culture's consequences: International differences in work-related values*. Beverly Hills, CA: Sage Publications.

Hofstede, G. (1991). *Cultures and organizations: Software of the mind.* New York: McGraw-Hill Publication.

Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations* (2nd ed.). Beverly Hills, CA: Sage Publications.

Hofstede, G. (2011). Dimensionalizing cultures: The Hofstede model in context. *Online Readings in Psychology and Culture, 2*(1).

Hofstede, G., & Hofstede, G. J. (2005). *Cultures and organizations: Software of the Mind* (2nd ed.). New York, NY: McGraw-Hill.

Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). *Cultures and organisations, Software of the mind. Intercultural cooperation and its importance for survival.* New York, NY: McGraw-Hill.

Hsiao, C. (2006). Panel data analysis – Advantages and challenges. *IEPR Working Paper No. 06.49*.

Hua, S., Gregory, A., & Whittaker, J. (2018). *How does the stock market reward companies with a lower carbon footprint?* Article in preparation.

Ioannou, I., & Serafeim, G. (2012). What drives corporate social performance? The role of nation-level institutions. *Journal of International Business Studies, 43*(9), 834-864.

Jensen, M. C. (2002). Value maximization, stakeholder theory, and the corporate objective function. *Business Ethics Quarterly, 12*(2), 235-256.

KPMG. (2017). Climate-related risks and opportunities: The appetite in the Netherlands. Retrieved March 30, 2020, from https://assets.kpmg/content/dam/kpmg/nl/pdf/2017/advisory/climate-related-risks-and-opportunities.pdf

Lee, K., Min, B., & Yook, K. (2015). The impacts of carbon (CO_2) emissions and environmental research and development (R&D) investment on firm performance. *International Journal of Production Economics, 167*, 1-11.

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

Luo, L. L., & Tang, Q. (2016). Does national culture influence corporate carbon disclosure propensity? *Journal of International Accounting Research, 15*(1), 17-47.

Mackey, A., Mackey, T. B., & Barney, J. B. (2007). Corporate social responsibility and firm performance: investor preferences and corporate strategies. *Academy of Management Review, 32*(3), 817-835.

Matsumura, E. M., Prakash, R., & Vera-Munoz, S. C. (2014). Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review, 89*(2), 695-724.

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.

Moon, J. (2004). Government as a driver of CSR. *ICCSR Working Articles*, 20.

Moore, D. S., Notz, W. I., & Flinger, M. A. (2013). *The basic practice of statistics* (6^{th} ed.). New York, NY: W. H. Freeman and Company.

Park, H., Russell, C., & Lee, J. (2007). National culture and environmental sustainability: A cross-national analysis. *Journal of Economics and Finance, 31*(1), 104-121.

Petruzzella, F., Salvi, A., & Giakoumelou, A. (2017). The impact of national culture on corporate environmental performance: How much does your origin say about how green you are? *Journal of Environmental Sustainability, 5*(1).

PricewaterhouseCoopers. (2012). *Do investors care about sustainability? Seven trends provide clues*. New York, NY: PwC.

Purwohandoko. (2017). The influence of firm's size, growth, and profitability on firm value with capital structure as the mediator: A study on the agricultural firms listed in the Indonesian Stock Exchange. *International Journal of Economics and Finance, 9*(8), 103-110.

Ringov, D., & Zollo, M. (2007). The impact of national culture on corporate social performance. *Corporate Governance International Journal of Business in Society, 7*(4), 476-485.

Rokhmawati, A, Sathye, M., & Sathye, S. (2015). The effect of GHG emission, environmental performance, and social performance on financial performance of listed manufacturing firms in Indonesia. *Procedia – Social and Behavioral Sciences, 211*, 461-470.

Russo, M., & Fouts, P. (1997). A resource-based perspective on corporate environmental performance and profitability. *Academy of Management Journal, 40*, 534-59.

Sharfman, M. P., & Fernando, C. S. (2008). Environmental risk management and the cost of capital. *Strategic Management Journal, 29*, 569-592.

Studenmund, A. H. (2017). *A practical guide to using econometrics* (7th edition). Edinburgh Gate, England: Pearson.

Thaler, R. H., & Sunstein, C. R. (2009). Nudge: Improving Decisions About Health, Wealth and Happiness. New York, NY: Penguin Books.

Thanetsunthorn, N. (2015). The impacts of national culture on corporate social responsibility: evidence from cross-regional comparison. *Asian Journal of Business Ethics, 4*(1), 35-56.

Thomson Reuters. (2013). *Thomson Reuters Corporate Responsibility Ratings (TRCRR)*. Retrieved from https://www.thomsonreuters.com/content/dam/openweb/documents/pdf/tr-com-financial/methodology/corporate-responsibility-ratings.pdf

Thomson Reuters. (2015). *Worldscope database: Data definitions guide (Issue 14.3)*. Retrieved from http://www.datastream.jp/wp/wp-content/uploads/2015/10/guide_Worldscope-Data-Definitions-Guide-Issue-14.3.pdf

Tsai, K-H., Huang, C-T, & Chen, Z-H. (2019). Understanding variation in the relationship between environmental management practices and firm performance across studies: A meta-analytic review. *Business Strategy and the Environment, 29*(2), 547-565.

Van der Laan Smith, J., Adhikari, A., & Tondkar, R. H. (2005). Exploring differences in social disclosures internationally: A stakeholder perspective. *Journal of Accounting and Public Policy, 24*(2), 123-151.

Williams, G., & Zinkin, J. (2008). The effect of culture on consumers' willingness to punish irresponsible corporate behaviour: Applying Hofstede's typology to the punishment aspect of corporate social responsibility. *Business Ethics: A European Review, 17*(2), 210-226.

Appendix

Table A1

Hofstede's cultural dimensions scores per country

Country	GGISN	PDI	IDV	MAS	UAI	LTO	IVR
Australia	AU	38	90	61	51	21	71
Austria	AT	11	55	79	70	60	63
Belgium	BE	65	75	54	94	82	57
Brazil	BR	69	38	49	76	44	59
Canada	CA	39	80	52	48	36	68
China	CN	80	20	66	30	87	24
Colombia	CO	67	13	64	80	13	83
Denmark	DK	18	74	16	23	35	70
Finland	FI	33	63	26	59	38	57
France	FR	68	71	43	86	63	48
Germany	DE	35	67	66	65	83	40
Greece	GR	60	35	57	100	45	50
Hong Kong	HK	68	25	57	29	61	17
Hungary	HU	46	80	88	82	58	31
India	IN	77	48	56	40	51	26
Indonesia	ID	78	14	46	48	62	38
Ireland	IE	28	70	68	35	24	65
Italy	IT	50	76	70	75	61	30
Japan	JP	54	46	95	92	88	42
Luxembourg	LU	40	60	50	70	64	56
Malaysia	MY	100	26	50	36	41	57
Mexico	MX	81	30	69	82	24	97
Netherlands	NL	38	80	14	53	67	68
New Zealand	NZ	22	79	58	49	33	75
Norway	NO	31	69	8	50	35	55
Philippines	PH	94	32	64	44	27	42
Poland	PL	68	60	64	93	38	29
Portugal	PT	63	27	31	99	28	33
Russia	RU	93	39	36	95	81	20
Singapore	SG	74	20	48	8	72	46
South Africa	ZA	49	65	63	49	34	63
Republic of Korea	KR	60	18	39	85	100	29
Spain	ES	57	51	42	86	48	44
Sweden	SE	31	71	5	29	53	78
Switzerland	CH	34	68	70	58	74	66
Taiwan	TW	58	17	45	69	93	49
Thailand	TH	64	20	34	64	32	45
Turkey	TR	66	37	45	85	46	49
United Kingdom	GB	35	89	66	35	51	69
United States	US	40	91	62	46	26	68

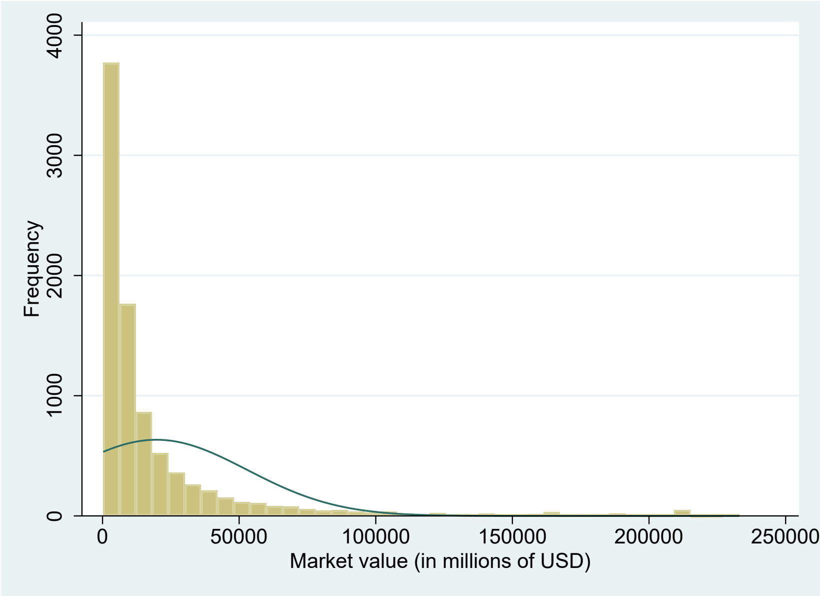

Figure A1. Histogram of market value

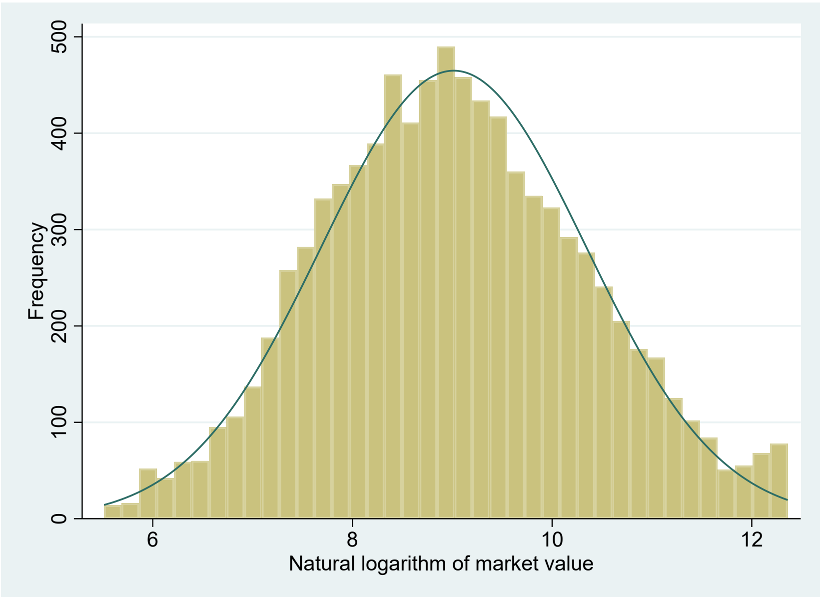

Figure A2. Histogram of the natural logarithm of market value

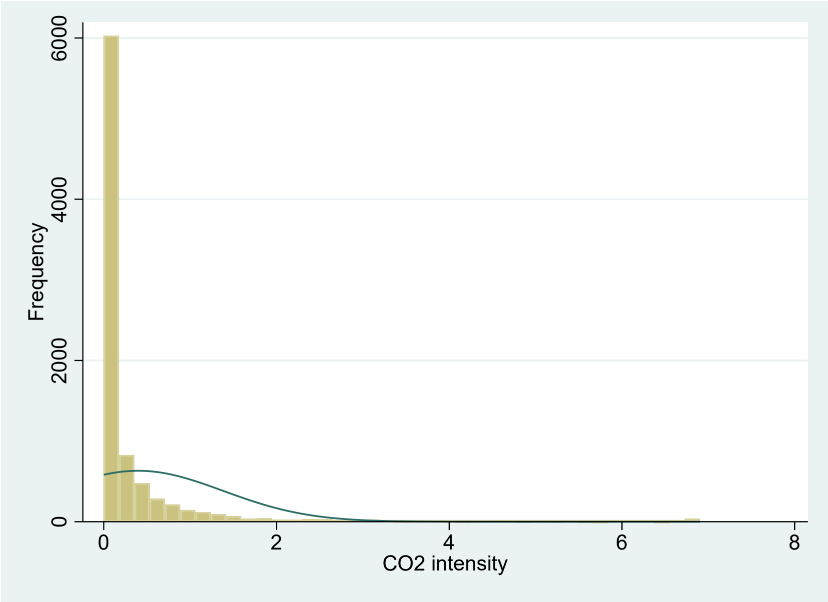

Figure A3. Histogram of CO2 intensity

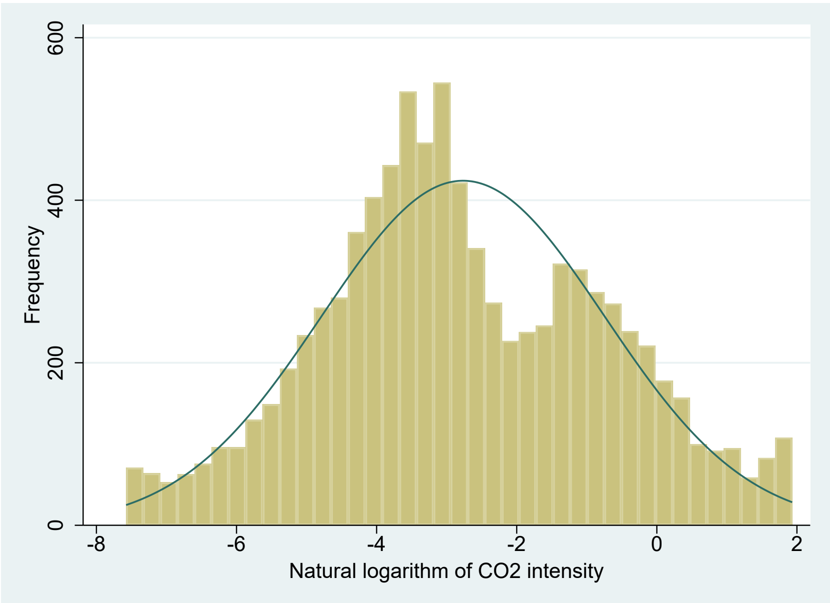

Figure A4. Histogram of the natural logarithm of CO2 intensity

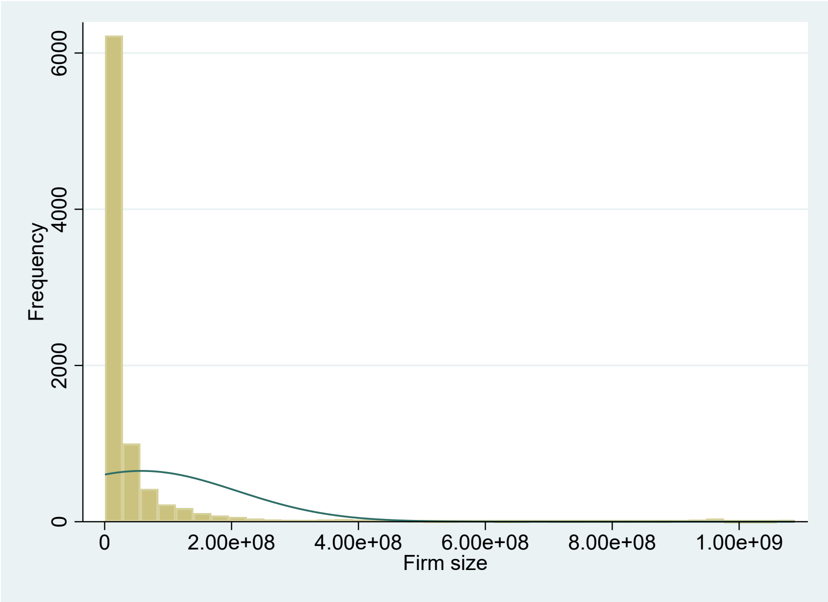

Figure A5. Histogram of firm size

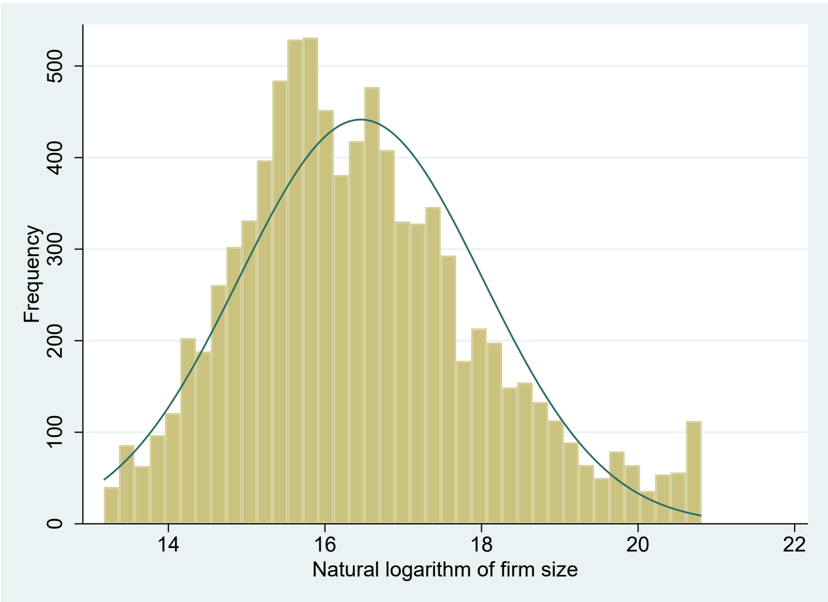

Figure A6. Histogram of the natural logarithm of firm size

Table A2

Hausman (1978) specification test for H1

	Coef.
Chi-square test value	22.081
P-value	.037

Table A3

Hausman (1978) specification test for H2a

	Coef.
Chi-square test value	42.803
P-value	0

Table A4

Hausman (1978) specification test for H2b

	Coef.
Chi-square test value	54.265
P-value	0

Table A5

Hausman (1978) specification test for H2c

	Coef.
Chi-square test value	18.334
P-value	.145

Table A6

Hausman (1978) specification test for H2d

	Coef.
Chi-square test value	36.837
P-value	0

Table A7

Hausman (1978) specification test for H2e

	Coef.
Chi-square test value	42
P-value	0

Table A8

Hausman (1978) specification test for H2f

	Coef.
Chi-square test value	26.755
P-value	.013

Table A9

Breusch and Pagan Lagrangian multiplier test for random effects for H1

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0896286       .2993803
                       u |   .4038016       .6354538

        Test:   Var(u) = 0
                             chibar2(01) = 20386.21
                          Prob > chibar2 =   0.0000
```

Table A10

Breusch and Pagan Lagrangian multiplier test for random effects for H2a

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |    .089639       .2993977
                       u |   .3910439       .6253351

        Test:   Var(u) = 0
                             chibar2(01) = 20107.62
                          Prob > chibar2 =   0.0000
```

Table A11

Breusch and Pagan Lagrangian multiplier test for random effects for H2b

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0895121       .2991857
                       u |   .3627953       .6023249

        Test:   Var(u) = 0
                             chibar2(01) = 19523.73
                          Prob > chibar2 =   0.0000
```

Table A12

Breusch and Pagan Lagrangian multiplier test for random effects for H2c

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0896401       .2993995
                       u |   .3759038       .6131099

        Test:   Var(u) = 0
                             chibar2(01) = 19844.23
                          Prob > chibar2 =   0.0000
```

Table A13

Breusch and Pagan Lagrangian multiplier test for random effects for H2d

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0894379       .2990617
                       u |   .3991277       .6317655

        Test:   Var(u) = 0
                             chibar2(01) = 20291.75
                          Prob > chibar2 =   0.0000
```

Table A14

Breusch and Pagan Lagrangian multiplier test for random effects for H2e

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0891653       .2986056
                       u |    .363142       .6026127

        Test:   Var(u) = 0
                             chibar2(01) = 19613.90
                          Prob > chibar2 =   0.0000
```

Table A15

Breusch and Pagan Lagrangian multiplier test for random effects for H2f

```
Breusch and Pagan Lagrangian multiplier test for random effects

        LNMV[ISIN,t] = Xb + u[ISIN] + e[ISIN,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    LNMV |   1.761471       1.327204
                       e |   .0896201       .2993662
                       u |   .3732512       .6109429

        Test:   Var(u) = 0
                             chibar2(01) = 19797.45
                          Prob > chibar2 =   0.0000
```

Table A16

Variance inflation factors

	VIF	1/VIF
Individuality	3.186	.314
Indulgence	3.006	.333
Long-term orientation	2.724	.367
Power distance index	2.446	.409
Uncertainty avoidance index	2.251	.444
Natural logarithm of firm size	1.348	.742
Masculinity	1.338	.748
Capital intensity	1.296	.772
Leverage	1.019	.982
Growth rate	1.015	.985
Mean VIF	1.963	.

Table A17

Wooldridge test for autocorrelation in panel data for H1

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 1100) = 956.754
Prob > F = 0.0000

Table A18

Wooldridge test for autocorrelation in panel data for H2a

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 1100) = 956.057
Prob > F = 0.0000

Table A19

Wooldridge test for autocorrelation in panel data for H2b

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
   F(  1,    1100) =    956.343
         Prob > F =      0.0000
```

Table A20

Wooldridge test for autocorrelation in panel data for H2c

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
   F(  1,    1100) =    955.021
         Prob > F =      0.0000
```

Table A21

Wooldridge test for autocorrelation in panel data for H2d

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
   F(  1,    1100) =    948.272
         Prob > F =      0.0000
```

Table A22

Wooldridge test for autocorrelation in panel data for H2e

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
   F(  1,    1100) =    929.870
         Prob > F =      0.0000
```

Table A23

Wooldridge test for autocorrelation in panel data for H2f

```
Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
   F(  1,    1100) =    959.083
         Prob > F =      0.0000
```