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Carbon emission reduction: the impact on the financial and operational performance of international companies

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ABSTRACT

Over the last few decades, companies operate in an environment in which exercising responsibility is a prerequisite for competing. Owing to the growing social concern for ethical, social, and environmental issues, the question of the impact of emissions trading on firm competitiveness has acquired special relevance in recent years. This research analyzes the impact of the variation in carbon dioxide emissions on financial and operational performance. By using international data consisting of 89 companies for the period 2006–2009, the findings show a reduction in emissions that generates a positive impact on financial performance. In addition, certain control variables are considered such as company size, sector, growth, sustainability index, and legal system, while a panel data methodology is used as the analysis technique. Overall, this research shows that companies promote greater environmental behaviour in order to obtain higher financial performance. Nonetheless, the findings do not show evidence for operational performance. This study contributes to the literature on carbon emission reduction and corporate performance. Moreover, it complements previous literature in the sense that results obtained show a reduction in emissions that generates a positive impact on financial performance.

1. Introduction

Some of the hottest research topics of recent years are related to responsibility and business ethics (Lindahl et al., 2014; Zhang, 2014). Specifically, one of the most important aspects in this regard is related to the environment because of the interest of society (Martínez-Ferrero and Frías-Aceituno, 2013; Shao et al., 2014). In this sense, society has paid increasing attention to environmental and social issues, and the frequency of information disclosure in this respect has increased substantially since the late 1970s (Patten, 2002; Frías-Aceituno et al., 2012). With regard to environmental issues, particularly climate change, organizations are concerned about the consumption and use of water, energy, biodiversity, and so on (Pulver, 2007; Stubbs and Cocklin, 2008; Boiral et al., 2012).

Although all these research priorities affect the environment, this study is focused on one related to climate change: greenhouse gas emissions (GHG). Companies – as part of society – are aligning themselves to the international proposal (put forward in the Kyoto protocol) to reduce emissions. While this reduction will serve the purpose of mitigating climate change, how it will affect companies' operations is less clear (Okereke, 2007; Weinhofer and Hoffmann, 2010; Hashmi and Al-Habib, 2013), particularly given the recent global financial crisis (Fidrmuc and Korhonen, 2009).

Specifically, during periods of crisis, some authors such as Cheney and McMillan (1990) and Njoroge (2009) have considered the need to reduce investment in environmental protection projects in order to reduce costs and improve corporate performance. Investments to protect the natural environment provide few benefits to businesses. Nonetheless, other authors such as Hart (1997), Michalisin and Stinchfield (2010), and Berrang-Ford et al. (2011) have noted that many companies are becoming more socially responsible and committed to the environment. These firms can reduce pollution and increase corporate profits at the same time since environmental strategies are rarely imitated, unique resources, or capabilities that would bring competitive advantages. Therefore, the effort aimed at environmental issues in general, and at climate change in particular, should lead firms to outperform competitors that are less proactive.

Considering that there is currently no unanimity on the link between the emission reduction ratio and performance, the purpose of this research is twofold: (i) to analyze the variation in

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carbon emissions shown by companies in their sustainability reports and (ii) to analyze how this variation influences companies' financial and operational performance.

With these aims in mind, the sample used for the analysis consists of 89 international companies. These companies belong to the Fortune 500 list of multinationals and they thus provided information on their GHG emissions in their sustainability reports during the period 2006–2009. The sample consists of 267 observations. Methodologically, the variation in carbon emissions is proxied for by variation in carbon dioxide (CO_2 hereafter). The data used to represent CO_2 emissions were obtained from the sustainability, sustainable development, and corporate social responsibility reports presented by each company on its website. The unit used by companies to measure their emissions is metric tonnes. Meanwhile, with the aim of demonstrating the possible differences in performance measures, two proxies are used: (i) return on equity (ROE) as a measure of financial performance and (ii) return on assets (ROA) as a measure of operational performance.

After applying a panel data methodology, the empirical evidence confirms the reduction in carbon emissions in the period analyzed. In particular, the findings show that this emission reduction positively influences financial performance but not operational performance. Therefore, in view of these results, this study obtains evidence of the different effects of the variation in carbon emissions on performance depending on the measure used.

The remainder of this paper is divided into the following sections. The next section contains the theoretical framework from the perspective of resource-based view (RBV) theory and formulates the research hypotheses. Next section describes the population and sample, the variables used in the research, and the methodology employed. After that, section fourth analyzes the results obtained. Finally, the general conclusions of the work are presented.

2. RBV theory and emission reductions

RBV theory was first introduced by Penrose (1959) and subsequently developed by Barney (1991). This theory supports the idea that companies are bundles of heterogeneous resources and capabilities that are imperfectly mobile across firms. These resources and capabilities are the main strength of organizations and should therefore guide their strategic choices. This theory understands competitive advantage through the link between the internal characteristics of the firm and its profit (Barney, 1991). Barney (1991) defined resources as "[…] everything that allows a firm to conceive and implement strategies that improve its efficiency and effectiveness."

Moreover, according to Castelo and Lima (2006, p. 116):

> […] resources include the assets that the firm uses to accomplish the activities they are engaging in to convert inputs into outputs and can be classified as tangible or intangible, and capabilities are thus seen as referring to the actions through which resources are used and that the firm engages in to get something done and accomplish its objectives. Resources and capabilities are used by firms to develop and implement their strategies.

Barney (1991) maintained that if these resources and capabilities are valuable, rare, inimitable, and non-substitutable, they can constitute a resource of sustainable competitive advantage, and firms can thus enjoy improved performance in the short-term. In view of this, RBV theory can be applied to an examination of companies' social and environmental actions and, more concretely, their climate change concerns. In this sense, one of the objectives considered by companies to promote these actions is to achieve competitive advantage compared with their less ethical competitors. Society, the market, investors, and other stakeholders can assess and react positively to ethical and environmental practices, leading to sustainable competitive advantage over time that is hardly imitable by the closest competitors. This environmental commitment, and in particular the commitment to a lower impact on the ecosystem, can positively impact on the business strategy. Indeed, developing clean production processes can yield important environmental and competitive advantages and benefits (Hart, 1997).

According to the definition developed by Peteraf and Barney (2003), a company enjoys competitive advantage as long as it has the ability to create higher marginal economic value than its competitors. Specifically, one of the possibilities that make a company unique is its tendency to preserve and protect the ecosystem. Companies' environmental actions and strategies are thus resources and capabilities that can provide such an advantage.

In this scenario, it is necessary to note the previous research by Russo and Fouts (1997) and Sharma and Vredenburg (1998). The first authors analyzed this theory empirically by using firm-level data on accounting and environmental profitability and found that companies with higher environmental performance also achieve higher financial performance. Meanwhile, Sharma and Vredenburg (1998) suggested that investments in a proactive corporate environmental strategy (i.e., beyond pollution control) can lead to the development of firm-specific capabilities. In particular, firms pursuing a proactive environmental research strategy develop capabilities that allow higher-order learning as well as collaborative problem solving with stakeholders. Furthermore, these capabilities take a long time to build up, lack an identifiable owner, are difficult for competitors to imitate, and cannot be reproduced in a shorter amount of time by rivals through mere increases in investment.

Similarly, this idea is referred to by Barney and Arikan (2001) in their assessment of 166 empirical articles that test RBV in one form or another. The authors concluded that of these 166 studies, only four (2%) presented results that were at least partially inconsistent with RBV logic. At the same time, these authors showed that some of the variables used in the different studies (to address innovation, human resources, environmental performance, knowledge, and so on as sources of competitive advantage) were interchangeably considered to be dependent and independent variables.

Regarding the concept of the environmental strategy being a competitive resource, other authors such as Nidumolu et al. (2009) have considered that in the future, only those firms that make sustainability a goal will achieve competitive advantage. This means rethinking business models as well as products, technologies, and processes.

However, RBV theory coexists with a more traditional outlook. It postulates that the improvement of a firm's environmental impact leads to a decrease in its profitability. In spite of witnessing a trend toward environmental preservation and sustainability, it is necessary to note that the main goal of any company is profit maximization (Friedman, 1962). As such, one of the purposes of promoting environmental strategies is the achievement of the aforementioned competitive advantage to generate better corporate performance.

As a result of the lack of unanimity in the prior literature, in the following section the relationship between environmental and corporate performance is analyzed in order to clarify its causality.

3. The relationship between emission reductions and financial/operational performance: research hypotheses

Many companies have been criticized for the problems caused by their social and environmental impacts despite the economic and technological progress they have also achieved (Reverte, 2009). In response, environmental policies and quality controls such as ISO 14000 or EMAS (ECO Management and Audit Scheme) have been adopted (Moneva and Llena, 2000). Thus, society is paying increasing attention to environmental and social issues, and the frequency of information disclosure in this respect has increased substantially since the late 1970s (Patten, 2002; Fernandez Orellano and Quiota, 2011; Frías-Aceituno et al., 2012). As reported by Moneva and Llena (2000), a significant number of relevant agencies worldwide have recommended the inclusion of environmental and social reporting in the annual company report (ICAEW, 1992; FEE, 1995). This has been evidenced in the research undertaken by Da Silva Monteiro and Aibar-Guzmán (2010) on the environmental aspects of Portuguese companies.

Environmental and social practices are included within the sustainability concept. Following Burress (2005) and Freitas et al. (2012), sustainable development must satisfy the requirement that "the resources left to each generation allow it to achieve a higher general standard of living than its predecessors." While this definition is not new, it has recently gained great importance internationally. Several organizations such as the United Nations have considered it to be part of the economic and social development of all humanity in relation to the natural environment. Further, companies now face not only the challenge of reducing their GHG emissions to mitigate climate change (Okereke, 2007; Weinhofer and Hoffmann, 2010), but also the impact of GHG emissions and thus climate change on their business activities.

Because of the necessity to propose measures to mitigate climate change (Wittneben and Kiyar, 2009), a significantly increased amount of recent research has related GHG emissions with entrepreneurship, especially with variables that measure the corporate outcome (Russo and Fouts, 1997; King and Lenox, 2002; Ziegler et al., 2007; Heras-Saizarbitoria et al., 2011; Boiral et al., 2012; Hatakeda et al., 2012). Moreover, the amount of research that employs theories to justify this relationship has also increased. In this sense, this research can note the previous study by Escobar and Vredenburg (2011), who applied RBV theory.

An analysis of the existing literature on the relationship between emission variation and corporate performance shows that early studies assumed that investments to protect the environment provided few economic and financial benefits to companies. For example, Walley and Whitehead (1994), among others, suggested a negative link between environmental management and financial performance. They argued that firms trying to enhance their environmental performance draw their resources and management effort away from the core areas of the business, resulting in lower profits. From this viewpoint, managers cannot make both environmental and competitive improvements (Klassen and Whybark, 1999; Hull and Rothenberg, 2008).

By contrast, Porter and Van der Linde (1995) suggested that companies can be both environmentally friendly and competitive. Similarly, King and Lenox (2001) stated that the strategic position of a company can lead to both lower pollution levels and improved financial performance, while Hart (1997) established that most companies tend to be socially and sustainably responsible, realizing that they can reduce pollution and increase corporate profits at the same time. Indeed, managers may possess unique resources or capabilities to employ environmental strategies that are difficult to imitate, which would bring about competitive advantages for companies resulting from the application of the RBV theory (Hart, 1997). Hence, companies promote sustainable actions with the aim of improving their performance, either economic or financial.

However, Telle (2006) was cautious about the idea that good environmental performance can improve firms' economic and financial performance. He considered that most previous quantitative empirical studies on the effects of environmental strategy on corporate performance suffer from several shortcomings. By using a panel dataset of Norwegian plants, this author confirmed that when firm characteristics such as size and industry were controlled for, the positive effect of environmental performance on economic performance could be confirmed. However, the omission of certain unobserved variables such as technology and management could make the interpretation difficult, such that one cannot be sure of the relationship. Therefore, for this author, the phrase "it pays to be green" was premature.

Boiral et al. (2012) argued that the analysis of the relationship between carbon emissions and corporate performance is polarized around two main approaches: (i) the win–lose approach and (ii) the win–win approach. The first approach suggests that the efforts that companies make to reduce their carbon emissions lead to costs that are detrimental to their competitiveness, which is not in accordance with the RBV argument (although see King and Lenox (2002), who deduced that pollution reduction or pollution treatment efforts do not affect ROA). By contrast, the second approach suggests that reductions to carbon emissions increase firm competitiveness and thus sustainable competitive advantage (Pulver, 2007; Stubbs and Cocklin, 2008; Boiral et al., 2012). Similarly, Russo and Fouts (1997) demonstrated the existence of a positive relationship between a firms' ranking and its operational performance, while Wang et al. (forthcoming) found a positive relationship between financial performance (measured by Tobin's q) and emissions.

Regarding the central aspect, emission reductions, it is also important to highlight the research conducted by Hart and Ahuja (1996). These authors analyzed the relationship between emission reductions and firm performance by using data from US firms obtained from Standard and Poor's 500 list for 1989–1992 and found no unanimity among emission reductions and operational and financial performance. However, from a statistical point of view, operational and financial performance (measured by ROA and ROE, respectively) began to be significant in 1990, increasing in 1991. This ratio started to decrease in 1992, while the relationship between emission reductions and ROE was not significant until 1991.

Previous research conducted in different countries and in different temporal periods is not unanimous in its results, especially because reducing emissions takes a long time (White et al., 1993). The great difference in the results of various investigations may also be due to the diverse performance measures (e.g., Tobin's q, ROA, ROE) used (Margolis et al., 2008; Horváthová, 2010). For instance, Busch and Hoffmann (2011) and Delmas and Nairn-Birch (2011) found a negative impact of the quantities of coal emissions on corporate performance by using Tobin's q, while this impact was modified when accounting measures such as ROA and ROE were used.

Based on the foregoing, the following two hypotheses are formulated:

H1: Emission variation in 2006–2009 positively affected financial performance from 2008 to 2010.

H2: Emission variation in 2006–2009 positively affected operational performance from 2008 to 2010.

4. Empirical research

This section describes the sample, explains the dependent, independent, and control variables, and presents the analysis techniques in detail.

4.1. Sample description

The sample used to test the proposed hypotheses consists of 89 international companies belonging to 21 countries (the United Kingdom, the United States, Canada, the Netherlands, Italy, France, Japan, Germany, Russia, Switzerland, South Korea, Norway, China, Australia, Brazil, Mexico, Sweden, Spain, Portugal, Austria, and Poland) in the period 2006–2009. These countries belong to different geographic areas and legal systems, and have different real and projected gross domestic products (GDPs), as shown in Appendices 1 and 2.

Companies were selected from the Fortune 500 list of large international companies classified by sector. Specifically, those sectors that are considered to produce more intensive GHG emissions and that are within the specifications in the *Green paper on greenhouse gas emissions trading within the European Union* (European Commission, 2000) and in the *Kyoto protocol* (United Nations Framework Convention on Climate Change, 2008) are chosen. Thus, the sectors included in the green paper as having the most intensive CO_2 emissions were electricity and heat production, iron and steel, refining, chemicals, glass, pottery and building material (including cement), and paper and printing (including paper pulping). This research is focused on aerospace and defence; airlines; chemicals; energy; forest and paper products; industrial and farm equipment; metals; mining; crude-oil production; motor vehicles and parts; and petroleum refining and utilities.

Of all these companies from different sectors, only 89 presented data on emissions from 2006 to 2009, and therefore the variation in emissions could only be determined for this number of firms (89). Specifically, 2006 was the most recent complete year for which emissions data were available in the sustainability or corporate social responsibility reports of each firm, to be regarded as character information disclosed voluntarily by companies. All the information needed to build this sample was selected from the annual accounts or financial information submitted by companies on their websites for 2008, 2009, and 2010.

4.2. Variables

4.2.1. Dependent variable: financial and operational performance

This research analyzes the impact of the variation in GHG emissions on corporate performance, the dependent variable. Among the main proxies for this variable, Table 1 shows those used in different international studies.

Table 1
Performance proxies.

Authors	Corporate performance
Cohen et al. (1995)	ROA, ROE
Hart and Ahuja (1996)	ROS, ROA, and ROE
Russo and Fouts (1997)	ROA, ROE, and ROS
Edward (1998)	ROE
King and Lenox (2002)	ROA and Tobin's q
Wagner et al. (2002)	ROS, ROE, and ROCE
Telle (2006)	ROS
Nakao et al. (2007)	ROA and ROE
Zhang et al. (2008)	ROE
Horváthová (2010)	Tobin's q
Wang et al. (forthcoming)	Tobin's q
Gallego-Álvarez et al. (2011)	ROA
Lannelongue, (forthcoming)	ROA, ROE, and Profits

ROA: Return on Assets; *ROE*: Return on Equity; *ROS*: Return on Sales; *ROCE:* Return on Capital Employed.

Table 1 shows that a great deal of research has used accounting measures such as ROA and ROE. Wang et al. (forthcoming) used Tobin's q as this outcome measure takes into account market expectations and financial risk, while Horváthová (2010) supported that Tobin's q is used to measure corporate financial performance based on market value. Nevertheless, the dependent variables are measured by using the proxies of ROE as a measure of financial performance and ROA as a measure of operational performance. *ROE* is calculated as the ratio between net income and stockholders' equity. *ROA* is calculated as the ratio between operating income and total assets. Therefore, the dependent variable in this analysis focuses on accounting and not on market variables.

4.2.2. Independent variable: variation in GHG emissions

The following measures of environmental performance have been used in previous studies: emissions of toxic chemicals (Hamilton, 1995; Hart and Ahuja, 1996), total emissions, relative industry emissions (King and Lenox, 2001), GHG emissions (Busch and Hoffmann, 2011; Delmas and Nairn-Birch, 2011), and the ratio of CO_2 emissions to plant sales (Lannelongue et al., forthcoming).

Concretely, in the present study and in accordance with Börjesson and Tufvesson (2011), Busch and Hoffmann (2011), Delmas and Nairn-Birch (2011), and Wang et al. (forthcoming), the independent variable is represented by the variation (increase or decrease)[2] in GHG emissions (***VAREMISS***) from 2006 to 2009, as shown in Appendix 2. These emissions were calculated by 2006/2007 (t) for 2008 ($t+1$), by 2007/2008 (t) for 2009 ($t+1$), and by 2008/2009 (t) for 2010 ($t+1$). In contrast to previous studies that have focused on a single country, the study found a strong imbalance in the dissemination of information internationally, especially around 2000. This absence of information prevented from obtaining previous data, since most companies have not begun to disclose this kind of voluntary information until recently. For this reason, this research considers this period of time from 2006, which was the most recent complete year for which emissions data were available in the sustainability or corporate social responsibility reports of each firm. Furthermore, this lack of availability of data has been highlighted by the Carbon Disclosure Project[3]. Hence, from 2006 emissions data were available at the international level for different countries (i.e., Germany, the United Kingdom, Japan, France, Canada, and the United States).

The choice of the measure of variation in GHG emissions is justified by the great current importance for companies and society at large to know the extent to which companies are decreasing their GHG emissions. In this sense, Brinkman et al. (2008) recognized that companies' efforts to reduce GHG emissions can lead to a systematic change in the business environment for two reasons. First, this issue is quickly becoming a major concern for key stakeholders such as governments, customers, and investors, which means that companies have to be vigilant and act proactively regarding this topic. Second, the regulatory effect of carbon may increase the cost to industry and thus policymakers will have to make decisions. It is, therefore, not only a subject that involves the corporate world, but also one in which governments have decision-making power.

For example, Hoffman (2005) identified a number of benefits of GHG reduction for companies such as the increase in their reputation; the creation of new market opportunities that can improve company morale, skills, and worker productivity; influence on the regulation of climate change; improvement in access to new sources of capital; and reduction in financial risk. Similarly, Escobar and Vredenburg (2011) showed that environmental strategies lead to a decrease in legal liability, costs, and risk exposure.

As before, the data used to represent GHG emissions were obtained from the sustainability reports, sustainable development reports, and corporate social responsibility reports presented by each company on its website, and the unit used by companies to measure emissions is metric tonnes.

4.2.3. Control variables

In terms of control variables, this study includes company size, sector, growth, sustainability index, and legal system. With respect to size (***SIZE***), King and Lenox (2001) proxied size by using the natural log of firm assets. Activity sector (***SECTOR***) as a control variable was included by Hart and Ahuja (1996) but not by King and Lenox (2001). The corporate growth rate (***CORPGROWTH***) measured as the firm's annual change in sales (Russo and Fouts, 1997; King and Lenox, 2001) was included. The other control variables used to test the hypotheses raised are the Dow Jones Sustainability Index (***DJSI***) and the legal system (***CIVILLAW***). The ***DJSI*** assesses the major environmental, social, and financial companies around the world that are committed to sustainability and show respect for the legal system. The sample includes companies from several countries representing diverse historic, cultural, social, economic, and institutional environments (Hope, 2003; Ding et al., 2005; Maijoor and Vanstraelen, 2006; Jackson and Deeg, 2008). Moreover, to analyze the country effect more deeply, the classification of legal origin defined by La Porta et al. (2008) is used. In line with previous research, the dummy variable of legal origin distinguishes civil law countries such as France, Germany, Italy, and Spain (coded 1) and common law countries such as the United Kingdom and the United States (coded 0).

4.3. Analysis techniques

To test the proposed hypotheses, two regression models for the panel data were estimated. According to Hsiao (2007), panel data models allow (i) to obtain a more accurate inference, because a larger number of observations are used, and thus there are more degrees of freedom and the efficiency of the model is enhanced; (ii) to control omitted variables (missing or unobservable), and also to capture the unobservable heterogeneity among individual units or over time; and (iii) to derive more accurate predictions for individual outcomes.

Using panel data enables to assess firm performance over time by analyzing observations from several consecutive years for the same sample companies. Moreover, considering the temporal dimension of the data, particularly in periods of great change, enriches the study. In this regard, panel data enable to control for the effects that sustainable practices may experience each year, providing the analysis with a certain degree of dynamism and achieving both greater consistency and better explanatory power. Panel data also allow obtaining more information on the same parameter, leading to greater efficiency.

The parameters were estimated consistently (and standard error) in the model in order to lead to valid inferences. In this way, this research relies on the literature for estimators that can deal with different endogeneity problems. However, even the most robust methods are not able to deal with all endogeneity problems, given the inconsistency of the model. Indeed, Pindado and Requejo (2012) stated that panel data are adequate for model specification and testing but warn against making predictions, because in the estimation process part of the error term (i.e., the unobservable heterogeneity) was eliminated. Lee (2006) argued that the consistency of parameter estimators and validity of their economic interpretations as marginal effects depend on the correct functional form specification and controlling for unobserved heterogeneity. It is applied the Hausman specification test to determine which one (random or fixed) is the correct model that controls for this heterogeneity in the model as per Lee (2006).

Another concern is about the representativeness of the sample. The data were collected as per their availability on the company's websites. According to Barros (2005), a priori, it cannot be generalized these results because they may not represent the population studied. However, this limitation does not invalidate the analysis, as it can assume that the results are valid for companies with the same characteristics of those in this sample.

With the aim of analyzing the impact of variation in GHG emissions on financial and operational performance, Models 1 And 2 are proposed, respectively:

$$\boldsymbol{ROE} = f(\boldsymbol{VAREMISS},\ Control\ variables) \tag{1}$$

$$\boldsymbol{ROA} = f(\boldsymbol{VAREMISS},\ control\ variables) \tag{2}$$

These models can be empirically estimated by using the following equations:

$$\mathbf{ROE_{it}} = \beta_0 + \beta_1 \mathbf{VAREMISS_{it}} + \beta_2 \mathbf{SIZE_{it}} + \beta_3 \mathbf{SECTORk_{it}} + \beta_4 \mathbf{CORPGROWTH_{it}} + \beta_5 \mathbf{DJSI_{it}} + \beta_6 \mathbf{CIVILLAW_{it}} + \beta_7 \mathbf{YEAR_{it}} + \varepsilon \quad \text{(Model 1)}$$

$$\mathbf{ROA_{it}} = \beta_0 + \beta_1 \mathbf{VAREMISS_{it}} + \beta_2 \mathbf{SIZE_{it}} + \beta_3 \mathbf{SECTORk_{it}} + \beta_4 \mathbf{CORPGROWTH_{it}} + \beta_5 \mathbf{DJSI_{it}} + \beta_6 \mathbf{CIVILLAW_{it}} + \beta_7 \mathbf{YEAR_{it}} + \varepsilon \quad \text{(Model 2)}$$

where:

i refer to the firm and *t* is time;
$\boldsymbol{ROE_{it}}$ is a numerical variable that represents the financial performance measured by the ratio between net income and stockholders' equity;
$\boldsymbol{ROA_{it}}$ is a numerical variable that represents the operational or economic performance measured by the ratio between operating income/total assets; β are the parameters to be estimated;
$\boldsymbol{VAREMISS_{it}}$ represents GHG emission variation;
$\boldsymbol{SIZE_{it}}$ is a numerical variable that represents corporate size;
$\boldsymbol{SECTORk_{it}}$ is a dummy variable that represents company sector;
$\boldsymbol{CORPGROWTH_{it}}$ is a numerical variable that represents corporate growth;
$\boldsymbol{DJSI_{it}}$ is a dummy variable that represents the Dow Jones Sustainability Index;
$\boldsymbol{CIVILLAW_{it}}$ is a dummy variable that represents the country's legal system.

5. Results

This section analyzes the main findings of the current study. First, the descriptive statistics and frequency of activity sector are shown. Second, the results obtained in the model estimations are described in detail.

5.1. Univariate analysis

As shown in Tables 2 and 3, the descriptive statistics for the dependent, independent, and control variables present the mean, standard deviation, and absolute and relative frequency. From

Table 2
Descriptive analysis.

Variable	Mean	Standard deviation
*ROE*_2008	0.0524	0.6472
*ROE*_2009	0.0844	0.2241
*ROE*_2010	0.1379	0.2459
*ROA*_2008	0.1016	0.2588
*ROA*_2009	0.0434	0.0640
*ROA*_2010	0.0826	0.1615
VAREMISS	−0.0183	0.2012
SIZE	10.73	0.384
CORPGROWTH	−0.2867	2.3364

Table 2, it can be interpreted firm performance as not having declined in the crisis period, especially when it is measure financial performance by ROE. ***ROE*** presents an increase from a mean performance, showing 0.0524 in 2008 and 0.0844 in 2009 (the years in which the crisis was most accentuated according to the International Monetary Fund, 2013), and increases once more in 2010 with a mean value of 0.1379. However, the mean performance of firms in the years of the economic crisis decreases a great deal as measured by operational performance (***ROA***). In this case, the biggest decrease takes place in 2009 with a mean value of 0.0434, followed by a slight recovery in 2010. It can also be observed that the average value decreases in sales growth (−0.2867) and a decrease occurs in emission variations (−0.0183) during the period investigated.

From the data for the industry variables (see Table 3), the activity sectors with the most influence in the sample are petroleum refining (19.1%), motor vehicles and parts (19.1%), and aerospace (11.2%), whereas that with the least weight is energy (4.5%).

5.2. Multivariate analysis

Several statistical assumptions are used to analyze the regression. In regard to normality, the Kolmogorov–Smirnov test is applied and finds that the variables do not show a normal distribution. This situation is also reflected in the normal distribution graph. According to Green (1999), the assumption of normality may be considered to be unnecessary to obtain most of the results found in multiple regression analysis.

In terms of heteroscedasticity, Hair et al. (1999) recognized that this constitutes common the non-fulfilment of the statistical models in regressions. The usual way to alleviate heteroscedasticity is by transforming the variables (e.g., changing to an inverse variable or transforming the variable into a logarithm). This last measure is used in the variable ***SIZE*** for the sample.

Regression analysis on the panel data was developed from 2008 to 2010; for this panel, the random-effects model was used. This model was chosen after an analysis of the Hausman test, which suggested that there is no systematic difference between random effects and fixed effects (Prob > chi2 > 0.05). The random-effects model is more appropriate when there is no correlation between the fixed effects and model variables, and this enables to obtain more efficient coefficients. Furthermore, it assumes that the variables are non-random and not correlated with the explanatory variables (Green, 1999). Moreover, the random-effects model is more efficient (the variance of the estimate is low) but less consistent than the fixed-effects model. In other words, it is more accurate for calculating the parameter value but this may be more biased than the fixed-effects model.

From a statistical point of view, the utilization of panel data fixed effects is a reasonable method because they always provide consistent results, but may not be the most efficient model to run. Random effects show better results for *p*-values because they are more efficient estimators; therefore, random effects should be used if there is statistical justification.

The Hausman test checks the null hypothesis of the absence of correlation between the individual effects and independent variables. When it is not rejected, the higher degree of efficiency in the estimation leads to the use of the random-effects model. In order to observe the effect of the years as well as the sectors in this study, the random effects were used.

With regard to the explanatory power of the model (R^2), Green (1999) considered an R^2 of 0.5 to be relatively high, although whether a regression gives a good fit to the model depends on the framework. In the proposed models, the highest R^2 values obtained are 0.2641 and 0.2669. Therefore, they are not considered to be bad models. In this sense, Patten (2002) obtained an explanatory power of 0.37992 and considered this to be relatively high. For instance, regarding the reduction of GHG emissions, Hart and Ahuja (1996), O'Connor et al. (2002), and Peters and Romi (forthcoming) all showed R^2 coefficients as low as 0.19, 0.14, 0.16, and 0.18 (in the first study), 0.1113, 0.1980, and 0.2443 (for the second one), and 0.27 (in the third study). However, these values did not nullify the viability of their models since they showed their explanatory capability but not their predictive capability. In the case of social science, a low coefficient of determination does not indicate that the dependent variable and explanatory variables are statistically independent. Indeed, an R^2 may be low if the number of observations (in this case, 267) is reduced and there are some residues of large size, while it is usually low in estimated models using time series variation (in this case, the CO_2 variation). The results of in the model estimations are synthesized in Table 4.

The estimated models allow determining whether the emission variation (reduction) in 2006–2009 positively affected financial performance (model 1) and operational or economic performance (model 2) from 2008 to 2010. Regarding model 1, financial performance is measured by ***ROE*** and explained by ***VAREMISS*** and the rest of the control variables. From this model, it can be obtained empirical evidence about the impact of the variation in GHG emissions (reduction) on financial performance. Concretely, the findings show that ***VAREMISS*** has a significant and positive effect at a confidence level of 90% (p-value < 0.10) with the dependent variable ***ROE***. Therefore, in view of this result, it can support the assertion that those companies that are more proactive in environmental issues, such as GHG emission reductions, can achieve competitive advantage and thus better financial performance. Therefore, in view of this finding, it cannot be rejected H1, which proposed that an emission reduction would increase financial performance.

Moreover, two control variables are statistically significant. Specifically, a statistically significant positive effect at a confidence

Table 3
Frequency.

Variable	Absolute	Relative
Saeroespace	10	11.2%
Sairlines	5	5.7%
Schemical	8	9%
Senergy	4	4.5%
Sindustrial	6	6.7%
Smetals	6	6.7%
Smining	8	9%
Smotors	17	19.1%
Spetroleum	17	19.1%
Sutilities	8	9%

Table 4
Results obtained from the models.

Random effects	Dependent variables			
Independent variables	Model 1 ROE		Model 2 ROA	
	COEF	P value	COEF	P value
Varemiss	**0.234**	**0.077*****	−0.0175	0.754
Size	−0.0377	0.606	**−0.077**	**0.022****
Aerospace and defence	0.1327	0.321	−0.031	0.646
Airplanes			−0.12	0.118
Chemical	0.0294	0.833	−0.0772	0.265
Energy	0.0716	0.665	−0.0337	0.643
Industrial and farm equipment	0.109	0.45		
Metals	−0.0584	0.0691	−0.0772	0.293
Mining crudeoil production	−0.123	0.38	0.096	0.162
Motorvehicles and parts	0.004	0.971	−0.074	0.231
Petroleum refining	0.0797	0.528	0.0604	0.328
Utilities	0.053	0.705	−0.045	0.5
Corp growth	**0.0407**	**0.0000*****	−0.001	0.817
Djsi	0.0847	0.147	0.0139	0.608
Civil law	**−0.11381**	**0.053****	0.0159	0.558
Year08	−0.634	0.298	0.0159	0.526
Year09	−0.038	0.0613	**−0.041**	**0.0990***
_cons	0.6700	0.4020	0.918	0.014
R^2	**0.2641**		**0.2669**	

Significant coefficients are in bold. *p value <0.1 and significant at 10%, **p value <0.05 and significant at 5%, ***p value <0.01 and significant at 1%.
ROE Wald Chi-squ. = 31.27** ROA Wald Chi-squ. = 36.24***.
ROE Hausman test Chi-square = 11.02.
ROA Hausman test Chi-square = 3.84.
Models with random or fixed effects are shown, depending on the value obtained for Hausman's test.
$N = 267$.
ROEit is return on equity, measured as the ratio between net income and stockholders' equity; ***ROAit*** is return on asset, measured as the ratio between operating income/total assets; β are the parameters to be estimated; ***VAREMISSit*** represents the variation (increase or decrease) in emissions based on computing the percentage change for each firm in CO_2 emissions according to Hart and Ahuja (1996) (see Appendix 2); ***SIZEit*** is corporate size measured by the log of firm total revenues (annual sales turnover); ***SECTORkit*** is a dummy variable that takes the value 1 if the company belongs to sector k, and 0 otherwise. Ten sectors ($k = 1 \ldots 10$) are considered in this study: aerospace, airlines, chemical, energy, industrial, metals, mining, motor, petroleum, and utilities. ***CORPGROWTHit*** is represented by the firm's annual change in sales; ***DJSIit***, the Dow Jones Sustainability Index, is a dummy variable that takes the value 1 if the company belongs to the said index, and 0 otherwise; and ***CIVILLAWit*** is a variable that refers to the country's legal system to which the company belongs, assigning the value 1 if the firm belongs to a civil law system and 0 if it belongs to a common law system.

level of 99% (p-value < 0.01) for ***CORPGROWTH*** is detected, which means that growth (measured by company sales variation) positively affects financial performance (***ROE***). However, the legal system variable has a negative and statistically significant influence on ***ROE***.

Regarding model 2, the dependent variables represent operational performance measured by ***ROA***. The independent variable ***VAREMISS*** shows a non-significant and negative effect. Therefore, in view of this finding, it can be rejected H2, which proposed that emission reductions would increase operational performance, since the explanatory variable is not significant.

For this model, two control variables are statistically significant. Specifically, ***SIZE*** and ***YEAR 2009*** show a statistically significant negative effect at a confidence level of 95% (p-value < 0.05) and 90% (p-value < 0.10), respectively, which means that in 2009, when the economic crisis was most accentuated, operational performance measured by ***ROA*** was negatively affected. Concerning the rest of the control variables, five show a non-significant and negative effect and the other shows a non-significant and positive effect when the dependent variable is ***ROA***.

In brief, when several years are used to analyze the link between variation in GHG emissions and firm performance, emissions are confirmed to have reduced. This reduction positively influences financial performance, which allows not rejecting H1. By contrast, H2 must be rejected for the period under review, since emission reductions do not affect operational performance.

6. Discussion

The present research reflected on an issue currently considered being of great importance for both private and public organizations as well as society: the monetary impact of environmental practices, especially the link between variation in GHG emissions and financial and operational performance. Moreover, in contrast to previous studies, such as those by Hart and Ahuja (1996), Russo and Fouts (1997), Lannelongue et al. (forthcoming), and Wang et al. (forthcoming), which focused on a single country, this study contributes to literature by examining an international sample of 21 countries, enriching it and enabling it to provide more generalizable results.

For the first time, the empirical evidence obtained has shown that in each time period there was a reduction in CO_2 emissions (as a proxy of environmental practices), especially in 2007/2008 and 2008/2009 (see Appendix 2). At the same time, this study proved that the financial performance of the analyzed companies did not decrease in 2009 when the economic crisis was accentuated according to the International Monetary Fund (2013), and even increased in 2010. However, the situation is different for operational performance, which showed a downward trend in 2009 and a slight improvement in the subsequent year.

Moreover, the assumptions made on how to measure firm performance are a factor to consider. For this reason, this performance was proxied by using financial performance measured by ROE and operational performance measured by ROA. The results showed that emissions variation leads to different impacts on performance. Concretely, from the results obtained when using ROE, emission reductions affect financial performance. Therefore, the initial idea that investments to protect the environment provide few financial benefits to companies cannot be maintained. When financial performance was measured by ROE, the result corroborates those obtained by Hart and Ahuja (1996), Pulver (2007), Stubbs and Cocklin (2008), and Boiral et al. (2012), who found the positive impact of emission reductions on corporate performance. This effect improves business competitiveness and leads to competitive advantage compared with their less proactive competitors. Thus, the results are supported by RBV theory, which states that companies may possess unique resources or capabilities to employ environmental strategies such as emission reductions that are difficult to imitate, leading to competitive advantage and better performance. Indeed, investments in a proactive environmental strategy (e.g., pollution control) can lead to the development of firm-specific capabilities in line with those established by Hoffman (2005) such as increasing their reputation, creating new market opportunities, improving company morale, and increasing skills and worker productivity.

Regarding operational performance measured by ROA, in times of economic crisis, the emission variation of CO_2 does not affect operational performance. This result is in agreement with the reviews of some authors (Cheney and McMillan, 1990; King and Lenox, 2002; Njoroge, 2009), who considered that in times of economic crisis it is necessary to reduce investments in environmental protection projects. This reduction can lower costs and to thus improve corporate performance. For this kind of performance, the finding concurs with the win–lose approach proposed by Boiral et al. (2012), who suggested that companies aim to reduce carbon emissions, resulting in costs that are detrimental to their competitiveness.

The findings of this study can be considered to be of great interest at the international level both because they show a reduction in GHG emissions by firms pertaining to strategic sectors and since a panel model was established to test how the variation in emissions affects firm performance under the RBV theory. However, as in previous research carried out in different countries and with different time periods, the results are not unanimous.

7. Conclusions and limitations

Now, companies are focusing on the promotion of several environmental actions in an attempt to reduce their impacts. However, it cannot be forgeted the monetary aspect of any environmental action. Most companies are willing to allocate resources to environmental projects (such as GHG emission reductions) in order to increase their economic value. This environmental information is essential for businesses, workers, and consumers since it can enhance firm reputation and attract investors, especially in a time of crisis. Workers and consumers also prefer to compare companies that provide this type of information. Companies can also gain access to new sources of capital, since governments are introducing financial incentives to reduce GHG emissions (World Bank, 2013). However, there is no consensus on the effect that such information as well as the promotion of environmental projects has on corporate performance.

Given the inconclusive link between the emission reduction ratio and performance, this research analyzed the variation in carbon emissions shown by companies in their sustainability reports and highlighted how this variation affects financial and operational performance. The empirical evidence was obtained for a sample of 89 international companies from 21 countries in the period 2006–2009. After applying a panel data methodology, the findings supported a reduction in carbon emissions in the analyzed period and the assertion that this variation led to better financial performance. For those more responsible companies, and according to RBV theory, a possible explanation for this financial improvement is the achievement of competitive advantage since sustainable resources and capabilities are rarely imitable by less environmentally proactive competitors. Nonetheless, this variation did not influence operational performance. Thus, in view of these results, it was obtained empirical evidence of the different effects of the variation in carbon emissions on performance, depending on the measure.

That the results vary depending on the measure of corporate performance corroborates the mixed findings of previous research. This contradiction presupposes that research on the relationship between emissions and corporate performance is inconclusive at this time. Nonetheless, it has increased and improved significantly in recent years. Therefore, this line of research will need to be continued in the future.

Theoretically, this study contributes to the literature on GHG emissions, climate change, environmental proactivity, and firm performance. The results of this research complement those obtained in the literature in the sense that there is still no consensus on how a variation in emissions affects corporate performance. In order to demonstrate possible differences depending on corporate performance, it was adopted two alternative proxies for financial performance and operational performance. In addition, the study contributes to the literature since it was developed for an international sample of 21 countries. Finally, the findings of the present study will be of particular interest to company owners who wish to determine the effectiveness of the sustainability decisions of directors and managers as well as to investors and public authorities for assessing the positive impact of environmental actions on the company's reputation and image and thus corporate performance. Managers must understand sustainable investments as a mechanism that allows them to achieve higher performance. The findings also provide the market with an alternative means of assessing environmental ethics.

Nonetheless, certain limitations of this study create interesting challenges for further research. Firstly, this research concerns a limited time period, suggesting that further studies should aim to build more comprehensive panel data. Further, the results obtained herein could be corroborated for another environmental measure, with the aim of achieving robust results. Finally, the different corporate governance, legal, and institutional systems according to countries' characteristics could also be considered in future analysis.

Notes

1. In this paper, the term emission variation refers to emission reduction, since in the years under study, there was a CO_2 reduction.
2. To measure the emission variation, it was computed the percentage of change in emissions for each firm, in accordance with Hart and Ahuja (1996).
3. www.cdp.net

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Appendix A

Appendix 1
Real GDP and projections of real GDP by country in the sample.

Country	2007	2008	2009	2010	2011	2012	2013	2014
UK	3.6	−1.0	−4.0	1.8	0.9	0.2	0.7	1.5
USA	1.9	−0.3	−3.1	2.4	1.8	2.2	1.9	3.0
Canada	2.1	1.1	−2.8	3.2	2.6	1.8	1.5	2.4
Netherlands	3.9	1.8	−3.7	1.6	1.0	−0.9	−0.5	1.1
Italy	1.7	−1.2	−5.5	1.7	0.4	−2.4	−1.5	0.5
France	2.3	−0.1	−3.1	1.7	1.7	0.0	−0.1	0.9
Japan	2.2	−1.0	−5.5	4.7	−0.6	2.0	1.6	1.4
Germany	3.4	0.8	−5.1	3.1	0.9	0.6	1.5	1.2
Russia	8.5	5.2	−7.8	4.5	4.3	3.4	3.4	3.8
Switzerland	3.8	2.2	−1.9	3.0	1.9	1.0	1.3	1.8
South Korea	5.1	2.3	0.3	6.3	3.6	2.0	2.8	3.9
Norway	2.7	0.0	−1.4	0.2	1.3	3.0	2.5	2.2
China	14.2	9.6	9.2	10.4	9.3	7.8	8.0	8.2
Australia	4.6	2.7	1.4	2.6	2.4	3.6	3.0	3.3
Brazil	6.1	5.2	−0.3	7.5	2.7	0.9	3.0	4.0
Mexico	3.2	1.2	−6.0	5.3	3.9	3.9	3.4	3.4
Sweden	3.4	−0.8	−5.0	6.3	3.8	1.2	1.0	2.2
Spain	3.5	0.9	−3.7	−0.3	0.4	−1.4	−1.6	0.7
Portugal	2.4	0.0	−2.9	1.9	−1.6	−3.2	−2.3	0.6
Austria	3.7	1.4	−3.8	2.1	2.7	0.8	0.8	1.6
Poland	6.8	5.1	1.6	3.9	4.3	2.0	1.3	2.2

Source: International Monetary Fund (2013).

Appendix 2
Emission variation by company.

Company	Sector	Country	VGAS 2006/2007	VGAS 2007/2008	VGAS 2008/2009
BAE systems	Aerospace and defense	UK	0.035	0.200	0.158
Boeing	Aerospace and defense	USA	−0.040	−0.046	−0.008
Bombardier	Aerospace and defense	Canada	−0.029	−0.100	−0.073
EADS	Aerospace and defense	Netherlands	0.140	0.006	−0.118
Finmeccanica	Aerospace and defense	Italy	0.160	0.396	0.169
Lockheed Martin	Aerospace and defense	USA	0.009	−0.058	−0.066
Northrop Grumman	Aerospace and defense	USA	0.100	−0.200	−0.287
Raytheon	Aerospace and defense	USA	0.093	−0.135	−0.216
Thales group	Aerospace and defense	France	0.025	−0.070	−0.094
United Technologies	Aerospace and defense	USA	0.045	−0.065	−0.107
Airfrance-KLM	Airlines	France	−0.038	−0.065	0.055
AMR	Airlines	USA	0.016	−0.110	0.000
Brithis Arways	Airlines	UK	−0.066	−0.006	0.060
Japan Airlines	Airlines	Japan	0.060	0.171	0.090
Lufthansa	Airlines	Germany	0.003	0.102	0.104
Akzo Nobel	Chemical	Netherlands	0.038	−0.080	−0.912
BASF	Chemical	Germany	−0.050	−0.247	−0.898
BAYER	Chemical	Germany	0.010	−0.013	−0.003
Dow Chemical	Chemical	USA	−0.005	−0.216	−0.043
DUPONT	Chemical	USA	0.020	−0.651	−0.169
Evonik Industries	Chemical	Germany	−0.016	−0.038	−0.023
Linde Group	Chemical	Germany	−0.014	−0.014	0.000
Mitsubishi Chemical Holding	Chemical	Japan	0.032	−0.067	−0.098
Constellation Energy	Energy	USA	−0.004	−0.164	−0.167
E.ON	Energy	Germany	−0.076	0.216	0.309
Gazprom	Energy	Russia	−0.010	−0.345	0.075
RWE	Energy	Germany	0.150	0.000	−0.160
ABB	Industrial and farm equipment	Switzerland	0.090	−0.011	−0.101
Caterpillar	Industrial and farm equipment	USA	0.036	0.000	−0.037
Hyunday Heavy Ubdustrues	Industrial and farm equipment	South Korea	−0.060	0.113	0.189
John Deere	Industrial and farm equipment	USA	0.080	−0.086	−0.161
Komatsu	Industrial and farm equipment	Japan	0.052	0.100	0.042
Mitsubishi Heavy Industries	Industrial and farm equipment	Japan	−0.030	−0.148	−0.011
ALCOA	Metals	USA	0.018	−0.008	−0.027
Baosteel Group	Metals	China	−0.100	0.000	0.104
JFE Holding	Metals	Japan	−0.060	−0.410	0.006
Kobe Steel	Metals	Japan	0.040	−0.145	−0.179
Nippon Steel	Metals	Japan	−0.030	−0.086	−0.058
Norsk Hydro	Metals	Norway	−0.026	−0.258	−0.041
Anglo American	Mining, crude-oil production	UK	0.290	−0.193	−0.431
BHP Billiton	Mining, crude-oil production	Australia	−0.003	0.035	0.038
CVRD	Mining, crude-oil production	Brazil	−0.078	0.440	0.553
Encana	Mining, crude-oil production	Canada	0.230	0.535	0.179
Occidental Petroleum	Mining, crude-oil production	USA	−0.006	0.019	0.025
Pemex	Mining, crude-oil production	Mexico	−0.120	0.248	0.401
RIO Tinto Group	Mining, crude-oil production	UK	0.000	0.148	0.148
Xstrata	Mining, crude-oil production	Switzerland	−0.380	0.000	0.385
Ainsi Seiki	Motor vehicles and parts	Japan	−0.040	0.099	0.150
BMW	Motor vehicles and parts	GERMANY	0.018	−0.076	−0.093
Continental	Motor vehicles and parts	Germany	−0.050	−0.049	0.000
Daimler	Motor vehicles and parts	Germany	0.026	−0.039	−0.064
Fiat	Motor vehicles and parts	Italy	−0.350	−0.177	0.112
Ford	Motor vehicles and parts	USA	0.085	−0.077	−0.156
General Motors	Motor vehicles and parts	USA	0.170	0.000	−0.179
Hyunday Motor	Motor vehicles and parts	South Korea	0.200	0.087	−0.132
Honda Motor	Motor vehicles and parts	Japan	−0.014	−0.374	−0.366
Johnson Controls	Motor vehicles and parts	USA	0.020	−0.023	−0.013
Man Group	Motor vehicles and parts	Japan	0.270	0.682	0.217
Peugeot	Motor vehicles and parts	France	0.018	−0.042	−0.060
Robert Bosch	Motor vehicles and parts	Germany	−0.070	0.004	0.076
Suzuki Motors	Motor vehicles and parts	Japan	0.200	−0.094	−0.284
Toyota Motor	Motor vehicles and parts	Japan	−0.012	−0.152	−0.163
Toyota Industries	Motor vehicles and parts	Japan	−0.020	−0.197	−0.157
Volvo	Motor vehicles and parts	Sweden	0.090	0.200	0.091
BP	Petroleum refining	UK	0.002	−0.102	−0.039
Cepsa	Petroleum refining	SPAIN	0.004	0.021	0.037
Chevron	Petroleum refining	USA	0.010	−0.018	−0.031
CHINA National Petrolium	Petroleum refining	China	0.043	0.000	−0.044
Conocophillips	Petroleum refining	USA	−0.001	0.027	0.029
ENI	Petroleum refining	ITALY	−0.100	−0.075	0.019
Exxon Mobil	Petroleum refining	USA	−0.030	−0.071	−0.910
GALP Energia	Petroleum refining	Portugal	0.026	−0.050	−0.023
NIPPON Mining Holding	Petroleum refining	Japan	0.043	−0.015	0.028

(*continued on next page*)

Appendix 2 (*continued*)

Company	Sector	Country	VGAS 2006/2007	VGAS 2007/2008	VGAS 2008/2009
OMV Group	Petroleum refining	Austria	0.120	−0.008	−0.032
Petro-Canada	Petroleum refining	Canada	0.035	−0.999	0.035
Petrobras	Petroleum refining	Brazil	0.016	−0.009	0.073
PKN Orlen Group	Petroleum refining	Poland	0.040	−0.018	−0.060
Repsol YPF	Petroleum refining	Spain	−0.030	−0.031	0.002
Royal Dutch Shell	Petroleum refining	Netherlands	0.060	−0.109	−0.128
SK Holding	Petroleum refining	South Korea	−0.050	0.000	0.055
Sunoco	Petroleum refining	USA	−0.019	−0.295	−0.083
Centrica	Utilities	UK	−0.740	−0.016	0.918
ÉLECTRICITÉ DE FRANCE	Utilities	France	0.017	0.170	0.087
GAZ DE FRANCE	Utilities	France	−0.005	−0.126	−0.121
Korea Electric	Utilities	South Korea	−0.200	−0.025	0.170
National Grid	Utilities	UK	0.120	0.187	0.039
Scottish & Southern Energy	Utilities	UK	−0.020	−0.122	−0.099
Vattenfall	Utilities	Sweden	0.003	−0.024	−0.027
Veolia Environnement	Utilities	France	−0.030	0.195	0.293
Total			0.39	−3.048	−2.226

Source: The authors.

Appendix 3
List of acronyms.

Acronym	Meaning
CO_2	Carbon dioxide
ROE	Return on equity
ROA	Return on assets
ROS	Return on sales
ROCE:	Return on capital employed
RBV	Resource-based view
DJSI	Dow jones sustainability index

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