The impact of multi-dimensional environmental performance on firm performance and risk

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Abstract

This paper investigates the effect of multi-dimensional corporate environmental performance (CEP) on firm's financial performance and risk. Considering two dimensions of CEP as environmental management performance (EMP) and environmental operational performance (EOP), we find an inverted U-shaped relationship between carbon performance and Tobin's Q, and a positive relationship between EMP and Tobin's Q. Our findings also provide evidences for the moderation effect of EMP on the EOP-Tobin's Q relationship. We also find a significant positive relationship between the carbon performance and firm risk within manufacturing industries and an inverse relationship within service industries. Our study demonstrates that different dimensions of CEP have different impacts on firms' financial performance and risk. It highlights the need to consider the complex relationship between outcome and process-based environmental performance with complex empirical models to derive substantial conclusions.

Keywords: Environmental management performance; Carbon performance; Multidimensionality; Financial performance; Firm risk

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1. Introduction

For the past few decades, research scholars have shown considerable interest in corporate environmental performance (CEP) and its impact on corporate financial performance (CFP). Previous research has studied the constitution of CEP and examined its relationship with various constructs of organizational performance (e.g. Clarkson, Li, Richardson, & Vasvari, 2008; Gomez-mejia, 2016; Horváthová, 2012; Kassinis & Vafeas, 2006; Trumpp, Endrikat, Zopf, & Guenther, 2015; Tyteca, 1997). In particular, an intense interest in the economics and management area focuses on the link between the firm's environmental performance and financial performance, and debate centres on the theoretical arguments to answer the question of whether "it pays to be green" (e.g. Dixon-Fowler, Slater, Johnson, Ellstrand, & Romi, 2013; Endrikat, Guenther, & Hoppe, 2014; Horváthová, 2010) or whether "it costs to be green" (e.g. King & Lenox, 2002; Preston & O'Bannon, 1997; Waddock & Graves, 1997). Later, debate centred on the fact that the relationship between CEP and CFP may in fact not be linear, meaning that the relationship could change direction from positive to negative, or vice versa (Wagner, Phu, Azomahou, & Wehrmeyer, 2002). Trumpp and Guenther (2015) summarize the non-linear CEP-CFP relationship as the "too-much-of-a-good-thing" (TMGT) effect or the "too-little-of-a-good-thing" (TLGT) effect. The complex nature of and inconsistent empirical evidence on the CEP-CFP relationship highlights the need for a greater depth of understanding concerning the theoretical foundation for the construct of CEP, and further clarification of the reliability of its dimensionality (Trumpp & Guenther, 2015; Trumpp et al., 2015; Walls, Phan, & Berrone, 2011).

Following the suggestions that CEP is a multidimensional construct, researchers recognize that it consists of at least two dimensions - environmental management performance (EMP) and environmental operational performance (EOP) - and that each dimension can be measured by various indicators (Busch & Hoffmann, 2011; Clemens & Bakstran, 2010; First & Khetriwal, 2010). While further studies on the impact of EMP and EOP on CFP enhanced our understanding of the CEP-CFP relationship, the results of such studies are still inconclusive. There are also arguments on whether EMP and EOP are interdependent on or independent of each other.

Moreover, only focusing on corporate financial performance in the study of the impact of CEP is flawed. A firm's economic performance demonstrates itself not only in financial returns but also in firm risk. Although many studies examine the relationship between corporate social responsibility (CSR) and firm risk (e.g. Oikonomou, Brooks, & Pavelin, 2009; Orlitzky & Benjamin, 2001; Salama, Anderson, & Toms, 2011) and find in general an inverse relationship between CSR and firm risk, only few focus particular on the firm's environmental performance (e.g. Cai, Cui, & Jo, 2015). While a number of studies investigated the impact of environmental performance information on the banks' risk assessment and lending decision (Campbell & Slack, 2011; Thompson & Cowton, 2004), no study thus far has comprehensively addressed the construct of CEP and its association with firm risk.

The aim of this paper is to generate insights into how different dimensions of CEP impact UK firms' overall economic performance including financial return and risk. Specifically, using a multi-industry sample of UK companies on the FTSE ALL SHARE from 2004 to 2013, we focus on testing three areas in this study:

- The impact of EMP and EOP on CFP and firm risk;
- The moderation effects of EMP on the relationship between EOP and corporate economic performance including CFP and firm risk; and
- The potential cross-industry variation in the above relationships.

The potential impact of CEP on firm risk has received scant attention in CEP literature. There has been very little work in the CEP-CFP relationship literature that comprehensively studied the interaction of the two dimensions of CEP - namely EMP and EOP - and the impact of such interaction on corporate economic performance including financial returns and firm risk. Thus, the paper makes a contribution to the literature on CEP and its impact by applying a refined theoretical framework and offering detailed empirical evidence. Apart from the research community, our results have particular relevance for policy-makers, companies and stakeholders who are concerned with the impact of CEP. Policy-makers could be better informed of the market reactions to companies' environmental performance, which reflect on not just financial performance but also firm risk. A fuller picture of the impact of CEP on firms' economic performance can be beneficial for investment and resource allocation decision-making. Companies and stakeholders would appreciate a clearer picture of whether and when firms' environment management strategies and the related outputs generate economic returns in terms of both financial performance and risk.

The remainder of this paper is structured as follows. In section 2, we describe the literature base on which we develop our hypotheses. In section 3, we present our data, variables and models used to test the CEP, financial performance and firm risk relationship. Following this, we present and discuss the empirical results in section 4. In the final section, we discuss the implications and limitations of this study and set out our overall conclusions.

2. Literature review and hypotheses development

2.1 Multi-dimensional corporate environmental performance

Corporate environmental performance (CEP) is the 'measurable results of an organization's management of its environmental aspects' (ISO, 2013). Literature suggests that CEP is a multidimensional construct and consists of at least two dimensions; namely environmental management performance (EMP) and environmental operational performance (EOP) (ISO, 2013; Trumpp et al., 2015; Xie & Hayase 2007). Based on stakeholder theory, it is argued that the stakeholder may react differently to firm's EMP and EOP; hence it is necessary to examine the different roles played by these two environmental dimensions separately (Misani & Pogutz, 2015). The EOP dimension represents the operational level of performance and focuses on the outcomes. Based on the various characteristics of the environmental issues a firm faces, different stakeholders might pay attention to different issues and the firm could enact different responses according to its capability. Hence EOP itself appears to be multidimensional, making it difficult to apply a single indicator to represent all the dimensions (Fujii, Iwata, Kaneko, & Managi, 2013; Misani & Pogutz, 2015; Trumpp et al., 2015). The indicators used in previous studies include waste intensity, CO2 emission, toxic emission, and water pollution, among others. Following previous studies (Busch & Hoffmann, 2011; Misani & Pogutz, 2015), we focus on carbon performance as the indicator of EOP dimension. Carbon performance has a direct link with climate change which is a global concern for human beings. Carbon performance has become a strategic issue for companies and has attracted increasing attention from stakeholders (Clemens & Bakstran, 2010).

The measures of EMP could be comprehensively captured from the elements of environmental management systems. After comprehensive examination of the framework of CEP construct, Trumpp et al. (2015) conduct factor-analysis using a two-dimension framework incorporating EMP and EOP. They suggest that, based on the elements of firms' environmental management system, the EMP dimension could be measured by indicators in five sub-dimensions – these are environmental policy, environmental objectives, environmental processes, organizational structure, and environmental monitoring.

Some research further suggests that these two dimensions are interdependent, since a firm's environmental management system identifies the firm's specific management environment; hence the EMP dimension mainly indicates the capability and effort a company invests in attempting to improve its environmental impacts (Trumpp et al., 2015). However, other studies find that EMP and EOP are independent of each other and offer possible explanations. First, as remarked by Delmas, Etzion and Nairn-Birch (2013), although proactive EMP represents a potential of improvement in the outcome, there is no guarantee that the materialization of such improvement would happen in a short time. Second, it is possible that firms with proactive EMP may aim to improve their reputation and moderate the relationship with various stakeholders such as customers and shareholders rather than actually reduce their environmental burdens (Jung, Kim, & Rhee, 2001; Xie & Hayase, 2007).

Hence, given the multi-dimensional nature of CEP, one could not transfer the results yielded by one dimension to the other, or infer conclusions regarding the overall construct using results captured by measures from one dimension. In this study, we incorporate separate measurements for the EMP and EOP dimensions to examine the impact of CEP on a firm's economic performance.

2.2 CEP and CFP

As one mainstream strand of environmental performance literature, economic and management scholars have paid extensive attention to the relationship between CEP and corporate financial performance (CFP), and found inconclusive results. The negative relationship between CEP and CFP indicates that "it costs to be green", and several theoretical explanations have been provided for this, including trade-off hypothesis, managerial opportunism hypothesis, and stakeholder activities against the firm. The trade-off hypothesis argues that because the environmental activities require additional input and are not directly related to the financial performance, the economic benefits of better environmental performance could not cover its costs and the additional environmental investment reduces the firm's market competitiveness (Fujii et al., 2013; Preston & O'Bannon, 1997; Waddock & Graves, 1997). Later, King and Lenox (2002) indicate that the improvement of CEP could conflict with the firm's primary target to maximize the shareholder value; and managers might choose to reduce environmental investment when their remuneration schemes are linked to short-term shareholder value. The instrumental stakeholder theory provides another explanation where, regarding environmental issues, different stakeholders have different expectations which could generate extra costs and lead to negative financial performance (Jones, 1995; Trumpp & Guenther, 2015).

On the other hand, based on Porter and van der Linde's (1995) argument, a win-win hypothesis is developed to explain the positive relationship between CEP and CFP which demonstrates that, due to the implementation of governmental regulation, companies with higher environmental efficiency would generate competitive advantage in the long term (Guenther & Hoppe, 2014; King & Lenox, 2001; Wagner & Schaltegger, 2004). Furthermore, the natural-resource-based view (NRBV) explains that, if companies pursue proactive environmental strategies, this could lead to a competitive advantage if the environmental strategy is supported by firms' organizational capabilities (Clarkson, Li, Richardson, & Vasvari, 2011; Dixon-Fowler et al., 2013; Hart, 1995; Hart & Ahuja, 1996; Sharma & Vredenburg, 1998). In addition, the instrumental stakeholder theory also offers an explanation for the positive CEP-CFP relationship in that the visible improvement of CEP could increase firms' reputation among stakeholders hence leading to a positive influence on CFP. The above theoretical considerations for both positive and negative relationships between CEP and CFP are each supported by a large number of empirical studies. However, empirical studies using meta-analyses demonstrate an overall positive relationship between CEP and CFP (Dixon-Fowler et al., 2013; Endrikat et al., 2014).

Later on, Wagner et al. (2002) argue that the relationship between CEP and CFP may not be linear, meaning that the relationship could change direction from positive to negative, or vice versa. Trumpp and Guenther (2015) summarize that the non-linear CEP-CFP relationship could be explained as the "too-much-of-a-good-thing" (TMGT) effect or the "too-little-of-a-good-thing" (TLGT) effect. The TMGT effect is considered as an explanation of the inverted U-shaped relationship where, after the point at which CFP is at its maximum and CEP reaches its optimum level, the increase of environmental performance would cause a decrease in financial performance as the additional benefit could not cover the costs required to achieve the improvement. The TLGT effect explains the U-shaped relationship as, after arriving at a certain level of CEP where CFP is at its minimum, the CEP-CFP relationship becomes positive, which might reflect the firm's choice of environmental strategy (Fujii et al., 2013). Reactive environmental strategies may generate extra costs, while proactive environmental strategies may lead to a positive relationship. The positive and negative relationship in the TMGT and TLGT effect could also be explained by the win-win hypothesis, the NRBV theory, the instrumental stakeholder theory, and the trade-off hypothesis and managerial opportunism hypotheses.

Given the significant differences between the EMP and EOP dimensions of CEP, scholars suggest that EMP and EOP might have different impacts on CFP, and that the separation of EMP and EOP in studying the CEP and CFP relationship may generate further insights. For example, using questionnaires covering both carbon emissions and carbon management strategies, Busch and Hoffmann (2011) find that the outcome-based measurement (EOP) has a positive relationship with CFP while the process-based measurement (EMP) has a negative relationship. In contrast, Delmas et al. (2013) find that EMP has a positive impact on CFP while EOP shows no significant relationship. More recently, Misani and Pogutz (2015) examined carbon-intensive companies and indicate a non-linear association between carbon performance and CFP; while in terms of EMP, they find a moderation effect on the relationship between EOP and CFP.

In terms of EOP, recent research using carbon performance as the EOP indicator suggests a non-linear relationship with CFP. Trumpp and Guenther (2015) find a U-shaped relationship between carbon performance and CFP; while Tatsuo (2010) and Misani and Pogutz (2015) suggest an inverted U-shaped (bell shaped) relationship between carbon performance and CFP. In this study, we focus on how the carbon performance impacts the firm's financial return; and following King and Lenox (2002) and Misani and Pogutz (2015), we use Tobin's q as a measurement of CFP since it captures the long-term benefits expected by shareholders from investments in improving a firm's carbon performance. Following prior research, we derive the following hypothesis:

Hypothesis 1. The relationship between firms' EOP measured by carbon performance and CFP follows an inverted U-shape (bell shape).

Environmental management performance reflects the management intention and processes for improvement; these, however, are difficult to measure and offer no guarantee of materialization. The direct impact of EMP on CFP is therefore largely neglected in previous studies. However, following the NRBV theory, it is argued that the development of resources and organizational capabilities for improving CEP largely involves the establishment of reputation and other intangible resources which would be reflected in a positive relationship between environmental management system (EMS) and market-based financial performance (Baird, Geylani, & Roberts, 2012; Delmas et al., 2013). Moreover, environmental processes may also influence a firm's relationship with stakeholders. Companies could invest in different activities to improve their EMP such as the establishment of EMS, development of environmentally-friendly innovations, and enhanced sustainability reporting, which will then improve the firm's environmental, social, and governance (ESG) rating, which in turn improves the market-based financial performance (Misani & Pogutz, 2015). Therefore, we derive the following hypothesis:

Hypothesis 2. There is a positive significant relationship between firms' EMP and CFP.

The potential interdependent relationship between EOP and EMP also suggests that environmental processes have a moderation effect on the relationship between the firm's carbon performance and market-based financial performance. When the firm's carbon performance is weak, environmental management could improve the firm's reputation and modify stakeholder perceptions to realise that the materialization of improvements takes time. When the firm's carbon performance is high, the stakeholder may consider the firms with better management performance as highly committed to environmental protection and provide further support in the business. According to Misani and Pogutz (2015), the shareholders and other stakeholders evaluate both a firm's carbon performance and environmental management performance. Therefore, we derive the following hypothesis:

Hypothesis 3. EMP moderates the U-shaped relationship between carbon performance and financial performance.

2.3 CEP and firm risk

Previous research on the relationship between CEP and firm risk is not as well-developed as the research on the CEP-CFP relationship. However, as an important aspect of CSR, the impact of CEP on firm risk may have similar characteristics to the CSR-risk relationship. Moreover, as another aspect of the firm's economic performance, firm risk also shares some similarity with the market-based financial performance; thus the CEP-risk relationship could also be explained by some of the theoretical frameworks discussed in previous sections.

Previous research indicates that CEP could benefit a firm's financial performance by increasing the firm's competitive advantage, improving the its reputation, or gaining stakeholders' support (Busch & Hoffmann, 2011; Clarkson et al., 2011; Fujii et al., 2013; Hart & Ahuja, 1996; Trumpp & Guenther, 2015). Meanwhile, scholars also assert that CSR engagement could benefit firms in different ways including increasing shareholder wealth through insurance-like protection, improved risk management, and improved transparency (Jo & Na, 2012). Some of these benefits may also potentially reduce firm's risk. Instrumental stakeholder theory and NRBV theory indicate that firms with a proactive environmental strategy could improve their reputation since they fulfil the stakeholders' expectation that the environmental processes and activities increase the company's intangible-assets (Clarkson et al., 2011; Sharma & Vredenburg, 1998). Firms with good CSR may be characterized as having a good relationship with a variety of stakeholders, since the environmental outcomes allow firms to anticipate the stakeholders' concerns and then improve their environmental management processes accordingly to reduce the variability of their business returns. Research also argues that relatively high financial risk could be caused by the potential threat of lawsuits or regulatory penalties in response to low corporate environmental and social performance (Orlitzky & Benjamin, 2001). Godfrey (2005) and Godfrey, Merrill and Hansen (2009) suggest that the CSR activities as intangible assets offer reputational benefits and insurance-like protection, and then reduce firm risk. In addition, similar to CSR, firms with better environmental performance are more likely to have more transparent disclosure on the environmental activities and outcome; better disclosure and higher transparency reduce the informational asymmetries between the firms and the investors, hence reducing the firms' risk (Cai et al., 2015). From the access-to-financial-market point of view, Cheng, Ioannou and Serafeim (2014) argue that firms with better CSR performance face significantly lower finance constraints, and improving CSR performance plays an important role in reducing capital constraints. Other studies also find that CSR engagement could reduce firms' cost of capital (Dhaliwal, Li, Tsang, & Yang, 2011; El Ghoul, Guedhami, Kwok, & Mishra, 2011; Goss & Roberts, 2011; Oikonomou, Brooks, & Pavelin, 2014a). Since reduced cost of capital may result from reducing a firm's risk, it is possible that improving environmental performance could help reduce firm risk. The research from the decision-usefulness perspective has also shown evidence of the potential materiality to banks of the environmental performance and risk of loan-book clients (Campbell & Slack, 2011; Thompson & Cowton, 2004).

Similar to the trade-off hypothesis, managers and stakeholders could consider investment in the improvement of CEP as a waste of core business resources which may lead to lower financial performance and higher firm risk. According to the managerial opportunism hypothesis, managers pursuing higher shareholder value would reduce the investment of environmental performance, hence reducing the additional risk, as risk negatively affects CFP. In short, when considering the limitations of business resources and short-term performance, the cost of improving a firm's environmental performance might not be able to generate enough benefits which, in turn, will then increase the firm's risk.

It is also suggested that CEP may have a different impact on firms' risk in the manufacturing and service industries (Salama et al., 2011). When considering the potential cross-industry variation in the CEP and firm risk relationship, Cai et al. (2015) find that environmental engagement in different industries shows different impact on the firm's risk. They argue that the overall negative environmental responsibility and firm-risk relationship is driven by the manufacturing sector, whereas in the service sector, corporate environmental responsibility tends to have a positive association with firm risk. Due to lack of supporting literature on the CEP and firm risk relationship, prior research on CSR-risk and CEP-CFP performance might be able to provide some evidence and theoretical explanations. For example, Jo and Na (2012) examine the relationship between CSR and firm risk in controversial industry sectors[1] and find an inverse relationship. They also compare the difference between non-controversial and controversial industries, and indicate that the inverse relationship between CSR and firm risk is more economically and statistically significant in controversial industries. Much of the research on the CEP-CFP relationship also examines the manufacturing and service industries separately since stakeholders in different industries have different expectations, and their concerns vary depending on the extent of the industries' environmental intensiveness.

In summary, we derive the following hypotheses:

[1] They followed the JBE special issue guideline, and defined controversial firms as the combination of sinful industries (e.g. tobacco, gambling, weapons, alcohol, adult entertainment) and other controversial firms that are inherently entail persistent or emerging environmental, social, or ethical issues (e.g. nuclear, oil, cement, biotech).

Hypothesis 4a. According to the risk-reduction hypothesis, there is a negative relationship between CEP and firm risk.

Hypothesis 4b. According to the resource constraint hypothesis, there is a positive relationship between CEP and firm risk.

Hypothesis 4c. Under the cross-industry context, there is an insignificant relationship between CEP and firm risk; and for companies in manufacturing and service industries the relationships between CEP and firm risk are different.

Regarding the CEP's multidimensional construct, to the best of our knowledge, no literature has studied the impact of EOP and EMP separately on firm's risk. However, we can indirectly acquire some accumulated knowledge from the arguments within some CSR research. For instance, Oikonomou, Brooks, and Pavelin (2014b) argue that, in terms of CSR, firms could simultaneously exhibit both positive and negative indicators and, in this case, stakeholders need to make judgments based on a "mixed picture". Similarly, when assessing the firms' environmental performance, investors and other stakeholders may also find that companies with weak environmental outcomes (i.e. high GHG emission) conduct active environmental management processes, or vice versa. How these two dimensions influence the stakeholders' judgment and their investment behaviour might lead to various effects on firm risk. In some controversial industries, some CSR activities are considered as "window-dressing" for their weak CSR performance or failure to meet basic social expectations (Jo & Na, 2012). When separating the EMP and EOP dimensions, we acquire a clearer understanding of how investors react to the firms' environmental outcomes and activities and provide evidence on how each dimension impacts the firm's risk. Notwithstanding, due to the lack of a theoretical framework and empirical support for the relationship between different dimensions of CEP and firm risk, we make no assumptions at this point regarding the direction of the relationship.

3. Research design

3.1 Data

In order to test the hypotheses and achieve the research objectives, we used a multi-industry sample of companies on the UK FTSE ALL SHARE taken from the Datastream database from 2004 to 2013. In particular, the measure for multi-dimensional CEP is gathered from ASSET4 which provides environmental, social and governance (ESG) information collected through a systematic and standardized process from different sources including annual reports, stock exchange documents, non-governmental organization reports, company websites, and various other sources (Ziegler, Busch, & Hoffmann, 2011). The ASSET4 ESG framework evaluates each company against approximately 700 individual data points which are then combined into over 250 key performance indicators (KPIs). These KPI scores are then aggregated into a framework with 18 categories grouped within four pillars - namely economic, environmental, social and governance - and a single overall score is allocated for each company. In the environment pillar, a company is assigned with 70 KPIs within three categories. To our best knowledge, ASSET4 is the only publicly available database that provides non-aggregated CEP data for UK companies, and the data have been used in previous research (e.g. Misani & Pogutz, 2015; Trumpp & Guenther, 2015; Ziegler et al., 2011).

The dataset from ASSET4 database is merged with the Thomson Datastream database for the financial information, stock prices, and volatilities. After matching the two databases and accounting for gaps and changes in CEP variables and financial variables, the final sample consisted of 1666 firm-year observations from 2004 to 2013. Of these, 939 firm-year observations are from manufacturing industries and 727 belonging to service industries. Table 1 presents the composition of the sample companies by sector and year. The actual samples used in the regression analyses are slightly different since the data availability of the variables varies across different regression models.

Insert TABLE 1 About Here

3.2 Variables

3.2.1 Independent variables

CEP is considered as a multidimensional construct (Endrikat et al., 2014; Trumpp et al., 2015). According to the literature (e.g. Busch & Hoffmann, 2011; Endrikat et al., 2014; Trumpp et al., 2015; Xie & Hayase, 2007), CEP consists of two main dimensions: a process dimension (EMP) and an outcome dimension (EOP). In this study, we incorporate two independent variables to represent the EMP and EOP dimensions.

We use the ASSET4 database to construct our measure of CEP. The environmental score in ASSET4 “measures a company’s impact on living and non-living natural systems… reflects how well a company uses best management practices to avoid environmental risks and capitalize on environmental opportunities” (Thomson-Reuters, 2015), thus it covers the management processes and activities as well as the environmental outcomes. With regard to the EMP dimension, we identified the relevant KPIs in the ASSET4 database that related to environmental management process, activities, policy and reporting and create a sophisticated new score by calculating the equal-weighted average of the relevant indicator scores (EMP) to represent the scope and intensity of a firm's environmental management performance[2]. In doing so, we exclude the KPIs that present the environmental outcomes and non-management-related activities; thus we are confident that the new EMP score is valid as a proxy of the firm's environmental process.

The EOP dimension is considered as the outcome of environmental management activities. Based on this definition, we follow previous research (Fujii et al., 2013) and use environmental efficiency (EE) as our EOP indicator. According to Fujii et al. (2013), EE is defined as the desirable output per environmental input, and represents the "production scale-adjusted environmental pollution"(p. 193). In this study, we use GHG emission to calculate EE. The GHG emissions data were obtained from the ASSET4 database measured as "total CO2 and CO2 equivalents emission in tonnes divided by net sales" (Thomson-Reuters, 2015). Hence the inverse ratio of GHG emissions per net sales was employed as our EE measurement; that is, higher sales per GHG emissions implies higher environment performance.

3.2.2 Dependent variables

Corporate Financial Performance. Our main financial performance measurement is Tobin's Q, which is calculated by dividing the sum of the firm's market capitalization, the book value of its long-term debt, and its net current liabilities by the book value of its total assets (King & Lenox, 2002; Misani & Pogutz, 2015). Tobin's Q reflects the firm's financial performance from the market perspective and measures the market valuation of a firm compared with the replacement costs of tangible assets (King & Lenox, 2002).

Firm Risk. The capital asset pricing model (CAPM) is one of the most notable models developed in finance to determine a theoretically appropriate rate of return on an asset. Following previous literature (i.e. Cai et al., 2015), we use the CAPM beta as the main measure of firm risk which indicates a firm's systematic risk relative to the risk of the stock market in general. To ensure the robustness of our finding, we also use the Fama-French market factor beta as the second measure of firm risk. The Fama-French four-factor model has been widely accepted as the explanation of stock prices in aggregate and investor returns and is extensively applied in both academia and practice (Cai et al., 2015).

3.2.3 Control variables

To further control for other firm characteristics in our CEP-CFP and CEP-risk relationship, we follow previous CEP-CFP (Fujii et al., 2013; Misani & Pogutz, 2015; Nollet, Filis, & Mitrokostas, 2015;

[2] The details of the EMP-related KPIs are listed in Appendix 1.

Trumpp & Guenther, 2015) and CSR-risk studies (Cai et al., 2015; Jo & Na, 2012; Kim, Li, & Li, 2014) to add al list of control variables to our models.

We add ASSET4's corporate governance score (CGSCORE) as a control to measure the company's corporate governance systems and processes since it could influence the shareholders' and investors' views of the firm, hence the firm's financial performance and risk (Misani & Pogutz, 2015). We also add a dummy variable to represent firms that join the United Nations' Global Compact Program (UNGC). This program is the largest voluntary corporate responsibility initiative in the world (Rasche, Waddock, & McIntosh, 2012), and the participants are encouraged to follow environmental, social and governance related principles. Hence, participation in this program could be considered as a proxy for a firm's ESG performance (Misani & Pogutz, 2015; Soleimani, Schneper, & Newburry, 2014). In addition, we include research and development intensity measured as R&D expenses divided by sales (R&D) to represent a firm's innovation capability, as prior research suggests it has an impact on the firm's financial performance and risk (Cai et al., 2015; Fujii et al., 2013; Hart & Ahuja, 1996; Oikonomou et al., 2009; Trumpp & Guenther, 2015).

We then include the natural logarithm of the firm's total assets (SIZE) to control for firm size since previous research suggests that firm size has an impact on the firm's responses to environmental issues (Cai et al., 2015; King & Lenox, 2001; King & Lenox, 2002; Lu, Wang, & Lee, 2013; Wang, Li, & Gao, 2014). We also include cash flow return on sales measured by the firm's net cash flow divided by sales (CASHFLOW), capital intensity by capital expenditures divided by beginning-of-the-year total assets (CAPITAL), leverage by total debts divided by total assets (LEVERAGE), and firm growth by change in total assets divided by beginning-of-period total assets (GROWTH). In order to control for the impact of firm's profitability on firm risk, we also include Tobin's Q as control variable in our CEP-firm risk models.

The definitions and constructions of all the variables are presented in Table 2.

Insert TABLE 2 About Here

3.3 Empirical models

This section presents the econometric models that are used to examine the intertemporal effect of EMP and EOP on financial performance and firm risk. We used ordinary least squares (OLS) regression to test our hypotheses. To alleviate the endogeneity issue and test the causal inference of CEP-CFP and CEP-firm risk relationships, we use a time-lagged measure of CEP. This procedure also allows us to test the long-term effect of CEP on the firms' economic performance, as the improvement of CEP is considered by the investors and capital market after a certain time period

(Fujii et al., 2013; Hart & Ahuja, 1996; Horváthová, 2012; Trumpp & Guenther, 2015). In this study, we use a one-year time lag as the main analysis (n=1) and incorporate a two-year time lag (n=2) as the robustness tests of the results. Furthermore, we centralize the component variables of the interaction terms to reduce potential multicollinearity. Our model specification is as follows:

Environmental Performance on Corporate Financial Performance

$$FP_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \beta_2 * EE^2_{i,t-n} + \delta Z_{it} + \varepsilon_{it} \tag{1}$$

$$FP_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \beta_2 * EE^2_{i,t-n} + \beta_3 * EMP_{i,t-n} + \delta Z_{it} + \varepsilon_{it} \tag{2}$$

$$FP_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \beta_2 * EE^2_{i,t-n} + \beta_3 * EMP_{i,t-n} + \beta_4 * EE_{i,t-n}EMP_{i,t-n} + \beta_5 * EE^2_{i,t-n}EMP_{i,t-n} + \delta Z_{it} + \varepsilon_{it} \tag{3}$$

Here, i denotes the firms and t the periods. Subscript n denotes the year time lag of CEP (n=1, 2). FP is the financial performance measure, EE is the environmental efficiency, and EMP is the environmental management performance. δ is a vector of parameters, and Z represents a vector of control variables including firm size, UN Global Compact, corporate governance score, R&D intensity, capital intensity, leverage, cash flow and growth, industry dummies, and year dummies.

We examine the relationship between EOP and FP in Eq. (1), where the relationship is assumed to be quadratic. To further examine the impact of EMP on FP, we use the model shown in Eq. (2). We then add the interactions between carbon performance and environmental management performance terms to explore the interaction effect of EOP and EMP on FP in Eq (3).

Environmental Performance on Firm Risk

$$FR_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \delta X_{it} + \varepsilon_{it} \tag{4}$$

$$FR_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \beta_2 * EMP_{i,t-n} + \delta X_{it} + \varepsilon_{it} \tag{5}$$

$$FR_{i,t} = \beta_0 + \beta_1 * EE_{i,t-n} + \beta_2 * EMP_{i,t-n} + \beta_3 * EE_{i,t-n}EMP_{i,t-n} + \delta X_{it} + \varepsilon_{it} \tag{6}$$

We estimate the above models to analyze the environmental impact on firm risk. Here, i denotes the firms and t the periods. Subscript n denotes the year time lag of CEP (n=1, 2). FR is the firm risk, EE is the environmental efficiency, and EMP is the environmental management performance. δ is a vector of parameters, and X represents a vector of all the control variables included in Z and Tobin's Q.

We examine the relationship between EOP and FR in Eq. (4), and the impact of EMP on FR in Eq. (5). We add the interactions between carbon performance and environmental management performance terms to explore the interaction effect of EOP and EMP on FR in Eq. (6).

4. Empirical results and Discussion

4.1 Descriptive statistics and Univariate results

Table 1 presents an overview of our sample distributed by year and industry, and indicates that the sample size increases for both manufacturing and service industries during the sample period, which might due to the expanding coverage of the ASSET4 database.

Table 3 provides descriptive statistics for the variables used in our analysis. To mitigate the impact of extreme values, we winsorized all the continuous variables at the 1% level. The average Tobin's Q in our sample is 1.418 with the median of 1.153. In terms of the firm risk measures used in this study, the average of CAPM beta is 0.992 and the median volatility is 0.942; the alternative measure, the Fama-French market beta has slightly higher value of which the mean (median) is 1.062 (1.021). In this study, we employ two distinctive measures for the two dimensions of CEP. The EOP's measure EE has the average of 0.712 and ranges from 0.001 to 20.239, and the EMP score in our sample ranges from 23.952 to 97.330 with the average of 55.199. The wide range of these two measures indicates that our sample consists of a broad cross-section of firms with various levels of environmental performance. Regarding the control variables used in the study, 19.3 percent of our sample companies are members of the UN Global Compact program. The average corporate governance score of our sample companies is 78.783 with a median of 82.565, indicating that most of the firms have good corporate governance practice and structure. The average research and development intensity in our sample is 1.262, suggesting that the investment in R&D by our sample companies is relatively low. The statistics of all the other control variables are also reported in Table 3, which presents the sample companies' characteristics.

Insert TABLE 3 About Here

Table 4 presents the correlation matrix; and the highest correlation exists between the two measures of firm risk. All correlations between dependent, independent and control variables are comfortably under 0.70, which indicates that multicollinearity is unlikely to be a problem (Bedeian, 2014). We also test the variance inflation factors (VIFs) [3] and find that all of the VIF figures are below 10, which also suggests that multicollinearity is not an issue in our study. The correlation results indicate that Tobin's Q is positively correlated with carbon performance and negatively impacted by EMP, suggesting that better carbon performance could lead to better financial performance, while better EMP results in lower market value. The results also indicate that carbon performance has a

[3] The VIF figures are not reported in the paper.

positive relationship with both firm-risk measures, while the EMP score only shows a positive relationship with the CAPM beta, not the Fama-French market factor. Thus we fail to come to a consistent conclusion on linkage between EMP and firm risk. These results could be influenced by other firm characteristics, as well as the firm's industry association and the time variation involved; hence we provide more comprehensive analyses in the following sections.

Insert TABLE 4 About Here

4.2 Multivariate analysis

4.2.1 The impact of carbon performance and environment management performance on Tobin's Q

Table 5 reports the results of regression analysis of the relationship between the two CEP dimensions and Tobin's Q after controlling for other potential determinants of financial performance. Model 1 tests the relationship between carbon performance and Tobin's Q; in order to examine the curvilinear relationship, we add the quadratic term of EE in the model. The coefficients of both the linear and the quadratic term of EE are statistically significant but the directions are opposite. The positive linear coefficient and negative quadratic coefficient suggest that carbon performance and Tobin's Q has an inverse U-shaped relationship, which supports Hypothesis 1.

In Model 2, we add the EMP score to test its impact on CFP and find a significant positive coefficient with Tobin's Q, which supports Hypothesis 2 that EMP itself has a direct positive impact on firms' financial performance.

To test Hypothesis 3, in Model 3 we add the interactions between EMP and the linear and quadratic EE terms. Both interactions are statistically significant, and the signs of the interactions suggest a positive U-shape which is opposite to the EE-Tobin's Q relationship. This result supports the argument of Hypothesis 3 that EMP has a moderation effect on the relationship between carbon performance and Tobin's Q, and provides evidence of an interdependent relationship between EOP and EMP. This suggests that when assessing the firm's environmental performance, the investors and other stakeholders simultaneously consider its carbon performance and efforts and activities it devotes to solve the environmental issues. For the robustness test with a two-year time lag (Model 4, 5, 6), the results are fairly consistent.

Insert TABLE 5 About Here

The inverse U-shaped relationship between carbon performance and CFP which we found in this study is consistent with Misani and Pogutz (2015) and Tatsuo (2010), but opposite to the findings in some literature, most notably in Trumpp and Guenther (2015). The inverse U-shaped relationship suggests a TMGT effect, implying that efforts and investments to improve carbon performance are beneficial for firms' market value at the onset, but beyond a certain point, it is difficult to cover the costs of further improvement of carbon performance by the potential benefits; hence this leads to a trade-off.

To the best of our knowledge, the significantly positive impact of EMP directly on Tobin's Q is first observed. Misani and Pogutz (2015)[4] indicate that stakeholders - particularly investors - would consider firms with better EMP, regardless of EOP, as having better a reputation and thus reward the investment on improving environmental management with a potential positive estimation of firms' performance. We also find the moderation effect of EMP, which further clarifies and confirms the findings of Misani and Pogutz (2015). Their study found the moderation effect of EMP within a full sample, but failed to find it significant when separately testing the US and UK firms. This might because, in their sample, there are only 51 firms from the UK and the US, and all these firms are from industries with intensive carbon emission; while in this study, we expand the sample size to over 1000 companies across various industries. The possible explanation for the inter-related carbon performance, EMP and CFP relationship is that when, initially, the carbon performance is low, the firm could choose to invest in cost-effective options to improve the carbon performance. This, in the meantime increases its financial performance. While after reaching a certain level, in order to further improve the carbon performance the firm needs to invest in more expensive approaches and increase the cost significantly, which will result in a negative relationship with environmental performance (Fujii et al., 2013). Hence a firm does not have strong incentives to continuously improve its carbon performance if it has already met the environmental requirement, unless other stakeholders demand so. This demand from the stakeholders provides a firm strong incentive to promote environmental management, and these stakeholders will value the efforts expended by a firm input to improve environmental management.

Following Trumpp ane Guenther (2015), we then separately test the relationship between multi-dimensional CEP and Tobin's Q in manufacturing and service industries. The descriptive statistics (see Appendix 2) indicate that manufacturing industries have a relatively lower carbon performance with an average of 0.286 compared with the service industries (with a mean of 1.268); while the EMP scores of the manufacturing and service industries do not show significant difference. In the

[4] In this study, only the model with interaction of carbon performance and environmental performance shows the significant positive impact of EMP on Tobin's Q, while in the model with carbon performance and environmental management, the relationship between EMP and Tobin's Q is not statistically significant.

meantime, 22 percent of the companies in manufacturing industries have joined the UN Global Compact program, with only 15.8 percent of the firms in service industries. Moreover, the manufacturing industries are more likely to have higher R&D investment, more capital intensity and higher growth opportunity.

Table 6 presents the results of a comparison between the manufacturing and service industries in terms of the relationship between multi-dimensional environmental performance and Tobin's Q[5]. Results in models 1, 2, and 3 indicate that, for manufacturing industries, the inverse U-shaped relationship between the carbon performance and Tobin's Q still exists; while EMP shows no significant direct impact on Tobin's Q, but only a moderation effect when including the interaction of EE and EMP. Models 4, 5, and 6 show the results for service industries where carbon performance and Tobin's Q still have an inverse U-shaped relationship and EMP also shows a significantly positive impact on Tobin's Q. Although the interactions between EMP and the linear and quadratic EE terms are still significant, the signs of the interactions also show an inverted U-shape which means that - rather than moderation effect - EMP has an enhancement effect on the EE-Tobin's Q relationship. The findings indicate that the inverse U-shaped relationship between carbon performance and Tobin's Q holds for both manufacturing and service industries, while the positive relationship between EMP and Tobin's Q only exists in service industries, and the interaction of EE and EMP shows an opposite influence on the EE-Tobin's Q relationship. Judging from our results, stakeholders may have a higher awareness of the efforts of environmental activities in the service than the manufacturing industries, which might because investment in improving EMP provides service industries extra competitive advantages and reputation in the market.

Insert TABLE 6 About Here

4.2.2 CEP and firm risk

Table 7 presents the results of the multivariate regressions of the relationship between carbon performance, EMP and firm risk. Two firm-risk measures are used and the adjusted R-square value indicates that models using the CAPM beta have better explanatory power than those that use the Fama-French market beta. Models 1a and 1b examine the impact of carbon performance on firm risk measured by the CAPM beta and the Fama-French market beta. Models 2a and 2b then add EMP into the regression and test the impact of EMP on firm risk. Models 3a and 3b add the interaction between EMP and EE to test the combined effect of the two CEP dimensions on firm risk.

[5] We also tested the univariate correlations and VIFs to exclude the multicollinearity issue for the sub-sample models. The correlation matrix for the manufacturing and service industries' sub-samples are shown in Appendix 3, and the VIF figures are not reported in the paper.

Results in the main tests of Table 7 (Models 1a, 2a, 3a, 1b, 2b, 3b) generally indicate that neither carbon performance nor environmental management has a significant impact on firm risk. When considering the inter-relationship between carbon performance and EMP, the results remain the same. In the tests with a two-year time lag, models using the CAPM beta as the dependent variable (Models 4a, 5a, 6a) indicate that the carbon performance has a positive relationship but which is only significant at the 10 percent level; while in the models using the Fama-French market beta (Models 4b, 5b, 6b), the positive relationship between carbon performance and firm risk is more statistically significant ($p<0.05$). The insignificant results we found are inconsistent with Cai et al. (2015) who find firms' environmental engagement inversely affects firm risk based on US data, while our study applies different environmental performance measures that distinguish the two dimensions of CEP, and we conduct the tests with UK firms under a different regulatory environment. Since we use a cross-industry sample in these models, the results provide evidence to support the first part of Hypothesis 4c that under the cross-industry variation, there is an insignificant CEP-firm risk relationship.

In addition, out of all the control variables, the firms with smaller size, higher R&D investment, and higher capital intensity seem to be associated with lower risk.

Insert TABLE 7 About Here

In order to test the second part of Hypothesis 4c, we then re-run the test separately for the manufacturing and service industries to examine the relationship between carbon performance, EMP and firm risk. Based on the descriptive statistics (see Appendix 2), the service industries have on average better carbon performance than the manufacturing industries, while they also have higher firm risk measured in both CAPM beta and Fama-French market beta. Table 8 presents the multivariate regression results of the CEP and firm-risk relationship in the manufacturing and service industries. For the manufacturing industries, models 1a and 2a indicate that carbon performance shows a significant positive impact on firm risk measured by the CAPM beta, although EMP shows no significant influence. Considering the potential interdependent relationship between carbon performance and EMP, results in model 3a indicate that EMP has an enhancement effect on the relationship between EE and firm risk. Models 1b, 2b, and 3b support these results with the Fama-French market beta as a measure of firm risk.

On the contrary, for the service industries, models 4a and 4b show a significant inverse relationship between carbon performance and firm risk; models 5a and 5b show that EMP also has a negative impact on firm risk; and using the Fama-French market beta as a measure of firm's risk, model 6a indicates that the interaction of EE and EMP enhances the inverse relationship. In short, results in Table 8 suggest that for manufacturing industries, better CEP would lead to higher firm risk; while for the service industries, better CEP reduces firm risk. Our results support the second part of Hypothesis 4c, which suggests different CEP-firm risk relationships in different industries, although they challenge Cai et al.'s (2015) findings. The possible explanation for our findings is that for firms in the service sector, poor environmental performance can easily draw attention from the investors since it reflects severe problems in the environmental issues as these firms do not need very costly investment to improve environmental performance and meet the regulatory requirements. As a result, investors tend to have strong reaction and intention to punish these firms when finding out about the firms' negative environmental issues. On the other hand, better environmental performance and management help the firms gain extra reputation and competitive advantages, which in turn brings support from other stakeholders which will reduce the firm's risk. Firms in the manufacturing industries are intensively related with environmental issues, so it is important for them to assure that their environmental performance meets the regulatory requirements and invest a certain level of resources and efforts in achieving this. However, it is very costly for manufacturing firms to significantly improve their environmental performance, and when this happens, the investors could assume that either it is a 'window-dressing' strategy that the firm employs to actually hide or make up for its problem, or the firm wastes too much business resources in CEP without generating sufficient benefit from it. For either reason, better CEP in the manufacturing sector would lead to higher firm risk.

Insert TABLE 8 About Here

4.2.3 Additional tests

In our main analysis, we use the marketed-based financial performance (Tobin's Q) as our CFP measure. Based on prior CEP-CFP research, other measures of CFP performance other than Tobin's Q are also useful because they reflect other aspects of firms' financial performance such as profitability and could be affected by different stakeholders (Dixon-Fowler et al., 2013; Fujii et al., 2013). These financial performance measures may express a different relationship between CEP and CFP. To investigate this issue, we apply return on asset (ROA) and return on equity (ROE)[6] as additional measures of firms' financial performance which represent the firms' accounting-based

[6] ROA is calculated as the net income divided by total assets, and ROE as the net income divided by the shareholder's equity; all the data are collected from the Thomson Datastream database.

profitability, and we re-run the analysis. Table 9 show the results of applying our CEP-CFP models to ROA and ROE. Models 1a, 2a, and 3a show a significant positive relationship between EMP and ROA while the inverted U-shaped relationship between carbon performance and ROA is only significant at the 10 percent level. The moderation effect of EMP on the EOP-CFP relationship does not exist here. When ROA is lagged forward by one more year, the statistical significance of the inverted U-shaped relationship between carbon performance and ROA disappears while the positive impact of EMP remains statistically significant (Models 4a, 5a, 6a). When measured by ROE, the inverted U-shaped relationship between carbon performance and financial performance and the positive impact of EMP are both statistically significant for two lagged periods (Models 1b, 2b, 4b, 5b); however, the interaction of EE and EMP is statistically insignificant for the two-year lagged period (Models 3b, 6b). These findings are consistent with previous research that carbon performance is more strongly linked to Tobin's Q than to accounting measures (Busch & Hoffmann, 2011; Fujii et al., 2013; Misani & Pogutz, 2015). Tobin's Q measures the investors' estimates about the firms' further performance and their financial return; hence it reflects that the shareholders and investors pay great attention to the firms' environmental performance, particularly their investments on the environmental management processes and activities. ROE reflects the internal efficiency of utilizing shareholders' equity which also has a strong relationship with shareholders' wealth and companies' internal efficiency. Hence, the results also suggest that these are also the benefits that firm could gain from investing in improving environmental performance.

Insert TABLE 9 About Here

We also re-run the tests for the manufacturing and service industries sub-samples using ROA and ROE as the measures of financial performance, and the results are shown in Table 10. In the manufacturing industries, the relationship between carbon performance and financial performance disappear when using ROA or ROE. While EMP shows a consistent significant positive impact on ROA and ROE (Models 1a, 2a, 3a, 1b, 2b, 3b), on the other hand, firms in service industries present a distinctive pattern. The carbon performance shows a significant inverted U-shaped relationship with ROA and ROE, while the EMP shows barely any significant impact (Models 4a, 5a, 6a, 4b, 5b, 6b). These findings suggest that for manufacturing industries, investing in environmental management systems and improving environmental management strategies provide more substantial benefits for firms' profitability than improving carbon performance does; while for the service industries, improving carbon performance is more important for firms' profitability.

Insert TABLE 10 About Here

5. Conclusions

Over the past 40 years, CEP has drawn increasing attention from regulators, academics, and practitioners. Although many scholars have tried to understand how the CEP influences firms' economic performance, only few considered the measurable economic consequences in the risk dimension; and when examining the financial performance dimension, they failed to find consistent results. In this study, we examine the empirical influence of CEP on two dimensions of firms' economic performance - financial performance and firm risk - using a comprehensive sample of UK companies from 2004 to 2013. Since CEP is recognized as a multidimensional construct, this study applies different measures for the EOP and EMP dimensions and examines the impact of each dimension as well as their interaction effect on firms' economic performance.

Regarding the impact on firms' financial performance, we find an inverted U-shaped relationship between carbon performance and CFP, and a positive direct relationship between EMP and financial performance. Our findings of the EOP-CFP relationship provide supportive evidence to the TMGT effect, meaning that the improvement of carbon performance could increase financial performance up to a certain point, after which the marginal costs of investment for further improvement would not be covered by the marginal benefit. As the first observation within the context of the UK firms, our finding of a positive EMP-CFP relationship suggests that firms' efforts in improving the environmental management system, process, and activities are considered by stakeholders as an increase of intangible assets and competitive advantage. Our findings also provide evidences for the moderation effect of EMP on the EOP-CFP relationship, which suggests that EOP and EMP are interdependent, at least for investors and other stakeholders as they simultaneously consider firms' environmental outcomes and the efforts firms invest to enhance environmental management.

When separating the manufacturing and service industries, the inverted U-shaped relationship between carbon performance and financial performance holds for both industries, while the positive impact of EMP only exists in service industries, not the manufacturing sector. The results indicate that EMP has a moderation effect on the EOP-CFP relationship for manufacturing industries but an enhancement effect for the service industries.

On the other hand, when examining the impact of CEP on firm risk, we fail to find significant relationship between carbon performance, EMP and firm risk in a cross-industry sample. It is argued that the insignificant result is because of the differing relationships between CEP and firm risk in the manufacturing and service industries since investors and stakeholders have various expectations for different industries. Therefore, we separately test the manufacturing and service industries and find opposite CEP-firm risk relationships. Our findings indicate that for manufacturing industries, the carbon performance has a significant positive relationship with firm risk, and EMP does not have direct influence on the firm risk but the interaction of EE and EMP shows an enhancement effect on the positive relationship between carbon performance and firm risk. However for service industries, both carbon performance and EMP have inverse relationships with firm risk indicating that improving performance outcome and processes will reduce firm risk; and the interaction of EE and EMP also enhances the inverse relationship between CEP and firm risk. Moreover, the opposite CEP-firm risk relationship in manufacturing and service industries also explains the insignificant result of the cross-industry sample.

Our study demonstrates that CEP has different impacts on firms' financial performance and risk, and has implications for managers, investors, policy makers. For managers, our findings help to better understand how to achieve the best economic consequences through investing in environmental outcomes and management processes. Combining financial return and firm risk, our results suggest that it is not beneficial for firms in the manufacturing industries to continuously invest in improving CEP since the investors do not value the efforts and resources they input for environmental management activities, and they could only achieve limited benefit in financial return under the danger of increasing firm's risk. On the contrary, improving outcome and process-based environmental performance will provide the firms in service industries with a better financial performance (until reaching the maximum point) and reduced firm risk. In particular, improvement of EMP is considered as supportive evidence for investors and other stakeholders that the firm is making efforts to reduce carbon emissions. For investors, our study implies the potential to pay more attention to the environmental management process undertaken by manufacturing companies and generate more time to and confidence in its influence. For policy makers, our study suggests that their attention should focus on manufacturing industries as the duty of supervising and regulating firms' environmental performance is mainly undertaken by the regulatory requirements, while the investors' reaction to CEP could not effectively encourage companies to proactively improve their CEP. Thus, only through enhancing the regulatory standards and policy can firms be effectively forced to improve their CEP. However, for the service industries, the investors and other stakeholders value firms' environmental performance, and the market reaction could effectively incentivize firms to invest in improving their environmental performance.

Our study highlights the need to consider the complicated relationship between outcome and process-based environmental performance with complex empirical models to derive substantial conclusions, which has implications for future research. While focusing on UK firms provides us benefits of comprehensive understanding of the relationship between CEP and firms' economic performance, the findings may not be extrapolated to other nations with different regulatory context. It would be fruitful, we believe, for future studies to examine whether different dimensions of CEP in other nations also affect firms' economic performance.

Appendix 1 CEP indicators as derived from the ASSET4 database

ASSET4 Code	Description
Environmental management performance (EMP)	
ENERD01S	Does the company have a policy for reducing environmental emissions or its impacts on biodiversity? AND Does the company have a policy for maintaining an environmental management system?
ENERD02S	Does the company describe the implementation of its emission reduction policy through a public commitment from a senior management or board member? AND Does the company describe the implementation of its emission reduction policy through the processes in place?
ENERD03S	Does the company monitor its emission reduction performance?
ENERD04S	Does the company set specific objectives to be achieved on emission reduction?
ENERO05S	Does the company show an initiative to reduce, reuse, recycle, substitute, phased out or compensate CO2 equivalents in the production process?
ENERO17S	The percentage of company sites or subsidiaries that are certified with any environmental management system.
ENERO22S	Is the company aware that climate change can represent commercial risks and/or opportunities?
ENPID01S	Does the company have an environmental product innovation policy (eco-design, life cycle assessment, dematerialization)?
ENPID02S	Does the company describe the implementation of its environmental product innovation policy?
ENPID03S	Does the company describe, claim to have or mention the processes it uses to accomplish environmental product innovation?
ENPID04S	Does the company set specific objectives to be achieved on environmental product innovation?
ENPIO04S	Does the company invest in R&D on new environmentally friendly products or services that will limit the amount of emissions and resources needed during product use?
ENPIO05S	Does the company develop new products that are marketed as reducing noise emissions?
ENPIO06S	Is the company developing hybrid vehicles?
ENPIO07S	Does the company develop products or technologies for use in the clean, renewable energy (such as wind, solar, hydro and geo-thermal and biomass power)?
ENPIO08S	Does the company develop products or technologies that are used for water treatment, purification or that improve water use efficiency?
ENPIO10S	Is the company a signatory of the Equator Principles (commitment to manage environmental issues in project financing)? OR Does the company claim to evaluate projects on the basis of environmental or biodiversity risks as well?
ENPIO12S	Does the company develop new products and services linked to liquefied natural gas?
ENPIO17S	Does the company make a commitment to exclude GMO ingredients from its products or retail offerings?
ENPIO18S	Does the company develop products and services that improve the energy efficiency of buildings?
ENPIO20S	Has the company received product awards with respect to environmental responsibility? OR Does the company use product labels (e.g. FSC, Energy Star,

	MSC) indicating the environmental responsibility of its products?
ENRRD01S	Does the company have a policy for reducing the use of natural resources? AND Does the company have a policy to lessen the environmental impact of its supply chain?
ENRRD02S	Does the company describe the implementation of its resource efficiency policy through a public commitment from a senior management or board member? AND Does the company describe the implementation of its resource efficiency policy through the processes in place?
ENRRD03S	Does the company monitor its resource efficiency performance?
ENRRD04S	Does the company set specific objectives to be achieved on resource efficiency? AND Does the company comment on the results of previously set objectives?
ENRRO07S	Does the company have environmentally friendly or green sites or offices?
ENRRO11S	Does the company use environmental criteria (ISO 14000, energy consumption, etc.) in the selection process of its suppliers or sourcing partners? AND Does the company report or show to be ready to end a partnership with a sourcing partner, if environmental criteria are not met?
ENERO01S	Does the company report on initiatives to protect, restore or reduce its impact on native ecosystems and species, biodiversity, protected and sensitive areas?
ENERO06S	Does the company report on initiatives to recycle, reduce, reuse or phase out fluorinated gases such as HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) or SF6 (sulphur hexafluoride)?
ENERO07S	Does the company report on initiatives to reduce, substitute, or phase out ozone-depleting (CFC-11 equivalents, chlorofluorocarbon) substances?
ENERO08S	Does the company report on initiatives to reduce, reuse, recycle, substitute, or phase out SOx (sulphur oxides) or NOx (nitrogen oxides) emissions?
ENERO09S	Does the company report on initiatives to reduce, substitute, or phase out volatile organic compounds (VOC) or particulate matter less than ten microns in diameter (PM10)?
ENERO14S	Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out total waste, hazardous waste or wastewater?
ENERO15S	Does the company report on the concentration of production locations in order to limit the environmental impact during the production process? OR Does the company report on its participation in any emissions trading initiative? OR Does the company report on new production techniques to improve the global environmental impact (all emissions) during the production process?
ENERO16S	Does the company report on partnerships or initiatives with specialized NGOs, industry organizations, governmental or supragovernmental organizations that focus on improving environmental issues?
ENERO18S	Does the company report or provide information on company-generated initiatives to restore the environment?
ENERO19S	Does the company report on initiatives to reduce the environmental impact of transportation of its products or its staff?
ENERO21S	Does the company report on initiatives to reduce, avoid or minimize the effects of spills or other polluting events (crisis management system)?
ENERO24S	Does the company report on its environmental expenditures or does the company report to make proactive environmental investments to reduce future risks or increase future opportunities?
ENPIO01S	Does the company report on at least one product line or service that is designed to have positive effects on the environment or which is environmentally labelled and marketed?
ENPIO02S	Does the company describe initiatives in place to reduce the energy footprint of

	its products during their use?
ENPIO09S	Does the company report on assets under management which employ environmental screening criteria or environmental factors in the investment selection process?
ENPIO13S	Does the company report on specific products which are designed for reuse, recycling or the reduction of environmental impacts?
ENPIO15S	Does the company report or show initiatives to produce or promote organic food or other products?
ENPIO16S	Does the company reports about take-back procedures and recycling programmes to reduce the potential risks of products entering the environment? OR Does the company report about product features and applications or services that will promote responsible, efficient, cost-effective and environmentally preferable use?
ENRRO03S	Does the company report on initiatives to reduce, reuse, substitute or phase out toxic chemicals or substances?
ENRRO08S	Does the company report on initiatives to use renewable energy sources? AND Does the company report on initiatives to increase its energy efficiency overall?
ENRRO10S	Does the company report on initiatives to reuse or recycle water? OR Does the company report on initiatives to reduce the amount of water used?
ENRRO12S	Does the company report on initiatives to reduce the environmental impact on land owned, leased or managed for production activities or extractive use?
Environmental operational performance (EOP)	
ENERO03V	Total CO2 and CO2 equivalents emission in tonnes divided by net sales or revenue.

Appendix 2 Descriptive statistics – sub-samples of manufacturing and service industries

Manufacturing industries

Variable	Mean	Median	Std dev	Minimum	Maximum	N
Tobin's Q	1.458	1.238	0.902	0.159	8.495	924
CAPM_BETA	0.976	0.919	0.409	0.166	2.325	934
FF4_BETA	1.047	1.002	0.392	0.267	2.251	934
EE	0.286	0.120	0.560	0.001	7.056	916
EMP	55.901	54.946	12.059	25.207	86.494	939
SIZE	14.892	14.632	1.594	11.609	19.414	939
UNGC	0.220	0.000	0.415	0.000	1.000	939
CGSCORE	79.812	83.030	12.956	5.070	97.330	939
R&D	2.105	0.070	5.721	0.000	47.990	939
CAPITAL	0.054	0.038	0.054	0.000	0.422	939
LEVERAGE	0.218	0.205	0.155	0.000	0.796	939
CASHFLOW	15.816	11.650	12.991	-35.620	74.130	939
GROWTH	0.101	0.058	0.224	-0.419	1.519	939

Service industries

Variable	Mean	Median	Std dev	Minimum	Maximum	N
Tobin's Q	1.325	0.982	1.282	0.111	9.778	392
CAPM_BETA	1.013	0.971	0.380	0.166	2.325	717
FF4_BETA	1.083	1.036	0.370	0.267	2.251	717
EE	1.268	0.283	2.899	0.001	20.239	703
EMP	54.293	53.703	11.848	23.952	83.129	727
SIZE	15.579	15.195	2.059	10.402	20.471	727
UNGC	0.158	0.000	0.365	0.000	1.000	727
CGSCORE	77.453	81.970	15.087	15.170	96.730	727
R&D	0.172	0.000	1.202	0.000	13.120	727
CAPITAL	0.038	0.023	0.045	0.000	0.330	727
LEVERAGE	0.271	0.260	0.202	0.000	1.672	727
CASHFLOW	17.550	15.000	18.271	-44.500	78.660	727
GROWTH	0.071	0.041	0.217	-0.419	1.519	727

Note: This table reports univariate statistics (number of observations, mean, standard deviation, minimum and maximum). Manufacturing and service industries sub-samples consist of 939 and 727 firm-year observations respectively, covering all firms listed on the London Stock Exchange using the ASSET4 database over the 2003-2014 period. The definitions of variables are presented in Table 2.

Appendix 3 Summary of bivariate correlations – sub-samples of manufacturing and service industries

Manufacturing industries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Tobin's Q	1												
2 CAPM_BETA	0.0130	1											
3 FF4_BETA	0.079**	0.906***	1										
4 EE	0.132***	0.036	0.073**	1									
5 EMP	-0.233***	0.047	-0.065**	-0.164***	1								
6 SIZE	-0.331***	0.143***	-0.043	-0.192***	0.648***	1							
7 UNGC	0.017	0.109***	0.001	-0.120***	0.383***	0.463***	1						
8 CGSCORE	-0.127***	-0.062*	-0.107***	0.007	0.342***	0.233***	0.134***	1					
9 R&D	0.234***	-0.094***	-0.072**	0.006	-0.022	-0.047	-0.033	0.006	1				
10 CAPITAL	0.007	0.168***	0.102***	-0.250***	-0.045	0.111***	0.182***	-0.065**	-0.175***	1			
11 LEVERAGE	-0.181***	-0.129***	-0.185***	-0.242***	0.116***	0.246***	0.046	0.008	-0.141***	0.029	1		
12 CASHFLOW	0.312***	0.126***	0.081**	-0.180***	-0.042	0.113***	0.165***	-0.003	0.086***	0.552***	-0.01	1	
13 GROWTH	0.051	0.066**	0.070**	-0.019	-0.089***	0.064**	0.012	-0.046	-0.018	0.314***	-0.011	0.220***	1

Service industries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Tobin's Q	1												
2 CAPM_BETA	-0.084**	1											
3 FF4_BETA	-0.001	0.900***	1										
4 EE	0.0680	0.088***	0.118***	1									
5 EMP	-0.250***	0.215***	0.073**	-0.152***	1								
6 SIZE	-0.474***	0.394***	0.262***	0.135***	0.598***	1							
7 UNGC	-0.171***	0.224***	0.122***	-0.075**	0.426***	0.454***	1						
8 CGSCORE	-0.123***	0.136***	0.078**	-0.014	0.361***	0.201***	0.210***	1					
9 R&D	0.059	-0.074**	-0.066**	-0.017	-0.052	-0.083**	-0.01	-0.052	1				
10 CAPITAL	0.068*	0.011	-0.048	-0.281***	0.032	-0.162***	0.053	0	-0.02	1			
11 LEVERAGE	0.069*	-0.136***	-0.128***	-0.182***	-0.028	-0.166***	-0.147***	-0.03	-0.048	-0.004	1		
12 CASHFLOW	0.277***	0.054	0.053	-0.054	-0.132***	-0.094***	0.021	-0.019	0.024	0.244***	-0.099***	1	
13 GROWTH	0.072*	0.114***	0.119***	0.002	-0.076**	0.066**	0.025	-0.048	-0.018	0.308***	-0.116***	0.213***	1

Note: This table reports Bravais–Pearson bivariate correlations for continuous variables (1–13). *, ** and *** indicate significance level at 0.10, 0.05, 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

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Table 1 Sample description

	Firms per year										Firm-years Total
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	
Manufacturing industries											
Oil & Gas (ICB 0)	4	6	6	8	8	8	8	10	12	12	82
Basic Materials (ICB 1)	5	6	7	10	13	14	17	20	19	23	134
Industrials (ICB 2)	10	22	28	38	41	49	52	58	58	62	418
Consumer Goods (ICB 3)	4	11	11	13	15	19	22	23	27	25	170
Health Care (ICB 4)	4	4	4	4	4	5	6	5	6	7	49
Utilities (ICB 7)	5	6	7	6	7	7	7	7	7	7	66
Technology Hardware & Equipment (ICB 9570)		2	2	2	2	2	2	2	3	3	20
Manufacturing industries total	32	57	65	81	90	104	114	125	132	139	939
Service industries											
Consumer Services (ICB 5)	9	14	22	27	30	40	44	45	47	56	334
Telecommunications (ICB 6)	2	2	2	2	4	4	4	4	3	4	31
Financials (ICB 8)	13	20	28	33	35	40	41	44	44	53	351
Software & Computer Services (ICB 9530)						2	2	1	2	4	11
Service industries total	24	36	52	62	69	86	91	94	96	117	727
Full sample	**56**	**93**	**117**	**143**	**159**	**190**	**205**	**219**	**228**	**256**	**1666**

Note: The overall sample consists of 1666 firm-year observations in 292 firms. ICBC, Industrial Classification Benchmark. Technology hardware & Equipment (ICB 9570), which is the manufacturing industry within the technology industry sector (ICB 9000). Software & Computer Service (ICB 9530), which is the service industry within the technology industry sector (ICB 9000).

Table 2 Variables definitions

Category	Variables	Definitions	Label
Dependent variable	Financial performance	Dividing the sum of the firm's market capitalization, the book value of its long-term debt, and its net current liabilities by the book value of its total assets	Tobin's Q
	Firm risk	CAPM Beta of individual stocks in current year, based on daily stock returns	CAPM_BETA
		Fama and French four-factor Model market beta of individual stocks in current year, based on daily stock returns	FF4_BETA
Independent variable	Environmental management performance	The average score of the firms' environmental management activities indicators from ASSET4	EMP
	Environmental operational performance	EOP is measured by net sales divided by CO2 and CO2 equivalent emissions	EE
Control variable	Corporate Governance Score	Asset4 Corporate Governance Score	CGSCORE
	UN Global Compact	Dummy variable: =1 if a firm adhered to the United Nations' Global Compact within a year, and =0 otherwise	UNGC
	R&D intensity	R&D expenses divided by sales	R&D
	Firm size	The company size is measured by the natural logarithm of total assets.	SIZE
	Cash flow	Net cash flow divided by sales	CASHFLOW
	Capital intensity	Capital expenditures divided by beginning-of-the-year total assets	CAPITAL
	Leverage	Total debt divided by total assets	LEVERAGE
	Growth	Change in total assets divided by beginning-of-period total assets	GROWTH

Note: This table gives the definition and description of each variable used in the analysis.

Table 3 Descriptive statistics

Variable	Mean	Median	Std dev	Minimum	Maximum	N
Tobin's Q	1.418	1.153	1.031	0.111	9.778	1316
CAPM_BETA	0.992	0.942	0.403	-0.366	2.917	1651
FF4_BETA	1.062	1.021	0.383	0.267	2.251	1651
EE	0.712	0.182	2.015	0.001	20.239	1619
EMP	55.199	54.295	11.991	23.952	86.494	1666
SIZE	15.192	14.844	1.843	10.402	20.471	1666
UNGC	0.193	0.000	0.395	0.000	1.000	1666
CGSCORE	78.783	82.565	13.971	5.070	97.330	1666
R&D	1.262	0.000	4.471	0.000	47.990	1666
CAPITAL	0.047	0.032	0.051	0.000	0.422	1666
LEVERAGE	0.241	0.229	0.179	0.000	1.672	1666
CASHFLOW	16.572	13.090	15.536	-44.500	78.660	1666
GROWTH	0.088	0.051	0.221	-0.419	1.519	1666

Note: This table reports univariate statistics (number of observations, mean, standard deviation, minimum, maximum). The sample consists of 1666 firm-year observations, covering all firms listed on the London Stock Exchange using the ASSET4 database over the 2003-2014 period. The firm's GHG emissions and environmental management score are taken from the ASSET4 database, which are used to calculate EE and EMP. The definitions of variables are presented in Table 2.

Table 4 Summary of bivariate correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1 Tobin's Q	1												
2 CAPM_BETA	-0.022	1											
3 FF4_BETA	0.047*	0.905***	1										
4 EE	0.088***	0.128***	0.143***	1									
5 EMP	-0.212***	0.119***	0.007	-0.134***	1								
6 SIZE	-0.374***	0.306***	0.163***	0.133***	0.574***	1							
7 UNGC	0.003	0.130***	0.049**	-0.051**	0.359***	0.399***	1						
8 CGSCORE	-0.108***	0.031	-0.014	-0.023	0.362***	0.199***	0.157***	1					
9 R&D	0.178***	-0.087***	-0.070***	-0.052**	-0.01	-0.076***	-0.007	0.017	1				
10 CAPITAL	0.046*	0.004	-0.043*	-0.238***	-0.002	-0.091***	0.063**	-0.045*	-0.102***	1			
11 LEVERAGE	-0.049*	-0.125***	-0.152***	-0.173***	0.032	0.003	-0.04	-0.012	-0.125***	0.075***	1		
12 CASHFLOW	0.309***	0.052**	0.031	-0.023	-0.079***	0.023	0.093***	-0.015	0.046*	0.266***	-0.02	1	
13 GROWTH	0.057**	0.058**	0.073***	0.007	-0.074***	0.067***	0.017	-0.046*	0	0.258***	-0.070***	0.175***	1

Note: This table reports Bravais–Pearson bivariate correlations for continuous variables (1–12). *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 5 Relationship between multi-dimension environmental performance and corporate financial performance

	Tobin's Q (t+1)			Tobin's Q (t+2)		
	(1)	(2)	(3)	(4)	(5)	(6)
EE	0.207***	0.231***	0.232***	0.365***	0.391***	0.381***
	(3.16)	(3.47)	(2.98)	(3.60)	(3.93)	(3.87)
Quad.EE	-0.010***	-0.011***	-0.010***	-0.052***	-0.054***	-0.046***
	(-3.07)	(-3.37)	(-2.72)	(-2.81)	(-3.03)	(-3.42)
EMP		0.010***	0.008**		0.008**	0.004
		(3.13)	(2.28)		(2.32)	(1.06)
EMP * EE			-0.006*			-0.009**
			(-1.67)			(-2.30)
EMP * Quad.EE			0.002*			0.004***
			(1.73)			(2.85)
SIZE	-0.286***	-0.325***	-0.324***	-0.281***	-0.312***	-0.308***
	(-12.46)	(-11.67)	(-11.56)	(-11.57)	(-10.82)	(-10.65)
UNGC	0.458***	0.421***	0.414***	0.455***	0.421***	0.412***
	(5.04)	(4.62)	(4.60)	(4.54)	(4.14)	(4.07)
CGSCORE	0.000	-0.002	-0.002	0.002	0.000	0.000
	(0.14)	(-0.73)	(-0.72)	(0.83)	(0.11)	(0.10)
R&D	0.019**	0.019**	0.019**	0.028**	0.028**	0.028**
	(2.00)	(2.05)	(2.02)	(2.21)	(2.24)	(2.21)
CAPITAL	0.366	0.302	0.349	0.635	0.656	0.765
	(0.39)	(0.32)	(0.37)	(0.67)	(0.70)	(0.83)
LEVERAGE	-0.079	-0.055	-0.071	0.169	0.191	0.165
	(-0.37)	(-0.25)	(-0.33)	(0.89)	(0.98)	(0.85)
CASHFLOW	0.024***	0.025***	0.025***	0.018***	0.019***	0.020***
	(7.34)	(7.50)	(7.51)	(6.70)	(7.00)	(7.09)
GROWTH	-0.142	-0.129	-0.131	0.079	0.062	0.077
	(-0.74)	(-0.67)	(-0.68)	(0.51)	(0.40)	(0.49)
Constant	5.104***	5.320***	5.428***	5.168***	5.328***	5.508***
	(11.76)	(11.94)	(11.93)	(11.69)	(11.76)	(11.98)
Industry Effects	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES
Observations	1043	1043	1043	872	872	872
Adj. R-squared	0.346	0.351	0.352	0.367	0.370	0.374

Note: Dependent variable - Tobin's Q. Environmental performance is defined in Table 2 and is constructed in the way that the higher firms´ sales/emissions generate higher scores for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 6 Relationship between multi-dimension environmental performance and corporate financial performance (comparison between manufacturing and service industries)

	Manufacturing industries Tobin's Q (t+1)			Service industries Tobin's Q (t+1)		
	(1)	(2)	(3)	(4)	(5)	(6)
EE	0.313**	0.340**	0.311**	0.432**	0.435**	0.579***
	(2.25)	(2.48)	(2.22)	(2.54)	(2.53)	(3.56)
Quad.EE	-0.061*	-0.066**	-0.062*	-0.022***	-0.022***	-0.033***
	(-1.85)	(-2.03)	(-1.91)	(-2.65)	(-2.64)	(-3.66)
EMP		0.003	0.001		0.015**	0.023***
		(0.96)	(0.29)		(2.33)	(3.17)
EMP * EE			-0.009**			0.036***
			(-2.55)			(3.47)
EMP * Quad.EE			0.002*			-0.009**
			(1.67)			(-2.19)
SIZE	-0.249***	-0.264***	-0.268***	-0.373***	-0.433***	-0.448***
	(-10.40)	(-9.14)	(-9.14)	(-6.51)	(-6.21)	(-6.37)
UNGC	0.490***	0.477***	0.456***	0.114	0.062	0.023
	(4.61)	(4.43)	(4.27)	(0.82)	(0.43)	(0.16)
CGSCORE	-0.002	-0.003	-0.003	0.004	0.001	0.000
	(-1.04)	(-1.25)	(-1.25)	(1.00)	(0.15)	(0.06)
R&D	0.015*	0.015*	0.015*	0.271*	0.263*	0.289*
	(1.71)	(1.74)	(1.70)	(1.87)	(1.73)	(1.93)
CAPITAL	-2.524***	-2.470***	-2.419**	7.814***	7.099***	7.285***
	(-2.64)	(-2.59)	(-2.54)	(5.67)	(4.79)	(4.93)
LEVERAGE	-0.011	0.016	-0.008	-0.478	-0.484	-0.508
	(-0.05)	(0.08)	(-0.04)	(-1.25)	(-1.24)	(-1.30)
CASHFLOW	0.027***	0.027***	0.028***	0.046***	0.048***	0.049***
	(8.30)	(8.33)	(8.37)	(4.04)	(4.06)	(4.13)
GROWTH	-0.086	-0.079	-0.088	-0.463	-0.449	-0.520
	(-0.69)	(-0.63)	(-0.69)	(-0.77)	(-0.75)	(-0.87)
Constant	4.845***	4.917***	5.136***	6.303***	6.639***	6.354***
	(10.76)	(10.73)	(10.89)	(6.66)	(6.69)	(6.53)
Industry Effects	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES
Observations	752	752	752	291	291	291
Adj. R-squared	0.383	0.383	0.385	0.404	0.411	0.425

Note: This table presents the regression results from our main regression, using alternative financial performance measure in two sub-samples (t+1 presented only). Environmental performance is defined in Table 2 and is constructed in a way that the higher firms´ sales/emissions generate higher scores for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 7 Relationship between multi-dimension environmental performance and firm risk

	CAPM_BETA (t+1)			CAPM_BETA (t+2)			FF4_BETA (t+1)			FF4_BETA (t+2)		
	(1a)	(2a)	(3a)	(4a)	(5a)	(6a)	(1b)	(2b)	(3b)	(4b)	(5b)	(6b)
EE	0.015	0.014	0.020	0.043*	0.041*	0.049*	0.013	0.012	0.016	0.044**	0.043*	0.049**
	(0.85)	(0.81)	(1.08)	(1.77)	(1.71)	(1.93)	(0.82)	(0.79)	(0.95)	(1.96)	(1.90)	(2.04)
EMP		-0.001	-0.001		-0.001	-0.001		-0.001	-0.001		-0.001	-0.001
		(-1.13)	(-1.08)		(-0.65)	(-0.61)		(-0.67)	(-0.64)		(-0.64)	(-0.61)
EE * EMP			0.001			0.001			0.001			0.001
			(1.13)			(0.87)			(0.63)			(0.64)
Tobin's Q	-0.008	-0.006	-0.006	-0.015	-0.014	-0.014	-0.012	-0.011	-0.011	-0.027*	-0.025	-0.025
	(-0.65)	(-0.49)	(-0.49)	(-0.95)	(-0.86)	(-0.86)	(-0.93)	(-0.82)	(-0.82)	(-1.71)	(-1.60)	(-1.60)
SIZE	0.045***	0.051***	0.052***	0.042***	0.047***	0.048***	0.004	0.008	0.008	-0.000	0.004	0.005
	(5.19)	(4.90)	(4.98)	(4.35)	(3.84)	(3.89)	(0.45)	(0.75)	(0.79)	(-0.02)	(0.36)	(0.40)
UNGC	-0.011	-0.006	-0.002	-0.001	0.003	0.007	-0.016	-0.013	-0.011	0.003	0.007	0.010
	(-0.37)	(-0.21)	(-0.08)	(-0.03)	(0.09)	(0.20)	(-0.57)	(-0.47)	(-0.39)	(0.10)	(0.22)	(0.30)
CGSCORE	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001*	-0.001	-0.001	-0.002*	-0.002*	-0.002*
	(-1.30)	(-0.91)	(-0.97)	(-1.28)	(-1.01)	(-1.08)	(-1.68)	(-1.40)	(-1.42)	(-1.96)	(-1.68)	(-1.72)
R&D	-0.004**	-0.004**	-0.004**	-0.005**	-0.005**	-0.005**	-0.004*	-0.004*	-0.004*	-0.005**	-0.005**	-0.005**
	(-2.16)	(-2.16)	(-2.15)	(-2.41)	(-2.40)	(-2.40)	(-1.91)	(-1.91)	(-1.91)	(-2.39)	(-2.39)	(-2.38)
CAPITAL	-0.506**	-0.488*	-0.496**	-0.396	-0.393	-0.402	-0.728***	-0.717***	-0.721***	-0.515*	-0.512*	-0.519*
	(-2.01)	(-1.93)	(-1.96)	(-1.42)	(-1.41)	(-1.44)	(-2.66)	(-2.60)	(-2.62)	(-1.72)	(-1.71)	(-1.72)
LEVERAGE	0.017	0.013	0.013	0.030	0.027	0.028	-0.017	-0.020	-0.020	0.024	0.021	0.021
	(0.24)	(0.18)	(0.18)	(0.40)	(0.35)	(0.37)	(-0.26)	(-0.30)	(-0.30)	(0.34)	(0.29)	(0.30)
CASHFLOW	0.002*	0.002	0.002	0.002*	0.002	0.002	0.002*	0.002	0.002	0.002	0.001	0.001
	(1.79)	(1.51)	(1.47)	(1.69)	(1.48)	(1.45)	(1.76)	(1.56)	(1.54)	(1.48)	(1.27)	(1.25)
GROWTH	0.043	0.039	0.040	0.066	0.067	0.065	0.075	0.073	0.073	0.099	0.100	0.099
	(0.75)	(0.68)	(0.71)	(0.85)	(0.86)	(0.84)	(1.28)	(1.23)	(1.26)	(1.26)	(1.27)	(1.26)
Constant	0.511***	0.464***	0.451***	0.623***	0.591***	0.580***	1.167***	1.138***	1.131***	1.307***	1.276***	1.267***
	(3.13)	(2.74)	(2.67)	(3.38)	(3.08)	(3.02)	(7.08)	(6.59)	(6.60)	(7.06)	(6.56)	(6.52)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1036	1036	1036	861	861	861	1036	1036	1036	861	861	861
Adj. R-squared	0.307	0.308	0.308	0.309	0.309	0.309	0.244	0.244	0.243	0.246	0.246	0.245

Note: Dependent variables – CAPM_BETA and FF4_BETA. Environmental performance is defined in Table 2 and is constructed in a way that the higher firms´ sales/emissions generate higher score for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 8 Relationship between multi-dimension environmental performance and firm risk (comparison between manufacturing and service industries)

	Manufacturing industries						Service industries					
	CAPM_BETA (t+1)			FF4_BETA (t+1)			CAPM_BETA (t+1)			FF4_BETA (t+1)		
	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)	(4a)	(5a)	(6a)	(4b)	(5b)	(6b)
EE	0.131***	0.130***	0.164***	0.117***	0.117***	0.148***	-0.014***	-0.015***	-0.024***	-0.013***	-0.014***	-0.027***
	(5.25)	(5.18)	(5.77)	(4.41)	(4.41)	(5.20)	(-3.03)	(-3.07)	(-3.04)	(-2.75)	(-2.85)	(-3.73)
EMP		-0.001	-0.001		-0.000	0.000		-0.003*	-0.004*		-0.004*	-0.004*
		(-0.50)	(-0.35)		(-0.04)	(0.10)		(-1.71)	(-1.89)		(-1.68)	(-1.93)
EE * EMP			0.004***			0.004***			-0.003			-0.004**
			(2.88)			(2.63)			(-1.52)			(-2.46)
Tobin's Q	-0.016	-0.016	-0.013	-0.011	-0.011	-0.009	-0.002	0.003	0.008	-0.015	-0.009	-0.003
	(-0.85)	(-0.83)	(-0.69)	(-0.57)	(-0.57)	(-0.44)	(-0.14)	(0.21)	(0.48)	(-0.93)	(-0.58)	(-0.18)
SIZE	0.045***	0.048***	0.053***	0.007	0.007	0.012	0.051***	0.066***	0.069***	0.002	0.017	0.021
	(4.06)	(3.62)	(3.95)	(0.64)	(0.54)	(0.88)	(3.57)	(4.23)	(4.28)	(0.11)	(1.05)	(1.25)
UNGC	0.014	0.017	0.029	-0.004	-0.003	0.008	-0.089*	-0.078	-0.077	-0.064	-0.052	-0.051
	(0.40)	(0.48)	(0.84)	(-0.11)	(-0.10)	(0.24)	(-1.79)	(-1.54)	(-1.53)	(-1.32)	(-1.06)	(-1.05)
CGSCORE	-0.002**	-0.002**	-0.002**	-0.003***	-0.003**	-0.003***	0.001	0.002	0.002	0.001	0.001	0.002
	(-2.48)	(-2.28)	(-2.40)	(-2.60)	(-2.51)	(-2.62)	(0.72)	(1.21)	(1.30)	(0.38)	(0.92)	(1.06)
R&D	-0.004**	-0.004**	-0.004**	-0.004**	-0.004**	-0.004**	0.069**	0.070**	0.069**	0.075**	0.076*	0.074*
	(-2.33)	(-2.35)	(-2.30)	(-2.06)	(-2.05)	(-2.00)	(2.21)	(2.06)	(2.03)	(2.03)	(1.91)	(1.87)
CAPITAL	-0.254	-0.260	-0.261	-0.551	-0.552	-0.552	-0.942**	-0.810**	-0.826**	-1.028**	-0.892**	-0.916**
	(-0.76)	(-0.77)	(-0.79)	(-1.47)	(-1.47)	(-1.48)	(-2.35)	(-1.98)	(-2.03)	(-2.45)	(-2.05)	(-2.12)
LEVERAGE	0.088	0.083	0.092	0.081	0.081	0.089	0.021	0.018	0.022	-0.062	-0.065	-0.060
	(0.98)	(0.93)	(1.03)	(0.88)	(0.87)	(0.96)	(0.20)	(0.17)	(0.20)	(-0.63)	(-0.65)	(-0.61)
CASHFLOW	0.002*	0.002*	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
	(1.73)	(1.65)	(1.53)	(1.64)	(1.61)	(1.51)	(1.17)	(0.88)	(0.74)	(1.08)	(0.83)	(0.65)
GROWTH	0.050	0.048	0.053	0.089	0.089	0.094	0.017	0.008	0.010	0.052	0.042	0.045
	(0.68)	(0.65)	(0.78)	(1.17)	(1.16)	(1.31)	(0.19)	(0.08)	(0.11)	(0.60)	(0.48)	(0.52)
Constant	0.563***	0.542**	0.444**	1.196***	1.195***	1.105***	0.059	-0.051	-0.082	0.807***	0.693***	0.648***
	(2.66)	(2.50)	(2.04)	(5.58)	(5.42)	(5.06)	(0.26)	(-0.23)	(-0.36)	(3.49)	(2.97)	(2.69)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	745	745	745	745	745	745	291	291	291	291	291	291
Adj. R-squared	0.359	0.359	0.364	0.294	0.293	0.298	0.106	0.111	0.113	0.105	0.110	0.116

Note: Dependent variables -- CAPM_BETA and FF4_BETA. Environmental performance is defined in Table 2 and is constructed in a way that the higher firms´ sales/emissions generate higher score for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 9 Relationship between multi-dimension environmental performance and corporate financial performance - Additional tests

	ROA (t+1)			ROA (t+2)			ROE (t+1)			ROE (t+2)		
	(1a)	(2a)	(3a)	(4a)	(5a)	(6a)	(1b)	(2b)	(3b)	(4b)	(5b)	(6b)
EE	0.462	0.682**	0.644*	0.095	0.327	0.239	6.760***	7.713***	8.402***	4.494**	5.429***	6.392***
	(1.40)	(2.03)	(1.94)	(0.33)	(1.17)	(0.83)	(3.74)	(3.89)	(3.86)	(2.41)	(2.64)	(2.75)
Quad.EE	-0.022	-0.031*	-0.031*	0.003	-0.006	-0.003	-0.274***	-0.313***	-0.324***	-0.172*	-0.209**	-0.243**
	(-1.27)	(-1.78)	(-1.74)	(0.21)	(-0.40)	(-0.19)	(-3.11)	(-3.29)	(-3.38)	(-1.94)	(-2.18)	(-2.26)
EMP		0.082***	0.081***		0.079***	0.073***		0.342***	0.367***		0.307**	0.302**
		(3.72)	(3.51)		(3.31)	(2.63)		(2.78)	(2.88)		(2.42)	(2.24)
EMP * EE			-0.012			-0.046			0.246*			0.198
			(-0.41)			(-1.24)			(1.65)			(1.18)
EMP * Quad.EE			-0.002			0.005			0.016			0.037
			(-0.28)			(0.35)			(0.34)			(0.71)
SIZE	-1.219***	-1.508***	-1.501***	-1.235***	-1.509***	-1.507***	-3.730***	-4.929***	-5.043***	-3.925***	-4.973***	-5.012***
	(-9.42)	(-9.92)	(-9.82)	(-9.15)	(-9.71)	(-9.68)	(-6.02)	(-6.20)	(-6.17)	(-5.92)	(-6.01)	(-5.98)
UNGC	3.267***	2.994***	2.952***	3.660***	3.367***	3.277***	13.362***	12.215***	12.919***	12.693***	11.557***	12.289***
	(6.32)	(5.76)	(5.67)	(6.51)	(5.95)	(5.81)	(3.87)	(3.59)	(3.74)	(3.78)	(3.46)	(3.64)
CGSCORE	0.010	-0.005	-0.004	0.010	-0.004	-0.002	0.388***	0.327***	0.308***	0.359***	0.304***	0.283***
	(0.60)	(-0.29)	(-0.22)	(0.49)	(-0.21)	(-0.09)	(4.36)	(3.86)	(3.77)	(3.36)	(2.88)	(2.72)
R&D	-0.026	-0.026	-0.025	0.051	0.053	0.053	0.002	0.002	-0.006	0.187	0.193	0.187
	(-0.64)	(-0.63)	(-0.62)	(0.89)	(0.93)	(0.94)	(0.01)	(0.01)	(-0.04)	(0.87)	(0.90)	(0.87)
CAPITAL	5.554	4.999	5.185	-5.794	-5.720	-5.216	19.620	17.802	14.131	-3.825	-2.957	-3.607
	(0.91)	(0.83)	(0.85)	(-0.84)	(-0.84)	(-0.78)	(0.68)	(0.63)	(0.50)	(-0.12)	(-0.10)	(-0.11)
LEVERAGE	1.622	1.694	1.675	2.792*	2.901*	2.823*	46.774***	47.224***	47.702***	32.932***	33.484***	34.169***
	(1.10)	(1.13)	(1.11)	(1.67)	(1.72)	(1.67)	(4.72)	(4.74)	(4.78)	(2.66)	(2.68)	(2.71)
CASHFLOW	0.083***	0.087***	0.087***	0.026	0.031*	0.030*	0.286***	0.303***	0.310***	0.158**	0.177**	0.177**
	(4.62)	(4.78)	(4.72)	(1.61)	(1.89)	(1.83)	(3.79)	(4.02)	(4.09)	(2.15)	(2.44)	(2.41)
GROWTH	6.675***	6.929***	6.943***	7.031***	7.100***	7.166***	18.452***	19.509***	19.194***	20.928***	21.198***	20.937***
	(4.12)	(4.24)	(4.24)	(3.98)	(4.03)	(4.07)	(3.14)	(3.26)	(3.24)	(2.71)	(2.73)	(2.70)
Constant	23.414***	24.580***	24.361***	27.092***	28.064***	28.199***	34.340***	38.995***	41.466***	49.153***	52.586***	55.632***
	(7.64)	(7.92)	(7.64)	(7.78)	(8.05)	(7.86)	(2.64)	(3.01)	(3.17)	(3.44)	(3.68)	(3.89)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1305	1305	1305	1095	1095	1095	1279	1279	1279	1072	1072	1072
Adj. R-squared	0.222	0.228	0.227	0.206	0.212	0.213	0.127	0.130	0.132	0.104	0.106	0.108

Note: Dependent variables – ROA (Return on Assets) and ROE (Return on Equity). Environmental performance is defined in Table 2 and is constructed in a way that the higher firms´ sales/emissions generate higher scores for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.

Table 10 Relationship between multi-dimension environmental performance and corporate financial performance (comparison between manufacturing and service industries) – Additional tests

	Manufacturing industries						Service industries					
	ROA (t+1)			ROE (t+1)			ROA (t+1)			ROE (t+1)		
	(1a)	(2a)	(3a)	(b1)	(2b)	(3b)	(4a)	(5a)	(6a)	(4b)	(5b)	(6b)
EE	0.157	0.663	0.095	-1.954	0.878	-0.725	0.722***	0.823***	0.880***	9.421***	9.564***	10.199***
	(0.10)	(0.41)	(0.06)	(-0.27)	(0.12)	(-0.10)	(2.63)	(3.00)	(3.20)	(4.18)	(3.84)	(3.94)
Quad.EE	0.297	0.191	0.230	1.442	0.845	0.932	-0.031**	-0.035**	-0.036**	-0.383***	-0.389***	-0.368***
	(0.45)	(0.29)	(0.35)	(0.64)	(0.37)	(0.40)	(-2.07)	(-2.37)	(-2.48)	(-3.55)	(-3.32)	(-3.25)
EMP		0.074**	0.072**		0.377***	0.392***		0.047	0.062*		0.066	0.180
		(2.39)	(2.20)		(3.07)	(3.06)		(1.47)	(1.87)		(0.26)	(0.70)
EMP * EE			-0.046			-0.063			0.073*			0.718**
			(-1.36)			(-0.48)			(1.69)			(2.29)
EMP * Quad.EE			-0.002			-0.028			-0.011			-0.007
			(-0.16)			(-0.75)			(-1.07)			(-0.08)
SIZE	-0.569***	-0.885***	-0.935***	-2.347**	-3.971***	-4.097***	-1.420***	-1.574***	-1.589***	-3.960***	-4.175***	-4.588***
	(-2.85)	(-3.58)	(-3.74)	(-1.97)	(-2.72)	(-2.85)	(-7.56)	(-7.73)	(-7.68)	(-4.61)	(-3.49)	(-3.63)
UNGC	3.567***	3.280***	3.118***	11.434***	9.937**	9.603**	3.372***	3.257***	3.250***	18.225***	18.061***	19.008***
	(5.30)	(4.84)	(4.65)	(2.80)	(2.57)	(2.37)	(5.14)	(4.92)	(4.83)	(2.89)	(2.89)	(2.92)
CGSCORE	-0.035	-0.047*	-0.046	0.070	0.014	0.019	0.041*	0.031	0.026	0.648***	0.635***	0.556***
	(-1.35)	(-1.67)	(-1.63)	(0.79)	(0.15)	(0.20)	(1.90)	(1.39)	(1.13)	(4.31)	(4.42)	(4.05)
R&D	-0.070*	-0.066	-0.066*	-0.182	-0.159	-0.157	-0.564	-0.600	-0.637	6.471	6.452	5.602
	(-1.78)	(-1.64)	(-1.65)	(-1.52)	(-1.29)	(-1.28)	(-0.97)	(-1.10)	(-1.11)	(0.64)	(0.65)	(0.55)
CAPITAL	-17.056**	-16.142**	-16.287**	-71.645***	-65.589***	-66.381***	37.528***	35.505***	35.293***	161.135***	158.330***	153.007**
	(-2.15)	(-2.03)	(-2.05)	(-2.96)	(-2.74)	(-2.77)	(3.88)	(3.69)	(3.63)	(2.66)	(2.63)	(2.52)
LEVERAGE	-3.841	-3.279	-3.418	18.008	21.915	21.763	2.939	2.899	2.949	59.445***	59.355***	59.683***
	(-1.63)	(-1.37)	(-1.42)	(1.15)	(1.35)	(1.34)	(1.42)	(1.39)	(1.40)	(4.25)	(4.26)	(4.34)
CASHFLOW	0.147***	0.154***	0.155***	0.320***	0.353***	0.354***	0.066***	0.067***	0.070***	0.342***	0.342***	0.392***
	(4.77)	(4.89)	(4.93)	(3.24)	(3.53)	(3.56)	(3.06)	(3.07)	(3.20)	(3.15)	(3.15)	(3.45)
GROWTH	4.488**	4.661**	4.579**	8.470	9.352	9.175	8.621***	8.791***	8.615***	26.108***	26.348***	23.777**
	(2.28)	(2.34)	(2.30)	(1.33)	(1.44)	(1.41)	(3.27)	(3.32)	(3.26)	(2.63)	(2.61)	(2.40)
Constant	18.865***	20.492***	21.494***	51.639***	59.819***	60.952***	21.772***	22.316***	22.128***	32.776	33.542	40.221*
	(4.24)	(4.43)	(4.53)	(2.80)	(3.08)	(3.28)	(5.67)	(5.87)	(5.64)	(1.54)	(1.58)	(1.83)
Industry Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	752	752	752	732	732	732	553	553	553	547	547	547
Adj. R-squared	0.173	0.178	0.179	0.060	0.067	0.066	0.323	0.324	0.324	0.178	0.176	0.185

Note: Dependent variables – ROA (Return on Assets) and ROE (Return on Equity). Environmental performance is defined in Table 2 and is constructed in a way that the higher firms´ sales/emissions generate higher score for environmental performance. Year and industry dummies are included to control for year industry effects. The numbers in parentheses are the heteroskedasticity-robust standard errors. *, ** and *** indicate significance level at 0.10, 0.05, and 0.01 (2-tail), respectively. The definitions of variables are presented in Table 2.