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Environmental and Financial Performance of Fossil Fuel Firms: A Closer Inspection of their Interaction

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ABSTRACT

We investigate the relationship between environmental and financial performance of fossil fuel firms. To this extent, we analyze a large international sample of firms in chemicals, oil, gas, and coal with respect to several environmental indicators in relation to financial performance for the period 2002–2013. We find that these firms have significantly higher scores on environmental performance efforts than other firms. We use a simultaneous equations system to identify the direction of the relationship between environmental and financial performance of the firms. We find that environmental outperformance has no impact on financial performance for chemical firms, reduces returns and risks for coal companies, has a mixed impact on returns in oil and gas, and reduces financial risks for oil and gas firms. Financial outperformance reduces environmental performance in all fossil fuel (sub)industries investigated. Our findings mainly support the opportunistic view regarding the impact of financial returns, which holds that financial performance negatively impacts social performance. Regarding financial risk, we find support for the stakeholder perspective where good environmental performance is beneficial from a finance perspective. We conclude to substantial differences in the environmental-financial performance relationship along fossil fuel firms in different subindustries.

1. Introduction

Given the impact of fossil fuels on climate change, it seems very relevant to investigate how the environmental performance of fossil fuel firms (firms in oil and gas, coal, and chemicals) relates to their financial performance. More specifically, is good financial performance associated with sound environmental performance, or is there a trade-off? Further, is this relationship the same along different performance measures and (sub)industries? Answering these questions is important to assess the potential for changes in operations by fossil fuel firms to transform the energy system. Several studies find that energy-intense companies are punished by the stock market for poor environmental performance (see Patten, 1992; Kolk et al., 2001; Kollias et al., 2012). These studies usually focus on the impact of events on company reputation (see, e.g., Spence, 2011), but not on company operations and related cash flows. Scholtens (2008) and Lioui and Sharma (2012) investigate the potential reasons why there would be a link between environmental and financial performance. The former study finds that it is highly dependent on the way in which these performances are being measured. The latter finds a negative direct impact of environmental on financial performance but a positive indirect impact.

Our study specifically investigates environmental and financial performance of fossil fuel firms. As such, it tries to focus on a much more homogeneous category than understood by the concept 'social performance' and its equivalents, which also relates to governance, ethical, and social issues with firms. To be precise, we investigate environmental and financial performance in three subindustries: chemicals, coal, and oil and gas. We rely on both qualitative and quantitative environmental performance indicators that are much more fine-grained than those used in the literature thus far. Further, we rely on different financial performance measures to avoid biases and to account for the underlying value structure of firms. We also address endogeneity and try to detect structural relations between environmental and financial performance. We find that fossil fuel firms have significantly higher scores for their environmental performance efforts relative to firms in other industries, but it shows that this is highly sensitive to (sub)industry classification. It will not come as a surprise that we also find that fossil fuel firms produce more waste and emissions than firms in other industries. Further, we find that environmental outperformance does not impact the financial performance of chemical firms, reduces returns and risks for coal companies, and has a mixed impact on returns in oil and gas, and reduces financial risks for firms in oil and gas. Financial

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outperformance reduces environmental performance in all the types of fossil fuel firms investigated. This shows that there are substantial differences in the relationships studied for the different subindustries. These findings suggest that any policy approach should account for the value chain at the subindustry level, since a 'one size fits all' policy is likely to have very distorting effects and, hence, is doomed to be ineffective.

The remainder of this paper proceeds as follows. We first discuss the background of the relationship between financial and environmental performance of the fossil fuel firms (i.e. firms in oil and gas, coal, chemicals). Then, we introduce the data and methods employed in our analysis. Next, we report the results from the univariate analysis and show the estimation results of the regression models. Finally, we discuss our conclusions.

2. Background and Hypotheses

Bénabou and Tirole (2006, 2010) argue that there are basically three reasons as to why firms and institutions would want to behave in a responsible manner (please note that these responsibilities pertain to environmental, ethical, social and governance characteristics). The first is altruism, that is, 'doing the right thing'. Here, the firm does incur costs to avoid or reduce externalities, but does not necessarily get something in return, such as lower expenses or higher revenues. The second reason is greenwashing, where the firm claims to behave in a responsible manner to gain benefits, but does not actually change the way it operates nor internalize externalities. The third reason is strategic behavior. Here, the firm makes an effort and incurs real costs to reduce externalities. However, it also succeeds in increasing its revenues from behaving in a responsible manner. Firms act on the basis of all three reasons, but may place different weightings on each of them, resulting in differing outcomes regarding social responsibility.

Views regarding the social (in a broad encompassing sense) responsibilities of companies mainly hold that their responsibilities go beyond maximizing shareholder returns, including a focus on the environment, ethical conduct of business operations, and responsibility to stakeholders (Campbell, 2007). From this perspective, companies should adopt policies and practices that align with the wider societal good (Matten and Moon, 2008). This approach aims at stakeholders like employees, customers, suppliers, communities, regulators, and the environment. The social policies and practices of firms reflect a behavioral standard regarding their social responsibilities (Campbell, 2007). It appears that the results of company policies and practices may vary widely and bear no straightforward relationship with financial performance (Dam and Scholtens, 2015). Furthermore, policies and practices regarding corporate responsibility often are not clearly defined and go beyond what is written into laws and regulations (Heal, 2008; Chatterji et al., 2009).

Two meta-studies that investigate the literature on the financial and responsibility performance of firms are Wu (2006) and Margolis et al. (2009). Wu (2006) researches the relationships between the financial and responsibility performance of firms (the latter relates to the environmental, social and governance performance of firms in general within the context of his research). This author arrives at several results: (1) there is a positive relationship between responsibility and financial performance indicators; (2) market-based measures are weaker predictors of responsibility than other financial measures, such as accounting indicators; and (3) perception-based measures report a stronger responsibility–financial performance relationship than performance-based measures. Margolis et al. (2009) find a small but statistically significant positive correlation between financial and social performance. One problem with such meta-analyses is that a lot of information gets lost and that studies are equally weighted despite huge differences in research design and quality.

Apart from methodological problems, indicators of social responsibility as well as those of financial performance widely differ among the studies included. Margolis et al. (2009) and Schultze and Trommer (2012) specifically mention this problem and the challenge of defining the responsibility construct. Indicators and measures of responsibility tend to capture either a single specific dimension, such as philanthropic donations or pollution control, or are broad appraisals of responsibility as a whole, like ratings. The issue of multi-dimensionality also plays a role with financial indicators (see Dam and Scholtens, 2015). For example, Gregory et al. (2014) mention that accounting measures are backward looking, and their objectivity and informational value is questionable. Stock market measures, by contrast, are much more forward-looking, with expectations of future cash flows and timing of these flows as well as risk embedded within the stock price (Gregory et al., 2014).

Based on Preston and O'Bannon (1997), Scholtens (2008) provides a brief overview as to why there might be a particular causal relationship between financial and environmental or social performance. There can be a negative link as the latter involves costs and therefore weakens the firm's competitive position, suggesting there is a trade-off between the two. As such, environmental and social issues may conflict with value maximizing behavior. In addition, managers may engage with social and environmental issues from an opportunistic perspective which may conflict with stakeholder and shareholder objectives. the managerial opportunism theory. This approach states that 'when financial performance is strong, managers may attempt to cash in by reducing social expenditure in order to take advantage of the opportunity to increase their own short-term private gains' (Allouche and Laroche, 2005). This is a form of agency costs. It also works the other way around: when financial performance weakens, managers might engage in social programs to offset or justify their disappointing results. The opportunism approach follows agency theory. Here, one believes a manager, when possible, has an incentive to put private gains first. When financial performance is strong, managerial opportunism expects less social performance. Thus, the opportunism approach assumes that financial performance precedes social performance. Please note that there can also be a positive association. For example, satisfying stakeholders' non-financial interests may result in improving the firm's financial performance due to increased loyalty. Firms do have a social impact and there is a demand from stakeholders for responsible conduct of the firm and in equilibrium the costs and benefits of servicing this demand would cancel out.

As to the direction of the causality, there is the financial resources-based view where financial means are essential in order to invest in responsible conduct and performance (the availability of funds, hereafter 'resources'). According to Orlitzky et al. (2003), the resource perspective suggests that investments in social performance may help firms develop new competencies, resources, and capabilities which are manifested in a firm's culture, technology, structure, and human resources (see also Russo and Fouts, 1997). Orlitzky et al. (2003) argue that social performance may help build managerial competencies because preventive efforts necessitate significant employee involvement, organization-wide coordination, and a forward thinking managerial style. They conclude that social performance can help management develop better scanning skills, processes, and information systems, which increase the organization's preparedness for external changes, turbulence, and crises. The same type of causality does occur in the more classical view of production which does occur to the detriment of social welfare (i.e. the classical externalities).

The causality can also run from environmental to financial performance. This is the case with stakeholder theory (which assumes a positive relationship) and the trade-off perspective (which assumes a negative relationship). Stakeholder theory suggests that social performance is positively associated with financial performance because it enhances the satisfaction of various stakeholders – and consequently the firm's external reputation – and leads to better financial performance (Allouche and Laroche, 2005). According to Preston and O'Bannon (1997), there is a lead-lag relationship between social and financial

performance; external reputation (favorable or unfavorable) develops first, then financial results (favorable or unfavorable) follow. According to Orlitzky et al. (2003) managers can increase the efficiency of their organization's adaption to external demands by addressing and balancing the claims of multiple stakeholders. Donaldson and Preston (1995) state that the widely believed notion is that stakeholder management contributes to successful economic performance, but they add that this is insufficient to stand alone as a basis for the stakeholder theory. They state that "studies have tended to generate implications suggesting that adherence to stakeholder principles and practices achieves conventional corporate performance objectives as well or better than rival approaches" (Donaldson and Preston, 1995).

As to the trade-off view, Preston and O'Bannon (1997) argue that social performance is the independent variable and that social accomplishments involve financial costs. Allouche and Laroche (2005) mention that because social accomplishments involve financial costs, social responsibility may siphon off capital and other resources from the firm, putting it at a disadvantage compared to other firms that are less socially active. Lioui and Sharma (2012) assess the impact of environmental performance on financial performance as measured by return on assets and Tobin's Q. They find a negative relationship between the two. However, they also detect a positive indirect effect as environmental performance fosters R&D efforts which general additional value for the firm (Lioui and Sharma, 2012). Pätäri et al. (2014) investigate how qualitative assessments of social responsibility "strengths and concerns" relate to the financial performance of 14 energy companies. They use Granger causality tests and find that social responsibility concerns Granger-cause corporate profitability and market value, whereas social responsibility strengths Granger-cause only market value. Furthermore, financial performance does not Granger-cause corporate social responsibility (Pätäri et al., 2014). However, they don't investigate environmental performance and refrain from investigating financial risk, and rely on accounting information only.

Stock market returns are widely used to analyze financial performance in relation to corporate social responsibility (see Margolis et al., 2009). But studies based on this indicator can produce misleading results because, in an efficient market, returns may be expected to reflect only (unexpected) changes in corporate social performance. This is problematic, as there is evidence to suggest that social responsibility indicators may be sticky (Chatterji et al., 2009). If social responsibility levels remain unchanged or if the changes are relatively small, then a returns-based study can give the impression that corporate social performance does not affect financial performance. But even when returns-based studies find some financial impact from social responsibility, care needs to be taken regarding interpretation of the results. For example, El Ghoul et al. (2011) find that firms with high social responsibility have lower cost of capital. Long-run returns to firms with high social responsibility may be lower for a given expected future cash flow because they are subject to less market risk. Then, if social responsibility does lower a firm's cost of capital, focusing solely on returns to indicate its financial impact will be misleading (Dam and Scholtens, 2015).

Understanding the overall financial implications of social responsibility requires that attention be given to both stock returns and firm value. To this extent, Dam and Scholtens (2015) provide underpinnings for the actual behavior of market participants. They relate social performance to measures like the market-to-book ratio (firm market value in relation to accounting value), return on assets, and stock market return. They conclude that there is a strong theoretical foundation for a positive relationship between social responsibility and financial performance, and argue that the relation is highly conditional on which financial performance measure is considered (Dam and Scholtens, 2015). Gregory et al. (2014) argue that markets positively value most aspects of social responsibility, and do so because, in the long run and measured across most dimensions, high social responsibility firms have a higher expected growth rate in their abnormal earnings. But this seems to be due primarily to industry effects rather than to a particular social responsibility strategy. Therefore, it is important to investigate different financial performance measures alongside a host of environmental indicators, and to focus on specific industries.

Heal (2008) argues that when a firm's private and social costs are about the same, markets generally are beneficial for society. However, when corporate and social costs are not closely aligned, markets do not work so well for society. In this respect, the conflicts between corporations and society over environmental issues almost always derive from the external costs associated with pollution (Heal, 2008). Firms may try to internalize some of these external costs and, as such, act in a more socially responsible manner. In part, this results from pressure of the market and society and this is stronger when the firm operates closer to both of these (e.g., there will be more scrutiny on firms in the downstream of the supply chain than in the upstream). Further, it appears that, in relating environmental performance to financial performance, it is important to pay attention to various types of indicator, as environmental performance is not a one-dimensional construct (Chatterji et al., 2009; Schultze and Trommer, 2012). Heal (2008) regards companies particularly in the tobacco, alcohol, pharmaceuticals, chemicals, and energy industries as facing great discrepancies between private and social costs. This is illustrated by Hong and Kacperczyk (2009), who find that investment portfolios consisting of firms in the tobacco, alcohol, and gambling industries in the US outperform portfolios without these industries. This suggests that these firms face higher cost of capital and incur more risk to attract investors.

We focus on the fossil fuel-intense firms (especially firms in oil and gas, coal, chemicals) and their environmental performance. Energy is a critical input to economic and societal processes and a part of all production processes. Thus far, several studies investigate the societal impact of energy companies. In this respect, they usually investigate disasters such as explosions or oil spills (e.g., Patten and Nance, 1998; Capelle-Blancard and Laguna, 2009). Further, the nature of these firms' operations requires high environmental exposure. Therefore, they are subject to economic, financial and political risks that are at least different in other industries. Thus, environmental outperformance can be regarded as a strategy of energy firms to limit their exposure and/or to improve their reputation (Heal, 2008). Kolk and Levy (2001) show that energy firms invest resources in low-emission and renewable sources as well as in anticipating regulation to hedge themselves against exposure to the environmental and societal impact of their operations.

From this broad overview of the literature, we arrive at several hypotheses we want to put to the test:

First, based on the views of a.o. Kolk et al. (2001), Heal (2008), and Kollias et al. (2012), is that we want to find out whether environmental performance of our sample of fossil firms differs from that of other firms. Here, based on the literature discussed above, we hypothesize that their policies will be more intense and that they score relatively high on environmental policies (H1).

Second is that their actual performance in terms of emissions may be worse as this basically is the reason as to why they would engage more with environmental responsibility (H2). This would be reflected in much more efforts regarding emission reduction, product innovation and resource reduction of the fossil fuel firms.

Next, we assume that within this group of firms, the performance of chemical firms is superior to that of oil & gas and coal companies (H3). This is because chemical firms operate closer to the market of end-users and are more competitive than the energy industry (Budde, 2011). In this respect, Heal (2008) argues that firms that are more subject to the scrutiny of market participants are more likely to invest in responsibility. However, he relates this argument to broad-based industry classifications. Kolk et al. (2001) investigate reporting practices at the industry level and their study tends to confirm Heal's view. We want to find out whether this also is the case for an industry that already is regarded as problematic. We don't expect a significant difference between oil and gas companies vis-à-vis coal

companies as they are more or less in the same position in this respect.

As to the relationship between financial and environmental performance, i.e. both the direction and the positive or negative relationship, we want to find out which of the different theoretical approaches in this respect would appear to hold (see Preston and O'Bannon, 1997; Scholtens, 2008). As such, we want to test whether the stakeholder theory (H4), the trade-off view (H5), the resources approach (H6), or the opportunism view (H7) does hold for our samples.

Thus, in H4 we test stakeholder theory which assumes there is a positive impact from environmental to financial performance.

In H5 we test the trade-off hypothesis which holds that there is a negative impact from environmental to financial performance.

In H6 we test the resources approach which implies that financial performance is having a positive impact on environmental performance.

In H7 about the opportunism hypothesis which holds that financial performance will negatively impact environmental performance.

Further, in line with Pätäri et al. (2014), we try to find out what determines firms' environmental performance and whether this differs for fossil fuel firms compared to other (i.e., non-fossil) firms.

3. Data and Method

We investigate environmental and financial performance of a large international sample of firms in both fossil fuel-related (firms in oil and gas, coal, chemicals) and 'non-fossil fuel-related' industries (of course, we are well aware of the indirect usage of fossil fuels in all firms and in fact there is no industry that does not indirectly consume any fossil fuel) for the period 2002–2013. This period is motivated primarily on the basis of data availability of both the financial and the environmental variables. As to the fossil fuel firms, we include all firms in the following 2-digit SIC codes: 12 ('coal'), 13 ('oil and gas'), and 28 and 29 ('chemicals').

The quality of the ways in which responsibility is measured is a concern in the academic literature (see Chatterji et al., 2009; Schultze and Trommer, 2012). Most research on corporate social responsibility tends to rely on qualitative assessments from specialized ratings agencies. However, such assessment is usually based on specialist views regarding corporate policies and not so much on actual firm performance (Chatterji et al., 2009). Further, the assessment is not verified and cannot be replicated by outsiders. Since the relationship between policy and performance is not one-on-one, it would be better to use both types of indicators, namely, categorical assessment data and environmental performance data for one specific industry, and to compare across industries. Therefore, we will want to use a wide array of indicators.

Our data about environmental performance are gathered from the Worldscope database provided by Thomson Reuters. The selection of sample firms is based on data availability at the ASSET4 ESG database in Worldscope. The literature is divided in terms of selecting data source to measure environmental as well as social and governance scores when they use an international sample. Arouri and Pijourlet (2016) use Intangible Value Assessment ratings from MSCI and list the following studies to use the same: Derwall et al., 2005; Aktas et al., 2011; Guenster et al., 2011; Marsat and Williams, 2013. However, the coverage of ASSET4 ESG database has increased importantly, and therefore the choice of very recent studies (i.e., Cheng et al., 2014; Stellner et al., 2015; Feng et al., 2015; El Ghoul et al., 2016). We also feel ASSET4 is to be preferred due to the consistency in the reporting (e.g. MSCI is faced with a major structural break in the series in 2009). Further, the same provider, i.e. Thomson Reuters, also provides financial information about the companies. Therefore, it is likely that the matching errors will be much more limited than in the case of combining different data sources.

The ASSET4 ESG database carries historical data for several key performance indicators on four pillars: economy, environment, social, and corporate governance. The ASSET4 ESG framework allows us to rate and compare companies against approximately 700 individual data points, which are combined into over 250 key performance indicators. The scores on the key performance indicators are aggregated into a framework of 18 categories grouped within the four pillars, which are integrated into a single overall score. This database has gathered data from publicly available information, such as company websites, annual reports, and proxy files since 2002. Therefore, our analysis will cover the period 2002 to 2013. The coverage of the database originally was limited to US and European firms, but expanded in more recent years. As such, we have an unbalanced panel. We will report the results of our analysis for the overall sample in the main text, but we will also report them for subsamples of countries in the appendix and discuss these in the main analysis.

In our analysis, first we use overall percentage scores of the environment pillar (the Environmental Score), and extend our analysis to the three constituting categories of environmental performance: emissions reduction, product innovation, and resource reduction. Environmental score in fact measures a company's impact on living and non-living natural systems, including air, land, and water, as well as complete ecosystems. It reflects how well a company uses best management practices to avoid environmental risks and to capitalize on environmental opportunities to generate long-term shareholder value. The three constituting categories (emissions reduction, product innovation, resource reduction) are labeled categorical indicators in the remainder of this paper. Next, we employ variables that are much closer to actual environmental performance, such as emissions and expenses. Appendix A provides definitions of the environmental variables used.

Financial data also are collected from Datastream/Worldscope for firms with available environmental performance indicators. We eliminate financial firms to avoid issues of regulatory influence on these firms. We compute five financial performance variables from the same database; three relate to value and return and two to risk. As to the former, we investigate two market performance variables, namely stock market excess returns, the difference in the percentage change in the US dollar stock return between the beginning and end of a year and the annual local market index return, and Tobin's Q, the ratio of (book value of total assets + market value of common equity − book value of common equity) to the book value of total assets. The accounting performance measure is the widely used return on equity, the ratio of net income to common equity. Further, and novel in this strand of the literature, we include two specific risk measures. The first is business risk, which measures firm earnings volatility as an unsystematic risk and is computed as the standard deviation of operating income ratio over three-year overlapping periods of the sample period. (Operating income ratio is the ratio of operating income, which is the difference between sales and operating expenses, to sales.) The second is Beta, which measures the firm's systematic risk and is calculated using daily stock returns in each year by running regressions for the firm's stock returns against local market index returns for each firm.

Worldscope data may contain errors, and thus all financial variables are winsorized at 0.01 and 0.99 to avoid outliers affecting results. Compared to previous studies (Patten and Nance, 1998; Capelle-Blancard and Laguna, 2009; Henriques and Sadorsky, 2010; Pätäri et al., 2014; Arslan-Ayaydin and Thewissen, 2015), our sample is highly international (it encompasses firms from over 50 countries), focuses on a more recent period, and uses a much wider scope of both financial and environmental indicators. More specifically, we include excess stock returns among the financial performance measures, account for risk characteristics, and concentrate on both qualitative and quantitative aspects of environmental performance. As such, we feel we are able to arrive at a much more detailed inspection of the interaction between environmental and financial performance.

We first perform univariate tests for comparisons of the means and the medians of the variables between the fossil fuel firms (chemicals, coal, oil and gas) and other firms. Standard t-tests for mean and non-parametric tests for median are used for statistical comparisons. Next, we concentrate on pooled ordinary least squares (OLS) regression estimations for the effects of financial performance variables on environmental performance scores. We investigate all industries within the economy (except for banks and other financial services providers) and control for the fossil fuel firms via a dummy variable. In this respect, we focus on firms' overall environmental score and its constituent categories (emissions reduction, product innovation, and resource reduction). We do this for the specific environmental performance indicators as well. We use the interaction variables between the fossil energy industry dummy and financial performance variables to test whether the effects of financial performance variables on environmental performance are statistically different between the fossil fuel firms and those in other industries. In line with the literature, we control for size, which is the natural logarithm of book value of assets in US dollars, research and development expenditures (R&D) scaled by book value of total assets, financial leverage, the ratio of the total of short- and long-term debt to book value of total assets, and net working capital, the ratio of the difference between current assets and current liabilities to book value of total assets, to control the liquidity of firms. We use country and year fixed effects in all regressions.

In our research framework, we propose that financial performance determines environmental performance, but we acknowledge that it could also be plausible, as documented in the literature, that environmental performance affects financial performance (see Margolis et al., 2009). In this case, the environmental performance equation contains an endogenous variable, financial performance, and vice versa. To address this reverse causality problem, as well as the possibility that some of the independent variables are jointly determined, we create a system of structural equations, including two equations for environmental and financial performance, separately. To estimate the model, we perform a three-stage process for systems of simultaneous equations by using two-stage least squares (2SLS) estimations for each equation. We produce the three-stage least squares (3SLS) estimates from a three-step process: In step one, we develop instrumental variable equations for both environmental and financial performance variables. The two instruments in the environmental performance equation are averages of the scores by country/year and by country/industry score (Cheng et al., 2014). We use leverage and net working capital as instruments of financial performance (see Vishani and Shah, 2007; Afza and Nazir, 2009). We use all other variables explained in the OLS regression analysis above as control variables along with country and year fixed effects, and expect them to impact the relationship in line with the literature (Wu, 2006; Margolis et al., 2009). These two equations create the predicted values resulting from a regression of each endogenous variable on all exogenous variables in the system; this is identical to the first step in conventional 2SLS. Thus, the 3SLS process creates a consistent estimate for the covariance matrix of the equation disturbances. These estimates are based on the residuals from the 2SLS estimation of each structural equation. In the last step of the third stage, the 3SLS performs a generalized least squares (GLS) type estimation using the covariance matrix estimated in the second stage, and with the instrumented values in place of the right-hand-side endogenous variables.

4. Results

We first present the descriptive statistics and the univariate analysis. Then, we provide the findings from the regression analyses.

4.1. Univariate analysis

Table 1 is an overview of the country composition of the sample. It shows that in the 51 countries under investigation, there are more than 23,000 firm-year observations, among which about 12% are fossil fuel firms. Most observations are for the US, Japan, and the UK; together the three make up 53% of total observations (that is also the main reason why will provide estimation results for subsamples in the Appendix, namely for Australia, Canada, Japan, UK, and US, for the sample excluding the UK and the US, and for the full sample excluding the US). Table 1 reports the means for the overall environmental score. Please see Appendix A for the definition of all the variables used in this construct. The environmental score is a performance pillar reflecting how well—according to the rating agency—a company uses best management practices to avoid environmental risks and to capitalize on environmental opportunities to generate long-term shareholder value. A higher score relates to relatively more (perceived) efforts by the firm. However, this score does not necessarily imply that the firm is cleaner

Table 1
Sample countries and mean values of environmental score. The environmental score is performance pillar reflecting how well a company uses best management practices to avoid environmental risks and capitalize on environmental opportunities to generate long-term shareholder value. The sample period is from January 2002 to December 2013.

Country	Total sample		Non-fossil fuel firms		Fossil fuel firms	
	N	Mean	N	Mean	N	Mean
Australia	1342	35.9975	1153	35.5700	189	38.6055
Austria	122	64.3275	110	61.3128	12	91.9617
Belgium	187	58.2609	175	55.9731	12	91.6242
Brazil	233	53.6554	209	51.6938	24	70.7375
Canada	1540	38.6769	1084	38.5328	456	39.0192
Chile	56	40.7763	51	38.9865	5	59.0320
China	278	32.8192	242	30.5463	36	48.0978
Colombia	12	46.7025	12	46.7025		
Czech Republic	5	37.0960	5	37.0960		
Denmark	206	59.8168	206	59.8168		
Egypt	29	23.1238	29	23.1238		
Finland	244	75.6037	230	74.6953	14	90.5271
France	747	76.2579	656	76.1179	91	77.2674
Germany	634	68.1313	590	66.9240	44	84.3189
Greece	142	42.1356	120	36.5048	22	72.8486
Hong Kong	472	32.1517	445	31.7184	27	39.2926
Hungary	15	74.9047	9	64.3589	6	90.7233
India	251	59.3308	220	57.7815	31	70.3258
Indonesia	91	49.2776	74	48.0028	17	54.8265
Ireland	143	39.6181	137	40.3483	6	22.9467
Israel	60	37.9598	52	31.2910	8	81.3075
Italy	258	51.9221	240	49.0643	18	90.0256
Japan	3175	63.2768	2881	62.0711	294	75.0915
Kuwait	6	53.4583	6	53.4583		
Luxembourg	44	55.7146	35	61.2540	9	34.1722
Malaysia	115	41.6329	115	41.6329		
Mexico	113	49.1227	113	49.1227		
Morocco	6	37.8750	6	37.8750		
Netherlands	294	67.9912	254	65.8918	40	81.3225
New Zealand	65	46.5683	65	46.5683		
Norway	166	62.9472	97	63.5037	69	62.1648
Peru	9	25.1511	9	25.1511		
Philippines	30	27.6917	30	27.6917		
Poland	39	37.6139	31	34.6958	8	48.9213
Portugal	77	71.3199	69	69.8606	8	83.9063
Qatar	6	11.3967	6	11.3967		
Russia	150	42.5271	101	33.0134	49	62.1369
Saudi Arabia	24	37.1158	11	20.2682	13	51.3715
Singapore	243	38.5595	238	38.8283	5	25.7620
South Africa	280	53.3428	266	52.8638	14	62.4443
South Korea	353	64.8985	320	63.6606	33	76.9024
Spain	285	70.3932	260	69.6515	25	78.1064
Sri Lanka	4	54.3050	4	54.3050		
Sweden	419	70.1715	402	71.9627	17	27.8147
Switzerland	484	59.8851	421	58.3516	63	70.1330
Taiwan	448	47.0445	401	48.3051	47	36.2892
Thailand	65	54.7940	30	33.1753	35	73.3243
Turkey	69	55.0149	63	51.9338	6	87.3667
United Arab Emirates	11	36.0527	11	36.0527		
United Kingdom	2421	60.3072	2245	60.9396	176	52.2393
United States	6839	43.8841	6029	43.5652	810	46.2578
Total	23,307	51.9057	20,568	51.6076	2739	54.1437

or better from an environmental perspective. To that extent, one has to investigate the actual performance indicators, which will be done later on in this study.

Table 1 reveals that the environmental score is higher for the 2739 fossil fuel firms (comprising firms in oil and gas, coal and chemicals) compared to the 20,568 non-fossil fuel firms (54.1 versus 51.6). This suggests support for the first hypothesis where it was assumed that fossil fuel firms would outperform others in this respect. Table 1 shows that fossil fuel firms in Austria, Belgium, Finland, Hungary, and Italy have the highest environmental scores, whereas those in Ireland, Singapore, and Sweden have the lowest.

Table 2 sets forth the sample composition for the 44 industries and their performance with respect to the main variables of interest. This table shows that most observations are for firms in oil and gas, business services, and in retail. The sectoral distribution of the observations is much less skewed than in the case of the country distribution: the three largest (oil and gas, retail, and business services) make up 20% of the total sample. Table 2 shows that the mean of the encompassing environmental score is relatively high (above 66) in aircraft, automobiles, computer hardware, business supplies, electronic equipment, consumer goods, chemicals, and recreation. It is relatively low (33 or less) in agriculture, defense, entertainment, personal care, precious metals, healthcare, and other industries. Among the fossil fuel firms, there is a marked difference between chemicals (68.7) on the one hand, and coal (39.1) and oil and gas (46.8) on the other. This is confirmation for the third hypothesis about the relative performance of fossil fuel subindustries. We want to point out that these findings align only to some degree with the general view put forward by Heal (2008). Industries with

Table 2
Descriptive statistics for financial performance and environmental score by industry. Tobin's Q is the ratio of (book value of total assets + market value of common equity − book value of common equity) to book value of total assets. Excess stock return is the annual buy and hold return in excess of local market return. Return on equity is the ratio of net income to the book value of common equity. Business risk is the standard deviation of operating income ratio over 3-year overlapping periods in the sample period. Annual beta is calculated using monthly stock return data in each year by running regressions for the firm stock return against local market index returns for each firm. Total beta is calculated using monthly stock return data for the entire sample period by running regressions for firm stock return against local market index returns for each firm. The environmental score is a performance pillar reflecting how well a company uses best management practices to avoid environmental risks and to capitalize on environmental opportunities to generate long-term shareholder value. The sample period is 2002 to 2013.

	Tobin's Q		Excess stock return		Return on equity		Business risk		Beta		Environmental score	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
Non-fossil fuel firms												
Agriculture	79	1.6643	79	0.0552	79	0.1464	79	0.0357	79	0.8363	79	33.031
Aircraft	180	1.5674	178	0.1179	180	0.2321	180	0.0157	180	0.9889	180	69.170
Apparel	211	2.0245	208	0.1189	211	0.1329	210	0.0143	210	0.9460	211	49.394
Automobiles and trucks	699	1.3688	697	0.1790	699	0.1161	696	0.0404	697	1.1394	699	78.258
Beer & liquor	219	1.6071	219	0.0978	219	0.1506	219	0.0140	219	0.7500	219	57.737
Business services	1491	2.0955	1475	0.1001	1502	0.1589	1486	0.0850	1490	0.9744	1502	38.583
Business supplies	299	1.4327	298	0.0810	299	0.1124	299	0.0198	299	0.9441	299	69.937
Candy & soda	228	1.9275	226	0.1118	228	0.2347	228	0.0114	228	0.6784	228	55.405
Communication	1384	1.7757	1358	0.0610	1389	0.1662	1,381	0.0933	1375	0.8750	1389	44.880
Computer hardware	383	1.8626	381	0.0733	383	0.0888	383	0.0235	383	1.0981	383	70.517
Computer software	856	2.9136	851	0.1111	855	0.1379	856	0.0507	857	1.0055	857	34.730
Construction	876	1.2617	873	0.0908	876	0.0776	875	0.0315	876	1.0651	876	58.449
Construction materials	630	1.4811	630	0.0861	630	0.0627	630	0.0982	630	1.0905	630	63.605
Consumer goods	517	2.6658	516	0.1025	517	0.2202	517	0.0166	516	0.8973	517	67.128
Defense	5	1.4011	5	−0.0106	5	0.2534	5	0.0042	5	0.8373	5	30.292
Electrical equipment	228	1.5341	227	0.0873	228	0.0605	228	0.0205	228	1.0929	228	67.946
Electronic equipment	1309	1.9417	1298	0.0530	1308	0.0239	1309	0.0833	1308	1.2012	1309	59.425
Entertainment	306	2.2008	300	0.1138	308	0.0869	307	0.0383	305	0.9357	308	28.840
Fabricated products	72	1.5109	66	0.1508	73	0.0639	73	0.0361	67	1.1883	73	57.364
Food products	619	1.7248	616	0.0727	620	0.1395	619	0.0144	619	0.7164	620	56.278
Healthcare	197	1.7174	197	0.1065	197	0.1289	197	0.0173	197	0.7306	197	27.828
Machinery	900	1.7697	897	0.1659	902	0.1466	900	0.0274	901	1.1700	903	64.747
Measuring and control equipment	233	2.1857	233	0.1132	233	0.1440	233	0.0331	233	1.1128	233	48.798
Medical equipment	418	3.2021	416	0.0816	423	0.1919	423	0.0177	418	0.8117	423	49.553
Non-metallic and industrial meta	702	2.1676	697	0.2106	705	0.0386	597	0.3924	702	1.4070	705	45.470
Personal services	204	2.2423	201	0.0765	204	0.1285	203	0.0300	204	0.9173	204	26.311
Pharmaceutical products	879	2.5879	876	0.0774	881	0.0861	878	0.2438	880	0.7893	882	49.909
Precious metals	462	2.4333	461	0.1133	462	−0.0204	363	0.3770	462	1.2573	462	32.107
Printing and publishing	323	1.9350	320	0.0048	324	0.1290	303	0.0185	322	0.8774	324	43.349
Recreation	208	1.5046	208	0.0714	208	0.0373	207	0.0260	208	1.0453	208	66.351
Restaurants, hotels, motels	380	2.1069	375	0.1443	380	0.0952	380	0.0776	379	0.9808	380	48.873
Retail	1540	2.0246	1531	0.1164	1543	0.1619	1540	0.0145	1535	0.9159	1543	43.287
Rubber and plastic products	101	1.6721	101	0.1399	101	0.1107	101	0.0158	101	0.9966	101	61.635
Shipbuilding, railroad equipment	87	1.4110	87	0.1620	87	0.1392	87	0.0237	87	1.2582	87	59.791
Shipping containers	117	1.3060	117	0.1085	117	0.0430	117	0.0134	117	1.0639	117	64.365
Steel works, etc.	628	1.3697	626	0.1252	630	0.0912	630	0.0389	628	1.2665	630	59.871
Textiles	49	1.2028	49	0.1310	49	0.0720	49	0.0332	49	1.1609	49	50.132
Tobacco products	97	3.7023	96	0.1228	97	0.3718	97	0.0200	97	0.6418	97	63.414
Transportation	1187	1.3959	1178	0.0864	1196	0.0767	1192	0.0356	1186	0.9398	1196	53.170
Wholesale	1131	1.7780	1121	0.1080	1133	0.1001	1133	0.0312	1128	0.9761	1134	47.115
Others	81	1.9977	80	0.0324	81	0.1233	80	0.0747	81	0.8765	81	32.003
Non-fossil fuel firms	20,515	1.9272	20,368	0.1024	20,562	0.1147	20,290	0.0693	20,486	1.0032	20,568	51.608
Fossil fuel firms												
Chemicals	964	1.5987	961	0.1204	966	0.1191	962	0.0295	965	1.0610	966	68.740
Coal	145	1.9615	144	0.0790	145	0.1161	142	0.3305	145	1.2824	145	39.074
Oil and gas	1627	1.6383	1615	0.1205	1627	0.1083	1598	0.1587	1626	1.1611	1628	46.825
Total	2736	1.6414	2720	0.1183	2738	0.1125	2702	0.1217	2736	1.1322	2739	54.144

substantial externalities, such as the aircraft, auto, chemical, machinery, rubber, shipping, steel, and tobacco industries, indeed score relatively high on the environmental score. However, this also is the case with industries where the differential between social and private costs seems much less obvious, including the computer hardware, business supplies, and recreation industries.

As to financial performance, Table 2 shows that the Tobin's Q of chemicals, and oil and gas is relatively low. Their excess stock return is higher than that of coal firms and of firms in most other sectors/industries. For coal, the excess stock return is below the average of non-fossil fuel industries. Return on equity is about the same in the three fossil fuel-related sectors and slightly lower than with non-fossil fuel firms. The financial risk indicators reveal that most indicators for all three types of fossil fuel firms sectors are much higher than those elsewhere. The exception is business risk in chemicals, which appears low compared to the average of the non-fossil fuel firms. In general, these findings are in line with those found elsewhere (e.g., Schultze and Trommer, 2012; Pätäri et al., 2014; Arslan-Ayaydin and Thewissen, 2015).

More detailed descriptives are shown in the six panels in Table 3, which also reports the median performances and provides more information regarding firm characteristics and environmental indicators. Furthermore, this table reports the test results regarding the differences between the mean and median performance of different subgroups (i.e., fossil fuel-intense firms and non-fossil fuel-intense firms; chemicals versus coal and oil and gas). Panel A in Table 3 compares the main financial characteristics. It shows that fossil fuel firms have lower Tobin's Q, higher excess stock market returns, are more risky, are much larger, have less R&D as well as less working capital, and have slightly lower leverage. In most cases, the differences are statistically significant with 99% confidence, both in the means and medians (except leverage). Return on equity does not significantly differ between fossil fuel firms and the other firms.

Panel B reports the differences between overall environmental score and the three other categorical indicators (emission reduction, product innovation, resource reduction). In this respect, the fossil fuel firms perform significantly better on overall environmental score and on efforts toward emission reduction, but do not significantly differ from other firms with respect to product innovation and resource reduction. Therefore, regarding the environmental score in general and the emission reductions in particular, we find support for H1, but not for H2. We don't find this in the case of product innovation and resource reduction.

Panel C gives details of the financial characteristics of firms in the three fossil fuel-related sectors and compares chemical firms with coal and oil and gas firms. This panel shows that median Tobin's Q and excess stock market return is significantly higher with chemicals but that the mean is not. Further, there is no statistically significant difference regarding stock market returns, and only a marginally significant (10% significance) difference for the median of return on equity. However, risk in coal and in oil and gas is much higher than that with chemicals. R&D and working capital are lower with coal and oil and gas firms compared to chemical firms; also, the former (especially oil and gas) are much larger than chemical firms.

Panel D provides an overview of the univariate tests of the four categorical environmental indicators for the three sectors. This panel clearly shows that chemical firms have much better environmental performance scores than those in coal, oil, and gas. This is supportive for H3 regarding the subindustries in fossil.

Panel E shows the performance of fossil fuel firms compared to other firms for a large number of environmental performance indicators. This panel shows that the fossil fuel firms exhibit greater use of resources, water, and energy, and generate more emissions of all types. This is clearly in support of our second hypothesis. The mean for their NOx and SOx emissions and their waste production is lower than in non-fossil fuel firms, but the median shows they are higher. The mean of the fossil fuel firms regarding the amount of waste is lower than with the non-fossil fuel firms, but the median does not confirm this. Resource-use reduction policies and monitoring in the non-fossil fuel firms are seen as superior to those with the fossil fuel firms. This contrasts with H1.

Panel F in Table 3 shows the performance on environmental indicators of different types of fossil fuel firms: It compares firms in chemicals with those in coal and in oil and gas. This panel shows that the latter have higher environmental expenditures and environmental provisions (in line with Heal, 2008). Coal and oil and gas firms also have higher NOx, SOx, and volatile organic compound (VOC) emissions than chemical firms. For most other environmental indicators (e.g., CO_2 equivalent emissions, water use, waste production, and energy use), chemical firms put more pressure on the environment. But this sector's emission reduction efforts rate better than those in the oil and gas and in coal. The policies, implementation, and monitoring of emission reduction of chemical firms is perceived as better than that of the coal and the oil and gas firms. As such, these findings confirm H3 and are in line with those of Pätäri et al. (2014) and Arslan-Ayaydin and Thewissen (2015) on the basis of KLD MSCI data.

4.2. Regression analysis

Table 4 reports the estimation results of the OLS regressions, where the environmental category proxies are regressed against financial variables. Thus, first, we try to explain what determines the overall environmental score and its three categorical components, namely, emissions reduction, product innovation, and resource reduction. The model accounts for a dummy variable to compare fossil fuel firms with non- fossil fuel firms, and interaction effects. As such, we investigate the impact of financial performance of a firm on environmental score, conditional on the firm belonging to one of the three fossil fuel-related sectors. Apart from the five financial performance indicators, we use firm size, leverage, R&D expenditure, and working capital as control variables, as in many studies on the relationship between financial and social performance (see Wu, 2006; Margolis et al., 2009). All regressions are run controlling for country and year fixed effects.

The estimated coefficients of the dummy variable representing fossil fuel firms (Dummy_Fossil) show that this variable is indeed a significant factor for the overall environmental score, and that it specifically relates to the emission reduction categorical score and to the product innovation category, which supports both H1 and H2. Further, Table 4 reveals that there is a mixed picture regarding how the financial performance indicators and the control variables relate to the different environmental categories. Tobin's Q is positively associated with environmental performance, but the significant coefficient of the interaction term reveals that the relationship is, in fact, a negative one for fossil fuel firms. This implies that firms that are relatively highly valued are associated with relatively low environmental categorical scores. This suggests that with fossil fuel firms there is a trade-off regarding firm value and environmental performance, which confirms the opportunism hypothesis (H7). Excess stock returns are negatively related to the overall environmental score and to the resources category. Here, we find that the interaction with energy is statistically significant and there is a positive relationship between excess returns and environmental performance. This supports the resources hypothesis (H6). For our third measure, return on equity, we find that these returns have a positive impact on the environmental performance scores but if we interact with the fossil fuel dummy, there is no significance. In general, these findings are in line with the predictions of Gregory et al. (2014) and Dam and Scholtens (2015). For business risk, there is a negative and significant relationship with environmental performance but if we investigate the interaction with Dummy_Fossil, it shows that this doesn't have a significant role to play. For Beta as a risk indicator, we find that there is a statistically significant and positive relationship with the environmental categories. But, as with business risk, we don't find that fossil fuel as such has an impact here (apart from a marginal negative impact regarding the product

Table 3
Comparisons of financial performance and environmental scores between non-fossil and fossil fuel firms. Tobin's Q is the ratio of (book value of total assets + market value of common equity − book value of common equity) to the book value of total assets. Excess stock return is the annual buy and hold return in excess of local market return. Return on equity is the ratio of net income to book value of common equity. Business risk is the standard deviation of operating income ratio over 3-year overlapping periods in the sample period. Annual beta is calculated using monthly stock return data in each year by running regressions for firm stock return against local market index returns for each firm. Total beta is calculated using monthly stock return data in the entire sample period by running regressions for firm stock return against local market index returns for each firm. Assets is measured by the US dollar value of the book value of total assets; leverage is the ratio of total book value of short and long-term debt to the book value of total assets, R&D is research and development expenditures; and net working capital is the ratio of the difference between current assets and current liabilities to the book value of total assets. Environmental performance scores are examined as categorical scores and indicators, which are items determining categorical scores for emission reduction, product innovation, and resource reduction. The significance of differences between means and medians is based on a t-test for mean differences and Wilcoxon rank-sum test for median differences, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels. The sample period is from 2002 to 2013.

Panel A: Financial performance and firm characteristics

	Total sample			Non-fossil fuel firms			Fossil fuel firms			Difference non-fossil and fossil	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Tobin's Q	23,251	1.8936	1.4612	20,515	1.9272	1.4750	2736	1.6414	1.3830	0.2858***	0.0921***
Excess stock return	23,088	0.1043	0.0411	20,368	0.1024	0.0401	2720	0.1183	0.0522	−0.0159*	−0.0121*
Return on equity	23,300	0.1144	0.1205	20,562	0.1147	0.1207	2738	0.1125	0.1194	0.0021	0.0013
Business risk	22,992	0.0754	0.0165	20,290	0.069	0.016	2702	0.1217	0.0255	−0.052***	−0.010***
Beta	23,222	1.0184	0.9831	20,486	1.0032	0.9647	2736	1.1322	1.1051	−0.1290***	−0.1405***
Assets (USD billion)	23,306	12.300	4.444	20,567	11.700	4.305	2739	17.600	5.784	−5.900***	−1.479***
Leverage	23,263	0.3477	0.3378	20,534	0.3487	0.3379	2729	0.3406	0.3373	0.0081*	0.0006
R&D	23,307	0.0186	0.0000	20,568	0.0199	0.0001	2739	0.0088	0.0000	0.0111***	0.0001***
Net working capital	23,189	0.1445	0.1217	20,450	0.1496	0.1282	2739	0.1067	0.0841	0.0429***	0.0441***

Panel B: Environmental categorical scores

	Total sample			Non-fossil fuel firms			Fossil fuel firms			Difference non-fossil and fossil	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Environmental score	23,307	51.9057	50.9000	20,568	51.6076	50.2300	2739	54.1437	57.0600	−2.5361***	−6.8300***
Emission reduction	23,307	51.8969	51.4700	20,568	51.0018	49.3400	2739	58.6182	66.7100	−7.6164***	−17.3700***
Product innovation	23,307	49.6024	34.9400	20,568	49.6976	35.1600	2739	48.8873	32.9400	0.8103	2.2200
Resource reduction	23,307	52.0223	53.0000	20,568	52.0777	52.8000	2739	51.6060	54.0300	0.4717	−1.2300

Panel C: Financial performance and firm characteristics of fossil fuel firms

	Chemicals			Coal			Oil and gas			Difference Chemicals and Coal, oil and gas	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Tobin's Q	964	1.5987	1.4183	145	1.9615	1.5125	1627	1.6383	1.3544	−0.066	0.056**
Excess stock return	961	0.1204	0.0672	144	0.0790	−0.0957	1615	0.1205	0.0457	0.003	0.030**
Return on equity	966	0.1191	0.1193	145	0.1161	0.1178	1627	0.1083	0.1199	0.010	0.000*
Business risk	962	0.0295	0.0175	142	0.3305	0.0503	1598	0.1587	0.0348	−0.143***	−0.019***
Beta	965	1.0610	1.0402	145	1.2824	1.2492	1626	1.1611	1.1425	−0.110***	−0.106***
Assets (USD billion)	966	10.000	5.802	145	6.110	2.819	1628	23.000	6.298	−11.700***	0.807***
Leverage	959	0.4050	0.4064	145	0.3096	0.3210	1625	0.3054	0.3020	0.0993***	0.1043***
R&D	966	0.0223	0.0175	145	0.0001	0.0000	1628	0.0015	0.0000	0.0208***	0.0175***
Net working capital	966	0.1598	0.1496	145	0.1340	0.0848	1628	0.0728	0.0481	0.0820***	0.0994***

Panel D: Environmental categorical scores of fossil fuel firms

	Chemicals			Coal			Oil and gas			Difference Chemicals and Coal, oil and gas	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Environmental score	966	68.7402	83.6300	145	39.0740	33.2800	1628	46.8249	39.2750	22.5492***	45.1500***
Emission reduction	966	66.5729	79.0300	145	51.7721	49.9900	1628	54.5079	58.1300	12.2887***	21.5400***
Product innovation	966	67.9836	79.9350	145	26.4548	19.7000	1628	39.5541	24.9700	29.5008***	54.9650***
Resource reduction	966	62.9757	72.4600	145	41.2369	34.9900	1628	45.7831	35.8150	17.5644***	36.6800***

Panel E: Environmental indicators

	Total sample			Non-fossil fuel firms			Fossil fuel firms			Difference non-fossil and fossil	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Emission reduction [policy]	23,307	53.3506	48.4100	20,568	52.3045	48.4100	2739	61.2094	85.0800	−8.9049***	−36.6700***
Emission reduction [implementation]	23,307	50.6347	55.4800	20,568	49.7989	55.4800	2739	56.9141	58.3000	−7.1152***	−2.8200***
Emission reduction [monitoring]	23,307	47.5979	35.5200	20,568	47.0520	35.5200	2739	51.6989	35.5200	−4.6469***	0.0000***
CO_2 equivalents emission total/USD total assets	9872	0.2051	0.0509	8528	0.1690	0.0412	1344	0.4343	0.3141	−0.2653***	−0.2729***
CO_2 equivalents emission direct/USD total assets	7192	0.1547	0.0189	6230	0.1245	0.0135	962	0.3501	0.2464	−0.2256***	−0.2330***
CO_2 equivalents emission indirect/USD total assets	6553	0.0555	0.0212	5769	0.0515	0.0195	784	0.0855	0.0431	−0.0340***	−0.0235***
NOx emissions/USD total assets	3789	0.0010	0.0001	2829	0.0011	0.0000	960	0.0007	0.0004	0.0004***	−0.0004***
SOx emissions/USD total assets	3643	0.0010	0.0001	2662	0.0010	0.0000	981	0.0007	0.0003	0.0003***	−0.0003***
VOC emissions/USD total assets	2232	0.0002	0.0000	1586	0.0001	0.0000	646	0.0005	0.0003	−0.0004***	−0.0002***
Waste total/USD total assets	6602	0.5978	0.0056	5718	0.6684	0.0052	884	0.1413	0.0088	0.5271***	−0.0036***
Non-hazardous waste/USD total assets	3129	0.7164	0.0043	2604	0.8402	0.0042	525	0.1024	0.0048	0.7378***	−0.0006
Waste recycled total/USD total assets	5064	0.0277	0.0033	4501	0.0291	0.0033	563	0.0163	0.0028	0.0128***	0.0005
Hazardous waste/USD total assets	3422	0.0218	0.0004	2790	0.0238	0.0003	632	0.0126	0.0022	0.0113*	−0.0019***

Table 3 (*continued*)

Panel E: Environmental indicators

	Total sample			Non-fossil fuel firms			Fossil fuel firms			Difference non-fossil and fossil	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Water discharged/USD total assets	2980	4.0505	0.5837	2469	3.4825	0.4642	511	6.7948	1.4607	−3.3123***	−0.9965***
Water pollutant emissions/USD total assets	2098	0.0022	0.0000	1517	0.0017	0.0000	581	0.0034	0.0001	−0.0017***	−0.0001***
Chemical oxygen demand COD effluents in discharge/USD total assets	1695	0.0005	0.0000	1245	0.0005	0.0000	450	0.0003	0.0001	0.0003***	−0.0001***
Environmental expenditures/USD total assets	4750	0.6401%	0.2826%	3748	0.5495%	0.2389%	1002	0.9790%	0.5721%	−0.4295%***	−0.3333%***
Environmental provisions/USD total assets	2606	1.0930%	0.4008%	2003	0.9070%	0.3399%	603	1.7109%	0.7382%	−0.8040%***	−0.3983%***
Emission reduction [CO_2 reduction]	23,307	46.9714	29.2200	20,568	45.6681	29.2200	2739	56.7625	34.9600	−11.0944***	−5.7400***
Emission reduction [F-gases emissions]	22,010	43.5171	39.7400	19,274	43.5585	39.7400	2736	43.2254	39.7400	0.3331	0.0000**
Emission reduction [ozone-depleting substances reduction]	23,307	44.3920	37.0300	20,568	44.3624	37.0300	2739	44.6145	37.0300	−0.2521	0.0000
Emission reduction [NOx and SOx emissions reduction]	22,010	42.5441	32.8400	19,274	41.1025	32.8400	2736	52.6997	33.0900	−11.5972***	−0.2500***
Emission reduction [VOC emissions reduction]	22,010	44.0481	32.6200	19,274	43.3663	32.6200	2736	48.8511	34.2200	−5.4848***	−1.6000***
Emission reduction [innovative production]	23,307	45.6009	31.4300	20,568	44.3210	31.4300	2739	55.2160	38.2100	−10.8950***	−6.7800***
Product produced total/USD total assets	2849	6.6104	0.5536	1835	2.0636	0.3217	1014	14.8386	0.8315	−12.7750***	−0.5099***
Resource reduction [policy]	23,307	53.6133	56.5600	20,568	53.8370	56.5600	2739	51.9328	43.7200	1.9042**	12.8400***
Resource reduction [improvements]	23,307	44.7784	40.5900	20,568	44.9843	40.5900	2739	43.2319	40.5900	1.7524***	0.0000***
Energy use total/USD total assets	7952	2.9274	0.5656	6920	2.4557	0.4454	1032	6.0902	3.9078	−3.6344***	−3.4623***
Direct energy purchased/USD total assets	7517	2.7634	0.5041	6665	2.3842	0.4128	852	5.7299	3.4461	−3.3458***	−3.0333***
Electricity purchased/USD total assets	6430	0.4487	0.1675	5835	0.4164	0.1609	595	0.7657	0.2960	−0.3493***	−0.1350***

Panel F: Environmental indicators of fossil fuel firms

	Chemicals			Coal			Oil and gas			Difference Chemicals and Coal, oil and gas	
Variables	N	Mean	Median	N	Mean	Median	N	Mean	Median	Mean	Median
Emission reduction [policy]]	966	67.1617	85.0800	145	57.4588	48.4100	1628	58.0115	62.9400	9.1954***	22.1400***
Emission reduction [implementation]	966	59.7083	58.3300	145	58.7866	58.3000	1628	55.0893	58.3000	4.3166***	0.0300***
Emission reduction/[monitoring]	966	63.2697	90.2400	145	39.5610	27.7400	1628	45.9142	32.6200	17.8751***	57.6200***
CO_2 equivalents emission total/USD total assets	608	0.4930	0.3368	37	0.3800	0.2063	699	0.3860	0.3070	0.1074***	0.0319**
CO_2 equivalents emission direct/USD total assets	401	0.3944	0.2402	26	0.3648	0.1815	535	0.3162	0.2573	0.0759***	−0.0140
CO_2 equivalents emission indirect/USD total assets	324	0.1434	0.1007	25	0.1346	0.0377	435	0.0395	0.0198	0.0987***	0.0791***
NOx emissions/USD total assets	459	0.0006	0.0002	11	0.0009	0.0000	490	0.0008	0.0006	−0.0001	−0.0003***
SOx emissions/USD total assets	458	0.0006	0.0001	13	0.0004	0.0000	510	0.0008	0.0004	−0.0002*	−0.0003***
VOC emissions/USD total assets	312	0.0003	0.0001	3	0.0001	0.0001	331	0.0007	0.0005	−0.0004***	−0.0004***
Waste total/USD total assets	478	0.2250	0.0168	11	0.2583	0.0017	395	0.0367	0.0052	0.1823***	0.0116***
Non-hazardous waste/USD total assets	230	0.2115	0.0127	9	0.1884	0.0006	286	0.0120	0.0034	0.1941***	0.0093***
Waste recycled total/USD total assets	295	0.0229	0.0050	14	0.0568	0.0011	254	0.0063	0.0018	0.0139**	0.0033***
Hazardous waste/USD total assets	289	0.0203	0.0050	14	0.0403	0.0005	329	0.0047	0.0016	0.0141***	0.0034***
Water discharged/USD total assets	242	11.7423	6.0252	12	21.4154	2.1292	257	1.4534	0.6526	9.3984***	5.3231***
Water pollutant emissions/USD total assets	350	0.0050	0.0003	4	0.0001	0.0001	227	0.0009	0.0000	0.0041***	0.0002***
Chemical oxygen demand COD effluents in discharge/USD total assets	313	0.0003	0.0001	4	0.0001	0.0001	133	0.0001	0.0000	0.0003***	0.0001***
Environmental expenditures/USD total assets	499	0.8891%	0.6189%	44	1.0106%	0.2858%	459	1.0738%	0.5528%	−0.1792%***	0.0783%
Environmental provisions/USD total assets	298	1.7062%	0.9552%	40	2.4612%	1.3961%	265	1.6030%	0.5459%	−0.0093%	0.3749%***
Emission reduction [CO_2 reduction]	966	61.4808	38.4400	145	54.6379	29.2200	1628	54.1521	33.8500	7.2890***	4.5900***
Emission reduction [F-gases emissions]	966	45.0632	39.7400	145	41.5239	39.6400	1625	42.2847	39.6400	2.8408***	0.1000***
Emission reduction [ozone-depleting substances reduction]	966	49.2118	37.0900	145	40.6003	36.9500	1628	42.2441	36.9500	7.1022***	0.1400***
Emission reduction [NOx and SOx emissions reduction]	966	53.5741	36.6900	145	45.3903	32.6900	1625	52.8321	33.0900	1.3516	3.6000***
Emission reduction [VOC emissions reduction]	966	54.3232	37.5300	145	40.2310	32.1200	1625	46.3674	32.6200	8.4585***	4.9100***
Emission reduction [innovative production]	966	56.8928	39.0000	145	45.1532	30.3500	1628	55.1173	38.2100	2.5904**	0.7900***
Product produced total/USD total assets	204	2.6387	0.6221	67	11.1494	7.0709	743	18.5209	0.8168	−15.2725***	−0.2641***
Resource reduction [policy]	966	63.6597	82.2100	145	39.7488	40.6000	1628	46.0597	42.6600	18.1162***	39.5500***
Resource reduction [improvements]	966	45.0434	41.2300	145	40.9323	40.4000	1628	42.3618	40.5900	2.7985***	0.6400***
Energy use total/USD total assets	532	6.9997	4.2786	30	3.5864	1.6136	470	5.2204	3.4779	1.8774***	0.9649***
Direct energy purchased/USD total assets	496	6.8652	4.0497	22	2.7327	1.6136	334	4.2415	2.3405	2.7169***	1.7947***
Electricity purchased/USD total assets	291	1.0888	0.5680	12	0.5479	0.1942	292	0.4526	0.1453	0.6325***	0.4178***

category). As to the controls, size clearly and positively contributes to a high score on the categorical environmental indicators, as do R&D and availability of net working capital. However, again, leverage is not significantly associated with environmental performance.

In Appendix B, we show the estimation results of the same model used to arrive at the findings in Table 4, but focus on geographic subsamples. Appendix B.1 gives the results for a sample of Australia, Canada, Japan, the UK, and the US, who make up about two thirds of the total sample. This shows that the relationships are much weaker than in the overall sample. Here, there is only weak support in the case of Tobin's Q and there is no longer a positive relationship between excess stock returns in energy and environmental performance. Therefore, we conclude that there is no longer support for the hypotheses. Further, it shows that business risk in energy positively impacts environmental product performance. Appendix B.2 shows the results when the US and the UK are excluded, which renders 60% of the total sample. Here, the results are very much in line with those for the overall sample as depicted in Table 4 and we again find strong confirmation for H7, but less so for H6. Another interesting difference is that for Beta as the risk indicator, it clearly shows that more risk reduces environmental performance. Appendix B.3 shows the results when we exclude the US, which leaves us with about 70% of the original sample. These results are basically in line with those of the previous sensitivity analysis.

Table 4
Regression analysis for environmental categories. This table reports pooled OLS regression results for the relationship between fossil fuel firms (Dummy_Fossil) and environmental performance score and its three categories, which are items determining categorical scores for emission reduction, product innovation, and resource reduction. The definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Dependent variables: Environmental performance scores			
Variables	Environment	Emission	Product	Resource
Dummy_Fossil	8.708**	10.642***	9.323**	2.925
	[4.003]	[3.544]	[4.004]	[4.183]
Tobin's Q	0.669***	0.592**	0.429*	0.911***
	[0.246]	[0.239]	[0.260]	[0.237]
Dummy_Fossil*Tobin's Q	−1.713***	−1.465**	−1.591**	−1.177
	[0.642]	[0.665]	[0.682]	[0.716]
Excess stock return	−0.859**	−1.232***	0.083	−1.242***
	[0.384]	[0.391]	[0.411]	[0.391]
Dummy_Fossil*Excess stock return	2.051**	1.132	1.565	2.638**
	[0.966]	[1.026]	[1.006]	[1.081]
Return on equity	1.870***	1.721***	1.613***	1.781***
	[0.446]	[0.418]	[0.447]	[0.429]
Dummy_Fossil*Return on equity	0.685	0.598	1.671	−0.27
	[1.500]	[1.313]	[1.739]	[1.341]
Business risk	−1.301***	−0.632	−1.512***	−1.263***
	[0.438]	[0.419]	[0.383]	[0.451]
Dummy_Fossil*Business risk	0.686	−0.737	2.162***	0.785
	[0.704]	[0.661]	[0.809]	[0.771]
Beta	3.080***	2.234**	4.404***	1.880*
	[1.022]	[0.997]	[1.014]	[0.994]
Dummy_Fossil*Beta	−2.798	−0.816	−5.717*	−1.4
	[3.284]	[2.889]	[3.163]	[3.319]
Size	14.065***	14.071***	10.126***	13.687***
	[0.381]	[0.380]	[0.383]	[0.382]
Leverage	−0.137	−1.898	2.66	−1.658
	[1.892]	[1.844]	[1.874]	[1.883]
R&D	113.806***	87.562***	134.501***	93.367***
	[12.669]	[11.794]	[12.630]	[12.869]
Net working capital	9.203***	5.867**	12.508***	6.336***
	[2.288]	[2.292]	[2.310]	[2.321]
Constant	−172.283***	−165.543***	−122.436***	−163.791***
	[5.707]	[5.813]	[5.705]	[5.697]
Adjusted R^2	0.375	0.362	0.274	0.333
Observations	22,636	22,636	22,636	22,636

Table 5 provides the estimation results of the pooled OLS regression for the different types of fossil fuel firms (chemicals, coal, oil and gas). It shows detailed information on how financial performance is associated with the environmental score. In general, the estimation results show that the relationship between environmental performance and financial performance differs among the three groups. The results suggest that being among the fossil fuel firms as such does not produce a straightforward impact on the overall environmental score. We find that only with oil and gas firms there is a significant and negative association between Tobin's Q and environmental score. This confirms the opportunism hypothesis (H7) for oil and gas firms. This result also seems to suggest that the negative relationship detected in Table 4 between this variable and environmental score is due to firms in the oil and gas sector in particular. We establish a significant and positive relationship between excess stock returns for oil and gas firms, but not for chemical firms and coal firms. Hence, we can conclude that H6 is supported for oil and gas companies, but not for the others. Table 5 shows that for firms in the coal industry, there is a statistically significant negative relationship between return on equity and environmental score. This too hints at a trade-off between financial and environmental performance and confirms H7. As to business risk, there is a clear positive association between this risk indicator and environmental performance for coal firms as well as for firms in oil and gas, but not for chemical firms. This suggests that particularly the relatively risky firms have higher environmental scores. For Beta, we observe that belonging to the oil and gas sector implies a significant negative relationship between this financial market risk (business risk) and environmental score. There is no significant relationship between the Beta of a coal firm and this score, whereas there is a significant positive one between the Beta of a chemical firm and the environmental score. The controls, again, show a significant and positive association with the dependent variable, with leverage the exception.

Table 5
Regression analysis for environmental score of fossil fuel firms. This table reports pooled OLS regression results for the relationship between fossil fuel firms in chemicals, coal, and gas and oil (Dummy_Fossil) and environmental score, separately. Definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Chemicals	Coal	Oil and gas
Dummy_Fossil	4.853	2.019	12.325***
	[5.740]	[11.571]	[4.761]
Tobin's Q	0.653***	0.683***	0.712***
	[0.245]	[0.247]	[0.246]
Dummy_Fossil*Tobin's Q	−0.489	−0.299	−2.092***
	[1.391]	[1.080]	[0.773]
Excess stock return	−0.884**	−0.917**	−0.945**
	[0.381]	[0.381]	[0.382]
Dummy_Fossil*Excess stock return	−0.046	1.134	2.473**
	[2.064]	[2.761]	[1.149]
Return on Equity	1.854***	1.868***	1.848***
	[0.442]	[0.442]	[0.445]
Dummy_Fossil*Return on equity	2.079	−3.340**	1.286
	[1.671]	[1.461]	[2.512]
Business Risk	−1.289***	−1.252***	−1.290***
	[0.435]	[0.436]	[0.435]
Dummy_Fossil*Business risk	−7.527	2.743***	1.677**
	[5.992]	[0.757]	[0.673]
Beta	2.891***	2.943***	3.169***
	[1.023]	[1.024]	[1.021]
Dummy_Fossil*Beta	8.181**	−1.68	−11.401***
	[4.017]	[6.886]	[3.609]
Size	13.967***	14.007***	14.210***
	[0.395]	[0.401]	[0.391]
Leverage	−1.185	−1.439	−1.91
	[1.974]	[2.004]	[1.931]
R&D	107.499***	105.205***	107.759***
	[12.522]	[12.708]	[12.678]
Net working capital	7.449***	8.014***	8.264***
	[2.410]	[2.423]	[2.312]
Constant	−171.047***	−172.201***	−173.487***
	[5.935]	[6.000]	[5.838]
Adjusted R^2	0.374	0.37	0.379
Observations	20,910	20,100	21,544

In Appendix C, we redo the estimations for Table 5 for three different subsamples. Appendix C.1 reports the results for Australia, Canada, Japan, UK and US. It shows that there is no significant association between Tobin's Q, excess returns and return on equity interacted with energy for any of the three subindustries. Hence, there is no support for the resources or opportunism hypotheses. As to risk, we find that there is a significant positive relationship between business risk and environmental score for the coal firms, and marginally so for oil and gas companies. There is a marginally negative relationship with chemical firms in this respect. But for Beta, there is a positive association between risk and environmental score with chemicals. Appendix C.2 with the results for the sample excluding the UK and the US, as well Appendix C.3 excluding US only, render highly similar results to those in the main analysis reported in Table 5.

In Table 6, we report the last phase of the estimation, namely, the 3SLS estimation of our simultaneous equation system regarding the effect of fossil fuel on environmental performance, as well as that of environmental score on financial performance. This is motivated by the

Table 6
Structure regression analysis for environmental score of fossil fuel firms. This table reports 3SLS estimation for simultaneous equation system for the relationship between fossil fuel firms (Dummy_Fossil) and environmental performance, and the effect of environmental score on financial performance. Definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

Panel A: All three fossil fuel firms combined

	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
Financial performance equations					
Dummy_Fossil	−0.324***	0.038**	−0.004	0.152***	0.233***
	[0.059]	[0.019]	[0.022]	[0.024]	[0.014]
Environmental performance	0.00	0.001**	0.001***	0.00	0.001***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
DummyFossil*Environmental performance	0.003***	0.00	0.00	−0.002***	−0.002***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Size	−0.415***	−0.034***	−0.006	−0.063***	0.007**
	[0.012]	[0.004]	[0.004]	[0.005]	[0.003]
Leverage	−0.400***	−0.006	−0.112***	0.069***	0.118***
	[0.045]	[0.015]	[0.017]	[0.018]	[0.011]
R&D	4.751***	−0.358***	−0.694***	1.119***	0.168***
	[0.259]	[0.084]	[0.096]	[0.104]	[0.063]
Net working capital	0.267***	0.095***	−0.056**	0.049**	0.280***
	[0.061]	[0.020]	[0.022]	[0.025]	[0.015]
Constant	7.958***	0.556***	0.137**	1.279***	0.665***
	[0.165]	[0.053]	[0.061]	[0.067]	[0.040]
Environmental performance equations					
Dummy_Fossil	23.794***	10.717***	0.008	5.182***	0.497
	[2.331]	[2.423]	[0.753]	[1.459]	[2.912]
Financial performance	19.821***	119.25***	8.807	96.408***	−1.201
	[1.605]	[21.977]	[5.835]	[15.574]	[2.826]
Dummy_Fossil*Financial performance	−13.111***	−111.93***	−6.999	−92.92***	−1.031
	[1.223]	[20.737]	[5.782]	[15.023]	[2.805]
Size	15.062***	10.185***	6.558***	11.072***	6.505***
	[0.725]	[0.766]	[0.132]	[0.814]	[0.123]
R&D	−65.194***	61.770***	46.122***	−66.55***	40.986***
	[10.298]	[10.365]	[4.840]	[19.645]	[3.584]
Mean environmental performance (country/year)	0.117**	0.200**	0.363***	0.569***	0.377***
	[0.053]	[0.089]	[0.030]	[0.084]	[0.028]
Mean environmental performance (country/industry)	0.873***	0.849***	0.868***	0.889***	0.873***
	[0.011]	[0.019]	[0.007]	[0.018]	[0.007]
Constant	−260.46***	−164.70***	−108.5***	−207.9***	−106.95***
	[12.804]	[11.901]	[2.024]	[17.030]	[2.974]
Observations	23,102	22,937	23,151	22,844	23,070

Panel B: Chemicals

	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
Financial performance equations					
Dummy_Fossil	−0.320**	0.01	0.059	−0.065	0.017
	[0.125]	[0.039]	[0.047]	[0.046]	[0.030]
Environmental performance	0	0	0.001***	0	0.001***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Dummy_Fossil*Environmental performance	0.002	0	−0.001	0	0.000
	[0.002]	[0.001]	[0.001]	[0.001]	[0.000]
Size	−0.433***	−0.030***	−0.008*	−0.053***	0.005*
	[0.012]	[0.004]	[0.005]	[0.005]	[0.003]
Leverage	−0.386***	−0.004	−0.119***	0.090***	0.127***
	[0.048]	[0.015]	[0.018]	[0.017]	[0.011]
R&D	4.724***	−0.324***	−0.707***	1.132***	0.181***
	[0.265]	[0.083]	[0.099]	[0.097]	[0.064]
Net working capital	0.239***	0.095***	−0.069***	0.085***	0.299***
	[0.064]	[0.020]	[0.024]	[0.023]	[0.015]
Constant	8.222***	0.510***	0.168***	1.054***	0.700***
	[0.175]	[0.055]	[0.065]	[0.065]	[0.042]
Environmental performance equations					
Dummy_Fossil	12.769***	6.198***	3.251***	1.462**	−0.554
	[2.362]	[1.609]	[0.995]	[0.742]	[3.407]
Financial performance	10.499***	56.995***	20.293***	4.466	0.134
	[1.414]	[13.506]	[6.147]	[6.414]	[2.791]
Dummy_Fossil*Financial performance	−5.877***	−53.151***	−18.260***	−4.801	1.688
	[1.274]	[12.720]	[6.320]	[7.492]	[3.237]
Size	11.116***	8.136***	6.384***	6.477***	6.220***

(continued on next page)

Table 6 (*continued*)

Panel B: Chemicals					
	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
	[0.679]	[0.501]	[0.153]	[0.363]	[0.129]
R&D	−17.246**	48.490***	50.252***	32.659***	37.710***
	[8.481]	[6.143]	[5.304]	[7.921]	[3.587]
Mean environmental performance (country/year)	0.238***	0.291***	0.345***	0.403***	0.385***
	[0.043]	[0.056]	[0.036]	[0.035]	[0.031]
Mean environmental performance (country/industry)	0.878***	0.867***	0.869***	0.880***	0.878***
	[0.008]	[0.011]	[0.008]	[0.007]	[0.008]
Constant	−191.15***	−134.29***	−106.63***	−111.1***	−105.27***
	[11.868]	[7.715]	[2.340]	[7.736]	[3.006]
Observations	21,333	21,181	21,382	21,107	21,302
Panel C: Coal					
	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
Financial performance equations					
Dummy_Fossil	0.133	0.041	0.160*	0.354***	0.347***
	[0.254]	[0.079]	[0.094]	[0.096]	[0.060]
Environmental performance	0	0	0.001***	0	0.001***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Dummy_Fossil*Environmental performance	−0.011*	−0.002	−0.005**	−0.003	−0.002*
	[0.006]	[0.002]	[0.002]	[0.002]	[0.001]
Size	−0.443***	−0.030***	−0.008*	−0.058***	0.006*
	[0.013]	[0.004]	[0.005]	[0.005]	[0.003]
Leverage	−0.370***	−0.005	−0.116***	0.095***	0.125***
	[0.049]	[0.015]	[0.018]	[0.018]	[0.012]
R&D	4.697***	−0.295***	−0.686***	1.158***	0.214***
	[0.274]	[0.086]	[0.101]	[0.103]	[0.065]
Net working capital	0.252***	0.095***	−0.069***	0.080***	0.298***
	[0.065]	[0.020]	[0.024]	[0.025]	[0.016]
Constant	8.370***	0.505***	0.164**	1.144***	0.699***
	[0.181]	[0.057]	[0.067]	[0.069]	[0.043]
Environmental performance equations					
Dummy_Fossil	12.919***	4.974**	3.09	0.105	8.408
	[3.643]	[2.433]	[1.909]	[1.800]	[5.130]
Financial performance	6.464***	33.670***	16.126***	−8.845	1.367
	[1.341]	[10.672]	[5.748]	[6.217]	[2.806]
Dummy_Fossil*Financial performance	−5.208***	−30.554***	−16.767***	8.401	−6.1
	[1.482]	[10.145]	[6.334]	[6.055]	[4.102]
Size	9.336***	7.406***	6.385***	5.787***	6.238***
	[0.657]	[0.402]	[0.149]	[0.361]	[0.131]
R&D	1.952	43.019***	46.762***	46.501***	35.780***
	[8.057]	[4.801]	[5.141]	[7.954]	[3.636]
Mean environmental performance (country/year)	0.306***	0.344***	0.372***	0.390***	0.407***
	[0.040]	[0.045]	[0.036]	[0.036]	[0.032]
Mean environmental performance (country/industry)	0.876***	0.870***	0.869***	0.876***	0.875***
	[0.007]	[0.009]	[0.008]	[0.007]	[0.008]
Constant	−159.61***	−123.21***	−107.07***	−96.07***	−106.96***
	[11.416]	[6.136]	[2.283]	[7.612]	[3.038]
Observations	20,520	20,369	20,568	20,294	20,488
Panel D: Oil and gas					
	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
Financial performance equations					
Dummy_Fossil	−0.369***	0.055**	−0.028	0.175***	0.270***
	[0.069]	[0.022]	[0.026]	[0.028]	[0.017]
Environmental performance	0	0.000*	0.001**	0	0.001***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Dummy_Fossil*Environmental performance	0.005***	−0.001**	0	−0.001***	−0.002***
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Size	−0.429***	−0.034***	−0.006	−0.063***	0.007**
	[0.012]	[0.004]	[0.004]	[0.005]	[0.003]
Leverage	−0.377***	−0.006	−0.111***	0.088***	0.120***
	[0.047]	[0.015]	[0.017]	[0.019]	[0.011]
R&D	4.786***	−0.316***	−0.674***	1.182***	0.223***

Table 6 (*continued*)

Panel D: Oil and gas					
	Financial performance measures				
	Tobin's Q	Excess return	ROE	Business risk	Beta
	[0.267]	[0.086]	[0.098]	[0.106]	[0.065]
Net working capital	0.247***	0.089***	−0.062***	0.069***	0.291***
	[0.063]	[0.020]	[0.023]	[0.025]	[0.015]
Constant	8.141***	0.549***	0.139**	1.249***	0.677***
	[0.171]	[0.055]	[0.063]	[0.069]	[0.042]
Environmental performance equations					
Dummy_Fossil	17.925***	6.764***	−2.023**	1.832	1.117
	[2.260]	[2.213]	[0.796]	[1.282]	[1.825]
Financial performance	17.740***	90.746***	5.377	68.303***	−4.329
	[1.553]	[18.319]	[5.629]	[11.064]	[2.851]
Dummy_Fossil*Financial performance	−11.255***	−85.382***	−2.858	−65.80***	−2.476
	[1.202]	[17.402]	[5.625]	[10.693]	[1.691]
Size	14.563***	9.488***	6.642***	9.944***	6.620***
	[0.726]	[0.650]	[0.134]	[0.604]	[0.128]
R&D	−58.060***	55.241***	42.507***	−39.42***	40.894***
	[10.100]	[8.540]	[4.837]	[14.621]	[3.637]
Mean environmental performance (country/year)	0.145***	0.245***	0.379***	0.530***	0.385***
	[0.052]	[0.075]	[0.031]	[0.066]	[0.030]
Mean environmental performance (country/industry)	0.865***	0.850***	0.864***	0.880***	0.871***
	[0.011]	[0.016]	[0.007]	[0.014]	[0.008]
Constant	−249.41***	−153.22***	−109.46***	−182.2***	−105.49***
	[12.707]	[10.053]	[2.042]	[12.550]	[2.922]
Observations	21,999	21,837	22,047	21,747	21,965

endogeneity of the relationship between environmental and financial performance, as is widely documented in the literature (see the reviews: Wu, 2006; Margolis et al., 2009). In all panels, we first have financial performance as the dependent variable and environmental performance as the independent variable in the upper half; this is reversed in the lower half of the panels.

Panel A in Table 6 shows the estimation results for all three fossil fuel-related industries combined, and panels B–D show those for chemical, coal, oil and gas firms, respectively. The overall results in Panel A suggest that environmental performance of fossil fuel firms (*Dummy_Fossil*EnvironmentalPerformance*) has a positive impact on Tobin's Q, but no significant impact on return on equity. This lends support for the stakeholder hypothesis (H4) in the case of Tobin's Q only. Further, environmental performance in fossil fuel firms significantly reduces excess returns and both risk measures, which is in support of the stakeholder hypothesis (H4). When financial performance is the independent variable, this shows that there is a statistically significant (<1%) and negative relationship with all financial variables, except return on equity and Beta (*Dummy_Fossil*Financial Performance*). This is understood as follows: the estimated coefficient of Dummy_Fossil is positive and mostly significant, suggesting that fossil fuel firms are to be associated with relatively higher environmental scores. Financial performance also yields a positive and significant sign, except for ROE and Beta. This suggests that better financial performance is associated with better environmental performance. But the combination of the two yields a statistically significant and negative sign for again three proxies of financial performance. This implies that, for fossil fuel firms that perform relatively well from a financial perspective, there is a significant and negative association with environmental score. This confirms the opportunism hypothesis (H7). For the two risk indicators, panel A in Table 6 shows there is a negative and significant association with business risk but no relationship with market risk (i.e., Beta). This confirms the resources view (H6) for business risk only.

Panels B–D show the results for fossil fuel firms in the three groups, chemicals, coal, and oil and gas, respectively. In the discussion, we again focus on the interaction coefficients in the upper and lower half of the three panels. Panel B shows that with environmental performance as the independent variable, there is no statistical significance for the coefficient of the interaction term, suggesting that environmentally outperformance of chemical firms has no impact on financial performance for any of the five performance measures. With financial performance as the independent variable, the result is quite different. Financially outperforming chemical firms have a significant negative impact on Tobin's Q, stock market returns, and return on equity. There is no significant relationship with the two financial risk measures. Again, this is supportive of the opportunism hypothesis (H7) which posits a negative relationship between financial and social performance.

Panel C shows the results for coal firms. These are quite similar to those in Panel B. However, there now is some marginal significance for the interaction coefficient when environmental performance is the independent variable regarding the Tobin's Q and Beta. And with return on equity with coal firms, we find support for the trade-off hypothesis (H5) where social outperformance is negatively associated with financial performance. When we use financial performance as our independent, the firms in the coal industry show the same behavior as those in chemicals, and we confirm H7.

The results for firms in oil and gas (Panel D) are quite different from those for chemicals and coal. This panel shows that when environmental performance is the independent variable, there is a significant positive impact on Tobin's Q (confirming the stakeholder view, H4), and a significant negative impact on excess stock market returns (confirming the trade-off view, H5) as well as on the two risk measures (again confirming the stakeholder view, H4). This suggests that environmentally outperforming firms in oil and gas have relatively higher value and lower stock market returns, as well as lower financial risk. Further, with financial performance as the independent variable and environmental performance as the dependent variable, panel C in Table 6 shows that oil and gas firms that perform well from the financial perspective have significantly lower Tobin's Q and excess stock market returns. This is strong support for the opportunism hypothesis (H7). There is no significant relationship with return on equity. In addition, these firms are associated with less business risk (confirming H6), but not with systematic risk. In all cases, this panel shows that the effects of our controls are highly statistically significant.

Sensitivity analysis regarding the 3SLS estimations for the simultaneous equation system for the effect of the fossil fuel (sub)industries for geographic subsamples is reported in Appendix D (due to the length of the Appendix D, this appendix is available online via the following link:

http://dx.doi.org/10.1016/j.ecolecon.2016.10.004). Appendix D.1 (available online) has the results for the subsample of Australia, Canada, Japan, the UK and the US. The overall results are similar to those in Panel A of Table 6, but the panels B-D all reveal that better environmental performance significantly reduces Tobin's Q with chemicals and coal, but it improves Tobin's Q with oil and gas companies. Regarding the risk measures, the results of this sensitivity analysis in general as in the same direction as in the main analysis but significance is weaker. Appendix D.2 (available online) shows the results for our sample excluding the US and the UK. These findings are highly similar to those in the main analysis as reported in Table 6. Appendix D.3 (available online) shows the results for our sample excluding the US. Here, again, the findings are highly similar to those in the main analysis as reported in Table 6.

We establish that the fossil fuel firms in general outperform other firms regarding the overall environmental score. This seems to be based on these firms' efforts to behave in a more responsible manner. However, we also establish that this especially results from outperformance by chemical firms. Firms in coal and in oil and gas significantly underperform firms in most other industries. If we investigate the relationship between financial and environmental performance for these three fossil fuel related sectors, we find that industry specifics is mainly of importance in the risk arena. Further, selection of the dependent and independent variables does matter. This is especially the case with the value and return indicators. If environmental performance is used as the independent variable, there is a significant positive relationship between environmentally outperforming firms in oil and gas and Tobin's Q, and a negative one for these firms and excess stock market returns. This confirms the predictions from the theoretical model of Dam and Scholtens (2015). We also discover a negative association between environmental outperformance and market risk which especially is the case with oil and gas firms. With financial performance as the independent variable, we observe a statistically significant and negative association with all three financial indicators in all three subindustries (apart from return on equity in oil and gas). Subindustry specifics, however, again clearly show up in the risk arena.

5. Discussion and Conclusion

We study the performance of a large, international sample of companies that are highly intense regarding the use of fossil fuels with respect to several environmental dimensions of corporate social responsibility in the period 2002–2013. We relate their environmental performance to various measures of corporate financial performance. The fossil fuel firms are of particular interest as their social costs are substantially above their private costs: External effects are a major concern with these firms. In particular, the role of fossil fuels in climate change is a topic of intense interest and debate. This is one of the main reasons fossil fuel firms place great effort into improving their social and environmental policies and performance (Kolk et al., 2001; Heal, 2008). We investigate how environmental performance relates to fossil fuel firms' financial performance. As to environmental performance, we use qualitative and quantitative information from Thomson Reuters' ASSET4. For financial performance, we investigate different, mostly hitherto unexplored, financial indicators relating to stock market and accounting performance, namely, Tobin's Q, excess stock returns, return on equity, business risk, and Beta (systematic risk). It shows that there is a lot of heterogeneity within our sample, both regarding indicators of environmental and financial performance.

We find that, in most instances, there is a strong and significant relationship between corporate environmental and financial performance of the fossil fuel firms. This especially concerns Tobin's Q and return on equity. For excess stock market returns, there usually is no relationship or only a small negative effect. In general, we conclude that when firms do well regarding Tobin's Q and return on equity, they also show high environmental scores. It should be remembered that these scores pertain to policies to a great extent. When we account for the fact that a firm operates in a particular fossil fuel-related sector (chemicals, coal, or oil and gas), this characteristic plays a very crucial role. Operating in the fossil fuel-related industry as such appears to change the general relationship between environmental and financial performance: there no longer is a significant and positive relationship and, especially in the case of Tobin's Q, there appears to be a statistically significant and negative association. When we investigate a wide range of environmental performance indicators (e.g., emissions, water use, waste production, resource use) it shows that better financial performance implies more emissions. This suggests that there is a trade-off between Tobin's Q and environmental performance with fossil fuel firms, reflecting the external effects of their production processes. In general, we infer that particularly financial outperformance matters. Environmental outperformance is not associated with Tobin's Q, stock market returns, or return on equity with firms in chemicals and coal. However, with oil and gas firms, we find that environmental outperformance is significantly associated with Tobin's Q and stock market returns. Furthermore, in oil and gas, both environmental and financial outperformance can be associated with lower risk.

We tested several hypothesis. We found support for the notion that fossil fuel firms have better policies (H1) but weaker actual performance (H2) than non-fossil ones. However, H2 is to be rejected for the chemical industry. We can also confirm our H3 which holds that environmental performance of firms in chemicals is better than that of firms in coal and in oil and gas, but only in a univariate setting. As to the relationship between financial and environmental performance, we found some support for the stakeholder theory (H4), especially in the risk dimension, which is well in line with the findings of Scholtens (2008). Furthermore, we find little support for the trade-off view (H5), which holds that social performance goes to the detriment of financial performance, apart from firms in coal. The same is the case with the resources hypothesis (H6), which assumes that financial performance has a positive impact on social performance. This especially seems to be the case for companies in oil and gas, where it shows that social performance significantly reduces the risk indicators (business risk and Beta). However, in most cases, we found that financial performance has a significant negative impact on social performance, as such confirming the opportunism hypothesis (H7).

Our findings contribute to the literature in several ways. First, we convincingly show that risk management in relation to environmental performance is an issue in oil and gas; this is in line with the theoretical notions of Bénabou and Tirole (2006, 2010). Secondly, we find that industry-specific issues are important, as put forward by Heal (2008) and we are able to show in more detail how they are so. Further, we add to the literature on the relationship between finance and corporate social responsibility, as discussed by Wu (2006) and Margolis et al. (2009), for a much broader range of environmental and financial indicators than has been studied so far for firms in chemicals, coal, and oil and gas. Fourth, we are able to illustrate the notions brought forward in the more theoretical studies of Gregory et al. (2014) and Dam and Scholtens (2015) via a case study of fossil fuel firms. Our study also complements the findings about the relationship between financial and environmental performance with energy firms, which thus far investigate mainly accidents (Patten and Nance, 1998; Capelle-Blancard and Laguna, 2009; Henriques and Sadorsky, 2010). Another novelty is that we show that the inclusion of financial risk sheds light on the relationship between environmental and financial performance, thus complementing Pätäri et al. (2014) and Arslan-Ayaydin and Thewissen (2015). Finally, we develop a broad international setting and perspective, as our data include more than 50 countries.

From a policy perspective, our findings suggest that environmental policies for fossil fuel firms need to account for industry-specifics, as a one size fits all approach is unlikely to achieve policy objectives. Policy design should be very careful as to what specific objective is targeted, given the complex relationships between environmental and financial performance in the fossil fuel-related sectors.

Limitations of our study include the quality of the environmental performance data, as these are not externally verified and validated. We

regard this as an important drawback regarding scientific research in this area and very much welcome initiatives to overcome this problem. Further, there is a bias in our study toward observations from richer countries. Although we include many more observations from developing countries than is the case in previous studies, we would like to investigate whether the relationships differ among subgroups of countries as well. Our sensitivity analyses show that in some instances sample composition has an impact on the conclusions. Regarding the methodology, we rely on a 3SLS approach that is subject to some weaknesses. In particular, finding the best instruments that impact environmental (financial) performance, but not financial (environmental) performance, is very difficult. Even though there may be validity arguments against our model and instruments, they are consistent with those used in the literature.

We conclude that efforts of fossil fuel firms do not appear sufficient to improve environmental performance and that there are both trade-offs and synergies between environmental and financial performance, which can differ along the various indicators and which are highly industry-specific.

Appendix A. Explanation of corporate social responsibility variables (environmental dimensions)

Environmental score	The environmental pillar measures a company's impact on living and non-living natural systems, including air, land, and water, as well as complete ecosystems. It reflects how well a company uses best management practices to avoid environmental risks and to capitalize on environmental opportunities to generate long-term shareholder value.
Emission reduction	The emission reduction category measures a company's management commitment and effectiveness toward reducing environmental emissions in production and operational processes. It reflects a company's capacity to reduce air emissions (greenhouse gases, F-gases, ozone-depleting substances, NOx and SOx, etc.), waste, hazardous waste, water discharges, spills, or its impacts on biodiversity and to partner with environmental organizations to reduce the environmental impact of the company in the local or broader community.
Product innovation	The product innovation category measures a company's management commitment and effectiveness toward supporting the research and development of eco-efficient products or services. It reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed, dematerialized products with extended durability.
Resource reduction	The resource reduction category measures a company's management commitment and effectiveness toward achieving efficient use of natural resources in the production process. It reflects a company's capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management.
Emission reduction [policy]	Does the company have a policy for reducing environmental emissions or its impacts on biodiversity? Does the company have a policy for maintaining an environmental management system?
Emission reduction [implementation]	Does the company describe the implementation of its emissions reduction policy through a public commitment from a senior management or board member? Does the company describe the implementation of its emission reduction policy through the processes in place?
Emission reduction [monitoring]	Does the company monitor its emission reduction performance?
CO_2 equivalents emission total/USD total assets	Total CO_2 and CO_2-equivalent emissions related to total assets
CO_2 equivalents emission direct/USD total assets	Direct CO_2 and CO_2-equivalent emissions related to total assets
CO_2 equivalents emission indirect/USD total assets	Indirect CO_2 and CO_2-equivalent emissions related to total assets
NOx emissions/USD total assets	Total amount of NOx emissions emitted related to total assets
SOx emissions/USD total assets	Total amount of SOx emissions emitted related to total assets
VOC emissions/USD total assets	Total amount of volatile organic compounds (VOC) emissions related to total assets
Waste total/USD total assets	Total amount of waste produced related to total assets
Non-hazardous waste/USD total assets	Total amount of non-hazardous waste produced related to total assets
Waste recycled total/USD total assets	Total recycled and reused waste produced related to total assets
Hazardous waste/USD total assets	Total amount of hazardous waste produced related to total assets
Water discharged/USD total assets	Total volume of water discharged related to total assets
Water pollutant emissions/USD total assets	Total weight of water pollutant emissions related to total assets
COD effluents in discharge/USD total assets	Total weight of Chemical Oxygen Demand (COD) in water discharged related to total assets
Commercial risks and/or opportunities due to climate change	Is the company aware that climate change can represent commercial risks and/or opportunities?
Environmental expenditures/USD total assets	Total amount of environmental expenditures related to total assets
Environmental provisions/USD total assets	Environmental provisions as reported within the balance sheet related to total assets
Environmental investments initiatives	Does the company report on making proactive environmental investments or expenditures to reduce future risks or increase future opportunities?
Emission reduction [CO_2 reduction]	Does the company show an initiative to reduce, reuse, recycle, substitute, phase out or compensate CO_2 equivalents in the production process?
Emission reduction [F-gases emissions]	Does the company report on initiatives to recycle, reduce, reuse or phase out fluorinated gases such as HFCs (hydrofluorocarbons), PFCs (perfluorocarbons), and SF6 (sulfur hexafluoride)?
Emission reduction [ozone-depleting substances reduction]	Does the company report on initiatives to reduce, substitute, or phase out ozone-depleting (CFC-11 equivalents, chlorofluorocarbon) substances?
Emission reduction [NOx and SOx emissions reduction]	Does the company report on initiatives to reduce, reuse, recycle, substitute, or phase out NOx (nitrogen oxides) or SOx (sulfur oxides) emissions?
Emission reduction [VOC emissions reduction]	Does the company report on initiatives to reduce, substitute, or phase out volatile organic compounds (VOC) or particulate matter less than 10 microns in diameter (PM10)?
Emission reduction [innovative production]	Does the company report on the concentration of production locations to limit environmental impact during the production process? Does the company report on its participation in any emissions trading initiative? Does the company report on new production techniques to improve the global environmental impact (all emissions) during the production process?
Product produced total/USD total assets	Product produced related to total assets
Resource reduction [policy]	Does the company have a policy for reducing the use of natural resources? Does the company have a policy to lessen the environmental impact of its supply chain?
Resource reduction [improvements]	Does the company set specific objectives to be achieved on resource efficiency? Does the company comment on the results of previously set objectives?
Energy use total/USD total assets	Total direct and indirect energy consumption related to total assets
Direct energy purchased/USD total assets	Direct energy purchased related to total assets
Electricity purchased/USD total assets	Electricity purchased related to total assets

Appendix B. Pooled OLS regression results for the relationship between fossil fuel firms and environmental performance

Table B.1
Regression analysis for environmental categories (including only Australia, Canada, Japan, UK, and US). This table reports pooled OLS regression results for the relationship between fossil fuel firms (Dummy_Fossil) and environmental performance score and its three categories, which are items determining categorical scores for emission reduction, product innovation, and resource reduction. The definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Dependent variables: Environmental performance scores			
Variables	Environment	Emission	Product	Resource
Dummy_Fossil	−6.547	1.527	−9.425*	−8.446
	[5.129]	[4.605]	[5.028]	[5.398]
Tobin's Q	0.327	0.436*	0.007	0.589**
	[0.264]	[0.263]	[0.321]	[0.277]
Dummy_Fossil*Tobin's Q	1.197	0.1	1.776*	1.249
	[0.970]	[0.953]	[1.051]	[1.227]
Excess stock return	−1.044**	−1.189***	−0.368	−1.310***
	[0.445]	[0.460]	[0.487]	[0.461]
Dummy_Fossil*Excess stock return	1.265	0.239	0.538	2.217
	[1.157]	[1.211]	[1.184]	[1.390]
Return on equity	1.537***	1.350***	1.501***	1.401***
	[0.459]	[0.433]	[0.463]	[0.440]
Dummy_Fossil*Return on equity	1.525	0.886	3.647	−0.63
	[2.089]	[1.781]	[2.503]	[1.760]
Business risk	−0.67	−0.15	−0.967***	−0.644
	[0.429]	[0.411]	[0.372]	[0.458]
Dummy_Fossil*Business risk	0.405	−1.254*	2.103**	0.481
	[0.780]	[0.732]	[0.879]	[0.871]
Beta	0.46	0.311	0.11	0.604
	[1.211]	[1.175]	[1.173]	[1.182]
Dummy_Fossil*Beta	3.394	3.638	2.319	2.562
	[3.878]	[3.363]	[3.671]	[3.898]
Size	14.629***	14.429***	9.953***	14.385***
	[0.482]	[0.482]	[0.515]	[0.482]
Leverage	−0.348	−1.423	1.738	−1.803
	[2.381]	[2.304]	[2.394]	[2.390]
R&D	85.826***	62.285***	109.139***	61.502***
	[14.143]	[13.201]	[14.349]	[14.373]
Net working capital	12.624***	8.334***	17.646***	7.969***
	[2.915]	[2.865]	[2.982]	[3.055]
Constant	−179.369***	−170.382***	−115.443***	−174.329***
	[7.222]	[7.364]	[7.725]	[7.197]
Adjusted R^2	0.345	0.341	0.193	0.333
Observations	11,693	11,693	11,693	11,693

Table B.2
Regression analysis for environmental categories (excluding UK and US). This table reports pooled OLS regression results for the relationship between fossil fuel firms (Dummy_Fossil) and environmental performance score and its three categories, which are items determining categorical scores for emission reduction, product innovation, and resource reduction. The definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Dependent variables: Environmental performance scores			
Variables	Environment	Emission	Product	Resource
Dummy_Fossil	17.975***	18.242***	20.123***	8.133
	[4.453]	[4.103]	[4.611]	[4.996]
Tobin's Q	0.940**	0.720**	0.702*	1.159***
	[0.366]	[0.352]	[0.372]	[0.340]
Dummy_Fossil*Tobin's Q	−2.378***	−1.714**	−2.050***	−2.182***
	[0.642]	[0.679]	[0.725]	[0.636]
Excess stock return	−0.376	−0.75	0.41	−0.79
	[0.505]	[0.531]	[0.529]	[0.513]
Dummy_Fossil*Excess stock return	1.754	1.124	1.065	2.449**
	[1.107]	[1.193]	[1.144]	[1.231]
Return on equity	1.916*	1.753*	1.386	2.001**
	[0.984]	[0.946]	[0.976]	[0.942]
Dummy_Fossil*Return on equity	−0.584	−0.495	−0.569	−0.229
	[1.742]	[1.647]	[1.696]	[1.790]
Business risk	−1.119**	−0.529	−1.433***	−1.057**
	[0.506]	[0.491]	[0.447]	[0.532]
Dummy_Fossil*Business risk	0.554	−0.717	2.107**	0.58
	[0.757]	[0.718]	[0.823]	[0.845]
Beta	7.222***	7.006***	9.493***	3.950***
	[1.537]	[1.575]	[1.517]	[1.530]
Dummy_Fossil*Beta	−8.924**	−7.511**	−12.670***	−3.66
	[3.609]	[3.440]	[3.677]	[3.989]
Size	13.613***	13.813***	9.674***	13.375***
	[0.489]	[0.490]	[0.473]	[0.496]
Leverage	−2.675	−6.092**	3.205	−4.510*
	[2.668]	[2.665]	[2.551]	[2.658]
R&D	152.412***	117.968***	167.442***	142.113***
	[21.959]	[19.989]	[22.368]	[21.687]
Net working capital	4.919	2.481	7.181**	3.507
	[3.099]	[3.178]	[2.940]	[3.082]
Constant	−165.295***	−162.081***	−119.970***	−156.346***
	[7.233]	[7.450]	[6.913]	[7.329]
Adjusted R^2	0.406	0.368	0.335	0.351
Observations	13,534	13,534	13,534	13,534

Table B.3
Regression analysis for environmental categories (excluding US). This table reports pooled OLS regression results for the relationship between fossil fuel firms (Dummy_Fossil) and environmental performance score and its three categories, which are items determining categorical scores for emission reduction, product innovation, and resource reduction. The definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Dependent variables: Environmental performance scores			
Variables	Environment	Emission	Product	Resource
Dummy_Fossil	14.644***	14.913***	16.344***	6.308
	[4.158]	[3.924]	[4.299]	[4.643]
Tobin's Q	0.627**	0.418	0.537*	0.852***
	[0.278]	[0.261]	[0.299]	[0.264]
Dummy_Fossil*Tobin's Q	−2.195***	−1.670**	−2.151***	−1.721**
	[0.610]	[0.662]	[0.698]	[0.670]
Excess stock return	−0.711	−0.924**	0.28	−1.332***
	[0.448]	[0.464]	[0.479]	[0.458]
Dummy_Fossil*Excess stock return	1.662	0.973	1.161	2.330*
	[1.052]	[1.131]	[1.079]	[1.216]
Return on equity	1.616***	1.594***	1.274**	1.391**
	[0.589]	[0.579]	[0.605]	[0.590]
Dummy_Fossil*Return on equity	−0.619	−0.293	−0.612	−0.015
	[1.481]	[1.429]	[1.425]	[1.652]
Business risk	−1.010**	−0.407	−1.330***	−0.973*
	[0.487]	[0.468]	[0.436]	[0.510]
Dummy_Fossil*Business risk	0.505	−0.857	2.114***	0.497
	[0.721]	[0.685]	[0.811]	[0.800]
Beta	4.227***	3.818***	6.354***	1.968
	[1.361]	[1.388]	[1.383]	[1.318]
Dummy_Fossil*Beta	−6.842**	−4.689	−10.158***	−3.037
	[3.355]	[3.321]	[3.349]	[3.692]
Size	13.223***	13.203***	9.732***	12.727***
	[0.413]	[0.412]	[0.423]	[0.417]
Leverage	−1.244	−3.339	1.871	−2.108
	[2.303]	[2.292]	[2.272]	[2.290]
R&D	121.262***	86.255***	147.310***	105.528***
	[16.604]	[15.569]	[16.750]	[17.527]
Net working capital	8.012***	5.613**	9.832***	5.944**
	[2.631]	[2.648]	[2.700]	[2.558]
Constant	−156.361***	−151.191***	−115.950***	−145.150***
	[6.222]	[6.386]	[6.328]	[6.259]
Adjusted R^2	0.394	0.357	0.311	0.343
Observations	15,876	15,876	15,876	15,876

Appendix C. Pooled OLS regression results for fossil fuel firms: Chemicals, coal, and gas and oil and environmental score

Table C.1
Regression analysis for environmental score of fossil fuel firms (including only Australia, Canada, Japan, UK, and US). This table reports pooled OLS regression results for fossil fuel firms: chemicals, coal, and gas and oil (Dummy_Fossil) on environmental score, separately. Definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Chemicals	Coal	Oil and gas
Dummy_Fossil	9.204	−21.694	−3.217
	[11.457]	[13.434]	[5.630]
Tobin's Q	0.42	0.421	0.414
	[0.263]	[0.264]	[0.261]
Dummy_Fossil*Tobin's Q	−1.828	0.005	1.766
	[3.374]	[0.827]	[1.230]
Excess stock return	−1.121**	−1.163***	−1.157***
	[0.446]	[0.447]	[0.443]
Dummy_Fossil*Excess stock return	−0.343	1.732	1.473
	[3.576]	[2.551]	[1.378]
Return on equity	1.478***	1.484***	1.504***
	[0.457]	[0.456]	[0.458]
Dummy_Fossil*Return on equity	2.211	−2.653	−0.318
	[3.057]	[2.245]	[2.392]
Business risk	−0.617	−0.619	−0.701*
	[0.432]	[0.429]	[0.424]
Dummy_Fossil*Business risk	−7.048*	2.398***	1.212*
	[3.869]	[0.879]	[0.706]
Beta	0.467	0.453	0.644
	[1.212]	[1.213]	[1.211]
Dummy_Fossil*Beta	10.117**	12.225	−5.503
	[4.878]	[7.440]	[4.016]
Size	14.672***	14.554***	14.658***
	[0.490]	[0.497]	[0.492]
Leverage	−1.947	−1.914	−2.577
	[2.481]	[2.505]	[2.418]
R&D	80.774***	79.571***	80.626***
	[13.998]	[14.008]	[13.904]
Net working capital	10.643***	10.432***	10.744***
	[3.007]	[3.005]	[2.907]
Constant	−181.592***	−180.188***	−179.267***
	[7.367]	[7.468]	[7.366]
Adjusted R^2	0.354	0.35	0.359
Observations	10,482	10,197	11,216

Table C.2
Regression analysis for environmental score of fossil fuel firms (excluding UK and US). This table reports pooled OLS regression results fossil fuel firms: chemicals, coal, and gas and oil (Dummy_Fossil) on environmental score, separately. Definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Chemicals	Coal	Oil and gas
Dummy_Fossil	16.165	10.548	13.810***
	[10.830]	[11.954]	[5.128]
Tobin's Q	0.889**	0.896**	0.943**
	[0.368]	[0.370]	[0.368]
Dummy_Fossil*Tobin's Q	−2.017	−0.748	−2.425***
	[1.637]	[1.298]	[0.723]
Excess stock return	−0.407	−0.429	−0.446
	[0.501]	[0.499]	[0.502]
Dummy_Fossil*Excess stock return	1.815	1.578	1.32
	[2.994]	[3.796]	[1.230]
Return on equity	2.042**	2.091**	1.958**
	[0.972]	[0.971]	[0.981]
Dummy_Fossil*Return on equity	1.268	−3.497*	−0.219
	[2.360]	[1.898]	[2.940]
Business risk	−1.205**	−1.151**	−1.099**
	[0.504]	[0.507]	[0.507]
Dummy_Fossil*Business risk	−1.963	2.539***	0.686
	[3.702]	[0.903]	[0.737]
Beta	7.063***	7.035***	7.181***
	[1.547]	[1.546]	[1.536]
Dummy_Fossil*Beta	−2.491	−7.477	−8.918**
	[9.412]	[7.612]	[3.845]
Size	13.369***	13.423***	13.742***
	[0.526]	[0.537]	[0.508]
Leverage	−3.092	−3.474	−3.86
	[2.849]	[2.900]	[2.743]
R&D	147.898***	146.183***	148.734***
	[22.205]	[23.340]	[23.281]
Net working capital	3.693	4.37	4.805
	[3.367]	[3.399]	[3.152]
Constant	−161.785***	−162.712***	−166.285***
	[7.727]	[7.848]	[7.437]
Adjusted R^2	0.397	0.392	0.404
Observations	12480	11917	12801

Table C.3
Regression analysis for environmental score of fossil fuel firms (excluding US). This table reports pooled OLS regression results for the effects of three fossil fuel-related industries: chemicals, coal, and gas and oil (Dummy_Fossil) on environmental score, separately. Definitions of variables are given in Table 3. All regressions control country and year fixed effects. The sample period is from 2002 to 2013. Robust standard errors presented in brackets are clustered at the firm level, and ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels.

	Chemicals	Coal	Oil and gas
Dummy_Fossil	11.551	3.025	10.920**
	[9.852]	[11.655]	[4.902]
Tobin's Q	0.572**	0.579**	0.634**
	[0.277]	[0.277]	[0.278]
Dummy_Fossil*Tobin's Q	−1.671	−0.421	−2.390***
	[1.332]	[1.182]	[0.719]
Excess stock return	−0.765*	−0.787*	−0.779*
	[0.445]	[0.444]	[0.446]
Dummy_Fossil*Excess stock return	1.574	0.738	1.513
	[2.821]	[3.593]	[1.175]
Return on equity	1.670***	1.689***	1.624***
	[0.583]	[0.582]	[0.588]
Dummy_Fossil*Return on equity	1.461	−3.806**	0.673
	[1.985]	[1.573]	[3.036]
Business risk	−1.085**	−1.030**	−0.986**
	[0.483]	[0.484]	[0.486]
Dummy_Fossil*Business risk	-2.399	2.255**	0.732
	[3.486]	[0.881]	[0.709]
Beta	4.031***	3.980***	4.161***
	[1.367]	[1.365]	[1.359]
Dummy_Fossil*Beta	1.196	−2.268	−7.296**
	[8.724]	[6.707]	[3.715]
Size	12.977***	13.001***	13.339***
	[0.441]	[0.448]	[0.425]
Leverage	−1.642	−1.931	−2.386
	[2.434]	[2.468]	[2.359]
R&D	116.052***	113.775***	116.788***
	[16.587]	[17.099]	[17.088]
Net working capital	7.274***	7.773***	7.847***
	[2.804]	[2.816]	[2.662]
Constant	−152.864***	−153.285***	−157.084***
	[6.609]	[6.677]	[6.361]
Adjusted R^2	0.384	0.381	0.393
Observations	14,693	14,100	15,087

Appendix D. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2016.10.004.

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