

## RESEARCH ARTICLE

# Does corporate social performance improve environmentally adjusted efficiency? Evidence from the energy sector

José Manuel Maside-Sanfiz<sup>1</sup>  | Óscar Suárez Fernández<sup>2</sup>  |  
María-Celia López-Penabaz<sup>1</sup>  | Mohammad Omar Alzghoul<sup>3</sup> 

<sup>1</sup>Financial and Accounting Department, ECOBAS Research Center, University of Santiago de Compostela, Santiago de Compostela, Spain

<sup>2</sup>Financial and Accounting Department, University of Santiago de Compostela, Santiago de Compostela, Spain

<sup>3</sup>Phd Universidad de Santiago de Compostela, Santiago de Compostela, Spain

## Correspondence

José Manuel Maside-Sanfiz, Financial and Accounting Department, ECOBAS Research Center, Faculty of Economics and Finance, University of Santiago de Compostela, Avda. do Burgo s/n, 15782 Santiago de Compostela, Spain.

Email: [josemanuel.maside@usc.es](mailto:josemanuel.maside@usc.es)

## Funding information

Spanish Ministry of Science and Innovation, Grant/Award Number: PID2021-127527OB-I00; State Investigation Agency; European Regional Development Fund

## Abstract

This study analyses the impact of corporate social performance (CSP), proxied by the Environmental, Social and Governance (ESG) Index and its pillars and dimensions, on the environmentally adjusted efficiency (EAE) of 239 listed companies, over the period 2016–2021, in the global energy sector. The EAE index, estimated via data envelopment analysis (DEA), assesses the efficiency of companies by considering economic aspects alongside CO<sub>2</sub> and energy consumption reduction targets. Our results support the hypothesis that only above a certain level of performance, do CSP practices positively influence EAE, so there is a non-linear U-shaped association between the overall ESG score and EAE. The same holds for the social and governance pillars, and the human rights and management subspecific dimensions, on EAE. Other ESG attributes show a positive linear relationship with EAE, namely the environmental pillar, the environmental innovation dimension and the shareholder dimension. Our paper has significant implications for companies, policy makers and researchers insofar as it estimates EAE and indicates which CSP practices should be invested in over the long term to have a positive effect on it.

## KEYWORDS

corporate social performance, data envelopment analysis, energy sector, environmental firm efficiency, ESG, U-shaped

## 1 | INTRODUCTION

Energy is essential for economic activity to develop and for social and economic progress to be fostered in society. Energy prices are an important component of production costs for many goods and services and they have a considerable influence on the profitability of companies (European Commission, 2020). For this reason, the sector that encompasses energy-producing and -distributing companies is considered of strategic importance. Moreover, the energy sector plays an essential role in the fight to mitigate the harmful effects of climate change since, first, fossil energy sources are

responsible for 80% of CO<sub>2</sub> emissions (International Energy Agency [IEA], 2018), and second, thanks to technological advances, the growth of the renewable energy industry is one of the pillars that will prevent the worst effects of rising temperatures from becoming a reality. Hence, two crucial goals are to reduce CO<sub>2</sub> emissions and energy use, which are closely related to each other (Kim et al., 2022).<sup>1</sup>

<sup>1</sup>According to the new report by Heidrick et al. (2023), reducing CO<sub>2</sub> emissions is included as a top priority for companies in the energy sector.

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2023 The Authors. *Corporate Social Responsibility and Environmental Management* published by ERP Environment and John Wiley & Sons Ltd.



Considering the sector's impact on the environment, Corporate Social Responsibility<sup>2</sup> (CSR) activity in the energy sector holds significant importance (Iazzolino et al., 2023; Pinheiro et al., 2023). Previous studies have highlighted this and its high potential for growth (Cariola et al., 2020), while also emphasising its role in sustainable global development and competitiveness among modern economies (La Rocca et al., 2023).

In an oligopolistic sector such as that of energy, companies are highly visible (Aguilera-Caracuel et al., 2017) and easy targets for the media and non-Governmental Organisations (NGOs) (Graafland & Smid, 2004). These companies have long adopted CSR practices to comply with regulatory requirements and international voluntary initiatives, such as the Sustainable Development Goals<sup>3</sup> (the SDGs) (Curran, 2017). Moreover, the businesses invest in CSR activity to create long-term value by way of enhancing their public image and reputation (Arena et al., 2019). For decades, the energy sector has been the most attentive industry for implementing CSR activity (D'Amato et al., 2022), developing multiple CSR practices, each of which tend to have different effects on performance. As CSR activity is so specific to the energy sector, coupled with its significance, CSR studies on this topic are clearly valuable.

Although the relationship between CSP and firm performance has been the focus of numerous studies since the seminal paper of Bragdon and Marlin (1972), this nexus had not specifically been examined in the energy sector until last decade (Bracco, 2015; Ekatah et al., 2011; Pätäri & Sinkkonen, 2014; Sepúlveda & Mendizabal, 2011; Shahbaz et al., 2020). The results from these studies vary and assume that there is a linear relationship between both variables, although this relationship may depend on its extent and the type of CSR activity undertaken. In addition, existing studies often rely on unidimensional indicators, overlooking key aspects such as emissions or resource utilisation. Recent papers, such as Lu et al. (2023) and Ren et al. (2022), have employed an overall measure of financial and environmental performance, although none of these papers have specifically explored this relationship within the energy sector. Moreover, as CSR practices may not have the same impact on company performance, it would be useful to thoroughly study the individual effects of each of the three pillars of CSR activity and their different dimensions, an aspect not addressed in the literature.

Consequently, there are still research gaps concerning the relationship between firm performance and CSR activity, particularly in the energy sector. This article aims to investigate the relationship between CSR practices and a measure that encompasses economic and environmental aspects from a non-linear perspective, contributing to the existing literature on multiple dimensions.

First, we propose the adoption of the concept of environmentally adjusted firm efficiency (EAE) by employing data envelopment analysis (DEA). EAE serves as a comprehensive indicator as, while taking into account several economic aspects, it acknowledges the

significance of enhancing environmental efficiency, in terms of reducing CO<sub>2</sub> emissions and energy consumption, contributing to an effective corporate sustainability policy being built in the energy sector. This approach stands in contrast to previous studies on this sector that have used unidimensional financial indicators and either accounting measures or market ones or both as proxies of firm performance.

Second, the lack of consensus in the existing literature suggests that the relationship between CSP and corporate performance may depend on the type and intensity of activity, as well as the industry's awareness of environmental concerns (Kludacz-Alessandri & Cygańska, 2021). Since the recent study of Kumar et al. (2022) is the only one that has analysed the curvilinear effect of CSP on firm performance in the energy sector, our paper makes a significant contribution to this field of research.

Third, this body of work is pioneering in its analysis of the impact of various CSR activity areas (namely, the overall ESG score, as well as its three individual pillars, which are 'environmental', 'social' and 'governance', and their dimensions, for example, environmental innovation or human rights) on EAE in the energy industry. ESG is an aggregated term that covers a wide range of thematic issues, where firms may strive to reduce CO<sub>2</sub> emissions and energy consumption but fail to deal with other environmental, social and governance issues. CO<sub>2</sub> emissions and energy use are seen as direct and tangible measures of company impact, while the vast majority of the other variables included in the ESG index reflect the mitigation efforts of companies (Broadstock et al., 2019).

The results obtained support a non-linear U-shaped relationship between overall CSP and EAE. We have observed similar curvilinear relationships in the pillars 'social' and 'governance' and in the CSR activity categories 'human rights' and 'management'. Said findings largely support the resource theory, the stakeholder theory and the 'too little of a good thing' (TLGT) metatheory, thus indicating that the initial implementation of CSR activity requires a significant initial investment and the rewards in terms of reputation and its consequent positive impact on efficiency can be seen in the medium to long term. Finally, we have found a linear and positive relationship between the 'environmental' pillar, the dimensions 'environmental innovation' and 'shareholder relations' and EAE. The application of the three-step method proposed by Lind and Mehlum (2010) has allowed us to confirm our results.

The rest of the paper is organised as follows: Section 2 presents the theoretical framework and the hypotheses based on previous literature; Section 3 describes the methodology used in the study; Section 4 presents and discusses the main empirical results; finally, Section 5 highlights the main conclusions, discusses the limitations, and makes suggestions for future research to expand upon the analysis performed.

## 2 | THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

### 2.1 | Theoretical framework

From the point of view of stakeholder theory (Freeman, 1984), managers must satisfy the needs of all stakeholders, not just shareholders. Thus, while shareholders are more interested in the economic aspect,

<sup>2</sup>CSR refers to the voluntary action taken by companies to integrate social and environmental concerns into their business operations and interactions with stakeholders. It involves the commitment to ethical practices, sustainability and the well-being of communities, employees and the environment. Carroll (1979) proposed this concept by encompassing economic, legal, ethical and philanthropic responsibilities.

<sup>3</sup>The SDGs are a set of 17 comprehensive goals established by the United Nations to address pressing social, economic, and environmental challenges worldwide. They provide a framework for international cooperation and guide efforts to achieve a sustainable future by 2030.

for other stakeholders, such as environmentalists and local community organisations, the environmental aspect of the company's performance is more important (Florini & Saleem, 2011). Hence, a measure of firm performance which captures both economic and environmental aspects is relevant, as it can measure the satisfaction levels of a wide range of stakeholders.

Reinhardt's (1999) question, 'When does it pay to be green?', sums up one of the main lines of enquiry in previous bodies of research on this topic. On the one hand, the neoclassical perspective argues (Friedman, 1970) that investing in CSR activity entails more costs than benefits. On the other hand, investment in CSR practices may be an important driver that leads to an improvement in firm performance (Coelho et al., 2023). The latter hypothesis is supported by the resource-based theory (Penrose, 1959), which posits that investment in social and environmental initiatives, although costly in principle, also creates value in the form of intangible assets such as reputation and brand image, which can become a long-term competitive advantage.

Therefore, stakeholders might only value efforts for CSR activity made by companies when the minimum threshold is exceeded (Trumpp & Guenther, 2017), known as the U-shaped effect, or TLGT. This implies that CSR activity has a negative impact on firm performance at first then a positive one, meaning that, in accordance with Reinhardt's hypothesis, the sign of this interaction depends on the CSP level (Reinhardt, 1999). The shift from negative to positive may be due to the CSR strategy carried out by companies. Thus, according to Fuji et al. (2013), if businesses in the energy sector follow a reactive strategy, carrying out CSR activities only to comply with the regulatory framework to which they are subject (Dilling & Harris, 2018), costs will outweigh benefits (Gollop & Roberts, 1983; Jiang et al., 2018). However, energy firms that use a proactive CSR strategy, also engage in CSR activity on a voluntary basis to, among other reasons, forge their corporate culture (Ngoasong, 2014) and/or safeguard their public image due to the reputational risk to which this sector is exposed (González-Ramos et al., 2018; Oh et al., 2010); both aspects are roots of a firm's success (Andersson et al., 2022).

It seems clear that if a company undertakes CSR activity to reduce its environmental impact, meeting stakeholder expectations may initially cause additional drawbacks (e.g., to reduce CO<sub>2</sub> emissions, significant upfront investments must be made in both tangible fixed assets and human resource training) that outweigh the upsides, but eventually, stakeholders may hold the corporate reputation in higher regard, which could in turn generate valuable intangible assets.

## 2.2 | Hypothesis development

### 2.2.1 | Global CSP and EAE

Most research examining how impactful CSR firm initiatives are, positively links them to business value, which seems more pronounced in industries with a more direct influence on the environment, such as those in the energy sector (Arslan-Ayaydin & Thewissen, 2015).

According to most studies (Bracco, 2015; Lee, 2021; Pätäri et al., 2012; Shukla & Geetika, 2022; Sidhoum & Serra, 2017; Zhou & Wei, 2016), the sustainability practices of energy companies increase firm value. The execution of CSR initiatives can positively influence firm performance, either by way of cost savings, for example, avoiding fines and hefty interest rates if they fail to comply with climate change regulations (Sepúlveda & Mendizabal, 2011), or, directly, from increased revenues (Ekatah et al., 2011). However, some studies on the energy sector have found that the relationship between the two variables is negative (Cho et al., 2019; Filbeck & Gorman, 2004; Kaupke & zu Knyphausen-Aufseß, 2023; Sueyoshi & Goto, 2009; Tupura et al., 2016) or neutral (Pätäri & Sinkkonen, 2014; Shahbaz et al., 2020).

The disparity of results in previous papers may be due, in part, to the indicator chosen to measure performance, which only captures the direct monetary benefits of the CSP (Cho & Lee, 2019), and the relationship assumed between the variables studied. Therefore, the measure of firm performance is frequently proxied by accounting and/or market information, which is more easily accessible than data based on firm operating performance (Huang, 2019). However, as demonstrated by several literature review papers (Busch & Friede, 2018; Hou et al., 2016), operational performance measures are more closely related to CSR activity, the latter having, therefore, a stronger correlation with the former than with accounting or market measures. Other studies, such as that of Laguir et al. (2019), have used energy efficiency as a measure of firm performance, but this is a purely technical measure,<sup>4</sup> so it does not incorporate financial or market aspects. The measures used in previous studies have only captured one aspect of firm performance. Trying to overcome these limitations, Choi et al. (2017) and Stefanoni and Voltes-Dorta (2021) in the automotive manufacturing sector, as well as Lu et al. (2023) and Ren et al. (2022) with a sample of Apple Inc.'s customers and partners, have used the DEA methodology to estimate a comprehensive measure of efficiency that incorporates economic and environmental factors.

Moreover, recent studies have explored the possibility of a non-linear relationship between CSR practices and firm performance, that is, the relationship may be positive or negative depending on the level of CSR activity undertaken. Kumar et al. (2022), in their study for the energy sector from an international sample in the period from 2006 to 2018, have concluded that CSR activity performance has an inverted U-shaped nexus with various accounting measures. The same conclusion has been reached by other papers on both the manufacturing (Sun et al., 2019) and hospitality sectors (Chen & Lin, 2015). This effect is known as the 'too much of a good thing' (TMGT) effect, which is based on the law of declining marginal returns. This metatheory states that there is a maximum level of CSR activity performance beyond which firm performance declines (Pierce & Aguinis, 2013).

CSR practices could also lead to negative firm performance up to a certain level, reflecting a U-shaped relationship between the two

<sup>4</sup>This variable has been measured with a dummy proxy that takes a value of 1 if the firm has engaged in a process to improve energy efficiency and/or to reduce greenhouse gas emissions, or 0 otherwise.

variables, this being the TLGT effect, which links to stakeholder and resource theory. Thus, bearing in mind the nature of energy sector activity, which is subject to high public scrutiny (Beck et al., 2018), companies should pursue a proactive CSR strategy seeking to meet stakeholders' needs so that they value their respective businesses for the efforts made when the minimum threshold is exceeded. This relationship has been confirmed by Nollet et al. (2016) for Standard & Poor's (S&P) listed companies, where, in the short term, profitability decreases as CSR activity increases, and in the long term, profitability rises. This metatheory has also been established in papers on specific sectors, such as Wang et al. (2016) in construction, Franco et al. (2020) in hospitality, and López-Penabad et al. (2022) in the financial sector. The same conclusion has been reached in multi-sector studies conducted in contrasting geographical contexts such as India (Maqbool & Bakr, 2019) and Germany (Nuber et al., 2020). Likewise, the papers of Ren et al. (2022) and Lu et al. (2023) have obtained the same results, but unlike in earlier papers, their studies have used an environmentally adjusted measure of firm performance.

Our first hypothesis is based on prior research and the examination of a sector characterised by hazardous activity and multiple CSR initiatives. Their initial costs may be outweighed by the benefits of generating competitive advantages, which is consistent with both stakeholders and resource-based theories. Hence, we have put forth our first hypothesis as follows:

**Hypothesis 1.** The relationship between CSP and EAE is non-linear and U-shaped.

## 2.2.2 | Individual CSR activity performance and EAE

In order to understand the impact of corporate social responsibility (CSR) activity on a company's performance, it is crucial to analyse the various practices involved. Not all CSR initiatives have the same effect on firm performance, as highlighted by Ren et al. (2022). For instance, Feng and Wang (2017) discovered that in the energy sector, environmental practices positively influence performance, while those related to employees do not.

Thus, several studies have suggested a non-linear relationship between environmental performance and firm performance. Kumar et al. (2022) have conducted a study on energy firms and have found an inverted U-shaped relationship between environmental performance and profitability. These findings are consistent with other studies involving multisectoral or industrial company samples, such as Misani and Pogutz (2015), Fuji et al. (2013), Broadstock et al. (2018), and Lahouel et al. (2022).

Additionally, regulations require the implementation of practices that reduce the environmental impact of companies in the energy sector. While these regulations may temporarily burden firm performance, they can have positive long-term effects, as noted by Xie et al. (2018) from international, Chinese, and Indian multi-sector firm samples, as well as Japanese manufacturing firms (Chen & Ma, 2021;

Ghosh et al., 2023; Grassmann, 2021; Hatakeda et al., 2012; Tatsuo, 2010; Trumpp & Guenther, 2017).

Given the significant impact that energy companies have on the environment, they make investments in environmental initiatives, while also addressing social issues (such as human rights advocacy and donations) to enhance their corporate reputation and, ultimately, to improve firm performance (Liu & Lu, 2011).

Multiple studies have examined the influence of social activities on firm performance. While recent research has generally supported a non-linear relationship between them, there is no consensus on whether high performance in social practices benefits firm performance in the short or long term. Kumar et al. (2022) and Grassmann (2021) have found an inverted U-shaped relationship between social performance and firm performance in energy companies and a multi-sector sample, respectively, suggesting short-term benefits. In contrast, other studies have indicated a U-shaped relationship and have highlighted the positive long-term effects of socially responsible investments, as observed in investment funds (Barnett & Salomon, 2006), international multi-sector firm samples (Barnett & Salomon, 2012; Brammer & Millington, 2008) and the financial (López-Penabad et al., 2022) and industrial (Ren et al., 2022) sectors.

Regarding the effectiveness of systems and processes aimed at implementing best corporate governance practices, Nollet et al. (2016) confirmed a U-shaped relationship with various accounting performance measures. This finding aligns with studies examining their impact on efficiency in both the financial sector, particularly banking (López-Penabad et al., 2022), and the EAE aspects of industrial companies (Ren et al., 2022).

Hence, allocating resources to various categories of CSR activity enables energy firms to build valuable intangible resources. This, in turn, and in line with stakeholder and resource-based theories, creates a sustainable competitive advantage in the long term as these resources cannot be easily replicated or purchased (Cho & Pucik, 2005). Based on these findings, we propose the following hypothesis:

**Hypothesis 2.** The environmental, social and corporate CSR pillars and their dimensions have a non-linear U-shaped relationship with EAE.

## 3 | EMPIRICAL RESEARCH

### 3.1 | Data

Our unbalanced data panel consists of 239 listed energy companies for the period 2016–2021 from a total of 46 countries (see Table A1) operating in the coal, multi-line utilities, oil, gas, renewables and uranium sub-sectors. We considered it appropriate to start in 2016 as this is when the Global Reporting Initiative (GRI) G3 guidelines were introduced, which offered 'greater corporate awareness of CSR practices' (Kumar et al., 2022, p. 6).

The ESG score, its three pillars, and eight of their dimensions extracted from the Thompson Reuters Refinitiv Eikon company

database were used as proxies for CSP. This database has been widely used in previous literature (Lahouel et al., 2022; López-Penabad et al., 2022; Ren et al., 2022), and has also been employed to obtain the financial data of the companies. The macroeconomic data was extracted from the World Development Indicators database managed by the World Bank.<sup>5</sup>

To perform the sample selection, we incorporated companies classified in the energy sector in the Thompson Reuters Refinitiv EIKON database. After discarding observations lacking data for some of the variables necessary to perform the analysis, the final sample comprised 973 company-year observations. The sample selection process is detailed in Table B1.

### 3.2 | Methodology

A widespread approach to assessing the performance of an industry involves estimating its efficiency. Traditionally, the efficiency of companies in the energy sector has been evaluated only in relation to operational and financial measures using different methodologies that can be grouped into two types: (1) the traditional analysis of accounting ratios; (2) the distance function approach. In the latter, the best practice output is represented by a 'production frontier' and efficiency scores for the remaining (non-frontier) companies are calculated by comparing them with the best performers. Efficiency is typically calculated using two methods: the Data Envelopment Analysis (DEA) (non-parametric) and the Stochastic Frontier Analysis (SFA) (parametric).

The use of traditional one-dimensional financial indicators may not adequately reflect business performance. In order to incorporate multiple inputs and outputs to estimate firm performance, different methodologies have been devised. Our study has applied a non-parametric approach, DEA, as a tool to estimate operational efficiency. The impact of ESG score on performance can vary depending on the proxies used. There are a gamut of measures of financial performance, mainly using both accounting and market measures. We estimated efficiency scores by including energy use as an input and CO<sub>2</sub> emissions as a bad output, both of which businesses should monitor and reduce, in combination with traditional operational and financial measures.

DEA is widely used for indicator construction, including energy (see Emrouznejad & Yang, 2018) and environmental assessment as two of the most popular application areas, the latter being so especially since the introduction of the concept of undesirable output (Sueyoshi et al., 2017).

The DEA methodology also has some limitations, one of which that is worthy of note being that it tends to generate biased estimates. To eliminate these problems, in the first stage, we employed a bootstrap procedure proposed by Simar and Wilson (2007) to estimate EAE and, in the second stage, the EAE scores evaluated were regressed on a set of ESG explanatory factors, utilising the truncated regression.

DEA is a mathematical method for estimating a firm's efficiency based on observed data on specified inputs/outputs of a set of firms known as Decision Making Units (DMUs). Charnes et al. (1978) considered the constant returns-to-scale (CRS) hypothesis, and Charnes and Cooper (1984) proposed an alternative model to include variable returns-to-scale (VRS), which means that the relative competence of each DMU is calculated by comparing it to other DMUs similar in size to the firm under evaluation which have similar operational resources. The CRS assumption is applicable only when all DMUs are running at optimal scale, therefore assuming that VRS is more appropriate, because the energy industry benefits from economies of scale.<sup>6</sup>

At each period  $t$  ( $t = 1, \dots, t$ ), each DMU ( $i = 1, 2, \dots, n$ ) has its own inputs ( $s = 1, 2, \dots, j$ ) that expend  $X_{it} = \{x_{sit}\}$  and outputs ( $r = 1, 2, \dots, m$ ) that create  $Y_{it} = \{y_{rit}\}$ . To calculate operational efficiency, we employed the output orientation of the VRS model because economic units typically aim to get the most out of earnings with an appropriate combination of inputs.

$$\text{Max } \theta_{0t} : x_{s0t} - \sum_{i=1}^{n_t} \lambda_{it} x_{sit} \geq 0; \sum_{i=1}^{n_t} \lambda_{it} y_{rit} - \theta_{0t} y_{r0t} \geq 0; \sum_{i=1}^{n_t} \lambda_{it} = 1; \lambda_{it} \geq 0 \quad (1)$$

$\theta_0$  is a radial efficiency score for DMUs and  $\lambda$  is the weight. The DMU is efficient if  $\theta_0$  is equal to 1 (located on the frontier) by construction, whereas it is inefficient (located inside the frontier) if  $\theta_0$  is greater than 1. In order to measure technical efficiency on a scale that could be interpreted in percentage points, we inverted the efficiency scores,  $EAE = (1/\theta_{it})$  so that values less than 1 would indicate inefficiency.

We followed the approach of Chung et al. (1997), which proposes a directional distance function. This is a generalised expression for an oriented DEA model, which allows both desirable and undesirable outputs to be considered under the same production frontier. In addition, we employed the procedure proposed by Simar and Wilson (2007), which combines the DEA model with the bootstrap procedure to estimate the bias corrected environmentally adjusted efficiency ( $\widehat{EAE}$ ) score.

Next, the study used truncated regression to examine the non-linear relationship between CSP (measured via ESG scores) and EAE. To achieve the study's objectives, the research equation models were as follows:

$$\widehat{EAE}_{it} = \gamma \text{ESG}_{it} + \delta \text{ESG}_{it}^2 + \beta Z_{it} + \eta D_t + \varepsilon_{it} \quad (2)$$

where  $\widehat{EAE}_{it}$  was the dependent variable, the bias corrected bootstrapped EAE score for DMU $i$  of each year  $t$ . ESG and  $Z_{it}$  were vectors of independent/control variables for efficiency determinants anticipated to interpret efficiency fluctuations and  $D_t$  was a year dummy vector (from 2016 to 2021). In the second stage, which linked

<sup>5</sup><https://databank.worldbank.org/source/world-development-indicators>.

<sup>6</sup>The presence of high fixed costs makes productivity in the energy sector vary according to the size of the company.

independent variables to efficiency, besides the yearly effects on efficiency,  $\gamma, \beta, \delta$  and  $\eta$  were the parameters which were evaluated;  $\varepsilon_{it}$  was an independent error term with a zero mean  $\sigma_\varepsilon^2$  variance  $N(0, \sigma_\varepsilon^2)$  with left-tail truncation  $(1 - \gamma ESG_{it} - \delta ESG_{it}^2 - \beta Z_{it} - \eta D_t)$ .

### 3.2.1 | Dependent variable: The environmentally adjusted efficiency measure

Given the significant environmental impact of the energy sector, and the growing concern with it from the public and from the authorities, we employed DEA models with desirable and undesirable outputs

**TABLE 1** DEA Models: Operational and environmental efficiency.

| Categories | Operational efficiency                                  | Environmental efficiency                                      |
|------------|---|---|
| Inputs     | Employees, Property plant and equipment, Operating cost | Operational efficiency inputs + Energy use                    |
| Outputs    | Operating revenues, Market capitalisation               | Operational efficiency outputs + CO <sub>2</sub> (bad output) |

Source: Own elaboration.

(operational and polluting), in line with previous literature (Lu et al., 2023; Ren et al., 2022; Sueyoshi et al., 2017).

Following other studies (Lu et al., 2023; Ren et al., 2022; Sánchez-Robles et al., 2022; Stefanoni & Voltes-Dorta, 2021; Sueyoshi et al., 2017) and since energy efficiency is essential for combatting global warming and climate change, we incorporated energy use along with the other inputs used in the calculation of operating efficiency (total number of employees, property plant and equipment [PPE] and operating cost).

Taking into account that in addition to producing desirable outputs, operating revenues and market value, the production process can also generate undesirable or bad output, we also incorporated CO<sub>2</sub> emissions in the model, which had already been used in previous studies (Du et al., 2018; Lu et al., 2023; Otani & Yamada, 2019; Ren et al., 2022; Sueyoshi et al., 2017; Sueyoshi & Goto, 2012a, 2012b). Therefore, in the descriptive analysis, we differentiated the operating efficiency from the EAE, although in the multivariate analysis we only used the latter. Table 1 shows the inputs and outputs of both efficiencies.

Table 2 shows the descriptive statistics of our inputs/outputs and Table 3 encompasses the Spearman correlation coefficients of all the input and output variables so as to assess the validity of the model. The proposed DEA model satisfied the isotonicity conditions, which required outputs not to decrease as inputs increased. There was a

**TABLE 2** Descriptive statistics of inputs and outputs for the EAE model.

| Variable                                     | Obs. | Mean       | Std. Dev. | Min.  | Max.        |
|--|------|------------|-----------|-------|-------------|
| Employees                                    | 973  | 24,051.24  | 57,388.75 | 8     | 477,600     |
| Property, plant and equipment (USD millions) | 973  | 21,147.13  | 41,689.16 | 31.60 | 259,651     |
| Operating costs (USD millions)               | 973  | 21,945.44  | 47,920.53 | 16.40 | 414,382.20  |
| Energy use (gigajoules millions)             | 973  | 174.33     | 1388.70   | 0.00  | 42,472      |
| Operating revenue (USD millions)             | 973  | 23,515.81  | 50,451.23 | 0.40  | 431,492.60  |
| Market capitalisation (USD millions)         | 973  | 692,089.40 | 7,260,996 | 23.72 | 136,301,842 |
| CO <sub>2</sub> (tons millions)              | 973  | 11.70      | 24.55     | 0     | 176.65      |

Source: Own elaboration.

**TABLE 3** Spearman rank correlation coefficients.

|                               | Inputs    |        |                 |            | Outputs            |                       |                 |
|-------------------------------|-----------|--------|-----------------|------------|--------------------|-----------------------|-----------------|
|                               | Employees | PPE    | Operating costs | Energy use | Operating revenues | Market capitalization | CO <sub>2</sub> |
| Employees                     | 1.0000    |        |                 |            |                    |                       |                 |
| Property, plant and equipment | 0.5009    | 1.0000 |                 |            |                    |                       |                 |
| Operating costs               | 0.7805    | 0.6642 | 1.0000          |            |                    |                       |                 |
| Energy use                    | 0.4495    | 0.6330 | 0.6269          | 1.0000     |                    |                       |                 |
| Operating revenues            | 0.7866    | 0.6826 | 0.9789          | 0.6426     | 1.0000             |                       |                 |
| Market capitalisation         | 0.5619    | 0.7069 | 0.6423          | 0.4777     | 0.6828             | 1.0000                |                 |
| CO <sub>2</sub>               | 0.4677    | 0.7201 | 0.6124          | 0.7535     | 0.6327             | 0.5454                | 1.0000          |

Note: The coefficients are significant at the 1% level.

Source: Own elaboration.

**TABLE 4** Descriptive statistics of control variables.

|                            | Obs. | Mean    | Std. Dev. | Min.     | Max.     |
|----------------------------|------|---------|-----------|----------|----------|
| Size                       | 973  | 23.4152 | 1.3187    | 20.8011  | 26.7425  |
| ROA                        | 973  | 0.0249  | 0.0880    | -0.5233  | 0.7324   |
| R&D                        | 973  | 0.0565  | 0.4988    | 0        | 1.0843   |
| Strategic shareholders (%) | 973  | 34.69   | 44.23     | 0        | 100      |
| Solvency ratio             | 973  | 1.4867  | 1.2264    | 0.13505  | 24.3418  |
| Interest coverage ratio    | 973  | 10.5250 | 22.8857   | -14.3720 | 166.8395 |
| Oil price                  | 973  | 56.7855 | 11.4240   | 41.2578  | 69.0706  |
| GDP growth                 | 973  | 1.6411  | 4.2216    | -11.3254 | 11.6682  |

Source: Own elaboration.

statistically significant and positive correlation between inputs and outputs (Golany & Roll, 1989) and coefficients were below 0.90 for both (Bowlin, 1998).

### 3.2.2 | Independent (ESG) and control variables

Following previous studies that had used the same measure of CSP (Ahmad et al., 2021; López-Penabad et al., 2022; Ren et al., 2022), we analysed the impact of each of the ESG dimensions on EAE as independent variables, incorporating those that the literature considers most relevant for each of the three pillars into the models. Therefore, we selected the following categories: the ESG overall index, the Environmental pillar (the Innovation dimension), the Social pillar (ESG controversy, Community, Human rights and Product responsibility dimensions) and the Governance pillar (the Management, CSR strategy and Shareholder dimensions).<sup>7</sup>

To prevent specification problems in the model, we incorporated certain control variables already identified in the literature that could be divided into two groups: the first one employed those related to specific characteristics of the companies; the second adopted macroeconomic variables. Among the company-specific variables, we included size as the logarithm of total assets (Xie et al., 2018), ROA as net income divided by average total assets, expressed as a percentage (Ren et al., 2022), R&D as R&D expenses divided by operating cost (Nollet et al., 2016), strategic share as the percentage of strategic shareholders in the company (De Mesnard, 2022), the solvency ratio as current assets divided by current liabilities (Sánchez-Robles et al., 2022) and interest coverage ratio as EBIT divided by financial expenses (Yildirim, 2020). Additionally, in the robustness analysis we included two variables that previous studies had shown influences efficiency: the oil price (Sánchez-Robles et al., 2022) and GDP growth (López-Penabad et al., 2022). In Table 4, the descriptive statistics for the control variables can be seen. For a complete description of all variables used, see (Table C1).

<sup>7</sup>A definition of each item can be found at the following link: [https://www.refinitiv.com/content/dam/marketing/en\\_us/documents/methodology/refinitiv-esg-scores-methodology.pdf](https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf).

## 4 | EMPIRICAL RESULTS AND DISCUSSION

### 4.1 | Descriptive statistics

Table 5 shows the descriptive statistics for the two types of efficiency calculated in the first stage of our analysis. The average operational efficiency was 42.64%, which may be considered a moderate level due to its capacity for improvement, whereas the results of Sánchez-Robles et al. (2022), in their analysis of the European oil sector, were lower, at 27%. In relation to EAE, its mean was 60.11%.

Regarding their evolution over time (Figure 1), both types of efficiency show a similar trend that is consistent with research done by Ismail et al. (2013) for 17 oil companies. These results showed that both types of efficiency decreased in the year prior to the start of the COVID-19 health crisis and decreased again in 2020, before improving in 2021.

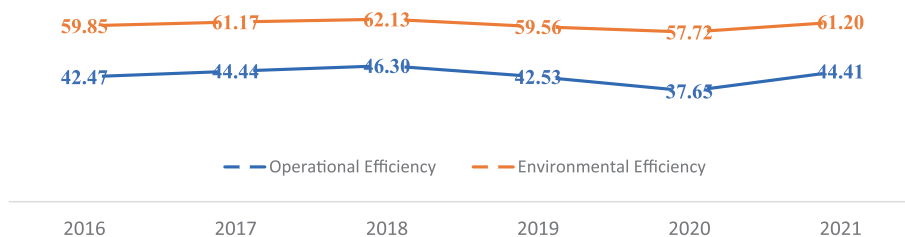
Table 6 comprises the descriptive statistics for the ESG category scores (ranging from 0 to 100). The energy sector showed moderate levels of performance both in the overall ESG score and in the pillars and their dimensions. The average ESG score was 62.06. The results for each of the pillars, namely, environmental, social and governance, were: 62.30, 62.88 and 60.73, respectively. As for the dimensions, there were significant variations. In the environmental pillar, innovation (31.26) had the worst result. The highest scores were: ESG controversies (83.08) in the social pillar and CSR strategy (69.66) in the governance one. There is, therefore, considerable scope for many companies in the energy sector to improve their current commitment to CSR.

We also examined the correlation between ESG index scores, the three individual ESG scores and the control variables. The ESG index and pillar scores were highly correlated but have not been incorporated into the same models. Following the rule stated by Brooks (2008), the correlation coefficients do not indicate any collinearity problems, with absolute values below 0.8 in all cases. This has also been supported by the Variance Inflation Factor (VIF), which was less than 1.5 in all our analyses, indicating no evidence of multicollinearity.<sup>8</sup>

<sup>8</sup>The results of the VIF have not been reported in this paper but are available on request from the authors.

|   | Obs. | Mean    | Std. Dev. | Min.    | Max. |
|---|------|---------|-----------|---------|------|
| Operational efficiency (%)              | 973  | 42.6390 | 24.9516   | 0.1676  | 100  |
| Environmentally adjusted efficiency (%) | 973  | 60.1114 | 14.1130   | 10.2861 | 100  |

Source: Own elaboration.



**TABLE 5** Descriptive statistics of operational and environmentally adjusted efficiency.

**FIGURE 1** Efficiency over time.

Source: own elaboration.

|                        | Obs. | Mean    | Std. Dev. | Min.    | Max.    |
|------------------------|------|---------|-----------|---------|---------|
| ESG score              | 973  | 62.0626 | 15.0355   | 0.9055  | 92.8378 |
| Environmental pillar   | 973  | 62.8753 | 19.3723   | 0.4434  | 95.7089 |
| Innovation             | 973  | 31.2644 | 32.1516   | 0       | 98.7500 |
| Social pillar          | 973  | 62.3037 | 17.9297   | 0       | 98.9074 |
| ESG controversies      | 973  | 83.0811 | 29.2573   | 0.7692  | 100     |
| Community              | 973  | 66.3916 | 26.9866   | 13.5135 | 99.8423 |
| Human rights           | 973  | 52.7347 | 31.3188   | 0       | 98.7500 |
| Product responsibility | 973  | 58.0370 | 29.7308   | 0       | 99.8055 |
| Governance pillar      | 973  | 60.7333 | 21.8123   | 26.1905 | 98.5652 |
| Management             | 973  | 60.7147 | 28.5096   | 10.8696 | 99.8778 |
| CSR strategy           | 973  | 69.6614 | 24.4472   | 0       | 99.9064 |
| Shareholders           | 973  | 54.8430 | 27.2445   | 0.4587  | 99.8350 |

Source: Own elaboration.

**TABLE 6** Descriptive statistics of independent variables: the ESG index and its pillars and dimensions.

## 4.2 | Truncated regression analysis for environmental efficiency

The truncated regression results, which can be seen in Table 7, have allowed us to examine the non-linear relationship between CSP and EAE. As noted above, we used the bootstrapped bias-corrected environmentally adjusted efficiency score as the dependent variable. As a U-shaped relationship was found, we performed the method proposed by Lind and Mehlum (2010) to test the significance of the coefficients obtained from the U-shaped quadratic specification (antepenultimate row) and to check whether the turning point of the curve lay in the interval of the data (penultimate row). In addition, in Figure D1, we have plotted the data based on the truncated regression model in Table 7 to visualise the U-shaped relationship in the subfigures, showing the mean change in EAE when ESG scores changed, holding other covariates constant.

The results shown in regression (1) of Table 7 indicate that the coefficient of the ESG index variable was negatively significant whereas the coefficient of the squared ESG index variable was positively significant, allowing us to draw the conclusion that there is a

U-shaped relationship, that is, convex and upward oriented, between CSP and EAE. Hence, the statistical evidence supports Hypothesis 1 and it is consistent with the findings of Ren et al. (2022) and Nollet et al. (2016) for multisectorial samples and with those of Wang et al. (2016), Franco et al. (2020) and López-Penabad et al. (2022) for the construction, hospitality and financial sectors, respectively. In addition, Nuber et al. (2020) for German companies, and Maqbool and Bakr (2019) for Indian ones, have come to the same conclusion.

The test results obtained confirm that the CSP-EAE relationship depends on the level of ESG investment. ESG initiatives have a negative impact on EAE in their initial phases as marginal costs outweigh marginal benefits, up to the lowest point of the curve (42.95), after which the relationship reverses and becomes positive. This is because the ESG initiatives reinforce competitive advantages and build up a reputation and legitimacy (Buallay, 2021).

The findings for the social pillar are similar (see regression (3) in Table 7). The shape of the curve and the inflexion point (41.67) show us that from this inflexion point onwards, the higher the performance of social activity, the more positive the effect on EAE. The findings for the governance pillar and EAE are similar (see regression (4) in

**TABLE 7** Results of truncated regressions for relationship between corporate social performance and environmentally adjusted efficiency.

|  | (1)            | (2)       | (3)            | (4)             | (5)       | (6)          | (7)             |
|--|----------------|-----------|----------------|-----------------|-----------|--------------|-----------------|
| ESG score                              | -0.004***      |           |                |                 |           |              |                 |
| ESG score <sup>2</sup>                 | 0.00005***     |           |                |                 |           |              |                 |
| Environmental pillar                   |                | -0.0006   |                |                 |           |              |                 |
| Environmental pillar <sup>2</sup>      |                | 0.0000*   |                |                 |           |              |                 |
| Social pillar                          |                |           | -0.0033***     |                 |           |              |                 |
| Social pillar <sup>2</sup>             |                |           | 0.00004***     |                 |           |              |                 |
| Governance pillar                      |                |           |                | -0.0024**       |           |              |                 |
| Governance pillar <sup>2</sup>         |                |           |                | 0.00002**       |           |              |                 |
| Innovation                             |                |           |                |                 | 0.0011*** |              |                 |
| Innovation <sup>2</sup>                |                |           |                |                 | -0.0000   |              |                 |
| ESG controversies                      |                |           |                |                 |           | -0.0003      |                 |
| ESG controversies <sup>2</sup>         |                |           |                |                 |           | -0.0000      |                 |
| Community                              |                |           |                |                 |           | 0.0005       |                 |
| Community <sup>2</sup>                 |                |           |                |                 |           | -0.0000      |                 |
| Human rights                           |                |           |                |                 |           | -0.0011**    |                 |
| Human rights <sup>2</sup>              |                |           |                |                 |           | 0.00002***   |                 |
| Product resp.                          |                |           |                |                 |           | 0.0007       |                 |
| Product resp. <sup>2</sup>             |                |           |                |                 |           | -0.0000      |                 |
| Management                             |                |           |                |                 |           |              | -0.0022***      |
| Management <sup>2</sup>                |                |           |                |                 |           |              | 0.00002***      |
| CSR strategy                           |                |           |                |                 |           |              | 0.0002          |
| CSR strategy <sup>2</sup>              |                |           |                |                 |           |              | -0.0000         |
| Shareholders                           |                |           |                |                 |           |              | 0.0011*         |
| Shareholders <sup>2</sup>              |                |           |                |                 |           |              | -0.0000         |
| Size                                   | 0.102***       | 0.1026*** | 0.1059***      | 0.1188***       | 0.1038*** | 0.1060***    | 0.1167***       |
| R&D                                    | 0.027***       | 0.0281*** | 0.0284***      | 0.0264***       | 0.0286*** | 0.0277***    | 0.0269***       |
| Strategic share                        | 0.031***       | 0.0217**  | 0.0289***      | 0.0206**        | 0.0247*** | 0.0200**     | 0.0269***       |
| Solvency ratio                         | 0.005          | 0.0040    | 0.0035         | 0.0045          | 0.0053    | 0.0064*      | 0.0049          |
| Interest coverage                      | 0.001***       | 0.0006*** | 0.0006***      | 0.0005***       | 0.0006*** | 0.0006***    | 0.0005***       |
| Constant                               | 0.585***       | 0.4836*** | 0.5584***      | 0.5860***       | 0.4938*** | 0.5242***    | 0.5313***       |
| Year dummy                             | Yes            | Yes       | Yes            | Yes             | Yes       | Yes          | Yes             |
| Sigma                                  | 0.124***       | 0.1238*** | 0.1233***      | 0.1263***       | 0.1245*** | 0.1197***    | 0.1256***       |
| Number of obs.                         | 973            | 973       | 973            | 973             | 973       | 973          | 973             |
| U-Shape test                           | 2.96***        |           | 3.02***        | 1.61*           |           | 2.33***      | 1.86**          |
| Turning point                          | 42.95          |           | 41.67          | 65.59           |           | 27.38        | 68.41           |
| 95% Fieller interval for extreme point | (27.33; 49.60) |           | (26.38; 48.36) | (54.95; 189.20) |           | (7.7; 33.12) | (58.59; 105.33) |

Note: The dependent variable is the bootstrapped environmentally adjusted efficiency score obtained by applying the BCC model with output orientation in the first stage. Inputs (Employees, Property plant and equipment, Operating costs and Energy use). Outputs [Operating revenues, Market capitalisation and CO<sub>2</sub> (bad output)]. 2000 bootstrap replications were used for the bias correction of the DEA scores. Estimates were made with the observed information matrix (OIM) corrected to account for potential heteroskedasticity.

\*Statistical significance at 10% level.

\*\*Statistical significance at 5% level.

\*\*\*Statistical significance at 1% level.

Table 7), although they have very different implications. Thus, as can be seen in the graph in Annex D, the inflexion point (65.59) is much higher and the right slope of the curve is smoother. Therefore, it is necessary to reach high values in corporate governance practices to achieve slight

increases in EAE. Our results are in line with those obtained by Ren et al. (2022) and López-Penabad et al. (2022) in other sectors.

However, the curvilinear relationship of the environmental variable cannot be supported (regression (2)). Therefore, the tests indicate



**TABLE 8** Robustness test for relationship between corporate social performance and environmentally adjusted efficiency.

|                                   | (1)        | (2)        | (3)       | (4)       | (5)        | (6)        | (7)       | (8)       | (9)       | (10)      | (11)       | (12)      | (13)       | (14)       |
|-----------------------------------|------------|------------|-----------|-----------|------------|------------|-----------|-----------|-----------|-----------|------------|-----------|------------|------------|
| ESG score                         | -0.0047*** | -0.0045*** |           |           |            |            |           |           |           |           |            |           |            |            |
| ESG score <sup>2</sup>            | 0.0001***  | 0.0001***  |           |           |            |            |           |           |           |           |            |           |            |            |
| Environmental pillar              |            |            | -0.0008   | -0.0007   |            |            |           |           |           |           |            |           |            |            |
| Environmental pillar <sup>2</sup> |            |            | 0.00002*  | 0.00002*  |            |            |           |           |           |           |            |           |            |            |
| Social pillar                     |            |            |           |           | -0.0035*** | -0.0034*** |           |           |           |           |            |           |            |            |
| Social pillar <sup>2</sup>        |            |            |           |           | 0.00004*** | 0.00004*** |           |           |           |           |            |           |            |            |
| Governance pillar                 |            |            |           |           |            |            | -0.0024** | -0.0025** |           |           |            |           |            |            |
| Governance pillar <sup>2</sup>    |            |            |           |           |            |            | 0.00002** | 0.00002** |           |           |            |           |            |            |
| Innovation                        |            |            |           |           |            |            |           |           | 0.0011**  | 0.0011**  |            |           |            |            |
| Innovation <sup>2</sup>           |            |            |           |           |            |            |           |           | -0.0000   | -0.0000   |            |           |            |            |
| ESG controversies                 |            |            |           |           |            |            |           |           |           |           | -0.0003    | -0.0002   |            |            |
| ESG controversies <sup>2</sup>    |            |            |           |           |            |            |           |           |           |           | -0.0000    | -0.0000   |            |            |
| Community                         |            |            |           |           |            |            |           |           |           |           | 0.0004     | 0.0004    |            |            |
| Community <sup>2</sup>            |            |            |           |           |            |            |           |           |           |           | -0.0000    | -0.0000   |            |            |
| Human rights                      |            |            |           |           |            |            |           |           |           |           | -0.0012**  | -0.0012** |            |            |
| Human rights <sup>2</sup>         |            |            |           |           |            |            |           |           |           |           | 0.00002*** | 0.0000*** |            |            |
| Product Resp.                     |            |            |           |           |            |            |           |           |           |           | 0.0007     | 0.0008    |            |            |
| Product Resp. <sup>2</sup>        |            |            |           |           |            |            |           |           |           |           | -0.0000    | -0.0000   |            |            |
| Management                        |            |            |           |           |            |            |           |           |           |           |            |           | -0.0021*** | -0.0022*** |
| Management <sup>2</sup>           |            |            |           |           |            |            |           |           |           |           |            |           | 0.0000***  | 0.0000***  |
| CSR Strategy                      |            |            |           |           |            |            |           |           |           |           |            |           | 0.0001     | 0.0002     |
| CSR Strategy <sup>2</sup>         |            |            |           |           |            |            |           |           |           |           |            |           | 0.0000     | -0.0000    |
| Shareholders                      |            |            |           |           |            |            |           |           |           |           |            |           | 0.0012*    | 0.0011*    |
| Shareholders <sup>2</sup>         |            |            |           |           |            |            |           |           |           |           |            |           | -0.0000    | -0.0000    |
| Size                              | 0.1017***  | 0.1027***  | 0.1022*** | 0.1028*** | 0.1051***  | 0.1060***  | 0.1180*** | 0.1188*** | 0.1032*** | 0.1040*** | 0.1059***  | 0.1068*** | 0.1159***  | 0.1168***  |
| R&D                               | 0.0321***  | 0.0321***  | 0.0337*** | 0.0336*** | 0.0343***  | 0.0342***  | 0.0328*** | 0.0328*** | 0.0346*** | 0.0345*** | 0.0345***  | 0.0344*** | 0.0333***  | 0.0332***  |
| Strategic share                   | 0.0290***  | 0.0309***  | 0.0198**  | 0.0217**  | 0.0270***  | 0.0291***  | 0.0186*   | 0.0203*   | 0.0228**  | 0.0248*** | 0.0188**   | 0.0208**  | 0.0249**   | 0.0266***  |
| Solvency ratio                    | 0.0053     | 0.0056     | 0.0045    | 0.0048    | 0.0038     | 0.0042     | 0.0052    | 0.0054    | 0.0058    | 0.0061*   | 0.0069**   | 0.0072**  | 0.0055     | 0.0058     |
| Interest coverage                 | 0.0006***  | 0.0006***  | 0.0006*** | 0.0006*** | 0.0006***  | 0.0006***  | 0.0006*** | 0.0006*** | 0.0006*** | 0.0006*** | 0.0006***  | 0.0007*** | 0.0005***  | 0.0005***  |
| GDP growth                        | 0.0023**   | 0.0020**   | 0.0020**  | 0.0020**  | 0.0025**   | 0.0025**   | 0.0021**  | 0.0021**  | 0.0021**  | 0.0021**  | 0.0025***  | 0.0021**  | 0.0021**   | 0.0009**   |
| Oil price                         | 0.0008**   | 0.0008**   | 0.0008**  | 0.0008**  | 0.0008**   | 0.0008**   | 0.0008**  | 0.0009**  | 0.0009**  | 0.0008**  | 0.0008**   | 0.0007**  | 0.0007**   | 0.0009**   |
| Constant                          | 0.5969***  | 0.5515***  | 0.4959*** | 0.1258*** | 0.5670***  | 0.5210***  | 0.5934*** | 0.5476**  | 0.5006*** | 0.4574*** | 0.5239***  | 0.4875**  | 0.5376**   | 0.4919***  |
| Wald chi <sup>2</sup>             | 280.58     | 279.04     | 278.70    | 279.63    | 292.15     | 290.79     | 230.35    | 231.92    | 266.23    | 266.52    | 364.04     | 360.28    | 243.50     | 245.43     |

TABLE 8 (Continued)

|                         | (1)     | (2)     | (3)    | (4)    | (5)     | (6)     | (7)     | (8)     | (9)     | (10)    | (11)    | (12)    | (13)    | (14)    |
|-------------------------|---------|---------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Prob > chi <sup>2</sup> | 0.0000  | 0.0000  | 0.0000 | 0.0000 | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  | 0.0000  |
| Log likelihood          | 599.294 | 598.693 | 598.57 | 598.93 | 603.886 | 603.357 | 579.639 | 580.269 | 593.788 | 593.901 | 631.237 | 629.873 | 584.959 | 585.725 |
| Number of obs.          | 973     | 973     | 973    | 973    | 973     | 973     | 973     | 973     | 973     | 973     | 973     | 973     | 973     | 973     |

Note: The table reports the estimation results for the Tobit model with random effects. Estimates were made with the observed information matrix (OIM) corrected to account for potential heteroskedasticity.

\*Statistical significance at 10% level.

\*\*Statistical significance at 5% level.

\*\*\*Statistical significance at 1% level.

that Hypothesis 2 cannot be fully confirmed, even though the relationship between EAE and the environmental pillar is linear and positive. Hence, any improvement in the performance of environmental activity in this sector clearly has a positive effect on our efficiency measure since on the financial side it means a reduction in costs and on the environmental side it means fewer resources used and/or lower CO<sub>2</sub> emissions (Sánchez-Robles et al., 2022). Our findings are in line with those of Feng and Wang (2017), also in the energy sector, but in contrast to those of Ren et al. (2022) on Apple partners. This difference between sectors is due to the importance of the ecological footprint and the long-term concern for this aspect in the energy sector.

In order to gain a deeper understanding of the impact of ESG activity on EAE, and bearing in mind that certain environmental, social and corporate governance practices may have a greater effect than others, we also tested the relationship between the performance of one environmental practice, and four social and three corporate governance ones on EAE (regressions (5)–(7), respectively).

We found a U-shaped relationship between human rights (the social pillar), the management dimension (the governance pillar) and EAE, but there are significant differences between them. In the first case, we noted that once the human rights scores of companies exceeds a relatively low level (turning point 27.38), there is a positive impact on EAE, due to improved brand image and reputation. Our findings were consistent with those of Ren et al. (2022) for the industrial sector and with the cross-sectoral research of Nielsen (2022). The management dimension (the governance pillar) and EAE had a convex relationship, and Ren et al. (2022) came to the same conclusion in their study of Apple's partners, suppliers and customers. The curve representing the relationship between the management dimension and EAE is very similar to that of the corporate governance pillar and EAE. Therefore, a high turning point (68.41%) makes it necessary for a high score to be reached in the development of management practices to achieve slight increases in EAE.

Other dimensions, however, displayed a positive linear relationship with EAE, that is, innovation in the environmental area and shareholder score in the corporate governance pillar. Investment in environmental innovation has a clear linear and positive effect on EAE, playing a key role in the development of sustainable economic growth (Bigerna et al., 2023) as it decreases both production costs (Reinhardt, 1998) and gas emissions and resource use (Murshed et al., 2021). This result is consistent with Lee (2021) for profitability in the energy sector. We found the same effect in the shareholder dimension, although in this case the significance was weak, at 10%.

Finally, initiatives in certain CSR dimensions, namely ESG controversies, community and product responsibility in the social pillar, and CSR strategy in the corporate governance pillar had a neutral effect on EAE. This result is in line with Ren et al. (2022) and Esteban-Sánchez et al. (2017), whose findings support the idea that the benefits obtained from these activities are balanced out by the costs.

Firm size positively and significantly influences EAE when the results of the control variables are taken into account; larger enterprises are more environmentally friendly. Some studies show that a



company's size influences how effective ESG is (Ramecesse, 2021). López-Penabad et al. (2022) and Martínez-Conesa et al. (2017) showed that the larger the firm, the stronger the nexus between the ESG scores and firm performance. Waddock and Graves (1997) and Ruggiero and Cupertino (2018) stated that this relationship in large companies is driven by the greater availability of resources and higher stakeholder expectations of sustainability. Furthermore, it is perceived that firms with higher profitability have higher EAE since more profitable firms tend to reduce production costs, thus demonstrating financial efficiency (Guo et al., 2020) which allows them to obtain resources that can be used to improve their CSR.

Regarding the link between R&D and EAE, it is positive, confirming the results of previous papers that have shown the moderating effect of innovation on the relationship between CSP and firm performance (Martínez-Conesa et al., 2017; Palacios-Manzano et al., 2021), between innovation and environmental performance (Uyar et al., 2023), and between innovation and eco-efficiency (Broadstock et al., 2019). Our results coincide with those of the study by Sánchez-Robles et al. (2022) on the energy industry in that the liquidity ratio and efficiency have a statistically positive relationship. Broadstock et al. (2019) have drawn the same conclusion for the liquidity ratio and eco-efficiency in a multi-sector study of Japanese companies. Our results also show that the companies with a higher interest coverage ratio are more efficient, as does the Yildirim (2020) study conducted on the banking sector which measures operational efficiency. The presence of strategic investors has positive effects in different models, although the results are not conclusive.

In summary, the results obtained indicate that the EAE benefits only occur with certain initiatives. This has notable implications for energy company managers who have to formulate efficient sustainable policies. The analysis of the results also has considerable economic and academic implications since the effects of CSR practices on EAE are different depending on what the relationship is between the variables studied. The results of our body of research should guide regulators through how to formulate an industrial policy in this sector by providing insight into what sustainability practices they will need to encourage.

### 4.3 | Robustness analysis

In this section, we examine whether our initial results with the baseline model were robust, by applying an alternative estimation method. Since environmentally adjusted efficiency may be affected by the omitted variable bias, we added the macroeconomic variables to our main model that had commonly been used in previous literature, that is, oil prices and GDP growth.

Regarding the estimation method, we followed another model that has been widely used in the literature on efficiency, the Tobit model, since the EAE values are censored between 0 and 1. The model was specified using random effects because fixed effects in non-linear models lead to inconsistent estimates (Sánchez-Robles et al., 2022).

In general, the results of the Tobit random effects model were like those of the reference model (Table 8), and the estimates of most of the coefficients were stable in both models. The U-shaped relationship was confirmed between the overall ESG score, the social and corporate governance pillar, the human rights and management dimensions and EAE. In addition, a positive linear relationship with EAE was confirmed for the environmental pillar, environmental innovation and the shareholder score. Therefore, overall, the results matched those of the truncated regression. Additionally, the control variables were consistent with the truncated regression, confirming the robustness of our findings to changes in the empirical model.

Regarding macroeconomic variables, oil price and GDP growth were positively and significantly related to environmental efficiency, in agreement with the findings of other authors such as Sueyoshi and Wang (2018) and Sánchez-Robles et al. (2022), who have pointed to there being procyclical behaviour when it comes to efficiency.

## 5 | CONCLUSIONS

As an environmentally sensitive industry, the energy sector is subject to greater public exposure than others (Beck et al., 2018) since it attracts the interest of stakeholders, such as environmentalists, shareholders, investors and regulators (Florini & Saleem, 2011). Therefore, ESG activity plays an important role in this industry, its influence on financial efficiency being much higher than in other sectors (Iazzolino et al., 2023).

CSR has become an important source of corporate risk and may affect a company's value. Given the relevance of sustainability in today's business world, it is more important than ever to have an in-depth understanding of this relationship and what it means for a company.

This study has analysed the association between several types of CSR activity, which were measured by ESG performance, and an environmentally adjusted efficiency (EAE) index, which combines economic factors with CO<sub>2</sub> emissions and energy consumption reduction targets, in a worldwide sample of companies in the energy sector. Hence, the results of this research go beyond traditional studies focusing on the effects of ESG policies on financial performance and may prevent companies from 'greenwashing', whereby they only pursue economic benefits and do not take action to limit the harm they cause to the environment (Pinheiro et al., 2023).

One stream of research advocates a linear relationship between CSP and performance, but the results are not conclusive about its sign (i.e., whether it is positive, negative or neutral). Thus, our hypotheses are based on the relationship between the CSP and EAE variables being non-linear, and, indeed, our results partially confirm this relationship, which is U-shaped. Also, the results support the premise that CSR is a multidimensional term and should be taken into account by way of a disaggregated approach, in order to better understand the link between CSR and EAE (Laguir et al., 2019).

The results show that high performance for environmental, social and governance CSR activity is connected to better EAE, but carrying

out an in-depth study of these practices has allowed us to see how significant their effects are. First, this study has identified CSR activity and social and corporate governance practices, which, despite their significant initial cost, generate considerable competitive advantages in terms of reputation and image and their consequent positive impact on EAE in the medium and long term. Second, it contributes to the literature on CSR by shedding light on which types of activity have a linear and positive relationship with the EAE and therefore on which area firms should focus their efforts if they wish to be rewarded by a wide range of stakeholders, regardless of their level of performance. Carrying out environmentally related practices, particularly in environmental innovation, is where we have found evidence that the most benefits can be reaped. Additionally, the effectiveness of companies towards the equal treatment of shareholders (corporate governance pillar) has a positive effect on our efficiency measure. In consequence, the results obtained largely support both the resource and the stakeholder theory and the TLGT metatheory, implying that certain types of CSR activity should be designed to prioritise the long over the short term.

## 5.1 | Managerial implications

In terms of practical implications, this body of research provides important suggestions for internal and external stakeholders. First, the EAE measurement enables managers to consider their goals for reducing their energy consumption and CO<sub>2</sub> emissions in addition to economic aspects, all of which can be useful for stakeholders looking to compare companies in the energy sector or in any of the sub-sectors that form part of it. Second, many corporations can be disorganised and lack a formalised framework when it comes to implementing CSR (Andersson et al., 2022). The value of energy firms in the long run will largely depend on how they deal with the transition to a low-carbon society and our paper provides a guide for managers to help them identify the right CSR activities for their businesses to improve their EAE. We may find that in the energy sector, some CSR resources do not have significant effects on EAE, while in other cases, the relationship is linear and positive. Nevertheless, non-linear effects among these variables are the most common relationship: CSR initiatives may not be financially advantageous in the near term, but once they are put in place, they may increase performance and competitiveness over time, enabling operating efficiency to improve and energy use and CO<sub>2</sub> emissions to be reduced. By the same token, reactive strategies are found to be counterproductive for corporate profitability (Gollop & Roberts, 1983; Jiang et al., 2018), so the shift from a negative to a positive association should be achieved with proactive (Trumpp & Guenther, 2017) and long-term strategies. Instead of being seen as a burden for conventional business tasks, CSR should be perceived as a business opportunity and a challenge that the energy sector must tackle to make the transition to carbon neutrality.

The process of decarbonisation will require public and private stakeholders to engage in intense dialogue due to the scope of the challenges and their implications. Unfortunately, commitment is

extremely varied from nation to nation when it comes to reducing carbon emissions and the use of clean energy. Our analysis provides ideas that should be useful for guiding industrial policy in this sector to ascertain which types of CSR activity should be promoted by way of regulations and voluntary programs. Industrial policy for this sector should, in any case, be designed and implemented very carefully. A transition to clean energy and a low carbon energy source will allow us not only to avoid the catastrophic effects of climate change, but also to reduce the vulnerability of certain countries or regions to energy price volatility. The sector's modest levels of EAE and ESG suggest that there is significant room for improvement via rationalisation and better allocation of ESG resources.

Moreover, expanding a company by encouraging the consolidation of the most environmentally efficient companies, showing innovation and improving financial management are factors that should be considered. The high energy prices of recent years should drive this sector towards higher efficiency, which would have a positive impact on the rest of the economy. In addition, public policies that prevent the disappearance of environmentally inefficient companies should be phased out. Last of all, our analysis provides some ideas for investors looking for guidance on evaluating companies according to Socially Responsible Investment criteria.

## 5.2 | Limitations and future research avenues

Although this study improves on the existing literature where the relationship between CSR engagement and performance is concerned, the results should be considered as having several limitations. First, the sample is limited to listed energy companies, so the results are not necessarily applicable to other sectors or to unlisted energy companies. Second, as for the period under study, the conclusions reached do not apply to the CSR practices of energy companies prior to 2016, as this was the year in which the GRI G3 guidelines were introduced, a significant contributor to corporate sustainability awareness. Third, the results could be affected by the indicators used to measure ESG aspects, which are not without certain elements of subjectivity in their construction; it should be noted that the sample is heavily biased towards developed countries, partly due to the limited availability of ESG data in developing countries. Fourth, our study focuses on financial and ESG characteristics at the company level and does not incorporate institutional factors or the regulatory and institutional environment of the home country of operation, which may also affect CSP. With this in mind, it could be wise to analyse the CSP relationship in different sub-sectors or geographical areas and according to the institutional environment of the country of operation. Fifth, although corporate governance scores have been taken into account, studying the individual effects of different board attributes, particularly gender diversity, could significantly improve EAE in the energy sector. Finally, we have incorporated two green aspects into the environmental efficiency model (CO<sub>2</sub> and resource use) for which a lot of data is available, although the model results could be sensitive to the use of different inputs/



outputs; therefore, future research could expand upon our results by using other factors.

## ACKNOWLEDGEMENTS

This work was supported by the Spanish Ministry of Science and Innovation, the State Investigation Agency (10.13039/501100011033) and European Regional Development Fund (Project number PID2021-127527OB-I00).

## ORCID

José Manuel Maside-Sanfiz  <https://orcid.org/0000-0001-5621-6546>

Óscar Suárez Fernández  <https://orcid.org/0000-0003-1659-1485>

María-Celia López-Penabaz  <https://orcid.org/0000-0001-8738-4366>

## REFERENCES

- Aguilera-Caracuel, J., Guerrero-Villegas, J., & García-Sánchez, E. (2017). Reputation of multinational companies: Corporate social responsibility and internationalization. *European Journal of Management and Business Economics*, 26(3), 329–346. <https://doi.org/10.1108/EJMBE-10-2017-019>
- Ahmad, N., Mobarek, A., & Roni, N. N. (2021). Revisiting the impact of ESG on financial performance of FTSE350 UK firms: Static and dynamic panel data analysis. *Cogent Business & Management*, 8(1), 1900500. <https://doi.org/10.1080/23311975.2021.1900500>
- Andersson, S., Svensson, G., Molina-Castillo, F. J., Otero-Neira, C., Lindgren, J., Karlsson, N. P., & Laurell, H. (2022). Sustainable development—Direct and indirect effects between economic, social, and environmental dimensions in business practices. *Corporate Social Responsibility and Environmental Management*, 29(5), 1158–1172. <https://doi.org/10.1002/csr.2261>
- Arena, M., Azzone, G., & Mapelli, F. (2019). Corporate social responsibility strategies in the utilities sector: A comparative study. *Sustainable Production and Consumption*, 18, 83–95. <https://doi.org/10.1016/j.spc.2018.12.006>
- Arslan-Ayaydin, Ö., & Thewissen, J. (2015). *The impact of environmental strengths and concerns on the accounting performance of firms in the energy sector* (pp. 83–107). Springer International Publishing. [https://doi.org/10.1007/978-3-319-13746-9\\_5](https://doi.org/10.1007/978-3-319-13746-9_5)
- Barnett, M. L., & Salomon, R. M. (2006). Beyond dichotomy: The curvilinear relationship between social responsibility and financial performance. *Strategic Management Journal*, 27(11), 1101–1122. <https://doi.org/10.1002/smj.557>
- Barnett, M. L., & Salomon, R. M. (2012). Does it pay to be really good? Addressing the shape of the relationship between social and financial performance. *Strategic Management Journal*, 33(11), 1304–1320. <https://doi.org/10.1002/smj.1980>
- Beck, C., Frost, G., & Jones, S. (2018). CSR disclosure and financial performance revisited: A cross-country analysis. *Australian Journal of Management*, 43(4), 517–537. <https://doi.org/10.1177/0312896218771438>
- Bigerna, S., D'Errico, M. C., Micheli, S., & Polinori, P. (2023). Environmental-economic efficiency for carbon neutrality: The role of eco-innovation, taxation, and globalization in OECD countries. *Applied Economics*, 1–14. <https://doi.org/10.1080/00036846.2023.2206634>
- Bowlin, W. F. (1998). Measuring performance: An introduction to data envelopment analysis (DEA). *The Journal of Cost Analysis*, 15(2), 3–27. <https://doi.org/10.1080/08823871.1998.10462318>
- Bracco, S. (2015). Effectiveness of EU biofuels sustainability criteria in the context of land acquisitions in Africa. *Renewable and Sustainable Energy Reviews*, 50, 130–143. <https://doi.org/10.1016/j.rser.2015.05.006>
- Bragdon, J. H., & Marlin, J. (1972). Is pollution profitable? *Risk Management*, 19(4), 9–18.
- Brammer, S., & Millington, A. (2008). Does it pay to be different? An analysis of the relationship between corporate social and financial performance. *Strategic Management Journal*, 29(12), 1325–1343. <https://doi.org/10.1002/smj.714>
- Broadstock, D. C., Collins, A., Hunt, L. C., & Vergos, K. (2018). Voluntary disclosure, greenhouse gas emissions and business performance: Assessing the first decade of reporting. *The British Accounting Review*, 50(1), 48–59. <https://doi.org/10.1016/j.bar.2017.02.002>
- Broadstock, D. C., Managi, S., Matousek, R., & Tzeremes, N. G. (2019). Does doing “good” always translate into doing “well”? An eco-efficiency perspective. *Business Strategy and the Environment*, 28(6), 1199–1217. <https://doi.org/10.1002/bse.2311>
- Brooks, C. (2008). *Introductory econometrics for finance* (2nd ed.). Cambridge University.
- Buallay, A. (2021). Sustainability reporting and agriculture industries' performance: Worldwide evidence. *Journal of Agribusiness in Developing and Emerging Economies*, 12(5), 769–790. <https://doi.org/10.1108/JADEE-10-2020-0247>
- Busch, T., & Friede, G. (2018). The robustness of the corporate social and financial performance relation: A second-order meta-analysis. *Corporate Social Responsibility and Environmental Management*, 25(4), 583–608. <https://doi.org/10.1002/csr.1480>
- Cariola, A., Fasano, F., La Rocca, M., & Skatova, E. (2020). Environmental sustainability policies and the value of debt in EU SMEs: Empirical evidence from the energy sector. *Journal of Cleaner Production*, 275, 123–133. <https://doi.org/10.1016/j.jclepro.2020.123133>
- Carroll, A. B. (1979). A three-dimensional conceptual model of corporate performance. *The Academy of Management Review*, 4(4), 497–505. <https://doi.org/10.2307/257850>
- Charnes, A., & Cooper, W. W. (1984). Preface to topics in data envelopment analysis. *Annals of Operations Research*, 2(1), 59–94. <https://doi.org/10.1007/BF01874733>
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2(6), 429–444. [https://doi.org/10.1016/0377-2217\(78\)90138-8](https://doi.org/10.1016/0377-2217(78)90138-8)
- Chen, M. H., & Lin, C. P. (2015). The impact of corporate charitable giving on hospitality firm performance: Doing well by doing good? *International Journal of Hospitality Management*, 47, 25–34. <https://doi.org/10.1016/j.ijhm.2015.02.002>
- Chen, Y., & Ma, Y. (2021). Does green investment improve energy firm performance? *Energy Policy*, 153, 112252. <https://doi.org/10.1016/j.enpol.2021.112252>
- Cho, H., & Pucik, V. (2005). Relationship between innovativeness, quality, growth, profitability, and market value. *Strategic Management Journal*, 26, 555–575. <https://doi.org/10.1002/smj.461>
- Cho, S. J., Chung, C. Y., & Young, J. (2019). Study on the relationship between CSR and financial performance. *Sustainability*, 11(2), 343. <https://doi.org/10.3390/su11020343>
- Cho, S. Y., & Lee, C. (2019). Managerial efficiency, corporate social performance, and corporate financial performance. *Journal of Business Ethics*, 158, 467–486. <https://doi.org/10.1007/s10551-017-3760-7>
- Choi, K., Kim, C., & Kim, H. J. (2017). Multi-period efficiency and productivity changes in global automobile: A VRS-VRM and SML productivity index approach. *Expert Systems with Applications*, 86, 77–86. <https://doi.org/10.1016/j.eswa.2017.05.022>
- Chung, Y. H., Färe, R., & Grosskopf, S. (1997). Productivity and undesirable outputs: A directional distance function approach. *Journal of Environmental Management*, 51(3), 229–240. <https://doi.org/10.1006/jema.1997.0146>
- Coelho, R., Jayantilal, S., & Ferreira, J. J. (2023). The impact of social responsibility on corporate financial performance: A systematic

- literature review. *Corporate Social Responsibility and Environmental Management*, 30, 1535–1560. <https://doi.org/10.1002/csr.2446>
- Curran, G. (2017). Social license, corporate social responsibility and coal seam gas: Framing the new political dynamics of contestation. *Energy Policy*, 101, 427–435. <https://doi.org/10.1016/j.enpol.2016.10.042>
- D'Amato, V., D'Ecclesia, R., & Levantesi, S. (2022). Firms' profitability and ESG score: A machine learning approach. *Applied Stochastic Models in Business and Industry*, 1–19. <https://doi.org/10.1002/asmb.2758>
- De Mesnard, L. (2022). Shareholders behavior, economic profit, profitability: New teachings from optimization theory. In 21st Journées Luis-André Gérard-Varet, *International Conference in Public Economics*.
- Dilling, P. F., & Harris, P. (2018). Reporting on long-term value creation by Canadian companies: A longitudinal assessment. *Journal of Cleaner Production*, 191, 350–360. <https://doi.org/10.1016/j.jclepro.2018.03.286>
- Du, J., Chen, Y., & Huang, Y. (2018). A modified Malmquist-Luenberger productivity index: Assessing environmental productivity performance in China. *European Journal of Operational Research*, 269(1), 171–187. <https://doi.org/10.1016/j.ejor.2017.01.006>
- Ekatah, I., Samy, M., Bampton, R., & Halabi, A. (2011). The relationship between corporate social responsibility and profitability: The case of Royal Dutch Shell Plc. *Corporate Reputation Review*, 14, 249–261. <https://doi.org/10.1057/crr.2011.22>
- Emrouznejad, A., & Yang, G. (2018). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016. *Socio-Economic Planning Sciences*, 61, 4–8. <https://doi.org/10.1016/j.seps.2017.01.008>
- Esteban-Sánchez, P., de la Cuesta-González, M., & Paredes-Gázquez, J. D. (2017). Corporate social performance and its relation with corporate financial performance: International evidence in the banking industry. *Journal of Cleaner Production*, 162, 1102–1110. <https://doi.org/10.1016/j.jclepro.2017.06.127>
- European Commission. (2020). *Study on energy prices, costs and their impact on industry and households: Final report*. Directorate-General for Energy, European Union. <https://doi.org/10.2833/49063>
- Feng, C., & Wang, M. (2017). Analysis of energy efficiency and energy savings potential in China's provincial industrial sectors. *Journal of Cleaner Production*, 164, 1531–1541. <https://doi.org/10.1016/j.jclepro.2017.07.081>
- Filbeck, G., & Gorman, R. F. (2004). The relationship between the environmental and financial performance of public utilities. *Environmental and Resource Economics*, 29(2), 137–157. <https://doi.org/10.1023/B:EARE.0000044602.86367.ff>
- Florini, A., & Saleem, S. (2011). Information disclosure in global energy governance. *Global Policy*, 2(S1), 144–154. <https://doi.org/10.1111/j.1758-5899.2011.00135.x>
- Franco, S., Caroli, M. G., Cappa, F., & Del Chiappa, G. (2020). Are you good enough? CSR, quality management and corporate financial performance in the hospitality industry. *International Journal of Hospitality Management*, 88, 102395. <https://doi.org/10.1016/j.ijhm.2019.102395>
- Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.
- Friedman, M. (1970). *The social responsibility of business is to increase its profits*. New York Times Magazine.
- Fuji, H., Iwata, K., Kaneko, S., & Managi, S. (2013). Corporate environmental and economic performance of Japanese manufacturing firms: Empirical study for sustainable development. *Business Strategy and the Environment*, 22(3), 187–201. <https://doi.org/10.1002/bse.1747>
- Ghosh, S., Pareek, R., & Sahu, T. N. (2023). U-shaped relationship between environmental performance and financial performance of non-financial companies: An empirical assessment. *Corporate Social Responsibility and Environmental Management*, 30, 1805–1815. <https://doi.org/10.1002/csr.2456>
- Golany, B., & Roll, Y. (1989). An application procedure for DEA. *Omega*, 17, 237–250. [https://doi.org/10.1016/0305-0483\(89\)90029-7](https://doi.org/10.1016/0305-0483(89)90029-7)
- Gollop, F. M., & Roberts, M. J. (1983). Environmental regulations and productivity growth: The case of fossil-fueled electric power generation. *Journal of Political Economy*, 91(4), 654–674.
- González-Ramos, M. I., Donate, M. J., & Guadamillas, F. (2018). An empirical study on the link between corporate social responsibility and innovation in environmentally sensitive industries. *European Journal of International Management*, 12(4), 402–422. <https://doi.org/10.1504/EJIM.2018.092842>
- Graafland, J., & Smid, H. (2004). Reputation, corporate social responsibility and market regulation. *Tijdschrift voor Economie en Management*, 49(2), 271–308. <https://mpr.ub.uni-muenchen.de/id/eprint/20772>
- Grassmann, M. (2021). The relationship between corporate social responsibility expenditures and firm value: The moderating role of integrated reporting. *Journal of Cleaner Production*, 285, 124840. <https://doi.org/10.1016/j.jclepro.2020.124840>
- Guo, H., Wang, C., Su, Z., & Wang, D. (2020). Technology push or market pull? Strategic orientation in business model design and digital start-up performance. *Journal of Product Innovation Management*, 37(4), 352–372. <https://doi.org/10.1111/jpim.12526>
- Hatakeda, T., Kokubu, K., Kajiwara, T., & Nishitani, K. (2012). Factors influencing corporate environmental protection activities for greenhouse gas emission reductions: The relationship between environmental and financial performance. *Environmental and Resource Economics*, 53, 455–481. <https://doi.org/10.1007/s10640-012-9571-5>
- Heidrick & Struggles, INSEAD, & BCG. (2023). *The role of the board in the sustainability era*. <https://www.heidrick.com/en/insights/sustainability/the-role-of-the-board-in-the-sustainability-era>
- Hou, M., Liu, H., Fan, P., & Wei, Z. (2016). Does CSR practice pay off in East Asian firms? A meta-analytic investigation. *Asia Pacific Journal of Management*, 33, 195–228. <https://doi.org/10.1007/s10490-015-9431-2>
- Huang, D. Z. (2019). Environmental, social and governance (ESG) activity and firm performance: A review and consolidation. *Accounting and Finance*, 61, 335–360. <https://doi.org/10.1111/acfi.12569>
- Iazzolino, G., Bruni, M. E., Veltri, S., Morea, D., & Baldissarro, G. (2023). The impact of ESG factors on financial efficiency: An empirical analysis for the selection of sustainable firm portfolios. *Corporate Social Responsibility and Environmental Management*, 30, 1917–1927. <https://doi.org/10.1002/csr.2463>
- IEA. (2018). *Topics: Climate change*. <https://www.iea.org/topics/climatechange>
- Ismail, Z., Tai, J. C., Kong, K. K., Law, K. H., Shirazi, S. M., & Karim, R. (2013). Using data envelopment analysis in comparing the environmental performance and technical efficiency of selected companies in their global petroleum operations. *Measurement*, 46(9), 3401–3413. <https://doi.org/10.1016/j.measurement.2013.04.076>
- Jiang, Y., Xue, X., & Xue, W. (2018). Proactive corporate environmental responsibility and financial performance: Evidence from Chinese energy enterprises. *Sustainability*, 10(4), 964. <https://doi.org/10.3390/su10040964>
- Kaupke, K., & zu Knyphausen-Aufseß, D. (2023). Sustainability and firm value in the oil and gas industry—A vicious circle? *Corporate Social Responsibility and Environmental Management*, 30, 1129–1144. <https://doi.org/10.1002/csr.2409>
- Kim, D. H., Wu, Y. C., & Lin, S. C. (2022). Carbon dioxide emissions, financial development and political institutions. *Economic Change and Restructuring*, 55, 837–874. <https://doi.org/10.1007/s10644-021-09331-x>
- Kludacz-Alessandri, M., & Cygańska, M. (2021). Corporate social responsibility and financial performance among energy sector companies. *Energies*, 14(19), 6068. <https://doi.org/10.3390/en14196068>
- Kumar, A., Gupta, J., & Das, N. (2022). Revisiting the influence of corporate sustainability practices on corporate financial performance: An evidence from the global energy sector. *Business Strategy and the Environment*, 31(7), 3231–3253. <https://doi.org/10.1002/bse.3073>



- La Rocca, T., La Rocca, M., Fasano, F., & Cariola, A. (2023). Does a country's environmental policy affect the value of small and medium sized enterprises liquidity in the energy sector? *Corporate Social Responsibility and Environmental Management*, 30(1), 277–290. <https://doi.org/10.1002/csr.2354>
- Laguier, I., Stekelorum, R., Elbaz, J., & Duchamp, D. (2019). Getting into the energy efficiency scene: Does corporate social responsibility matter for energy efficiency in SMEs? *Applied Economics*, 51(47), 5191–5204. <https://doi.org/10.1080/00036846.2019.1610719>
- Lahouel, B. B., Zaied, Y. B., Managi, S., & Taleb, L. (2022). Re-thinking about U: The relevance of regime-switching model in the relationship between environmental corporate social responsibility and financial performance. *Journal of Business Research*, 140, 498–519. <https://doi.org/10.1016/j.jbusres.2021.11.019>
- Lee, S. P. (2021). Environmental responsibility, CEO power and financial performance in the energy sector. *Review of Managerial Science*, 15(8), 2407–2426. <https://doi.org/10.1007/s11846-020-00430-z>
- Lind, J. T., & Mehlum, H. (2010). With or without U? The appropriate test for a U-shaped relationship. *Oxford Bulletin of Economics and Statistics*, 72(1), 109–118. <https://doi.org/10.1111/j.1468-0084.2009.00569.x>
- Liu, S., & Lu, K. (2011). *The development & management of China Tourism Hotel industry: Review of the 11th five year and outlook for the 12th year*. China Tourism Hotel Industry Association. The Yearbook of China Hotel.
- López-Penabad, M. C., Iglesias-Casal, A., Neto, J. F. S., & Maside-Sanfiz, J. M. (2022). Does corporate social performance improve bank efficiency? Evidence from European banks. *Review of Managerial Science*, 17, 1399–1437. <https://doi.org/10.1007/s11846-022-00579-9>
- Lu, W. M., Kweh, Q. L., Ting, I. W. K., & Ren, C. (2023). How does stakeholder engagement through environmental, social, and governance affect eco-efficiency and profitability efficiency? Zooming into Apple Inc.'s counterparts. *Business Strategy and the Environment*, 32(1), 587–601. <https://doi.org/10.1002/bse.3162>
- Maqbool, S., & Bakr, A. (2019). The curvilinear relationship between corporate social performance and financial performance: Evidence from Indian companies. *Journal of Global Responsibility*, 10(1), 87–100. <https://doi.org/10.1108/JGR-11-2018-0060>
- Martínez-Conesa, I., Soto-Acosta, P., & Palacios-Manzano, M. (2017). Corporate social responsibility and its effect on innovation and firm performance: An empirical research in SMEs. *Journal of Cleaner Production*, 142, 2374–2383. <https://doi.org/10.1016/j.jclepro.2016.11.038>
- Misani, N., & Pogutz, S. (2015). Unraveling the effects of environmental outcomes and processes on financial performance: A non-linear approach. *Ecological Economics*, 109, 150–160. <https://doi.org/10.1016/j.ecolecon.2014.11.010>
- Murshed, M., Rahman, M., Alam, M. S., Ahmad, P., & Dagar, V. (2021). The nexus between environmental regulations, economic growth, and environmental sustainability: Linking environmental patents to ecological footprint reduction in South Asia. *Environmental Science and Pollution Research*, 28(36), 49967–49988. <https://doi.org/10.1007/s11356-021-13381-z>
- Ngoasong, M. Z. (2014). How international oil and gas companies respond to local content policies in petroleum-producing developing countries: A narrative enquiry. *Energy Policy*, 73, 471–479. <https://doi.org/10.1016/j.enpol.2014.05.048>
- Nielsen, C. (2022). *Corporate social responsibility and financial performance, an empirical study*. Master's thesis. University of Vaasa. <https://osuva.uwasa.fi/handle/10024/13625>
- Nollet, J., Filis, G., & Mitrokostas, E. (2016). Corporate social responsibility and financial performance: A non-linear and disaggregated approach. *Economic Modelling*, 52, 400–407. <https://doi.org/10.1016/j.econmod.2015.09.019>
- Nuber, C., Velte, P., & Hörisch, J. (2020). The curvilinear and time-lagging impact of sustainability performance on financial performance: Evidence from Germany. *Corporate Social Responsibility and Environmental Management*, 27(1), 232–243. <https://doi.org/10.1002/csr.1795>
- Oh, T. H., Pang, S. Y., & Chua, S. C. (2010). Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth. *Renewable and Sustainable Energy Reviews*, 14(4), 1241–1252. <https://doi.org/10.1016/j.rser.2009.12.003>
- Otani, S., & Yamada, S. (2019). An analysis of automobile companies' intensity targets for CO<sub>2</sub> reduction: Implications for managing performance related to carbon dioxide emissions. *Total Quality Management and Business Excellence*, 30(3–4), 335–354. <https://doi.org/10.1080/14783363.2017.1304818>
- Palacios-Manzano, M., León-Gomez, A., & Santos-Jaén, J. M. (2021). Corporate social responsibility as a vehicle for ensuring the survival of construction SMEs. The mediating role of job satisfaction and innovation. *IEEE Transactions on Engineering Management*. <https://doi.org/10.1109/TEM.2021.3114441>
- Pätäri, S., Jantunen, A., Kyläheiko, K., & Sandström, J. (2012). Does sustainable development foster value creation? Empirical evidence from the global energy industry. *Corporate Social Responsibility and Environmental Management*, 19(6), 317–326. <https://doi.org/10.1002/csr.280>
- Pätäri, S., & Sinkkonen, K. (2014). Energy service companies and energy performance contracting: Is there a need to renew the business model? Insights from a Delphi study. *Journal of Cleaner Production*, 66, 264–271. <https://doi.org/10.1016/j.jclepro.2013.10.017>
- Penrose, E. (1959). *The theory of the growth of the firm*. John Wiley.
- Pierce, J. R., & Aguinis, H. (2013). The too-much-of-a-good-thing effect in management. *Journal of Management*, 39(2), 313–338. <https://doi.org/10.1177/0149206311410060>
- Pinheiro, A. B., Panza, G. B., Berhorst, N. L., Toaldo, A. M. M., & Segatto, A. P. (2023). Exploring the relationship among ESG, innovation, and economic and financial performance: Evidence from the energy sector. *International Journal of Energy Sector Management*. <https://doi.org/10.1108/IJESM-02-2023-0008>
- Ramecesse, A. D. (2021). Corporate social responsibility and firm performance in SMEs: Empirical evidence from Cameroon. *Business and Economic Research*, 11(3), 88–105. <https://doi.org/10.5296/ber.v11i3.18986>
- Reinhardt, F. (1998). Environmental product differentiation: Implications for corporate strategy. *California Management Review*, 40(4), 43–73. <https://doi.org/10.2307/41165964>
- Reinhardt, F. (1999). Market failure and the environmental policies of firms. *Journal of Industrial Ecology*, 3(1), 9–21. <https://doi.org/10.1162/108819899569368>
- Ren, C., Ting, I. W. K., Lu, W. M., & Kweh, Q. L. (2022). Nonlinear effects of ESG on energy-adjusted firm efficiency: Evidence from the stakeholder engagement of apple incorporated. *Corporate Social Responsibility and Environmental Management*, 29(5), 1231–1246. <https://doi.org/10.1002/csr.2266>
- Ruggiero, P., & Cupertino, S. (2018). CSR strategic approach, financial resources and corporate social performance: The mediating effect of innovation. *Sustainability*, 10(10), 3611. <https://doi.org/10.3390/su10103611>
- Sánchez-Robles, B., Herrador-Alcaide, T. C., & Hernández-Solís, M. (2022). Efficiency of European oil companies: An empirical analysis. *Energy Efficiency*, 15(8), 1–28. <https://doi.org/10.1007/s12053-022-10069-2>
- Sepúlveda, J., & Mendizabal, M. (2011). Business in climate or climate in business? *Management of Environmental Quality: An International Journal*, 22(5), 632–651. <https://doi.org/10.1108/14777831111159752>
- Shahbaz, M., Karaman, A. S., Kilic, M., & Uyar, A. (2020). Board attributes, CSR engagement, and corporate performance: What is the nexus in the energy sector? *Energy Policy*, 143, 111582. <https://doi.org/10.1016/j.enpol.2020.111582>
- Shukla, A., & Geetika, N. A. (2022). Impact of corporate social responsibility on financial performance of energy firms in India. *International*

- Journal of Business Governance and Ethics*, 16(1), 88–105. <https://doi.org/10.1504/IJBGE.2022.119356>
- Sidhoum, A. A., & Serra, T. (2017). Corporate social responsibility and dimensions of performance: An application to US electric utilities. *Utilities Policy*, 48, 1–11. <https://doi.org/10.1016/j.jup.2017.06.011>
- Simar, L., & Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*, 136(1), 31–64. <https://doi.org/10.1016/j.jeconom.2005.07.009>
- Stefanoni, S., & Voltes-Dorta, A. (2021). Technical efficiency of car manufacturers under environmental and sustainability pressures: A data envelopment analysis approach. *Journal of Cleaner Production*, 311, 127589. <https://doi.org/10.1016/j.jclepro.2021.127589>
- Sueyoshi, T., & Goto, M. (2009). Can environmental investment and expenditure enhance financial performance of US electric utility firms under the clean air act amendment of 1990? *Energy Policy*, 37(11), 4819–4826. <https://doi.org/10.1016/j.enpol.2009.06.038>
- Sueyoshi, T., & Goto, M. (2012a). Data envelopment analysis for environmental assessment: Comparison between public and private ownership in petroleum industry. *European Journal of Operational Research*, 216(3), 668–678. <https://doi.org/10.1016/j.ejor.2011.07.046>
- Sueyoshi, T., & Goto, M. (2012b). DEA radial measurement for environmental assessment and planning: Desirable procedures to evaluate fossil fuel power plants. *Energy Policy*, 41, 422–432. <https://doi.org/10.1016/j.enpol.2011.11.003>
- Sueyoshi, T., & Wang, D. (2018). DEA environmental assessment on US petroleum industry: Non-radial approach with translation invariance in time horizon. *Energy Economics*, 72, 276–289. <https://doi.org/10.1016/j.eneco.2018.02.003>
- Sueyoshi, T., Yuan, Y., & Goto, M. (2017). A literature study for DEA applied to energy and environment. *Energy Economics*, 62, 104–124. <https://doi.org/10.1016/j.eneco.2016.11.006>
- Sun, W., Yao, S., & Govind, R. (2019). Reexamining corporate social responsibility and shareholder value: The inverted-U-shaped relationship and the moderation of marketing capability. *Journal of Business Ethics*, 160, 1001–1017. <https://doi.org/10.1007/s10551-018-3854-x>
- Tatsuo, K. (2010). An analysis of the eco-efficiency and economic performance of Japanese companies. *Asian Business & Management*, 9(2), 209–222. <https://doi.org/10.1057/abm.2010.3>
- Trumpp, C., & Guenther, T. (2017). Too little or too much? Exploring U-shaped relationships between corporate environmental performance and corporate financial performance. *Business Strategy and the Environment*, 26(1), 49–68. <https://doi.org/10.1002/bse.1900>
- Tuppura, A., Toppinen, A., & Puumalainen, K. (2016). Forest certification and ISO 14001: Current state and motivation in forest companies. *Business Strategy and the Environment*, 25(5), 355–368. <https://doi.org/10.1002/bse.1878>
- Uyar, A., Kuzey, C., Gerged, A. M., & Karaman, A. S. (2023). Research and development intensity, environmental performance, and firm value: Unraveling the nexus in the energy sector worldwide. *Business Strategy and the Environment*, 32, 1582–1602. <https://doi.org/10.1002/bse.3206>
- Waddock, S. A., & Graves, S. B. (1997). Quality of management and quality of stakeholder relations: Are they synonymous? *Business & Society*, 36(3), 250–279. <https://doi.org/10.1177/000765039703600303>
- Wang, H., Lu, W., Ye, M., Chau, K. W., & Zhang, X. (2016). The curvilinear relationship between corporate social performance and corporate financial performance: Evidence from the international construction industry. *Journal of Cleaner Production*, 137, 1313–1322. <https://doi.org/10.1016/j.jclepro.2016.07.184>
- Xie, B. C., Gao, J., Zhang, S., Pang, R. Z., & Zhang, Z. (2018). The environmental efficiency analysis of China's power generation sector based on game cross-efficiency approach. *Structural Change and Economic Dynamics*, 46, 126–135. <https://doi.org/10.1016/j.strueco.2018.05.002>
- Yildirim, A. (2020). The effect of relationship banking on firm efficiency and default risk. *Journal of Corporate Finance*, 65, 101500. <https://doi.org/10.1016/j.jcorpfin.2019.101500>
- Zhou, L., & Wei, Y. (2016). Impact of renewable energy law on the correlation between CSR and financial performance. In *2016 international conference on smart grid and clean energy technologies (ICSGCE)* (pp. 150–154). IEEE. <https://doi.org/10.1109/ICSGCE.2016.7876043>

**How to cite this article:** Maside-Sanfíz, J. M., Suárez Fernández, Ó., López-Penabad, M.-C., & Alzghoul, M. O. (2023). Does corporate social performance improve environmentally adjusted efficiency? Evidence from the energy sector. *Corporate Social Responsibility and Environmental Management*, 1–21. <https://doi.org/10.1002/csr.2650>

## APPENDIX A

| Country   | Frequency | Percentage | Country                  | Frequency | Percentage |
|-----------|-----------|------------|--------------------------|-----------|------------|
| Argentina | 6         | 0.62       | Kazakhstan               | 5         | 0.51       |
| Australia | 41        | 4.21       | South Korea              | 20        | 2.06       |
| Austria   | 6         | 0.62       | Luxembourg               | 6         | 0.62       |
| Belgium   | 2         | 0.21       | Malaysia                 | 20        | 2.06       |
| Bermuda   | 27        | 2.77       | Monaco                   | 4         | 0.41       |
| Brazil    | 18        | 1.85       | Netherlands              | 11        | 1.13       |
| Canada    | 114       | 11.72      | Norway                   | 18        | 1.85       |
| Chile     | 6         | 0.62       | Papua New Guinea         | 4         | 0.41       |
| China     | 47        | 4.83       | Poland                   | 18        | 1.85       |
| Colombia  | 9         | 0.92       | Portugal                 | 6         | 0.62       |
| Denmark   | 8         | 0.82       | Romania                  | 1         | 0.10       |
| Finland   | 5         | 0.51       | Russia                   | 36        | 3.70       |
| France    | 33        | 3.39       | Singapore                | 10        | 1.03       |
| Germany   | 13        | 1.34       | South Africa             | 6         | 0.62       |
| Greece    | 16        | 1.64       | Spain                    | 21        | 2.16       |
| Hong Kong | 24        | 2.47       | Sweden                   | 4         | 0.41       |
| Hungary   | 6         | 0.62       | Switzerland              | 6         | 0.62       |
| India     | 22        | 2.26       | Taiwan                   | 5         | 0.51       |
| Indonesia | 14        | 1.44       | Thailand                 | 30        | 3.08       |
| Israel    | 2         | 0.21       | Turkey                   | 4         | 0.41       |
| Italy     | 41        | 4.21       | United Arab Emirates     | 1         | 0.10       |
| Japan     | 29        | 2.98       | United Kingdom           | 61        | 6.27       |
| Jersey    | 4         | 0.41       | United States of America | 183       | 18.81      |

**TABLE A1** Distribution of sample observations by country.

## APPENDIX B

**TABLE B1** Sample selection.

|   | Observations/companies |
|---|------------------------|
| Firm-year observations/companies in Refinitiv EIKON database in energy industry from fiscal year 2016 to 2021 | 22.386/3.731           |
| Less observations/companies with missing ESG data   | (16.578)/(2.763)       |
| Less observations/companies with missing operational data   | (3.463)/(499)          |
| Less observations/companies with missing accounting data  | (1.372)/(230)          |
| Final sample  |                        |
| • Observations  | 973                    |
| • Unique companies  | 239                    |

## APPENDIX C

TABLE C1 Variables description.

|                               | Definition   | Source                    |
|-------------------------------|--|---------------------------|
| Dependent variable            |  |                           |
| Environmental efficiency      | Measurement of operational efficiency adjusted by environmental inputs and outputs.  | Author's own calculations |
| Inputs                        |  |                           |
| Employees                     | Average of Employees at the beginning and at the end of the year.  | EIKON database            |
| Property, plant and equipment | Net book value of all property, plant and equipment.   |                           |
| Operating cost                | All expenses applied to the income statement before EBIT for the period  |                           |
| Energy use                    | Total direct and indirect energy consumption in gigajoules   |                           |
| Outputs                       |  |                           |
| Operating revenues            | Revenue from all of a company's operating activities   |                           |
| Market capitalization         | Value of a company that is traded on the stock market, calculated by multiplying the total number of shares by the present share price.  |                           |
| CO <sub>2</sub> (bad output)  | Total carbon dioxide (CO <sub>2</sub> ) and equivalents emission in tonnes.  |                           |
| Independent variables         |  |                           |
| ESG score                     | Overall company score based on the self-reported information in the environmental, social and corporate governance pillars.  | EIKON database            |
| Environmental pillar          |  |                           |
| Innovation                    | Company's capacity to reduce the environmental costs and burdens for its customers, and thereby creating new market opportunities through new environmental technologies and processes or eco-designed products. |                           |
| Social pillar                 |  |                           |
| ESG controversies             | Company's exposure to environmental, social and governance controversies and negative events reflected in global media   |                           |
| Community                     | Company's commitment towards being a good citizen, protecting public health and respecting business ethics.  |                           |
| Human rights                  | Company's effectiveness towards respecting the fundamental human rights conventions.   |                           |
| Product responsibility        | Company's capacity to produce quality goods and services integrating the customer's health and safety, integrity and data privacy.   |                           |
| Governance pillar             |  |                           |
| Management                    | Company's commitment and effectiveness towards following best practice corporate governance principles.  |                           |
| CSR strategy                  | Company's practices to communicate that it integrates the economic (financial), social and environmental dimensions into its day-to-day decision-making processes.   |                           |
| Shareholders                  | Company's effectiveness towards equal treatment of shareholders and the use of anti-takeover devices.  |                           |

(Continues)



TABLE C1 (Continued)

|                            | Definition   | Source   |
|----------------------------|--|--|
| Control variables          |  |  |
| Size                       | Taking a value equal to 1 if banks equal or exceed the 50th percentile of Neperian logarithm of total assets, 0 otherwise. | Author's own calculations                          |
| R&D                        | Research and Development expenses to Operating Cost  |  |
| Strategic shareholders (%) | Percent of shares held by strategic entities (individuals, corporations, holding companies and government agencies)        | EIKON database                                     |
| Solvency ratio             | Total Current Assets divided by Total Current Liabilities  |  |
| Interest coverage ratio    | Earnings Before Interest and Taxes for the fiscal period divided by Interest Expense for the same period.                  |  |
| Oil price                  | Brent crude oil, average annual price (USD)  | World Bank. World Development Indicators database. |
| GDP growth                 | Annual percentage growth rate of GDP at market prices based on constant local currency                                     |  |



APPENDIX D

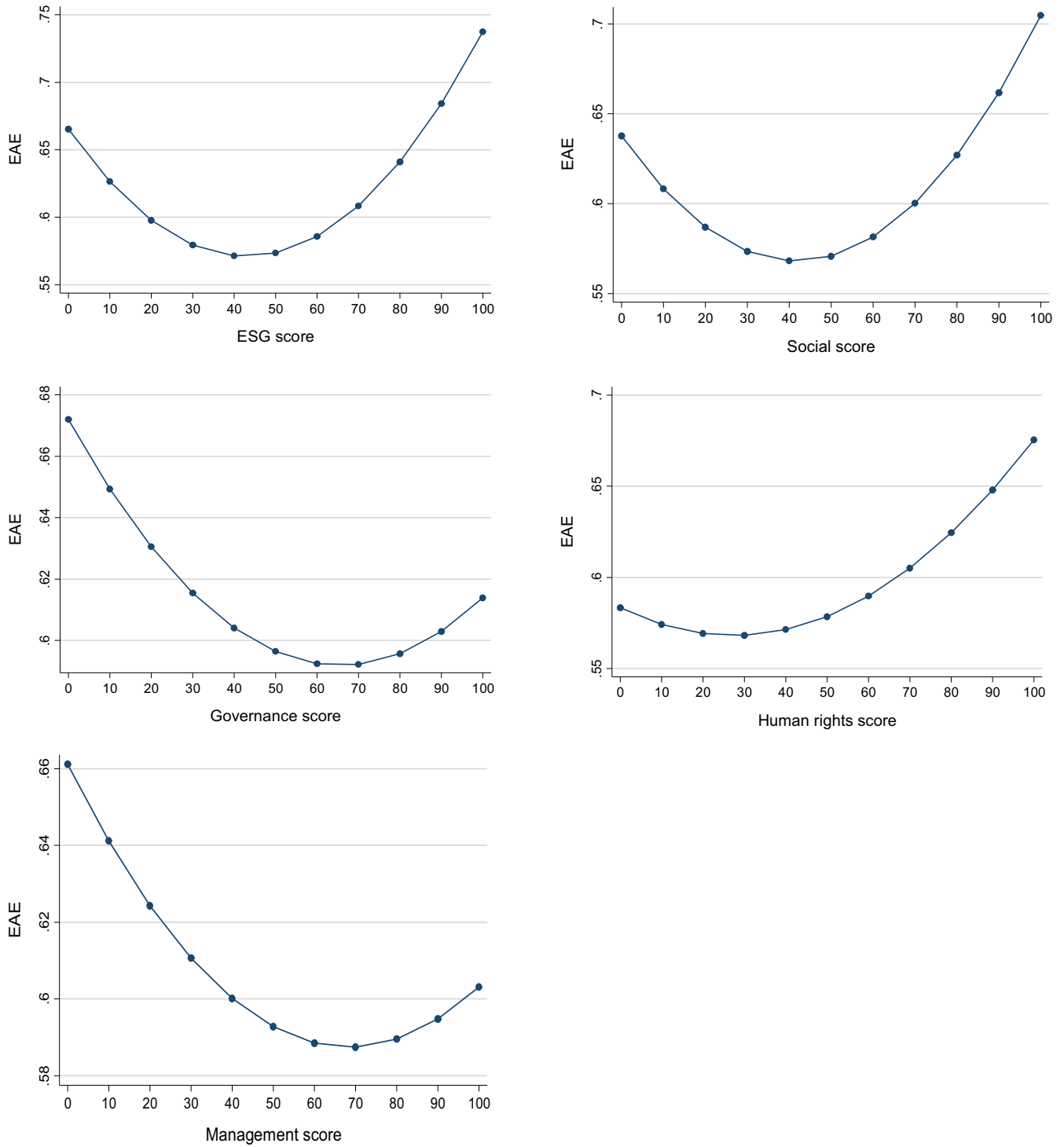


FIGURE D1 U shaped relation. Predictive margins between EAE and ESG, social, governance, human rights, and management scores.