

The effect of innovation on environmental, social and governance (ESG) practices

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Abstract

Purpose – This paper aims to investigate if and to what extent environmental, social and governance (ESG) practices are influenced by innovation, measured by investment in research and development (R&D) and the number of patents developed by companies.

Design/methodology/approach – To test this hypothesis, the authors estimated a regression model for the panel data considering a time horizon of eight years. The analysis was conducted on a sample of listed firms operating in the industrial sector in France, Germany, Italy, Spain, the UK and the USA.

Findings – The empirical analysis shows that there is a positive and significant relationship between ESG practices and innovation. Companies investing more in R&D and patents have better ESG performance.

Originality/value – This study contributes to the existing literature by improving the understanding of the importance of innovation in improving ESG practices for firms in the industrial sector. Furthermore, it provides empirical evidence of the ability of innovation to be a valuable tool for sustainable industry development through R&D investment and patent development.

Keywords Patents, Research and development (R&D), Sustainability, Innovation, Panel data, Environmental, social, governance (ESG) score

Paper type Research paper

1. Introduction

In recent years, companies, investors and consumers have been turning their focus toward increasingly crucial corporate sustainability (Melinda and Wardhani, 2020). The topic of sustainability is leading most organizations to pay more and more attention to the environment, its conservation (Kotze *et al.*, 2010) and the development of a sustainable corporate culture that encourages the optimization of business operations (Nowak *et al.*, 2011). Sustainability implies constant and ideally increasing well-being (environmental, social and economic) with a view to leaving future generations a quality of life that is not inferior to the present one.

Corporate sustainability is often observed by considering ESG factors (Buallay, 2019; Drempetic *et al.*, 2019). The environmental aspect refers to a company's ability to efficiently



use natural resources in its processes, thereby reducing environmental emissions. The social dimension measures a company's capacity to promote ethical values and generate trust in its employees, ensuring respect for human rights. Finally, the governance dimension refers to a company's capacity to act in the interests of its shareholders through efficient corporate management systems and effective processes.

A useful tool to promote sustainable business is innovation (Barbieri *et al.*, 2010; De Santis and Presti, 2018). It is clear that efforts to achieve sustainability goals, such as increasing resources and energy efficiency, are inextricably linked to technological progress. Without technology and innovation, there will be no opportunity for growth, let alone industrialization and without industrialization, there will be no economic development and no well-being for individuals (Carayannis *et al.*, 2015). Indeed, it is widely recognized in the literature that there is a relationship between innovation and sustainability performance (Ahmad and Wu, 2021). However, the results are not conclusive. On the one hand, previous studies have analyzed the relationship bi-directionally (CSR-innovation and innovation-CSR) (Gallego-Álvarez *et al.*, 2011). On the other hand, prior findings are mixed in terms of signs, showing both a positive (Carrasco and Buendía-Martínez, 2016; Du and Li, 2019) and a negative relationship (von Höivik and Shankar, 2011; Marsat and Williams, 2014; Mithani, 2017).

According to institutional theory, the values institutionalized within a society very often represent the ideals that organizations set for themselves to follow (Meyer and Roman, 1991). Within the context of these values, sustainability is, especially in the current scenario, one of the main pillars of strategic decisions and medium-to long-term company growth. In this sense, institutional theory may explain how the pressures exerted by society influence a company's sustainability practices and the shifts in internal organizational practices in terms of new internal processes, practices and structures (Campbell, 2007; Lombardi *et al.*, 2021; Matten and Moon, 2008). As observed by the European Commission (2008), engagement with stakeholders can push the innovation activity of companies toward more sustainable practices (Carrasco and Buendía-Martínez, 2016; European Commission, 2008).

Companies operating in the industrial sector, due to pollutant emissions from production activities, are among the main companies responsible for environmental pollution (Arango-Miranda *et al.*, 2018; Nartey, 2018). In the past few decades, the industrial sector has begun to embrace the concept of sustainability, as demonstrated by large companies articulating sustainability strategies and publishing annual reports that track progress toward economic, environmental and social goals (Kunz *et al.*, 2013). These efforts have contributed to considerable reductions in the environmental impacts of production processes through waste reduction, resource conservation and the development of clean production initiatives (Kotze *et al.*, 2010; Renukappa *et al.*, 2012).

In light of the above considerations, this study analyzes whether firms in the industrial sector use innovation to improve their sustainability performance in response to institutional pressure. Few empirical studies have demonstrated the relationship between corporate ESG initiatives and innovative performance (Zhang *et al.*, 2020a); however, studies focusing on the relationship between ESG performance and a firm's economic and financial performance are prevalent (Do and Kim, 2020). Furthermore, few studies investigating the relationship between ESG performance and innovation have focused on green innovation (Xu *et al.*, 2021).

The present study aims to extend the literature on this topic by providing empirical evidence of the relationship between innovation, as measured by R&D expenditures and patent production, and ESG performance in the industrial sector.

To achieve our goal, we conducted a regression analysis on panel data to estimate the effect on the dependent variable related to the sustainability (ESG score) of R&D

expenditures, patents and environmental innovation scores as a predictor of the level of green innovation. The results show that there is a positive and significant relationship between the explanatory variables under investigation and ESG score (dependent variable).

This study offers theoretical and practical implications. First, this study contributes to previous literature by analyzing the impact of R&D investment, firms' abilities to develop patents (in terms of the number of patents developed annually), on the improvement of sustainable practices of industrial firms that operate in European and US contexts. Second, this study provides useful insights for managers trying to build innovation strategies.

The paper is structured as follows: Section 2 presents the literature review; Section 3 describes the research methodology; Section 4 shows the results of empirical analysis; Section 5 discusses the conclusions; and finally, Section 6 presents theoretical and practical implications and recommendations for future research.

2. Literature review

There are an increasing number of measures promoted by the international community to steer companies toward sustainable development, such as the Paris Agreement on Climate Change in 2015 and the 2030 Agenda for Sustainable Development Goals (SDGs), the goal of which is to stimulate investment choices that safeguard environmental quality (Ying and Xin-gang, 2021). The interest shown by investors and consumers in corporate sustainability issues (Melinda and Wardhani, 2020) has led most organizations to pay increasing attention to the environment by developing a sustainable corporate culture (Kotze *et al.*, 2010; Tarquinio and Posadas, 2020). Achieving sustainable performance requires companies to integrate ESG aspects into business strategy (Atan *et al.*, 2016), and the ESG score is the most widely used variable in the literature for measuring sustainable performance (Xu *et al.*, 2021).

The choice of firms to integrate ESG practices often has positive effects in terms of reduced costs, improved product quality and higher customer satisfaction (De Klerk and De Villiers, 2012; Magon *et al.*, 2018). These benefits often lead to improved firm performance; in fact, some studies have found that ESG practices have a positive and significant impact on return on assets (ROA) (Almeyda and Darmansya, 2019) as well as on competitive advantage and corporate reputation (Alsayegh *et al.*, 2020; Chen *et al.*, 2015; Zhai *et al.*, 2018). According to others, however, integrating ESG practices does not necessarily improve corporate profitability (Buallay, 2019; Farooq, 2015; Zaman *et al.*, 2021), due to the high investment costs in R&D that the path to sustainability requires (Marsat and Williams, 2014). Indeed, achieving and improving ESG performance requires firms to invest in R&D (Fernández *et al.*, 2021; Triguero *et al.*, 2018).

Innovation represents the tool most companies use to initiate their sustainable change path, addressing earnings management, corporate social responsibility, accountability and transparency (Lombardi and Secundo, 2020), by adopting innovations that take into account the three dimensions of sustainability (i.e. ESG) (Barbieri *et al.*, 2010). The innovation capacity of firms can be measured through R&D expenditures or technological output, such as patents or patent applications (Broadstock *et al.*, 2020). Previous literature has investigated the association between innovation and sustainability performance although it shows mixed results (Ahmad and Wu, 2021). In particular, there are studies that analyze the relationship bidirectionally (i.e. the link between CSR and innovation and between innovation and CSR) (Gallego-Álvarez *et al.*, 2011); others have found a positive association (Carrasco and Buendía-Martínez, 2016; Du and Li, 2019) or a negative association (Marsat and Williams, 2014; Mithani, 2017; von Höivik and Shankar, 2011).

In the USA, for example, investments in innovation oriented toward sustainability have increased by more than 40% since 2015 (US SIF Foundation, 2018) and the development of patents instrumental in improving ESG performance is also steadily increasing (Xu *et al.*, 2021). Therefore, companies that want to improve their ESG performance must engage in innovation activities by investing in R&D (Aras *et al.*, 2018).

A relevant form of innovation for sustainability goals is green innovation. While innovation is defined as “a continuous improvement in the overall ability of companies to generate innovation to develop new products to meet market needs” (Szeto, 2000, p. 150), the shift to the concept of green innovation requires a change in the concept of technological innovation, focusing on aspects of eco-innovation or environmental innovation (Ahmad and Wu, 2021). The integration of environmental innovation into corporate strategy is increasingly common, representing one of the factors that can strengthen corporate competitiveness (Chen *et al.*, 2015; Zhai *et al.*, 2018), fostering long-term value creation for the benefit of shareholders and improving engagement with stakeholders relevant to the company (Ilyas and Osiyevskyy, 2021; Nicolò *et al.*, 2021). Green innovation is a useful tool for promoting the sustainable success of an industry while maintaining its environmental benefits (Ghadimi *et al.*, 2020; Zhang *et al.*, 2019; Zhang *et al.*, 2020b).

In the environmental context, it is therefore essential to assess the impact of business activities on the environment and the company’s ability to offer products and services that can meet climate and environmental challenges. The efficient use of natural resources, optimization of production processes (eco-innovation), and development of technologies that reduce environmental impact (eco-design) are typical actions of a corporate strategy focused on environmental innovation (Kemp and Pearson, 2007). Specifically, eco-innovation refers to the pursuit of SDGs according to a logic of “responsible” behavior as a result of mitigating the ecological pressures caused by production processes and making natural capital resilient to these pressures (OECD, 2018). Although such a strategy guarantees an improvement in performance and corporate image (Liao, 2020) while being positively valued by institutional investors, it requires incurring significant costs that negatively affect profitability (García-Sánchez *et al.*, 2020). Although investments in eco-innovation and eco-design may negatively affect financial performance in the short term, the return on such investments may exceed the relative cost of the initial investment in the long term (García-Sánchez *et al.*, 2021). Therefore, to develop these technological capabilities and implement environmentally friendly innovations (Jové-Llopis and Segarra-Blasco, 2018), firms must invest in R&D (Fernández *et al.*, 2021; Triguero *et al.*, 2018).

Based on the foregoing, the interest of academics and practitioners has focused on the impact of ESG on a firm’s economic and financial performance (Do and Kim, 2020), while few studies have empirically investigated the relationship between ESG performance and innovation performance in general (Zhang *et al.*, 2020a), including green innovation (Xu *et al.*, 2021). As sustainability represents a widely institutionalized value in modern society, as evidenced by numerous companies that have developed business models in line with new social needs based on economic efficiency and respect for the environment and human rights (Barbieri, 2007), it is interesting to analyze whether companies, in response to social pressures, recognize innovation as a tool to improve their ESG performance. The European Commission (2008) has highlighted how corporate stakeholders influence the innovation activity of companies toward more sustainable practices (Carrasco and Buendía-Martínez, 2016; European Commission, 2008).

In light of these considerations and given that ESG is an expression of the concept of green economy, CSR and responsible investment (Deng and Cheng, 2019), this study aims to analyze whether the ability to innovate, measurable through investment in R&D and

patents (Broadstock *et al.*, 2020), improves ESG performance (Fernández *et al.*, 2021; Triguero *et al.*, 2018). It tests the following research hypothesis:

H1. Innovation, measured by R&D and patents, positively influences ESG performance in the industrial sector.

3. Research design

To test our hypothesis, we used a panel data regression model, which is useful for examining a given sample of firms over time (Wooldridge, 2010). This model has several major advantages over conventional cross-sectional or time series data sets, including more accurate inference of model parameters, uncovering dynamic relationships and controlling the impact of omitted variables (Hsiao, 2014). The panel data regression model is a valuable tool for examining the incremental contribution of innovation to sustainability.

3.1 Sample and data collection

The analysis focused on 1,787 listed firms operating in the industrial sector in France, Germany, Italy, Spain, the UK and the USA. These countries were chosen because they represent major European Union (EU) economies and more than half of the EU's international activities (Bpifrance, 2018; EUROSTAT, 2016; Symons *et al.*, 2002); and the USA is the largest economy in the world.

Given the large emissions of pollutants and production activity energy consumption, it is important to analyze the industrial sector (Zhu *et al.*, 2021). In addition, the industrial sector is a powerful player within society and thus can have a significant influence on regional and global sustainability outcomes (Kunz *et al.*, 2013).

Our final sample consisted of 182 firms for which data on ESG scores and the number of patents developed were available for the period of analysis. We constructed an eight-year panel dataset from 2013 to 2020. The period of analysis came immediately after a conference that took place in Rio de Janeiro in 2012, the aim of which was to renew the political commitment to sustainable development by seeking to steer companies toward common sustainability goals (Naciti, 2019).

Longitudinal data observations exist for the same companies in several different periods (Kennedy, 2008). A panel data set has multiple entities, each of which has repeated measurements at different periods. Panel data may have individual (group) effects, time effects or both, which are analyzed using fixed-effect or random-effect models.

The data regarding R&D, environmental innovation score and ESG practices have been extrapolated by the Refinitiv database (previously called Thomson Reuters Asset4) and the Datastream database. In addition, the number of patents developed by each company was hand-collected by "Espacenet," which is a free online service developed by the European Patent Office together with the member states of the European Patent Organization (Vincent *et al.*, 2017). This database contains national patents from many European states, as well as European, international, and national patents from other countries. In addition, we used the US Patent and Trademark Office (USPTO) database as a further source of data, which is considered reliable for studying the global innovation model (Su, 2017).

3.2 Research model

The analysis was carried out using panel data analysis. Using the fixed-effects model, it is possible to identify a set of characteristics specific to each unit that remains constant over time. Fixed-effect regression models have as many intercepts as there are units. Conversely,

the random-effects model treats individual effects as part of the error term and then considers them stochastic components unrelated to regressors.

More specifically, the estimation model is as follows:

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t} + \alpha_i + u_{i,t}$$

where the i and t indices represent the company identifier and the period (year), respectively; the dependent variable ($Y_{i,t}$) is the ESG score, β_0 is the constant and $X_{i,t}$ refers to a vector of independent variables. We intended to test the research hypothesis using the following model:

$$\text{ESG}_{i,t} = \beta_0 + \beta_1 \text{LnR\&D}_{i,t} + \beta_2 \text{Patents}_{i,t} + \beta_3 \text{CSR_Com}_{i,t} + \beta_4 \text{GRI_Guid}_{i,t} + \beta_5 \text{EIS}_{i,t} + \beta_6 \text{Prod_resp}_{i,t} + \beta_7 \text{TA}_{i,t} + \beta_8 \text{Mkt_cap}_{i,t} + \beta_9 \text{ROA}_{i,t} + \alpha_i + u_{i,t}$$

3.3 Dependent variable

In line with previous studies (Drempetic *et al.*, 2019; Shahbaz *et al.*, 2020; Xu *et al.*, 2021), we used Refinitiv's ESG performance data (ESG score) as the dependent variable. The ESG score is the result of three sub-scores related to the ESG areas. the categories that make up the environment pillar (E) are as follows:

- resource use, which refers to the ability of enterprises to reduce the use of resources, such as materials, water or energy, and to identify eco-efficient solutions for the production of products;
- emission reduction; and
- innovation, which refers to the ability of the enterprise to adopt technological solutions to reduce environmental costs and create new market prospects.

In terms of social aspects (S), the following are considered:

- the focus on the workforce (i.e. the ability of the company to create satisfaction for its employees, maintain gender diversity and ensure equal opportunities for all);
- the focus on human rights;
- the protection of community aspects, measured by the company's involvement in the protection of public health and respect for business ethics; and
- product responsibility, which reflects the ability of a company to produce goods or provide services that integrate customer health, safety, integrity and privacy.

Finally, with regard to screening in terms of corporate governance (G), the following are considered:

- the skills of management;
- shareholder protection in terms of the company's ability to ensure fair treatment for shareholders; and
- corporate social responsibility strategies in terms of the company's ability to integrate economic, financial, social and environmental dimensions into business management.

In the corporate governance pillar, in addition to the analysis of the structure and composition of the board of directors as internal information, the role of companies in protecting other stakeholders is also examined.

The overall ESG score is the arithmetic mean of the three scores and is expressed as a percentage.

3.4 Independent and control variables

R&D expenditure and patents are typical proxies for innovation input and output (Cruz-Càzares *et al.*, 2013). R&D investment is a representation of a firm's technological knowledge. According to previous studies (Liao *et al.*, 2021; Qi *et al.*, 2018; Zhang *et al.*, 2020a), innovation performance is also measured by the total number of patents (Xu *et al.*, 2021), so we included the number of patents and hand-collected data as explanatory variables.

To avoid model specification errors, we checked for additional variables that could affect the ESG score. We used the presence of a committee for CSR (Shahbaz *et al.*, 2020), the adoption of guidelines for Global Reporting Initiative (GRI) reports (Dremptic *et al.*, 2019), the commitment of a company's management in supporting R&D of eco-efficient products or services (Arena *et al.*, 2018), the ability of a company to produce quality goods and services designed for reuse, recycling or reduction of environmental impact (Duque-Grisales *et al.*, 2020), size (Khaled *et al.*, 2021), market capitalization (Pasquini-descomps, 2016) and ROA as control variables. Table 1 presents a summary of the measurements of all variables.

4. Results and discussion

4.1 Descriptive statistics

Table 2 shows descriptive statistics for dependent and independent variables, both for each individual year of analysis and for the aggregated period (2013–2020). The descriptive statistics include the minimum, maximum, mean and standard deviation.

The average level of ESG performance (ESG score) of the companies analyzed was 54.11%, with a maximum of 92.98%. This reveals that the sustainability performance of the

| Independent variables | Variable code | Variable description |
|--------------------------------|---------------|--|
| Research and development | LnR&D | Logarithm of the amount of investment in Research and Development |
| No. of patents | Patents | Number of patent application |
| Control variables | Variable code | Variable description |
| CSR sustainability committee | CSR_Com | Does the company have a CSR sustainability committee? |
| GRI report guidelines | GRI_Guid | Is the company's CSR report published in accordance with the GRI guidelines? |
| Environmental innovation score | EIS | Environmental innovation category score reflects a 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 |
| Product responsibility | Prod_resp | Product responsibility reflects a company's ability to produce products or offer services that promote responsibility, efficiency, cost-effectiveness and environmental sensitivity |
| Ln total assets | TA | Ln Total Assets |
| Market capitalization | Mkt_cap | Total market value of a company's outstanding shares of stock |
| Return on assets | ROA | ROA is calculated as the net profit divided by the total assets |

Table 1.
Variable description

companies for the period 2013–2020 was very satisfactory in terms of the scoring definition. The amount of R&D investment over the entire period of analysis shows an average value of €243,267.90, with a maximum of €4,627,000. During the whole period of analysis, the average number of patents was 84, with a maximum value of 1998 in 2020. In addition, 65% of the sample had a committee for CSR, and 99% of the examined companies published their CSR reports in accordance with GRI guidelines. The average environmental innovation score was 37.92%, and the maximum value was 99.38%, suggesting that many of the companies used technologies to increase their level of sustainability. This result was also confirmed by the variable “product responsibility,” which had an average value of 55.10 during the examined period. In terms of total assets and market capitalization, the average value was €11,500,000 (maximum value €152,000,000) for total assets and €11,200,000 (maximum value €183,000,000) for market capitalization. Finally, ROA had an average value of 6.50.

We checked the normality of the sets of residuals using the Jarque–Bera Lagrange multiplier test. Based on a p -value greater than 0.05, the null hypothesis cannot be rejected. Therefore, the residuals were distributed normally. In other words, there is no violation of the hypothesis of normal distribution for the error terms, as the residuals are normal.

4.2 Correlation analysis

To assess the correlation of a variable simultaneously with two or more variables, we performed a multiple correlation analysis (Pearson correlation). The correlation matrix (Table 3) highlights a positive relationship between the dependent variable and the study’s explicative independent variables. A company’s sustainability performance (ESG score) was found to be positively associated with innovation performance, which was measured in this study by the amount of R&D investment and the number of patents. The other control variables included in the econometric model were also positively correlated with the dependent variable ESG score.

Furthermore, we performed the variance inflation factor (VIF) test to check for multicollinearity among the variables. Chatterjee and Hadi (2012) indicated a VIF value of 10 as a cut-off for considering high correlations between variables. In the present case, the VIFs were all less than 3, suggesting the absence of multicollinearity (Table 4).

4.3 Findings

Linear regressions were performed with fixed and random effects, verifying solidity both for heteroskedasticity and for correlation. To identify which model, the fixed-effects or the random-effects model, would best describe our analysis, we performed the Hausman test and the Breusch–Pagan test. To this end, we ran the same regressions without consideration of robustness. The Hausman test, which presented a chi-square p -value greater than 10%, suggested the use of a random-effects model. Subsequently, the Breusch–Pagan test was performed, which, presenting a p -value lower than 10%, confirmed that the second specification (fixed-effects model or random-effects model) must be used. On the basis of this test, and as the p -value of the Hausman test was greater than 10%, the random-effects model was used.

To verify the joint statistical significance of the temporal effects, for each regression in relation to the resulting p -values, it was possible to affirm that the null hypothesis could be accepted and therefore the temporal effects were always statistically significant at 1%, 5% or 10%. The results of our analysis are reported in Table 5.

Using the random effects model, the two explanatory variables (R&D and patents) were statistically significant at 1% and 10%, and both had a positive association with the ESG

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| ESG | | | | | | | | | |
| Mean | 46.962 | 47.873 | 51.141 | 52.637 | 54.732 | 57.048 | 60.348 | 62.508 | 54.119 |
| SD | 17.616 | 17.823 | 18.440 | 18.133 | 17.487 | 17.459 | 16.024 | 14.968 | 18.030 |
| Min | 4.01 | 3.29 | 4.02 | 6.02 | 11.83 | 15.03 | 14.67 | 13.09 | 3.29 |
| Max | 86.97 | 83.09 | 86.03 | 88.15 | 90.72 | 90.2 | 92.98 | 88.67 | 92.98 |
| R&D | | | | | | | | | |
| Mean | 236.315.7 | 232.444.2 | 232.639.9 | 244.020.6 | 236.005.8 | 250.020.1 | 267.193.4 | 247.607.4 | 243.267.9 |
| SD | 490.792.4 | 478.711.6 | 492.921.1 | 586.255.3 | 476.753.1 | 496.524.6 | 508.550.6 | 446.917.1 | 496.458.1 |
| Min | 0 | 0 | 71 | 86 | 44 | 0 | 221 | 114 | 0 |
| Max | 3,071,000 | 3,047,000 | 3,331,000 | 4,627,000 | 3,179,000 | 3,269,000 | 3,219,000 | 2,476,000 | 4,627,000 |
| Patents | | | | | | | | | |
| Mean | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| SD | 67.170 | 76.890 | 86.582 | 85.626 | 87.686 | 85.818 | 86.554 | 99.296 | 84.453 |
| Min | 174.532 | 201.915 | 240.144 | 234.789 | 231.996 | 234.076 | 231.262 | 274.163 | 229.091 |
| Max | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CSR_Com | | | | | | | | | |
| Mean | 1,129 | 1,397 | 1,737 | 1,792 | 1,820 | 1,642 | 1,706 | 1,998 | 1,998 |
| SD | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| Min | 0.664 | 0.642 | 0.598 | 0.598 | 0.620 | 0.642 | 0.692 | 0.769 | 0.653 |
| Max | 0.473 | 0.480 | 0.491 | 0.491 | 0.486 | 0.480 | 0.462 | 0.422 | 0.475 |
| GRI_Guid | | | | | | | | | |
| Mean | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| SD | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| EIS | | | | | | | | | |
| Mean | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| SD | 31.873 | 34.158 | 36.332 | 36.872 | 37.648 | 40.037 | 43.714 | 42.774 | 37.926 |
| Min | 31.815 | 31.076 | 31.137 | 31.452 | 31.473 | 31.615 | 31.572 | 31.579 | 31.620 |
| Max | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 99.36 | 99.34 | 99.38 | 97.16 | 97.4 | 97.92 | 99.21 | 99.1 | 99.38 |

(continued)

Table 2.
Descriptive statistics

Table 2.

| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
|-----------|-------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|
| Prod_resp | | | | | | | | | |
| Mean | 48.967 | 48.942 | 52.936 | 54.875 | 57.498 | 58.246 | 58.565 | 60.812 | 55.105 |
| SD | 30.960 | 30.860 | 30.210 | 30.546 | 29.518 | 29.249 | 28.691 | 27.154 | 29.897 |
| Min | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max | 99.5 | 99.44 | 99.66 | 99.72 | 99.73 | 99.78 | 99.87 | 99.84 | 99.87 |
| TA | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| Mean | 10,000,000 | 10,200,000 | 10,500,000 | 10,600,000 | 11,100,000 | 12,100,000 | 13,600,000 | 14,100,000 | 11,500,000 |
| SD | 14,500,000 | 14,800,000 | 14,900,000 | 14,800,000 | 15,500,000 | 17,700,000 | 20,000,000 | 21,100,000 | 16,900,000 |
| Min | 99,307 | 61,622 | 60,603 | 52,875 | 58,615 | 51,995 | 61,484 | 56,373 | 51,995 |
| Max | 89,700,000 | 92,600,000 | 94,100,000 | 89,700,000 | 92,000,000 | 117,000,000 | 133,000,000 | 152,000,000 | 152,000,000 |
| Mkt_cap | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| Mean | 8,820,158 | 9,487,616 | 9,004,906 | 9,965,626 | 12,700,000 | 11,100,000 | 14,100,000 | 14,800,000 | 11,200,000 |
| SD | 14,300,000 | 15,500,000 | 135,000,000 | 15,500,000 | 21,400,000 | 19,800,000 | 23,700,000 | 24,700,000 | 19,100,000 |
| Min | 13727 | 9655 | 106604 | 124190 | 112458 | 58125 | 31473 | 26142 | 9655 |
| Max | 102,000,000 | 105,000,000 | 96,400,000 | 99,500,000 | 174,000,000 | 183,000,000 | 183,000,000 | 146,000,000 | 183,000,000 |
| ROA | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2013-2020 |
| Mean | 6.477 | 6.821 | 6.892 | 6.307 | 7.44 | 7.987 | 7.217 | 3.639 | 6.597 |
| SD | 6.473 | 7.875 | 6.906 | 6.560 | 5.835 | 8.030 | 7.329 | 9.286 | 7.442 |
| Min | -22.06 | -53.22 | -17.96 | -17.06 | -15.32 | -17.32 | -17.84 | -54.66 | -54.66 |
| Max | 29.66 | 45.23 | 35.98 | 39.44 | 27.52 | 73.86 | 58.19 | 35.66 | 73.86 |

| | ESG | R&D | Patents | CSR_Com | GRI_Guid | EIS | Prod_resp | TA | Mkt_cap | ROA |
|-----------|------------|-----------|------------|------------|----------|------------|------------|------------|-----------|-----|
| ESG | 1 | | | | | | | | | |
| R&D | 0.3084*** | 1 | | | | | | | | |
| Patents | 0.1478*** | 0.5206*** | 1 | | | | | | | |
| CSR_Com | 0.5216*** | 0.1563*** | 0.1264*** | 1 | | | | | | |
| GRI_Guid | 0.0705* | -0.0653 | -0.0894** | -0.0155 | 1 | | | | | |
| EIS | 0.5065*** | 0.3050*** | 0.1927*** | 0.1999*** | 0.0541 | 1 | | | | |
| Prod_resp | 0.5107*** | 0.1019*** | 0.0264 | 0.2430*** | 0.0626 | 0.2704*** | 1 | | | |
| TA | 0.4773*** | 0.6577*** | 0.3081*** | 0.1940*** | -0.0296 | 0.2911*** | 0.1873*** | 1 | | |
| Mkt_cap | 0.2664*** | 0.5577*** | 0.4069*** | 0.1405*** | -0.0082 | 0.1344*** | 0.0074 | 0.5963*** | 1 | |
| ROA | -0.1686*** | -0.0220 | -0.0902*** | -0.1316*** | 0.0079 | -0.1332*** | -0.1112*** | -0.1821*** | 0.0905*** | 1 |

Table 3.
Correlation matrix

score. Among the control variables, those related to company size (TA and Mkt_cap) and company profitability (ROA) were not significant. On the contrary, the variable indicating the presence or absence of a sustainability committee, as well as the variable indicating the adoption or lack of adoption of the GRI guidelines, were statistically significant at 1%. The variable measuring a company's ability to produce products or offer services that promote responsibility, efficiency, cost-effectiveness and environmental sensitivity was also significant and positively associated with the ESG score. Finally, the environmental innovation score (EIS) variable indicating a company's ability to reduce environmental costs and burdens for its customers and thus create new market opportunities through new environmental technologies and processes or eco-designed products, was significant at 1%.

The evidence supports our research hypothesis. A positive impact of R&D investment and patent development on ESG performance was found (Broadstock *et al.*, 2020). Indeed, an increase in R&D investment led to an improvement in the ESG score. At the same time, the increase in the number of patents developed by each company also had a positive impact on the ESG score. These results suggest that companies that are inclined to innovate are also those that perform better in terms of adopting ESG practices. Therefore, there is a positive and significant relationship between sustainable performance, as measured by the ESG score, and innovation performance, as measured by R&D investment, and the number of patents developed.

Furthermore, the findings show a positive and significant relationship expressed by the variable EIS, which indicates a company's ability to create new market opportunities through new environmental technologies and processes or eco-designed products. This result is consistent with the literature, which states that technological innovation offers the greatest opportunity to transform organizations and societies toward more sustainable behaviors (Stolze *et al.*, 2012).

The CSR sustainability committee regressor was a dummy variable. It assumed a value of 1 when the company had a CSR committee; otherwise, it was 0. The evidence showed that the presence of a CSR committee positively affected the ESG score, resulting in an increase of 5.63%. This finding is in line with numerous studies on the implementation of ESG practices by firms, and it confirms the benefit of a sustainability committee, which has the task of promoting the principles and values of sustainable development and proposing related objectives, programs and initiatives for CSR issues, thereby translating into an improvement in the level of corporate sustainability (Shahbaz *et al.*, 2020). The control variable "Product responsibility" also had a positive and significant impact at 1% on the ESG coefficient.

Table 4.
Variance inflation
factor

| Variable | VIF |
|-----------|------|
| R&D | 2.41 |
| Patents | 1.64 |
| CSR_Com | 1.11 |
| GRI_Guid | 1.03 |
| EIS | 1.11 |
| Prod_resp | 1.12 |
| TA | 2.11 |
| Mkt_cap | 2.25 |
| ROA | 1.21 |
| Mean VIF | 1.55 |

| Model | (A) | (B) | (C) |
|----------------------------------|--|---|--|
| | Pooled OLS Coefficient (Robust SE) | Fixed effects Coefficient (Robust SE) | Random effects Coefficient (Robust SE) |
| R&D | 1.89** (0.589) | 3.145*** (1.299) | 2.012*** (0.898) |
| Patents | 0.005* (0.003) | 0.001 (0.005) | 0.005* (0.003) |
| CSR_Com | 8.39*** (2.21) | 4.696 (2.917) | 5.63*** (2.099) |
| GRI_Guid | 9.67*** (3.22) | 1.42*** (0.462) | 2.08*** (0.364) |
| EIS | 0.134*** (0.04) | 0.207*** (0.032) | 0.187*** (0.031) |
| Prod.resp | 0.227*** (0.036) | 0.171*** (0.034) | 0.202*** (0.030) |
| TA | -0.619 1.049 | 1.47 (3.337) | -0.476 (1.24) |
| Mkt_cap | 0.00 0.00 | 0.00 0.00 | 0.00 0.00 |
| ROA | -0.010 (0.106) (0.504) | -0.097 (0.071) (omitted) | -0.088 (0.073) (0.545) |
| Hausman test | | 16.08 (<i>p</i> -value = 0.412) | |
| Breusch and Pagan test | | 198.48 (<i>p</i> -value = 0.000) | |
| Years | 2013–2020 | 2013–2020 | 2013–2020 |
| Temporal effects | No | Yes | Yes |
| Standard errors for grouped data | Yes | Yes | Yes |
| <i>R</i> -square | 58.19 | 36.34 | 54.79 |
| Statistics <i>F</i> | – | – | Chi-square 588.7*** |

Notes: *** = significant at 1%; ** = significant at 5%; * = significant at 10%. Parentheses indicate the standard error of robust regression

Table 5.
Regression results

The chi-square test in our model had a *p*-value of 0.000. The regressors were all jointly significant at 1% and therefore had an effect on the ESG score.

For a regression model to be satisfactory, the *R*-sq must, in accordance with the theory, have values greater than 50% (Nau, 2019). Although the regressors were all statistically significant using the random-effects model, both individually and jointly, the overall *R*-sq (i.e. the average between the *R*-sq in the groups and the *R*-sq within the groups) was 54.79%.

With regard to the temporal effects, they were statistically significant at 1%, and consequently it is possible to say that they also influenced the dependent variable (ESG score).

5. Discussion and conclusion

The focus of companies on sustainability issues has increased significantly in recent years as a result of worsening environmental pollution and the climate change crisis (Ying and Xin-gang, 2021). The growing interest of companies in sustainability issues is also the result of social pressures to do so, as suggested by institutional theory (Meyer and Roman, 1991). This has encouraged the adoption of more sustainable production policies (Kotze *et al.*, 2010) and the development of business models in line with new ESG requirements (Barbieri, 2007). Instrumental to the pursuit of these objectives and, more generally, to sustainable development is innovation (Maffei *et al.*, 2019; van der Velden, 2018), promoting the reduction of the environmental impact of business processes through the efficient use of resources (Cappiello *et al.*, 2013; Recker *et al.*, 2012). Innovation in general is accompanied by environmental innovation in terms of eco-innovation or eco-design, which are among the tools that promote the development of a sustainable corporate culture (Ahmad and Wu, 2021) and strengthen corporate competitiveness (Ilyas and Osiyevskyy, 2021; Nicolò *et al.*, 2021).

Although the importance of innovation in improving ESG performance is recognized in the literature, there are still only a few empirical studies that analyze this relationship (Zhang *et al.*, 2020a) with a focus on the relationship between ESG and green innovation (Xu *et al.*, 2021). This stems from the increased attention paid by academics to investigating the relationship between ESG performance and firms' economic and financial performance (Do and Kim, 2020). This study aims to fill this gap by investigating the relationship between R&D and patent investment and firm ESG performance.

The analysis focused on a sample of 182 companies observed for 8 years from 2013 to 2020, providing an integrative framework highlighting the relationships between the adoption of ESG practices and corporate innovation. We considered the ESG scores to provide insight into the role of companies in contributing to sustainability performance. To this end, we analyzed a company's proactivity in innovating and the potential associations between innovation and ESG performance. The results suggest that companies investing more in innovation (measured by R&D investment and patents) show better ESG performance than less innovative companies. These findings are consistent with the assertion of institutional theory that companies that are more focused on sustainability issues recognize the importance of innovation in achieving these goals, leading to a better corporate image and reputation.

Environmental sustainability and innovation are the two main guidelines of the Next Generation EU which is a European Union plan aimed at supporting member states affected by the COVID-19 pandemic and promoting a sustainable, zero-emission economy. Therefore, innovation, and environmental awareness must be addressed by all players with a univocal and synergistic approach, because for society to rest on solid foundations of development and prosperity in the future, innovation must be increasingly allied with sustainability and vice versa.

Therefore, the positive relationship between ESG performance and innovation is crucial because it signals the awareness of industrial companies of the instrumentality of investment in innovation, both for sustainable development and survival. Indeed, it is essential for companies to integrate sustainability objectives with corporate competitiveness goals, as they represent two closely linked dimensions. In this context, innovation is the most effective way to achieve both corporate and ESG sustainability objectives.

6. Research implications, limitations and future research

The academic community, practitioners and policy makers can draw on the theoretical and practical implications of our results to address the problems of integrating new technologies into ESG sustainability practices with a better understanding of the positive effects of innovation on company sustainability. In this sense, our contribution has practical implications, as the results could spur companies to invest in innovation to realize a positive effect on sustainability.

Given the positive and significant correlation between corporate innovation and ESG practices, national regulators should strengthen laws associated with sustainability practices to ensure greater transparency in disclosure, especially in light of the different theoretical frameworks that exist for non-financial disclosure that limit the comparability of statements (European Commission, 2017).

Regarding the effect of eco-innovation on ESG practices, our study, by showing a positive relationship, provides important practical implications for practitioners and companies investing in innovation. In other words, companies should be encouraged to continuously increase their level of innovation by improving their ESG performance.

Therefore, it would be relevant for policymakers to disseminate specific subsidies for companies' innovation activity, thus indirectly supporting their ESG practices as well.

Finally, we stress the limitations of our study. The data set includes only companies listed in France, Germany, Italy, Spain, the UK and the USA, with specific reference to the industrial sector. Therefore, the results are not generalizable to the universe of companies, operating in other business sectors. In this sense, future research could investigate the effects of the same variables in other contexts. In addition, other factors influencing ESG performance, such as corporate governance, in terms of qualitative and quantitative composition of the board of directors, as well as systematic risk, should be considered in further research. Although our work looks at the logical link between innovation and sustainability, future research could yield interesting information about the relationship between sustainability and evolving generic green digital technologies. Furthermore, future studies could investigate these issues in different economic sectors and examine the differences or similarities between the results.

References

- Ahmad, M. and Wu, Y. (2021), "Combined role of green productivity growth, economic globalization, and eco-innovation in achieving ecological sustainability for OECD economies", *Journal of Environmental Management*, Vol. 302, p. 113980.
- Almeyda, R. and Darmansya, A. (2019), "The influence of environmental, social, and governance (ESG) disclosure on firm financial performance", *IPTEK Journal of Proceedings Series*, Vol. 5, p. 278.
- Alsayegh, M.F., Rahman, R.A. and Homayoun, S. (2020), "Corporate economic, environmental, and social sustainability performance transformation through ESG disclosure", *Sustainability*, Vol. 12 No. 9, doi: [10.3390/su12093910](https://doi.org/10.3390/su12093910).
- Arango-Miranda, R., Hausler, R., Romero-López, R., Glaus, M. and Ibarra-Zavaleta, S.P. (2018), "An overview of energy and exergy analysis to the industrial sector, a contribution to sustainability", *Sustainability*, Vol. 10 No. 2, pp. 1-19.
- Aras, G., Tezcan, N. and Kutlu Furtuna, O. (2018), "The value relevance of banking sector multidimensional corporate sustainability performance", *Corporate Social Responsibility and Environmental Management*, Vol. 25 No. 6, pp. 1062-1073.
- Arena, C., Michelon, G. and Trojanowski, G. (2018), "Big egos can be green: a study of CEO hubris and environmental innovation", *British Journal of Management*, Vol. 29 No. 2, pp. 316-336.
- Atan, R., Razali, F.A., Said, J. and Zainun, S. (2016), "Environmental, social and governance (esg) disclosure and its effect on firm's performance: a comparative study", *International Journal of Economics and Management*, Vol. 10 No. 2, pp. 355-375.
- Barbieri, J.C. (2007), "Organizações inovadoras sustentáveis", in *Organizações inovadoras sustentáveis: uma reflexão sobre o futuro das organizações*, Atlas.
- Barbieri, J.C., Vasconcelos, I.F.G., de Andreassi, T. and Vasconcelos, F.C.D. (2010), "Innovation and sustainability: new models and propositions", *RAE Revista de Administração de Empresas*, Vol. 50 No. 2, pp. 146-154.
- Bpifrance (2018), "France, Germany, Italy, Spain, and the United Kingdom", *Internationalisation of European SMEs – Taking Stock and Moving Ahead*.
- Broadstock, D.C., Matousek, R., Meyer, M. and Tzeremes, N.G. (2020), "Does corporate social responsibility impact firms' innovation capacity? The indirect link between environmental and social governance implementation and innovation performance", *Journal of Business Research*, Vol. 119, pp. 99-110.
- Buallay, A. (2019), "Is sustainability reporting (ESG) associated with performance? Evidence from the European banking sector", *Management of Environmental Quality: An International Journal*, Vol. 30 No. 1, pp. 98-115.

- Campbell, J.L. (2007), "Why would corporations behave in socially responsible ways? An institutional theory of corporate social responsibility", *Academy of Management Review*, Vol. 32 No. 3, pp. 946-967.
- Cappiello, C., Plebani, P. and Vitali, M. (2013), "Energy-aware process design optimization", *Proceedings – 2013 IEEE 3rd International Conference on Cloud and Green Computing*, pp. 451-458, doi: [10.1109/CGC.2013.77](https://doi.org/10.1109/CGC.2013.77).
- Carayannis, E.G., Sindakis, S. and Walter, C. (2015), "Business model innovation as lever of organizational sustainability", *The Journal of Technology Transfer*, Vol. 40 No. 1, pp. 85-104.
- Carrasco, I. and Buendía-Martínez, I. (2016), "From the business strategy result to a source of economic development: the dual role of csr", *Journal of Small Business Strategy*, Vol. 26 No. 1, pp. 69-86.
- Chatterjee, S. and Hadi, A.S. (2012), "Regression analysis by example", *Wiley Series In Probability And Statistics*.
- Chen, H., Zeng, S., Lin, H. and Ma, H. (2015), "Munificence, dynamism, and complexity: how industry context drives corporate sustainability", *Business Strategy and the Environment*, Vol. 26 No. 2, doi: [10.1002/bse.1902](https://doi.org/10.1002/bse.1902).
- Cruz-Cázares, C., Bayona-Sáez, C. and García-Marco, T. (2013), "You can't manage right what you can't measure well: technological innovation efficiency", *Research Policy*, Vol. 42 Nos 6/7, pp. 1239-1250.
- De Klerk, M. and De Villiers, C. (2012), "The value relevance of corporate responsibility reporting: South African evidence", *Meditari Accountancy Research*, Vol. 20 No. 1, pp. 21-38.
- De Santis, F. and Presti, C. (2018), "The relationship between intellectual capital and big data: a review", *Meditari Accountancy Research*, Vol. 26 No. 3, pp. 361-380.
- Deng, X. and Cheng, X. (2019), "Can ESG indices improve the enterprises' stock market performance? An empirical study from China", *Sustainability (Switzerland)*, Vol. 11 No. 17, doi: [10.3390/su11174765](https://doi.org/10.3390/su11174765).
- Do, Y. and Kim, S. (2020), "Do higher-rated or enhancing ESG of firms enhance their long-term sustainability? Evidence from market returns in Korea", *Sustainability*, Vol. 12 No. 7, pp. 1-22.
- Drempetic, S., Klein, C. and Zwergel, B. (2019), "The influence of firm size on the ESG score: corporate sustainability ratings under review", *Journal of Business Ethics*, Vol. 167 No. 2, doi: [10.1007/s10551-019-04164-1](https://doi.org/10.1007/s10551-019-04164-1).
- Du, K.R. and Li, J.K. (2019), "Towards a green world: how do green technology innovations affect total factor carbon productivity", *Energy Policy*, Vol. 131, pp. 240-250.
- Duque-Grisales, E., Aguilera-Caracuel, J., Guerrero-Villegas, J. and García-Sánchez, E. (2020), "Does green innovation affect the financial performance of multinationals? The moderating role of ISO 14001 and R&D investment", *Business Strategy and the Environment*, Vol. 29 No. 8, pp. 3286-3302.
- European Commission (2008), *European Competitiveness Report*, European Commission Enterprise and Industry, available at: www.eurosfair.prd.fr/7pc/doc/1251892016_competitivite_ue_2008.pdf
- European Commission (2017), "Communication from the commission, guidelines on non-financial reporting (methodology for reporting non-financial information)", (2017/C 215/01).
- Eurostat (2016), "Sustainable development in the European Union", A Statistical Glance from the Viewpoint of the Un Sustainable Development Goals 2016, European Union, Vol. 43.
- Farooq, O. (2015), "Financial centers and the relationship between ESG disclosure and firm performance: evidence from an emerging market", *Journal of Applied Business Research (JABR)*, Vol. 31 No. 4, pp. 1239-1244.
- Fernández, S., Torrecillas, C. and Labra, R.E. (2021), "Drivers of eco-innovation in developing countries: the case of Chilean firms", *Technological Forecasting and Social Change*, Vol. 170, doi: [10.1016/j.techfore.2021.120902](https://doi.org/10.1016/j.techfore.2021.120902).
- Gallego-Álvarez, I., Prado-Lorenzo, J.M. and García-Sánchez, I.M. (2011), "Corporate social responsibility and innovation: a resource-based theory", *Management Decision*, Vol. 49 No. 10, pp. 1709-1727.
- García-Sánchez, I.M., Gallego-Álvarez, I. and Zafra-Gómez, J.L. (2021), "Do independent, female and specialist directors promote eco-innovation and eco-design in agri-food firms?", *Business Strategy and the Environment*, Vol. 30 No. 2, pp. 1136-1152.

- García-Sánchez, I.M., Oliveira, M.C. and Martínez-Ferrero, J. (2020), "Female directors and gender issues reporting: the impact of stakeholder engagement at country level", *Corporate Social Responsibility and Environmental Management*, Vol. 27 No. 1, pp. 369-382.
- Ghadimi, P., O'Neill, S., Wang, C. and Sutherland, J.W. (2020), "Analysis of enablers on the successful implementation of green manufacturing for Irish SMEs", *Journal of Manufacturing Technology Management*, Vol. 32 No. 1, doi: [10.1108/JMTM-10-2019-0382](https://doi.org/10.1108/JMTM-10-2019-0382).
- Hsiao, C. (2014), *Analysis of Panel Data, Analysis of Panel Data: Third Edition*, Cambridge University Press, doi: [10.1017/CBO9781139839327](https://doi.org/10.1017/CBO9781139839327).
- Ilyas, I.M. and Osiyevskyy, O. (2021), "Exploring the impact of sustainable value proposition on firm performance", *European Management Journal*, doi: [10.1016/j.emj.2021.09.009](https://doi.org/10.1016/j.emj.2021.09.009).
- Jové-Llopis, E. and Segarra-Blasco, A. (2018), "Eco-innovation strategies: a panel data analysis of Spanish manufacturing firms", *Business Strategy and the Environment*, Vol. 27 No. 8, pp. 1209-1220.
- Kemp, R. and Pearson, P. (2007), "Final report MEI project about measuring eco-innovation", *UM Merit, Maastricht*, Vol. 32 No. 3, pp. 121-124.
- Khaled, R., Ali, H. and Mohamed, E.K.A. (2021), "The sustainable development goals and corporate sustainability performance: mapping, extent and determinants", *Journal of Cleaner Production*, Vol. 311, p. 127599.
- Kotze, D., Malan, H., Ellery, W., Samuels, I. and Saul, L. (2010), "Assessment of the environmental condition, ecosystem service provision and sustainability of use of two wetlands in the Kamiesberg uplands, wetland health and importance research programme".
- Kunz, N.C., Moran, C.J. and Kastle, T. (2013), "Conceptualising 'coupling' for sustainability implementation in the industrial sector: a review of the field and projection of future research opportunities", *Journal of Cleaner Production*, Vol. 53, pp. 69-80.
- Liao, Z. (2020), "Is environmental innovation conducive to corporate financing? The moderating role of advertising expenditures", *Business Strategy and the Environment*, Vol. 29 No. 3, pp. 954-961.
- Liao, Z., Liu, P. and Liu, S. (2021), "A meta-analysis of environmental innovation and firm performance", *Journal of Environmental Planning and Management*, Vol. 64 No. 11, pp. 2047-2065.
- Lombardi, R., Cosentino, A., Sura, A. and Galeotti, M. (2021), "The impact of the EU directive on non-financial information: novel features of the Italian case", *Meditari Accountancy Research*, doi: [10.1108/MEDAR-06-2019-0507](https://doi.org/10.1108/MEDAR-06-2019-0507).
- Lombardi, R. and Secundo, G. (2020), "The digital transformation of corporate reporting – a systematic literature review and avenues for future research", *Meditari Accountancy Research*, Vol. 29 No. 5, doi: [10.1108/MEDAR-04-2020-0870](https://doi.org/10.1108/MEDAR-04-2020-0870).
- Maffei, A., Grahn, S. and Nuur, C. (2019), "Characterization of the impact of digitalization on the adoption of sustainable business models in manufacturing", *Procedia CIRP*, Vol. 81, pp. 765-770, doi: [10.1016/j.procir.2019.03.191](https://doi.org/10.1016/j.procir.2019.03.191).
- Magon, R.B., Thome, A.M.T., Ferrer, A.L.C. and Scavarda, L.F. (2018), "Sustainability and performance in operations management research", *Journal of Cleaner Production*, Vol. 190.
- Marsat, S. and Williams, B. (2014), "Does the market value social pillar? SSRN", *Electronic Journal*, doi: [10.2139/ssrn.2419387](https://doi.org/10.2139/ssrn.2419387).
- Matten, D. and Moon, J. (2008), 'Implicit' and 'explicit' CSR: a conceptual framework for a comparative understanding of corporate social responsibility", *Academy of Management Review*, Vol. 33 No. 2, pp. 404-424.
- Melinda, A. and Wardhani, R. (2020), "The effect of environmental, social, governance, and controversies on firms' value: evidence from Asia", *Advanced Issues in the Economics of Emerging Markets*, Vol. 27.
- Meyer, J. and Roman, B. (1991), "Institutionalized organizations: formal structure as myth and ceremony", *The new institutionalism in organizational analysis*, The University of Chicago Press, Chicago, pp. 1-91.

- Mithani, M.A. (2017), "Innovation and CSR – do they go well together?", *Long Range Planning*, Vol. 50 No. 6, pp. 699-711.
- Naciti, V. (2019), "Corporate governance and board of directors: the effect of a board composition on firm sustainability performance", *Journal of Cleaner Production*, Vol. 237, p. 117727.
- Nartey, E. (2018), "Determinants of carbon management accounting adoption in Ghanaian firms Edward Nartey", *Meditari Accountancy Research*, Vol. 26 No. 1, pp. 88-121.
- Nau, R. (2019), "What 's a good value for R-squared?", *Statistical Forecasting: Notes on Regression and Time Series Analysis*, pp. 1-10.
- Nicolò, G., Zampone, G., Sannino, G. and De Iorio, S. (2021), "Sustainable corporate governance and non-financial disclosure in Europe: does the gender diversity matter?", *Journal of Applied Accounting Research*, Vol. 23 No. 1, doi: [10.1108/JAAR-04-2021-0100](https://doi.org/10.1108/JAAR-04-2021-0100).
- Nowak, A., Leymann, F. and Schumm, D. (2011), "The differences and commonalities between green and conventional business process management", *Institute of Architecture of Application Systems', Institute of Architecture of Application Systems*, doi: [10.1109/DASC.2011.105](https://doi.org/10.1109/DASC.2011.105).
- OECD (2018), TALIS 2018 Technical Report.
- Pasquini-Descomps, H. (2016), "ESG impact on a firm's performance In".
- Qi, S.Z., Lin, S. and Cui, J.B. (2018), "Do environmental rights trading schemes induce green innovation? Evidence from listed firms in China", *Economic Research Journal*, Vol. 53 No. 12, pp. 129-143.
- Recker, J., Rosemann, M., Hjalmarsson, A. and Lind, M. (2012), "modeling and analyzing the carbon footprint of business processes", in Berlin/Heidelberg, S. (Ed.), *Green Business Process Management: Towards the Sustainable Enterprise*, pp. 93-109, doi: [10.1007/s35114-019-0177-4](https://doi.org/10.1007/s35114-019-0177-4).
- Renukkappa, S., Egbu, C., Akintoye, A. and Goulding, J. (2012), "A critical reflection on sustainability within the UK industrial sectors", *Construction Innovation*, Vol. 12 No. 3, pp. 317-334.
- Shahbaz, M., Karaman, A.S., Kilic, M. and Uyar, A. (2020), "Board attributes, CSR engagement, and corporate performance: what is the nexus in the energy sector?", *Energy Policy*, Vol. 143, p. 111582.
- Stolze, C., Semmler, G. and Thomas, O. (2012), "Sustainability in business process management research – a literature review", *18th Americas Conference on Information Systems 2012, AMCIS 2012*, Vol. 6, pp. 4343-4352.
- Su, H.N. (2017), "Global interdependence of collaborative R&D-typology and association of international co-patenting", *Sustainability*, Vol. 9 No. 4, doi: [10.3390/su9040541](https://doi.org/10.3390/su9040541).
- Symons, E.J., Speck, S. and Proops, J.L.R. (2002), "The distributional effects of carbon and energy taxes: the cases of France, Spain, Italy, Germany, and UK", *European Environment*, Vol. 12 No. 4, pp. 203-212.
- Szeto, E. (2000), "Innovation capacity: Working towards a mechanism for improving innovation within an inter-organizational network", *The TQM Magazine*, Vol. 12 No. 2, pp. 149-158.
- Tarquino, L. and Posadas, S.C. (2020), "Exploring the term 'non-financial information': an academics' view", *Meditari Accountancy Research*, Vol. 28 No. 5, pp. 727-749.
- Triguero, A., Fernández, S. and Sáez-Martinez, F.J. (2018), "Inbound open innovative strategies and eco-innovation in the Spanish food and beverage industry", *Sustainable Production and Consumption*, Vol. 15, pp. 49-64.
- US SIF Foundation (2018), "The 2018 report on US sustainable, responsible, and impact investing trends", Washington, DC, available at: www.ussif.org/store_product.asp?prodid=37
- Vincent, C.L., Singh, V., Chakraborty, K. and Gopalakrishnan, A. (2017), "Patent data mining in fisheries sector: an analysis using questel-orbit and espacenet", *World Patent Information*, Vol. 51, pp. 22-30.
- von Hövnik, H.W. and Shankar, D. (2011), "How can SMEs in a cluster respond to global demands for corporate responsibility?", *Journal of Business Ethics*, Vol. 101 No. 2, pp. 175-195.
- Wooldridge, J.M. (2010), *Econometrics Analysis of Cross Sectional and Panel Data*, 2nd ed., The MIT Press, Cambridge, MA.

-
- Xu, J., Liu, F. and Shang, Y. (2021), "R&D investment, ESG performance and green innovation performance: evidence from China", *Kybernetes*, Vol. 50 No. 3, pp. 737-756.
- Ying, Z. and Xin-Gang, Z. (2021), "The impact of renewable portfolio standards on carbon emission trading under the background of China's electricity marketization reform", *Energy*, Vol. 226, p. 120322.
- Zaman, R., Farooq, M.B., Khalid, F. and Mahmood, Z. (2021), "Examining the extent of and determinants for sustainability assurance quality: the role of audit committees", *Business Strategy and the Environment*, Vol. 30 No. 7, pp. 1-20.
- Zhai, Y.M., Sun, W.Q., Tsai, S.B., Wang, Z., Zhao, Y. and Chen, Q. (2018), "An empirical study on entrepreneurial orientation, absorptive capacity, and SMEs' innovation performance: a sustainable perspective", *Sustainability*, Vol. 10 No. 2, doi: [10.3390/su10020314](https://doi.org/10.3390/su10020314).
- Zhang, F., Qin, X. and Liu, L. (2020a), "The interaction effect between ESG and green innovation and its impact on firm value from the perspective of information disclosure", *Sustainability*, Vol. 12 No. 5, doi: [10.3390/su12051866](https://doi.org/10.3390/su12051866).
- Zhang, D., Rong, Z. and Ji, Q. (2019), "Green innovation and firm performance: evidence from listed companies in China", *Resources, Conservation and Recycling*, Vol. 144, pp. 48-55.
- Zhang, Y., Sun, J., Yang, Z. and Wang, Y. (2020b), "Critical success factors of green innovation: technology, organization and environment readiness", *Journal of Cleaner Production*, Vol. 264, p. 121701, doi: [10.1016/j.jclepro.2020.121701](https://doi.org/10.1016/j.jclepro.2020.121701).
- Zhu, Q., Li, X., Li, F., Wu, J. and Sun, J. (2021), "Analyzing the sustainability of China's industrial sectors: a data-driven approach with total energy consumption constraint", *Ecological Indicators*, Vol. 122, p. 107235.

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