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RESEARCH & DEVELOPMENT INTENSITY, ECO-FRIENDLY PRACTICES, AND FIRM VALUE: UNRAVELING THE NEXUS IN THE ENERGY SECTOR

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Research & Development Intensity, Environmental Performance, and Firm Value: Unravelling the Nexus in the Energy Sector Worldwide

ABSTRACT

The lack of a focused study on the nexus of research & development (R&D) intensity, eco-friendly practices, firm value in the energy sector, and the stakeholders' concerns for ecology motivated us to realize this study. The study sample covers the period from 2002 to 2019, resulting in 4,016 firm-year observations affiliated with 43 countries. The data were retrieved from the Thomson Reuters Eikon, and a country-year fixed-effects regression analysis was executed. Our empirical findings are threefold. First, the results show that energy firms' R&D intensity spurs eco-friendly practices in three dimensions, namely resource consumption reduction, emissions reduction, and eco-innovation. Second, our study revealed that corporate environmental performance could induce greater firm value, implying a positive shareholders' reaction to the environmental engagement. Third, moderation analysis revealed that while R&D intensity's interaction with eco-innovation is value-enhancing, its interaction with resource consumption reduction and emissions reduction is not. The results are largely robust to alternative sampling, endogeneity concerns, and alternative variables measurements. The findings suggest implications for energy firms, R&D activities, and capital markets.

KEYWORDS: R&D intensity, environmental performance, eco-innovation, firm value, energy sector

JEL CODES: P18, O32, L10

1. INTRODUCTION

In an era of climate change, due to natural resource restraints, and other socio-environmental pressures, eco-friendly practices have been gradually pushed to the forefront of corporate agenda, communication, and decision-making processes (Haque & Ntim, 2018; Yadav, Han & Rho, 2016). As such, environmental concerns have captured the attention of governments, businesses, and academicians in various ways (Cho & Patten, 2007). Crucially, since the Kyoto Protocol of 1997, the deterioration in major environmental indicators and pollution has continued to rise despite the consciousness of environmental concerns. Hence, the Paris Climate Change Conference in 2015 once again attempted to gather the entire world into recognition of the greatest ever environmental challenges confronted by humanity (Savaresi, 2016). Very recently, in October 2021, the conference of parties (COP) 26[1] , the global summit, aimed to bring various parties together to accelerate action toward the goals of the Paris Agreement and the UN Framework Convention on Climate Change. Based on this, high carbon emitters, such as the US, Germany, the UK, and China, are under enormous international pressure to significantly decrease greenhouse gas (GHG) emissions arising from fossil fuel energy consumption (Randers, 2012). These ecological protocols were vast milestones in shaping awareness about environmental problems created and faced by humans. Addressing these environmental concerns is a step-by-step procedure. The first step in this procedure is accepting these challenges as a more significant threat than first appreciated. Then, an operational plan follows to mitigate these issues, where corporate

[1] COP26 is the United Nations Climate Change Conference that was the 26th United Nations Climate Change conference, held at the SEC Centre in Glasgow, Scotland, UK, between 31 October and 13 November 2021.

environmental performance is regarded as the first step in the operational side of the solution (Gallego-Álvarez, 2018).

Corporations are the first to blame for the increasing trends in GHG emissions due to their energy consumption behaviour (Alam, Atif, Chien-Chi & Soytaş, 2019). As mentioned earlier, because of the growing ecological pressure from international bodies and governments, corporations search for means to reduce their environmental footprint by minimizing pollution and raising energy efficiencies (Porter, Reinhardt, Schwartz, Esty, Hoffman, Schendler & Rendlen, 2007). Nevertheless, investing in environmental matters seems to increase costs, sometimes without leading to financial returns. Consequently, the primary question that managers of firms ask now is how to reduce their companies' environmental impacts without decreasing firm value (Alam et al., 2019; Gerged, Beddewela & Cowton, 2021). In this regard, Yadav et al. (2016) argue that corporations' adherence to environmental regulations by implementing ecological programs to conduct eco-friendly operations can result in obtaining competitive advantages over other competitors and increase their financial value, which is referred to as '*investment with values*'.

The mainstream of extant environmental performance-to-firm value studies indicates inconclusive results. For example, in their study of the added value of the environmental performance of a sample of large US firms, Konar and Cohen (2001) indicate that carbon emissions are negatively associated with various market value measures. Using UK data, Thomas (2001) similarly finds that adopting an environmental policy and prosecution for breach of environment standards are significantly attributable to a corporation's excess returns. Within a more comprehensive investigative framework, Sharfman and Fernando (2008) indicate that better corporate environmental performance results not only in reducing firms' costs of capital but also leads to (i) more incredible tax benefits related to the capability to add debt and (ii) a shift from equity to debt-based financing. Although Klassen and McLaughlin (1996) also suggest that environmental performance is linked with significant positive returns, others (e.g., Bauer & Hann, 2010; Graham, Maher & Northcut, 2001) support a negative relationship between environmental factors and corporate bond ratings. This mixed evidence poses our first question: *Are there any contingencies or conditions under which eco-friendly practices influence firm value?*

Recent literature highlights the '*win-win*' environmental policy notion that investing in eco-friendly activities will add not only ecological benefits but also financial value to firms (Alam et al., 2019; Banerjee & Gupta, 2017; Churchill, Inekwe, Smyth & Zhang, 2019). In this context, research and development (R&D) investments play a considerable role in limiting firms' negative environmental effects without compromising their financial returns (Lee & Min, 2014). In line with the natural resource-based view, firms' allocation of resources to develop new products or services, processes, and technologies, including R&D investments, might simultaneously stimulate firm performance and reduce environmental effects (Padgett & Galan, 2010). Crucially, R&D intensity is often associated with developing innovative machinery and technologies that improve production efficiency with low energy consumption levels, which reduces the energy to output ratio '*energy intensity*' (Chakrabarty & Wang, 2012; Huang, Xiang, Wang & Chen, 2021). Similarly, corporate R&D investments can foster the advancement of new green energy technologies that can play a crucial role in adopting cleaner energy sources

(Jiang, Lin & Lin, 2014). Collectively, R&D intensity can be an essential tool to improve corporate environmental performance, reduce corporations' energy consumption and carbon emissions, and enhance their financial performance (Alam et al., 2019; Churchill, Inekwe & Ivanovski, 2021). As such, we pose the following questions: *Does R&D intensity influence firms' eco-friendly activities? Is the impact of environmental performance on firm value contingent on R&D intensity?*

Furthermore, a body of prior literature lacks a focused study on the energy sector regarding the potential effect of R&D intensity as a contingent factor on the association between eco-friendly practices and firm value. Given the ecological sensitivity of energy industries, we dedicated this study to the investigation of the above-stated relationships in the energy sector worldwide. To answer these questions, our study contributes to the ongoing debate by examining the moderating effect of R&D intensity on the relationship between environmental performance and firm value among a sample of 456 energy firms across 43 countries and over a period from 2002 to 2019 resulting in 4,016 firm-year observations. We employed a fixed-effects regression model to test the main research hypotheses. This technique was supplemented by conducting a two-stage least squares (2SLS) regression model to tackle the possible occurrence of endogeneity concerns. Our empirical findings are threefold. First, our evidence indicates that energy firms' R&D intensity is positively attributed to their eco-friendly practices, including resource consumption reduction, emissions reduction, and eco-innovation. Second, the results show that global stock markets do value energy firms' environmental performance, implying investors' positive reaction to the environmental engagement of these environmentally sensitive firms. Third, moderation analysis revealed that while R&D

intensity’s interaction with eco-innovation is value-enhancing, its interaction with resource consumption and emissions reduction is not. Our results are reasonably robust to different sampling techniques, alternative measures of variables, and endogeneity concerns.

The remainder of this article is designed as follows: Section 2 discusses the theoretical framing of hypotheses. Section 3 explains the methodology and research design, while Section 4 discusses the empirical findings. Section 5 discusses and concludes the key results, and finally, Section 6 provides policy and practitioner implications and suggests agendas for future studies.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

2.1. R&D intensity and eco-friendly practices

Sustainable advantages have become imperative in the modern business world as companies encounter massive environmental pressures from regulatory authorities and the marketplace (Cheng et al., 2014). To address such forces, the natural resource-based view posits that firms can gain sustainable competitive advantages by employing their capabilities and resources for long-term eco-friendly technologies, processes, and products instead of short-term returns (Hart, 1995; Zahor and Gerged, 2021). Thus, the natural resource-based view theory provides a comprehensive perspective on the association between a firm’s resources, competence, and performance, including the foundation for sustainable competitiveness (Alam et al., 2019). Specifically, Padgett and Galan (2010) argue that firms' allocation of resources and capabilities to develop new technologies, processes, and products or services (i.e., among which are firms' investments in R&D) might reduce environmental effects and stimulate financial performance simultaneously.

Even though there is a wide range of literature available on the association between R&D intensity and various aspects of environmental, social, and governance (ESG) performance of firms (e.g., Kabongo & Okpara, 2013; Kabongo, 2019; Xue, Zhang & Li, 2020; Xu, Liu & Shang, 2021), few studies examined the influence of R&D intensity on specific environmental concerns, such as energy conservation, carbon emissions reduction, and eco-innovation (Alam et al., 2019). To the best of our knowledge, there is not a single study focusing on the studied relationships specifically dedicated to the energy sector in an international context. In this regard, Padgett and Galan (2010) provide empirical evidence that shows that R&D intensity is significantly attributable to the CSR performance of environmentally-sensitive industries. In contrast, an insignificant influence is noted in less sensitive industries in the same study. This has motivated our first aim to examine the relationship between corporate R&D intensity and specific environmental concerns such as resource consumption, including energy conservation, GHG emissions reductions, and eco-innovation, among a sample of energy firms worldwide.

A shred of previous studies indicates a positive association of firms' investments in R&D with CSR activities (Hull & Rothenberg, 2008; McWilliams & Siegel, 2000; Rothenberg & Zyglidopoulos, 2007), sustainability performance (Chakrabarty & Wang, 2012; Kabongo, 2019; Khezri, Heshmati & Khodaei, 2021), and various environmental performance aspects (Alam et al., 2019; Jiang et al., 2014; Lee & Min, 2015; Sohag, Begum, Abdullah & Jaafar, 2015). More relatedly, Inglesi-Lotz (2017) and Sohag et al. (2015) indicate that R&D intensity enables economies and companies to shift from non-renewable to renewable and green energy sources, minimizing energy costs and consumption. Likewise, Ahmed, Uddin, and Sohag (2016), Alam et al. (2019), and Lee and Min (2015) find that R&D intensity and technological progress have a significant effect on reducing carbon emissions in various settings around the world, such as Japan, EU, and G6 countries, respectively. Similarly, Scarpellini, Aranda, Aranda, Llera, and Marco (2012), Demirel and Kesidou (2019), and Lee and Min (2015) claim that investing in R&D provides firms with the specific and relevant technological resources to enable technology transition towards environmental sustainability, improving their eco-innovation capabilities. Theoretically, the natural resource-based view suggests that devoting companies' capabilities and resources to environmental activities assists them in achieving sustainable competitiveness by minimizing energy consumption and GHG emissions (Hart, 1995).

Our review of the extant body of literature indicates that little is known about the possible effect of corporate R&D intensity on energy consumption, carbon emissions, and eco-innovation in the energy sectors worldwide. Therefore, we address the first objective of the current study by testing the following hypothesis:

> H1: R&D intensity stimulates eco-friendly practices (i.e., resource consumption reduction, emissions reduction, and eco-innovation) in the energy sector.

2.2. Environmental performance and firm value

In line with the resource-based view perspective, Hart (1997) argues that firms' sustainable competitiveness is linked with effectively developing organizational values, establishing efficient communication channels with influential stakeholders, and integrating firms' environmental objectives into managerial strategies. Resource-based view theory further posits that eco-friendly performance is a way through which firms obtain a competitive advantage, enhancing their market value (Utomo, Rahayu, Kaujan & Irwandi, 2020).

Sarkis (2006) indicates that firms are motivated by various internal strategic benefits and regulatory requirements to tackle a crucial management challenge of environmental sustainability concerns. In this regard, Capelle-Blancard and Laguna (2010) explored how the stock exchange responds to ecological disasters by highlighting the case of 64 explosions in chemical refineries and plants internationally from 1990 to 2005. After disastrous environmental incidents, the study reported a 1.3% decrease in firms' market value. Similarly, Lee and Garza-Gomez (2012) indicate that the Deepwater Horizon oil spill cost was estimated at $251.9 billion in September 2010. Thus, an influence of an unexpected environmental incident in a competitive marketplace may reduce a firm's market value substantially. Contrarily, corporate engagement in eco-friendly practices can increase firm value (Muhammad, Scrimgeour, Reddy & Abidin, 2015).

Several prior studies indicate a negative influence of environmental performance on firm value (e.g., Bauer & Hann, 2010; Graham, Maher & Northcut, 2001). In contrast, the mainstream existing literature suggests a positive association between environmental performance and firm value in various developed and developing settings around the world, such as the US (e.g., Al-Tuwaijri, Christensen & Hughes, 2004; Konar & Cohen, 2001), the UK (e.g., Broadstock, Collins, Hunt & Vergos, 2018; Thomas, 2001), Australia (e.g., Muhammad et al., 2015a; 2015b), Malaysia (e.g., Che-Ahmad & Osazuwa, 2016), Indonesia (e.g., Sarumpaet, Nelwan & Dewi, 2017) and most relatedly in international *multi-sectoral* studies (e.g., Xie, Nozawa, Yagi, Fujii & Managi, 2019; Zuraida, Houqe &

van Zijl., 2018). In a meta-analysis of 64 findings from 37 empirical studies, Horváthová (2010) revealed that a positive relationship between environmental performance and firm value is found more often in common law states than in their civil law counterparts. Nevertheless, the extant literature lacks a sectoral study that investigates the possible value relevance of eco-friendly practices in energy sectors worldwide. Thus, in light of recourse-based view theory and the above reviews of relevant studies, we address the second objective and contribute to the existing body of knowledge by examining the following hypothesis:

> H2: Eco-friendly practices (i.e., resource consumption reduction, emissions reduction, and eco-innovation) fosters firm value in the energy sector.

2.3. The moderating role of R&D intensity

The inconclusive results of previous studies regarding the impact of eco-friendly activities on firm value (*See* Horváthová, 2010) suggest a potential effect of other contingencies and conditions under which eco-friendly activities can engender greater market value of firms. Based on the natural resource-based view, firms can obtain sustainable competitiveness through R&D investment; that is, allocating firms' resources for new products or services, processes, and technologies may help firms improve operational efficiency, reduce environmental adversities (Alam et al., 2019), and thus, increase firms' market value (Xie et al., 2019). Consequently, it has been argued that effective R&D investment might create a '*win-win*' situation by improving the firm's environmental and financial performance subsequently (Hazarika, 2021; Jiang & Fu, 2019). Thus, we argue that the value relevance of eco-friendly activities is contingent on the R&D investments of firms. For example, King and Lenox (2002) claim that when a firm allocates resources to R&D investments, this enhances productivity and reduces environmental costs, and leads to increased market value. Similarly, McWilliams and Siegel (2001) indicate that incurring costs in eco-friendly activities influences a firm's reputation, boosting its value. Additionally, Hazarika (2021) finds that R&D investment reaps financial returns that sooner or later will offset the initial investment cost.

Therefore, we argue that an environmentally active firm may simultaneously enjoy both environmental benefits and financial returns from its investment in R&D. Given this, our paper addresses the third objective and adds to this ongoing debate by examining the possible moderating influence of R&D intensity on the relationship between eco-friendly activities and financial performance of energy firms worldwide by testing the following hypothesis:

H3: R&D intensity positively moderates the relationship between eco-friendly practices (i.e., resource consumption reduction, emissions reduction, and eco-innovation) and firm value in the energy sector.

The theoretical background of the study is illustrated in Figure 1.

[Insert Figure 1 here]

3. RESEARCH METHODOLOGY

In the research methodology section, multiple data analysis methods with the relevant justifications are investigated in detail. The raw data is retrieved from the database, cleaned, and subject to the purification steps. After the data preprocessing step, the research variables are defined and examined using the univariate analysis with descriptive statistics. Then, the research variables are examined based on the bivariate linear correlation analysis. In the baseline research analysis section, country-year fixed-effects regression analysis, as well as the moderation analysis, are performed to examine the research models. Finally, the robustness of the results from the baseline research analysis is tested using 2SLS regression analysis, an alternative moderator for the moderation analysis, and alternative sampling by excluding the US-based firms.

3.1. Variables' description

The research design involves four sets of variables: eco-friendly practices, firm value, R&D intensity, and control variables.

In line with prior studies (Banerjee et al., 2019; Orazalin & Baydauletov, 2020), eco-friendly practices are measured by the following three dimensions of the environmental pillar as presented in Thomson Reuters Eikon: resource consumption reduction (RESUSE), emissions reduction (EMISSN), and eco-innovation (ECOINN). All these variables are measured based on a scale of 0 to 100. More specifically, RESUSE depends on themes including energy, water, sustainable packaging, and environmental supply chain, among others, which is further evaluated from 20 metrics from company public disclosures. EMISSN, on the other hand, is based on themes such as emissions, waste, biodiversity, and environmental management systems, among others, and is assessed from 28 metrics. ECOINN is contingent upon product innovation, green revenues, and environmental R&D expenditures, among others, and is measured from 20 metrics (Refinitiv, 2022).

Firm value is measured by TOBINQ1 in the baseline analysis, which is proxied by market capitalization plus total liabilities scaled by total assets (Chen et al., 2020; Cummins et al., 2006). Subsequently, we use TOBINQ2 in the robustness tests, which is proxied by market capitalization plus total debt scaled by total assets (Govindan et al., 2021; Kuzey et al., 2021).

In line with previous studies, R&D intensity (R&D_INT) is proxied by the research and development expenditures scaled by total assets (Banerjee et al., 2019; Hsu et al., 2015; Xiao, 2013). In the robustness tests, we adopt R&D_DUM, dummy variable refers to 1 if research and development expenditures exist, and otherwise 0 (Dilling-Hansen et al., 2003). Following prior studies, we set missing R&D values equal to zero (Henderson et al., 2006; Miller et al., 2009).

Following prior studies (Govindan et al., 2021; Kuzey et al., 2021), we also incorporated a battery of control variables into the research design, which is likely to affect the eco-friendly practices of firms as well as their firm value. Among board structure controls, we included the number of directors on the board as board size (BORDSIZE), percentage of non-executive directors on boards as board independence (BORDIND), and CEO duality (CEODUAL), referring to the combination of chairman and CEO position into one person. Among financial characteristics, we included the natural logarithm of total assets as firm size (FIRMSIZE), return on assets as profitability (ROA), and LEVERAGE as the proportion of total liabilities to total assets. Lastly, FREEFLOAT referring to the percentage of shares freely available to stockholders for trading is added as ownership structure control.

All variables are listed and defined in Table A1 in Appendix.

3.2. Sample

The research sample includes 43 countries, 456 unique firms within the countries, and 4,016 data points between 2002 and 2019 in the energy sector (Please see Table A4 in the Appendix section). The sample distribution based on years is presented in Table 1. The number of observations ranges between 17 (0.42%) and 456 (11.35%), with a steady increase each year.

The data screening process is very crucial before examining the research models and testing the research hypotheses (Hair et al., 2019). The raw data is retrieved and subject to the purification phase. The raw data is cleaned by removing the typos and strings within the numerical values, converting the categorical variables to the numerical variables by defining the value labels, organized the variables and records in a spreadsheet environment. Then, it is prepared for the forthcoming analysis by importing the data analysis software for the next analysis approaches. The research data includes firm-year observations in the energy sector.

The initial descriptive statistics of the research variables show that some of the variables are heavily skewed with large variability around the mean values. Thus, TOBINQ1, TOBINQ2, R&D_INT, BORDSIZE, ROA, and LEVERAGE are winsorized at the one percent level of the two tails by replacing the extreme values at both ends with the winsorized counterpart values (Cox, 2006).

In the next phase, the multivariate outliers are investigated using the minimum covariance determinant-MCD method (Verardi & Dehon, 2010) that can robustify the Mahalanobis distance. The results reveal that nine significant outliers were detected and removed from the research sample. Following this phase, 4,016 observations between 2002 and 2019 are left for the forthcoming analysis.

Next, the missing data analysis is performed based on the frequency analysis with the ratios. The distribution of the missing values indicates that ECOINN has 1.79% of firm-year missing records, TOBINQ1 has 1.27%, TOBINQ2 has 1.27%, R&D_INT has 0.40%, BORDSIZE has 0.12%, BORDIND has 1.99%, FIRMSIZE has 0.35%, ROA has 0.95%, LEVERAGE has 0.35%, and FREEFLOAT has 2.32% firm-year missing observations. The ratios of the missing values are significantly less than 10% as well as 5%. Missing observations with less than a ratio of 5% are inconsequential (Schafer, 1999). Moreover, missing values with more than a ratio of 10% may likely generate biased results in the statistical analyses (Bennett, 2001).

In the final phase of the data preprocessing, the imputation step is performed. Although the ratios of the missing values of the research sample are less than 5% and significantly less than 10%, the aforementioned variables with the missing values are subject to the imputation phase. For the imputation, the Markov Chain Monte Carlo (MCMC) imputation method is utilized with linear regression as the model type for scale variables.

[Insert Table 1 here]

3.3. Empirical methodology

The empirical methodology section includes the formulation of the research models as well as the justifications for the selection of the approaches in detail. The baseline research models are analyzed using the fixed-effects (FE) panel regression analysis. The country is used as the panel variable. The research models are subject to the country-year FE panel regression analysis to alleviate the possible time-variant endogeneity concerns (Feenstra et al., 2013; Nunn, 2007; Rjiba et al., 2020; Schons & Steinmeier, 2016). Furthermore, the FE panel regression analysis has certain benefits as well. It alleviates the possible risk of multicollinearity estimation bias (Baltagi, 2005) and can control the omitted variable bias (Wooldridge, 2010).

Three post-estimation tests are performed to examine the correct estimator. First, the F-test is used to determine the appropriateness of applying either FE panel regression or Ordinary Least Square (Pooled OLS) regression analysis. The result of the F-test shows that FE panel regression should be used instead of the pooled OLS regression analysis (F-test - p-values < 0.05). Moreover, the Breusch-Pagan Lagrange Multiplier (LM) reveals that random-effects (RE) panel regression analysis should be used instead of pooled OLS regression analysis (LM test – P-values < 0.05). Finally, Hausman's test reveals that FE panel regression analysis should be used instead of RE panel regression analysis (Hausman's test – p-values < 0.05). The three post-estimation results indicate that FE panel regression analysis is the most appropriate data analysis method to use for testing the research hypotheses. The formulation of the research models based on the functional relationship between the dependent and the independent variables is presented in equation (1) below.

$$y_{it} = \alpha + \beta X_{it} + \vartheta_{it} + \epsilon_{it} \qquad (1).$$

The dependent variables are RESUSE, EMISSN, ECOINN, TOBINQ1, and TOBINQ2, represented by "y_i" term in equation (1). Moreover, R&D_INT, R&D_DUM, RESUSE, EMISSN, and ECOINN are the independent testing variables. They are included in the analyses separately. Also, BORDSIZE, BORDIND, CEODUAL, FIRMSIZE, ROA, LEVERAGE, and FREEFLOAT are the independent control variables. The independent testing and the control variables are represented by the "X_i" term.

There are two sets of dependent variables and two sets of independent testing variables. In the first group, the dependent variables, including RESUSE, EMISSN, and ECOINN, are subject to the analysis together with the independent testing variables such as R&D_INT and R&D_DUM. In the second group, the dependent variables, including TOBINQ1 and TOBINQ2, are subject to the analysis together with the independent variables such as RESUSE, EMISSN, and ECOINN. The aforementioned control variables are included in both groups of the research models. Furthermore, the Country is defined as the panel variable while the Year is included as the dummy variable in the analysis.

The term “$\vartheta_i + \epsilon_i$” represents the country-specific error term as well as the regular error term in equation (1). Finally, the robust standard errors (heteroscedasticity-consistent errors) are reported in the regression analysis using the Huber-White sandwich estimator (Huber, 1967; White, 1980). The heteroscedasticity-consistent errors can alleviate the risk of the heteroscedasticity issue (Wooldridge, 2020).

3.4. Multicollinearity

The multicollinearity analysis is performed to determine if there is any significantly large linear correlation among the independent variables. The Variance Inflation Factor (VIF) of the independent variables of the research models is calculated (Please see Table A2 in the Appendix section). The results show that the values of VIF range between 1.04 and 2.11, which are significantly less than the suggested cut-off value of 10 (Hair et al., 2019; Kennedy, 2008; Neter et al., 1996). Thus, there is no risk of multicollinearity among the independent variables of the research models.

3.5. Moderation analysis

The moderation analysis is implemented to examine the research hypothesis. In this regard, the moderating role of R&D_INT on the relationship of RESUSE, EMISSN, and ECOINN with TOBINQ1 and TOBINQ2 is examined. Toward this end, Hayes's (2017) moderation analysis method using a Stata module developed by Jose (2013) is utilized. The formulation of the moderation analysis of the research models is shown in equation (1) below.

$$y_i = \alpha + \beta_1 x_{1i} + \beta_2 M_i + \beta_3 (x_{1i} * M_i) + \beta_4 x_{2i} + \epsilon_{it} \qquad i = 1,\ldots,N \qquad (2)$$

In equation (2), TOBINQ1 and TOBINQ2 are the dependent variables denoted by the "y_i" term. Also, RESUSE, EMISSN, and ECOINN are the independent testing variables denoted by the "x_{1i}" term. Moreover, R&D_INT is the moderating variable denoted by the "M_i" term. Finally, BORDSIZE, BORDIND, CEODUAL, FIRMSIZE, ROA, LEVERAGE, and FREEFLOAT are the independent control variables denoted by the "x_{2i}" term. The Country and Year variables are included in the analysis as the dummy control variables.

4. FINDINGS

4.1. Descriptive statistics

The summary of the research variables based on mean, standard deviation, minimum, maximum, and the number of observations is presented in Table 2. The results show that the mean value of RESUSE is 36.58, EMISSN is 40.46, ECOINN is 12.49, TOBINQ1 is 1.51, and TOBINQ2 is 1.24 with a relatively small or moderate variability around mean values. Moreover, the mean value of R&D_INT is 0.01, while 39.37% of the firm-year observations of R&D_DUM exist. The mean values of three environmental performance proxies are less or more similar to the mean values of RESUSE, EMISSN, and ECOINN in the transportation and logistics sector, which are 39.45, 40.82, and 13.01, respectively (Kuzey et al., 2022). Furthermore, the mean value of TOBINQ2 appears to be smaller than Tourism (i.e., 1.91), Healthcare (i.e., 1.58) sectors but greater than the Finance sector (i.e., 0.81) (Kuzey et al., 2021). However, to make a more consistent comparison between the energy sector and other sectors, we thought that it would be more convenient to calculate the mean values of the key variables of ten major business sectors presented in the Thomson Reuters Eikon database for the same sample period. Hence, based on Table A3 in Appendix, it is observed that the energy sector has moderate RESUSE and EMISSN scores, but it has the weakest ECOINN score relative to other sectors. This highlights the sector's need to focus more on eco-innovation to develop more sustainable solutions to ecological concerns in the long term. In terms of TOBINQ1, TOBINQ2, R&D_DUM, and R&D_INT, the energy sector has moderate mean values compared to other sectors.

[Insert Table 2 here]

4.2. Correlation analysis

The bivariate linear correlation analysis of the research variables is investigated (Table 3). The correlation analysis is based on Pearson's Correlation coefficients. The results show that R&D_DUM has a significant and positive linear correlation with RESUSE ($p<0.05$), EMISSN ($p<0.05$), and ECOINN ($p<0.05$), while it does not have a significant correlation with TOBINQ1 and TOBINQ2. Moreover, R&D_INT has a negative and significant linear correlation with RESUSE ($p<0.05$) and EMISSN ($p<0.05$), while it has a significant and positive linear correlation with TOBINQ1 ($p<0.05$) and TOBINQ2 ($p<0.05$). Finally, R&D_INT does not have a significant linear correlation with ECOINN.

[Insert Table 3 here]

4.3. Baseline analysis

The first group of the research models is subject to country-year FE regression analysis. The results are provided in Table 4, where the dependent variables are RESUSE, EMISSN, and ECOINN, while the independent testing variables are R&D_INT and R&D_DUM. The results reveal that R&D_INT and R&D_DUM[2] have a significant and positive relationship with RESUSE ($p<0.01$), EMISSN ($p<0.01$), and ECOINN ($p<0.01$). Hence, H1 is supported.

[Insert Table 4 here]

The second group of the research models is also subject to the country-year FE regression analysis (Table 5). In this group, the dependent variables are TOBINQ1 and TOBINQ2, while the independent testing variables are RESUSE, EMISSN, and ECOINN. The results indicate that RESUSE ($p<0.01$), EMISSN ($p<0.01$), and ECOINN ($p<0.01$) have a significant and positive relationship with TOBINQ1 and TOBINQ2[3]. Thus, H2 is accepted.

[Insert Table 5 here]

4.4. Moderation analysis

The baseline research models also incorporate the moderation analysis. The moderating role of R&D_INT on the relationship of RESUSE, EMISSN, and ECOINN with TOBINQ1 and TOBINQ2 is investigated (Table 6). The results reveal that the interaction variable of *ECOINN x R&D_INT* ($p<0.01$) has a significant and positive association with TOBINQ1 and TOBINQ2, while the coefficients of the interaction variables, including *RESUSE x*

[2] R&D_DUM is used as an alternative proxy for R&D_INT as a robustness test.
[3] TOBINQ2 is used as an alternative firm value proxy for TOBINQ1 as a robustness test.

R&D_INT and *EMISSN x R&D_INT,* are not statistically significant. Therefore, R&D_INT is a significant moderator of the relationship of ECOINN with TOBINQ1 and TOBINQ2. Thus, H3 is accepted only for ECOINN but not RESUSE and EMISSN.

[Insert Table 6 here]

4.5. Robustness tests

This section includes various analyses to test the robustness of the results from the baseline analysis. Four further analyses are performed, including an alternative estimator, alternative moderating variable, and alternative sample by excluding the US-based firms.

First, 2SLS regression analysis is performed as an alternative analysis method to address endogeneity concerns. The results are provided in Table 7. One-year lag of the independent testing variables is included in the 2SLS regression analysis as the instrumental variables since they can be likely to be correlated with the endogenous variables while they cannot be correlated with the error term (Bellemare et al., 2017; Godos-Díez et al., 2018; Gong & Ho, 2018; Ngare et al., 2014; Orazalin et al., 2019; Wooldridge, 2010, Wooldridge, 2020). Thus, the lag of R&D_INT (Columns # 1-3) and lag of RESUSE, EMISSN, and ECOINN (Columns # 4-6) as the instrumental variables are utilized in the 2SLS method. The method of 2SLS has the advantage of alleviating the possible endogeneity issue and the omitted variable bias (Angrist & Alan, 2001). Therefore, these two important concerns are addressed by alleviating the likely correlation between the error term and the independent variables (Cui et al., 2018; Sun & Yu, 2015; Wooldridge, 2013). The 2SLS regression analysis approach is a commonly used method to handle the endogeneity concerns that may take place when some of the independent variables are likely to be correlated with the unobserved error term. It is widely used since it may reduce the parameter estimation inconsistencies in accounting research (Larcker & Rusticus, 2010).

The results show that R&D_INT ($p<0.01$) has a significant and positive relationship with RESUSE, EMISSN, and ECOINN. Moreover, the results reveal that RESUSE ($p<0.01$), EMISSN ($p<0.01$), and ECOINN ($p<0.10$) have a significant and positive relationship with TOBINQ2. The outcome of this test completely validates the baseline analysis.

[Insert Table 7 here]

Second, another alternative approach is performed to address the endogeneity concern. To this end, we incorporate a Two-Step GMM-Based dynamic panel regression method which can reduce the endogeneity threat (Wooldridge, 2010; Naik & Padhi, 2015). In the analysis results, the Two-step GMM estimator with WC-robust (Windmeijer, 2005) bias-corrected variance-covariance-estimator type of standard errors are reported to handle the heteroskedasticity concern as well. In the analysis, GMM-type instruments for differenced equations are generated, and the first difference of all independent variables are used as standard instruments. Accordingly, the baseline research models are re-examined (Table 8). The results of the Two-Step GMM-based dynamic panel regression analysis are compatible with the initial analysis results.

[Insert Table 8 here]

Third, an alternative moderator variable is used to examine the moderation analysis. Toward this end, R&D_DUM is used as an alternative moderator. Thus, the moderating role of R&D_DUM on the relationship of RESUSE, EMISSN, and ECOINN with TOBINQ1 and TOBINQ2 is investigated (Table 9). The results reveal that the interaction variables of *RESUSE x R&D_DUM* (p<0.01) and *EMISSN x R&D_DUM* (p<0.05) have a significant and positive relationship with TOBINQ1 and TOBINQ2 while the coefficients of the interaction variable of *ECOINN x R&D_DUM* are not significant. This alternative test produced results just opposite to the baseline moderation analysis reported in Table 6, where *R&D_INT* was the moderator. Although these two opposing findings appear to reveal a contradiction, indeed, they highlight very well the difference between *R&D_INT* and *R&D_DUM* in leveraging eco-friendly practices to firm value. While *R&D_DUM* is sufficient to stimulate RESUSE and EMISSN, it is not for ECOINN. ECOINN requires deeper R&D activity proxied by *R&D_INT* to appease shareholders.

[Insert Table 9 here]

Finally, an alternative sub-sample excluding the US-based firms is generated for the baseline research models. The baseline research models, including the moderation role of R&D_INT on the relationship of RESUSE, EMISSN, and ECOINN with TOBINQ2, are analyzed using the alternative sample excluding the US-based firms (Table 10). The results show that R&D_INT (p<0.01) has a significant and positive association with RESUSE, EMISSN, and ECOINN (Columns #1, 2, and 3). Also, the results reveal that RESUSE (p<0.01), EMISSN (p<0.01), and ECOINN (p<0.01) have a significant and positive relationship with TOBINQ1 (Columns #4, 5, and 6). Finally, the outcome highlights that the interaction variables of *RESUSE x R&D_INT* (p<0.05) and *ECOINN x R&D_INT* (p<0.01) are significant, while the coefficient of the interaction variable of *EMISSN x R&D_INT* is not significant (Columns # 7, 8, and 9). While these outcomes are completely in line with the baseline analysis of indirect relationships, they diverge from the baseline moderation analysis at one point. While the interaction variable *ECOINN x*

R&D_INT has a significant positive association with firm value in both the baseline analysis (whole sample) and this robustness test (excluding the US), the interaction variable *RESUSE x R&D_INT* has a significant positive association with firm value in the sample excluded the US per se. This shows the discrepancy between US shareholders and other countries' shareholders in assessing resource reduction's interaction with R&D activity.

[Insert Table 10 here]

5. DISCUSSION AND CONCLUSION

Due to the energy sector's sensitivity to the environment and stakeholders' ecological concerns, we dedicated this study to the energy sector's eco-friendly practices, including resource consumption reduction, emissions reduction, and eco-innovation. Furthermore, the lack of a focused study on the nexus of R&D intensity, eco-friendly practices, and firm value in the energy sector motivated us to realize this study. Hence, we aim to explore whether energy firms' R&D activities involve addressing ecological concerns and also whether environmental engagement drives firm value. Besides, the study investigates whether shareholders approve energy firms' allocation of R&D resources to environmental activities. The findings suggest implications for energy firms, R&D activities, and capital markets.

First, the results show that energy firms' R&D intensity spurs eco-friendly practices in three dimensions, namely resource consumption reduction, emissions reduction, and eco-innovation. This outcome confirms the findings of a Japanese study (Lee & Min, 2015) and also a G6 countries study (Alam et al., 2019) which concluded that R&D intensity reduces carbon emission. Our finding extends some prior studies which investigated and explored the association between R&D intensity and aggregate CSR performance (Padgett and Galan, 2010; Fu et al., 2020). Second, highlighted three environmental practices induce greater firm value implying the shareholders' positive reaction to the environmental engagement. This finding is in line with prior studies which found that environmental performance is positively associated with accounting performance in the US (Hoang et al., 2020; Bassetti et al., 2021), accounting and market performance in the hospitality sector (Ioannidis et al., 2021), accounting and market performance in the cross-country and cross-industry setting (Miroshnychenko et al., 2017). However, Horváthová (2010), based on a meta-analytic study, concludes that the association between environmental and financial performance is still inconclusive, which may be attributable to the variations among the samples, country coverage, sector coverage, and variables used in the past studies. Third, moderation analysis revealed that while R&D intensity's interaction with eco-innovation is value-enhancing, its interaction with resource consumption reduction and emissions reduction is not. The finding suggests firms distinguish between eco-innovation and traditional environmental practices (i.e., resource consumption reduction and emissions reduction) (Geng et al., 2021). Although it is argued that R&D intensity might lead to a 'win-win' situation by fostering both environmental and financial performance (Hazarika, 2021; Jiang & Fu, 2019), this finding implies that this moderation is contingent upon the dimensions of eco-friendly practices in the energy sector. Additionally, the moderating effect of R&D intensity between eco-innovation and firm value justifies that firms investing in R&D reap their financial returns sooner or later, offsetting their initial investment cost (Duque-Grisales et al., 2020; Hazarika, 2021). The results are largely robust to alternative sampling, endogeneity concerns, and alternative variables measurements.

6. IMPLICATIONS AND FUTURE RESEARCH PERSPECTIVE

While pursuing financial goals, it is imperative to address stakeholders' growing ecological concerns in a world increasingly becoming more polluted as a result of economic activities. The energy sector is under the spotlight in these growing concerns, and its legitimacy is under the scrutiny of various stakeholders, particularly environmentalists[4]. The sector is also in the face of heavy regulatory sanctions as a result of incompatibilities[5].

Theoretically speaking, our empirical evidence gives credibility to the idea of a '*win-win*' environmental policy that implies that allocating resources to R&D investments will add not only environmental benefits but also financial value to firms in line with the natural resource-based view.

The findings also suggest several implications for energy firms, R&D activities, and shareholders. First, the relationship between R&D intensity and eco-friendly practices implies that energy firms should embed ecological concerns within R&D activities and shape their product and process development accordingly. Besides, firms are suggested to budget their R&D expenditures incorporating this relationship between R&D and environmental engagement. As all three eco-friendly practices are significant, the firms can develop a detailed corporate strategy for integrating resource consumption reduction, hazardous emission reduction, and eco-innovation into R&D activities. Second, although stockholders approve of the value relevance of all three eco-friendly activities, they

[4] Please see Stasch and Crane (2018).
[5] BP paid more than $60 billion for the spill it caused in the Gulf of Mexico (The Conversation, 2010).

confirm the allocation of R&D expenditures to eco-innovation but not to resource consumption reduction and emissions reduction. The differential market reaction to three eco-practices may suggest firms distinguish them and help firms configure their environmental engagement in co-consideration of them with R&D. The findings may assist existing and potential shareholders of energy firms, particularly those who seek socially responsible investment, in formulating their portfolios by integrating the environmental concerns. Furthermore, the results might jointly inspire other polluting sectors to shape their environmental engagement and R&D activities.

As the sample includes energy firms, the validity of the results in other sectors may require further justification. Future studies can explore the relevancy of other external and internal contingencies' roles in linking eco-friendly practices and R&D activities and whether they jointly trigger greater market performance. For example, the strength of board monitoring, CSR configurations, and external factors (i.e., regulations) may augment the positioning of the firms in terms of investigated relationships in the study.

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Table 1: Sample distribution across years

Variable	Category	Freq.	Percent
Sector	Energy	4,016	100.00
	Total	*4,016*	*100.00*
Year	2002	17	0.42
	2003	41	1.02
	2004	69	1.72
	2005	97	2.42
	2006	103	2.56
	2007	121	3.01
	2008	153	3.81
	2009	192	4.78
	2010	220	5.48
	2011	249	6.20
	2012	264	6.57
	2013	275	6.85
	2014	290	7.22
	2015	310	7.72
	2016	346	8.62
	2017	389	9.69
	2018	424	10.56
	2019	456	11.35
	Total	*4,016*	*100.00*

Table 2: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
RESUSE	4,016	36.58	33.93	0	99.75
EMISSN	4,016	40.46	33.49	0	99.76
ECOINN	4,016	12.49	24.21	0	90.91
TOBINQ1	4,016	1.51	1.11	0.62	9.36
TOBINQ2	4,016	1.24	1.11	0.08	9.11
R&D_DUM	4,016	0.39	0.49	0	1
R&D_INT	4,016	0.01	0.02	0	0.27
BORDSIZE	4,016	9.35	3.21	4	21
BORDIND	4,016	78.32	14.99	0	100
CEODUAL	4,016	0.39	0.49	0	1
FIRMSIZE	4,016	22.31	1.87	10.65	26.74
ROA	4,016	0.06	0.1	-0.37	0.36
LEVERAGE	4,016	0.53	0.21	0.05	1.16
FREEFLOAT	4,016	74.50	27.06	0	100

Table 3: Pearson correlation analysis

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	RESUSE	1													
2	EMISSN	0.810*	1												
3	ECOINN	0.381*	0.385*	1											
4	TOBINQ1	-0.125*	-0.165*	-0.097*	1										
5	TOBINQ2	-0.149*	-0.190*	-0.124*	0.990*	1									
6	R&D_DUM	0.148*	0.139*	0.110*	-0.007	-0.009	1								
7	R&D_INT	-0.069*	-0.104*	0.002	0.156*	0.163*	0.347*	1							
8	BORDSIZE	0.426*	0.485*	0.258*	-0.121*	-0.145*	0.134*	-0.104*	1						
9	BORDIND	0.123*	0.143*	0.046*	-0.043*	-0.047*	-0.02	-0.045*	0.008	1					
10	CEODUAL	-0.092*	-0.091*	-0.002	0.054*	0.048*	0.035*	-0.02	0.103*	-0.033*	1				
11	FIRMSIZE	0.514*	0.588*	0.253*	-0.263*	-0.285*	0.171*	-0.232*	0.568*	0.139*	0.113*	1			
12	ROA	0.126*	0.153*	-0.031*	0.106*	0.088*	-0.063*	-0.332*	0.182*	0.093*	0.046*	0.351*	1		
13	LEVERAGE	0.149*	0.186*	0.122*	0.011	-0.051*	-0.091*	-0.183*	0.149*	0.036*	0.106*	0.224*	0.026	1	
14	FREEFLOAT	-0.173*	-0.170*	-0.091*	0.022	0.037*	-0.025	0.040*	-0.104*	0.173*	0.097*	-0.047*	-0.042*	-0.057*	1

$p<0.05$

Table 4: Regression analysis with country-year FE for the association between R&D intensity and eco-friendly practices

Independent variables	(1) RESUSE	(2) EMISSN	(3) ECOINN	(4) RESUSE	(5) EMISSN	(6) ECOINN
R&D_INT	90.7^{***}	73.9^{***}	59.5^{***}			
	(5.00)	(4.46)	(3.65)			
R&D_DUM				4.40^{***}	3.76^{***}	3.53^{***}
				(5.28)	(4.93)	(4.71)
BORDSIZE	1.67^{***}	1.78^{***}	1.40^{***}	1.66^{***}	1.77^{***}	1.39^{***}
	(9.21)	(10.72)	(8.58)	(9.19)	(10.69)	(8.53)
BORDIND	0.100^{***}	0.15^{***}	0.0069	0.098^{***}	0.14^{***}	0.0058
	(2.87)	(4.55)	(0.22)	(2.82)	(4.51)	(0.19)
CEODUAL	-0.53	-2.60^{***}	1.25	-0.69	-2.73^{***}	1.12
	(-0.57)	(-3.05)	(1.49)	(-0.74)	(-3.21)	(1.34)
FIRMSIZE	9.39^{***}	10.2^{***}	3.23^{***}	8.98^{***}	9.89^{***}	2.92^{***}
	(30.97)	(36.88)	(11.85)	(29.29)	(35.25)	(10.60)
ROA	5.11	5.60	-15.4^{***}	0.52	1.97	-18.0^{***}
	(1.04)	(1.24)	(-3.48)	(0.11)	(0.46)	(-4.24)
LEVERAGE	5.10^{**}	6.23^{***}	1.83	4.90^{**}	6.12^{***}	1.88
	(2.57)	(3.43)	(1.03)	(2.48)	(3.38)	(1.06)
FREEFLOAT	0.0040	-0.046^{**}	-0.042^{**}	0.012	-0.039^{**}	-0.036^{**}
	(0.20)	(-2.52)	(-2.37)	(0.58)	(-2.16)	(-2.05)
Constant	-208.1^{***}	-244.9^{***}	-113.2^{***}	-200.2^{***}	-238.3^{***}	-107.5^{***}
	(-18.16)	(-23.34)	(-10.98)	(-17.48)	(-22.73)	(-10.44)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	4,016	4,016	4,016	4,016	4,016	4,016
Adj. R^2	0.520	0.587	0.237	0.520	0.588	0.239
F-stat.	65.90^{***}	86.23^{***}	19.66^{***}	65.99^{***}	86.39^{***}	19.84^{***}

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Regression analysis with country-year FE for the association between eco-friendly practices and firm value

Independent variables	(1) TOBINQ1	(2) TOBINQ1	(3) TOBINQ1	(4) TOBINQ2	(5) TOBINQ2	(6) TOBINQ2
RESUSE	0.0052*** (7.96)			0.0049*** (7.48)		
EMISSN		0.0048*** (6.76)			0.0046*** (6.42)	
ECOINN			0.0022*** (3.05)			0.0014* (1.85)
BORDSIZE	0.023*** (3.07)	0.023*** (3.07)	0.029*** (3.80)	0.018** (2.32)	0.018** (2.31)	0.024*** (3.16)
BORDIND	-0.0028* (-1.92)	-0.0029** (-2.04)	-0.0023 (-1.57)	-0.0025* (-1.75)	-0.0027* (-1.87)	-0.0021 (-1.42)
CEODUAL	0.14*** (3.57)	0.15*** (3.81)	0.13*** (3.40)	0.14*** (3.52)	0.14*** (3.75)	0.13*** (3.39)
FIRMSIZE	-0.30*** (-21.74)	-0.30*** (-20.91)	-0.26*** (-20.39)	-0.30*** (-21.50)	-0.30*** (-20.72)	-0.26*** (-20.14)
ROA	2.04*** (10.57)	2.03*** (10.49)	2.07*** (10.63)	1.90*** (9.83)	1.89*** (9.77)	1.92*** (9.82)
LEVERAGE	0.59*** (7.29)	0.58*** (7.21)	0.61*** (7.46)	0.28*** (3.46)	0.28*** (3.38)	0.30*** (3.64)
FREEFLOAT	0.00091 (1.12)	0.0012 (1.42)	0.0010 (1.26)	0.0014* (1.73)	0.0016** (2.01)	0.0015* (1.82)
Constant	7.05*** (14.43)	7.16*** (14.26)	6.24*** (12.99)	6.93*** (14.10)	7.04*** (13.95)	6.07*** (12.58)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	4,016	4,016	4,016	4,016	4,016	4,016
Adj. R^2	0.239	0.236	0.229	0.238	0.235	0.227
F-stat.	19.84***	19.50***	18.78***	19.67***	19.38***	18.64***

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Moderating role of R&D intensity between eco-friendly practices and firm value

Independent variables	(1) TOBINQ1	(2) TOBINQ1	(3) TOBINQ1	(4) TOBINQ2	(5) TOBINQ2	(6) TOBINQ2
RESUSE	0.0045*** (6.76)			0.0043*** (6.42)		
EMISSN		0.0043*** (5.94)			0.0042*** (5.74)	
ECOINN			0.00090 (1.17)			0.000049 (0.06)
R&D_INT	7.36*** (8.52)	7.83*** (9.63)	6.15*** (6.68)	7.12*** (8.19)	7.57*** (9.26)	5.81*** (6.27)
RESUSE x R&D_INT	0.021 (0.69)			0.011 (0.36)		
EMISSN x R&D_INT		-0.0065 (-0.17)			-0.022 (-0.57)	
ECOINN x R&D_INT			0.16*** (3.36)			0.15*** (3.30)
BORDSIZE	0.020*** (2.74)	0.021*** (2.76)	0.025*** (3.37)	0.015** (2.01)	0.015** (2.04)	0.020*** (2.73)
BORDIND	-0.0025* (-1.78)	-0.0027* (-1.89)	-0.0022 (-1.57)	-0.0023 (-1.62)	-0.0025* (-1.73)	-0.0020 (-1.42)
CEODUAL	0.13*** (3.55)	0.14*** (3.77)	0.13*** (3.53)	0.13*** (3.50)	0.14*** (3.72)	0.13*** (3.52)
FIRMSIZE	-0.28*** (-20.73)	-0.28*** (-19.81)	-0.25*** (-19.47)	-0.28*** (-20.51)	-0.28*** (-19.62)	-0.24*** (-19.25)
ROA	2.67*** (13.34)	2.67*** (13.34)	2.72*** (13.55)	2.50*** (12.45)	2.51*** (12.47)	2.54*** (12.58)
LEVERAGE	0.71*** (8.84)	0.71*** (8.75)	0.73*** (8.96)	0.40*** (4.90)	0.39*** (4.81)	0.41*** (5.05)
FREEFLOAT	0.00077 (0.96)	0.00097 (1.20)	0.00092 (1.14)	0.0013 (1.58)	0.0015* (1.79)	0.0014* (1.71)
Constant	6.63*** (13.66)	6.69*** (13.42)	5.84*** (12.31)	6.51*** (13.35)	6.58*** (13.12)	5.69*** (11.92)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	4,016	4,016	4,016	4,016	4,016	4,016
Adj. R^2	0.259	0.256	0.253	0.255	0.253	0.249
F-stat.	21.36***	21.06***	20.67***	20.96***	20.72***	20.30***

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robustness

Table 7: 2SLS for the association between R&D intensity and eco-friendly practices as well as eco-friendly practices and firm value

Independent variables	(1) RESUSE	(2) EMISSN	(3) ECOINN	(4) TOBINQ2	(5) TOBINQ2	(6) TOBINQ2
R&D_INT	101.8***	93.6***	82.1***			
	(3.83)	(3.84)	(3.36)			
RESUSE				0.0045***		
				(6.49)		
EMISSN					0.0042***	
					(5.62)	
ECOINN						0.0012*
						(1.69)
BORDSIZE	1.77***	1.76***	1.53***	0.017**	0.018***	0.024***
	(9.23)	(9.97)	(8.66)	(2.50)	(2.59)	(3.42)
BORDIND	0.11***	0.15***	0.014	0.000015	-0.00014	0.00049
	(2.96)	(4.54)	(0.39)	(0.01)	(-0.11)	(0.37)
CEODUAL	-0.53	-3.16***	1.44	0.22***	0.23***	0.21***
	(-0.54)	(-3.50)	(1.58)	(6.27)	(6.56)	(6.11)
FIRMSIZE	9.51***	10.3***	3.64***	-0.25***	-0.26***	-0.22***
	(29.45)	(34.87)	(12.24)	(-19.57)	(-18.73)	(-18.61)
ROA	4.16	6.22	-17.0***	1.88***	1.87***	1.89***
	(0.75)	(1.23)	(-3.35)	(10.59)	(10.50)	(10.52)
LEVERAGE	5.79***	7.23***	2.42	0.23***	0.22***	0.25***
	(2.72)	(3.70)	(1.23)	(3.16)	(3.07)	(3.37)
FREEFLOAT	0.00056	-0.046**	-0.061***	0.0020***	0.0022***	0.0021***
	(0.03)	(-2.38)	(-3.11)	(2.72)	(2.98)	(2.81)
Constant	-175.3***	-220.2***	-101.1***	5.06***	5.20***	4.40***
	(-15.33)	(-21.01)	(-9.61)	(12.14)	(12.03)	(10.76)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	3,560	3,560	3,560	3,560	3,560	3,560
Adj-R^2	0.53	0.59	0.26	0.26	0.26	0.25
χ^2-stat.	4013.87***	5197.81***	1279.29***	1269.64***	1254.12***	1213.02***

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Two-Step GMM-based dynamic regression analysis

Independent variables	(1) RESUSE	(2) EMISSN	(3) ECOINN	(4) TOBINQ2	(5) TOBINQ2	(6) TOBINQ2
RESUSE(t-1)	0.60*** (76.55)					
EMISSN(t-1)		0.68*** (52.82)				
ECOINN(t-1)			0.63*** (100.88)			
TOBINQ2(t-1)				0.35*** (99.83)	0.35*** (90.58)	0.37*** (108.46)
R&D_INT	17.8** (2.24)	13.7* (1.66)	1.68* (1.70)			
RESUSE				0.0040*** (13.12)		
EMISSN					0.0038*** (14.94)	
ECOINN						0.00020* (1.77)
BORDSIZE	-0.33*** (-13.93)	0.045 (1.05)	0.22*** (2.64)	-0.0043 (-1.50)	-0.0026 (-0.84)	-0.0020 (-0.65)
BORDIND	0.035*** (2.63)	0.0099 (0.56)	0.0031 (0.30)	0.0026*** (5.29)	0.0025*** (5.25)	0.0025*** (5.15)
CEODUAL	-1.57*** (-3.40)	0.90** (2.38)	-0.91 (-1.34)	0.10*** (5.30)	0.081*** (4.61)	0.10*** (5.29)
FIRMSIZE	4.77*** (20.74)	2.96*** (12.40)	1.08*** (3.32)	-0.59*** (-44.19)	-0.60*** (-47.26)	-0.65*** (-51.96)
ROA	-8.86*** (-11.22)	-1.01** (-2.01)	1.35 (1.08)	0.34*** (5.49)	0.35*** (5.97)	0.53*** (8.18)
LEVERAGE	0.30 (0.19)	0.47 (0.44)	3.19** (2.49)	0.39*** (14.03)	0.39*** (11.49)	0.38*** (11.57)
FREEFLOAT	-0.035*** (-2.86)	0.032** (2.12)	-0.033*** (-2.82)	0.00060 (1.24)	0.00082 (1.61)	0.00093** (2.10)
Constant	-87.1*** (-18.49)	-56.2*** (-9.11)	-21.3*** (-2.85)	13.6*** (41.81)	13.8*** (44.63)	14.8*** (49.40)
N	3136	3136	3136	3136	3136	3136
χ^2-stat.	1547493.14***	911518.84***	17887.70***	85064.88***	98414.76***	61795.08***

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Moderating role of R&D dummy between eco-friendly practices and firm value

Independent variables	(1) TOBINQ1	(2) TOBINQ1	(3) TOBINQ1	(4) TOBINQ2	(5) TOBINQ2	(6) TOBINQ2
RESUSE	0.0037*** (4.87)			0.0036*** (4.63)		
EMISSN		0.0037*** (4.64)			0.0036*** (4.46)	
ECOINN			0.0015 (1.50)			0.00052 (0.53)
R&D_DUM	0.044 (0.88)	0.061 (1.16)	0.15*** (4.00)	0.032 (0.65)	0.049 (0.91)	0.13*** (3.45)
RESUSE x R&D_DUM	0.0030*** (3.01)			0.0028*** (2.76)		
EMISSN x R&D_DUM		0.0024** (2.34)			0.0022** (2.15)	
ECOINN x R&D_DUM			0.0011 (0.79)			0.0013 (0.93)
BORDSIZE	0.021*** (2.80)	0.021*** (2.72)	0.027*** (3.58)	0.016** (2.08)	0.015** (2.00)	0.022*** (2.94)
BORDIND	-0.0024* (-1.69)	-0.0027* (-1.84)	-0.0022 (-1.53)	-0.0022 (-1.54)	-0.0024* (-1.69)	-0.0020 (-1.37)
CEODUAL	0.14*** (3.58)	0.14*** (3.70)	0.13*** (3.26)	0.14*** (3.54)	0.14*** (3.66)	0.13*** (3.27)
FIRMSIZE	-0.31*** (-22.39)	-0.31*** (-21.47)	-0.27*** (-20.96)	-0.31*** (-22.03)	-0.31*** (-21.17)	-0.27*** (-20.62)
ROA	2.11*** (10.92)	2.10*** (10.82)	2.18*** (11.16)	1.97*** (10.12)	1.96*** (10.04)	2.02*** (10.28)
LEVERAGE	0.63*** (7.81)	0.63*** (7.76)	0.65*** (7.98)	0.32*** (3.91)	0.32*** (3.88)	0.34*** (4.12)
FREEFLOAT	0.0011 (1.30)	0.0014* (1.69)	0.0012 (1.51)	0.0015* (1.88)	0.0018** (2.25)	0.0017** (2.04)
Constant	7.30*** (14.88)	7.38*** (14.63)	6.38*** (13.28)	7.15*** (14.49)	7.23*** (14.27)	6.20*** (12.84)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes
N	4,016	4,016	4,016	4,016	4,016	4,016
Adj. R^2	0.244	0.240	0.233	0.241	0.238	0.231
F-stat.	19.81	19.42	18.68	19.52	19.20	18.46

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Regression analysis by excluding US-based firms direct and moderating effects

Independent variables	(1) RESUSE	(2) EMISSN	(3) ECOINN	(4) TOBINQ1	(5) TOBINQ1	(6) TOBINQ1	(7) TOBINQ2	(8) TOBINQ2	(9) TOBINQ2
R&D_INT	56.8***	53.9***	43.7**				5.13***	5.92***	2.27**
	(2.89)	(2.98)	(2.40)				(5.46)	(6.73)	(2.16)
RESUSE				0.0047***			0.0040***		
				(5.82)			(4.92)		
EMISSN					0.0052***			0.0047***	
					(5.94)			(5.33)	
ECOINN						0.0026***			0.00069
						(2.97)			(0.77)
RESUSE x R&D_INT							0.076**		
							(2.16)		
EMISSN x R&D_INT								0.032	
								(0.69)	
ECOINN x R&D_INT									0.37***
									(6.06)
BORDSIZE	1.63***	1.47***	1.52***	0.023***	0.023***	0.027***	0.020**	0.020**	0.022**
	(7.79)	(7.64)	(7.89)	(2.61)	(2.61)	(3.02)	(2.29)	(2.29)	(2.50)
BORDIND	0.062	0.11***	0.036	-0.0035**	-0.0037**	-0.0033**	-0.0032**	-0.0034**	-0.0033**
	(1.61)	(3.06)	(1.03)	(-2.19)	(-2.35)	(-2.06)	(-2.02)	(-2.17)	(-2.09)
CEODUAL	-2.60**	-2.58**	1.22	0.11**	0.11**	0.095*	0.11**	0.11**	0.099**
	(-2.15)	(-2.32)	(1.09)	(2.20)	(2.22)	(1.89)	(2.16)	(2.15)	(1.99)
FIRMSIZE	8.52***	9.42***	3.17***	-0.27***	-0.28***	-0.24***	-0.26***	-0.27***	-0.23***
	(24.20)	(29.07)	(9.71)	(-17.07)	(-16.97)	(-16.31)	(-16.53)	(-16.27)	(-15.88)
ROA	2.41	7.88	-19.9***	1.27***	1.24***	1.32***	1.83***	1.81***	1.93***
	(0.41)	(1.47)	(-3.68)	(5.52)	(5.40)	(5.68)	(7.66)	(7.51)	(8.06)
LEVERAGE	7.76***	6.47***	7.33***	0.50***	0.50***	0.51***	0.66***	0.65***	0.67***
	(3.19)	(2.89)	(3.25)	(4.99)	(5.03)	(5.11)	(6.56)	(6.49)	(6.74)
FREEFLOAT	-0.043*	-0.068***	-0.033	0.0022**	0.0024**	0.0021**	0.0019**	0.0021**	0.0020**
	(-1.91)	(-3.33)	(-1.58)	(2.38)	(2.54)	(2.25)	(2.09)	(2.28)	(2.23)
Constant	-185.0***	-221.3***	-120.5***	6.68***	6.96***	6.13***	6.40***	6.62***	5.86***
	(-15.02)	(-19.53)	(-10.57)	(12.59)	(12.79)	(11.74)	(12.12)	(12.19)	(11.38)
Country effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,743	2,743	2,743	2,743	2,743	2,743	2,743	2,743	2,743
Adj. R^2	0.540	0.611	0.279	0.255	0.256	0.248	0.272	0.271	0.274
F-stat.	49.79***	66.22***	17.08***	15.25***	15.27***	14.73***	16.06***	16.00***	16.25***

t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix

Table A1: List of variables

Variable	
RESUSE	Resource reduction metrics were assessed based on a scale of 0 to 100.
EMISSN	Emission reduction metrics were assessed based on a scale of 0 to 100.
ECOINN	Eco-innovation metrics were assessed based on a scale of 0 to 100.
TOBINQ1	Firm value proxy refers to market capitalization plus total liabilities scaled by total assets.
TOBINQ2	Alternative firm value proxy refers to market capitalization plus total debt scaled by total assets.
R&D_INT	Research and development expenditures are scaled by total assets.
R&D_DUM	Binary variable: if research and development expenditures exist, it takes 1; otherwise, 0.
BORDSIZE	Number of board members at year-end.
BORDIND	Percentage of non-executive members on board.
CEODUAL	If the CEO and the chairman are the same person, it takes 1; otherwise, 0.
FIRMSIZE	Natural logarithm of total assets.
ROA	The ratio of earnings before interest and tax to total assets.
LEVERAGE	The proportion of total liabilities to total assets.
FREEFLOAT	The percentage of shares freely available to stockholders for trading.

Table A2: Multicollinearity analysis

Panel A: Models with the dependent variables including RESUSE, EMISSN, and ECOINN

Variable	VIF	Variable	VIF
FIRMSIZE	1.74	FIRMSIZE	1.78
BORDSIZE	1.51	BORDSIZE	1.51
ROA	1.25	ROA	1.17
R&D_INT	1.18	LEVERAGE	1.09
LEVERAGE	1.10	R&D_DUM	1.08
BORDIND	1.07	BORDIND	1.07
FREEFLOAT	1.06	FREEFLOAT	1.06
CEODUAL	1.04	CEODUAL	1.04
Mean VIF	*1.24*	*Mean VIF*	*1.23*

Panel B: Models with the dependent variables including TOBINQ1 and TOBINQ2

Variable	VIF	Variable	VIF	Variable	VIF
FIRMSIZE	1.99	FIRMSIZE	2.11	FIRMSIZE	1.76
BORDSIZE	1.56	EMISSN	1.77	BORDSIZE	1.53
RESUSE	1.52	BORDSIZE	1.59	ROA	1.17
ROA	1.16	ROA	1.16	ECOINN	1.12
FREEFLOAT	1.09	FREEFLOAT	1.09	LEVERAGE	1.07
BORDIND	1.08	BORDIND	1.08	BORDIND	1.07
CEODUAL	1.07	CEODUAL	1.08	FREEFLOAT	1.07
LEVERAGE	1.07	LEVERAGE	1.07	CEODUAL	1.04
Mean VIF	*1.32*	*Mean VIF*	*1.37*	*Mean VIF*	*1.23*

Table A3: Mean values of the main variables of interest based on sectors

Sectors	RESUSE	EMISSN	ECOINN	TOBINQ1	TOBINQ2	R&D_DUM	R&D_INT
Energy	**36.58**	**40.46**	**12.49**	**1.51**	**1.24**	**0.39**	**0.01**
Basic Materials	41.72	43.22	22.37	1.60	1.33	0.48	0.01
Consumer Cyclicals	35.02	34.08	20.45	1.99	1.66	0.23	0.01
Consumer Non-Cyclicals	39.46	39.05	22.72	2.19	1.86	0.22	0.00
Financials	29.43	29.65	17.75	1.25	0.77	0.02	0.00
Healthcare	26.18	24.18	13.87	3.06	2.80	0.78	0.08
Industrials	38.37	38.75	26.28	1.72	1.36	0.28	0.01
Technology	33.53	32.24	23.88	2.62	2.30	0.73	0.06
Telecommunications Service	39.47	38.78	27.56	1.67	1.38	0.10	0.00
Utilities	44.45	47.51	32.84	1.24	0.94	0.10	0.00

Table A4: Number of unique firms and data points within each country

	Country	**Distinct firms (n)**	**Percent (%)**	**Data points (n)**	**Percent (%)**
1	Argentina	3	0.66	9	0.22
2	Australia	35	7.68	346	8.62
3	Austria	2	0.44	20	0.50
4	Belgium	2	0.44	18	0.45
5	Brazil	5	1.10	47	1.17
6	Canada	62	13.60	665	16.56
7	Chile	3	0.66	17	0.42
8	China	16	3.51	121	3.01
9	Colombia	2	0.44	13	0.32
10	Denmark	3	0.66	37	0.92
11	Finland	1	0.22	15	0.37
12	France	7	1.54	67	1.67
13	Germany	5	1.10	34	0.85
14	Greece	2	0.44	31	0.77
15	Hong Kong	8	1.75	82	2.04
16	Hungary	1	0.22	12	0.30
17	India	9	1.97	67	1.67
18	Indonesia	6	1.32	54	1.34
19	Israel	1	0.22	10	0.25
20	Italy	5	1.10	78	1.94
21	Japan	6	1.32	56	1.39
22	Kazakhstan	2	0.44	4	0.10
23	Korea; Republic (S. Korea)	5	1.10	52	1.29
24	Malaysia	5	1.10	41	1.02
25	Netherlands	5	1.10	66	1.64
26	New Zealand	2	0.44	11	0.27
27	Norway	22	4.82	175	4.36
28	Pakistan	1	0.22	3	0.07
29	Philippines	1	0.22	9	0.22
30	Poland	5	1.10	39	0.97
31	Portugal	1	0.22	14	0.35
32	Qatar	3	0.66	12	0.30
33	Russia	9	1.97	108	2.69
34	Saudi Arabia	2	0.44	3	0.07
35	Singapore	1	0.22	7	0.17
36	South Africa	2	0.44	19	0.47
37	Spain	4	0.88	57	1.42
38	Sweden	1	0.22	18	0.45
39	Taiwan	1	0.22	11	0.27
40	Thailand	5	1.10	56	1.39
41	Turkey	2	0.44	12	0.30
42	United Kingdom	24	5.26	227	5.65
43	United States of America	169	37.06	1,273	31.70
	Total	*456*	*100.00*	*4,016*	*100.00*

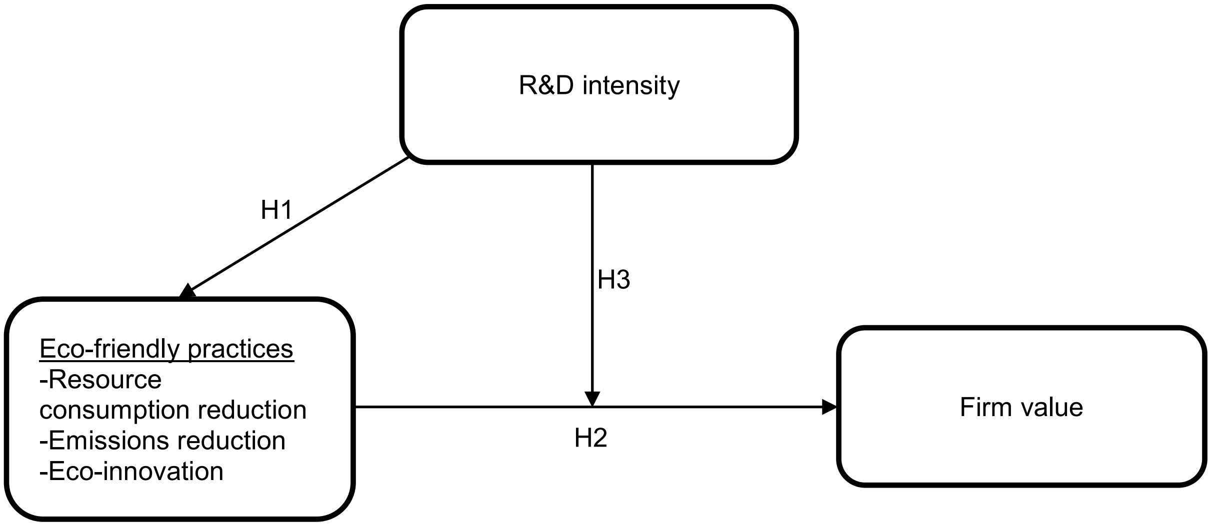

Figure 1. The theoretical background of the study and hypothesized relationships.