Balancing environment and economy: the interplay between eco-innovation, carbon emission and firm performance

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Abstract

With an ever-increasing human ecological footprint, the United Nations Sustainable Development Goals require global collaboration in terms of sustainable business practices to combat global ecological issues. Our study examines the complex relationship between eco-innovation, CO2 emissions, and financial performance using fixed effects panel data regression. While R&D is positively correlated with financial performance, we also found a negative relationship between R&D and CO2 emissions, particularly after the implementation of the United Nations Sustainable Development Goals. Surprisingly, environmental innovation shows a slight positive correlation with CO2 emissions, differing from previous studies. However, it has a positive impact on financial performance. Our findings highlight the need for further research to understand the complex impact of sustainable practices on CO2 emissions across industries. We underscore the importance of sustainable practices and environmental responsibility for a sustainable future. Overall, our study finds evidence to support the theory that eco-innovation may benefit firms' financial performance and not just the environment.

Key words: Eco-innovation, financial performance, natural resource-based view, stakeholder theory, Tobin's Q

LIST OF ACRONYMS

CO_2 emission	Carbon dioxide emission
CSR	Corporate social responsibility
NRBV	Natural-resource-based view
RBV	Resource-based view
ROA	Return on assets
R&D	Research and development
SCA	Sustained competitive advantage
SDG	Sustainable Development Goal
UN	United Nations
UNSDG	United Nations Sustainable Development Goals
UNDESA	United Nations Department of Economic and Social Affairs

The following terms are used interchangeably:

Eco-innovation, Green innovation

Financial performance, Tobin's Q

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1. INTRODUCTION

"For those who believe that ecological disaster will somehow be averted, it must also be clear that, over the next decade or so, sustainable development will constitute one of the biggest opportunities in the history of commerce. And innovation will be the name of the game." (Hart, 2010, p.52)

The topic of sustainable ecological footprints has received ever-increasing attention since the 1960s (Holdgate, 1987; Wolf, 2013), parallel with the increasing need for stakeholder governance (Amis et al., 2020; Barney, 2018; Barney et al., 2021). Our aim in this research is to answer the frequently asked question among scholars "Do the firm's financial and environmental performance benefit from increased eco-innovation?" (See e.g., McWilliams Siegel, 2000; Orlitzky et al., 2003; Menguc & Ozanne, 2005; Lee & Min, 2014; Medina et al., 2022). Moreover, the goal of this study is to serve as a valuable resource in providing guidelines and offering encouragement to corporate managers in their efforts to align with and contribute to the United Nations' Sustainable Development Goals (UNSDG). However, eco-innovation is a relatively new research area with limited data availability and an insufficient theoretical foundation, which increases the difficulty for researchers to investigate the relationship between eco-innovation on firms' financial and environmental performance (Lee & Min, 2015; Medina et al., 2022). Given this, it is even more important to emphasise the empirically demonstrated mutually beneficial relationship to establish clear guidelines and encouragement for corporate managers (Lee and Ball, 2003; Lee and Kim, 2011; Lee and Min, 2015; Andersén, 2021).

Economic growth has contributed to a growing human ecological footprint (Eteokleous, 2016; Barnett, 2020; Iqbal & Ahmad, 2021). In response, the United Nations set 17 sustainable development goals (SDGs) in 2015, aiming to tackle education, poverty, climate change, biodiversity, and oceans by 2030 (UNDESA, 2023). The SDGs require global collaboration and that businesses with a significant environmental impact reassess their business practices and focus on environmental innovation, including sustainable product development, to combat global ecological issues (Hart, 1995; Iqbal & Ahmad, 2021; Lee & Kim, 2011; Lee & Min, 2015; Medina et al., 2022; Wolf, 2013). These efforts are driven by stakeholder pressure from the government, civil society, and non-governmental institutions (Eteokleous, 2016; Barnett, 2020; Iqbal & Ahmad, 2021). Hart (1995) uses the lens of the natural resource-based view (NRBV) and suggests that firms have environmental considerations in mind during business practices. Moreover, to adapt to a changing market environment and maintain competitive advantage, firms should commit to eco-innovation and environmental goals (Hart, 1995; Medina et al., 2022; Lee and Ball, 2003; Lee and Kim, 2011; Lee and Min, 2015; Andersén, 2021).

This study aims to investigate the impact of eco-innovation on both financial and environmental performance. With increasing stakeholder pressures, firms need to adopt environmental strategies to sustain competitiveness and improve economic outcomes. There is evidence that sustainable business practices, including emission reduction, contribute to enhanced financial performance (Ibid). Consistent with previous research by Lee and Min (2015), this study uses environmental innovation and R&D as a proxy for eco-innovation, the yearly carbon dioxide emission as a proxy for environmental performance, while Tobin's Q is employed as a proxy for the financial performance of the firm. To test our hypotheses, we utilise panel data of 3162 companies, over 20 years, in a fixed effects regression model. We also aim to compare the outcomes in terms of financial and environmental performance across different time periods ”the pre-and post-UNSDG eras” and industries, to provide valuable insights into the relationship between eco-innovation, financial performance, and environmental performance.

Our results show a sizable negative relationship between R&D and CO2 emissions, corroborating earlier findings and demonstrating its efficiency in minimising them. Additionally, the results show a change in the association between R&D and CO2 emissions following the implementation of the UNSDG, with a stronger negative association seen in the post-2015 era. In addition, a significant positive correlation between R&D and Tobin's Q is seen. This is consistent with earlier findings, implying its efficiency on firm valuation. However, there is a strong positive correlation between environmental innovation and CO2 emissions, which differs from previous studies but emphasises the need for more research. Notably, environmental innovation and R&D are positively related to Tobin’s Q after the implementation of the UNSDG. This implies firms' increasing incentives in environmentally sustainable production and emission reduction and the role of R&D in improving financial performance.

Overall, our contribution allows us to close the gap between conventional and green perspectives, concerning the frequently asked question of whether a firm's financial and environmental performance benefits from increased eco-innovation. Additionally, this study sheds light on the complexity and diversity of the impacts of sustainable practices on CO2 emissions and Tobin's Q across different industries. This underscores the need for continued research to deepen our understanding and guide efforts towards environmental responsibility and sustainable business practices.

The remaining sections of this essay are organised as follows: First, a review of the literature on stakeholder pressure and its impact on environmental business practices. The second is research on eco-innovation and how it affects business performance from a resource-based and natural resource-based standpoint, conducted to lay the groundwork for followed hypotheses. Later a section explaining our model is presented with a brief description of the data selection. Continuing with presentation of our results as well as analysis, and discussion of the implications. The essay's limitations, future recommendations and conclusions are presented at the end.

2. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

This chapter focuses on the relationship and importance of corporate social responsibility and stakeholder theory. Additionally, it provides a deeper understanding of resource-based and natural resource-based views as well as previous studies, followed by hypothesis development and the conceptual framework.

2.1 Corporate Social Responsibility and Stakeholder Theory

"Those with a moral claim on the actions of the firm are its stakeholders, namely consumers, employees, competitors, suppliers, government, as well as other actors in society." (Verbeke & Tung, 2012, p. 529)

Throughout history, corporate social responsibility (CSR) has had different definitions. Bowen (1953, p. 6), defined CSR as ''obligations of businessmen to pursue those policies, to make those decisions, or to follow those lines of action that are desirable in terms of the objectives and values of our society.'' The scepticism of Friedman (1962), who insisted that firms' sole social responsibility was to generate profit and that CSR violated obligations to shareholders, was disproved by many scholars and lawyers (Freeman & Dmytriyev, 2017). Firms cannot solely prioritise the shareholders as their social responsibility, as their success is also dependent on addressing the diverse interests of stakeholders (Russo & Perrini, 2010). CSR paradigms are voluntarily adopted by firms through codes of conduct that are not legally required. The symbiotic relationship between "business and society" must be long-lasting and progressively evolve into a necessary integration of "business in society," in which society engages with business at large and contributes to the legitimacy and prestige of the firm (Freeman & Dmytriyev, 2017). CSR is addressed as a part of corporate responsibility to all stakeholders. Thus, both the concept of CSR and stakeholder theory are required when discussing business ethics, as both emphasise the importance of incorporating social interest into business practices (Ibid). While CSR from a business perspective concentrates on local communities and society at large, including charity, volunteering, environmental efforts, and moral labour practices. Furthermore, stakeholders only focus on their relationships with stakeholders, who stand in for employees, clients, communities, suppliers, and financiers, and they view things on a smaller scale, i.e., where the business operates and the local communities. Trade-offs among stakeholders should be avoided (Ibid).

According to Hart (2005), companies should focus on developing innovative and sustainable businesses to maximize profits while generating value for all stakeholders. The development of a company's sustainability has also been found to be significantly influenced by stakeholders, and sequentially, structural implementation of sustainability has a favourable impact on a company's performance (Wolf, 2013). It has been demonstrated that institutional pressure from stakeholders has a significant positive correlation with a company's green resources, (Eteokleous, 2016; Barnett, 2020; Huang and Chen, 2021; Iqbal & Ahmad, 2021) and both exploratory and exploitative green product innovation (Huang and Chen, 2021). The evidence presented by Hart and Ahuja (1996) suggests that environmentally friendly practices, such as emission reduction, improve businesses' operational efficiency, lower costs, and strengthen stakeholder relationships, ultimately improving financial performance.

With that said, businesses seek strategies that generate value for all stakeholders and balance economic profitability with social and environmental metrics to achieve positive sustainable performance and financial performance while maintaining a competitive advantage (Lee & Min, 2015; Iqbal & Ahmad, 2021; Medina et al., 2022).

2.2 The Resource-Based and Natural Resource-Based Views

The resource-based view (RBV) and the natural resource-based view (NRBV) provide an appropriate theoretical framework for discussing how resources and capabilities affect eco-innovation performance (Menguc and Ozanne, 2005; Dangelico and Pujari, 2010; Lee and Kim, 2011; Lee & Min, 2015). Both theories aim to thoroughly explain how resources, capabilities, and performance—the three pillars of eco-innovation—relate to one another (Lee & Min, 2015).

Wernerfelt (1984) used Porter's Five Forces as the starting point of the resource-based view (RBV) and concluded that the five forces analyse external factors that affect an industry's competitive environment. While the RBV explains the internal factors, that resources and capabilities are the primary determinants of firms' competitive advantage and performance (Kraaijenbrink et al., 2010; Wernerfelt, 1984). The resources refer to tangible and intangible assets, inputs such as raw materials, employees' competence, and organisational (social) processes. While capabilities refer to the firm's performance, which is a result based on its resources and routines (processes and procedures) (Hart, 2010). The internal factors mentioned above need to be valuable in terms of improving efficiency and rare among competitors to attain a sustained competitive advantage (SCA). Furthermore, it needs to be inimitable and substitutable by competitors (Barney, 1991, 1994, 2002; Hart, 1995; Wernerfelt, 1984). The RBV is frequently used, and over the past 20 years, it has emerged as a crucial element in strategy research. However, like any other theory, it has received harsh criticism for several of its flaws (Lockett et al., 2009; Kraaijenbrink et al., 2010). The various perspectives among scholars regarding RBV over time helped to shape the framework for understanding the connection between firms' strategic behaviour and achieving a sustained competitive advantage (Kraaijenbrink et al., 2010; Lockett et al., 2009).

Barney (1991), Peteraf (1993), and Rumelt (1984) highlighted the significance of a firm's resources and capabilities, which were challenging for rivals to imitate to provide SCA. Further, some resources are distinct as “static resources", which refers to physical and tangible stock of assets, once installed, they can be used as needed over a limited time frame (Lockett et al., 2009). However, this view adds to the criticism about how RBV fails to explain the utilisation of resources when changes in technological advancement, social and environmental challenges, and government policies occur; therefore, static resources limit firms’ ability to sustain themselves for long-term success (Hart, 1995; DeSarbo et al., 2005; Bhandari et al., 2022). Simultaneously, other scholars argue that” dynamic resources” adapt quickly to changes in the external market environment. With that said, firms with strong dynamic resources generate strong dynamic capabilities, in turn, are better equipped for long-term challenges and value creation through continuous innovation and process improvement (Collis, 1994; Hart, 1995; Katkalo et al., 2010; Bhandari et al., 2022).

Hart (1995) provided an important extension of the RBV and introduced the Natural-Resource-Based View (NRBV), which discusses the environmental issues that have arisen due to the combination of population growth, the expansion of industrial activities, and the increased use of resources for their purposes following World War II. Hart (2010) argues that business leaders need to focus on incremental sustainability strategies, such as eco-efficiency and corporate social responsibility (CSR) and integrate the NRBV into strategic management theory and practice to resolve social and environmental problems rather than just reduce negative impacts. The author advocates for dynamic capabilities and emphasises environmental and social factors in driving firm performance and how natural resources are a critical factor in shaping firms' SCA and environmental impact (Hart, 1995, 2010; Andersén, 2021).

2.2.1 Previous Research

From a conventional view of different scholars, the implementation of environmental strategies, such as eco-innovation has often been regarded as insufficient in generating positive financial performance for the firm (Walley and Whitehead, 1994; Palmer et al., 1995; Ambec and Lanoie, 2008; Latupeirissa & Adhariani, 2020; Mahsina and Agustia, 2023). However, to analyse environmental innovation, some authors divide it into different categories, such as, organisational, managerial, process, and production (Junaid et al., 2021; Medina et al., 2022). While Junaid et al. (2021) argue that green-process innovation has a significantly negative impact, meaning that the firms' profit gets eaten up by the cost of rapid changes in manufacturing processes and operational procedures, their findings also suggest that green managerial innovation is significantly positive on financial performance. Medina et al. (2022) argue that organisational eco-innovation and process eco-innovation are significantly positively related to financial and environmental performances, while production eco-innovation does not show any effect. Additionally, some authors like Du et al. (2019) did not find evidence that eco-innovation will lead to CO_2 emission reduction.

However, taking a green perspective, some authors argue that early investment in terms of environmental management holds the potential not only to alleviate operational costs but also to drive substantial financial returns in the long run (Porter and van der Linde, 1995; Aragón-Correa et al., 2008; Sambasivan et al., 2013; Lee & Min, 2015; Andersén, 2021). Additionally, some researchers discovered a favourable correlation between proactive practices in terms of environmental strategies and financial performance, in line with the paradigm of dynamic-natural resources and their impact on firms' financial and environmental performance discussed previously (Aragón-Correa et al., 2008; Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023). Their research also revealed a link between eco-innovation and environmental performance (Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023). This viewpoint, championed by influential authors (Porter and van der Linde, 1995; Aragón-Correa et al., 2008; Sambasivan et al., 2013; Lee & Min, 2015; Andersén, 2021), underscores the transformative power of environmentally conscious practises, which can significantly enhance the firm's financial viability and pave the way for the United Nations sustainable development goals (UNSDG).

The empirical results of 64 former studies between the years 1978 and 2008 showed that 55% of the results were positive and significant, 15% were negatively significant, and 30% were insignificant (Horváthová, 2010). Overall, the empirical evidence likely suggests a positive relationship between eco-innovation and firm performance, but the gap needs to be mitigated further with empirical studies, to be able to establish clear guidelines for corporate managers.

However, research from Lee and Min (2015) is more relevant to our research and we will be using the same proxy as them; they examined the relationship between eco-innovation on firms' financial and environmental performance with 10 years of data from Japanese manufacturing firms. The researchers use environmental innovation and research and development (R&D) as proxies for eco-innovation, as for the financial performance, Tobin's Q is used to express the firm's profitability. Additionally, CO_2 emissions served as the environmental performance of the firm. They found a negative relationship between eco-innovation and environmental performance and a positive relationship between eco-innovation and firms' financial performance. The author suggests that firms need to develop unique resources and capabilities to adopt a proactive environmental strategy for superior environmental and financial performance (Lee & Min, 2015).

2.3 Hypotheses Development

As discussed in the preceding sections, businesses can enhance both their environmental and financial performance through the adoption of environmental innovation and research and development (R&D). This is driven by the increasing demand for stakeholder engagement and environmental sustainability, along with the implementation of the UNSDG. By investing in these areas, businesses can create new market opportunities, sustain a competitive advantage, and generate value for all stakeholders. They achieve this by developing specialised resources and capabilities, leveraging new environmental technologies and processes, and advancing eco-designed products to improve environmental impact reduction. While these initiatives contribute to a reduction in CO_2 emissions, it is important to note that contradictory researchers (such as Walley and Whitehead, 1994; Palmer et al., 1995; Ambec and Lanoie, 2008; Latupeirissa & Adhariani, 2020), suggest that eco-innovation alone may not generate sufficient positive financial performance for the firm, primarily due to the associated high costs.

In this study, environmental innovation and R&D will be employed as proxies for eco-innovation, while CO_2 emissions will serve as a proxy for environmental performance. Additionally, Tobin's Q will be utilised as a proxy for financial performance, all with the aim of emphasising the mutually beneficial nature of these relationships. Following Lee and Min (2015), the inclusion of control variables such as Capital Intensity, Leverage, Return on Asset (ROA), and Total Asset (TA) in the analysis serves an important purpose, to account for the influence of financial resources and capabilities that firms possess, which may affect their ability to implement eco-innovation initiatives.

2.3.1 Eco-innovation and Environmental Performance

In previous research, many scholars have revealed a positive link between eco-innovation and environmental performance (Aragón-Correa et al., 2008; Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023). According to Kemp and Pearson (2008, p. 7), environmental innovation is *"the production, assimilation, or exploitation of a product, production process, service, or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resources used (including energy use) compared to relevant alternatives."* Furthermore, Refinitiv (2022) explains environmental innovation as a company's capacity to reduce environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes or eco-designed products. Moreover, R&D focuses on the development of products and services, including green R&D to improve environmental impact reduction and innovation. Both proxies have the same aim to reduce environmental impact. The main difference between the two proxies lies in the focus and measurement, while environmental innovation assesses a company's overall capacity for reducing environmental costs and creating market opportunities. R&D specifically measures the financial investment dedicated to research and development activities, including improving environmental impact reduction and innovation.

Considering the implementation of UNSDG (2015) together with stakeholder pressures, adapting environmental practices is a necessity for business survival and to maintain a sustainable competitive advantage (SCA). Particularly businesses with a significant environmental impact are compelled to enhance their environmental strategies and incorporate eco-innovations into their business practices to combat global ecological issues (Hart, 1995; Lee & Kim, 2011; Wolf, 2013; Lee & Min, 2015; Eteokleous, 2016; Barnett, 2020; Huang and Chen, 2021; Iqbal & Ahmad, 2021; Iqbal & Ahmad, 2021; Huang and Chen, 2021; Medina et al., 2022). This proactive approach leads to a reduction in CO2 emissions as a direct outcome.

Based on the above theoretical frameworks, this study proposes the following hypotheses:
H1: *Environmental innovation has a negative relationship with CO2 emissions.*
H2: *R&D has a negative relationship with CO2 emissions.*

H3: *The negative relationship between environmental innovation/R&D and CO2 emissions has strengthened during the post-2015 compared to the pre-2015 period.*

2.3.2 Eco-innovation and Firms' Performance

The positive relationship between environmental impact reduction and financial performance has previously been empirically demonstrated in several countries and industries. While it can be challenging to simultaneously develop environmentally friendly products, invest in emission reduction innovations, and maintain a sustainable competitive advantage, the overall perspective emphasises the mutually beneficial nature of this exchange (Lee and Ball, 2003; Lee and Kim, 2011; Lee and Min, 2015; Andersén, 2021). Thus, it becomes crucial to establish clear guidelines and provide encouragement for corporate managers to embrace this mutually beneficial relationship.

With the increasing demand for sustainable practices from firms, including pollution prevention, CO2 emissions reduction, exploratory and exploitation of green product innovation (Eteokleous, 2016; Barnett, 2020; Huang and Chen, 2021; Iqbal & Ahmad, 2021; Huang and Chen, 2021). It has become crucial for companies to focus on environmental strategies, including environmental innovations and R&D. Environmental innovations involve refining and enhancing existing products, incorporating more sustainable features, and improving their overall environmental impact through continuous improvement efforts. R&D entails investing and exploring new technologies, materials, and design concepts to create innovative and environmentally sustainable products. Both approaches are essential for sustainable businesses to maximise profits while generating value for all stakeholders (Hart, 2005; Kemp and Pearson, 2008; Lee & Min, 2015; Iqbal & Ahmad, 2021; Medina et al., 2022). This, in turn, leads to the development of resources and capabilities that fulfil the requirements of NRBV and facilitate a mutually beneficial exchange, resulting in a reduced ecological footprint and improved financial performance for firms.

Mindful of the above empirical frameworks, the study postulates the last three hypotheses:
H4: *Environmental innovation has a positive relationship with financial performance.*
H5: *R&D has a positive relationship with financial performance.*

H6: *CO2 has a negative relationship with financial performance.*
H7: *The positive relationship between environmental innovation/R&D and financial performance has strengthened during the post-2015 compared to the pre-2015 period.*

3. METHODOLOGY

This chapter describes the chosen econometric method, followed by data collection, variable selection and definitions, as well as the sample selection.

3.1 Conceptual Framework & Model

In Figure 1 below, the conceptual framework of this study is summarised. CO2 and Tobin's Q are the two dependent variables in this model. Environmental innovation and R&D serve as proxies for Eco-innovation. Capital Intensity, Leverage, Return on Asset (ROA), Total Asset (TA), and Energy Intensive are the seven independent variables used to investigate CO2. Tobin's Q uses an additional independent variable, carbon dioxide (CO2), in addition to the original seven independent variables. Capital Intensity, CO2, Leverage, ROA, and TA act as control variables, while Energy Intensive acts as an interaction variable. The model itself is based on the theoretical argumentation above, suggesting eco-innovation and R&D will reduce CO2 and, consequently, improve firms' financial performance.

By creating environmental resources and capabilities that are valuable and rare for the firm, but inimitable, and unsubstitutable for the competitors, this in turn, create differentiate advantage and sustain a competitive advantage and improve their financial performance. On the other hand, creating environmental solutions is demanded by stakeholders. Eco-innovations will improve environmental performance, in terms of pollution prevention and emission reduction, further improving financial performance, and achieving and embracing mutually beneficial relationships.

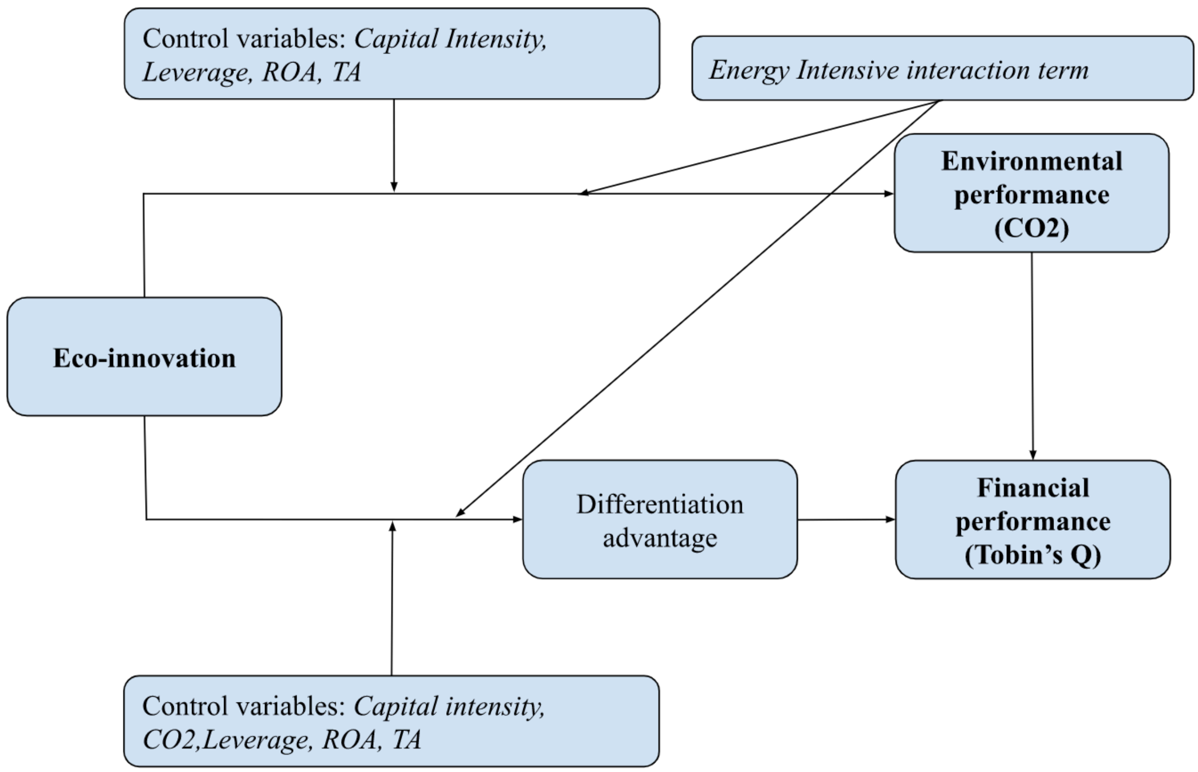

Figure 1: conceptual model

3.2 Research Method

Many different methods have been applied when analysing the effects of environmental innovation or green R&D on environmental and financial performance, such as the OLS regression method by Lee & Min (2015). Several authors have used a structural equation method concerning the link between environmental innovation and financial performance (Li, 2014; Ong, 2019; Aragón-Correa et al., 2008; Sambasivan et al., 2013). Moreover, different types of panel data models have been used when attempting to analyse the link between eco-innovation and carbon dioxide emission as well as financial performance, (Carrion-Flores & Innes, 2010; Többelmann & Wendler, 2020; Fethi & Rahuma, 2020). Panel data models, such as the one-step difference Generalised Method of Moments (GMM) estimator were used by Többelmann & Wendler (2020), and the autoregressive distributed lag (ARDL) approached by Fethi & Rahuma (2020).

The econometric method applied in this thesis is a two-way fixed effects panel data regression. The method has previously been used to analyse similar hypotheses (Carrion-Flores & Innes, 2010; Przychodzen & Przychodzen, 2015) and is a well-established econometric method. Heterogeneity among companies is assumed, meaning that each company has an individual specific effect caused by factors such as differences in leadership, geographic circumstances, and human capital etc. The benefit of using a fixed effects model compared to a cross-sectional model, such as the one used by Lee & Min (2015), is that the fixed effect model eliminates the part of the error term that is individually specified (Baltagi 2021a, p.15-17). Thus, it lowers the risk of omitted variable bias. Initially, a Hausman test was performed to choose between a fixed effects model and a random effects model (Baltagi, 2021a p.89). The null hypothesis that the individual-specific effects are uncorrelated with the independent variables was rejected, meaning that fixed effects indeed would be the more appropriate of the two estimators.

The fixed effect model becomes:

$$Y_{it} = \alpha + X_{it}\beta + \eta_i + \varepsilon_{it} \qquad (1)$$

where Y_{it} is a vector of our respective dependent variables, X_{it} is a matrix of our independent variables, ηi is a vector that is part of the error term caused by the company's individually specified effect, which is constant over time, and ε_{it} is the error term independent over time and individuals (Baltagi 2021a, p.363). The individual-specific error η_i is then removed by using the within estimator. This is performed by subtracting the individual mean of each term from the model:

$$Y_{it} - \bar{Y}_i = X_{it} + \beta + \eta_i + \varepsilon_{it} - \bar{X}_i\beta - \bar{\eta}_i - \bar{\varepsilon}_i = (X_{it} - \bar{X}_i)\beta + (\varepsilon_{it} - \bar{\varepsilon}_i) = \tilde{Y}_{it} = \tilde{X}_{it}\beta + \tilde{\varepsilon}_{it} \qquad (2)$$

Since $\bar{\eta}_i = \eta_i$ the individual specific effect is removed from the estimate (Ibid). The β is then found using OLS. Since both the observed and unobserved individual-specific factors are removed, we eliminate a potential source of omitted variable bias among firms (Ibid).

In order to provide consistent estimates, the fixed effects model assumes strict exogeneity (Baltagi 2021a, p.157), meaning that:

$$\mathrm{E}[\varepsilon_{it} | X_1, \dots, X_{it}, \eta_i] = 0 \qquad (3)$$

Two of the most common violations of the exogeneity assumption in panel data are time-specified unobserved shocks that affect either the dependent or independent variables in our model, and the simultaneity bias, which occurs when the independent variables react to previous years of the dependent variable or if the independent variables are affected by the dependent variables. To control for potential time variable bias, we have also added year-specific fixed effects to our regressions. This creates a year dummy variable for every year that captures any year-specified events occurring in a specific year impacting our dependent variables that are not captured by any of the control variables (Baltagi, 2021 p. 47).

To investigate the validity of our model assumptions, tests for heteroscedasticity and autocorrelation were performed. The test for heteroscedasticity involved calculating a modified version of the Wald test statistic, conducive to the fixed effects panel data regression model (Greene, 2000). The null hypothesis, being that the variance of all companies equals a constant parameter was rejected, indicating that heteroscedasticity indeed is likely. In addition, we performed a Woolridge test for autocorrelation (Woolridge, 2002), in which the null was rejected, meaning that autocorrelation is present in our data. Hence, in order to make our standard errors consistent we used the cluster-robust estimator when estimating the standard errors. The resulting clustered standard errors take into consideration that observations within the same cluster, i.e., the same firm, may be correlated or have similar characteristics (Liang & Zeger, 1986). These standard errors are so-called Huber–White standard errors, and consistent even with heteroscedasticity present (Huber, 1967; White, 1980).

In summary, we used a fixed effects regression model using panel data with clustered standard errors for our standard errors to remain consistent, even though we had autocorrelation and heteroscedasticity in our data. In order to avoid time varying omitted variable bias, we added year fixed effects in our model. In the following sections our dependent and independent variables, including our control variables will be discussed.

3.3 Data Collection and Sample Selection

Environmental innovations and financial performance play a crucial role in both the present and the foreseeable future, as the importance of sustainability continues to grow. As mentioned earlier, the rising demand for sustainable corporate practices has accompanied economic development. This leading to a shift from solely pursuing profit maximisation on the behalf of the stakeholders, towards profit seeking in line with stakeholder values. It is incentivised for firms to integrate environmental innovation and financial performance to sustain their market presence, maintain a competitive advantage and leverage valuable resources and capabilities. This collaborative effort across all sectors aims to minimise environmental impact, enhance operational efficiency, and ultimately align with the United Nations Sustainable Development 2030 agenda. Following the alignment of the UNSDG 2030 agenda, which includes 162 countries (UNSDG | 2030 Agenda, n.d.).

Secondary data from 59 countries were collected from Refinitiv Eikon for this study to test our hypothesis and the relationship between our variables in the conceptual framework. Refinitiv Eikon is a financial analysis and trading software. The reason for choosing Refinitiv Eikon is its accessibility and affordability, as it was provided by Lund University. All the variables used in estimation are reported annually from corporate annual reports between 2002 to 2022. We chose to collect data from 2002 onward since that is the year when the environmental innovation index started to be reported by Refinitiv Eikon.

The study aims to collect extensive data on eco-innovation and R&D from a diverse range of countries that have committed to pursuing the UNSDG by the year 2030. The selection of this study was based on a systematic filtering process using the independent variables as interest, including Eco-innovation, R&D, Capital Intensity, Total Assets, Leverage, ROA, and Energy Intensity. These variables served as filters to identify countries that exhibit significant variations and represent a diverse range of environmental and financial performance indicators. Moreover, a year filter with 21 years was applied to ensure the inclusion of data from a specific time-period relevant to the research objectives. By applying specific criteria and thresholds to the independent variables and incorporating a year filter, a subset of 59 countries and 4174 companies were carefully chosen to provide a comprehensive representation of different contexts and facilitate meaningful analysis of the relationship between these variables and the achievement of the United Nations Sustainable Development Goals.

To focus on industries with significant environmental impact, certain industries were excluded from the dataset based on their low emission levels. This exclusion was determined using the Global Industry Classification Standard (GICS) codes, which categorise industries based on their primary business activities. Industries with GICS codes are not typically associated with high emissions, as identified by Ritchie (2020). Specifically, industries such as 40 Financials, 50 Communications and 60 Real Estate, were not included in the analysis. By excluding these industries, the study aimed to concentrate on sectors that have a more substantial influence on environmental and financial performance.

Following the extraction of data from Refinitiv Eikon, a rigorous data selection process was undertaken. From the 4174 companies, we excluded companies with less than three years of history of reported eco-innovation score. Subsequently, companies that had not released any annual reports in the last two years were also excluded. As a result of these exclusions, the final dataset consisted of 3162 companies.

Fixed-year effects are incorporated into the panel data framework. The inclusion of fixed year effects enables capturing the time-specific variation and control for any system changes that occur at a specific year within the dataset, which is to account for time-dependent factors and ensure robustness against potential confounding effects associated with temporal changes.

Moreover, a time-period for this study is selected based on the establishment of UNSDG together with incorporated time effects. The established year 2015 serves as a global framework for addressing various social, economic, and environmental challenges. We aim to examine the impact of these goals and their subsequent implementation on the variables under investigation. This approach allows for analysis within the context of the pre- and post-UNSDG era and the broader sustainability agenda.

3.4 Variable Selection

This section presents the theoretical framework of variables and their relationship to each other. Winsorizing is used on all variables excluding Energy Intensive to reduce the impact of outliers by replacing extreme values with values that are closer to the rest of the data. Our model contained lagged variables in order to better capture the delayed effect that the independent variables may have on the dependent variables. R&D and Environmental Innovation where both lagged two years when used as regressors on CO_2, since the effect of innovation may take longer to affect the companies (Hart & Ahuja, 1996), while the other independent variables were lagged one year.

3.4.1 Firm's Financial Performance - Tobin's Q

The study utilises two dependent variables: CO_2 emission and Tobin's Q, serving as proxies for environmental performance and financial performance, respectively. Tobin's Q is frequently used in the accounting and finance literature, the ratio assesses the relationship between the market value of a firm and the replacement cost of its asset, a statistical measure influenced by firms' profitability and the financial market's required return (Faleye & Trahan, 2011). In empirical studies of corporate behaviour and structure, Tobin's Q is an effective metric for forecasting the firm's investment spending and controlling present and future profitability (Bodie et al., 2018, p. 395). This study will use it to measure firms' financial performance, following Lee & Min (2015) and other earlier studies (such as Gai et al., 2020; Vuong, 2022). The Q of this study is determined by dividing the firm's equity market value by total assets, in accordance with Lee & Min (2015) and Bodie et al. (2018, p. 395). Tobin's Q of 1 implies that the cost to replace a firm's assets is equal to the value of its equity. A Q value that is greater than 1 implies that the cost to replace a firm's assets is less than the value of its equity, suggesting that the firm may be overvalued.

3.4.2 Firm's Environmental Performance - CO_2 Emission

Assessing environmental performance in terms of sustainability typically necessitates a comprehensive range of variables, including the measurement of pollutants and environmental capacity (Lee & Min, 2015). However, due to limited data availability and to ensure a more suitable presentation and facilitate interpretation, CO_2 emissions will be the sole variable employed as a proxy for environmental performance at a firm level throughout our sample period. Moreover, a logarithm transformation was applied to the CO_2 emissions, normalising its distribution, and improving the fit of the model. Transforming the distribution of the features to a more normal-shaped bell curve helps to reduce the influence of extreme CO_2 emission values and allows for a percentage change interpretation (Baltagi, 2021b p.248).

3.4.3 Eco-Innovation

Environmental innovation and R&D are employed both as proxies for eco-innovation and have the same goal of reducing environmental impact; the main distinction between the two is the focus and measurement. While environmental innovation evaluates a company's overall capacity for reducing environmental costs, focusing on environmental technologies, processes, and products. R&D measures the financial investment dedicated to research and development activities, with environmental R&D expenditure included. Both variables are used as proxies for eco-innovation, since they are related to improvement of both environmental impact reduction and green innovation. An increase in these variables could create new market opportunities and the measurements are updated from publicly available documents published by companies worldwide (Refinitiv, 2022).

Environmental innovation is presented as an index ranging from 0 to 100, where higher scores indicate a higher degree of eco-innovation (Ibid). As for R&D, this study follows Lee & Min (2015) and divides R&D by the revenue of the firm, giving us the proportion of R&D in percentage and minimising the problem of heterogeneity, due to the size variety of the firm.

3.4.4 Control Variables

Capital intensity, measured as the ratio of Total Assets to revenue, serves as an indicator of capital efficiency and productivity within a firm. A higher level of capital intensity suggests a greater need for capital investment to support the firm's operations. This aspect can have implications for the cost of implementing eco-innovations and, consequently, impact the environmental and financial performance of the firm in various ways. Furthermore, firms with higher capital intensity typically possess greater financial resources and infrastructure, enabling them to allocate more funds toward eco-innovation projects.

However, Total Asset serves as an indicator of firm size in this study. Considering the variations in firm sizes, larger firms may exhibit different levels of financial and environmental performance compared to smaller firms due to their greater resource capacities and operational scale. Firms with larger total assets generally have greater financial capabilities and resources, which can support their efforts in implementing eco-innovation projects.

Leverage is the ratio of debt to total assets, which refers to the level of debt financing relative to the total assets of a firm. High levels of leverage may indicate higher financial risk and potential constraints on a firm's ability to invest in eco-innovation initiatives and in turn, affect the impact on environmental and financial performances.
Moreover, Return on Assets (ROA) is a financial metric that measures the profitability of a firm by calculating the ratio of its net income to its total assets. In the context of this study, ROA is included as a variable to assess the impact of profitability on eco-innovation. Allowing this study to examine whether higher profitability has a stronger or weaker effect on eco-innovation, thus the environmental and financial performance of the firm.

Furthermore, to account for the impact of environmental innovation on energy-intensive firms in the regression analysis, we introduce the Energy Intensive interaction variable. This variable combines a dummy variable for the Materials and Utilities industries with the Environmental Innovation variable. The inclusion of this variable allows us to control for the influence of energy innovation in these industries on CO2 emissions and Tobin's Q. Previous studies (Lee & Min, 2015) have highlighted the significance of eco-innovation implementation in these industries, given their high emission levels. By incorporating control variables, we aim to isolate and provide a more precise analysis of the specific impact of eco-innovation, while also accounting for potential confounding factors and considering the influence of energy usage or efficiency.

4. EMPIRICAL RESULTS AND DISCUSSION

This chapter presents and discusses the results of this study. The descriptive statistics are introduced first, followed by multiple regressions focusing on the relationship between Environmental Innovation, R&D, and CO2 emissions in relation to the financial and environmental performance of the firm.

Table 1 presents the descriptive statistics for all observations, followed by additional descriptive statistics in Tables 2 and 3, which present all the variables in two separate periods, pre- and post-2015, it is referred to as periods 1 and 2 respectively. Table 4 presents the correlation relationship among variables. The estimation results from Tables 5 and 6, present the impact of Environmental

Innovation, R&D and CO2 on firms' financial performance and on environmental performance, respectively the final Tables 7 and 8, illustrate the environmental and financial performances when divided by different GICS industry subgroups, respectively.

4.1 Descriptive Statistics

From the descriptive data in Table 1, we observe a relatively high mean of Tobin's Q of 1.915 and a maximum value of 9.030. This suggests that, on average, the replacement cost of the asset is less than the value of its stock (Bodie et al., 2018, p. 395). These findings can indicate that investors show a favourable attitude towards firms committed to eco-innovation, demonstrating their awareness of sustainable business practices.

Table 1 presents all variables and observations used in this study between the years 2002 and 2022.

Variable	Number of observations	Mean value	Standard deviation	Minimum value	Maximum value
CO2	28,338	11.590	2.978	3.851	18.128
Tobin's Q	52,464	1.915	2.034	0.091	9.030
Environmental Innovation	28,467	24.821	31.226	0.000	99.888
R&D	40,231	0.421	1.374	0.000	7.167
Capital Intensity	53,799	5.603	22.208	0.380	189.106
Total Assets	56,084	20.814	2.265	14.330	25.585
Leverage	55,945	0.203	0.182	0.000	0.716
ROA	37,541	0.044	0.137	-0.658	0.321
Energy Intensive	72,726	0.169	0.374	0.000	1.000

Definition and Description of Variables: *CO2* is the logarithm of *CO2*. *Tobin's Q* is equity market value/firms' book value. *Environmental innovation* is presented in scores from 0-100, estimated by Refinitiv Eikon. *R&D* is the firm's R&D expenditure/ total revenue. *Capital Intensity is* defined by the asset/revenue of the firm. *Total Asset*, also the size of the firm, is defined by the logarithm of Total asset. *Leverage* is the ratio of debt/total assets. *Return on Asset (ROA)* is revenue/total asset. *Energy intensive* is an indicator equal to 1 if a firm belongs to an energy-intensive industry and 0 otherwise. Winsorizing at the 1% level is used on all variables excluding *Energy Intensive*.

Moreover, this reflects the increasing awareness and recognition of sustainable business practices among investors, who may also be clients or stakeholders of the firm. These dynamics underscore the growing pressure from stakeholders and investors for firms to address environmental issues more seriously. With that being said, the mean value of Environmental Innovation is 24.821 with a maximum value of 99.888, which implies a relatively low level. This indicates that firms, on average, have limited capabilities in reducing environmental costs and show a low focus on environmental technologies and products. Consequently, this may result in missed market opportunities.

Interestingly, it is noteworthy that, on average, firms allocate a significant portion, approximately 40 percent of their revenue to R&D, as evidenced by the mean value of 0.421. However, there are cases where certain firms invest up to seven times their revenue in R&D, as indicated by the maximum value of 7.167. This suggests that some firms obtain additional capital for their R&D activities from sources other than their revenue. Such substantial investments underscore their strong commitment to tackling environmental challenges and finding innovative solutions to reduce environmental impact. It is plausible that this substantial investment in research and development contributes to the overvaluation of these firms.

Table 2 presents all variables and observations used in this study before and includes the year (2015) of the implementation of UNSDG. ***Period 1***

Variable	Number of observations	Mean value	Standard deviation	Minimum value	Maximum value
CO2	10,680	12.695	2.305	3.851	18.128
Tobin's Q	31,299	1.827	1.938	0.091	9.030
Environmental Innovation	10,697	25.586	31.778	0.000	99.738
R&D	22,415	0.398	1.322	0.000	7.167
Capital Intensity	33,123	5.142	20.822	0.380	189.106
Total Assets	34,376	20.548	2.343	14.330	25.585
Leverage	34,252	0.198	0.180	0.000	0.716
ROA	15,875	0.050	0.126	-0.658	0.321
Energy Intensive	50,592	0.169	0.374	0.000	1.000

For the Definition and Description of variables see Table 1.

Table 3 presents all variables and observations used in this study after the year(2015) implementation of UNSDG. ***Period 2***

Variable	Number of observations	Mean value	Standard deviation	Minimum value	Maximum value
CO2	17,658	10.921	3.135	3.851	18.128
Tobin's Q	21,165	2.044	2.162	0.091	9.030
Environmental Innovation	17,770	24.360	30.880	0.000	99.888
R&D	17,816	0.450	1.437	0.000	7.167
Capital Intensity	20,676	6.341	24.247	0.380	189.106
Total Assets	21,708	21.236	2.068	14.330	25.585
Leverage	21,693	0.210	0.183	0.000	0.716
ROA	21,666	0.040	0.144	-0.658	0.321
Energy Intensive	22,134	0.169	0.374	0.000	1.000

For the Definition and Description of variables see Table 1.

Upon comparing the descriptive data from Tables 2 and 3 for periods 1 and 2, a decline in Environmental Innovation is observed. This decline suggests a decrease in firms' capabilities to effectively reduce environmental costs and a diminished focus on environmental technologies and products. Consequently, there is a potential risk of missed market opportunities due to the reduced emphasis on environmentally sustainable practices. One possible explanation for this decline could be the difference in the number of observations between the two periods. Period 1 consisted of 10,697 observations, while Period 2 had a larger sample size of 17,770 observations. The lower mean value of Environmental Innovation in Period 2 can be attributed to the increased sample size. Additionally, this significant increase in the number of firms' reporting their Environmental Innovation initiatives after the year 2015, coincided with the implementation of UNSDG.

However, our other proxy for eco-innovation, R&D, increased from Period 1 to 2. This suggests that the firm allocates a moderate proportion of its revenue towards R&D efforts, which can be seen as a measure of its commitment to innovation and technological advancement. Furthermore, we observed a significant reduction in CO2 emission, even though the observations in Period 1 were significantly lesser than in Period 2. This indicates that several firms have successfully reduced their CO2 emission in recent decades. Additionally, we found an increasing trend in the average profitability of firms, as indicated by Tobin's Q, from period 1 to period 2. However, it's important to note that the number of observations for Tobin's Q was 10,134 lower than in Period 2, which could have influenced the observed increasing trend.

Overall, our interpretation of the descriptive data suggests that firms have shown an increasing trend in their efforts towards green development, particularly in terms of improving environmental impact reduction and innovation, following the implementation of the UNSDG. However, due to the decrease in Environmental Innovation, we cannot definitively conclude that companies have fully enhanced their capacity to reduce environmental costs and capitalise on new market opportunities through environmental technologies and eco-designed products.

Periods 1 and 2 of our study align with previous research (such as Aragón-Correa et al., 2008; Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023) indicating a positive impact of R&D and reduced CO2 emissions on Tobin's Q, it is important to consider that the number of observations in our study may have influenced the outcomes. The difference in the number of observations between periods 1 and 2 could potentially introduce bias or affect the generalizability of the findings. Therefore, it is crucial to interpret the results with caution, considering the potential impact of the varying sample sizes on the observed relationship.

Table 4 presents the correlation relationship between all selected variables.

	CO2	**Tobin's Q**	**Environmental Innovation**	**R&D**	**Capital Intensity**	**Total Assets**	**Leverage**	**ROA**
CO2	1							
Tobin's Q	-0.4001	1						
Environmental Innovation	0.3423	-0.1959	1					
R&D	-0.4379	0.1474	-0.1827	1				
Capital Intensity	-0.312	0.0798	-0.1306	0.7145	1			
Total Assets	0.7902	-0.3515	0.4035	-0.4016	-0.2813	1		
Leverage	0.2394	-0.2411	0.1026	-0.1137	-0.0975	0.242	1	
ROA	0.0296	0.0022	-0.0119	-0.0002	0.0016	0.0381	-0.024	1
Energy Intense	0.3713	-0.1716	0.0431	-0.0873	-0.0025	0.0853	0.1163	0.0062

In terms of the correlation matrix analysis, the results reveal interesting associations between variables. Environmental innovation demonstrates a positive relationship with CO2 emissions, contrary to our initial hypothesis (H1) regarding this relationship. Additionally, it exhibits a negative relationship with Tobin's Q, further deviating from our hypothesis (H4). On the other hand, R&D exhibits a negative relationship with CO2 emissions, aligning with previous findings, and a positive relationship with Tobin's Q, consistent with earlier research and our hypothesis H2 and H5, respectively. Furthermore, CO2 emissions show a negative relationship with Tobin's Q, supporting the findings from previous studies and our H6. It is noteworthy that Total Asset is correlated with CO2 emissions, which is to be expected since larger firms on average produce more emissions. These outcomes shed light on. the complex dynamics between environmental innovation, R&D, CO2 emissions, and financial performance, which require further investigation to understand the underlying mechanisms.

4.2 Impact of Eco-innovation on Environmental Performance

The results regarding Environmental Innovation, as presented in Column 1, Table 5 of the analysis. There is an indication of a negative relationship between Environmental Innovation and CO2 emissions, but the lack of significance suggests that this relationship may be influenced by other factors or variations within the data. To further explore this relationship, we incorporated the time effect in Column 2. Interestingly, with the inclusion of the time effect, we observed a significant positive association between Environmental Innovation and CO_2 emissions.

Table 5: Present the regression results of Eco-innovation on CO2 emissions.

VARIABLES	(1)	(2)	(3)	(4)
Environmental Innovation	-0.0006	0.0015**	0.0015*	0.0010
	(0.0006)	(0.0006)	(0.0008)	(0.0008)
R&D	-0.0644**	-0.0714***	0.0199	-0.0443*
	(0.0254)	(0.0265)	(0.1425)	(0.0248)
Capital Intensity	-0.0065***	-0.0065***	-0.0023	-0.0041**
	(0.0016)	(0.0016)	(0.0050)	(0.0020)
Total Assets	0.4592***	0.6209***	0.3569***	0.6032***
	(0.0534)	(0.0569)	(0.0868)	(0.0707)
Leverage	-0.7028***	-0.5998***	-0.5531**	-0.4664**
	(0.1821)	(0.1719)	(0.2371)	(0.2069)
ROA	-0.0646	-0.0750	0.0790	-0.0947
	(0.1411)	(0.1383)	(0.2480)	(0.1639)
Energy Intensive	0.0005	0.0017	0.0038	-0.0006
	(0.0013)	(0.0012)	(0.0024)	(0.0016)
Constant	1.7365	-1.3759	4.8761**	-1.5761
	(1.1719)	(1.2357)	(1.9348)	(1.5307)
Time effects	No	Yes	Yes	Yes
Observations	9,048	9,048	2,195	6,853
R-squared	0.0657	0.0989	0.0358	0.0782
Number of Companies	2,187	2,187	593	2,109

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This unexpected finding diverges from our initial hypothesis (H1), suggesting that the impact of environmental innovation on CO_2 emissions may vary over time and be influenced by additional contextual factors. This finding is not reflected in most previous research (Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023), where Environmental Innovation often has been found to lower CO_2 emissions. However, Eikon's Environmental Innovation Index seems not to be used in previous studies.

As for the analysis regarding R&D and its relationship to CO_2 emission, considering the presence of time effects. In Column 1, which excludes the time effect, R&D demonstrates a significant negative relationship with CO_2 emissions, highlighting its effectiveness in reducing environmental impact. Moreover, it is in line with our second hypothesis (H2) and previous findings (Lee and Min, 2015; Andersén, 2021; Mustafa et al., 2022; Nureen et al., 2023). In Column 2, which incorporates the time effect, the negative relationship between R&D and CO_2 emissions remains significant. This further strengthens our confidence in the robustness of our findings and the validity of our hypothesis.

Columns 3 and 4 in Table 5 correspond to the pre-2015 and post-2015 periods, respectively. Environmental Innovation continues to deviate from our initial hypothesis (H1) and earlier findings. It exhibits weak statistical significance in the pre-2015 period but disappears in the post-2015 period. Therefore, based on these results, we cannot draw any conclusive findings regarding the relationship between environmental innovation and CO2 emissions. In relation to R&D, the initially observed insignificant positive relationship with CO2 emissions in the pre-2015 period underwent a notable shift in the post-2015 era. Specifically, it became significantly negative, indicating a stronger negative association between R&D and CO2 emissions. This finding suggests that after the implementation of UNSDG, firms' investment in R&D has effectively contributed to the development of products and services focusing on improving environmental impact reduction and innovation. Thus, the reduction of CO2 emissions is somewhat consistent with the third hypothesis (H3).

4.3 Impact of Eco-innovation and CO2 Emissions on Financial Performance

When comparing the results of Environmental Innovation analysis with and without the time effect, as presented in columns 1 and 2 of Table 6, interesting patterns emerge. In column 1, there is a weak but significant positive relationship between Environmental Innovation and Tobin's Q, which aligns with our hypothesis (H4) and earlier studies (Porter and van der Linde, 1995; Aragón-Correa et al., 2008; Sambasivan et al., 2013; Lee & Min, 2015; Andersén, 2021). However, with the incorporation of the time effect in column 2, this positive relationship becomes insignificant. This finding raises questions about the strength and reliability of the relationship. The disappearance of significance after the inclusion of the time effect undermines our confidence in the robustness of the findings and the validity of our hypothesis.

Table 6: Present the regression results of Eco-innovation and CO2 Emissions on Tobin's Q.

VARIABLES	(1)	(2)	(3)	(4)
Environmental Innovation	0.0017*	0.0010	-0.0001	0.0022*
	(0.0009)	(0.0009)	(0.0009)	(0.0013)
R&D	0.0948***	0.0770**	0.0342	0.0615*
	(0.0340)	(0.0334)	(0.1539)	(0.0370)
CO2	-0.0327	-0.0444**	-0.0082	-0.0353
	(0.0229)	(0.0217)	(0.0296)	(0.0253)
Capital Intensity	-0.0023	-0.0019	-0.0057**	-0.0001
	(0.0015)	(0.0014)	(0.0028)	(0.0017)
Total Assets	-0.5399***	-0.5086***	-0.4324***	-0.7402***
	(0.0652)	(0.0687)	(0.0901)	(0.0782)
Leverage	0.2430	0.0373	-0.4964	-0.0142
	(0.2943)	(0.2859)	(0.3599)	(0.2848)
ROA	-0.3429**	-0.1518	0.3311	-0.1643
	(0.1734)	(0.1598)	(0.2174)	(0.2044)
Energy Intensive	-0.0024**	-0.0031***	0.0009	-0.0040***
	(0.0011)	(0.0010)	(0.0014)	(0.0013)
Constant	13.8243***	13.0875***	11.0962***	18.0105***
	(1.3890)	(1.4423)	(2.0613)	(1.6740)
Time effects	No	Yes	Yes	Yes
Observations	10,439	10,439	2,557	7,882
R-squared	0.0483	0.1299	0.2162	0.1490
Number of Companies	2,280	2,280	631	2,190

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In relation to R&D and Tobin's Q, both columns 1 and 2 in Table 6 reveal a significant positive association, irrespective of whether the time effect is considered. This finding is consistent with our hypothesis (H5) and supports previous research findings (Porter and van der Linde, 1995; Aragón-Correa et al., 2008; Sambasivan et al., 2013; Lee & Min, 2015; Andersén, 2021). In terms of CO2 emissions, the analysis in column 1 of the study revealed an insignificant negative relationship with Tobin's Q when the time effect was not considered. However, upon incorporating the time effect in the analysis (column 2), the negative relationship became statistically significant. This indicates that when the temporal dynamics are considered, the negative association between CO2 emissions and financial performance becomes more evident and robust, which provides a more reliable basis for drawing conclusions. This finding supports our hypothesis (H6) and is in line with previous research by Hart and Ahuja (1996).

Remarkably, we uncovered a highly compelling finding in columns 3 and 4, presented as the pre- and post-2015. The relation between Environmental Innovation and Tobin's Q went from statistically insignificant to significantly positive, implying that the implementation of the UNSDG led to increased capabilities and focus on more environmental production in terms of emission reduction. However, it is important to notice that the number of observations increases from 631 in the pre-2015 period to 2190 in the post-2015 period. More observations in the pre-period would have improved the robustness of this result. Regarding R&D, the coefficient not only remained significant but also strengthened. The implementation of the UNSDG introduced a higher level of pressure on firms, driven by the increased demand from stakeholders for environmentally responsible business practices. This alignment with the UNSDG highlights the growing importance placed on environmental sustainability and reinforces the need for firms to invest in research and development to meet these evolving expectations and achieve a mutually beneficial exchange. Both findings provided further support for our hypothesis (H3) and (H7), further, for previous findings (Porter and van der Linde, 1995; Aragón-Correa et al., 2008; Sambasivan et al., 2013; Lee & Min, 2015; Andersén, 2021).

The significant positive relationship between R&D and Tobin's Q can be attributed to the firms' substantial investments in research and development, particularly in developing new products and services aimed at reducing environmental impact and promoting innovation. These investments enable firms to produce and allocate resources in alignment with the NRBV, allowing them to enhance and sustain their competitive advantage.

By focusing on improving environmental performance and innovation, firms can effectively address the demands of environmentally aware stakeholders. This commitment not only helps in fulfilling the expectations of stakeholders but also enhances the firm's reputation and attractiveness to potential investors. The allocation of significant revenue to research and development activities underscores the firm's dedication to developing environmentally friendly solutions and products, which are increasingly sought after in the market.

4.4 Impact of Eco-innovation on Environmental Performance per Industry

The following present the regression results on environmental impact of Environmental innovation and R&D, categorised by different industries. Our objective is to examine the behaviour of these industries and determine if there are varying levels of environmental commitment based on their emission intensity. Numerous authors, including Hart (1995), Lee and Kim (2011), Wolf (2013), Lee and Min (2015), Eteokleous (2016), Barnett (2020), Huang and Chen (2021), Iqbal and Ahmad (2021), and Medina et al. (2022), have emphasised the importance of environmental commitment within industries that have a significant environmental impact, especially after the implementation of UNSDG.

Interesting results are found in Table 7 regarding Transport, IT hardware, Pharmaceutical and Semiconductor industries. The Transport industry is reported as an emission-intensive industry (European Commission, n.d). The result implies a significant positive relationship between R&D and CO2 emissions, which indicates the inefficiency in implementing sustainable practices to reduce CO2 emissions within the Transportation industry. This is in line with the findings from (Du et al., 2019). In the case of the IT hardware industry, which is classified as a pollution-heavy sector according to McKinsey (2022), our results reveal a significant positive relationship between Environmental Innovation and CO2 emissions. This finding contradicts the green perspective but is consistent with the findings of (Du et al., 2019). The reason for this could be explained by two factors; one is the technical issues with the data source and the possibility of endogeneity bias. The other reason is the lack of differentiation into categories of eco-innovation that are introduced by several authors, such as organisational eco-innovation, managerial eco-innovation, process eco-innovation and production-related eco-innovation. The first three have previously been demonstrated to have the impact of reducing CO2 emission, while the production-related eco-innovation did not display the same impact (Junaid et al., 2021; Medina et al., 2022).

Interestingly, Pharmaceuticals and Semiconductors have shown a significant negative relationship between R&D and CO2 emissions, as these two industries commit to sustainable practices that result in CO2 emission reductions. Both industries belong to the emission-intensive sectors according to Belkhir and Elmeligi (2019), Lee & Kim (2011) and McKinsey (2022), respectively. These results support the previous findings by Aragón-Correa et al. (2008), Lee and Min (2015), Andersén (2021), Mustafa et al. (2022) and Nureen et al. (2023). The negative relationship observed between R&D and CO2 emissions in the Pharmaceuticals industry can be attributed to several factors. The industry has even higher CO2 emissions than the automotive industry, leading to concerns about "greenwashing" practices and lack of transparency in reporting emissions (Deblonde & P, 2013; Belkhir and Elmeligi, 2019; Quesada et al., 2019). Previous studies highlight the need for the pharmaceutical sector to address its environmental impact and reduce CO2 emissions. Stakeholder pressure may be a driving factor behind the negative relationship, as stakeholders demand greater transparency and accountability. However, more efforts are required to translate R&D investments into significant emission reductions. The latter negative relationships within the Semiconductor industry can be explained by the nature of the industry's supply chain and the close relationship with the customers (Lee & Kim, 2011). Semiconductors have great access to external information and have opportunities to gain valuable knowledge and expertise, which can contribute to their success. This in turn enhances their chances of achieving favourable outcomes. This can include the successful development of environmentally friendly products and innovations, which in turn reduce CO2 emissions (Ibid).

Findings regarding other industries, Utilities, Materials, Capital Goods, Car Industry, Health Care, IT software, and Energy sectors, were not statistically significant, while there may be observed trends indicating potential impacts of Environmental Innovation and R&D on CO2 emissions in these industries, the absence of statistical significance emphasises the need for caution in drawing conclusive statements about their relationship. This might be explained by the data source, as well as the possibility of endogeneity bias.

Table 7. presents regression results between the impact on CO2 emission by eco-innovation when dividing by different GICS industry subgroups.

VARIABLES	Materials	Energy Sector	Capital Goods	Transport	Car Industry	Healthcare	Pharmaceutical	Semiconductors	IT Hardware	IT Software	Utilities
Environmental Innovation	-0.0001	-0.0028	0.0025	0.0017	0.0014	0.0009	0.0025	0.0028	0.0029*	0.0008	0.0008
	(0.0014)	(0.0021)	(0.0016)	(0.0028)	(0.0023)	(0.0018)	(0.0016)	(0.0035)	(0.0017)	(0.0021)	(0.0026)
R&D	0.0082	-0.0783	2.4454	0.1321**	0.9629	0.0255	-0.0470*	-4.4664**	-1.0569	1.6873	5.8994
	(0.0914)	(0.0495)	(2.5042)	(0.0645)	(1.9843)	(0.0561)	(0.0264)	(2.2182)	(0.7109)	(1.6493)	(31.5519)
Capital Intensity	-0.0050	-0.0099*	-0.0055**	-0.0032*	-0.0197	-0.0883**	-0.0054***	-0.0053	-0.0287	-0.1895***	-0.0894
	(0.0045)	(0.0053)	(0.0023)	(0.0016)	(0.0139)	(0.0438)	(0.0015)	(0.0041)	(0.0402)	(0.0605)	(0.0806)
Total Assets	0.9132***	0.4772***	0.9185***	0.0076	1.2189**	0.7633***	0.5716***	0.5642**	0.4902***	0.5713***	0.6216
	(0.2012)	(0.1790)	(0.1499)	(0.4289)	(0.4641)	(0.1107)	(0.0777)	(0.2327)	(0.1829)	(0.1423)	(0.4531)
Leverage	-0.6719*	0.1045	-1.1203**	-0.1702	-1.4250	-0.2035	-0.2238	0.5097	0.0228	-1.0557**	2.0102
	(0.3625)	(0.5622)	(0.5089)	(1.0195)	(0.9340)	(0.2380)	(0.2625)	(0.7286)	(0.4696)	(0.4670)	(1.6652)
ROA	0.0258	-0.0643	-0.0595	0.4406	-0.1108	0.2073	0.4700	0.1050	-0.6676	-0.8556	0.6878
	(0.2445)	(0.3529)	(0.2542)	(0.5303)	(0.3236)	(0.4392)	(0.3928)	(0.7167)	(0.5122)	(1.0619)	(0.6490)
Constant	-6.0777	3.4515	-8.8098***	10.9306	-14.8891	-5.4925**	-1.2172	-0.2799	1.5811	-2.2614	0.2629
	(4.3808)	(3.9303)	(3.3726)	(9.1883)	(10.5802)	(2.2407)	(1.5733)	(4.9388)	(4.0622)	(2.9612)	(11.0188)
Observations	1,501	593	1,417	122	371	544	1,168	474	976	567	136
R-squared	0.2011	0.1386	0.1796	0.1812	0.4024	0.3916	0.2308	0.1652	0.1379	0.1268	0.5442
Number of Companies	307	120	324	35	80	153	355	111	214	150	37

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.5 Impact of Eco-innovation on Financial Performance per Industry

The results regarding the effect of eco-innovation and CO2 emissions on Tobin's Q are presented in Table 8. The results became more interesting regarding Capital Goods, Transport, Semiconductors, IT hardware and Utilities industries.

Capital Goods are referred to as durable goods used in the production of other goods or services, such as machinery, equipment, and infrastructure (US EPA, 2023). While capital goods themselves do not directly emit greenhouse gases, their production, operation, and maintenance processes can contribute to emissions. Counted as an indirect emission that impacts its value chain (Ibid). The Capital Goods industry demonstrates a significant positive relationship between Environmental Innovation and Tobin's Q. This can be attributed to the industry's crucial role as a supplier of machinery, equipment, and technologies to various sectors. As environmental stakeholder pressure continues to rise, there is an increasing demand across industries for environmentally sustainable product solutions.

Given that the production processes in these industries heavily rely on capital goods, the incorporation of Environmental Innovation by the Capital Goods industry becomes paramount. By meeting the market demand for sustainable solutions and integrating environmental considerations into their offerings, the industry not only contributes to environmental sustainability but also enhances its financial performance, as reflected by the positive impact on Tobin's Q. This positive relationship underscores the market's recognition of the industry's commitment to sustainability and its ability to generate value both in environmental and financial terms.

Simultaneously, the Capital Goods industry demonstrates a notable significant negative relationship between R&D and Tobin's Q. This might be able to explain by the nature of the industry, as a supplier of machinery, equipment, and technologies to various sectors, their focus might not be investing their revenues in R&D activities in this context. Their primary focus might be more towards incremental improvements or cost optimisation rather than ground-breaking innovations toward sustainability in terms of the environment.

Table 8 presents regression results between the impact on Tobin's Q by eco-innovation and CO2 emissions when dividing by different GICS industry subgroups.

VARIABLES	Materials	Energy Sector	Capital Goods	Transport	Car Industry	Healthcare	Pharmaceutical	Semiconductors	IT Hardware	IT Software	Utilities
Environmental Innovation	-0.0012	-0.0003	0.0015*	-0.0049	0.0009	0.0096	0.0011	-0.0049	-0.0013	0.0025	0.0032***
	(0.0013)	(0.0010)	(0.0008)	(0.0048)	(0.0025)	(0.0060)	(0.0049)	(0.0034)	(0.0029)	(0.0058)	(0.0008)
R&D	0.0509	0.1469	-7.4242***	-0.3838*	0.9638	-0.0591	0.0414	-3.0150*	1.4706***	-1.9444	-0.7692
	(0.0853)	(0.1072)	(2.5117)	(0.2186)	(1.0062)	(0.1834)	(0.0397)	(1.7958)	(0.3058)	(2.3268)	(8.2534)
CO2	0.0211	0.0454	-0.0573*	-0.0298	0.1876	0.2132	-0.1462*	-0.1628	-0.1932**	-0.1108	-0.0126
	(0.0436)	(0.0324)	(0.0311)	(0.1460)	(0.1308)	(0.1539)	(0.0861)	(0.1030)	(0.0808)	(0.1261)	(0.0225)
Capital Intensity	-0.0021	-0.0041	-0.0025***	-0.0026	-0.0288	0.0806	-0.0008	-0.0010	-0.1676***	-0.2645**	0.0046
	(0.0023)	(0.0032)	(0.0007)	(0.0036)	(0.0345)	(0.0690)	(0.0019)	(0.0069)	(0.0507)	(0.1318)	(0.0099)
Total Assets	-0.9108***	-0.4033***	-0.2731***	-0.7758*	-0.1499	-0.7663***	-0.4590***	-0.1440	-0.1607	-0.7853**	-0.2932***
	(0.1274)	(0.1372)	(0.0821)	(0.4343)	(0.4103)	(0.2774)	(0.1188)	(0.3758)	(0.1938)	(0.3049)	(0.0615)
Leverage	-0.2771	-0.2592	-0.8472***	-2.9252	1.1123	-0.5128	0.5558	1.8672*	-0.4486	0.3341	-0.4966
	(0.2986)	(0.4096)	(0.2636)	(2.2073)	(1.4470)	(1.1141)	(0.5300)	(1.0372)	(0.4981)	(1.1189)	(0.2981)
ROA	-0.1235	0.0846	0.1487	0.2861	0.5459	-1.0885	0.1653	-0.1996	-0.0139	-0.9302	-0.1815
	(0.1775)	(0.3034)	(0.2489)	(0.8476)	(0.3616)	(1.4855)	(0.5837)	(1.2275)	(0.3699)	(1.3776)	(0.2368)
Constant	20.5855***	9.6644***	8.3826***	19.3630*	2.2488	17.8877***	13.4929***	6.3708	7.6867**	20.7600***	7.9954***
	(2.8571)	(3.2454)	(1.7348)	(9.9518)	(8.9040)	(4.7587)	(2.3121)	(7.8413)	(3.7697)	(5.9768)	(1.6676)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,671	652	1,615	144	418	648	1,434	543	1,119	671	154
R-squared	0.2657	0.2328	0.1815	0.2953	0.1487	0.2518	0.1849	0.3367	0.1494	0.3574	0.3580
Number of Companies	322	122	331	34	82	160	383	118	219	155	36

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Regarding the Transportation and Semiconductors industries, we found a significant negative relation between R&D and Tobin's Q, supported by previous findings (Walley and Whitehead, 1994; Palmer et al., 1995; Ambec and Lanoie, 2008; Latupeirissa & Adhariani, 2020; Medina et al., 2022; Mahsina and Agustia, 2023). Since both are accounted for heavy pollution industries, and often have high operational costs, competitive pressures, or the complexity of implementing environmentally sustainable practices within the industry (Junaid et al., 2021).

Interestingly, IT hardware showed a significant positive relation between R&D and Tobin's Q, supporting Aragón-Correa et al. (2008), Lee and Min (2015), Andersén (2021), Mustafa et al. (2022) and Nureen et al. (2023). The IT hardware sector is known for its innovation and rapid technological advancement. To maintain their competitiveness and release new and improved products onto the market, businesses in this sector heavily invest in research and development activities. IT hardware companies can create cutting-edge technologies, improve product quality, and add cutting-edge features that draw customers and produce higher financial returns by allocating resources to R&D (Kim et al., 2011).

Moreover, our result also showed a significant positive relationship between Environmental Innovation and Tobin's Q in the Utilities industry. The industry is defined as businesses that provide electric power, natural gas, steam supply, waste collection, treatment and disposal activities and telecommunications, to mention a few (Eurostat, 2020). As mentioned, businesses stand for 72 percent of the total utility industry and are classified as an energy-heavy sector (Lee and Min, 2015; Imperiale et al., 2023). The positive relation implies that by implementing environmental innovation practices, such as adopting renewable energy sources, improving energy efficiency, and implementing sustainable infrastructure. These practices are favourable to the stakeholders and regulation implementers and can lead to positive outcomes in terms of reducing CO_2 emissions, minimising resource consumption, and thus improving both financial performance and sustainability performance. Even though Table 7 did not show any evidence that environmental innovation in the Utilities industry reduces CO_2 emissions.

Results regarding other industries, such as Materials, Energy sector, Car Industry, Healthcare, Pharmaceuticals and IT software, were not statistically significant, indicating that we cannot draw strong conclusions regarding the presence of a robust statistical association about the relationship between Tobin's Q and eco-Innovation within these industries. This puts emphasis on the need for caution in drawing conclusions.

Overall, the data in Tables 7 and 8 provide insight into the complex web of relationships that exist between environmental innovation, R&D, CO_2 emissions, and financial performance across various industries. The importance of further research and the adoption of sustainable strategies to successfully address environmental challenges are highlighted by the significance of these relationships and their consistency with earlier studies. These results highlight the ongoing requirement for businesses to prioritise environmental sustainability and create cutting-edge strategies that not only reduce CO_2 emissions but also improve their financial performance. A deeper understanding of these connections will come from further research in this area, which could also guide current and future initiatives to encourage environmental responsibility and sustainable business practices across industries.

4.6 Limitations & Future Research

The reason for our first hypothesis, H1**,** not being supported by our findings when adding a time trend may be due to a violation of the exogeneity assumption regarding the Environmental Innovation index. Since larger companies have access to more funds being able to be spent on R&D and Green R&D or Environmental Innovation, these companies might score higher on the index while still emitting a larger amount of CO2 emissions due to their size. Simultaneously, data availability of the Environmental Innovation Index seems to be more widely available among larger companies. Lowering the threshold from 250 million USD did not greatly increase the number of firms in the data collection phase. This leads to data more often being available among larger firms, causing the data available to be correlated with aspects that define a large company, such as larger CO2 emissions. In order to control for such size effects of firms on CO2, we used the log of Total Assets. Additionally, a fixed effects model also aids in the purpose of controlling for size, since the individual specific error term η_i is controlled for through the subtraction of the mean as seen in equation (2).

The above-mentioned issues regarding data availability are connected to another limitation, consisting of us having an unbalanced panel dataset. We have attempted to gather as much data as possible to create as representative a set of companies as possible to represent the target population of large companies. Lastly, the accuracy of our Environmental Innovation variable is completely dependent on the quality of the Index made by Refinitiv Eikon, which in turn gathers data reported by the companies themselves. Eikon does not provide extensive public information on what exact metrics are used when collecting this data.

Additional limitation can be the lack of differentiation into categories of eco-innovation, since we did not have availability to categorised eco-innovation data used by Junaid et al. (2021) and Medina et al. (2022). For example, the effect of organisational eco-innovation, managerial eco-innovation and process eco-innovation on emission reduction might be neglected by the difficulties in product eco-innovation.

In the light of these limitations, there are several suggestions for future research. One would be to use alternative measurements of environmental innovation such as green R&D spending using a similar fixed effects model. Another would be to create a balanced panel dataset when data availability continues to improve. Thirdly, would be to further study the effect of environmental innovation in certain industries and compare them to each other. Fourthly, the inclusion of categorised eco-innovation data. Considering the results of this study, it seems likely that environmental innovation affects some industries in different ways compared to others.

5. CONCLUSION

In conclusion, our study provides insights into the relationship between R&D, Environmental Innovation, environmental performance, and financial performance. We find a substantial negative relationship between R&D and CO_2 emissions, supporting previous research and highlighting its effectiveness in reducing emissions. The association between R&D and CO_2 emissions is stronger after the implementation of the UNSDG in the post-2015 era, indicating the positive influence of this sustainability initiative.

Consistent with earlier findings, we observe a significant positive correlation between R&D and Tobin's Q, as well as Environmental Innovation and Tobin’s Q after 2015, indicating the positive impact of these respective variables on financial performance. However, our study reveals a surprisingly slight positive correlation between Environmental Innovation and CO_2 emissions, when adding time effects, contrasting previous studies and our hypotheses. This suggests the need for further investigation in this area. Additionally, we find no significant relationship between Tobin's Q and Environmental Innovation when observing across all years and with time effects, suggesting that Environmental Innovation only benefits financial performance in recent years.

The implementation of the UNSDG has also played a role in shaping firms' capabilities in environmental production and emission reduction, creating better financial incentives for firms. This could contribute to explaining the increased financial incentive for Environmental Innovation and R&D. Our findings highlight the complexity and diversity of the impacts of sustainable practices on CO_2 emissions across different industries, emphasising the need for more research to deepen our understanding and guide efforts towards sustainable responsibility and business practices.

Overall, our study contributes to the existing knowledge by shedding light on the interplay between R&D, CO_2 emissions, Environmental Innovation, and financial performance, and the influence of the UNSDG. It emphasises the importance of adopting sustainable practices, further research, and directing efforts towards environmental responsibility in order to achieve a more sustainable future.

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