ECO-INNOVATION AND CORPORATE ENVIRONMENTAL PERFORMANCE: EVIDENCE FROM G20 COUNTRIES

by

Huu Thanh Nguyen

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Dalhousie University is located in Mi'kma'ki,

the ancestral and unceded territory of the Mi'kmaq.
We are all Treaty people.

Table of Contents

List of Tables

List of Figures

Abstract

This study examines the impact of eco-innovation on corporate environmental performance by using a sample of publicly listed firms from G20 countries during the period 2002–2022. My research provides a comprehensive analysis by examining four aspects of corporate environmental performance, including energy consumption, water withdrawal, carbon emission, and waste generation, and using four alternative measures of eco-innovation, namely R&D investment, environmental innovation score, process innovation, and product innovation proposed in the recent literature. Overall, I find that at the firm level, eco-innovation has a positive impact on corporate environmental performance by reducing all its four aspects. In addition, the findings are more pronounced for R&D investment, environmental innovation score and product innovation suggesting their relative effectiveness in measuring eco-innovation and reducing firms' environmental impacts. The findings are robust to alternative model specifications, econometric methods, and the addition of control variables such as country and board characteristics.

Keywords: eco-innovation, corporate environmental performance, G20 countries

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Chapter 1: Introduction

Environmental concerns continue to grow globally. Over recent decades, the magnitude of the impact on the caused by human activities has become increasingly severe. Past environmental degradation was caused by human activities and the industrialization process (Oldfield and Dearing, 2003). In response to this escalating problem, numerous countries and societies are displaying robust support for environmental conservation, with a particular focus on assisting communities facing severe environmental challenges (Inglehart, 1995). Many international meetings and agreements have been established to address the far-reaching impacts of business operations on environmental quality. They aim to foster collaboration among countries and promote collective action to mitigate the adverse effects on the environment caused by corporate activities. During the Paris Climate Conference (COP21) in December 2015, a global climate agreement was approved by 195 countries, marking the first-ever legally binding accord of its kind. All signatories of the agreement reached a consensus on the need to reduce greenhouse gas (GHG) emissions, especially carbon emissions, as a crucial measure to mitigate the risks of global warming.

Countries worldwide are increasingly embracing sustainable development and environmental protection strategies as an objective to address the ongoing conflict between economic growth and environmental preservation. The aim is to find a balance that promotes economic prosperity while simultaneously protecting the environment (Tian et al., 2020). One of the major contributors to the pollution of the environment and depletion of resources is the operation of corporations through their increasing resource use and emissions. For example, research has shown that 100 active fossil fuel producers have generated approximately 71% of industrial greenhouse gas emissions since 1988, a significant year when human-induced climate change was formally recognized with the establishment of the Intergovernmental Panel on Climate Change (IPCC) (Griffin, 2017). Hence, firms are under increasing pressure to adopt sustainable practices and reduce their environmental impact. One of the keyways businesses can contribute to a greener future is by channeling their investments into eco-innovation initiatives that prioritize environmental considerations (Lee and Min, 2015; Alam at al., 2019; Erdoğan et al., 2020). Hence, my study aims to examine whether eco-innovation at firm-level can indeed help improve corporate environmental performance.

From the corporation’s side, Hart (1995) posits in his introduction of Natural Resource Based View Theory that sustainability strategies may seem counterintuitive, but they have potential to generate competitive advantage for firms. Likewise, although eco-innovation activities may require costs and investments, they are also believed to yield numerous beneficial outcomes for corporations. First, they can contribute to increasing the corporation's revenue by providing access to specific markets and differentiating its products. Secondly, implementing environmental solutions can lead to reduced production costs, further enhancing financial performance (Ambec and Lanoie, 2008). Thirdly, they motivate improvements in environmental performance, which helps reduce firms’ related risks and financing costs (Benlemlih and Cai, 2019). In addition, firms with better environmental protection strategies can avoid and reduce regulatory compliance costs, and taxes such as greenhouses gas tax and refuse tax. Corporate investment is costly and irreversible, allocating it successfully is one of the most crucial decisions of financial management. Therefore, examining whether eco-innovation investments can indeed enhance the environmental performance of the corporations is critical for management.

A corporation can have impacts on the environment through different ways, including its energy consumption, water withdrawal, carbon emissions, and waste generation, which have garnered significant attention from the public and sparked global controversies. According to Refinitiv (2022), those dimensions are divided into two different categories: corporate resource use (energy consumption and water withdrawal) and emissions (carbon and waste disposal). This classification gives insights into both the input and output side of the business process, and some of these dimensions have been used in prior studies (Aragon-Correa, Hurtado-Torres, Sharma et al., 2008; Martín and Herrero, 2019). Hence, I follow Refinitiv's classification to consider all four aspects to provide a comprehensive view of corporate environmental performance.

This study is conducted with a large sample of publicly-listed firms from G20 (Group of 20) countries, comprising 19 sovereign countries, and the European Union (EU). The G20 countries brings together the most developed economies and emerging ones, accounting for over 80% of the world's GDP, three-quarters of international trade, and 60% of the global population (Government of Canada, 2023). The G20 produces almost 80% of the emissions that cause various environmental problems on the global scope (Warren, 2021). On the other hand, the G20, being the wealthiest countries, has the financial ability for innovation to shift rapidly to zero-emission economies. They also host crucial carbon-absorbing ecosystems. G20 stays focused on the process of the UN 2030 Agenda for Sustainable Development, adopted in 2015, with the aim of reaching sustainability in many aspects including climate change and innovation. In addition, all G20 members have declared their full commitment to the Paris Agreement, whose mission is to reduce climate change, low carbon, and energy-efficient economies. Furthermore, Figure 1 shows that most G20 members spend a considerable amount of their GDP on R&D activities, e.g., South Korea (3.6%), Japan (3.2%), Germany (2.8%), USA (2.7%) and the EU (1.9%). This investment could motivate corporate eco-innovation, which results in greener and cleaner production and business operations. Hence, it is important and essential to study the effects of those eco-innovative efforts of G20 countries on the environmental performance.

More specfcially, this research aims to examine the impact of eco-innovation on four aspects of corporate environmental performance: whether a firm's commitment to eco-innovation can help reduce its energy consumption; whether a firm's commitment to eco-innovation can help reduce its water withdrawal**;** whether a firm's commitment to eco-innovation can help reduce its carbon emissions; whether a firm's commitment to eco-innovation can help reduce its waste generation.

I follow the empirical design of Alam et al. (2019) to test the effects of eco-innovation on corporate environmental performance. The results show that in general, eco-innovation could help to improve corporate environmental performance by reducing all of the four discussed dimensions. The impacts are more pronounced for energy consumption and carbon emissions reduction. Water withdrawal experiences less improvement because corporations may not focus on this environmental aspect in their strategies. Water does not cost companies much and not many governments around the world pay attention to industrial water use. R&D-to-sales ratio, environmental innovation score, and product innovation provide consistent results in reducing energy, carbon, and waste intensity, which supports their future use in the empirical work of measuring eco-innovation at the firm level. Process innovation does not result in an empirical relationship with corporate environmental performance, which could be explained by its slow adoption rate in firms. The results are robust to alternative econometric specifications such as Two-Stage least squares (2SLS) and weighted least squares (WLS). Furthermore, my findings are consistent with the inclusion of country and board characteristics in the regression analysis and among subsamples of developing countries, non-financial firms, and with lagging eco-innovation. Eco-innovation results in better corporate environmental performance in developing countries indicating its roles in those regions.

This study makes several contributions to the literature. First of all, my study considers all four dimensions of corporate environmental performance, including resource use such as energy consumption and water withdrawal, and emissions such as carbon emissions and waste generation. Second, I utilize four alternative proxies for eco-innovation including R&D investments, environmental innovation scores, process and product innovation scores as suggested in recent studies (Lee and Min, 2015; Alam et al., 2019; Arena et al., 2018; Nadeem et al., 2020). Although past studies have examined the impact of eco-innovation on environmental performance, they usually use only an individual proxy and examine one or two of the dimensions discussed above (Alam et al., 2019; Lee and Min, 2015). Hence, by considering all four dimensions of corporate environmental performance and alternative measures of eco-innovation, my study provides a more comprehensive understanding of the relationship between corporate environmental performance and eco-innovation. Third, my research is conducted on a sample of G20 members, which is more inclusive for both developed and developing countries. Past studies tended to focus on one nation or one similar sample group such as developed and developing countries (Yurdakul and Kazan, 2020; Albitar et al., 2022; Alam et al., 2019). Therefore, my research's sample size can ensure consistency of results on a more comprehensive global scale.

The findings of my paper have various policy implications. In this era of raising concerns, the paper aims to enhance comprehension of the efficacy of company investments in navigating the shifts in regulations and policies, providing valuable insights on how eco-innovation can contribute to coping with these changes. It sheds light on firm-level behaviors to cope with environmental risks. Concurrently, my findings can contribute to the research and development of green policies for both the legislative authorities and the company management itself. The empirical results strengthen companies' confidence in investing in eco-innovation. It also sheds light on how investment in eco-innovation can improve their environmental performance and how important it is for each kind of environmental dimension. From the government side, these results offer policymakers a strong basis for developing and putting into practice plans that support environmental sustainability and eco-innovation at the firm level.

The remainder of this thesis proceeds as follows. Section 2 discusses the theoretical background of the research and how I develop the research hypothesis. Section 3 introduces sample construction, the research design, and the variables used in the paper. Following that, Section 4 presents and discusses the empirical analysis. Section 5 concludes the research, interpretes the research meanings for many stakeholders groups, and provides future research directions.

Chapter 2: Background, Literature, and Hypothesis Development

2.1. Background Information on Environmental Issues

Since Second Industrial Revolution (1870–1900), the environment has suffered severe consequences due to human activities. Figures 2., 3., 4., and 6., aggregate information provided by https://ourworldindata.org, show the increase in the annual total of the four dimensions of environmental performance including energy consumption, water withrawal by industry, carbon emissions, and waste generation on a global scope. Those measures have exhibited a substantial rise during those last few decades, contributing to the environmental challenges we face today. Indeed, these measures are closely linked to the industrialization process, and represent the environmental impacts of corporations' activities. Therefore, comprehending these measures and their correlation with eco-innovation holds significant importance. By assessing these factors, this study provides valuable insights into a company's efforts toward sustainable practices and environmental responsibility.

In terms of resource use, which is the common input of manufacturing and other business processes, the increase in energy and water consumption had severe impacts on the environment. When considering energy consumption, the elevated energy usage by corporations is widely recognized to have significant adverse effects on the environment. Excessive energy consumption triggers problems such as resource depletion, heightened carbon emissions, and increased strain on ecosystems, collectively exacerbating the environmental challenges our planet faces. The use of fossil fuels (coal, oil, and gas) has surged, establishing its dominance in energy supply on the global scope. Fossil fuel burning has resulted in a proportional acceleration of CO2 emissions, contributing to more than

80% of the total greenhouse gas emissions (GHGs) emissions by 2008 (Akpan and Akpan, 2012). On the other hand, Akhmat et al. (2014) find that there is unidirectional causality between energy consumption and climatic factors among different regions in the world. Figure 2. illustrates a notable and substantial increase in energy consumption. This rise represents that the increase in in industrialization and business operation plays a significant role in energy consumption. Since excessive energy consumption results in serious issues and largely originates from industrial operations, firms' understanding and actions in eco-innovation could help to achive the better environmental performance.

For water withdrawal, its substantial rise in industries is directly linked to the depletion of water resources, an essential component of the environment. Water is fundamental resource that plays a crucial role in human life. It serves as a cornerstone for the advancement of food security and the prosperity of agriculture, both of which significantly contribute to the overall well-being and living conditions of humanity (Rosegrant at al., 2009). Meanwhile, water acts as a significant driver of economic development on a global scale, providing motivation for various industries and sectors (Goswami and Bisht, 2017). However, industrialization threatens the quality of water resources. In addition, the demand for water for manufacturing and other industries has increased significantly. According to Boretti and Rosa (2019), the use of water for industry, on the world scope, currently accounts for 20% of the total amount. It will increase everywhere around the world by the end of 2050 (800% in Africa, 250% in Asia) and this demand by the manufacturing industry will rise by 400%. Figure 3 shows that industrial water withdrawal has increased significantly in recent decades, which could trigger water scarcity around the world. Among industries, the agriculture and manufacturing sectors leave the most significant water footprint due to their large water withdrawal. However, they have the most potential for reducing their water use (Marston et al., 2020).

When it comes to corporate emissions, there are two main kinds: carbon emisions and waste generation. Carbon emissions have been widely employed by prior research as a metric to gauge the impact of firms' operations on the environment (Lee and Min, 2015; Alam et al., 2019; Gallego-Álvarez et al., 2015). As CO_2 emissions result in direct and visible impacts on the environment, reducing them becomes the top priority in corporate environmental protection strategies. For example, CO_2 is a major greenhouse gas responsible for global warming and climate change. As shown in Figure 4., the amount of CO_2 released during the last few decades has risen significantly sparking widespread concern on the global scope. Indeed, CO_2 emissions have become a central topic of discussion in various international conferences and agreements focused on addressing climate change and environmental issues such as the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and The Paris Agreement. Figure 5. reveals a concerning trend: the mortality rate among humans resulting from pollutants emanating from industrial operations, specifically ambient particulate matter, is on the rise. Notably, this mortality rate is surpassing the impact of air pollutants originating from households, indicating a more critical and fatal environmental issue associated with industrial gas emissions.

Another significant factor from corporations contributing to the depletion of environmental quality is the disposal of waste. As the World Bank (2019) reports, the global production of solid waste amounted to roughly two billion tons in 2016. This figure is forecasted to surge to 3.88 billion tons by the year 2050, primarily driven by considerable population expansion and the rapid pace of industrialization. However, Clifford (2021) suggests that poor waste management triggers climate change through the leak of adverse GHGs to the environment. The solid waste landfill is ranked third as a source of methane emissions in the US. releasing 15% of methane emissions, equivalent to emissions of 21.6 million cars in 2019 (Clifford, 2021). Figure 6 illustrates that the waste from the production process has overwhelmed the amount of waste from households. Moreover, this number has increased significantly during the last two decades, which raises alarming concern among countries about the impact on environmental standards. Figure 7 shows that the manufacturing waste accounts for 35%, the mining industry causes 55%, while households generate just 1% of the global waste in 2020. It supports the importance of waste management from the industries' side.

2.2. Theoretical Background

2.2.1. Corporate Social Responsibility Theories

According to the Commission of the European Communities (CEC, 2001), corporate social responsibility (CSR) is a conceptual framework through which companies proactively include considerations related to social and environmental aspects in their business operations. This approach extends to encompass how they interact with their various stakeholders. Importantly, this integration of social and environmental concerns into business practices and stakeholder relationships is undertaken on a voluntary basis, indicating a sense of ethical and moral commitment beyond obligatory requirements.

There are three foundational theories that provide a clear explanation for the relationship between eco-innovation and corporate environmental performance, including the Triple Bottom Line (TBL), Resource-based view (RBV), and stakeholder's theory. These theories serve as crucial frameworks for understanding how eco-innovation activities intersect with a company's performance in environmental sustainability.

2.2.1.1. Triple Bottom Line Framework

The triple bottom line (TBL) framework was first fully articulated by Elkington (1997). It emphasizes three dimensions: economy, society, and environment in firms' strategies, indicating their other responsibilities beyond financial profits. TBL framework has become a cornerstone in sustainability and corporate social responsibility studies, shaping how organizations measure their success and impacts in a more comprehensive framework. Figure 2.1 presents the three dimensions with examples in the TBL framework, illustrated by Lounis and Mcallister (2016). In the environmental pillar, TBL posits that companies are responsible to benefit the environment or at least reduce their impacts on it.

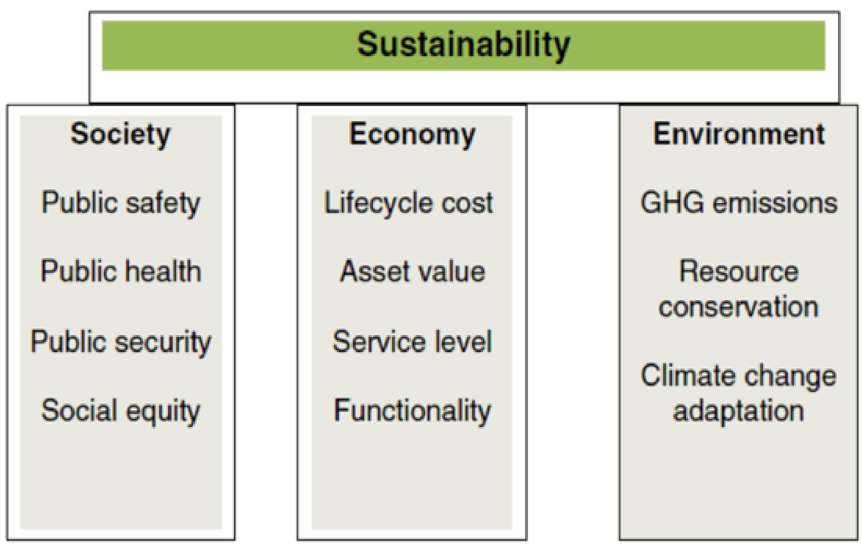

Figure 2.1. Triple Bottom Line

(Source: Lounis and Mcallister, 2016)

Under the TBL framework, Goel (2010) posits that corporate sustainable strategies are related to the efficient use of energy resources, and reduction of GHG emissions and ecological footprints. The TBL framework, indeed, has many effects on corporate strategies. It can motivate green purchasing practices to improve the TBL performance of manufacturing firms (Khan et al., 2022). Green purchasing prioritizes the use of products or services that have fewer impacts on human health and the environment than other existing peers. Moreover, by considering the TBL framework, Karman et al. (2023) find that green initiatives encompass more than just financial expenditures; they also yield advantages in increasing firm value, particularly during COVID-19. They find that companies that do not cut their investment in green initiatives during the crisis can maintian positive economic, environmental, and social results. Green initiatives serve as a safeguard, upholding the efficacy of the TBL approach in a fluctuating market.

Therefore, guided by the TBL framework, companies tend to invest more to achieve better triple-bottom-line performance including on the environmental dimension. Innovation aimed at improving environmental performance aligns with TBL's objective of achieving sustainability through economic, social, and environmental considerations. Hence, under the TBL framework, firms have motives to invest in eco-innovation, which yields better improvement in their environmental performance.

2.2.1.2. Resource-based View (RBV) and Natural Resource-based View (NRBV)

Achieving sustainable competitive advantage is the crucial mission of business operations. Developed by Barney (1991), the Resource-based View (RBV) posits that firms are heterogeneous since they can access different resources, which makes their decisions vary depending on their resource mix. As a result, firms can achieve a competitive advantage by acquiring and developing valuable, rare, inimitable, and non-substitutable resources. By leveraging its unique resources and capabilities, a firm can differentiate itself from competitors, create value for customers, and achieve superior performance.

However, the conventional RBV model does not take into consideration constraints of the natural environment in a firm's ability to create competitive advantages in a changing external environment (Hart, 1995). Sustainable competitiveness from natural sources becomes more and more crucial for corporations in this era due to the increase in social concerns and pressure. Therefore, the Natural Resource-based View (NRBV) proposed by Hart (1995) emphasizes that a company can achieve this competitive advantage by utilizing its natural resources to develop more environmentally friendly operations and technologies aiming at sustainability (Hart, 1995). Hart asserts that companies can attain sustained competitiveness through the implementation of three interrelated strategies: pollution prevention, product stewardship, and sustainable development. The goal of pollution prevention is to reduce or eliminate emissions and waste at the source by streamlining operations and improving procedures. Product stewardship is the approach of reducing the environmental impact of the firm's products throughout their entire life cycle, from raw material selection and disciplines in product design. Sustainable development strategies are intended to creat markets and goods that satisfy demand without endangering the interests of future generations and other regions (Hart, 1995). This novel idea provides motifs for how companies develop their innovation linking with natural resources to achieve more sustainable competitiveness.

Eco-innovation motivates unique technological capabilities that differentiate a company from its competitors in terms of the process and products. In the context of environmental performance, NRBV can explain the corporate investment in innovative technologies to reduce both resource costs and environmental impacts, while increasing competitiveness in gaining new markets and customers. Therefore, under the NRBV theory, the eco-innovation activities may attract higher investments, which results in better corporate environmental performance.

2.2.1.3. Stakeholder Theory

Freeman's (1984) stakeholder theory suggests that corporations have the responsibility to ensure the interests of all related groups that can affect or be affected by their decisions. These individuals or groups, known as stakeholders, include a wide range of entities such as employees, customers, suppliers, shareholders, communities, government agencies, and more. Moreover, Freeman (1984) asserts that the stakeholder theory provides a framework for tackling the expectations of various groups with different degrees of legitimate interest in the company. A firm possessing the capability to foster and nurture relationships in mutual trust and cooperative efforts with stakeholder groups can achieve a competitive advantage (Jones, 1995). The stakeholder theory aligns well with the concepts of other corporate social responsibilities theories and can be used to cross-explain each other (Freeman and Dmytriyev, 2017).

In the context of green management, corporations have to improve their environmental performance for the benefit of various stakeholder groups. Henriques and Sadorsky (1999) categorized environmental stakeholders into four distinct groups: regulatory entities (governments), organizational entities (customers, suppliers, employees and shareholders), community entities (communities group and environmental organizations), and the media. Companies that disregard the demands of these stakeholders run the risk of potential losses.

Moreover, other stakeholders may require improvements in companies' environmental performance. For example, stockholders can benefit from an increase in the company's value and stock price due to better reported environmental performance or debtholders ask for those improvements to consider the cost of debt (Liu and Anbumozhi, 2009).

Eco-innovation can be considered one way for corporations to address stakeholders' concerns about sustainability and contribute to the well-being of the environment. Hence, according to stakeholder theory, firms would promote the eco-innovation to better protect the environment.

2.2.2. Innovation Theories

2.2.2.1. Porter Hypothesis

The Porter hypothesis emerged shortly after two influential papers by Porter (1991) and Porter and van der Linde (1995). The hypothesis proposes that well-designed environmental regulations and policies can motivate economic performance and innovation for businesses. It posits a positive relationship between environmental regulations and the innovation and competitiveness of corporations. Jaffe and Palmer (1997) suggest two different variants of Porter hypothesis showing potential for empirical work. The "weak" version of this hypothesis suggests that environmental regulations can encourage specific types of environmental innovations. However, innovation may cause opportunity costs, which exceed the financial benefits of the companies. This version does not consider other socially added outcomes, so it does not imply whether innovation is good or bad for both corporations and society. However, the "strong" version posits that well-constructed regulation can motivate innovation to such an extent that it not only offsets the costs of compliance but also enhances the financial results of the firm. Hence, the strong form concludes that those flexible regulatory policies and instruments are believed to bring benefits to both the companies and the environment. This strong version of this hypothesis directly explains the willingness of firms to invest more in eco-innovation.

Prior papers used the Porter hypothesis to discover the effects of environmental regulation on the innovation level and financial outcome of firms. Arimura et al. (2007) find that regulatory policy results in a positive outcome from the investment in environment-related R&D. Moreover, the regulation is found to have a beneficial impact on firms' environmental and financial performance. For instance, the Clean Air Act of 1990 proposing SO2 emissions permits has motivated the firm to remove emission more efficiently and reduce their operating and removal costs (Popp, 2003).

In the context of this research, the Porter hypothesis aligns well with the idea that firms proactively invest in eco-innovation to improve environmental performance. First, the demand for technical innovation of firms to cope with regulation changes has contributed to the improvement of companies' energy efficiency (Wu and Lin, 2022). In addition, Yuan and Zhang (2017), based on the strong and weak Porter hypothesis, propose that R&D activities motivate substantial innovation in corporations, which will improve environmental performance in the long term. In terms of productivity, the environmental protection credit policy does not impede firm performance but motivates green total factor productivity at the firm level (Zhang, 2021). Hence, under the Porter hypothesis, legal and governmental requirements support the eco-innovation development, which results in improved corporate environmental performance.

2.2.2.2. Eco-innovation

Innovation is defined as the invention of a new product or service or an improvement of an existing product or service in both its characteristics, and environmental impacts (OECD, 1997). However, Rennings (2000) points out the weakness of OECD's 1997 definition when it can not separately identify environmental and non-environmental innovations, which causes difficulties in the development of empirical studies. Eco-innovation has become a new and interesting concept that has not been well-defined and standardized among researchers. Hence, in 2009, the Organisation for Economic Co-operation and Development (OECD) gave its first definition of eco-innovation: "Eco-innovation represents innovation that results in a reduction of environmental impact, no matter whether that effect is intended or not. The scope of eco-innovation may go beyond the conventional organisational boundaries of the innovating organisation and involve broader social arrangements that trigger changes in existing socio-cultural norms and institutional structures." (OECD, 2009).

There are many drivers of the eco-innovation process of firms. On the macro level, regulation and public policy are believed to motivate the eco-innovation and its diffusion (You et al., 2019; Kemp and Volpi, 2008). Those studies are consistent with Porter's position that environmental regulations act as a catalyst for innovation and create a "win-win" situation. Pollution is diminished, and simultaneously, firms' competitiveness is enhanced. At the micro level, cost leadership and competitiveness are also motives for eco-innovation by firms. Elmawazini et al. (2022) discover that higher green innovation intensity diminishes the cost of capital at the firm level. In addition, Lee and Min (2015) find that eco-innovation can contribute to corporate financial performance while increasing the resource's utility and competitive advantages, contributing to firm-level success. However, while many companies try to develop high technology to compete with others in many aspects, it is important for firms to embrace and adapt to these environmental advancements in order to thrive and ensure survival (Albers and Brewer, 2003). Figure 8 illustrates that the eco-innovation index in the EU has been increasing in the last decade representing the efforts and trends of pursuing environmental innovation by the people in many countries.

The eco-innovation process requires companies to invest in R&D to improve corporate environmental performance. Through this process, R&D activities play a dynamic role in finding solutions for companies to environmental issues (Lee and Min, 2015). Indeed, the impacts of eco-innovation on companies' environmental performance have been discovered in many aspects, such as carbon emissions reduction (Fethi and Rahuma, 2020), renewable energy use promotion (Su et al., 2021), and recycled product performance (Fernando et al., 2021). Hence, it is believed that eco-innovation through R&D activities yields many benefits to firms' environmental performance.

Assessing the level of eco-innovation in a corporation remains challenging. Lee and Min (2015) and Alam et al. (2019) suggest that R&D activities are at the center of improvements in eco-innovation of corporations. Hence, they propose that the investment in R&D is a good measure of the eco-innovation at firm level. However, Cuerva et al. (2014) argue that the developments associated with R&D activities are not always addressed to eco-innovations. Horbach et al. (2013) find that eco-innovative corporations tend to invest less in internal R&D than other firms in France, which means internal R&D is not the most crucial contributor to eco-innovation. Consistently, Borghesi et al. (2012) investigate the

Italian firms and suggest the same. Furthermore, Tseng et al. (2013) and Cuerva et al. (2014) divide the eco-innovation of firms between two different indicators: process innovation and product innovation to address which aspects of the corporation's business innovation contribute to firms' environmental performance. Those measures may add new and unique insights to eco-innovation activities at firm level.

2.3. Hypothesis Development

Eco-innovation is believed to yield beneficial outcomes for firms environmental performance. This performance at firm level is illustrated through the reducing impact of their business on nature (Gutowski et al., 2005). Aragon-Correa et al. (2008) suggest that corporate environmental strategies include practices to reduce resource consumption, emission generation, and pollution. These solutions require eco-innovative development in processes, products, and operations, with the goal of reducing resource use and emissions. Environmental leadership strategies go even further by redesigning products, processes, and business models to reduce overall environmental impact throughout the life cycle of the product (Rennings, 2000). Those developments are believed to be the results of eco-innovation activities. This study assesses the effect of eco-innovation on corporate environmental performance in four aspects: energy consumption and water withdrawal as resource use; waste generation and air pollution as corporate emission according to the category of Refinitiv (2022).

In terms of energy consumption, eco-innovation generates new approaches that play an important role in minimizing the energy use at the firm level. First of all, technological innovation could help achieve sustainability through improving energy efficiency and developing energy structure (Jin et al., 2018). Jin and Zhang (2016) confirm that R&D for innovation motivate a balanced growth path in which consumption and technology all grow, but fossil energy consumption declines. Hence, the rise in efficiency in the manufacturing process due to new innovations can contribute to reducing conventional energy consumption while maintaining productivity. In addition, the innovation triggers the introduction of new energy-saving technologies (van Soest and Bulte, 2001). When firms utilize new technologies with higher productivity levels and energy saving operation, their energy consumption is expected to decline.

In addition, the innovation allows firm to develop their own micro energy system, which helps to convert chemical, thermal, or solar energy into electrical power, propulsion or cooling (Fréchette, 2008). Indeed, some large and energy-intensive corporations such as Walmart, BMW, Methanex, Fujifilm and Apple are harvesting their own renewable electricity by investing in wind power. The consumption of energy from conventional sources is expected to decrease when firms achieve higher eco-innovation activities.

Hypothesis 1: Eco-innovation has no impact on energy consumption intensity at firm level.

Eco-innovation can significantly contribute to the reduction of a corporation's need for water withdrawal through various means. First, as innovation motivates the efficiency in resource use at firm-level (Rennings and Rammer, 2009), it will reduce the use of water in corporations. New technologies support water management with water auditing to distribute the water flow and detect leaks, which helps to reduce the losses and increase the efficiency (Neelofar et al., 2023; Manne et al., 2021). In addition, innovation supports for the water recycling at the firm-level, which is needed to formulate a sustainable water use (Anderson, 2003; Angelakis et al., 2003). Furthermore, innovation can yield development of water harvesting systems in corporations. The innovative technologies allow companies to collect water from many sources such as fog and rainfall, which results in an alternative supply for water withdrawals with high efficiency and low costs (Jarimi et al., 2020; Pandey et al., 2003). This innovation in reducing water withdrawal at the firm level has inspired me to propose the following hypothesis.

Hypothesis 2: Eco-innovation has no impact on the water withdrawal intensity at firm level.

Eco-innovation can contribute to the reduction of carbon emissions to the environment. Fei et al. (2014) utilize the autoregressive distributed lag model to confirm that R&D investment for innovation could promote the use of clean energy, which helps minimize CO2 emissions to the air environment. energy. Geng and Ji (2016) suggest that technological innovation in corporations has a strong relationship with the usage of renewable energy. They find that technological innovation has the potential to effectively foster development of renewable energy, irrespective of the economic situation and energy policies. Consistently, eco-innovation is detected to be a driver for renewable energy consumption in prior research (Li et al., 2020). In addition, Figure 9 shows the increase in investment and the usage of renewable energy from the last decades.

Meanwhile, while the innovative technological progress could motivate corporate operation efficiency, it also results in decreased carbon emissions from the manufacturing process (Ahmed et al., 2016). Moreover, eco-innovation could allow the use of new and environment friendly production factors, which produce fewer air pollutants (Ma et al., 2022). To mitigate the emissions, some companies also apply the new treatment as carbon dioxide capture technologies, which utilize the innovation as internal air filters to transform and store them in geological formations (Vaz Jr. et al., 2022). Therefore, eco-innovation activities can produce many aids to mitigating carbon emissions in corporations.

Hypothesis 3: Eco-innovation has no impact on carbon emissions intensity at firm level.

Eco-innovative activities play a crucial role in developing waste management strategies at the firm level. This impact is particularly pronounced due to the mission of eco-innovation to create new technologies, which in turn drive mechanisms for waste reduction and effective disposal. This decrease can be explained through multiple pathways. First, the innovative technologies stemming from eco-innovative efforts can induce transformative changes in production factors and manufacturing processes, leading to a significant reduction in waste (Tang et al., 2017; Aragon-Correa et al., 2008).

Second, the introduction of green product innovations engenders a significant shift in the utilization of raw materials. Notably, these innovations not only optimize material consumption but also offer the potential for conversion of waste materials into valuable resources via recycling processes (Porter and van der Linde, 1995). This multidimensional role of eco-innovation in waste management encompasses waste reduction and the strategic recycling of waste materials, thereby reducing the amount of waste to the environment from corporations.

Hypothesis 4: Eco-innovation has no impact on waste generation intensity at firm level.

Chapter 3: Methodology

3.1. Sample

I construct the research sample by extracting data from multiple sources. Environmental measures, including energy consumption, water withdrawal, carbon emissions, and waste generation, requireb data from the Refinitiv ESG database. Financial data are sourced from the Refinitiv Worldscope database. Country-level data are collected from the World Development Indicators databank provided by the World Bank. The sample includes panel data for firms from G20 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Turkey, United Kingdom, United States, and the European Union), from 2002 to 2022. I require a country with more than 50 firms having scores in the environment pillar from ESG scores to be a part of the research. This score is provided by Thomson Reuters Refinitiv Eikon as one component of ESG scores. The final country list includes Argentina, Australia, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, India, Indonesia, Italy, Japan, Mexico, Netherlands, Russia, Saudi Arabia, South Africa, Republic of Korea, Spain, Sweden, Turkey, United Kingdom, and the United States. The research period is on a yearly basis.

Consistent with Alam et al. (2019), my sample includes firm-year observations with data for at least one of those four dimensions of environmental performance, including carbon emissions intensity, energy consumption intensity, waste generation intensity, water withdrawal intensity, as well as the required accounting data. The variables are winsorized at the 1st and 99th percentiles. My final sample includes 52,965 observations for 7,573 firms from 25 countries.

3.2. Baseline Regression

Following Alam et al. (2019), I consider the following baseline regression model:

$$\mathrm{EP}_{\mathrm{i,t}} = \alpha_1 + \beta_1 \mathrm{Eco\_inno}_{\mathrm{i,t}} + \delta_2 (\mathrm{Firm\ \_controls})_{\mathrm{i,t}} +$$
$$\delta_3 \Sigma(\mathrm{Industry\_effects})_{\mathrm{i}} + \delta_4 \Sigma(\mathrm{Year\_effects})_{\mathrm{t}} + \delta_5 \Sigma(\mathrm{Country\_effects})_{\mathrm{t}} + \varepsilon_{\mathrm{i,t}} \qquad (1)$$

Where $EP_{i,t}$ represents the environmental performance proxies (energy consumption intensity, water withdrawal intensity, carbon emissions intensity, or waste generation intensity, respectively) of firm i at time t. While energy consuption intensity is used to examine Hypothesis 1, water withdrawal intensity is employed to test Hypothesis 2. Carbon emissions intensity is used for investigating Hypothesis 3 and waste generation intensity tests Hypothesis 4 of the research. The main independent variable $\mathrm{Eco\_inno}_{\mathrm{i,t}}$ stands for eco-innovation measures (R&D/Sales, Environmental innovation scores, Process innovation, and Product innovation, respectively) of firm i at the period t.

Since investments and free cash flow of the corporations are affected by many factors, which can cause the omitted variables problem, this paper employs some control variables as suggested by Lee and Min (2015), including capital intensity (Cap_intens), firm size (Ln_asset), return on assets (ROA), financial leverage (Lev), insider ownership (Insider), and market-to-book ratio (MTB) (Measuring details are given in Table 1). They are all included in $(Firm\ \_controls)_{i,t}$, which are the control variables for firm i at time t. Further, industry fixed effects, year fixed effects and country fixed effects are considered in the regression. I use the ordinary least squares (OLS) regression method for studying the model. The standard errors are corrected clustering of residuals at the firm level to remove the impacts of heteroscedasticity (Petersen, 2009).

Based on the testing hypotheses, β_1 in the baseline model is expected to be negative indicating better environmental performance for firms with more eco-innovation.

3.3. Independent Variable: Environmental Performance

Following the category of Refinitiv (2022), this study primarily focuses on four aspects of a firm's environmental performance: energy consumption, water withdrawal, carbon emissions, and waste generation. According to the definitions provided by the Refinitiv ESG database, energy consumption is "the total direct and indirect energy consumption within the boundaries of the company's operations in gigajoules", while water withdrawal is defined as "the total volume of water withdrawn from any water source that was either withdrawn directly by the reporting organization or through intermediaries such as water utilities in cubic meters". Carbon emissions include "total carbon dioxide (CO2) and CO2 equivalents emission (methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCS), perfluorinated compound (PFCS), sulfur hexafluoride (SF6), nitrogen trifluoride (NF3)) measured in tonnes". Those emissions all contribute to climate change and other environmental problems according to the Kyoto Protocol. Finally, waste generation is the "total amount of solid waste produced in tonnes". I follow Alam et al. (2019) to scale those four variables by total sales. I choose to measure those environmental performance proxies on the units of sales to better reflect the actual resouce consumption and emissions of the business activities. Companies with high sales tend to expand their manufacturing activities, which are more likely to cause environmental impacts, so it is essential to study the effects of eco-innovation on the resource consumption and emissions of the unit of sale. On the other hand, this measure can help minimize the issue of heterogeneity, as suggested by Lee and Min (2015).

3.4. Explanatory Variables

3.4.1. Eco-innovation

The desire to attain sustainable competitiveness motivates firms to increase their investments in eco-innovation according to the natural resource-based theory (Hermundsdottir and Aspelund, 2021). However, researchers have proposed different ways to measure firm-level eco-innovation (Eco_inno). In this study, I utilize four alternative measures that have been used in recent research.

First of all, following Lee and Min (2015) and Alam et al. (2019), I use R&D investment to measure the eco-innovation of firms. They argue that R&D activities motivate and contribute to the development of innovation at corporations, which means that firms with more R&D investment are more likely to achieve better eco-innovation. In addition, R&D investment is a critical measure used in the field of innovation and corporate technological activity analysis (Costa-Campi et al., 2017). R&D activities, in the relarionship with eco-innovation, focus on the development of new products, services, processes, and technologies aimed at improving the firm's operational efficiency and simultaneously minimizing environmental impacts (Alam et al., 2019). Lantz and Sahut (2005) find that R&D activities yield innovations for companies. Furthermore, Alam et al. (2019) suggest that corporate R&D can help minimize environmental depletion without decreasing the business return. In terms of the manufacturing process, R&D investment aims at reaching new technological development, which helps to enhance the total factor productivity of the manufacturing process, thus reducing the input resources (Wang et al., 2022). In terms of the selling process, R&D activities contribute to the eco-innovation in producing greener goods and services (Dangelico, 2016). R&D investment has been used to proxy for the eco-innovation in recent studies (Alam et al., 2019; Arimura et al., 2007; Lee and Min, 2015). Similar to environmental performance measures, I scale R&D expenses by total sales to get the R&D-to-sales ratio (R&D_Sales).

Second, I follow the research of Arena et al. (2018) and use the Environmental Innovation Score (EIS) provided by the Refinitiv ESG database to represent a firm's the eco-innovation level. EIS shows "a company's capacity to reduce the environmental costs and burdens for its customers, and thereby creating new market opportunities through new environmental technologies and processes or eco-designed products" (Refinitiv, 2022). This variable has been used in earlier papers (Quintana-García et al., 2022; Dicuonzo et al., 2022; Fiorillo et al., 2022). to examine production performance, environmental, social and governance (ESG) practices, and firms' financial performance. In addition, the Refinitiv ESG database, previously known as ASSET4, is believed to be one of the most objective, relevant, auditable, and systematic ESG sources (Cheng et al., 2014).

The third and fourth eco-innovation measures used in this paper are product innovation (PRD_Inno) and process innovation (PRC_Inno), as suggested by Nadeem et al. (2020). The two measures are constructed from relevant data points in the Refinitiv ESG database, according to the definitions of process and production innovation provided by Cuerva et al. (2014) and Tseng et al. (2013). Process innovation is defined as the efforts to achieve environmental technologies that promote the sustainable use of natural resources and energy efficiency, while motivating the reduction and recycling of waste and other emissions (Cuerva et al., 2014; Tseng et al., 2013). In terms of product innovation, this development is considered as firms' willingness to design and produce ecological products and commit to products' environment management system (Cuerva et al., 2014). The product innovation is believed to be more complex than process innovation since the manufacturers have to assess the competitiveness and the market's demand (Tseng et al., 2013). In line with those definitions, Nadeem et al. (2020) suggest the measure of process innovation (Process_inno) including following six indicators:

1. Targets Energy Efficiency: "Has the company set targets or objectives to be achieved on energy efficiency?"
2. Targets Water Efficiency: "Has the company set targets or objectives to be achieved on water efficiency?"
3. Eco-Design Products: "Does the company report on specific products which are designed for reuse, recycling or the reduction of environmental impacts?"
4. Policy Emissions: "Does the company have a policy to improve emission reduction?"
5. Resource Reduction Policy: "Does the company have a policy for reducing the use of natural resources or to lessen the environmental impact of its supply chain?"
6. Waste Reduction Initiatives: "Does the company report on initiatives to recycle, reduce, reuse, substitute, treat or phase out total waste?"

Likewise, the product innovation (Produc_inno) is constructed based on the following five indicators:

1. Product Environmental Responsible Use: "Does the company report about product features and applications or services that will promote responsible, efficient, cost-effective and environmentally preferable use?"
2. Sustainable Building Products: "Does the company develop products and services that improve the energy efficiency of buildings?"

3. Organic Products Initiatives: “Does the company report or show initiatives to produce or promote organic food or other products?”
4. Product Access Low Price: “Does the company distribute any low-priced products or services specifically designed for lower income categories (e.g., bridging the digital divide, telecommunications, low cost cars and micro-financing services)?”
5. Product Responsibility Monitoring: “Does the company monitor the impact of its products or services on consumers or the community more generally?”

Those indicators are binary variables, which are assigned the value of 1 if the companies have disclosed the information as requested, and 0 otherwise. Each indicator is assigned an equal weight when constructing the final measure. Therefore, the Process_inno is the equal sum of six indicators, which is scored 0 (no disclosure for any indicator) to 6 (disclose all indicators). Similarly, the Product_inno is the equal sum of five indicators, which is scored 0 (no disclosure for any indicator) to 5 (disclose all indicators). Those two measures have been used in several studies (Iqbal et al., 2022; Nadeem et al., 2021).

3.4.2. Control Variables

Since some firms’ characteristics may influence a firm’s environmental performance on the relationship between eco-innovation and corporate environmental performance, I follow prior research (Lee and Min, 2015; Alam et al., 2019) to employ several firm characteristics as control variables. They include capital intensity (Cap_intens), firm’s size (Ln_asset), return on assets (ROA), financial leverage ratio (Lev), insider ownership (Insider), and market-to-book ratio (MTB) (measuring details are given in Table 1). They are all incorporated in Firm_controls.

Profitability has been found to have a negative impact on corporate environmental performance (Vinayagamoorthi et al., 2016). Companies have to trade off some of their interests for environmental protection, described by Russo and Fouts (1997) as “pay to be green”. Environmental performance is closely related to the cost of debt of firms (Eichholtz et al., 2019), so firms with higher financial leverage ratio would improve their environmental performance to satisfy their debtholders and achieve favorable financing costs. In terms of insider ownership, the higher percentage of insider holdings would benefit the environmental performance, because it can align the interests of many stakeholders in the companies (Silva, 2023). Regarding capital intensive, more capital intensive industries may be more polluting (Carrión-Flores and Innes, 2010) as their production process requires a huge amount of assets. Another factor is firm’s size, which has a positive impact on the firm environmental performance, according to Younis and Sundarakani (2019). This is because that larger firms would have higher capacity and willingness to set up environmental practices to improve their performance. The growth opportunities reflecting in MTB ratio also afftects the firms’ environmental performance (Alam et al., 2019). Hence, I incorporate those variables in my research to better capture their impacts in corporate environmental performance.

Moreover, firms’ environmental performance is believed to be volatile during crises. Alam et al. (2019) shows that the financial crisis of 2008 had a significantly negative impact on the R&D investment of firms. This is because the crisis has triggered uncertainty, which causes the investment risk for the market (Alam et al., 2019). However, the slow economic growth reduces the customers’ demand for environment-friendly products and firms (Manrique and Martí-Ballester, 2017). In addition, the green investment of firms is found to slow down during the COVID-19 crisis, while the firm-level environmental indicators tend to be more favorable due to the short-term decline in manufacturing (Guérin and Suntheim, 2021). Those impacts on eco-innovation and the environmental performance of firms during the two crises would be captured by the fixed-year effects.

Chapter 4: Results and Discussion

4.1. Descriptive Statistics

[See Table 2 in Appendix]

Since my research uses a sample of publicly listed firms from G20 countries over a long period, Table 2 presents the distribution of my sample across country, year, and industry. Panel A shows the country-wise distribution of this sample. The United States, United Kingdom, and Japan account for significant parts of my sample at 36.87%, 11.02%, and 10.38%, respectively. Argentina accounts for the smallest portion (about 0.29%). Panel B illustrates the distribution of firm-year observations across the sample period. It exhibits an overall increasing trend as the numbers of observation increase constantly during the last two decades. This indicates that more and more firms have published information on their environmental performance. Especially since the recovery from COVID-19, more firms report their environmental performance information as there are more firm-year observations in 2020 and 2021. Finally, Panel C presents the distribution of my sample among different industries. I use 2-digit SIC code to idientify the industry of firms. Manufacturing firms are a crucial part of my sample, accounting for over 40%. Since their production process is more likely to consume energy and generate emissions and waste, their environmental performance attracts more public attention and hence manufacturing firms face more pressure to disclose those environmental data.

[See Table 3 in Appendix]

The descriptive statistics in Table 3 illustrate the characteristics of each variable used in the regression model. As mentioned in Chapter 3, I keep firm-year observations that report at least one of the four measures of environmental performance. Table 3 shows significant variation of available information on these four environmental performance measures. While carbon emission information (47,804 observations) is available for most firms, followed by energy usage information (40,800 observations), relatively fewer firms report information on water withdrawal (36,987 observations) or waste disposal (27,314 observations).

The energy intensity, which is energy consumption scaled by sales, has a mean of 3.565 gigajoules over 1000 USD sales. Another resource use dimension is water intensity measured by the amount of water withdrawal divided by sales showing the mean value of 12.033 cubic meters over 1000 USD sales. Carbon intensity, which is total carbon emissions over sales, presents the mean value of 0.372 tones over 1000 USD sales. However, the waste intensity measured by the total waste disposals scaled by sales experiences an average of 1.756 tones over 1000 USD sales.

In terms of the eco-innovation measures, the availability of four measures varies across firms. The research and development measure (RD_sales) is available for 52,965 firm-year observations, which cover the entire sample used for my study. R&D_sales have the mean value of 1.978, indicating that the average R&D expenses count about 1.978% of sales. The environmental innovation scores (EIS), as measured by the Refinitiv ESG database divided by 100, result in a mean value of 0.336. The firms' scores range from a minimum of 0 to a maximum score of 0.999. The next two eco-innovation measures are process innovation and product innovation as suggested by Nadeem et al. (2020). The process innovation scores range from 0 to 6 with an average of 3.444 and are available for 47,903 firm-year observations. The product innovation scores, ranging between 0 and 5 are available for 52,136 observations, and the mean value is 1.002.

ROA, measured as net income scaled by total assets, has an average of 0.043 for the whole sample. Financial leverage (Lev), measured by total debts over total assets, has the mean value of 0.264. The next controlling variable is capital intensity (Capital intens), which is measured as the total asset divided by total sales, takes the mean value of 4.13. The firm's size, which is the natural logarithm of the total asset (Lnasset), shows a mean value of 15.985. Market-to-book ratio (MTB), as the measure of a firm's growth opportunities, has an average value of 2.956. Finally, the insider ownership variable (Insider) measured as the percentage of shares held by insiders that has the 0.244 mean value but the data are only available for 49,676 observations.

[See Table 4 in Appendix]

The correlation matrix in Table 4 provides preliminary information about the relationship among variables. The correlation between firm environmental performance meaures (Energy_intensity, Water_intensity, Carbon_intensity, and Water_intensity) and eco-innovation measures (R&D_sales, EIS, Process innovation, and Product innovation) are negative and statistically significant, which supports the hypothesis that firms' engagement in eco-innovation are associated with better environmental performance, as measured by resource uses and emissions.

Furthermore, the positive correlations observed among the four measures of eco-innovation suggest that these measures are consistent in capturing the same underlying concept of eco-innovation within firms. However, the correlation between R&D-to-sales ratio and the other three proxies is relatively low, motivating further study of their individual efficiency in assessing the relationship between eco-innovation and firm environmental performance. This indicates that the proxies may provide unique insights into the relationship. Overall, correlations among the other variables is relatively low, indicating the absence of multicollinearity in the research sample. This suggests that these variables are relatively independent of each other in the analysis. Additionally, to assess the potential presence of multicollinearity, I computed the variance inflation factor (VIF) for all variables. The VIF for each variable was less than 1.8, confirming the absence of multicollinearity issues in the tests. This suggests that the variables used in the analysis are not highly correlated with each other.

[See Table 5,6,7,8 and 9 in Appendix]

Furthermore, descriptive statistics for each subsample used in the baseline regression analysis are provided in Tables 5,6,7,8 and 9. Because my research examines the impacts of four alternative proxies for eco-innovation on four aspects of corporate environmental performance respectively, each of these regressions is conducted on a different subsample. Table 5 presents the descriptive statistics for the subsamples used for the regressions on the for eco-innovation and environmental performance without other controlling variables. Table 6,7,8,9 presents the descriptive statistics for the subsamples used for the regressions examining the impact of eco-innovation, along with other explanatory variables, on environmental performance. These tables are organized according to four aspects of environmental performance, including energy consumption intensity, water withdrawal intensity, carbon emissions intensity, and waste generation intensity, respectively.

4.2. Energy Intensity and Eco-innovation

[See Table 10 in Appendix]

Table 10 presents the findings regarding the influence of eco-innovation on energy intensity. Columns 1 and 2 report the regression results by using R&D-to-sales ratio as the measures for eco-innovation, without and with other control variables. The coefficient estimates of R&D-to-sales ratio is negative and statistically significant at 1%, indicating that a firm with more R&D investment tends to use energy more efficiently. For example , when a firm increases 1% of R&D investment over sales, it will reduce 0.167 gigajoules over 1000 USD sales. In terms of the economic significance, an increase in R&D_sales by one standard deviation (i.e., using data from Table 5 – Panel 1) reduces the energy consumption per sale by 21.23%. (R&D_sales standard deviation (4.53) * (-0.167)/Energy_intensity_sale (3.563) = -0.2123). This relationship still holds after including various control variables in the regression analysis, which emphasizes the impact of R&D, as a measure of eco-innovation, on energy use at corporations. Our findings are consistent with those of Alam et al. (2019) for G6 countries.

Columns 3 and 4 of Table 5 present results of regression using the environmental innovation scores (EIS) as the measure of eco-innovation, without and with other control variables. Similar to the R&D-to-sales ratio, the coefficient of EIS is negative and statistically significant at 1%, which suggests that a firm achieving a higher environmental innovation score is more likely to consume energy more efficiently. When a firm increases one score (over the scale of 100), it will reduce 0.015 gigajoules over 1000 USD sales (1.533/100 = 0.015). In terms of economic significance, a one-standard-deviation increase in EIS (i.e., using data from Table 5 – Panel 2) decreases the energy consumption per sale by 14.43%. (EIS standard deviation (0.335) * (-1.533)/Energy_intensity_sale (3.559) = -0.1443). This suggests that when a company achieves a one-unit increase in the environmental innovation score, energy consumption decreases by approximately 1.494 tonnes relative to one unit of sales. This finding still holds after incorporating various control variables in the regression analysis.

Finally, the last four columns (5,6,7, and 8) show the regression results for two alternative measures of eco-innovation, product innovation (Product_inno) and process innovation (Process_inno), as suggested by Nadeem et al. (2020). For process innovation, the results reported in Columns 5 and 6 show that there is no statistically significant relationship between the measure of process innovation and energy intensity. However, the coefficient of product innovation (Product_inno) is negative and statistically significant at 1%, showing that more product innovation are associated with better energy efficiency. With an increase in product innovation score, energy intensity would reduce by 0.608 gigajoules over 1000 USD sales. The economic significance shows that a one-standard-deviation increase in Product_inno (i.e., using data from Table 5 – Panel 4) reduces energy consumption per sale by 15.91%. (Product_inno standard deviation (0.936) * (-0.608)/Energy_intensity_sale (3.576) = -0.1591). My findings are consistent when other control variables in the regression analysis are included

Overall, the empirical evidence rejects the first hypothesis (H1), and suggests the positive effects of eco-innovation on the energy efficiency at the firm-level.

4.3. Water Intensity and Eco-innovation

[See Table 11 in Appendix]

Table 11 reveals empirical results of eco-innovation's impact on water intensity. Columns (1) and (2) present outcomes of the regression analysis by using R&D-to-sales ratio as the measures for eco-innovation, without and with other control variables. The coefficient estimates of R&D-to-sales ratio is negative and statistically significant at 1%, positing that R&D investment could help to improve efficient use of water. When companies increase one percentage of R&D investment over sales, the firm's water withdrawal can be reduced 0.252 cubic meters on 1000 USD sales. For the economic significance, a one-standard-deviation increase in R&D_sales (i.e., using data from Table 5 – Panel 5) reduces water withdrawal per sale by 9.22%. (R&D_sales standard deviation (4.403) * (-0.252)/Water_intensity_sale (12.027) = -0.0922). This finding is still consistent after including the firm characteristics controlling variables. Overall, this empirical result rejects the second hypothesis (H2) and it shows eco-innovation could help to reduce the water intensity and hence improve water usage efficiency at firm level.

However, the relationship among the other three measures of eco-innovation and water withdrawal is not confirmed when the coefficients in columns (3)–(8) are all insignificant at the level of 5%.

4.4. Carbon Intensity and Eco-innovation

[See Table 12 in Appendix]

Table 12 presents the findings on the effects of eco-innovation on carbon intensity. Columns (1) and (2) display the outcomes for the regression using R&D-to-sales ratio as the measure for eco-innovation, without and with other control variables. The coefficients of R&D-to-sales ratio are negative and statistically significant at 1%, indicating that a firm with more R&D investment tends to emit less carbon. When a company increases one unit of R&D investment over sales, it can reduce 0.015 tonnes of carbon emissions on 1000 USD sales. Regarding the economic significance, a one-standard-deviation increase in R&D_sales (i.e., using data from Table 5 – Panel 9) reduces carbon emissions per sale by 17.98%. (R&D_sales standard deviation (4.458) * (-0.015)/Carbon_intensity_sale (0.372) = -0.1798). This relationship is still consistent after including companies' characteristics control variables in the regression analysis, which emphasizes the impact of R&D investment on reducing emissions in corporations. The findings are consistent with prior studies (Lee and Min, 2015; Alam et al., 2019).

Columns (3) and (4) present the regression results using environmental innovation score (EIS) as eco-innovation proxy, without and with other control variables. The coefficient estimates of EIS are negatively significant at the level of 1%, suggesting a firm is more likely to cut its carbon emssions when achieving a higher environmental innovation score. When the firms have their EIS increased by one score over the scale of 100, carbon emissions decrease by 0.002 tonnes per 1000 USD sales (0.209/100=0.002). The economic significance shows that a one-standard-deviation increase in EIS (i.e., using data from Table 5 – Panel 10) can reduce carbon emissions per sale by 18.76%. (EIS standard deviation (0.333) * (-0.209)/Carbon_intensity_sale (0.371) = -0.1876). This relationship still holds after including various control variables in the regression analysis. These findings are consistent with Albitar et al., (2022), where they discuss the relationship of the EIS as the measure for eco-innvation and CO2 emissions on the London Stock Exchange.

Columns (5)–(8) present the findings for two firms' eco-innovation measures, which are product innovation (Product_inno) and process innovation (Process_inno) proposed by Nadeem et al. (2020). Similar to the results of resource effiency, the results of process innovation indicate that there is no statistically significant relationship between process innovation and carbon intensity. However, the coefficients of product innovation in columns (7) and (8) are significant at 1%, suggesting that a firm with better product innovation is more likely to reduce its carbon emissions. When a company achieves an additional point in product innovation, its emissions per 1000 USD sales will drop by approximately 0.072 tonnes. For the economic significance, a one-standard-deviation increase in Product_inno (i.e., using data from Table 5 – Panel 12) can reduce carbon emissions per sale by 17.94%. (Product_inno standard deviation (0.932) * (-0.072)/Carbon_intensity_sale (0.374) = -0.1794). This finding is consistent after incorporating different control variables in the regression emphasizing the effects of product innovation on reducing carbon emissions at firms.

Overall, those results from alternative measures of eco-innovation reject the third hypothesis (H3) and confirm that the eco-innvation could help reduce carbon emissions at the firm level.

4.5. Waste Intensity and Eco-innovation

[See Table 13 in Appendix]

The last dimension of environmental performance examined in this research is waste intensity, calculated as the total waste disposals by firms divided by their sales. Table 13 reveals the empirical results for the impacts of eco-innovation on waste generation. Columns (1) and (2) present results on the influence of R&D investment (R&D_sales) on waste intensity, without and with other control variables. The finding shows that the coefficient estimates of R&D-to-sales are negatively significant at the level of 5% for the research model (1) including the firm's control variables. Those findings confirm the effects of R&D investment on reducing waste generation with the contribution of firms' control variables. When a firm spends one additional R&D investment unit per sales on eco-innovation, it can reduce waste generation for 0.019 tonnes per 1000 USD sales. The economic significance shows that one-standard-deviation increases in R&D-to-sales (i.e., using data from Table 5 – Panel 13) can reduce waste generation per sale by 4.44%. (R&D_sales standard deviation (4.081) * (-0.019)/Waste_intensity_sale (1.748) = -0.044).

Columns (3) and (4) present empirical results on the influence of the environmental innovation score (EIS), as an eco-innovation measure, on waste intensity, without and with other control variables. The coefficients of EIS are all negatively significant at the level of 1%, indicating that a firm tends to reduce its waste generation when it has a higher environmental innovation score. If there is an additional point over the scale of 100, firms may reduce 0.026 tonnes of wastes over 1000 USD sales (2.588/100=0.026). In terms of the economic significance, an additional standard deviation in EIS (i.e., using data from Table 5 – Panel 14) can cut the waste generation per sale by 5.1% (EIS standard deviation (0.338) * (-0.2588)/Waste_intensity_sale (1.724) = -0.051). My finding is consistent with the inclusion of various firms' characteristics control variables in the regression analysis.

Columns (5)–(8) display the results for two other corporate eco-innovation metrics: product innovation (Product_inno) and process innovation (Process_inno), suggested by Nadeem et al. (2020). Similar to previous environmental performance measures, process innovation, shown in columns (5) and (6), results in no statistically significant relationship with waste intensity. On the other hand, columns (7) and (8) show that cofficient estimmates of product innovation (Product_inno) are negatively significant at 1%, indicating that firms with higher product innovation are more likely to reduce their waste generation. The finding posits that when a firm achieves an additional score for product innovation, it can cut 0.903 tonnes of waste generation per 1000 USD sales. Regarding the economic significance, a one-standard-deviation increase in Product_inno (i.e., using data from Table 5 – Panel 16) will reduce the waste generation per sale by 48.57% (Product_inno standard deviation (0.951) * (-0.903)/Waste_intensity_sale (1.768) = -0.044). The finding still holds with the inclusion of other firms' control variables in the regression analysis emphasizing product innovation effects on reducing waste generation.

Overall, the empirical evidence from different tests rejects hypothesis 4 (H4), and indicates that firms with higher eco-innovation level will reduce the waste generation.

Conclusion

Sections 4.2, 4.3, 4.4, and 4.5 results and discussion, the study finds that eco-innovation level can have positive effects on the corporate environmental performance at firm level. Eco-innovation efforts result in improved resource efficiency, on the input side of a firm's business, encompassing areas like energy and water consumption. Furthermore, eco-innovation contributes to reducing emissions on the output side of corporate processes, which includes carbon emissions and waste generation. This dual impact highlights the multifaceted benefits of eco-innovation in enhancing firms' environmental performance.

4.6. Controlling Variable and Efficiency of Eco-innovation Measures

Turning to controlling variables, the ROA in the regression of four eco-innovation proxies on both energy intensity and water intensity consistently results in negatively significant coefficients at 5%. This finding posits that firms with higher profits will reduce their use of resources, including energy and water. My finding is in contrast to the research of Vinayagamoorthi et al. (2016). The financial leverage ratio (Lev) shows strong positively significant coefficients with energy use and carbon emissions at the level of 5%, suggesting that firms with higher debt financing use more energy and generate more carbon emissions compared to others. However, its coefficients estimates of the test with waste intensity are negatively significant at 1%, which indicates that firms with higher debt financing would cut their waste disposal. The coefficients of capital intensive in all the regressions are positively significant at 5%, emphasizing that companies with a high capital intensive level will increase their resource use and emissions leading to worse environmental performance. Those findings on the G20 scope are consistent with the results of Alam et al. (2019), whose sample is G6. Another factor is MTB level, whose coefficients estimates are negatively significant at 10%, indicating that firms with higher growth opportunities will improve their environmental performance by reducing resource use and emissions. Constrasting with Alam et al. (2019), I find that insider ownership (Insider) contributes to the increase in energy consumption and carbon emissions, since their coefficients are all positively significant at 5%.

As mentioned in the literature review, this study would contribute to the empirical test of those eco-innovation measures on a larger scope with G20. R&D investment (R&D_sales) seems to be an appropriate indicator for eco-innovation since the results are significant and consistent among those four dimensions. This measure has been used in many research papers (Lee and Min, 2015; Alam et al., 2019; Lantz and Sahut, 2005). Likewise, environmental innovation score (EIS) results are also significant for all four dimensions suggesting its obvious impacts on firm environmental performance. The couple of measures suggested by Nadeem et al. (2020), including process innovation (Process_inno) and product innovation (Product_inno), have different results. While product innovation (Product_inno) outcomes are always consistent with the other two previous measures of eco-innovation, the process innovation (Process_inno) could not statistically contribute to the corporate environmental performance. In contrast to product innovation, process innovation focuses on the maufacturing and other logistics processes but not on reaplacing the raw materials. However, the change in environmentally friendly materials has a more pronounced impact than innovation in the manufacturing process on environmental performance (Vinodh and Jayakrishna, 2011). For example, Gallimore and Cheung (2016) find that replacing the materials in automotive design can reduce the carbon footprint as well as water and energy consumption. Furthermore, process innovations are adopted at a lower rate and speed compared to process innovation and usually adhere to the product–process pattern of adoption (Damanpour and Gopalakrishnan, 2002). Those reasons may explain the statistically insignificant relationship of the process-innovation and firms' environmental performance in my research.

4.7. Identification

The independent variable, which is the eco-innovation, may face criticism about potential endogeneity bias (Alam et al., 2019). This bias arises from the fact that companies may be compelled to invest in improving and developing new technologies as a response to regulatory pressure. This forced investment could create a situation where the relationship between eco-innovation and environmental performance becomes intertwined and difficult to accurately determine causality. Moreover, the economic condition may also influence the eco-innovation level of firms, which leads to the poor environmental performance of firms. Hence, the change in dependent variables may not stem from the eco-innovation. When the linearity assumption of regression analysis is violated, the baseline model would provide the spurious estimation.

Following Alam et al. (2019), I incorporate those variables of $(Country\_effects)_t$ including GDP growth (GDP_growth), government effectiveness (Gov_effect), regulatory quality(Reg_quality), and corruption control index (Corruption_control) to prevent omitted problems, with the definitions:

- GDP growth: “Annual percentage growth rate of GDP at market prices based on constant local currency”.
- Government effectiveness: “Captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.”
- Regulatory quality: “Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.”
- Corruption control index: “Captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.”

For GDP growth, to achieve extremely speedy economic development, some countries have lowered their standards around environmental protection. Hence, the environmental performance would be affected by GDP growth (Chowdhury and Islam, 2017). However, Gök and Sodhi (2021) suggest that high government effectiveness countries have a tendency to prioritize environmental protection, since government decisions that are insulated from political pressures will be more open and beneficial for human settlements, which leads to more favorable environmental policies. Those effects are similar for regulatory quality. The higher quality the regulations, the more efficiency they bring to the environment. Likewise, corruption triggers environmental degradation because firms tend to bribe government officials or regulators instead of adhering to environmental laws and regulations to reduce their costs (Chen et al., 2018). Hence, I controlled the effects of those country characteristics by adding those variables into model (1) to better confirm the research results. I employ country-level variables including GDP growth, government effectiveness, regulatory quality, and corruption controls as a controlling variable set to the model (1) according to the approach suggested by Alam et al. (2019).

[See Tables 14–17 in Appendix]

Tables 14 – 17 show the results for the relationship of four eco-innovation measures and four dimensions for environmental performance with company and country controlling variables. Overall, the regression outcomes confirm that after controlling for the nation-level characteristics, the relationship between eco-innovation and corporate environmental performance still holds. The results are qualitatively consistent with the baseline results of model (1). Furthermore, these empirical outcomes shed light on the impact of those country traits on the improvement of firms' environmental performance. The government's effectiveness (Gov_effect) has negatively significant coefficients at 5% in the regression of eco-innovation on energy and waste intensity, indicating its contribution to the reduction of energy consumption and waste generation. Corruption control (Corruption_control) shows negatively significant coefficients estimate at 5% in the regression of eco-innovation on water and carbon intensity, which emphasizes their effects in reducing water withdrawal and carbon emissions at the firm level. The coeffiecients of GDP growth (GDP_growth) in the regresion of eco-innovation on energy intensity are negatively significant at 5%. It means that the economic growth of a country can improve the efficiency of energy consumption at the firm level.

Secondly, to answer the actual reason for those concerns, I also use the instrumental variables (IV) approach, following prior studies by de Villiers and van Staden (2011) and Haque (2017). This approach requires the identification of valid instruments to satisfy two conditions.

- The instrument correlates with R&D investment after accounting for the set of variables included in the model
- The instrument influences energy consumption intensity and carbon emissions intensity solely through its correlation with R&D investment, after controlling for the full set of control variables.

To obtain suitable instruments, I perform an IV regression. This involves regressing each endogenous variable (e.g., the test variables) on known determinants of R&D investment (ROA, GFCD, Lev). The second stage requires changing the model (1) by replacing the endogenous variable on the right-hand side with the fitted value obtained from the first-stage.

[See Tables 18–21 in Appendix]

The regressions of eco-innovation measures on instrument variables results in significant coefficients at 5% (not reported), which ensures the validity of instrument variables. In addition, the Cragg–Donald F-statistic is less than 0.05 for all of the scenarios (not reported) suggesting the strong validity of my IVs. The regression results shown in the Tables 18-21 are consistent with my baseline findings indicating that after controlling for the endogeneity concerns, I can ensure that eco-innovation itself has the impacts on firms environmental performance as discussed.

4.8. Robustness Checks

4.8.1. A Longer Time-lag Effect of Eco-innovation

[See Tables 22–29 in Appendix]

This research studies the impact of current eco-innovation on corporate environmental performance. However, Xie et al. (2020) argue that R&D investment has a longer delay than one period. Moreover, they find that it takes two to three years for R&D investments to reflect in the innovation of the companies. This improvement may be more obvious when eco-innovation lags for at least one year. Hence, I conduct the baseline research method for one-period and three-period lags to see the effects of eco-innovation on improvement of environmental innovation in longer periods of time. Tables 22–25 and 26–29 show the results of model (1) with the replacement of the main independent variables (eco-innovation variables) by their lag-one and three-period versions, respectively. The R&D investments, measured by R&D-to-sales ratio, show their negatively significant coefficient estimates in reducing the environmental impacts of the corporation in both regression analysis of lag-one and lag-three explanatory variables. Similarly, the two eco-innovation measures of environmental innovation score (EIS) and product innovation (Product_inno) have negatively significant coefficient estimates in the analysis, which indicates their strong impact on corporate environmental performance. Process innovation (Process_inno) does not affect firms' environmental performance in spite of time lagging. Overall, my findings in the baseline research are consistent with the time lags for one and three periods of time.

4.8.2. Alternative Proxy for Environmental Performance

[See Tables 30–33 in Appendix]

Our research uses the measures of environmental performance scaled by net sales of corporations, which represents the amount of resource use and emissions over one unit of sales. However, Alam et al. (2019) suggest another proxy for environmental performance which is scaled by total assets of firms in lieu of net sales. This proxy measures the resource use and emissions of corporations on the basis of firms' size. Hence, I employ the measures of environmental performance scaled by total assets to see the impacts of eco-innovation on the reduction of environmental impacts on the basis of firm's size. To conduct the test, I replace the measures of firm's environmental performance intensity with energy consumption, water withdrawal, carbon emissions, and waste generation scaled by total assets to the model (1). After replacing the denominators from the sales to total assets, tables 30–33 show that the impacts of eco-innovation level on corporate environmental performance do not change both the significant level and the dimension of the relationship. This finding suggests that the improvement in eco-innovation can help reduce resource use and emissions on the basis of firm's size.

4.8.3. The Effect of Board Characteristics

Corporate boards are believed to have significant impacts on the environmental performance of companies in many aspects. First, larger board size can help reduce corporate impacts on environment because they are likely to be more diverse and possess more experienced and knowledgeable directors (de Villiers et al., 2011). Second, a higher percentage of independent directors can enhance the efficiency of management oversight, motivating adherence to environmental regulations (Liao et al., 2015). Another consideration is the experience of the board. The participation of industry experts on the board results has a significantly positive influence on firms' environmental performance as they can give resource-efficient advice and motivate adoption of corporate ethical practices (Almaqtari et al., 2023). In addtition, board diversity, measured by the percentage of female members, can contribute to the development of environmental protection strategies in corporations due to the higher commitment of women to stakeholders' interests and social reponsibility (Haque, 2017). Finally, directors with longer tenure can improve corporate environmental performance because they are more likely to have the knowledge and reputation to deal with environmental challenges and resource efficiency (de Villiers et al., 2011). Therefore, I employ board characteristics in the baseline model to avoid omitted variables bias. I follow the research of Almaqtari et al. (2023) and use the Thomson Reuters database to extract data for the following variables:

1. Board size (B_size): "The number of board members at the end of fiscal year".
2. Independent Board Members (B_independence): "Percentage of independent board members as reported by the company".

3. Board Specific Skills (B_expertise): "Percentage of board members who have either an industry-specific background or a strong financial background".
4. Board Gender Diversity (B_diversity):" Percentage of females on the board".
5. Average Board Tenure (B_tenure): "Average number of years each board member has been on the board".

[See Tables 34–37 in Appendix]

After controlling for board characteristics, the empirical outcomes from Tables 34–37 show that eco-innovations' effects on firms' environmental performance remain qualitatively similar for all the baseline regression analysis. Furthermore, the effectiveness of board characteristics in reducing firms' impacts is discovered in energy consumption and waste generation, specifically for board diversity and board tenure, whose coefficients are all negatively significant at 5% for tests with four eco-innovation measures. Boards with a higher participation level of female members show more commitment to green strategies and are empirically confirmed to have strong improvements in energy efficiency and waste reduction. Likewise, the tenure of board members, which means the length of service, is found to affect the environmental performance of firms. Longer board tenure serves as a factor in reducing the use of energy and solid waste emissions.

4.8.4. The Sample of Developing Country and Non-financial Industry

The G20, comprising both developed and developing countries, serves as an excellent sample for gaining a comprehensive overview of the relationship between environmental performance and eco-innovation in a global setting. However, business activities may have different impacts on the environment in developed and developing nations due to the differences in strategies (Gutiérrez and Teshima, 2018; Luo et al., 2013; Yao and Tang, 2021). According to the classification of Development Policy and Analysis Division (DPAD) of the United Nations Secretariat (EAPD, 2022), G20 comprises 11 developing countries—China, South Africa, Russia, Indonesia, Brazil, India, Saudi Arabia, Korea, Turkey, Argentina and Mexico. To investigate the impact on this group, I re-run the baseline model for the sample of developing countries within the G20.

[See Tables 38–41 in Appendix]

The results displayed in Tables 38–41 confirm that the impact of firms' eco-innovation on their environmental performance stay strong for developing countries, regardless of their social economic development stages. In addition, the effects of eco-innovation on environmental performance are more pronounced when the coefficient estimates of eco-innovation are more negative, specifically for energy consumption and carbon emissions. This finding posits that eco-innovation activities are more critical in those developing countries' firms, since each of the eco-innovation improvement units results in a higher energy efficiency and smaller emissions amount. It suggests that, in the context of developing countries, eco-innovation is not only a strategic choice but also a necessity for firms aiming to improve their environmental performance and competitiveness.

[See Tables 42–45 in Appendix]

The finance, insurance, and real estate industry account for 16.68% of my research sample. However, its business does not directly relate to resource consumption and emissions, which means that its effects on the environment are not likely to cause environmental deterioration. To address that issue, I do the regression analysis for model (1) on the sample excluding the finance, insurance, and real estate industry. I report the results in Tables 42–45. Those findings are consistent with the research conducted on the entire sample, which suggests that the eco-innovation is beneficial for corporate environmental performance in various industries regardless of their business.

4.8.5. High Variation Issues among Countries

[See Tables 46-49 in Appendix]

This paper uses a sample of firms from many countries, so it could be a chance that the eco-innvation levels exhibit high variation across countries. This phenomenon may lead to an issue of heterokedasticity in the regression. I follow Alam et al. (2019) to use weighted least square (WLS) regression to address this issue. The weight for each regression is the inverse of within-country variance of the relevant eco-innovation measure. Those tests are conducted on the baseline model (1). Tables 46-49 show the results for those tests. After applying weight least square (WLS) regression to the model (1), I find that the empirical outcomes are largely consistent with the previous baseline regression. It suggests that my results are overal robust to alternative econometric methodology.

Chapter 5: Conclusion and Limitations

Using a sample of firms from G20 members between 2002 and 2022, this paper examines the effect of eco-innovation on corporate environmental performance in two categories, resource use (energy consumption and water withdrawal) and corporate emissions (carbon emissions and waste generation). After controlling for a list of firm-level variables, this study reveals a negative relationship between eco-innovation and energy, water, carbon, and waste intensity, which indicates the effects of eco-innovation level on improving corporate environmental performance.

In this research, I use various proxies for eco-innovation including R&D-to-sale ratio, environmental innovation score, process innovation score, and product innovation score as suggested by prior studies (Alam et al., 2019; Lee and Min, 2015; Arena et al., 2018; Nadeem et al., 2020). Overall, the results reveal that the R&D-to-sale ratio has consistently negative relationship with the energy, water, carbon, and waste intensity indicating the effects of R&D investment on reducing a firm's environmental impacts in all four dimensions. Environmental innovation score and product innovation show the negatively significant relationship with energy, carbon, and waste intensity, which means that the improvements in EIS and production innovation may reduce the energy use, carbon, and waste emissions. However, the process innovation, as suggested by Damanpour and Gopalakrishnan (2002), does not show the significant role in reducing corporate environmental impacts. This finding is surprising because process innovation is an important part of eco-innovation, and the measure for process innovation used in this paper is based on a firm's stated objectives and initiatives to improve its environmental performance. This may be due to the slow implementation of process innovation, the lack of technology in corporations, and even potential greenwashing. Exploring the potential explanations for this surprising finding is beyond the scope of my thesis, so I will leave it for future research.

My findings are consistent in various robustness analysis with alternative model specifications and econometric methods. Furthermore, the relationship still holds with the addition of extra control variables to the regression such as country characteristics, including government effectiveness, regulatory quality, GDP growth and corruption control, and board characteristics, encompassing boards' size, independence, diversity and tenure. Those impacts remain qualitatively similar when eco-innovation lagged for one and three periods. The relationship still holds in the subsample of non-financial industries and developing countries. In addition, the effect of eco-innovation is more pronounced in the sample of developing countries emphasizing its crucial role in reducing environmental impacts in those nations. Similarly, my findings are consistent under the new proxy which replaces the environmental performance on a unit of sales by the environmental performance over total assets.

This research contributes to the literature of corporate sustainability and the findings further support the existing theories of corporate social responsibility and eco-innovation. Specifically, it is motivated by, and concurrently provides empirical support for the Triple Bottom Line Framework, Natural Resource-based View (NRBV), and Stake holder theories. The study becomes more significant in the era of raising concerns since firms may face more pressure to improve their environmental performance. The study also provides some practical contributions. From the firm side, empirical findings substantiating eco-innovation advantages not only bolster managers' confidence in the success and outcomes of the initiatives but also encourage them to embrace a long-term perspective and invest in innovation and eco-friendly practices. On the government side, these findings provide policymakers with a solid foundation upon which to formulate and implement strategies that promote eco-innovation and environmental sustainability.

There are some limitations present in this research, which also lead to future research directions. First, the research subject, which is eco-innovation, is a complex term that requires more comprehensive definition. Therefore, it is essential to add more eco-innovation proxies to better analyze the relationship between eco-innovation and environmental performance. Secondly, the research sample is G20 members, who are all showing commitments to the high environmental standards of these organizations. Those findings may not provide a general framework for the benefits of eco-innovation on countries with low commitments to environmental protection. Hence, future studies can be more specific to any region, country or a broader setting once the data becomes available. Thirdly, the impact of eco-innovation level on the environmental performance is a complex process that intersects with many characteristics of the business. Consequently, this relationship would be moderated by some of the firms' traits. Hence, it is essential to discover the factors that moderate the effects of eco-innovation activities on reducing the environmental impacts. Finally, there are few papers to discuss about the nexus between eco-innovation, environmental, and financial performance of firms. This relationship is also important when companies consider their investment in eco-innovation activities that are costly and may only generate financial benefits in the long run. Therefore, it would be beneficial to clarify this nexus through future empirical work.

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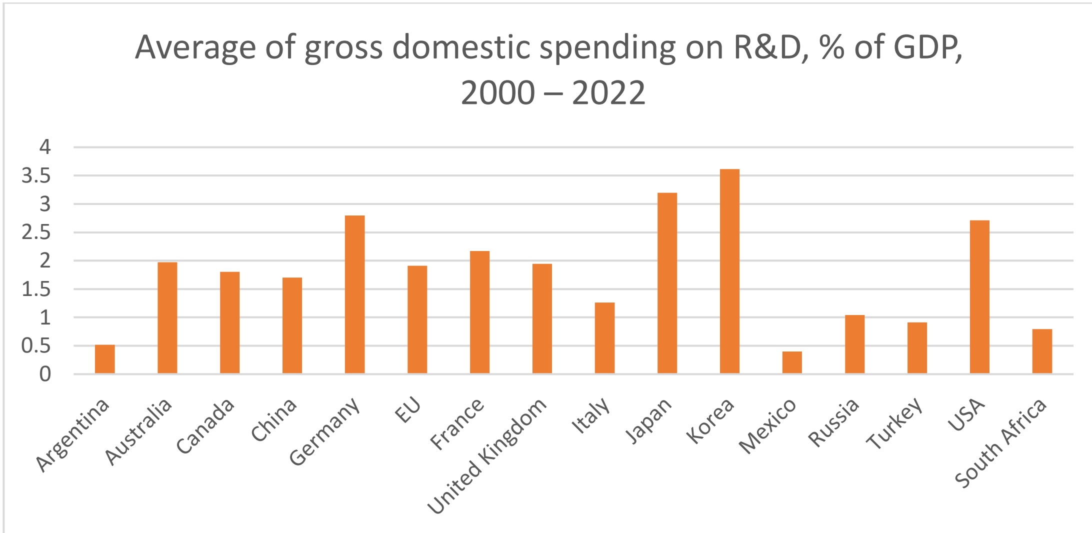
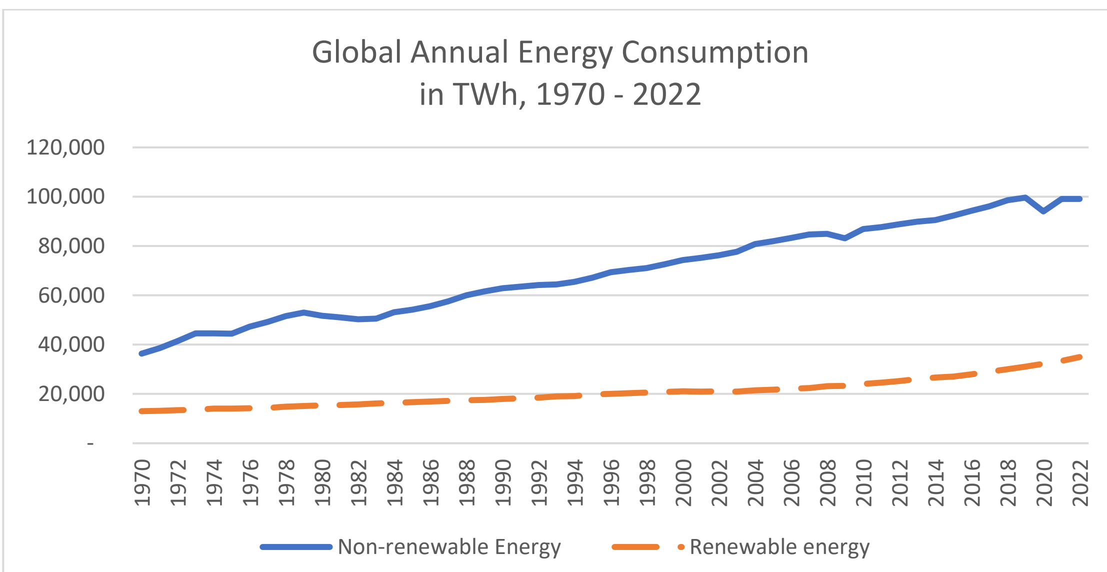
Appendix

Figure 1. Average of gross domestic spending on R&D



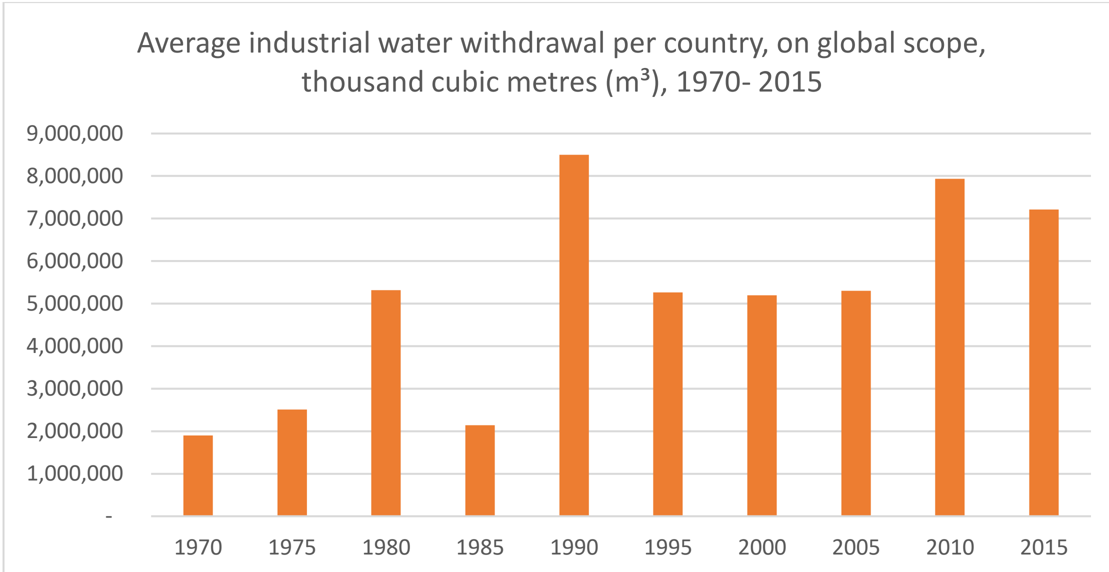
(Source: Main Science and Technology Indicators on OECD)

Figure 2. Global annual energy consumption



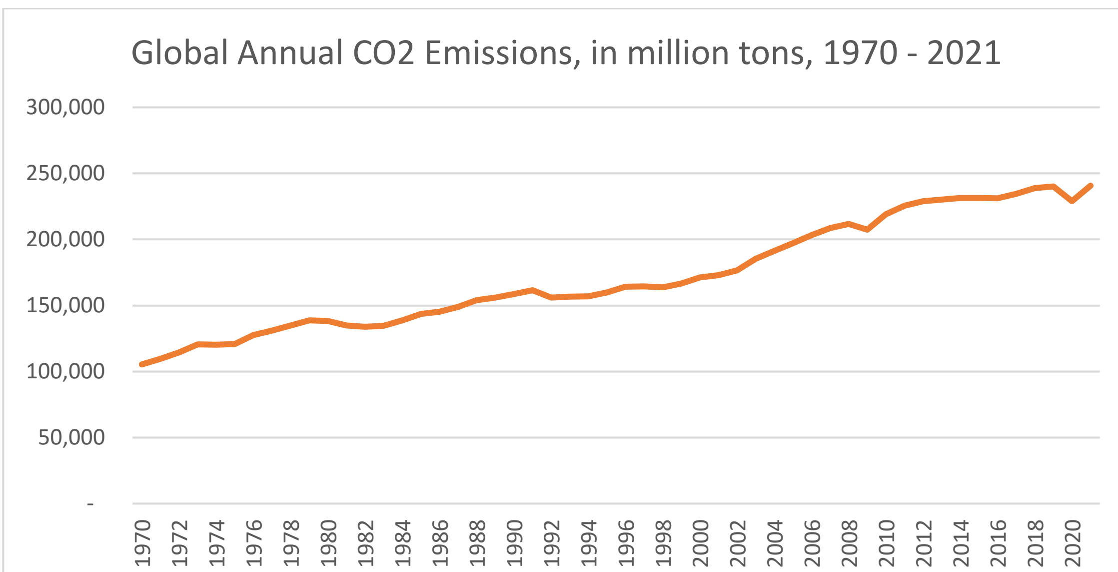
(Source:https://ourworldindata.org)

Figure 3. Average industrial water withdrawal per country



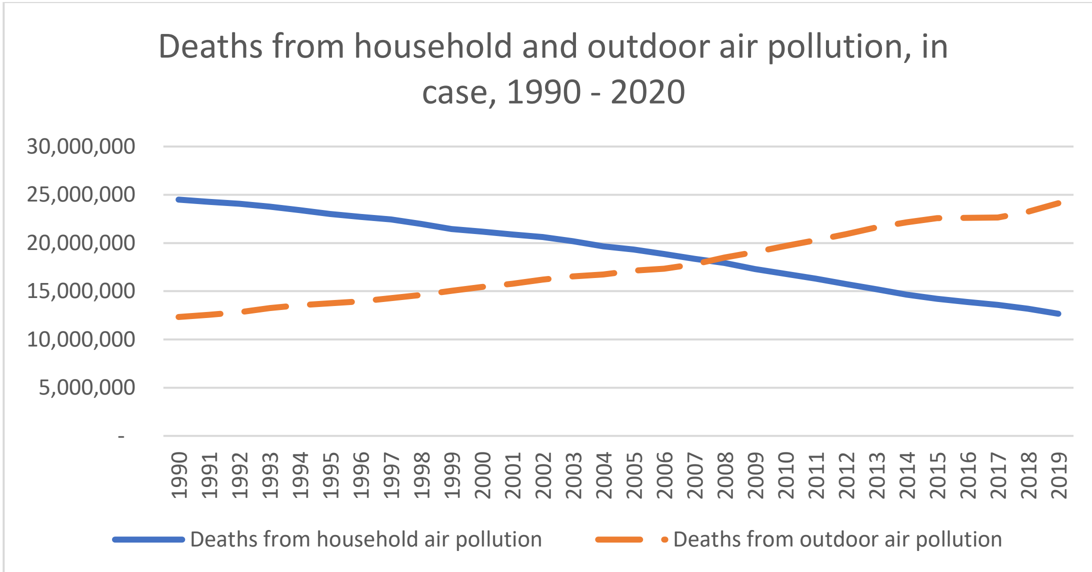
(Source:https://ourworldindata.org)

Figure 4. Global annual CO2 emissions



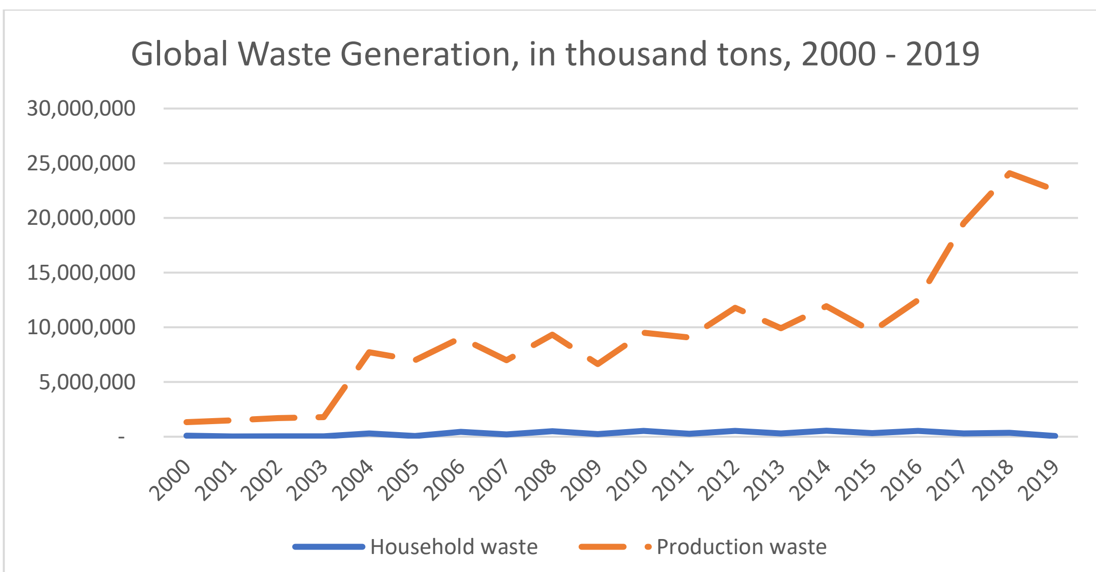
(Source:https://ourworldindata.org)

Figure 5. Deaths from household and outdoor air pollution



(Source:https://ourworldindata.org)

Figure 6. Global annual waste generation

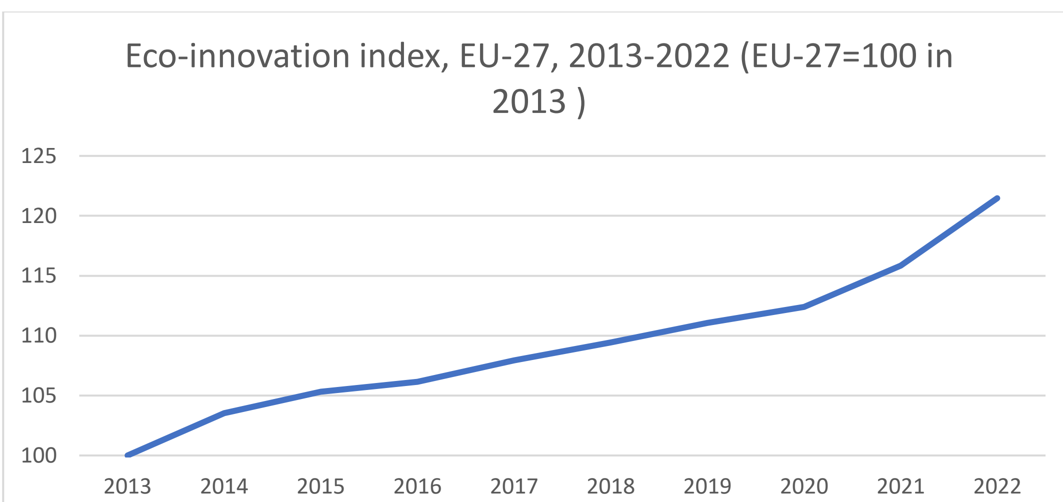


(Source:https://ourworldindata.org)

Figure 7. Global distribution of total waste

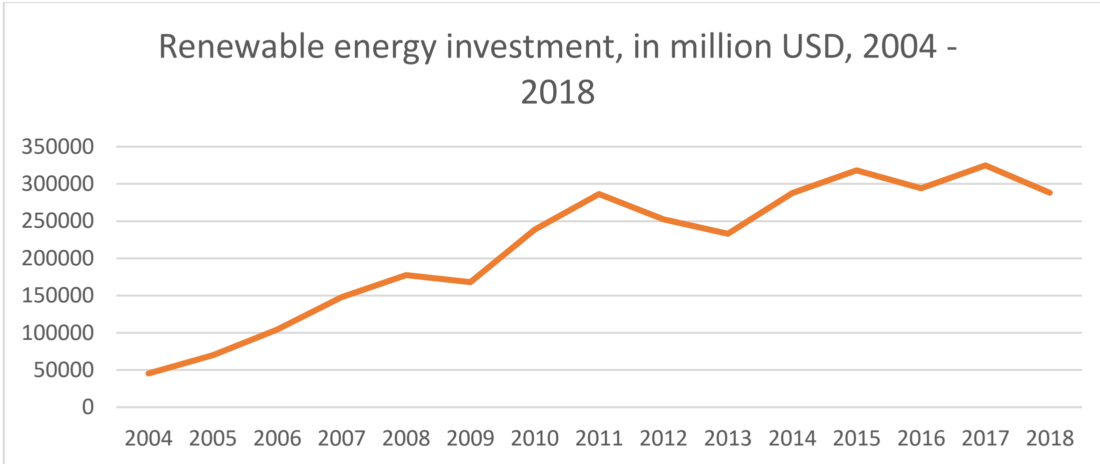
(Source:https://ourworldindata.org)

Figure 8. Eco-innovation index



(Source: European Environment Agency)

Figure 9. Global renewable energy investment



(Source:https://ourworldindata.org)

Table 1. Variables definitions

Variables	Explanation	Calculation
$EP_{i,t}$	Energy consumption intensity	Energy consumption per sales
	Water withdrawal intensity	Water withdrawal per sales
	Carbon emissions intensity	Carbon emissions per sales
	Waste disposal intensity	Waste disposal per sales
$Eco\_inno_{i,t}$	R&D_sale	Research and development investment divided by sales
	EIS	Environmental innovation score scales by 100
	PRC_inno	Process innovation score
	PRD_inno	Product innovation score
$Capital\_intens_{i,t}$	Capital intensity	Total assets scaled by sales
$Ln\_Asset_{i,t}$	Size of firm	Logarithm of total assets
$ROA_{i,t}$	Return on assets	Net income scaled by total assets
$Lev_{i,t}$	Level of debt	Ratio of total debt to total assets.
$\%insider\_OWN_{i,t}$	Insider ownership	A percentage of shares held by insiders
$MTB_{i,t}$	Market growth opportunities	Market value divided by book value

Variables	Explanation	Calculation
GDP_growth_t	GDP growth	Annual percentage growth rate of GDP at market prices based on constant local currency
Gov_effect_t	Government effectiveness	Government effectiveness score
$Reg\_quality_t$	Regulatory quality	Regulatory quality score
$Corruption\_Control_t$	Corruption control index	Corruption control index
$B\_size_{i,t}$	Board size	Logarithm of total number of board members at the end of fiscal year
$B\_independence_{i,t}$	Independent Board Members	Percentage of independent board members as reported by the company
$B\_expertise_{i,t}$	Board Specific Skills	Percentage of board members who have either an industry-specific background or a strong financial background
$B\_diversity_{i,t}$	Board Gender Diversity	Percentage of female on the board
$B\_diversity_{i,t}$	Average Board Tenure	Average number of years each board member has been on the board

Table 2. Sample distribution by nation, year, and industry

Pannel A: Country	Freq.	Percent	Cum.
Argentina	156	0.29	0.29
Australia	2198	4.15	4.44
Belgium	415	0.78	5.23
Brazil	965	1.82	7.05
Canada	2214	4.18	11.23
China	2454	4.63	15.86
Denmark	485	0.92	16.78
Finland	575	1.09	17.86
France	1872	3.53	21.40
Germany	1630	3.08	24.48
India	1254	2.37	26.84
Indonesia	398	0.75	27.60
Italy	830	1.57	29.16
Japan	5499	10.38	39.54
Mexico	392	0.74	40.29
Netherlands	698	1.32	41.60
Russia	455	0.86	42.46
Saudi Arabia	95	0.18	42.64
South Africa	1215	2.29	44.94
South Korea	1105	2.09	47.02
Spain	872	1.65	48.67
Sweden	1356	2.56	51.23
Turkey	468	0.88	52.11
United Kingdom	5838	11.02	63.13
United States	19526	36.87	100.00
Total	52965	100.00	

Panel B: Year	Freq.	Percent	Cum.
2002	290	0.55	0.55
2003	358	0.68	1.22
2004	615	1.16	2.38
2005	938	1.77	4.16
2006	1075	2.03	6.19
2007	1321	2.49	8.68
2008	1559	2.94	11.62
2009	1950	3.68	15.30
2010	2269	4.28	19.59
2011	2391	4.51	24.10
2012	2509	4.74	28.84
2013	2528	4.77	33.61
2014	2595	4.90	38.51
2015	2805	5.30	43.81
2016	3010	5.68	49.49
2017	3352	6.33	55.82
2018	3897	7.36	63.18
2019	4602	8.69	71.87
2020	5338	10.08	81.94
2021	5671	10.71	92.65
2022	3892	7.35	100.00
Total	52965	100.00	

Panel C: Industry	Freq.	Percent	Cum.
Agriculture, Forestry, and Fishing	243	0.46	0.46
Construction	1729	3.27	3.72
Finance, Insurance, and Real Estate	8830	16.68	20.40
Manufacturing	21320	40.26	60.66
Mining	4126	7.79	68.45
Retail Trade	2889	5.46	73.91
Services	5285	9.98	83.89
Transportation, Communications, Electric, Gas and Sanitary service	7435	14.04	97.93
Wholesale Trade	1095	2.07	100.00
Total	52952	100.00	

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Median	p25	p75	Min	Max
Energy intensity	40,800	3.565	8.929	0.450	0.123	2.241	0.002	60.311
Carbon intensity	47,804	0.372	0.985	0.040	0.011	0.225	0	6.628
Waste intensity	27,314	1.756	9.804	0.006	0.001	0.027	0	76.772
Water intensity	36,987	12.033	53.066	0.408	0.072	2.771	0.001	432.552
RD sale	52,965	1.978	4.494	0	0	1.708	0	25.305
EIS	52,841	0.336	0.332	0.275	0	0.618	0	0.999
Process inno	47,903	3.444	1.335	3	3	4	0	6
Product inno	52,136	1.002	0.926	1	0	2	0	5
ROA	52,952	0.043	0.071	0.038	0.010	0.074	-0.238	0.274
Lev	52,954	0.264	0.174	0.251	0.131	0.375	0	0.761
Cap intens	52,954	04.13	7.045	1.600	1.035	3.169	0.358	42.348
Lnasset	52,961	15.985	1.810	15.873	14.780	17.087	11.890	20.953
MTB	50,507	2.956	3.626	1.808	1.077	3.291	0.216	24.423
Insider	49,676	0.245	0.254	0.149	0.015	0.438	0	0.876

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 4. Pairwise correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Energy_intensity	1.000												
(2) Carbon_intensity	0.624	1.000											
	(0.000)												
(3) Waste_intensity	0.092	0.088	1.000										
	(0.000)	(0.000)											
(4) Water_intensity	0.175	0.380	0.053	1.000									
	(0.000)	(0.000)	(0.000)										
(5) RD_sale	-0.116	-0.121	-0.081	-0.081	1.000								
	(0.000)	(0.000)	(0.000)	(0.000)									
(6) EIS	-0.080	-0.069	-0.174	0.020	0.022	1.000							
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)								
(7) Process_inno	-0.013	-0.012	-0.060	-0.030	0.065	0.383	1.000						
	(0.012)	(0.013)	(0.000)	(0.000)	(0.000)	(0.000)							
(8) Product_inno	-0.080	-0.064	-0.158	-0.004	0.038	0.646	0.407	1.000					
	(0.000)	(0.000)	(0.000)	(0.432)	(0.000)	(0.000)	(0.000)						
(9) ROA	-0.054	-0.053	-0.021	-0.039	0.011	-0.042	0.038	0.004	1.000				
	(0.000)	(0.000)	(0.001)	(0.000)	(0.014)	(0.000)	(0.000)	(0.363)					
(10) Lev	0.090	0.117	-0.079	0.079	-0.151	0.033	0.059	0.007	-0.236	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.106)	(0.000)				
(11) Cap_intens	-0.052	-0.041	-0.018	-0.016	-0.116	0.102	-0.101	-0.008	-0.178	0.009	1.000		
	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)	(0.000)	(0.000)	(0.061)	(0.000)	(0.047)			
(12) Lnasset	-0.065	-0.007	-0.095	0.003	-0.083	0.338	0.263	0.317	-0.117	0.086	0.379	1.000	
	(0.000)	(0.154)	(0.000)	(0.561)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
(13) MTB	-0.088	-0.092	-0.036	-0.050	0.196	-0.087	-0.017	-0.039	0.309	0.059	-0.167	-0.194	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

Table 5. Descriptive statistics of the subsamples used for examining the impact of eco-innovation, without other control variables, on environmental performance

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel 1: Sample for regression energy intensity on RD_sale					
Energy intensity	40,792	3.563	8.924	.002	60.311
RD sale	40,792	2.103	4.530	0	25.305
Panel 2: Sample for regression energy intensity on EIS					
Energy intensity	40,733	3.559	8.919	.002	60.311
EIS	40,733	0.365	0.335	0	0.999
Panel 3: Sample for regression energy intensity on Process_inno					
Energy intensity	37,867	3.581	8.941	.002	60.311
Process inno	37,867	3.620	1.274	0	6
Panel 4: Sample for regression energy intensity on Product_inno					
Energy intensity	40,199	3.576	8.923	.002	60.311
Product inno	40,199	1.092	0.936	0	5
Panel 5: Sample for regression water intensity on RD_sale					
Water intensity	36,976	12.027	53.069	.001	432.552
RD sale	36,976	2.121	4.403	0	25.305
Panel 6: Sample for regression water intensity on EIS					
Water intensity	36,880	12.009	53.047	.001	432.552
EIS	36,880	0.379	0.336	0	0.999
Panel 7: Sample for regression water intensity on Process_inno					
Water intensity	33,620	12.286	54.139	.001	432.552
Process inno	33,620	3.745	1.247	0	6
Panel 8: Sample for regression water intensity on Product_inno					
Water intensity	36,357	12.042	53.009	.001	432.552
Product inno	36,357	1.123	0.945	0	5
Panel 9: Sample for regression carbon intensity on RD_sale					
Carbon intensity	47,793	0.372	0.985	0	6.628
RD sale	47,793	1.977	4.458	0	25.305
Panel 10: Sample for regression carbon intensity on EIS					
Carbon intensity	47,720	0.371	0.984	0	6.628
EIS	47,720	0.352	0.333	0	0.999
Panel 11: Sample for regression carbon intensity on Process_inno					
Carbon intensity	43,688	0.368	0.982	0	6.628
Process inno	43,688	3.519	1.316	0	6
Panel 12: Sample for regression carbon intensity on Product_inno					
Carbon intensity	47,112	0.374	0.988	0	6.628
Product inno	47,112	1.049	0.932	0	5
Panel 13: Sample for regression waste intensity on RD_sale					
Waste intensity	27,305	1.748	9.774	0	76.772
RD sale	27,305	2.037	4.081	0	25.305
Panel 14: Sample for regression waste intensity on EIS					
Waste intensity	27,255	1.724	9.703	0	76.772
EIS	27,255	0.399	0.338	0	0.999
Panel 15: Sample for regression waste intensity on Process_inno					
Waste intensity	24,773	1.764	9.815	0	76.772
Process inno	24,773	3.856	1.169	0	6
Panel 16: Sample for regression waste intensity on Product_inno					
Waste intensity	26,863	1.768	9.820	0	76.772
Product inno	26,863	1.184	0.951	0	5

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 6. Descriptive statistics of subsample used for examining the impact of eco-innovation, along with explanatory variables, on energy intensity

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: Sample for regression energy intensity on RD_sale and other explanatory variables					
Energy intensity	36,900	3.465	8.759	.002	60.311
RD sale	36,900	2.111	4.529	0	25.305
ROA	36,900	0.044	0.068	-.238	0.274
Lev	36,900	0.261	0.166	0	0.761
Cap intens	36,900	4.228	7.180	.358	42.348
Lnasset	36,900	16.078	1.824	11.89	20.953
MTB	36,900	2.933	3.576	.216	24.423
Insider	36,900	0.253	0.256	0	0.876
Panel B: Sample for regression energy intensity on EIS and other explanatory variables					
Energy intensity	36,854	3.464	8.759	.002	60.311
EIS	36,854	0.367	0.334	0	0.999
ROA	36,854	0.044	0.068	-.238	0.274
Lev	36,854	0.262	0.166	0	0.761
Cap intens	36,854	4.227	7.180	.358	42.348
Lnasset	36,854	16.079	1.824	11.89	20.953
MTB	36,854	2.934	3.577	.216	24.423
Insider	36,854	0.253	0.256	0	0.876
Panel C: Sample for regression energy intensity on Process_inno and other explanatory variables					
Energy intensity	34,402	3.48	8.782	0.002	60.311
Process inno	34,402	3.612	1.272	0	6
ROA	34,402	0.043	0.068	-0.238	0.274
Lev	34,402	0.262	0.166	0	0.761
Cap intens	34,402	4.289	7.260	0.358	42.348
Lnasset	34,402	16.049	1.829	11.89	20.953
MTB	34,402	2.931	3.604	0.216	24.423
Insider	34,402	0.254	0.258	0	0.876
Panel D: Sample for regression energy intensity on Product_inno and other explanatory variables					
Energy intensity	36,373	3.476	8.755	0.002	60.311
Product inno	36,373	1.093	0.935	0	5
ROA	36,373	0.044	0.068	-0.238	0.274
Lev	36,373	0.261	0.166	0	0.761
Cap intens	36,373	4.245	7.208	.358	42.348
Lnasset	36,373	16.073	1.827	11.89	20.953
MTB	36,373	2.933	3.577	0.216	24.423
Insider	36,373	0.252	0.256	0	0.876

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 7. Descriptive statistics of subsample used for examining the impact of eco-innovation, along with explanatory variables, on water intensity

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: Sample for regression water intensity on RD_sale and other explanatory variables					
Water intensity	33,425	12.259	53.995	0.001	432.552
RD sale	33,425	2.127	4.396	0	25.305
ROA	33,425	0.044	0.067	-0.238	0.274
Lev	33,425	0.263	0.163	0	0.761
Cap intens	33,425	4.132	6.968	0.358	42.348
Lnasset	33,425	16.208	1.768	11.89	20.953
MTB	33,425	2.798	3.429	0.216	24.423
Insider	33,425	0.256	0.258	0	0.876
Panel B: Sample for regression water intensity on EIS and other explanatory variables					
Water intensity	33,343	12.238	53.964	0.001	432.552
EIS	33,343	0.380	0.335	0	0.999
ROA	33,343	0.044	0.067	-0.238	0.274
Lev	33,343	0.263	0.163	0	0.761
Cap intens	33,343	4.133	6.971	0.358	42.348
Lnasset	33,343	16.21	1.768	11.89	20.953
MTB	33,343	2.799	3.431	0.216	24.423
Insider	33,343	0.256	0.258	0	0.876
Panel C: Sample for regression water intensity on Process_inno and other explanatory variables					
Water intensity	32,885	12.299	54.042	0.001	432.552
Product inno	32,885	1.125	0.943	0	5
ROA	32,885	0.044	0.067	-0.238	0.274
Lev	32,885	0.262	0.163	0	0.761
Cap intens	32,885	4.151	7.001	0.358	42.348
Lnasset	32,885	16.203	1.769	11.89	20.953
MTB	32,885	2.797	3.423	0.216	24.423
Insider	32,885	0.254	0.257	0	0.876
Panel D: Sample for regression water intensity on Product_inno and other explanatory variables					
Water intensity	32,885	12.299	54.042	0.001	432.552
Product inno	32,885	1.125	0.943	0	5
ROA	32,885	0.044	0.067	-0.238	0.274
Lev	32,885	0.262	0.163	0	0.761
Cap intens	32,885	4.151	7.001	0.358	42.348
Lnasset	32,885	16.203	1.769	11.89	20.953
MTB	32,885	2.797	3.423	0.216	24.423
Insider	32,885	0.254	0.257	0	0.876

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 8. Descriptive statistics of subsample used for examining the impact of eco-innovation, along with explanatory variables, on carbon intensity

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: Sample for regression carbon intensity on RD_sale and other explanatory variables					
Carbon intensity	43,407	0.366	0.978	0	6.628
RD sale	43,407	1.979	4.454	0	25.305
ROA	43,407	0.044	0.069	-0.238	0.274
Lev	43,407	0.259	0.167	0	0.761
Cap intens	43,407	4.169	7.129	0.358	42.348
Lnasset	43,407	16.021	1.801	11.890	20.953
MTB	43,407	2.961	3.616	0.216	24.423
Insider	43,407	0.232	0.247	0	0.876
Panel B: Sample for regression carbon intensity on EIS and other explanatory variables					
Carbon intensity	43,350	0.366	0.978	0	6.628
EIS	43,350	0.352	0.332	0	0.999
ROA	43,350	0.044	0.069	-0.238	0.274
Lev	43,350	0.259	0.167	0	0.761
Cap intens	43,350	4.169	7.131	0.358	42.348
Lnasset	43,350	16.022	1.801	11.890	20.953
MTB	43,350	2.961	3.618	0.216	24.423
Insider	43,350	0.232	0.247	0	0.876
Panel C: Sample for regression carbon intensity on Process_inno and other explanatory variables					
Carbon intensity	39,883	0.362	0.977	0	6.628
Process inno	39,883	3.507	1.313	0	6
ROA	39,883	0.043	0.069	-0.238	0.274
Lev	39,883	0.259	0.167	0	0.761
Cap intens	39,883	4.245	7.231	0.358	42.348
Lnasset	39,883	15.984	1.809	11.890	20.953
MTB	39,883	2.959	3.651	0.216	24.423
Insider	39,883	0.233	0.249	0	0.876
Panel D: Sample for regression carbon intensity on Product_inno and other explanatory variables					
Carbon intensity	42,799	0.368	0.981	0	6.628
Product inno	42,799	1.049	0.931	0	5
ROA	42,799	0.044	0.069	-0.238	0.274
Lev	42,799	0.258	0.167	0	0.761
Cap intens	42,799	4.188	7.157	0.358	42.348
Lnasset	42,799	16.014	1.803	11.890	20.953
MTB	42,799	2.960	3.616	0.216	24.423
Insider	42,799	0.231	0.246	0	0.876

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 9. Descriptive statistics of subsample used for examining the impact of eco-innovation, along with explanatory variables, on waste intensity

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: Sample for regression waste intensity on RD_sale and other explanatory variables					
Waste intensity	24,589	1.856	10.093	0	76.772
RD sale	24,589	2.026	4.061	0	25.305
ROA	24,589	0.043	0.064	-0.238	0.274
Lev	24,589	0.255	0.161	0	0.761
Cap intens	24,589	3.939	6.965	0.358	42.348
Lnasset	24,589	16.199	1.740	11.890	20.953
MTB	24,589	2.587	3.133	0.216	24.423
Insider	24,589	0.280	0.255	0	0.876
Panel B: Sample for regression waste intensity on EIS and other explanatory variables					
Waste intensity	24,550	1.833	10.024	0	76.772
EIS	24,550	0.398	0.337	0	0.999
ROA	24,550	0.043	0.064	-0.238	0.274
Lev	24,550	0.255	0.161	0	0.761
Cap intens	24,550	3.940	6.970	0.358	42.348
Lnasset	24,550	16.200	1.740	11.890	20.953
MTB	24,550	2.587	3.134	0.216	24.423
Insider	24,550	0.280	0.255	0	0.876
Panel C: Sample for regression waste intensity on Process_inno and other explanatory variables					
Waste intensity	22,413	1.873	10.134	0	76.772
Process inno	22,413	3.843	1.166	0	6
ROA	22,413	0.043	0.064	-0.238	0.274
Lev	22,413	0.255	0.161	0	0.761
Cap intens	22,413	4.042	7.100	0.358	42.348
Lnasset	22,413	16.18	1.756	11.890	20.953
MTB	22,413	2.561	3.139	0.216	24.423
Insider	22,413	0.282	0.258	0	0.876
Panel D: Sample for regression waste intensity on Product_inno and other explanatory variables					
Waste intensity	24,201	1.876	10.137	0	76.772
Product inno	24,201	1.182	0.948	0	5
ROA	24,201	0.043	0.064	-0.238	0.274
Lev	24,201	0.254	0.161	0	0.761
Cap intens	24,201	3.960	7.001	0.358	42.348
Lnasset	24,201	16.194	1.742	11.890	20.953
MTB	24,201	2.581	3.123	0.216	24.423
Insider	24,201	0.279	0.255	0	0.876

Note: All variables are collected from Eikon database and winsorized at 1% and 99% to remove the impact of outliers

Table 10. Regressions of eco-innovation impacts on energy intensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Energy_intensity	Energy_intensity	Energy_intensity	Energy_intensity	Energy_intensity	Energy_intensity	Energy_intensity	Energy_intensity
RD_sale	-0.167***	-0.119***						
	[0.018]	[0.017]						
EIS			-1.533***	-1.494***				
			[0.287]	[0.319]				
Process_inno					-0.052	0.012		
					[0.066]	[0.070]		
Product_inno							-0.608***	-0.488***
							[0.098]	[0.108]
ROA		-3.380**		-2.560*		-2.911**		-2.535*
		[1.436]		[1.431]		[1.447]		[1.424]
Lev		3.506***		3.874***		3.746***		3.803***
		[0.652]		[0.646]		[0.662]		[0.646]
Cap_intens		0.092***		0.090***		0.088***		0.086***
		[0.022]		[0.022]		[0.023]		[0.023]
Lnasset		-0.154**		-0.044		-0.177**		-0.044
		[0.065]		[0.072]		[0.070]		[0.073]
MTB		-0.197***		-0.219***		-0.223***		-0.223***
		[0.027]		[0.027]		[0.026]		[0.025]
Insider		2.410***		2.460***		2.461***		2.424***
		[0.470]		[0.468]		[0.483]		[0.473]
Constant	13.155***	12.341***	13.022***	10.683***	16.331***	17.151***	12.962***	10.803***
	[3.169]	[3.275]	[3.161]	[3.296]	[4.050]	[4.493]	[3.141]	[3.278]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,792	36,900	40,733	36,854	37,867	34,402	40,199	36,373
R-squared	0.135	0.153	0.134	0.154	0.133	0.153	0.135	0.155

Note: This table presents the regression results of eco-innovation impacts on energy intensity. Columns (1) and (2) show the effect of R&D investment on energy intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on energy intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on energy intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on energy intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 11. Regressions of eco-innovation impacts on water intensity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity
RD_sale	-0.252***	-0.256***						
	[0.082]	[0.094]						
EIS			1.431	1.573				
			[1.916]	[2.125]				
Process_inno					-0.154	-0.149		
					[0.412]	[0.453]		
Product_inno							-1.148*	-1.102
							[0.686]	[0.773]
ROA		-19.565***		-18.786***		-16.112**		-17.823**
		[7.112]		[7.081]		[7.462]		[7.094]
Lev		1.443		1.915		2.823		1.900
		[4.149]		[4.130]		[4.326]		[4.156]
Cap_intens		0.320***		0.311***		0.255**		0.295***
		[0.106]		[0.106]		[0.099]		[0.106]
Lnasset		-0.639		-0.739*		-0.521		-0.378
		[0.399]		[0.414]		[0.422]		[0.428]
MTB		-0.353***		-0.407***		-0.417***		-0.415***
		[0.114]		[0.109]		[0.115]		[0.111]
Insider		0.361		0.624		0.284		0.469
		[3.199]		[3.174]		[3.284]		[3.191]
Constant	2.708	19.014	2.658	20.337	4.713	20.139	2.863	15.904
	[14.409]	[15.824]	[14.377]	[15.796]	[15.292]	[16.466]	[14.947]	[16.197]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,976	33,425	36,880	33,343	33,620	30,588	36,357	32,885
R-squared	0.205	0.219	0.205	0.219	0.212	0.224	0.205	0.217

Note: This table presents the regression results of eco-innovation impacts on Water intensity. Columns (1) and (2) show the effect of R&D investment on Water intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Water intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Water intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Water intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 12. Regressions of eco-innovation impacts on carbon intensity

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity	(5) Carbon_intensity	(6) Carbon_intensity	(7) Carbon_intensity	(8) Carbon_intensity
RD_sale	-0.015***	-0.011***						
	[0.001]	[0.001]						
EIS			-0.209***	-0.234***				
			[0.030]	[0.035]				
Process_inno					-0.004	-0.004		
					[0.006]	[0.007]		
Product_inno							-0.072***	-0.075***
							[0.011]	[0.012]
ROA		-0.200*		-0.113		-0.174		-0.123
		[0.111]		[0.109]		[0.111]		[0.109]
Lev		0.314***		0.349***		0.323***		0.337***
		[0.069]		[0.068]		[0.067]		[0.068]
Cap_intens		0.009***		0.009***		0.009***		0.008***
		[0.002]		[0.002]		[0.002]		[0.002]
Lnasset		-0.022***		-0.004		-0.020***		-0.005
		[0.007]		[0.008]		[0.007]		[0.007]
MTB		-0.018***		-0.020***		-0.019***		-0.019***
		[0.002]		[0.002]		[0.002]		[0.002]
Insider		0.114**		0.118**		0.129**		0.113**
		[0.051]		[0.050]		[0.052]		[0.051]
Constant	1.195***	1.520***	1.203***	1.284***	1.353***	1.583***	1.214***	1.302***
	[0.377]	[0.445]	[0.376]	[0.445]	[0.395]	[0.459]	[0.375]	[0.439]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	47,793	43,407	47,720	43,350	43,688	39,883	47,112	42,799
R-squared	0.250	0.269	0.252	0.272	0.242	0.262	0.251	0.271

Note: This table presents the regression results of eco-innovation impacts on Carbon intensity. Columns (1) and (2) show the effect of R&D investment on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 13. Regressions of eco-innovation impacts on waste intensity

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity	(5) Waste_intensity	(6) Waste_intensity	(7) Waste_intensity	(8) Waste_intensity
RD_sale	-0.019	-0.047**						
	[0.019]	[0.023]						
EIS			-2.588***	-2.748***				
			[0.357]	[0.413]				
Process_inno					-0.092	-0.009		
					[0.113]	[0.114]		
Product_inno							-0.903***	-0.962***
							[0.137]	[0.154]
ROA		-3.806		-2.901		-2.880		-3.647
		[2.578]		[2.460]		[2.646]		[2.579]
Lev		-5.246***		-5.215***		-5.035***		-5.424***
		[1.032]		[1.011]		[1.062]		[1.032]
Cap_intens		0.050***		0.047**		0.034**		0.038*
		[0.019]		[0.019]		[0.017]		[0.019]
Lnasset		-0.213*		-0.007		-0.182		-0.010
		[0.121]		[0.125]		[0.121]		[0.125]
MTB		-0.052*		-0.062**		-0.064*		-0.051
		[0.031]		[0.031]		[0.034]		[0.032]
Insider		0.588		0.499		0.533		0.277
		[0.803]		[0.796]		[0.822]		[0.794]
Constant	-0.164	4.016*	-0.262	1.057	0.499	3.869*	-0.160	1.345
	[0.482]	[2.057]	[0.503]	[2.101]	[0.570]	[2.071]	[0.465]	[2.079]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,305	24,589	27,255	24,550	24,773	22,413	26,863	24,201
R-squared	0.208	0.222	0.213	0.227	0.210	0.223	0.216	0.229

Note: This table presents the regression results of eco-innovation impacts on Waste intensity. Columns (1) and (2) show the effect of R&D investment on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively

Table 14. Regressions of eco-innovation impacts on energy intensity with country characteristics

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity
RD_sale	-0.106***			
	[0.018]			
EIS		-1.422***		
		[0.330]		
Process_inno			0.035	
			[0.072]	
Product_inno				-0.513***
				[0.109]
ROA	-4.802***	-4.173***	-4.490***	-3.941***
	[1.522]	[1.517]	[1.524]	[1.507]
Lev	3.250***	3.578***	3.446***	3.520***
	[0.680]	[0.673]	[0.688]	[0.673]
Cap_intens	0.088***	0.085***	0.083***	0.081***
	[0.021]	[0.021]	[0.021]	[0.021]
Lnasset	-0.126*	-0.022	-0.157**	-0.010
	[0.066]	[0.073]	[0.070]	[0.073]
MTB	-0.179***	-0.197***	-0.206***	-0.205***
	[0.026]	[0.026]	[0.024]	[0.023]
Insider	1.703***	1.689***	1.696***	1.638***
	[0.505]	[0.501]	[0.519]	[0.507]
Gov_effect	-1.109*	-1.210**	-1.348**	-1.302**
	[0.615]	[0.614]	[0.645]	[0.624]
Reg_quality	-0.884*	-0.944*	-0.782	-0.861
	[0.525]	[0.523]	[0.536]	[0.528]
GDP_growth	0.054	0.053	0.064*	0.049
	[0.035]	[0.035]	[0.033]	[0.034]
Corruption_Control	-0.078	0.033	-0.015	-0.014
	[0.450]	[0.449]	[0.467]	[0.453]
Constant	12.698***	11.143***	17.558***	11.143***
	[3.558]	[3.574]	[4.768]	[3.554]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	32,224	32,183	29,959	31,810
R-squared	0.164	0.165	0.165	0.166

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and country level variables. Column (1) shows the effect of R&D investment on energy intensity per sale and column (2) presents the effect of environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 15. Regressions of eco-innovation impacts on water intensity with country characteristics

VARIABLES	(1) Water_intensity	(2) Water_intensity	(3) Water_intensity	(4) Water_intensity
RD_sale	-0.250**			
	[0.111]			
EIS		1.432		
		[2.288]		
Process_inno			-0.189	
			[0.492]	
Product_inno				-1.563*
				[0.797]
ROA	-20.661***	-19.651**	-17.680**	-19.181**
	[7.830]	[7.800]	[8.291]	[7.873]
Lev	1.152	1.831	2.782	1.680
	[4.558]	[4.558]	[4.772]	[4.577]
Cap_intens	0.321***	0.316***	0.250**	0.294**
	[0.117]	[0.117]	[0.109]	[0.117]
Lnasset	-0.509	-0.610	-0.389	-0.167
	[0.434]	[0.449]	[0.461]	[0.458]
MTB	-0.391***	-0.427***	-0.435***	-0.430***
	[0.118]	[0.118]	[0.125]	[0.120]
Insider	1.971	2.164	1.829	1.843
	[3.316]	[3.306]	[3.445]	[3.325]
Gov_effect	10.108**	9.917**	10.781**	9.665**
	[4.497]	[4.482]	[4.786]	[4.554]
Reg_quality	1.422	1.663	0.939	1.476
	[3.164]	[3.156]	[3.390]	[3.207]
GDP_growth	-0.501**	-0.493**	-0.521**	-0.516**
	[0.225]	[0.225]	[0.234]	[0.229]
Corruption_Control	-10.143***	-10.379***	-10.269***	-9.909***
	[3.068]	[3.069]	[3.264]	[3.095]
Constant	14.558	15.981	15.042	10.235
	[17.142]	[17.119]	[17.586]	[17.247]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	29,277	29,238	26,733	28,916
R-squared	0.222	0.222	0.229	0.222

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and country level variables. Column (1) shows the effect of R&D investment on water intensity per sale and column (2) presents the effect of environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 16. Regressions of eco-innovation impacts on carbon intensity with country characteristics

	(1)	(2)	(3)	(4)
VARIABLES	Carbon_intensity	Carbon_intensity	Carbon_intensity	Carbon_intensity
RD_sale	-0.011***			
	[0.002]			
EIS		-0.229***		
		[0.037]		
Process_inno			-0.001	
			[0.007]	
Product_inno				-0.082***
				[0.013]
ROA	-0.345***	-0.271**	-0.349***	-0.263**
	[0.121]	[0.119]	[0.122]	[0.120]
Lev	0.304***	0.339***	0.304***	0.326***
	[0.075]	[0.073]	[0.073]	[0.073]
Cap_intens	0.008***	0.008***	0.008***	0.007***
	[0.002]	[0.002]	[0.002]	[0.002]
Lnasset	-0.021***	-0.005	-0.021***	-0.003
	[0.007]	[0.008]	[0.008]	[0.008]
MTB	-0.016***	-0.018***	-0.017***	-0.017***
	[0.002]	[0.002]	[0.002]	[0.002]
Insider	0.079	0.076	0.088	0.071
	[0.054]	[0.053]	[0.055]	[0.054]
Gov_effect	0.148**	0.135*	0.139*	0.130*
	[0.072]	[0.072]	[0.078]	[0.073]
Reg_quality	-0.067	-0.078	-0.079	-0.063
	[0.055]	[0.055]	[0.058]	[0.056]
GDP_growth	0.005*	0.005	0.005*	0.005
	[0.003]	[0.003]	[0.003]	[0.003]
Corruption_Control	-0.121**	-0.104**	-0.119**	-0.113**
	[0.047]	[0.047]	[0.049]	[0.047]
Constant	1.570***	1.341***	1.661***	1.338***
	[0.485]	[0.484]	[0.499]	[0.478]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	38,214	38,164	34,954	37,728
R-squared	0.280	0.283	0.272	0.282

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and country level variables. Column (1) shows the effect of R&D investment on carbon intensity per sale and column (2) presents the effect of environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 17. Regressions of eco-innovation impacts on waste intensity with country characteristics

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity
RD_sale	-0.023			
	[0.024]			
EIS		-2.683***		
		[0.443]		
Process_inno			0.001	
			[0.118]	
Product_inno				-0.913***
				[0.163]
ROA	-5.499*	-4.633*	-5.477*	-5.385*
	[2.861]	[2.733]	[2.955]	[2.854]
Lev	-5.264***	-5.283***	-5.526***	-5.471***
	[1.073]	[1.056]	[1.128]	[1.073]
Cap_intens	0.075***	0.071***	0.061***	0.062***
	[0.021]	[0.021]	[0.019]	[0.022]
Lnasset	-0.175	0.034	-0.174	0.019
	[0.133]	[0.140]	[0.133]	[0.139]
MTB	-0.034	-0.042	-0.039	-0.030
	[0.034]	[0.034]	[0.038]	[0.036]
Insider	0.974	0.852	0.634	0.597
	[0.925]	[0.921]	[0.953]	[0.911]
Gov_effect	-1.747**	-1.705**	-2.014***	-1.814**
	[0.700]	[0.698]	[0.765]	[0.716]
Reg_quality	-0.407	-0.555	-0.588	-0.365
	[0.692]	[0.694]	[0.721]	[0.698]
GDP_growth	-0.005	-0.007	-0.013	-0.010
	[0.029]	[0.029]	[0.030]	[0.029]
Corruption_Control	0.522	0.681	0.681	0.559
	[0.613]	[0.618]	[0.674]	[0.634]
Constant	3.773*	0.715	4.285*	1.226
	[2.282]	[2.357]	[2.345]	[2.319]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	21,447	21,410	19,455	21,154
R-squared	0.232	0.237	0.236	0.239

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and country level variables. Column (1) shows the effect of R&D investment on waste intensity per sale and column (2) presents the effect of environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 18. 2SLS regressions of eco-innovation impacts on energy intensity with instrument variable (IVs)

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity
RD_sale_hat	-1.467***			
	[0.274]			
EIS_hat		-66.246***		
		[12.352]		
Process_inno_hat			-16.032***	
			[2.989]	
Product_inno_hat				-24.748***
				[4.614]
ROA	-12.933***	-0.023	13.190***	1.408
	[2.564]	[1.436]	[3.073]	[1.509]
Lev	-3.611**	5.478***	8.833***	0.834
	[1.546]	[0.712]	[1.124]	[0.867]
Cap_intens	-0.007	-0.021	-0.577***	-0.389***
	[0.027]	[0.028]	[0.123]	[0.089]
Lnasset	-0.154**	3.981***	3.856***	4.726***
	[0.065]	[0.778]	[0.755]	[0.917]
MTB	0.182**	-0.402***	-0.245***	-0.161***
	[0.079]	[0.044]	[0.027]	[0.029]
Constant	17.274***	-30.402***	4.901	-37.842***
	[3.298]	[8.939]	[3.689]	[10.244]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	36,900	36,900	36,900	36,900
R-squared	0.151	0.151	0.151	0.151

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions with 2SLS regression method and instrument variables. Column (1) shows the effect of R&D investment on energy intensity per sale and column (2) presents the effect of environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 19. 2SLS regressions of eco-innovation impacts on water intensity with instrument variable (IVs)

	(1)	(2)	(3)	(4)
VARIABLES	Water_intensity	Water_intensity	Water_intensity	Water_intensity
RD_sale_hat	-0.351			
	[1.834]			
EIS_hat		-15.849		
		[82.810]		
Process_inno_hat			-3.836	
			[20.041]	
Product_inno_hat				-5.921
				[30.937]
ROA	-20.584	-17.495**	-14.334	-17.153**
	[14.699]	[7.755]	[20.974]	[8.656]
Lev	0.413	2.587	3.390	1.476
	[10.818]	[4.311]	[6.890]	[6.053]
Cap_intens	0.291*	0.288*	0.155	0.200
	[0.157]	[0.171]	[0.836]	[0.604]
Lnasset	-0.641	0.348	0.318	0.527
	[0.399]	[5.194]	[5.037]	[6.123]
MTB	-0.297	-0.437*	-0.399***	-0.379***
	[0.519]	[0.249]	[0.115]	[0.137]
Constant	19.966	8.560	17.006	6.780
	[16.749]	[56.249]	[18.609]	[65.228]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	33,425	33,425	33,425	33,425
R-squared	0.219	0.219	0.219	0.219

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions with 2SLS regression method and instrument variables. Column (1) shows the effect of R&D investment on water intensity per sale and column (2) presents the effect of environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 20. 2SLS regressions of eco-innovation impacts on carbon intensity with instrument variable (IVs)

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity
RD_sale_hat	-0.072**			
	[0.029]			
EIS_hat		-3.253**		
		[1.325]		
Process_inno_hat			-0.787**	
			[0.321]	
Product_inno_hat				-1.215**
				[0.495]
ROA	-0.638***	-0.004	0.645*	0.067
	[0.235]	[0.120]	[0.333]	[0.135]
Lev	-0.019	0.427***	0.592***	0.199**
	[0.167]	[0.074]	[0.118]	[0.093]
Cap_intens	0.004	0.003	-0.024*	-0.015
	[0.003]	[0.003]	[0.013]	[0.010]
Lnasset	-0.022***	0.181**	0.175**	0.218**
	[0.007]	[0.084]	[0.081]	[0.099]
MTB	0.000	-0.028***	-0.021***	-0.017***
	[0.008]	[0.004]	[0.002]	[0.002]
Constant	1.758***	-0.584	1.150**	-0.949
	[0.445]	[0.999]	[0.481]	[1.135]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	43,407	43,407	43,407	43,407
R-squared	0.267	0.267	0.267	0.267

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions with 2SLS regression method and instrument variables. Column (1) shows the effect of R&D investment on carbon intensity per sale and column (2) presents the effect of environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 21. 2SLS regressions of eco-innovation impacts on waste intensity with instrument variable (IVs)

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity
RD_sale_hat	-0.367			
	[0.461]			
EIS_hat		-16.566		
		[20.793]		
Process_inno_hat			-4.009	
			[5.032]	
Product_inno_hat				-6.189
				[7.768]
ROA	-6.103*	-2.875	0.429	-2.517
	[3.505]	[2.890]	[6.192]	[3.153]
Lev	-6.987***	-4.714***	-3.875**	-5.875***
	[2.471]	[1.175]	[1.937]	[1.327]
Cap_intens	0.025	0.021	-0.118	-0.071
	[0.036]	[0.040]	[0.210]	[0.151]
Lnasset	-0.215*	0.819	0.788	1.005
	[0.121]	[1.337]	[1.298]	[1.570]
MTB	0.042	-0.104*	-0.065**	-0.044
	[0.134]	[0.061]	[0.031]	[0.039]
Constant	5.260***	-6.662	2.166	-8.523
	[1.969]	[14.375]	[3.670]	[16.694]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	24,589	24,589	24,589	24,589
R-squared	0.222	0.222	0.222	0.222

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions with 2SLS regression method and instrument variables. Column (1) shows the effect of R&D investment on waste intensity per sale and column (2) presents the effect of environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 22. Regressions of one-period eco-innovation impacts on energy intensity

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity
lag1RD_sale	-0.134***			
	[0.017]			
lag1EIS		-1.539***		
		[0.332]		
lag1Proc_inno			0.009	
			[0.070]	
lag1Prod_inno				-0.479***
				[0.110]
lag1ROA	-2.676*	-1.842	-2.418	-1.716
	[1.551]	[1.549]	[1.575]	[1.544]
lag1Lev	3.546***	3.967***	3.896***	3.919***
	[0.676]	[0.676]	[0.700]	[0.674]
lag1Cap_intens	0.069***	0.067***	0.069***	0.063***
	[0.023]	[0.023]	[0.024]	[0.023]
lag1Lnasset	-0.112*	0.000	-0.152**	-0.007
	[0.066]	[0.074]	[0.073]	[0.075]
lag1MTB	-0.201***	-0.224***	-0.235***	-0.233***
	[0.028]	[0.028]	[0.026]	[0.025]
lag1Insider	2.446***	2.501***	2.476***	2.464***
	[0.497]	[0.494]	[0.514]	[0.502]
Constant	10.068***	8.270**	10.562***	8.507**
	[3.481]	[3.500]	[3.491]	[3.459]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	32,673	32,636	29,894	32,180
R-squared	0.161	0.161	0.160	0.161

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the one-period lagged effect of eco-innovation. Column (1) shows the effect of one-period lagged R&D investment on energy intensity per sale and column (2) presents the effect of one-period lagged environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of one-period lagged process innovation and one-period lagged product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 23. Regressions of one-period eco-innovation impacts on water intensity

VARIABLES	(1) Water_intensity	(2) Water_intensity	(3) Water_intensity	(4) Water_intensity
lag1RD_sale	-0.294***			
	[0.097]			
lag1EIS		1.243		
		[2.245]		
lag1Proc_inno			-0.319	
			[0.477]	
lag1Prod_inno				-1.234
				[0.810]
lag1ROA	-14.929**	-13.787**	-11.877*	-13.395**
	[6.502]	[6.481]	[6.849]	[6.532]
lag1Lev	1.748	2.530	3.918	2.409
	[4.482]	[4.493]	[4.720]	[4.517]
lag1Cap_intens	0.216**	0.213**	0.190*	0.203**
	[0.098]	[0.098]	[0.100]	[0.099]
lag1Lnasset	-0.497	-0.596	-0.409	-0.235
	[0.426]	[0.442]	[0.466]	[0.458]
lag1MTB	-0.490***	-0.530***	-0.540***	-0.534***
	[0.105]	[0.105]	[0.110]	[0.106]
lag1Insider	0.455	0.752	-0.048	0.451
	[3.510]	[3.487]	[3.632]	[3.516]
Constant	16.256	17.415	19.826	12.769
	[17.680]	[17.637]	[18.015]	[17.705]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	29,816	29,781	26,986	29,413
R-squared	0.230	0.229	0.235	0.228

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the one-period lagged effect of eco-innovation. Column (1) shows the effect of one-period lagged R&D investment on water intensity per sale and column (2) presents the effect of one-period lagged environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of one-period lagged process innovation and one-period lagged product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 24. Regressions of one-period eco-innovation impacts on carbon intensity

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity
lag1RD_sale	-0.012***			
	[0.002]			
lag1EIS		-0.240***		
		[0.036]		
lag1Proc_inno			-0.005	
			[0.007]	
lag1Prod_inno				-0.078***
				[0.013]
lag1ROA	-0.179	-0.104	-0.131	-0.091
	[0.126]	[0.124]	[0.128]	[0.126]
lag1Lev	0.316***	0.355***	0.330***	0.345***
	[0.074]	[0.073]	[0.073]	[0.073]
lag1Cap_intens	0.008***	0.008***	0.008***	0.007***
	[0.002]	[0.002]	[0.002]	[0.002]
lag1Lnasset	-0.020***	-0.003	-0.019**	-0.002
	[0.007]	[0.008]	[0.008]	[0.008]
lag1MTB	-0.018***	-0.020***	-0.020***	-0.020***
	[0.002]	[0.002]	[0.002]	[0.002]
lag1Insider	0.097*	0.100*	0.116**	0.095*
	[0.053]	[0.053]	[0.055]	[0.053]
Constant	1.365***	1.113**	1.326***	1.135***
	[0.445]	[0.446]	[0.450]	[0.440]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	38,061	38,014	34,437	37,506
R-squared	0.273	0.277	0.264	0.275

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the one-period lagged effect of eco-innovation. Column (1) shows the effect of one-period lagged R&D investment on carbon intensity per sale and column (2) presents the effect of one-period lagged environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of one-period lagged process innovation and one-period lagged product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 25. Regressions of one-period eco-innovation impacts on waste intensity

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity
lag1RD_sale	-0.033			
	[0.025]			
lag1EIS		-2.715***		
		[0.432]		
lag1Proc_inno			0.042	
			[0.115]	
lag1Prod_inno				-0.945***
				[0.166]
lag1ROA	-4.365	-3.344	-4.317	-4.044
	[2.840]	[2.665]	[2.953]	[2.832]
lag1Lev	-5.340***	-5.325***	-5.262***	-5.518***
	[1.092]	[1.072]	[1.139]	[1.093]
lag1Cap_intens	0.054***	0.050**	0.037**	0.042**
	[0.020]	[0.019]	[0.018]	[0.020]
lag1Lnasset	-0.243*	-0.036	-0.220*	-0.039
	[0.130]	[0.135]	[0.133]	[0.134]
lag1MTB	-0.043	-0.054	-0.052	-0.042
	[0.034]	[0.034]	[0.037]	[0.035]
lag1Insider	0.517	0.406	0.573	0.200
	[0.836]	[0.832]	[0.867]	[0.831]
Constant	5.220**	2.156	6.837**	2.549
	[2.148]	[2.180]	[2.854]	[2.159]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	22,236	22,204	19,926	21,893
R-squared	0.225	0.231	0.226	0.231

Note: This table presents the regression results of eco-innovation on environmental performance dimensions after controlling for industry/year/country effects with the one-period lagged effect of eco-innovation. Column (1) shows the effect of one-period lagged R&D investment on waste intensity per sale and column (2) presents the effect of one-period lagged environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of one-period lagged process innovation and one-period lagged product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 26. Regressions of three-period eco-innovation impacts on energy intensity

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity
lag3RD_sale	-0.139***			
	[0.020]			
lag3EIS		-1.667***		
		[0.366]		
lag3Proc_inno			0.013	
			[0.074]	
lag3Prod_inno				-0.471***
				[0.120]
lag3ROA	-2.092	-1.386	-2.146	-1.364
	[1.803]	[1.801]	[1.920]	[1.813]
lag3Lev	3.561***	4.000***	3.995***	3.999***
	[0.733]	[0.734]	[0.784]	[0.740]
lag3Cap_intens	0.060**	0.057**	0.066**	0.053**
	[0.027]	[0.027]	[0.029]	[0.027]
lag3Lnasset	-0.052	0.073	-0.089	0.056
	[0.074]	[0.083]	[0.084]	[0.083]
lag3MTB	-0.217***	-0.236***	-0.250***	-0.244***
	[0.030]	[0.030]	[0.031]	[0.029]
lag3Insider	2.715***	2.753***	2.861***	2.744***
	[0.558]	[0.553]	[0.588]	[0.568]
Constant	9.891**	7.782*	10.923**	8.287*
	[4.327]	[4.344]	[4.327]	[4.280]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	24,830	24,805	21,691	24,334
R-squared	0.178	0.178	0.180	0.180

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the three-period lagged effect of eco-innovation. Column (1) shows the effect of three-period lagged R&D investment on energy intensity per sale and column (2) presents the effect of three-period lagged environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of three-period lagged process innovation and three-period lagged product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 27. Regressions of three-period eco-innovation impacts on water intensity

	(1)	(2)	(3)	(4)
VARIABLES	Water_intensity	Water_intensity	Water_intensity	Water_intensity
lag3RD_sale	-0.352***			
	[0.121]			
lag3EIS		1.692		
		[2.465]		
lag3Proc_inno			-0.379	
			[0.492]	
lag3Prod_inno				-1.516*
				[0.873]
lag3ROA	-16.888**	-15.521**	-13.923*	-15.219**
	[7.641]	[7.620]	[8.234]	[7.702]
lag3Lev	-0.029	0.850	3.158	0.779
	[5.272]	[5.305]	[5.704]	[5.372]
lag3Cap_intens	0.153	0.151	0.151	0.133
	[0.100]	[0.100]	[0.108]	[0.101]
lag3Lnasset	-0.142	-0.284	-0.092	0.199
	[0.483]	[0.501]	[0.551]	[0.508]
lag3MTB	-0.448***	-0.491***	-0.505***	-0.492***
	[0.113]	[0.114]	[0.124]	[0.116]
lag3Insider	-0.234	0.085	-0.742	-0.416
	[4.051]	[4.031]	[4.211]	[4.090]
Constant	14.655	16.428	12.798	9.869
	[16.947]	[16.903]	[17.505]	[17.147]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	23,088	23,064	20,155	22,676
R-squared	0.264	0.263	0.268	0.263

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the three-period lagged effect of eco-innovation. Column (1) shows the effect of three-period lagged R&D investment on water intensity per sale and column (2) presents the effect of three-period lagged environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of three-period lagged process innovation and three-period lagged product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 28. Regressions of three-period eco-innovation impacts on carbon intensity

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity
lag3RD_sale	-0.013***			
	[0.002]			
lag3EIS		-0.248***		
		[0.040]		
lag3Proc_inno			-0.005	
			[0.008]	
lag3Prod_inno				-0.080***
				[0.014]
lag3ROA	-0.177	-0.094	-0.174	-0.088
	[0.160]	[0.158]	[0.168]	[0.160]
lag3Lev	0.288***	0.329***	0.294***	0.322***
	[0.086]	[0.085]	[0.085]	[0.085]
lag3Cap_intens	0.006***	0.006***	0.006***	0.005**
	[0.002]	[0.002]	[0.002]	[0.002]
lag3Lnasset	-0.016**	0.002	-0.015*	0.002
	[0.008]	[0.009]	[0.009]	[0.009]
lag3MTB	-0.019***	-0.021***	-0.021***	-0.021***
	[0.002]	[0.002]	[0.002]	[0.002]
lag3Insider	0.074	0.079	0.093	0.069
	[0.059]	[0.059]	[0.062]	[0.060]
Constant	1.199**	0.898*	1.182**	0.937*
	[0.493]	[0.496]	[0.496]	[0.487]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	28,369	28,340	24,722	27,829
R-squared	0.285	0.289	0.275	0.287

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the three-period lagged effect of eco-innovation. Column (1) shows the effect of three-period lagged R&D investment on carbon intensity per sale and column (2) presents the effect of three-period lagged environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of three-period lagged process innovation and three-period lagged product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 29. Regressions of three-period eco-innovation impacts on waste intensity

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity
lag3RD_sale	-0.025			
	[0.030]			
lag3EIS		-2.612***		
		[0.465]		
lag3Proc_inno			0.081	
			[0.121]	
lag3Prod_inno				-0.975***
				[0.197]
lag3ROA	-5.016	-4.369	-6.115*	-4.854
	[3.386]	[3.316]	[3.685]	[3.417]
lag3Lev	-5.376***	-5.326***	-5.423***	-5.591***
	[1.215]	[1.191]	[1.308]	[1.219]
lag3Cap_intens	0.064***	0.059***	0.054**	0.049**
	[0.021]	[0.021]	[0.022]	[0.022]
lag3Lnasset	-0.331**	-0.136	-0.333**	-0.113
	[0.149]	[0.153]	[0.158]	[0.154]
lag3MTB	-0.064	-0.068*	-0.073*	-0.058
	[0.039]	[0.039]	[0.044]	[0.041]
lag3Insider	0.680	0.565	0.838	0.436
	[0.922]	[0.923]	[1.006]	[0.950]
Constant	6.328***	3.263	8.018***	3.355
	[2.439]	[2.479]	[3.017]	[2.483]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	17,691	17,668	15,192	17,334
R-squared	0.233	0.240	0.237	0.240

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects with the three-period lagged effect of eco-innovation. Column (1) shows the effect of three-period lagged R&D investment on waste intensity per sale and column (2) presents the effect of three-period lagged environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of three-period lagged process innovation and three-period lagged product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 30. Regressions of eco-innovation impacts on energy intensity per asset

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity	(5) Energy_intensity	(6) Energy_intensity	(7) Energy_intensity	(8) Energy_intensity
RD_sale	-0.124***	-0.093***						
	[0.011]	[0.011]						
EIS			-0.711***	-0.633***				
			[0.186]	[0.205]				
Process_inno					-0.033	-0.001		
					[0.043]	[0.045]		
Product_inno							-0.280***	-0.219***
							[0.064]	[0.071]
ROA		-0.037		0.572		0.276		0.610
		[0.950]		[0.945]		[0.955]		[0.940]
Lev		1.553***		1.843***		1.763***		1.834***
		[0.402]		[0.398]		[0.405]		[0.398]
Cap_intens		-0.015*		-0.017*		-0.015		-0.019**
		[0.009]		[0.009]		[0.009]		[0.009]
Lnasset		-0.036		0.011		-0.048		0.014
		[0.039]		[0.044]		[0.042]		[0.044]
MTB		-0.122***		-0.139***		-0.141***		-0.142***
		[0.017]		[0.017]		[0.016]		[0.016]
Insider		1.362***		1.428***		1.436***		1.424***
		[0.314]		[0.313]		[0.326]		[0.317]
Constant	8.341***	7.773***	8.232***	6.994***	9.815***	10.332***	8.163***	7.009***
	[1.855]	[2.118]	[1.863]	[2.145]	[2.346]	[2.746]	[1.844]	[2.134]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	40,788	36,900	40,729	36,854	37,864	34,402	40,195	36,373
R-squared	0.145	0.153	0.141	0.152	0.141	0.153	0.141	0.152

Note: This table presents the regression results of eco-innovation impacts on energy intensity per asset. Columns (1) and (2) show the effect of R&D investment on energy intensity per assets without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on energy intensity per assets without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on energy intensity per assets without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on energy intensity per assets without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 31. Regressions of eco-innovation impacts on water intensity per asset

VARIABLES	(1) Water_intensity	(2) Water_intensity	(3) Water_intensity	(4) Water_intensity	(5) Water_intensity	(6) Water_intensity	(7) Water_intensity	(8) Water_intensity
RD_sale	-0.191***	-0.167***						
	[0.033]	[0.036]						
EIS			0.640	0.606				
			[0.748]	[0.835]				
Process_inno					0.021	-0.050		
					[0.161]	[0.179]		
Product_inno							-0.392	-0.447
							[0.270]	[0.297]
ROA		-4.111		-3.407		-2.729		-2.964
		[2.502]		[2.498]		[2.615]		[2.500]
Lev		0.278		0.677		0.868		0.684
		[1.625]		[1.623]		[1.679]		[1.633]
Cap_intens		-0.080***		-0.084***		-0.089***		-0.090***
		[0.023]		[0.024]		[0.024]		[0.023]
Lnasset		-0.064		-0.106		-0.041		0.036
		[0.150]		[0.158]		[0.159]		[0.156]
MTB		-0.217***		-0.248***		-0.251***		-0.251***
		[0.044]		[0.043]		[0.045]		[0.044]
Insider		0.280		0.462		0.357		0.375
		[1.177]		[1.170]		[1.200]		[1.177]
Constant	3.298	6.551	3.223	7.005	2.970	6.681	3.249	5.204
	[4.889]	[5.475]	[4.870]	[5.496]	[5.167]	[5.645]	[5.080]	[5.611]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,973	33,425	36,877	33,343	33,617	30,588	36,354	32,885
R-squared	0.174	0.185	0.173	0.184	0.179	0.189	0.173	0.183

Note: This table presents the regression results of eco-innovation impacts on water intensity per asset. Columns (1) and (2) show the effect of R&D investment on water intensity per assets without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on water intensity per assets without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on water intensity per assets without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on water intensity per assets without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 32. Regressions of eco-innovation impacts on carbon intensity per asset

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity	(5) Carbon_intensity	(6) Carbon_intensity	(7) Carbon_intensity	(8) Carbon_intensity
RD_sale	-0.010***	-0.008***						
	[0.001]	[0.001]						
EIS			-0.090***	-0.102***				
			[0.015]	[0.017]				
Process_inno					0.000	-0.001		
					[0.003]	[0.003]		
Product_inno							-0.027***	-0.030***
							[0.006]	[0.006]
ROA		0.043		0.098*		0.051		0.096*
		[0.057]		[0.056]		[0.058]		[0.056]
Lev		0.114***		0.139***		0.126***		0.134***
		[0.033]		[0.033]		[0.033]		[0.033]
Cap_intens		-0.002***		-0.002***		-0.002***		-0.002***
		[0.000]		[0.000]		[0.000]		[0.000]
Lnasset		-0.004		0.003		-0.004		0.002
		[0.003]		[0.004]		[0.004]		[0.004]
MTB		-0.009***		-0.011***		-0.010***		-0.011***
		[0.001]		[0.001]		[0.001]		[0.001]
Insider		0.064**		0.069***		0.076***		0.068***
		[0.026]		[0.025]		[0.026]		[0.026]
Constant	0.749***	0.856***	0.751***	0.750***	0.849***	0.932***	0.753***	0.763***
	[0.186]	[0.219]	[0.186]	[0.219]	[0.199]	[0.231]	[0.186]	[0.217]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	47,790	43,407	47,717	43,350	43,685	39,883	47,109	42,799
R-squared	0.221	0.229	0.220	0.230	0.213	0.223	0.217	0.228

Note: This table presents the regression results of eco-innovation impacts on carbon intensity per asset. Columns (1) and (2) show the effect of R&D investment on carbon intensity per assets without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on carbon intensity per assets without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on carbon intensity per assets without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on carbon intensity per assets without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 33. Regressions of eco-innovation impacts on waste intensity per asset

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity	(5) Waste_intensity	(6) Waste_intensity	(7) Waste_intensity	(8) Waste_intensity
RD_sale	-0.012	-0.019**						
	[0.008]	[0.009]						
EIS			-1.025***	-1.071***				
			[0.155]	[0.181]				
Process_inno					-0.044	-0.014		
					[0.047]	[0.048]		
Product_inno							-0.371***	-0.394***
							[0.057]	[0.065]
ROA		0.529		0.781		0.919		0.634
		[1.073]		[1.051]		[1.100]		[1.075]
Lev		-1.872***		-1.843***		-1.799***		-1.944***
		[0.423]		[0.416]		[0.442]		[0.423]
Cap_intens		0.005		0.004		-0.000		-0.000
		[0.007]		[0.007]		[0.007]		[0.007]
Lnasset		-0.082		-0.004		-0.073		0.001
		[0.051]		[0.054]		[0.052]		[0.054]
MTB		-0.029**		-0.033***		-0.034**		-0.029**
		[0.013]		[0.013]		[0.014]		[0.013]
Insider		0.265		0.230		0.233		0.148
		[0.333]		[0.331]		[0.344]		[0.332]
Constant	-0.135	1.392	-0.173	0.268	0.137	1.376	-0.135	0.293
	[0.197]	[0.873]	[0.208]	[0.899]	[0.240]	[0.886]	[0.192]	[0.893]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	27,303	24,589	27,253	24,550	24,771	22,413	26,861	24,201
R-squared	0.193	0.205	0.198	0.209	0.192	0.204	0.201	0.212

Note: This table presents the regression results of eco-innovation impacts on waste intensity per asset. Columns (1) and (2) show the effect of R&D investment on waste intensity per assets without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on waste intensity per assets without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on waste intensity per assets without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on waste intensity per assets without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively

Table 34. Regressions of eco-innovation impacts on energy intensity with board characteristics

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity
RD_sale	-0.108***			
	[0.018]			
EIS		-1.580***		
		[0.375]		
Process_inno			0.028	
			[0.084]	
Product_inno				-0.608***
				[0.123]
ROA	-2.210	-1.339	-1.827	-1.426
	[1.426]	[1.408]	[1.420]	[1.413]
Lev	4.005***	4.313***	4.201***	4.227***
	[0.741]	[0.736]	[0.751]	[0.736]
Cap_intens	0.086***	0.085***	0.083***	0.079***
	[0.025]	[0.025]	[0.026]	[0.026]
Lnasset	-0.130	-0.023	-0.162**	-0.005
	[0.079]	[0.086]	[0.082]	[0.086]
MTB	-0.196***	-0.216***	-0.216***	-0.218***
	[0.029]	[0.028]	[0.029]	[0.028]
Insider	2.843***	2.851***	2.926***	2.872***
	[0.559]	[0.552]	[0.574]	[0.561]
B_size	0.192	0.253	0.276	0.389
	[0.438]	[0.438]	[0.443]	[0.440]
B_independence	0.627	0.518	0.683	0.563
	[0.576]	[0.576]	[0.591]	[0.579]
B_expertise	0.149	0.076	0.301	0.005
	[0.523]	[0.523]	[0.544]	[0.524]
B_diversity	-1.858**	-1.554*	-1.749*	-1.453
	[0.901]	[0.912]	[0.927]	[0.919]
B_tenure	-0.104***	-0.101***	-0.106***	-0.104***
	[0.036]	[0.036]	[0.036]	[0.036]
Constant	8.096**	6.538**	9.968***	6.175*
	[3.324]	[3.310]	[3.300]	[3.272]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	27,548	27,524	26,355	27,150
R-squared	0.170	0.171	0.167	0.171

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and board characteristics variables. Column (1) shows the effect of R&D investment on energy intensity per sale and column (2) presents the effect of environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 35. Regressions of eco-innovation impacts on water intensity with board characteristics

	(1)	(2)	(3)	(4)
VARIABLES	Water intensity	Water _intensity	Water _intensity	Water _intensity
RD_sale	-0.267***			
	[0.085]			
EIS		0.337		
		[2.532]		
Process_inno			-0.234	
			[0.517]	
Product_inno				-1.542
				[0.954]
ROA	-15.062**	-13.453*	-13.179*	-13.538*
	[7.659]	[7.520]	[7.876]	[7.616]
Lev	2.887	3.608	3.725	3.379
	[4.565]	[4.523]	[4.670]	[4.562]
Cap_intens	0.165*	0.159*	0.137	0.146
	[0.091]	[0.091]	[0.091]	[0.090]
Lnasset	-0.487	-0.520	-0.416	-0.164
	[0.466]	[0.486]	[0.492]	[0.500]
MTB	-0.332***	-0.374***	-0.363***	-0.373***
	[0.123]	[0.120]	[0.124]	[0.121]
Insider	5.069	5.313	5.251	5.183
	[3.266]	[3.244]	[3.332]	[3.259]
B_size	1.719	1.752	2.114	2.027
	[2.207]	[2.199]	[2.263]	[2.212]
B_independence	16.390***	16.311***	16.844***	16.558***
	[4.034]	[4.023]	[4.159]	[4.040]
B_expertise	3.922	3.807	5.023	3.632
	[3.011]	[3.006]	[3.146]	[3.064]
B_diversity	0.105	0.291	0.315	1.050
	[7.108]	[7.156]	[7.429]	[7.197]
B_tenure	0.225	0.218	0.217	0.220
	[0.260]	[0.259]	[0.261]	[0.258]
Constant	18.051	18.269	21.398	13.408
	[20.173]	[20.105]	[20.493]	[20.085]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	24,350	24,320	23,237	24,021
R-squared	0.250	0.250	0.250	0.250

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and board characteristics variables. Column (1) shows the effect of R&D investment on water intensity per sale and column (2) presents the effect of environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 36. Regressions of eco-innovation and impacts on carbon intensity with board characteristics

VARIABLES	(1) Carbon_intensity	(2) Carbon _intensity	(3) Carbon _intensity	(4) Carbon _intensity
RD_sale	-0.010***			
	[0.002]			
EIS		-0.229***		
		[0.041]		
Process_inno			0.001	
			[0.008]	
Product_inno				-0.085***
				[0.015]
ROA	-0.270**	-0.181	-0.230*	-0.197
	[0.126]	[0.124]	[0.127]	[0.124]
Lev	0.294***	0.323***	0.320***	0.312***
	[0.078]	[0.077]	[0.079]	[0.077]
Cap_intens	0.009***	0.009***	0.009***	0.008***
	[0.003]	[0.003]	[0.003]	[0.003]
Lnasset	-0.029***	-0.013	-0.030***	-0.011
	[0.009]	[0.009]	[0.009]	[0.009]
MTB	-0.018***	-0.020***	-0.019***	-0.019***
	[0.002]	[0.002]	[0.002]	[0.002]
Insider	0.221***	0.224***	0.240***	0.223***
	[0.062]	[0.061]	[0.063]	[0.062]
B_size	0.071*	0.081*	0.079*	0.088**
	[0.043]	[0.043]	[0.044]	[0.043]
B_independence	0.189***	0.179***	0.182***	0.180***
	[0.063]	[0.063]	[0.065]	[0.063]
B_expertise	0.081	0.071	0.085	0.060
	[0.054]	[0.054]	[0.056]	[0.054]
B_diversity	-0.071	-0.031	-0.059	-0.028
	[0.104]	[0.104]	[0.106]	[0.105]
B_tenure	-0.002	-0.002	-0.003	-0.002
	[0.004]	[0.004]	[0.004]	[0.004]
Constant	1.203**	0.982**	1.185**	0.968**
	[0.474]	[0.475]	[0.463]	[0.468]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	32,258	32,223	30,662	31,813
R-squared	0.280	0.283	0.277	0.283

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and board characteristics variables. Column (1) shows the effect of R&D investment on carbon intensity per sale and column (2) presents the effect of environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 37. Regressions of eco-innovation impacts on waste intensity with board characteristics

VARIABLES	(1) Waste_intensity	(2) Waste _intensity	(3) Waste _intensity	(4) Waste _intensity
RD_sale	-0.064*			
	[0.033]			
EIS		-3.405***		
		[0.561]		
Process_inno			0.135	
			[0.154]	
Product_inno				-1.102***
				[0.198]
ROA	-3.433	-3.126	-2.303	-3.246
	[2.897]	[2.829]	[2.909]	[2.887]
Lev	-5.595***	-5.635***	-5.227***	-5.873***
	[1.314]	[1.297]	[1.319]	[1.324]
Cap_intens	0.056***	0.055***	0.052**	0.041*
	[0.021]	[0.021]	[0.021]	[0.021]
Lnasset	-0.134	0.093	-0.151	0.090
	[0.158]	[0.164]	[0.164]	[0.167]
MTB	-0.035	-0.040	-0.044	-0.035
	[0.038]	[0.039]	[0.040]	[0.039]
Insider	1.427	1.299	1.505	1.158
	[1.114]	[1.106]	[1.126]	[1.102]
B_size	-0.514	-0.383	-0.488	-0.368
	[0.697]	[0.695]	[0.726]	[0.704]
B_independence	1.552**	1.506**	1.411*	1.543**
	[0.752]	[0.752]	[0.782]	[0.758]
B_expertise	0.931	0.933	0.984	0.876
	[0.825]	[0.820]	[0.882]	[0.831]
B_diversity	-4.377***	-3.685**	-4.322***	-3.771***
	[1.448]	[1.434]	[1.479]	[1.450]
B_tenure	-0.128**	-0.105*	-0.145**	-0.125**
	[0.062]	[0.062]	[0.063]	[0.061]
Constant	2.412	-1.250	3.895	-0.750
	[2.839]	[3.012]	[2.562]	[2.916]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	16,464	16,437	15,588	16,192
R-squared	0.236	0.243	0.238	0.244

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects and board characteristics variables. Column (1) shows the effect of R&D investment on waste intensity per sale and column (2) presents the effect of environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 38. Regressions of eco-innovation impacts on energy intensity for developing countries

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity	(5) Energy_intensity	(6) Energy_intensity	(7) Energy_intensity	(8) Energy_intensity
RD_sale	-0.261***	-0.177**						
	[0.065]	[0.069]						
Eco_inno			-2.415***	-2.808***				
			[0.864]	[0.904]				
Process_inno					-0.074	-0.129		
					[0.214]	[0.222]		
Product_inno							-1.107***	-1.204***
							[0.290]	[0.311]
ROA		6.589*		7.653**		8.146**		7.588**
		[3.775]		[3.704]		[3.836]		[3.772]
Lev		3.441*		3.831**		4.000**		3.667**
		[1.813]		[1.798]		[1.804]		[1.803]
Cap_intens		0.100*		0.102*		0.097*		0.095*
		[0.056]		[0.055]		[0.056]		[0.055]
Lnasset		-0.020		0.180		0.024		0.258
		[0.192]		[0.197]		[0.190]		[0.199]
MTB		-0.423***		-0.439***		-0.444***		-0.439***
		[0.066]		[0.064]		[0.066]		[0.065]
Insider		1.443		1.500		1.541		1.544
		[1.272]		[1.257]		[1.279]		[1.275]
Constant	3.462	2.794	3.317	-0.070	-0.649	7.864*	3.395	-0.871
	[3.352]	[4.382]	[3.352]	[4.406]	[3.455]	[4.406]	[3.354]	[4.341]
Observations	7,525	7,054	7,523	7,053	7,335	6,888	7,387	6,925
R-squared	0.200	0.208	0.200	0.210	0.193	0.203	0.200	0.211

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample of developing countries in G20. Columns (1) and (2) show the effect of R&D investment on energy intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on energy intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on energy intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on energy intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 39. Regressions of eco-innovation impacts on water intensity for developing countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity	Water_intensity
RD_sale	0.004	0.246						
	[0.171]	[0.215]						
Eco_inno			-2.645	-3.266				
			[4.892]	[4.909]				
Process_inno					-1.339	-1.216		
					[1.091]	[1.068]		
Product_inno							-3.706**	-4.369***
							[1.705]	[1.676]
ROA		9.188		4.418		10.690		8.533
		[13.729]		[13.475]		[12.996]		[12.859]
Lev		4.495		2.640		2.981		1.928
		[9.996]		[9.667]		[9.827]		[9.752]
Cap_intens		0.163		0.156		0.129		0.140
		[0.212]		[0.212]		[0.213]		[0.216]
Lnasset		-0.449		-0.318		-0.157		0.414
		[1.029]		[1.078]		[1.006]		[1.070]
MTB		-0.585**		-0.611**		-0.628**		-0.614**
		[0.276]		[0.242]		[0.250]		[0.248]
Insider		8.172		8.217		7.803		7.635
		[5.249]		[5.177]		[5.278]		[5.214]
Constant	13.937	38.793	14.040	37.940	0.938	8.227	15.404	29.401
	[20.319]	[24.716]	[20.345]	[24.452]	[21.730]	[21.149]	[20.644]	[24.634]
Observations	7,180	6,762	7,165	6,749	6,985	6,595	7,029	6,623
R-squared	0.191	0.199	0.193	0.201	0.195	0.202	0.195	0.205

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample of developing countries in G20. Columns (1) and (2) show the effect of R&D investment on Water intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Water intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Water intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Water intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 40. Regressions of eco-innovation impacts on carbon intensity for developing countries

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity	(5) Carbon_intensity	(6) Carbon_intensity	(7) Carbon_intensity	(8) Carbon_intensity
RD_sale	-0.029***	-0.020**						
	[0.007]	[0.008]						
Eco_inno			-0.347***	-0.391***				
			[0.105]	[0.116]				
Process_inno					0.032	0.023		
					[0.023]	[0.024]		
Product_inno							-0.125***	-0.142***
							[0.035]	[0.038]
ROA		0.311		0.450		0.413		0.387
		[0.440]		[0.429]		[0.443]		[0.436]
Lev		0.193		0.239		0.248		0.215
		[0.246]		[0.244]		[0.244]		[0.243]
Cap_intens		0.007		0.008		0.008		0.006
		[0.008]		[0.008]		[0.008]		[0.008]
Lnasset		-0.005		0.020		-0.008		0.025
		[0.025]		[0.027]		[0.026]		[0.027]
MTB		-0.034***		-0.036***		-0.036***		-0.035***
		[0.007]		[0.007]		[0.007]		[0.007]
Insider		0.248*		0.258*		0.283**		0.259*
		[0.138]		[0.136]		[0.140]		[0.137]
Constant	2.030***	1.378**	2.035***	1.150*	5.849***	-0.035	2.077***	1.177*
	[0.372]	[0.613]	[0.371]	[0.615]	[0.431]	[0.564]	[0.371]	[0.603]
Observations	7,196	6,754	7,193	6,752	7,018	6,598	7,064	6,632
R-squared	0.285	0.289	0.288	0.294	0.284	0.289	0.288	0.295

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effectsin the sample of developing countries in G20. Columns (1) and (2) show the effect of R&D investment on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 41. Regressions of eco-innovation impacts on waste intensity for developing countries

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity	(5) Waste_intensity	(6) Waste_intensity	(7) Waste_intensity	(8) Waste_intensity
RD_sale	0.116**	0.162**						
	[0.058]	[0.067]						
Eco_inno			-1.083	-1.428*				
			[0.744]	[0.828]				
Process_inno					0.181	0.116		
					[0.203]	[0.213]		
Product_inno							-0.575**	-0.703**
							[0.272]	[0.327]
ROA		7.510		6.150		6.155		5.990
		[4.868]		[4.751]		[4.961]		[4.923]
Lev		-0.727		-1.080		-1.093		-1.274
		[2.244]		[2.298]		[2.370]		[2.359]
Cap_intens		0.000		-0.001		0.003		-0.007
		[0.042]		[0.043]		[0.042]		[0.044]
Lnasset		0.327		0.390		0.283		0.434*
		[0.241]		[0.247]		[0.250]		[0.258]
MTB		0.033		0.053		0.047		0.055
		[0.072]		[0.073]		[0.074]		[0.074]
Insider		3.122		3.047		3.093		3.017
		[2.554]		[2.517]		[2.576]		[2.569]
Constant	1.054	-5.658	1.158	-6.376	-5.264**	-11.356**	1.377	-6.271
	[1.149]	[4.032]	[1.141]	[4.078]	[2.218]	[4.774]	[1.192]	[4.125]
Observations	5,408	5,111	5,404	5,108	5,279	4,998	5,308	5,019
R-squared	0.174	0.186	0.174	0.186	0.175	0.186	0.177	0.189

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effectsin the sample of developing countries in G20. Columns (1) and (2) show the effect of R&D investment on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively

Table 42. Regressions of eco-innovation impacts on energy intensity for non-financial sample

VARIABLES	(1) Energy_intensity	(2) Energy_intensity	(3) Energy_intensity	(4) Energy_intensity	(5) Energy_intensity	(6) Energy_intensity	(7) Energy_intensity	(8) Energy_intensity
RD_sale	-0.165***	-0.133***						
	[0.018]	[0.019]						
Eco_inno			-1.653***	-1.498***				
			[0.348]	[0.383]				
Process_inno					-0.070	-0.024		
					[0.078]	[0.085]		
Product_inno							-0.596***	-0.458***
							[0.114]	[0.123]
ROA		-3.018**		-2.119		-2.612*		-1.995
		[1.532]		[1.529]		[1.546]		[1.517]
Lev		3.428***		3.912***		3.840***		3.953***
		[0.865]		[0.847]		[0.871]		[0.851]
Cap_intens		0.387***		0.364***		0.340***		0.356***
		[0.095]		[0.097]		[0.097]		[0.097]
Lnasset		0.011		0.103		-0.015		0.095
		[0.082]		[0.090]		[0.090]		[0.089]
MTB		-0.194***		-0.219***		-0.227***		-0.226***
		[0.029]		[0.029]		[0.028]		[0.027]
Insider		2.800***		2.885***		2.877***		2.848***
		[0.561]		[0.558]		[0.579]		[0.567]
Constant	16.250***	11.244***	16.186***	9.849**	19.782***	16.915***	16.025***	10.037**
	[4.015]	[4.223]	[3.995]	[4.238]	[4.863]	[5.423]	[3.988]	[4.210]
Observations	33,985	30,764	33,930	30,721	31,449	28,573	33,444	30,280
R-squared	0.130	0.156	0.129	0.156	0.128	0.154	0.129	0.156

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample without finance industry. Columns (1) and (2) show the effect of R&D investment on energy intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on energy intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on energy intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on energy intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 43. Regressions of eco-innovation impacts on water intensity for non-financial sample

VARIABLE	(1) Water_intensity	(2) Water_intensity	(3) Water_intensity	(4) Water_intensity	(5) Water_intensity	(6) Water_intensity	(7) Water_intensity	(8) Water_intensity
RD_sale	-0.250***	-0.369***						
	[0.086]	[0.106]						
Eco_inno			2.423	2.585				
			[2.312]	[2.528]				
Process_inno					-0.128	-0.248		
					[0.474]	[0.530]		
Product_inno							-1.133	-1.093
							[0.809]	[0.877]
ROA		-17.927**		-16.137**		-14.820*		-15.507**
		[7.604]		[7.574]		[7.966]		[7.579]
Lev		-2.981		-1.744		-0.901		-1.839
		[5.347]		[5.288]		[5.524]		[5.320]
Cap_intens		1.875***		1.854***		1.546***		1.749***
		[0.467]		[0.472]		[0.438]		[0.464]
Lnasset		-0.015		-0.219		0.105		0.201
		[0.515]		[0.527]		[0.554]		[0.530]
MTB		-0.293**		-0.375***		-0.387***		-0.381***
		[0.124]		[0.119]		[0.125]		[0.120]
Insider		0.510		0.973		0.743		0.811
		[3.841]		[3.807]		[3.953]		[3.839]
Constant	2.833	9.934	2.805	12.512	4.553	12.071	2.911	7.716
	[17.208]	[19.162]	[17.136]	[19.077]	[18.422]	[20.081]	[17.972]	[19.633]
Observations	31,317	28,350	31,228	28,274	28,353	25,824	30,750	27,852
R-squared	0.206	0.225	0.206	0.226	0.214	0.230	0.206	0.224

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample without finance industry. Columns (1) and (2) show the effect of R&D investment on Water intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Water intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Water intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Water intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 44. Regressions of eco-innovation impacts on carbon intensity for non-financial sample

VARIABLES	(1) Carbon_intensity	(2) Carbon_intensity	(3) Carbon_intensity	(4) Carbon_intensity	(5) Carbon_intensity	(6) Carbon_intensity	(7) Carbon_intensity	(8) Carbon_intensity
RD_sale	-0.015***	-0.013***						
	[0.002]	[0.002]						
Eco_inno			-0.250***	-0.260***				
			[0.037]	[0.042]				
Process_inno					-0.008	-0.007		
					[0.007]	[0.009]		
Product_inno							-0.077***	-0.076***
							[0.013]	[0.015]
ROA		-0.165		-0.075		-0.136		-0.070
		[0.135]		[0.134]		[0.137]		[0.135]
Lev		0.357***		0.400***		0.380***		0.401***
		[0.093]		[0.091]		[0.090]		[0.091]
Cap_intens		0.039***		0.035***		0.036***		0.035***
		[0.009]		[0.009]		[0.009]		[0.009]
Lnasset		-0.015*		0.002		-0.014		0.000
		[0.009]		[0.010]		[0.010]		[0.010]
MTB		-0.018***		-0.020***		-0.020***		-0.020***
		[0.002]		[0.002]		[0.002]		[0.002]
Insider		0.123**		0.130**		0.146**		0.124**
		[0.061]		[0.060]		[0.062]		[0.061]
Constant	1.448***	1.637***	1.457***	1.406***	1.656***	1.741***	1.469***	1.441***
	[0.444]	[0.534]	[0.442]	[0.533]	[0.465]	[0.549]	[0.442]	[0.525]
Observations	39,775	36,085	39,706	36,031	36,205	32,999	39,150	35,524
R-squared	0.244	0.267	0.247	0.270	0.237	0.260	0.244	0.268

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample without finance industry. Columns (1) and (2) show the effect of R&D investment on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Carbon intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 45. Regressions of eco-innovation impacts on waste intensity for non-financial sample

VARIABLES	(1) Waste_intensity	(2) Waste_intensity	(3) Waste_intensity	(4) Waste_intensity	(5) Waste_intensity	(6) Waste_intensity	(7) Waste_intensity	(8) Waste_intensity
RD_sale	-0.010	-0.046*						
	[0.021]	[0.026]						
Eco_inno			-2.974***	-3.092***				
			[0.417]	[0.475]				
Process_inno					-0.092	-0.025		
					[0.129]	[0.131]		
Product_inno							-1.007***	-1.051***
							[0.159]	[0.176]
ROA		-4.272		-3.519		-3.555		-4.188
		[2.783]		[2.667]		[2.873]		[2.782]
Lev		-6.391***		-6.398***		-6.121***		-6.566***
		[1.273]		[1.244]		[1.317]		[1.273]
Cap_intens		0.074		0.041		-0.007		0.033
		[0.087]		[0.085]		[0.069]		[0.086]
Lnasset		-0.136		0.089		-0.092		0.075
		[0.156]		[0.162]		[0.161]		[0.161]
MTB		-0.041		-0.049		-0.052		-0.039
		[0.033]		[0.034]		[0.036]		[0.035]
Insider		0.967		0.871		0.940		0.600
		[0.952]		[0.941]		[0.978]		[0.943]
Constant	-0.230	2.841	-0.327	-0.362	0.560	2.719	-0.235	0.077
	[0.544]	[2.491]	[0.570]	[2.562]	[0.650]	[2.523]	[0.520]	[2.530]
Observations	23,521	21,223	23,472	21,184	21,246	19,246	23,108	20,856
R-squared	0.217	0.232	0.223	0.238	0.219	0.234	0.226	0.240

Note: This table presents the regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in the sample without finance industry**.** Columns (1) and (2) show the effect of R&D investment on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (3) and (4) illustrate the effect of environmental innovation score on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (5) and (6) report the impact of process innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Columns (7) and (8) present the effects of product innovation on Waste intensity per sales without and with firm-specific control variables, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 46. WLS Regressions of eco-innovation impacts on energy intensity

	(1)	(2)	(3)	(4)
VARIABLES	Energy_intensity	Energy _intensity	Energy _intensity	Energy _intensity
RD_sale	-0.060***			
	[0.019]			
EIS		-3.460***		
		[0.157]		
Process_inno			-0.126***	
			[0.040]	
Product_inno				-0.470***
				[0.056]
ROA	-9.773***	-10.136***	-10.527***	-10.264***
	[0.607]	[0.606]	[0.619]	[0.610]
Lev	-2.836***	-2.972***	-3.106***	-3.000***
	[0.302]	[0.300]	[0.307]	[0.302]
Cap_intens	0.326***	0.335***	0.294***	0.323***
	[0.009]	[0.009]	[0.009]	[0.009]
Lnasset	-0.321***	-0.102***	-0.248***	-0.219***
	[0.030]	[0.031]	[0.032]	[0.032]
MTB	-0.119***	-0.117***	-0.121***	-0.109***
	[0.017]	[0.017]	[0.018]	[0.017]
Insider	2.046***	1.979***	1.941***	2.036***
	[0.198]	[0.197]	[0.202]	[0.198]
Constant	18.774	15.524	17.421	17.301
	[49.936]	[49.584]	[49.554]	[49.594]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	36,900	36,854	34,402	36,373
R-squared	0.219	0.230	0.218	0.220

Note: This table presents the WLS regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in. Column (1) shows the effect of R&D investment on energy intensity per sale and column (2) presents the effect of environmental innovation score on energy intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on energy intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 47. WLS Regressions of eco-innovation impacts on water intensity

	(1)	(2)	(3)	(4)
VARIABLES	Water_intensity	Water _intensity	Water _intensity	Water _intensity
RD_sale	-0.160			
	[0.115]			
EIS		-4.397***		
		[0.967]		
Process_inno			-1.149***	
			[0.254]	
Product_inno				0.328
				[0.341]
ROA	-44.368***	-43.585***	-39.411***	-42.603***
	[3.760]	[3.619]	[3.776]	[3.676]
Lev	1.933	-15.270***	-15.695***	-14.999***
	[1.850]	[1.812]	[1.893]	[1.836]
Cap_intens	0.594***	1.755***	1.389***	1.716***
	[0.046]	[0.057]	[0.060]	[0.057]
Lnasset	-3.165***	-2.767***	-2.522***	-3.151***
	[0.171]	[0.190]	[0.198]	[0.195]
MTB	-0.839***	-0.348***	-0.433***	-0.388***
	[0.109]	[0.103]	[0.109]	[0.105]
Insider	0.533	5.351***	4.040***	5.721***
	[1.062]	[1.220]	[1.274]	[1.239]
Constant	62.497***	89.703	103.776	96.078
	[2.622]	[335.816]	[344.233]	[342.208]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	33,431	33,343	30,588	32,885
R-squared	0.021	0.159	0.159	0.158

Note: This table presents the WLS regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in. Column (1) shows the effect of R&D investment on water intensity per sale and column (2) presents the effect of environmental innovation score on water intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on water intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 48. WLS Regressions of eco-innovation impacts on carbon intensity

	(1)	(2)	(3)	(4)
VARIABLES	Carbon_intensity	Carbon _intensity	Carbon _intensity	Carbon _intensity
RD_sale	-0.007***			
	[0.002]			
EIS		-0.386***		
		[0.015]		
Process_inno			-0.001	
			[0.004]	
Product_inno				-0.083***
				[0.005]
ROA	-0.244***	-0.224***	-0.219***	-0.253***
	[0.056]	[0.055]	[0.057]	[0.056]
Lev	-0.123***	-0.157***	-0.141***	-0.152***
	[0.027]	[0.027]	[0.028]	[0.027]
Cap_intens	0.025***	0.025***	0.024***	0.025***
	[0.001]	[0.001]	[0.001]	[0.001]
Lnasset	-0.019***	0.007**	-0.015***	-0.000
	[0.003]	[0.003]	[0.003]	[0.003]
MTB	-0.009***	-0.008***	-0.010***	-0.008***
	[0.001]	[0.001]	[0.002]	[0.001]
Insider	0.088***	0.081***	0.077***	0.084***
	[0.019]	[0.019]	[0.019]	[0.019]
Constant	2.200	1.847	2.143	1.976
	[5.580]	[5.520]	[5.586]	[5.546]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	43,407	43,350	39,883	42,799
R-squared	0.229	0.242	0.228	0.233

Note: This table presents the WLS regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in. Column (1) shows the effect of R&D investment on carbon intensity per sale and column (2) presents the effect of environmental innovation score on carbon intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on carbon intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.

Table 49. WLS Regressions of eco-innovation impacts on waste intensity

	(1)	(2)	(3)	(4)
VARIABLES	Waste_intensity	Waste _intensity	Waste _intensity	Waste _intensity
RD_sale	-0.009			
	[0.048]			
EIS		-5.816***		
		[0.331]		
Process_inno			-0.396***	
			[0.097]	
Product_inno				-1.578***
				[0.120]
ROA	-8.964***	-5.525***	-8.097***	-10.071***
	[1.368]	[1.349]	[1.436]	[1.393]
Lev	-17.702***	-19.339***	-17.815***	-18.765***
	[0.663]	[0.650]	[0.689]	[0.671]
Cap_intens	0.080***	0.086***	-0.010	0.068***
	[0.020]	[0.020]	[0.021]	[0.020]
Lnasset	-0.475***	-0.003	-0.180**	-0.146**
	[0.065]	[0.067]	[0.071]	[0.070]
MTB	-0.074**	-0.074**	-0.102***	-0.072*
	[0.037]	[0.036]	[0.039]	[0.038]
Insider	0.162	0.229	-0.188	-0.011
	[0.441]	[0.432]	[0.457]	[0.445]
Constant	10.265	3.487	9.440	5.950
	[94.152]	[92.120]	[95.284]	[94.255]
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	24,589	24,550	22,413	24,201
R-squared	0.282	0.292	0.285	0.290

Note: This table presents the WLS regression results of eco-innovation impacts on environmental performance dimensions after controlling for industry/year/country effects in. Column (1) shows the effect of R&D investment on waste intensity per sale and column (2) presents the effect of environmental innovation score on waste intensity per sale. Columns (3) and (4) illustrate the effect of process innovation and product innovation on waste intensity per sales, respectively. Robust standard errors in brackets. Standardised beta coefficients are reported at the 1%, 5% and 10% levels of significance with ***, **, * respectively.