# Investment in Green Innovation: How does It Contribute to Environmental and Financial Performance?

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## ABSTRACT

Investment in green innovation has become a vital driver in many industries today. How green innovation contributes to a firm's environmental and financial performance remains uncertain and there is debate about this relationship. Using data gathered from 243 firms between 2013 and 2020, our study aims to provide new evidence on this topic. Our results indicate that green innovation has a clear, positive effect on environmental and financial performance in corporations striving to achieve sustainability and environmental protection. We also find that green innovation mediates the relationship between environmental and financial performances. Based on our findings, we suggest that green innovation is a profitable strategy in the long run with a positive influence on the environmental and financial performances of a firm. Our findings are robust when tested by alternative econometric


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and variable specifications and offer insights to policymakers and business managers.

KEYWORDS: Green Innovation, Environmental Performance, Financial Performance, Green Patents, Green Citations

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Responding to the problem of global climate change caused by greenhouse gas (GHG) emissions is a major challenge for the world (Ma *et al.*, 2021; O'Garra, Fouquet, 2022; Sun *et al.*, 2022). Now is the time to change, reconstruct, and reimagine our global economy in support of a more sustainable and equitable society. By setting our ambitions high and embracing change, it is possible to create a more sustainable low-carbon future that leaves no one behind. Thus, for economies, "going green" has become a critical issue (Du, Li, 2019). Growing concerns about the environment had led academia and policymakers to focus substantial attention on GHG emissions. Green innovation and the development of environmentally-sound technologies has been highlighted as a powerful way of counteracting the environmental harm caused by economic development (Xu *et al.*, 2021). Consequently, management in firms needs to commit to the green process to implement environmental initiatives in response to increased pressure from stakeholders (Yu *et al.*, 2017). We expect green investment to contribute to the firm's performance on two levels, by improving its environmental performance (Rehman *et al.*, 2021), which in turn enhances its financial performance (Yuan *et al.*, 2021).

Green investment is an economic behavior and a complicated management process (Chen, Ma, 2021). In the case of the energy industry, it has become a predominant concern and its rapid growth is primarily driven by China (Eyraud *et al.*, 2013). The literature on green investment reveals that firms are attempting to reach a "win-win" situation with benefits accruing in both their economic outcomes and ecological footprint (Picard, 2012; Stucki, 2019). Previous scholars of green investment have found that firms invest in green technology if this produces profits, and this decision is conditioned by the financial rewards for emission reduction and the investment costs. Yang *et al.* (2019) explain that the difference between the costs of investment and the benefits of emission reduction opens up a significant path for firms to invest in green technology. Stucki (2019) indicates that firms solely invest in green technology if it is profitable, while King and Lenox (2002) affirm that firms are motivated by the financial rewards from environmental protection investment and not the increased worth of a 'greener' organization.

Green investment can signal that firms are enthusiastically embracing their social responsibility, and this can boost their reputation externally, thus contributing to improved economic performance (Tang *et al.*, 2018). Firms are keen to increase the scale of their green investment to avoid paying the penalties associated with not meeting current environmental laws and regulations. Thus, firms actively engage in green investment of their own volition (Maxwell, Decker, 2006). The "pay to be green" strategy seeks to enhance a firm's environmental credentials, but the reality of green investment can vary greatly between firms (Clarkson *et al.*, 2011). Not all firms are able to implement a similarly ambitious green strategy. China, the largest energy consumer and $CO_2$ emitter, has developed various carbon emission reduction policies. Previous studies have concentrated on the general environmental effects of emission reduction policies (Zhang *et al.*, 2017) or on comparing the utility of different policies' utility (Blanco *et al.*, 2020; Du, Li, 2019).

Previous literature affirms that green innovation plays a critical role in improving sustainable performance (Chen, 2008). Schaltenbrand *et al.* (2018) find that the environmental investment decisions of managers are highly influenced by the effect on the firm's financial performance as they attempt to respond to consumer and societal pressure. Qiu *et al.* (2020) demonstrate that the level of investment in green innovation is a key factor in a firm's financial performance. "Innovation compensation" is a key consideration inciting firms to engage in green applications (Porter, Van-der-Linde, 1995). Therefore, firms' green investment behavior needs to take into account the "cost focus" approach (Hassel *et al.*, 2005) as well as the "value creation" approach (Tang *et al.*, 2018; Ülgen, 2019). Scant attention is paid in the literature to how green innovation contributes to environmental and financial performance. Therefore, the question of how a firm's investment in green innovation impacts on its environmental and financial performance requires further exploration. Following on from this exposition, this study seeks to answer the question: Does a firm's good behavior lead to good results? How does green innovation by firms affect their environmental and financial performance? To perform our empirical analysis, we collected panel data on green innovation activities by the most sustainable firms worldwide from 2013 to 2020 and compared these to their environmental and financial performances.

Overall, our study makes several contributions. It contributes to the literature on GHG emissions, (Benkraiem *et al.*, 2022; Kabir *et al.*, 2021), climate change (Boiral *et al.*, 2012), environmental proactivity and green innovation (Chen *et al.*, 2021; Du, Li, 2019; Scarpellini *et al.*, 2019; Xu *et al.*, 2021) and business financial performance (Busch, Hoffmann, 2011; Downar *et al.*, 2021;

Ganda, Milondzo, 2018; Shuwaikh *et al.*, 2022). First, we demonstrate the positive impact of green innovation on financial and environmental performance. We then analyze the mediating role of green innovation in the relationship between environmental performance and financial performance. Research has not been conducted to date on the impact of green innovation on GHG reduction or financial performance in the most sustainable firms worldwide. Our study fills this gap by opening a new avenue of research to explore the effects of firms' green innovation and GHG reduction policies on financial performance. Second, we join previous studies on the impacts of environmental policies on green innovation by firms, in support of the Porter hypothesis (Bu *et al.*, 2020)). We provide a practical reason for firms to actively carry out green innovation activities. Third, our study shows that firms' innovation capabilities need to be rationally designed to improve their GHG-reduction policies. Our study provides a reference for improving GHG reduction policies at the firm level. It has reference value for the impact of green innovation on a firm's financial performance. This conclusion is helpful to overcome the limitations of some literature on the correlation between green innovation and environmental and financial performance and has important policy implications. We argue that green investment should be seen by firms as a long-term strategy.

The rest of this paper is laid out as follows: Section 2 provides a literature review, Section 3 explains the research design, Section 4 presents the empirical results and conclusions, and policy implications are outlined in Section 5.

## Literature Review

### RBV and NRBV Theories: Green Innovation as a Competitive Advantage

Wernerfelt (1984) presents the term "*resource-based*" to describe firms and suggests that a firm is an assembly of resources rather than a set of product-market positions. The work of Wernerfelt (1984) draws inspiration from the concept of Penrose (1959). In a related vein, Rumelt (1984, p. 557-558) suggests that competitive advantage is created by management's handling of the firm's unique resources. Rumelt adds "*a firm's competitive position is defined by a bundle of unique resources and relationships and that the task of general management is to adjust and renew these resources and relationships as time, competition, and change erode their value*." The resource-based view emerges directly from the research of Wernefelt (1984) and Rumelt (1984). Barney (1991) posits that the key idea driving the resource-based approach is that the core of a firm's competitive advantage derives from the tangible and intangible resources and the specific competencies and skills of the firm. Grant (1991) argues that in the presence of environmental uncertainty, certain resources and capabilities of the firm provide a sustainable base for competitive advantage. Wittneben and Kiyar (2009) focus attention on the emergency call to suggest actions and policies that mitigate climate change. Interestingly, these studies are focusing on the different measures of corporate outcome and linking them to GHG emissions (Boiral *et al.*, 2012; Russo, Fouts, 1997). The empirical results of these interactions have been uncertain and even contradictory.

The natural resource-based view (NRBV) provides an appropriate theoretical framework for discussing the contribution of and relationships between resources, capabilities, and performance (Menguc, Ozanne, 2005). When factors such as stakeholder influence, market pressure, and changing environmental laws and regulations are taken into consideration, it can be seen that the resource-based view (RBV) has apparent shortcomings in demonstrating how to enhance business performance through protection of the natural environment. The RBV is criticized for not demonstrating how to marshal resources to deliver a competitive advantage within a dynamic external environment (Hart, 1995). The RBV has disregarded the captivity inflicted by the natural environment, and "*given the growing magnitude of ecological problems, this omission has rendered existing theory inadequate as a basis for identifying important emerging sources of competitive advantage*" (Hart, 1995, p. 987). Although the RBV has important implications for understanding the role of a firm's resources in establishing its competitive advantage, Hart (1995) argues that the theory does not sufficiently consider environmental factors. Therefore, Hart (2005) subsequently expanded the concept of RBV to propose the Natural Resource Based View (NRBV) of the firm. He argues that the relationship of a firm with the natural environment affects its competitive advantage.

Hart (1995) presents three interconnected strategies that firms may use to build sustainable competitive advantage: pollution prevention, product stewardship, and sustainable development. The NRBV recommends that firms take a long-term approach to their use of natural resources and their management of capabilities in order to achieve sustainability and ultimately long-term success (Hart, 2005). Later, Hart and Dowell (2011) reviewed the initial NRBV concept and they confirm, in light of economic, societal, and technological developments, the ongoing relevance of linking sustainable strategies to environmental capabilities and competitiveness at the firm level (Hart, Dowell, 2011). In addition to the RBV and NRBV, extensive research has been conducted on stakeholders. Based on the notion of an interconnected relationship between firms and their stakeholders, Freeman and Reed (1983) were the first authors to formulate the stakeholder theory which argues that firms should create value not only for its shareholders but for all of its stakeholders. Subsequently, scholars started to apply stakeholder theory to a variety of business contexts. In the context of this paper, stakeholder theories focusing on corporate sustainability and corporate social responsibility (CSR) provide a point of reference. Weng *et al.* (2015), for example, examine the relationship between green innovation, environmental, and financial performance through the lens of stakeholder theory. Further germane studies that explore the importance of considering the different stakeholders in decisions on corporate sustainability include the works of Hörisch *et al.* (2014), Schaltegger *et al.* (2019) and Szostak and Boughzala (2021).While traditionally, the RBV view classifies the resources available to firms into physical, human, or organizational capital resources (Barney, 1991), more recent literature is suggesting an expansion of this traditional view, as summarized by Pereira and Bamel (2021).

## Green Innovation and Environmental Performance

Green innovation refers to new technology that conserves energy, minimizes the use of fossil fuels, reduces air pollution, conserves water, or reduces waste (Kraus *et al.*, 2020). Li *et al.* (2020) highlight that global warming is a severe problem facing the entire world. To reduce carbon emissions and pollution, firms are being encouraged by both governments and the general public to invest in innovative environmental technologies. Adegbile *et al.* (2017) demonstrate that a firm's environmental performance is strongly boosted by investment in green innovation. Redesigning products and production methods can improve environmental performance by lowering energy consumption and carbon emissions. Weng *et al.* (2015) find that green processes minimize both waste and costs which enhance a firm's performance on organizational, social and financial levels.

Kabir *et al.* (2021) provide evidence that green initiatives and environmental commitments by companies mitigate the risk of not meeting emission targets, whereas environmental debates deepen the effect. They document that emissions have a significant and negative impact on firms' default risk using a panel dataset of 2785 individual firms from 42 countries over the period 2004-2018. There are two branches in the literature that address the influence of a firm's "good behavior" on financial performance. One branch indicates that green investment hurts financial performance. Green investment may absorb resources that could otherwise be used by firms for standard operations and production which will affect their production and sales and hurt their financial performance. Green technology investment creates advantages for society as a whole but investors must bear the totality of the costs, thus reducing a firm's motivation to invest in new technologies to benefit the public interest.

Most firms invest in green innovation in an effort to comply with environmental regulation, causing firms to incur high private costs and divert resources away from profitable commercial projects (Ambec, Lanoie, 2008). Chen *et al.* (2021) provide evidence of the impact of China's pilot scheme for carbon emission trading on green innovation using data on green patents to examine the "weak" version of the Porter hypothesis. The outcomes indicate that the "weak" Porter hypothesis has not materialized in China's current carbon trading market and that the pilot policy reduced the proportion of green patents. Most significantly, in order to reach their emission reduction targets, companies mainly choose to reduce output rather than increase green technological innovation.

The second branch in the literature indicates that green investment positively impacts financial performance. De Marchi (2022) indicates that incorporating environmental considerations when formulating strategy helps firms to consolidate competitive advantage through the implementation of green innovation. Green investment is also affected by firm characteristics, such as the frequency of audit committee meetings, industry profile, firm size, and foreign ownership. Chen and Ma (2021) analyzed Chinese energy companies between 2008 and 2017 to explore the relationship between green investment and firm performance. They demonstrate that increasing green investment improves financial performance, with a significant and positive correlation between green investment and financial performance. Financial performance improved in the third year after investment in energy conservation and emission reduction. They recommend that firms use environmental investment as a long-term strategy. They find that green investment helps reduce environmental violations and promotes environmental performance which ultimately improves firms' long-term performance.

Cai and Zhou (2014) contribute to our understanding of the primary factors that boost eco-innovation. They investigate that eco-innovation is activated by a mixture of internal and external drivers. Cai and Li (2018) investigate how eco-innovation impact firm performance. To do so, they shed light on the keys, for example, (competitive pressures, environmental, organizational capabilities, and technological capabilities) contributing to eco-innovation's evolution. These instruments give the firms incentives to embrace eco-innovation. Adopting eco-innovation significantly enhances a firm's environmental performance and, as a result, its economic performance.

Consequently, green innovation helps a firm to develop and improve its capacity to exploit its unique resources that determine future financial and environmental performance. By adopting the RBV, we expect green innovation to become a critical element of organizational strategy as firms seek to improve their environmental performance. The following hypothesis is advanced on the link between green innovation and environmental performance:

> *Hypothesis 1: Green innovation positively influences environmental performance.*

## Green Innovation and Financial Performance

There are two primary paths in green innovation: green process innovation and green product innovation (Salvadó *et al.*, 2012). Green innovation includes corporate environmental management and technological advancements that prevent pollution, recycle waste, save energy, and develop green products through creative design (Aguilera-Caracuel, Ortiz-de-Mandojana, 2013). Green innovation has a positive effect on firms' competitive advantage and sustainability, as shown in the previous literature (Chan *et al.*, 2016; Chen *et al.*, 2021; Tian, Wang, 2020). Li *et al.* (2017) indicate that investing in green innovation makes sound business sense for firms. Tian and Wang (2020) indicate that through green innovation processes, firms can become more sustainable and competitive, thus confirming the positive role green innovation plays in their financial performance.

Firms implementing green innovation strategies can gain and maintain different competitive advantages (Albort-Morant *et al.*, 2016; Laperche, Burger-Helmchen, 2019), resulting in higher profitability and better cost efficiency (Chan *et al.*, 2016). Green innovation management is potentially an effective way to enhance customer loyalty, retain customers, grow sales, increase market share, generate cash returns Meng *et al.* (2016) build the firm's reputation, and establish a good public image (Zhu *et al.*, 2014). Ambec and Lanoie (2008) demonstrate that firms can derive profit from going green by 'identifying' and cutting costs in addition to developing advantageous opportunities: "*(a) better access to certain markets, (b) differentiated products, (c) sale of pollution-control technology, (d) risk management and relations with external stakeholders, (e) reduced cost of materials, energy, and services, (f) reduced cost of capital, and (g) reduced labor costs*" (Ambec, Lanoie, 2008, p. 45). Xie *et al.* (2016) find that end-of-pipe and clean technologies, critical elements of green process innovation, are positively related to financial performance. Chiou *et al.* (2011) provide empirical evidence to enable firms to execute green innovation and green supply chains to enhance their environmental performance and improve their competitive advantage. Chiou *et al.* (2011) demonstrate that green innovation contributes significant advantages to the environmental performance and competitive advantage of the firm. Green innovation contributes to business sustainability because it influences the firm's social, environmental, and financial outcomes. Hence, we propose the following hypothesis:

> *Hypothesis 2: Green innovation positively influences financial performance.*

## The Relationship between a Firm's Environmental Performance and Financial Performance

Boiral *et al.* (2012) claim that there are two different ways of investigating the link between corporate performance and carbon emissions. The first takes a win–lose approach, where companies' efforts to reduce their carbon emissions are thought to entail sacrifices harmful to the competitiveness of the business. The second path is the win–win approach, which suggests that reducing carbon emissions gives the firm a sustainable competitive advantage (Stubbs, Cocklin, 2008). Companies are now facing the obligation to reduce their GHG emissions to mitigate climate change and need to understand the associated impact of these emissions on their business activities (Okereke, 2007). Burress (2005) states that the aim of sustainable development is to act in such a way that "the resources left to each generation allow it to achieve a higher general standard of living than its predecessors" Financial performance and corporate emission reduction performance are sensitive to corporate environmental strategies that strive to reduce carbon emissions (Iwata, Okada, 2011). Walley and Whitehead (1994), taking the win–lose approach, claim that when firms endeavor to enhance their environmental performance, they divert management actions and resources away from the core areas of the business, resulting in lower economic and financial benefits to companies. However, White *et al.* (1993) reveal that due to the long lead time required to reduce emissions, earlier studies over various periods for different countries have not been consistent in their outcomes. Among others from the early literature, Hull and Rothenberg (2008) and Klassen and Whybark (1999) conclude that managers cannot make both competitive and environmental enhancements.

In the "win-win" approach, over the last three decades, corporate environmental strategies have been shown to have a positive impact on financial performance (Blanco *et al.*, 2020; Jacobs *et al.*, 2010; Semenova, Hassel, 2008;

You *et al.*, 2019). Al-Tuwaijri *et al.* (2004) find a significant positive relationship between economic performance and environmental performance and propose that economic performance is enhanced by environmental efforts. Semenova and Hassel (2008) indicate that investors may be more motivated to invest in environmentally proactive firms and that customers may accept to pay higher prices which compensate for the higher costs the firm may incur. Therefore, environmentally proactive firms are growing their reputation and accruing benefits that increase firm value over those lagging in environmental efforts. Further, Jacobs *et al.* (2010) claim that convalescent environmental performance can reduce costs, thus resulting in enhanced performance. Gallego-Álvarez *et al.* (2015) show that companies promote more radical environmental behavior to achieve higher financial performance as measured by ROA and ROE. They applied international data from 89 companies between 2006 and 2009 and their results highlight that a reduction in emissions had a positive effect on financial performance. Downar *et al.* (2021) examine the impact of a carbon disclosure mandate for GHG emissions adopted in 2013 on subsequent emission levels and financial operating performance in UK firms. Using a difference-in-differences design, the results indicate that firms subject to the mandate reduced their emissions by about 8% relative to a control group of European firms. Therefore, we predict that environmental performance plays a significant and positive role in financial performance, supporting the "win-win" approach. Mongo *et al.* (2022) demonstrate that in the short-term circular economy approaches raise CO2 emissions, while the result is the contrary in the long term.

> *Hypothesis 3: Environmental performance positively influences financial performance.*

## The Mediating Role of Green Innovation

Green investment is fast becoming an essential measure of competitive advantage for firms. By mastering green innovation technology and related information, this becomes a critical driving force towards sustainable development and ultimately enhances their financial performance. Zhang *et al.* (2020) examine how ready firms are for green innovation regarding technology and environmental dimensions. They find that the necessary and sufficient conditions along each dimension enable and facilitate green innovation, leading to competitive advantage through mediating environmental performance and firm performance. Zhang *et al.* (2021) find that both environmental and social performance mediates the relationship between green innovation and financial performance.

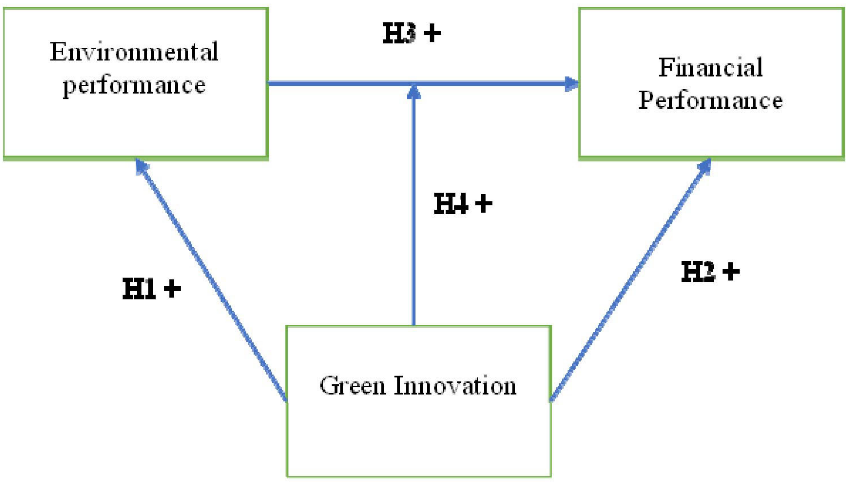
Firms' environmental policies define the type and direction of their green innovation. Therefore, the environmental policy tools chosen to influence the effect green innovation will have on a firm's financial performance. According to Porter's hypothesis, relevant environmental performance can produce innovation that recoups the costs of environmental investment and improves the firm's resource productivity (Porter, Van-der-Linde, 1995). Thus, increased regulatory pressures on environmental standards escalates the propensity of firms to invest in environmental innovation (Berrone *et al.*, 2013) and affects firms' green investment decision-making. Therefore, environmental policies encourage firms to boost green investment that develops environmental protection technology and conserves energy which has a dual benefit for both the environment and the economy. Environmental performance results from initiatives implemented by a firm to respond to societal demands to protect the natural environment (Chan, 2005) in a way that goes beyond mere compliance with the minimum standards imposed by rules and regulations (Chen *et al.*, 2015). Green innovation boosts the environmental performance of a firm in association with an environmental management strategy (Cruz, Paulino, 2015; Kammerer, 2009). Furthermore, process innovation and green products diminish the negative consequences of business operations on the environment and boost social and financial performance through waste and cost reduction (Weng *et al.*, 2015).

Previous studies point out that green innovation should not be perceived as a reactive measure to stakeholder pressures but rather as proactive organizational practices intended to augment environmental performance and gain competitive advantage (Lin *et al.*, 2013, 2021). Eyraud *et al.* (2013) refer to green investment as an investment with the objective of decreasing air pollutants and GHG emissions without significantly decreasing the consumption and production of non-energy goods. Long *et al.* (2017) find that environmental innovation has a significantly more positive impact on environmental performance than on economic performance, demonstrating the benefits of the environmental protection approach in decreasing pollution. Rehman *et al.* (2021), having tested a sample of 244 large manufacturing firms, argue that green innovation mediates the relationship between green intellectual capital and environmental performance. They suggest that environmental strategies are directly related to environmental performance and moderate the relationship between green innovation and environmental performance.

Adopting the NRBV, we expect green innovation to be a critical organizational practice by which firms gain goodwill among key stakeholders and enhance their environmental performance. Our earlier discussion on the association between green innovation and environmental and financial performance suggests that green innovation influences environmental performance and leads to improving financial performance. In summary, the following hypothesis is proposed:

> *Hypothesis 4: Green innovation mediates significantly between environmental performance and financial performance.*

***Figure 1*** **– Research Framework (Green Innovation, Environmental and Financial Performance)**




## Methodology

The GHG emission data used in this study were taken from the most sustainable corporations in the world's Global 100 Corporate Knights[1] rating report, an annual ranking of corporate sustainability performance. The green innovation set used in this empirical analysis consisted of patents and citations relating to climate change. Patent data were obtained from the European Patent Office (EPO) PATSTAT database. The methodology used to match the firms from the sample with the firms in PATSTAT was based on the description by Tarasconi and Menon (2017). For the citation count, citations were tallied by filing year for each patent. To avoid double counting

1. Corporate Knights (CK) is a media, research and financial information products company based in Toronto, Canada, that promotes an economic system where prices fully incorporate social, economic and ecological costs and benefits, and market participants are clearly aware of the consequences of their actions. https://www.corporateknights.com

of inventions across different patent offices, patent family citations were applied. Furthermore, the green International Patent Classification (IPC) has been developed within the EC tender "Measurement and analysis of knowledge and R&D exploitation flows, assessed by patent and licensing data". For the reclassification, IPC and Cooperative Patent Classification (CPC), patent codes, retrieved from PATSTAT, were used. Financial and accounting data were collected from Standard and Poor's Compustat database. The target period between 2013 and 2020 was chosen because GHG emissions data for firms were only available from Corporate Knights starting in 2013. The final sample consisted of 243 firms with 800 observations through 8 years. Each year we have 100 observations for 100 companies. Some companies continue for more one year in the top 100 ranking and some are out of the list for one or more years and then back to the list or not listed again as 100 most sustainable companies. For that we don't see 800 companies for the 8 years. The Global 100 list is changing yearly and dominated by companies from North America and Europe. On an individual country basis, the U.S., with 54 companies, and Canada, with 27, Europe (96) Asia Pacific region hosts 34 of the index's members, UK (28) while Latin America (2), Africa (1) and the Middle East (1) continue to lag. According to the Global Industry Classification Standard, the sample consists of the following: Financials (120), Health care (112), Energy (19), software (89), Materials (56), Industrials (79), Consumer Services (58), Information technology (76), Communication services (63), Utilities (92) and Real state (36).

**Dependent Variables**

We used ROA, ROE, and Tobin's Q as measures to reflect financial performance. ROA and ROE are used as short-term measures, with ROA indicating the return on investment with respect to the total assets of a firm and ROE with respect to equity. Tobin's Q, a measure of intangible value that reflects both short-term and long-term financial performance, is the ratio of a firm's market value to the replacement costs of its tangible assets. Tobin's Q is a market-based measure that is preferred over other accounting-based proxies. According to Chung and Pruitt (1994), Tobin's Q is measured as market value equity (MVE), plus preferred stock value (PS), plus debt value (DEBT) over total assets (AT).

**Independent Variables**

Environmental performance (*EnvPer*) was assessed using carbon emissions following the GHG protocol (Bhatia *et al.*, 2004) for Scope 1 and Scope 2 carbon emissions. Two different measures were used to assess environmental performance: the natural logarithm of GHG emissions (*ln*GHG) and GHG emissions per unit of revenue, that is, GHG emissions intensity (*GHGrev*).

Emission intensity with GHG emissions in the numerator was used as the results were more comparable to *ln*GHG, unlike emissions productivity. The ratio of GHG emissions to revenue is commonly used to assess environmental performance (Busch, Hoffmann, 2011).

Green Innovation (GRInnov) was assessed through patents and citations. Green patents are the key output of the green innovation process and an important manifestation of innovation results (Zhao *et al.*, 2022). We use the number of granted patents in environment-related technologies to measure green innovation and green citations as a measurement index of the quality of the green technological innovation (Zhao *et al.*, 2022). Green patents and citations reflect the attention given by firms to green, sustainable behavior and development (Yuan *et al.*, 2021). Our first proxy that captures the quantity of innovation output is the natural logarithm of one plus the patent count for company (i) at year (t), ln (1+Green_$Patents_{i,t}$), denoted ln ($GRPatents_{i,t}$). The variable ln ($GRPatents_{i,t)}$ includes the number of patent applications filed in the granting year (Zhang *et al.*, 2019). We build the second proxy, which indicates the patent quality (Shuwaikh, Dubocage, 2022) by including one plus the number of citations collected by each patent ln (1+$Green\_Citations_{i,t}$) denoted ln ($GRCitations_{i,t}$).

**Control Variables**

In line with previous studies, we include several control variables that could have affected the main variables. Financial leverage (*Leverage*) is the ratio of total debt to total assets. Firm size (*Size*) is calculated as the natural logarithm of the firms' total assets. Capital intensity (*CapIntensity*) measures the ratio of capital expenditure to total assets. Revenue growth (*Growth*) depicts the year-on-year growth in revenue. Innovation capacity (*InnovCap*) measures R&D expenses/revenue – three years trailing. In the first step, each company's innovation capacity score is determined by measuring the ratio of research and development (R&D) expenditure to total revenue averaged over a trailing three-year period. In the second step, each company's innovation capacity score was percent-ranked against all of the same Corporate Knights (CK) - CK industry group peers within the CK coverage universe. *Cash* was calculated as cash and cash equivalents held of total assets.

**Estimation Approach**

To estimate the empirical models and test the hypotheses, ordinary least squares (OLS) regressions were used as the baseline method while controlling for industry (based on SIC codes), year and country effects, in addition to applying fixed-effect models. The decision to use fixed-effect rather than random-effect models was justified by a Hausman test (Hausman, 1978).

Equation (1) analyzes the effect of green innovation on the environmental performance of top sustainable firms (H1):

where $GRInnov_{i,t}$ is introduced as a new variable of interest, measuring green innovation in terms of quantity (*GRPatents*) and quality (*GRCitations*). The control variables are leverage (*Leverage*), firm size (*Size*), capital intensity (*CapIntensity*), revenue growth (*Growth*), innovation capacity (*InnovCap*), and cash and cash equivalents over total assets (*Cash*). $Z_i$ is a set of a dummy variables controlling for industry, year, and country effects.

In order to address the effect of carbon emissions on a firm's financial performance (H1), equation (1) contains the following parameters:

$$FinPer_{i,t} = \alpha + \beta_1 EnvPer_{i,t} + \beta_2 Leverage_{i,t} + \beta_3 Size_{i,t} + \beta_4 CapIntensity_{i,t} + \beta_5 Growth_{i,t} + \beta_6 InnovCap_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Z_i + \varepsilon_{i,t} \quad (1)$$

where $FinPer_{i,t}$ represents firm i's financial performance, measured as either ROA or Tobin's Q. The independent variable $EnvPer_{i,t}$ measures the environmental performance of the firm, based on its carbon emissions. The control variables are leverage (*Leverage*), firm size (*Size*), capital intensity (*CapIntensity*), revenue growth (*Growth*), innovation capacity (*InnovCap*), and cash and cash equivalents over total assets (*Cash*).  is a set of a dummy variables controlling for industry, year and country effects.

Equation (2) analyzes the effect of green innovation on the financial performance of top sustainable firms (H2):

$$FinPer_{i,t} = \alpha + \beta_1 GRInnov_{i,t} + \beta_2 Leverage_{i,t} + \beta_3 Size_{i,t} + \beta_4 CapIntensity_{i,t} + \beta_5 Growth_{i,t} + \beta_6 InnovCap_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Z_i + \varepsilon_{i,t} \quad (2)$$

where $GRInnov_{i,t}$ is introduced as a new variable of interest, measuring green innovation in terms of quantity (*GRPatents*) and quality (*GRCitations*). All control variables remain the same as in Equation (1).

To address the effect of carbon emissions on a firm's financial performance (H3), Equation (3) contains the following parameters:

Equation (3) aims to analyze the effect of green innovation on the environmental performance of top sustainable firms (H3):

Where $FinPer_{i,t}$ represents firm i's financial performance, measured as ROA, ROE, or Tobin's Q. The independent variable $EnvPer_{i,t}$ measures the environmental performance of a firm, based on its carbon emissions. All control variables remain the same as in Equation (1).

$$EnvPer_{i,t} = \alpha + \beta_1 GRInnov_{i,t} + \beta_2 Leverage_{i,t} + \beta_3 Size_{i,t} + \beta_4 CapIntensity_{i,t} + \beta_5 Growth_{i,t}\ \beta_6 InnovCap_{i,t} + \beta_7 Cash_{i,t} + \beta_8 Z_i + \varepsilon_{i,t} \quad (3)$$

where $GRInnov_{i,t}$ is introduced as a new variable of interest, measuring green innovation in terms of quantity (*GRPatents*) as well as quality (*GRCitations*). All control variables remain the same as in equation (1).

Lastly, equations (4.1) and (4.2) consider the mediating effect of green innovation on environmental and financial performance (H4).

First, the variables for environmental performance and green innovation from equations (1) and (2) were applied simultaneously to analyze the effect of adding one of these variables to either model, either by adding a variable measuring *GRInnov* to equation (1) or by adding a variable measuring *EnvPer* to equation (2):

$$FinPer_{i,t} = \alpha + \beta_1 EnvPer_{i,t} + \beta_2 GRInnov_{i,t} + \beta_3 Leverage_{i,t} + \beta_4 Size_{i,t} + \beta_5 CapIntensity_{i,t} + \beta_6 GrowthH_{i,t} + \beta_7 InnovCap_{i,t} + \beta_8 Cash_{i,t} + \beta_9 Z_i + \varepsilon\iota_{,t} \quad (4.1)$$

Second, the joint effect of firms' environmental performance and green innovation on their financial performance (H4) was addressed by adding an interaction variable to Equation (4.1). This interaction variable is denoted *EnvPer*GRInnov*, where *EnvPer* and *GRInnov* may stand for either of the previously introduced variables for environmental performance and green innovation:

$$FinPer_{i,t} = \alpha + \beta_1 EnvPer_{i,t} + \beta_2 GRInnov_{i,t} + \beta_3 (EnvPer * GRInnov)_{i,t} + \beta_4 Leverage_{i,t} + \beta_5 Size_{i,t} + \beta_6 CapIntensity_{i,t} + \beta_7 Growth_{i,t} + \beta_8 InnovCap_{i,t} + \beta_9 Cash_{i,t} + \beta_{10} Z_i + \varepsilon_{i,t} \quad (4.2)$$

## Results and Discussion

Table 1 summarizes the statistics of the underlying research sample. The 243 firms included in the sample had an average (st. dev.) ROA of 0.05 (430.58). The average value for Tobin's Q as an additional financial performance measure was 1.01 (1.59). Considering the environmental performance measures, prior to inversing the values, the mean (median) natural logarithm of GHG emissions and the average (st. dev.) GHG emissions productivity were observed at -0.50 (2.45) and 10.64 (2.05), respectively. The measures of green innovation – green patent count and green citation count – showed average (st. dev.) values of 120.53 (430.58) and 92.52 (329.63), respectively. The financial leverage of the sample companies, measured by the ratio of total debt to total assets, was found to be an average (st. dev.) of 0.201 (0.26). The average values for firm size, capital intensity, revenue growth, innovation capacity, and cash corresponded to 10.70 (2.035), 0.951 (11.093), 0.043 (0.162), 0.05 (0.07), and 2.294 (26.06), respectively.

Table 2 demonstrates that Tobin's Q has positive correlations with ROA, ROE, capital intensity, size, and cash. However, ROA was negatively associated with leverage, with a correlation of -0.16. The third financial performance measure, Tobin's Q, was negatively related to ln GHG with a correlation of 0.22. Environmental performance (lnGHG) is positively related to green patents and green citations, while it is negatively linked to leverage, capital intensity, and cash. Furthermore, GHG productivity has a positive correlation of 0.11 with size. Green patent and green citations are both positively correlated with size at 0.29.

***Table 1*** **– Summary statistics**

| **Variable** | **Observations** | **Mean** | **Std. Dev.** | **Min** | **Max** |
|---|---|---|---|---|---|
| Tobin's Q | 800 | 1.006942 | 1.590407 | -5.41784 | 13.18823 |
| ROA | 800 | 0.05 | 0.06 | -0.23 | 0.37 |
| ROE | 800 | 0.083465 | 1.033623 | -22.5295 | 4.482467 |
| GHG emissions | 800 | -0.505787 | 2.450374 | -6.861075 | 11.56653 |
| GHG rev | 800 | 10.64445 | 2.050021 | -1.137483 | 18.53295 |
| Green Patents | 800 | 120.5343 | 430.5887 | 1 | 4301 |
| Green Citations | 800 | 92.52714 | 329.6326 | 0 | 3195 |
| Leverage | 800 | 0.201363 | 0.26181 | 0 | 4.407821 |
| Size | 800 | 10.70488 | 2.03591 | 5.187386 | 17.53446 |
| Capital Intensity | 800 | 0.951265 | 11.09329 | 0 | 202.1341 |
| Growth | 800 | 0.043397 | 0.162734 | -0.79199 | 0.889271 |
| Innovation Capacity | 800 | 0.054 | 0.07042 | 0 | 0.4273 |
| Cash | 800 | 2.29431 | 26.06245 | 0 | 404.6034 |

This table shows the summary statistics for all dependent, independent, and control variables used in the different models.

Table 3 presents the results of the estimation of equation (1). The results demonstrate that environmental performance has a significant positive effect on corporate investors' financial performance. This means that the better a firm's environmental performance through lower GHG emissions, the higher its financial performance, on average, in the sample. Considering lnGHG as a measure of GHG emissions, the strongest positive relationship is found with respect to Tobin's Q, with an increase in environmental performance of one unit resulting in an increase of 10.3 percentage points (pp) in Tobin's Q, on average. This result is statistically significant at the 5% level. This confirms the results of Busch and Hoffmann (2011) who find that carbon emissions negatively affect Tobin's Q as a measure of both

*Table 2* – Correlation matrix

| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** | **(8)** | **(9)** | **(10)** | **(11)** | **(12)** | **(13)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1)Tobin's Q | 1.00 | | | | | | | | | | | | |
| (2)ROA | 0.21*** | 1.00 | | | | | | | | | | | |
| (3)ROE | 0.21*** | 0.58*** | 1.00 | | | | | | | | | | |
| (4)Ln GHG | -0.22*** | 0.02 | -0.07 | 1.00 | | | | | | | | | |
| (5)GHG rev | 0.08 | -0.03 | 0.05 | -0.71*** | 1.00 | | | | | | | | |
| (6)Green Patents | -0.07 | -0.03 | -0.03 | -0.27*** | 0.02 | 1.00 | | | | | | | |
| (7)Green citations | -0.08 | -0.03 | -0.03 | -0.28*** | 0.01 | 1.00*** | 1.00 | | | | | | |
| (8)Leverage | 0.57*** | -0.16** | -0.04 | -0.07 | 0.02 | -0.01 | -0.00 | 1.00 | | | | | |
| (9)Size | 0.44*** | 0.15** | 0.03 | 0.41*** | 0.11* | 0.29*** | 0.29*** | 0.28*** | 1.00 | | | | |
| (10)Capital Intensity | 0.61*** | -0.07 | -0.05 | -0.05 | 0.08 | -0.03 | -0.03 | 0.92*** | 0.39*** | 1.00 | | | |
| (11)Growth | 0.07 | 0.12* | 0.02 | -0.01 | 0.09 | -0.02 | -0.02 | 0.03 | 0.12* | 0.04 | 1.00 | | |
| (12) Innovation | 0.07 | 0.11* | -0.07 | 0.04 | 0.04 | 0.06 | 0.07 | -0.10 | 0.21*** | -0.07 | 0.13* | 1.00 | |
| (13)Cash | 0.64*** | -0.07 | -0.05 | -0.05 | 0.08 | -0.03 | -0.03 | 0.90*** | 0.41*** | 0.99*** | 0.05 | -0.07 | 1.00 |

short- and long-term financial performance. Similarly, a negative effect of GHG emissions on ROA and ROE is detected. Regarding GHGpro, a positive and statistically significant relationship is observed for all three measures of financial performance, with ROA and Tobin's Q being significant at the 5% level and ROE at 10%. Our results are in line with previous empirical findings that mainly uphold a positive relationship between financial and environmental performance (H1) (Benkraiem *et al.*, 2022; Ganda, Milondzo, 2018). Orlitzky *et al.* (2003) present extensive reviews at the firm level on the link between financial and environmental performance. Additional noteworthy relationships are observed among the control variables. First, a strong negative association existed between leverage and ROA, demonstrating that higher leverage and therefore higher financial risk on average imply a lower financial performance for the firms. Second, larger firms in terms of revenue seem to have a higher ROA. We find, in our sample, that innovation capacity has a strong positive effect on Tobin's Q, thus on both short- and long-term performance. This result was expected, as investment in R&D usually has a long-term payoff. In a previous study, Lee and Min (2015) find a similar positive relationship between green R&D and Tobin's Q. Z. Tang *et al.* (2012) show superior performance due to profitable pollution-prevention opportunities. Hart (1997) argue that spontaneous attempts to enhance environmental performance usually yield financial interest.

Table 4 summarizes the results of equation (2). The effects of both the quantity (*GRPatents*) and the quality (*GRCitations*) of green patents on firms' financial performance were separately assessed. For both measures, similar results were obtained. In our sample, increased green innovation lead to better financial performance on average as measured by Tobin's Q, ROA, and ROE. The effects on Tobin's Q are positive and statistically significant at the 5% level and ROA and ROE at the 1% level, suggesting that green innovation pays off for firms. Consequently, the positive relationship between green innovation and financial performance (H2), as previously shown by Aguilera-Caracuel and Ortiz-de-Mandojana (2013) and Scarpellini *et al.* (2019), is confirmed by the findings of this study, as both the short- and long-term financial performance of firms seem to benefit from green innovation. Considering ROE, however, no significant results were observed. Lee and Min (2015) find a positive effect of green R&D on Tobin's Q in a sample of Japanese manufacturing firms. However, the authors used green R&D expenditures instead of green patents to measure green innovation. Furthermore, our results suggest that this effect decreases with leverage and firm size, as depicted by the negative and significant coefficients for leverage and size.

Table 5 summarizes the results of Equation (3). The effects of both the quantity (*GRPatents*) and the quality (*GRCitations*) of green patents on firms' environmental performance were separately assessed. Increased green innovation, on average, leads to better environmental performance. The effects on *lnGHG* are positive and statistically significant at the 5% level, suggesting that green innovation pays off for firms. Some firms may acceptE different levels of responsibility in applying environmental practices to decrease their carbon emissions. Delivering green innovation to enhance environmental performance requires a certain level of investment in environmental R&D which will affect financial performance. Consequently, we find a positive relationship between green innovation and environmental performance (H3), which is in line with Arora and Cason (1996), who show a positive link between environmental management systems and R&D expenditures. In the same vein, González-Benito (2005) finds a positive relationship between operational performance and environmental investment. Kraus *et al.* (2020) find that corporate social responsibility is positively correlated to green innovation and environmental strategy, enhancing environmental performance. Du and Lin (2017) explain that carbon emission reduction innovation is conducive to carbon emission reduction and has a synergistic effect on carbon emission performance.

**Table 3 – Environmental and Financial Performance**

| | Panel A: lnGHG | | | Panel B: GHG rev | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | Tobin's Q | ROA | ROE | Tobin's Q | ROA | ROE |
| EnvPer | -0.103** | -0.00267* | -0.0568* | 0.0343** | 0.001** | 0.0005* |
| | (0.0325) | (0.00233) | (0.0883) | (0.0149) | (0.0231) | (0.0162) |
| Leverage | 0.786 | -0.162*** | -0.451 | 0.931 | -0.114*** | -0.338 |
| | (0.506) | (0.0355) | (1.343) | (0.568) | (0.0263) | (0.615) |
| Size | 0.732*** | 0.00896** | 0.143 | 0.168*** | 0.00491** | 0.00593 |
| | (0.0397) | (0.00291) | (0.110) | (0.0401) | (0.00188) | (0.0439) |
| CapIntensity | -4.565* | 0.242 | -1.133 | -0.116*** | 0.00358* | 0.00937 |
| | (2.254) | (0.166) | (6.281) | (0.0343) | (0.00161) | (0.0375) |
| Growth | -0.217 | 0.0370* | -0.577 | 0.285 | 0.0464* | -0.325 |
| | (0.222) | (0.0159) | (0.603) | (0.434) | (0.0199) | (0.466) |
| InnovCapacity | 3.869** | -0.292** | 3.355 | 1.567 | 0.0144 | -1.373 |
| | (1.310) | (0.0940) | (3.556) | (0.966) | (0.0446) | (1.041) |
| Cash | 5.305*** | 0.00748 | -1.159 | 0.0746*** | -0.000832 | -0.00145 |
| | (0.888) | (0.0621) | (2.349) | (0.0143) | (0.000672) | (0.0157) |
| Constant | -7.856*** | -0.0165*** | -1.060*** | -1.071*** | 0.0193*** | 0.120*** |
| | (0.608) | (0.0446) | (1.688) | (0.451) | (0.0211) | (0.494) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.8304 | 0.5969 | 0.1836 | 0.4586 | 0.1020 | 0.012 |

This table examines the effect of firms' environmental performance on their financial performance. The models are estimated using ordinary least squares (OLS). Panel A; Models (1)-(3) use the variable lnGHG as a measure of environmental performance. Panel B; Models (1)-(3) are based on GHGpro. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively

***Table 4*** **– Green Innovation and Financial Performance**

| | *Panel A: GRPatents* | | | *Panel B: GRCitations* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| GRInnov | 0.0244** | 0.00138* | 0.00930* | 0.0250*** | 0.00123** | 0.00481* |
| | (0.0139) | (0.00146) | (0.0333) | (0.0110) | (0.00116) | (0.0264) |
| Leverage | -0.404** | -0.144*** | -0.253 | -0.378** | -0.143*** | -0.255 |
| | (0.248) | (0.0260) | (0.594) | (0.248) | (0.0261) | (0.595) |
| Size | -0.863*** | -0.00651*** | -0.0232 | 0.863*** | -0.00649*** | -0.0222 |
| | (0.0151) | (0.00159) | (0.0362) | (0.0150) | (0.00158) | (0.0360) |
| CapIntensity | -0.0838*** | 0.00404* | 0.00729 | -0.0845*** | 0.00401* | 0.00735 |
| | (0.0155) | (0.00163) | (0.0372) | (0.0155) | (0.00163) | (0.0372) |
| Growth | 0.438* | 0.0338 | -0.323 | 0.438* | 0.0337 | -0.326 |
| | (0.180) | (0.0189) | (0.432) | (0.180) | (0.0189) | (0.432) |
| InnovCapacity | 2.820*** | 0.00186** | -1.026 | 2.714*** | 0.00185** | -1.009 |
| | (0.422) | (0.0443) | (1.011) | (0.427) | (0.0449) | (1.025) |
| Cash | 0.0782*** | -0.000722 | -0.00146 | 0.0783*** | -0.000717 | -0.00145 |
| | (0.00642) | (0.000673) | (0.0154) | (0.00640) | (0.000673) | (0.0154) |
| Constant | 2.104*** | 0.142*** | 0.399*** | 2.088*** | 0.142*** | 0.392*** |
| | (0.178) | (0.0186) | (0.426) | (0.177) | (0.0186) | (0.425) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.5481 | 0.1188 | 0.1013 | 0.7675 | 0.1191 | 0.013 |

This table examines the effect of firms' green innovation on their financial performance. Panel A; Models (1)-(3) use green patent count as a measure of green innovation. Panel B; Models (1)-(3) are based on green patent citations. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

*Table 5* – **Green Innovation and Environmental Performance**

| | **Model (1)** | **Model (2)** |
|---|---|---|
| | **EnvPer** | **EnvPer** |
| GRPatents | 0.265*** | |
| | (0.0543) | |
| GRCitations | | 0.252*** |
| | | (0.0428) |
| Leverage | 0.488 | 0.722 |
| | (0.969) | (0.958) |
| Size | 0.543*** | 0.541*** |
| | (0.0589) | (0.0578) |
| CapIntensity | -0.0213 | -0.0276 |
| | (0.0600) | (0.0591) |
| Growth | -0.458 | -0.425 |
| | (0.726) | (0.715) |
| Innovation Capacity | -1.475 | -2.413 |
| | (1.681) | (1.682) |
| Cash | 0.0106 | 0.0116 |
| | (0.0247) | (0.0244) |
| Constant | -6.840*** | -6.998*** |
| | (0.692) | (0.681) |
| Year | Yes | Yes |
| Country | Yes | Yes |
| Industry | Yes | Yes |
| Observations | 800 | 800 |
| R-squared | 0.2660 | 0.2869 |

This table examines the effect of firms' green innovation on environmental performance. Models (1)-(2) are all based on lnGHG as a measure of environmental performance. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

We now examine the combined effects of environmental performance and green innovation on financial performance. Our results show a positive effect of both environmental performance (H1) and green innovation (H2) on financial performance. Table 6 shows the effects of adding variables measuring both environmental performance and green innovation to the models. In Table 6, lnGHG is used as a measure of environmental performance. For green innovation, two variables were used to capture green innovation quantity (*GRPatents*) and quality (*GRCitations*). The results suggest a positive and highly significant relationship between green innovation and Tobin's Q at the 1% level and a positive significant effect between the environmental performance measure and Tobin's Q at the 5% level. Lastly, both environmental performance and green innovation seem to have a positive and statistically significant effect on Tobin's Q as a financial performance measure. This is clear evidence in support of H4, showing that both independent variables positively affect the financial performance of firms. Furthermore, these results did not differ between the two measures for green innovation, as demonstrated by the results in Table 5. By adding both environmental performance and green innovation to the empirical model, the results combine and confirm the findings of previous studies from both fields (Chen *et al.*, 2021; Xu *et al.*, 2021), suggesting that both environmental performance and green innovation have positive effects on the financial performance of firms.

In addition to the previously discussed findings supporting H4, Table 7 provides another result that strengthens the understanding of the nature of the impact environmental performance and green innovation have on financial performance. We added the interaction between environmental performance and green innovation to the model, denoted *EnvPer*Innov*. The results show that the interaction between environmental performance and green innovation has a positive and strongly significant impact on firms' financial performance, as measured by Tobin's Q. Considering these factors in isolation in the model, an additional positive effect is found for green innovation, whereas the isolated effect of environmental performance is found to be negative. The analysis also reveals a positive effect of the interaction term on firms' ROA, and again a negative effect for the environmental performance measure when taken in isolation.

We conducted a series of robustness tests and supplementary analyses to challenge our findings. First, we replicated all four previously analyzed hypotheses with lagged performance variables. In the first step, the effect of lagged environmental performance on financial performance was examined. Next, the green innovation variables were lagged to investigate their effects on firms' environmental and financial performance. Lastly, these lagged variables were combined in an interaction term. As the effect of a firm's environmental performance on its financial performance might be reflected with a delay, it was of interest to evaluate the impact of previous years' environmental performance on current financial performance. Appendix B shows the results for the one-year and two-year lagged environmental performance variables. The results clearly demonstrate the relationship between one-year and two-year lagged environmental performance and financial performance. For *lnGHG*, a negative and significant effect exists between one-year lagged environmental performance and the short-term financial performance measure, ROE. For the two-year lagged variable, a negative and significant relationship is found with Tobin's Q as a long-term measure.

*Table 6* – **Environmental and Financial Performance**

| | Panel A: GRPatents | | | Panel B: GRCitations | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| EnvPer | -0.00363* | -0.0360 | -0.0170 | -0.00354* | -0.0170 | -0.0416 |
| | (0.00143) | (0.0286) | (0.0336) | (0.00145) | (0.0341) | (0.0290) |
| GRInnov | 0.00486*** | 0.0548*** | 0.0183 | 0.00551*** | 0.0125*** | 0.0523* |
| | (0.00150) | (0.0297) | (0.0351) | (0.00121) | (0.0285) | (0.0242) |
| Leverage | -0.132*** | 0.0628 | -0.343 | -0.131*** | -0.339 | 0.118 |
| | (0.0259) | (0.520) | (0.606) | (0.0259) | (0.609) | (0.521) |
| Size | -0.00886*** | -0.271*** | -0.0125 | -0.00884*** | -0.0114 | -0.268*** |
| | (0.00175) | (0.0346) | (0.0411) | (0.00175) | (0.0411) | (0.0345) |
| CapIntensity | 0.00381* | -0.102** | 0.00939 | 0.00379* | 0.00929 | -0.104** |
| | (0.00160) | (0.0316) | (0.0375) | (0.00160) | (0.0376) | (0.0316) |
| Growth | 0.0435* | 0.388 | -0.298 | 0.0436* | -0.301 | 0.388 |
| | (0.0194) | (0.391) | (0.454) | (0.0194) | (0.454) | (0.390) |
| InnoCapacity | 0.0312 | 2.051* | -1.537 | 0.0284 | -1.538 | 1.855* |
| | (0.0449) | (0.903) | (1.053) | (0.0457) | (1.071) | (0.918) |
| Cash | -0.000758 | 0.0768*** | -0.00148 | -0.000755 | -0.00145 | 0.0771*** |
| | (0.000660) | (0.0130) | (0.0155) | (0.000660) | (0.0155) | (0.0130) |
| Constant | 0.168*** | 3.598*** | 0.295 | 0.167*** | 0.282 | 3.526*** |
| | (0.0209) | (0.414) | (0.490) | (0.0211) | (0.494) | (0.416) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.55 | 0.1047 | 0.0102 | 0.5498 | 0.1390 | 0.012 |

This table examines the effect of firms' environmental performance and green innovation on their financial performance. All models are based on lnGHG as a measure of environmental performance Panel A; Models (1)-(3) use green patent count as a measure of green innovation. Panel B; Models (1)-(3) are based on green patent citations. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

***Table 7*** **– Interaction between Environmental Performance and Green Innovation**

| | *Panel A: lnGHG*GRPatents* | | | *Panel B: lnGHG*GRCitations* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| EnvPer | -0.150*** | 0.00196 | -0.0311 | -0.126*** | 0.00244 | -0.0342 |
| | (0.0329) | (0.00169) | (0.0399) | (0.0349) | (0.00181) | (0.0427) |
| GRInnov | 0.0140 | -0.000196 | 0.0153 | 0.0266 | -0.0000749 | 0.00982 |
| | (0.0293) | (0.00152) | (0.0359) | (0.0235) | (0.00123) | (0.0290) |
| GRInnov*EnvPer | 0.0477*** | 0.00208*** | 0.00175 | 0.0425*** | 0.00157*** | 0.00239 |
| | (0.0105) | (0.000544) | (0.0128) | (0.00814) | (0.000427) | (0.0101) |
| Leverage | 1.333** | -0.102*** | -0.319 | 1.377** | -0.103*** | -0.319 |
| | (0.508) | (0.0261) | (0.618) | (0.504) | (0.0262) | (0.619) |
| Size | 0.392*** | 0.00882*** | 0.0181 | 0.392*** | 0.00857*** | 0.0178 |
| | (0.0430) | (0.00223) | (0.0528) | (0.0424) | (0.00223) | (0.0526) |
| CapIntensity | -0.106*** | 0.00365* | 0.00998 | -0.107*** | 0.00365* | 0.00994 |
| | (0.0306) | (0.00160) | (0.0377) | (0.0303) | (0.00160) | (0.0377) |
| Growth | -0.0828 | 0.0346 | -0.318 | -0.0340 | 0.0359 | -0.324 |
| | (0.381) | (0.0194) | (0.459) | (0.377) | (0.0195) | (0.459) |
| InnovCapacity | 0.471 | -0.00155 | -1.568 | 0.184 | -0.00239 | -1.557 |
| | (0.899) | (0.0460) | (1.087) | (0.905) | (0.0468) | (1.105) |
| Cash | 0.0598*** | -0.00107 | -0.00230 | 0.0599*** | -0.00105 | -0.00228 |
| | (0.0129) | (0.000672) | (0.0159) | (0.0127) | (0.000673) | (0.0159) |
| Constant | -3.544*** | -0.0227 | -0.0406 | -3.572*** | -0.0199 | -0.0391 |
| | (0.470) | (0.0244) | (0.576) | (0.463) | (0.0243) | (0.573) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |

| | *Panel A: lnGHG*GRPatents* | | | *Panel B: lnGHG*GRCitations* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| R-squared | 0.5750 | 0.1413 | 0.0104 | 0.5839 | 0.1382 | 0.0151 |

This table examines the effect of firms' environmental performance and green innovation on their financial performance. All models are based on lnGHG as a measure of environmental performance. Panel A; Models (1)-(3) use green patent count as a measure of green innovation. Panel B; Models (1)-(3) are based on green patent citations. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectivel

The lagged effect of green innovation on financial performance was of interest as new innovation by a firm might only be reflected in financial performance with a time lag. We replicated the results of environmental performance and green innovation, lagged by both one and two periods (Appendix C and D). We then replicated the interactions between environmental performance and green innovation with one-period and two-period time lag effects on firms' financial performance. The results show a positive and highly significant (1%) effect of the interaction variable *EnvPer*Innov* on Tobin's Q (Appendix E).

## Conclusion

"Going green" is a critical issue in current business practices as the world strives to achieve sustainable development. This study examines the influence of green innovation on a firm's performance. The results indicate that green innovation is significantly and positively correlated with environmental and financial performances. We also find that green innovation has a clear positive impact on GHG emission performance in sustainable corporations acting for environmental protection. We also find that green innovation mediates the relationship between environmental and financial performance. As the effect of reducing GHG emissions may only be reflected in a firm's financial performance after a certain time delay, lagged environmental performance measures were introduced. It appears that a similar relationship between environmental and financial performance exists for both one-year and two-year lagged variables. Therefore, firms should consider emission reduction as part of their overall corporate strategy to increase profitability. We also evaluate the impact of green innovation on firms' financial performance. The results show that, on average, firms with more green innovation, in terms of both quantity (patent count) and quality (patent citations), have better environmental and financial performances. When we combine both of the previous analyses by investigating the joint effect of environmental performance and green innovation on financial performance, we reveal that the interplay of the two independent variables positively affects firm financial performance in the sample.

Our study offers several key suggestions to policy makers and managers to encourage them to implement green innovation so as to improve environmental and financial performance. Our results suggest that investing in green innovation is beneficial for firms to boost their image with stakeholders who are demanding that firms become increasingly environmentally proactive in all their activities. The managerial implications of our study's findings indicate that committing to environmental business practices, such as green innovation practices, may assist companies in gaining a competitive advantage and improving their environmental and financial performance. The adoption and implementation of such activities are driven by market demand for green activities, corporate environmental ethical practices, and stakeholder pressure. The successful execution of environmental practices helps overcome the technological challenges of green innovation, achieves a proper balance between environmental and financial performance, and gains competitive advantage. Our study has several implications for decision makers and managers as it confirms the importance of green innovation and the influence of successful implementation on financial performance. Acknowledging the need for a green innovation strategy will help decision makers to devise strategies and policies that advance green innovation and overcome technological challenges. Moreover, managers can use this knowledge and the firm's dedication to green innovation to successfully promote environmental practices in their companies and establish a corporate reputation for green performance.

In the context of the urgent need to reduce GHG emissions, this study contributes to the underlying relationships between green innovation, environmental performance, and the consequences of these for a firm's financial performance. A lot of the papers mentioned in our study, test the research model using survey observations while our paper uses comprehensive corporate data from the 100 global sustainable companies. Our findings are helpful to overcome the limitations of some literature on the correlation between green innovation and environmental and financial performance at the firm level with comprehensive data analysis. Our study opens a new avenue of research to explore the effects of firms' green innovation and GHG reduction policies on financial performance in the most sustainable firms worldwide. We provide a practical reason for firms to actively carry out green innovation activities. We show that green investment should be seen by firms as a long-term strategy. Nonetheless, certain limitations of this study open interesting opportunities for future research. One limitation of our paper is that the "pay to be green" strategy which aims to enhance a firm's performance is implemented in very different ways in different firms (Clarkson *et al.*, 2011). The same green strategy cannot be easily replicated in all firms. Therefore, it would be worthwhile for future research to investigate the firm's characteristics that facilitate the implementation of green innovation activities. Other limitations are the narrow sample size and limited time period covered due to data availability. The robustness of the results might be further improved by building a more comprehensive panel data for future research.

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# Appendices

## Appendix A – Variables Description

| Variables list. | | |
|---|---|---|
| *Panel A: Environmental performance/Financial Performance / Green Innovation* | | |
| FinPer | Financial performance | |
| ROA | Return on assets | The ratio of net profit to total assets |
| ROE | Return on equity | The ratio of net profit to the market value of equity |
| Tobin's Q | Tobin's Q | The sum of the market value of equity and the book value of debt divided by total assets |
| EnvPer | Environmental performance | |
| lnGHG | ln of GHG emissions | The natural logarithm of GHG emissions |
| GHGrev | GHG intensity | The ratio of GHG emissions scaled by revenue |
| GRINNOV | Green innovation | |
| GRPatents | Green patent count | The natural logarithm of one plus the green patent count |
| GRCitations | Green patent citation count | The natural logarithm of one plus the green patent citation count, adjusted for truncation bias |
| CitationCount | Citation-weighted patent count | The ratio of green patent citation count to the green patent count |
| *Panel B: Firm characteristics* | | |
| Leverage | Financial leverage | The ratio of total debt to total assets |
| Size | Firm size | The natural logarithm of total assets |
| CapIntensity | Capital intensity | The ratio of capital expenditures to total assets |
| Growth | Revenue growth | The year-on-year growth in revenue |
| InnovCap | Innovation capacity | The ratio of R&D expenditures to revenue |
| Cash | Cash | Cash and cash equivalents to total assets |

## Appendix B – Lagged Environmental Performance

| | *Panel A: One-period lag (t-1)* | | | *Panel B: Two-period lag (t-2)* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| EnvPer | -0.214*** | -0.00101* | 0.0125* | -0.225*** | 0.000776* | -0.0234* |
| | (0.0274) | (0.00137) | (0.0316) | (0.0403) | (0.00190) | (0.0211) |
| Leverage | 1.743** | -0.111*** | -0.300 | 1.155 | -0.119*** | 0.339 |
| | (0.547) | (0.0273) | (0.627) | (0.763) | (0.0354) | (0.395) |
| Size | 0.320*** | 0.00591** | -0.00633 | 0.338*** | 0.00481 | 0.0246 |
| | (0.0424) | (0.00213) | (0.0490) | (0.0584) | (0.00276) | (0.0308) |
| CapIntensity | -0.133*** | 0.00353* | 0.00784 | -0.0947* | 0.00363* | -0.00581 |
| | (0.0327) | (0.00165) | (0.0378) | (0.0381) | (0.00180) | (0.0201) |
| Growth | -0.113 | 0.0359 | -0.332 | -0.717 | 0.0299 | -0.202 |
| | (0.406) | (0.0200) | (0.461) | (0.572) | (0.0270) | (0.301) |
| InnovCapacity | 0.950 | -0.00897 | -0.919 | 0.358 | -0.0249 | 0.420 |
| | (0.922) | (0.0447) | (1.027) | (1.235) | (0.0561) | (0.625) |
| Cash | 0.0702*** | -0.000867 | -0.000714 | 0.0566*** | -0.000788 | -0.00131 |
| | (0.0136) | (0.000688) | (0.0158) | (0.0155) | (0.000737) | (0.00822) |
| Constant | -2.937*** | 0.00606 | 0.233 | -3.137*** | 0.0189 | -0.274 |
| | (0.478) | (0.0241) | (0.553) | (0.662) | (0.0313) | (0.349) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.53400 | 0.0746 | 0.0156 | 0.5320 | 0.102 | 0.0145 |

This table examines the effect of firms' environmental performance lagged by one year in Panel A and two years in Panel B on their financial performance. The models are estimated using ordinary least squares (OLS). Panel A: Models (1)-(3) use the variable lnGHG as a measure of environmental performance. Panel B: Models (1)-(3) are based on GHGrev. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively

# Appendix C – Lagged Green Innovation

| | Panel A: One-period lag (t-1) | | | Panel B: Two-period lag (t-2) | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (1)** | **Model (2)** | **Model (3)** |
| | Tobin's Q | ROA | ROE | Tobin's Q | ROA | ROE |
| GRInnov | 0.0519** | 0.00889*** | 0.00207* | 0.0297* | 0.00372*** | 0.000838* |
| | (0.0303) | (0.00141) | (0.0321) | (0.0254) | (0.00118) | (0.0268) |
| Leverage | 1.112 | -0.124*** | -0.246 | 1.124 | -0.123*** | -0.244 |
| | (0.576) | (0.0264) | (0.602) | (0.578) | (0.0264) | (0.602) |
| Size | 0.200*** | 0.00565** | 0.00252 | 0.193*** | 0.00546** | 0.00207 |
| | (0.0425) | (0.00198) | (0.0451) | (0.0424) | (0.00197) | (0.0450) |
| CapIntensity | -0.117*** | 0.00385* | 0.00678 | -0.118*** | 0.00382* | 0.00670 |
| | (0.0352) | (0.00164) | (0.0373) | (0.0352) | (0.00164) | (0.0373) |
| Growth | 0.244 | 0.0269 | -0.331 | 0.258 | 0.0272 | -0.330 |
| | (0.418) | (0.0191) | (0.435) | (0.419) | (0.0191) | (0.435) |
| InnovCapacity | 1.931 | 0.00261 | -0.900 | 1.831 | -0.000407 | -0.907 |
| | (1.022) | (0.0455) | (1.037) | (1.034) | (0.0460) | (1.049) |
| Cash | 0.0724*** | -0.000879 | -0.00102 | 0.0729*** | -0.000863 | -0.000982 |
| | (0.0147) | (0.000686) | (0.0156) | (0.0147) | (0.000686) | (0.0156) |
| Constant | -1.412** | 0.0128 | 0.130 | -1.362** | 0.0139 | 0.133 |
| | (0.461) | (0.0215) | (0.489) | (0.460) | (0.0214) | (0.488) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.4496 | 0.1064 | 0.0146 | 0.4468 | 0.0936 | 0.0283 |

This table examines the effect of firms' green innovation on financial performance lagged by one year in Panel A and two years in Panel B. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

## Appendix D – Lagged Green Innovation with Environmental Performance

| | *Panel A: One-period lag (t-1)* | | *Panel B: Two-period lag (t-2)* | | *Panel AI: One-period lag (t-1)* | | *Panel BI: Two-period lag (t-2)* | |
|---|---|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** | **Model (5)** | **Model (6)** | **Model (7)** | **Model (8)** |
| | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** |
| GRPatents | 0.232*** | | 0.291*** | | 0.134** | | 0.190** | |
| | (0.0528) | | (0.0672) | | (0.0452) | | (0.0578) | |
| GRCitations | | 0.211*** | | 0.253*** | | 0.121*** | | 0.148*** |
| | | (0.0442) | | (0.0573) | | (0.0356) | | (0.0131) |
| GRPatents*lnGHG | | | | | 0.174*** | | 0.187*** | |
| | | | | | (0.0146) | | (0.0203) | |
| GRCitationss*lnGHG | | | | | | 0.144*** | | 0.159*** |
| | | | | | | (0.0101) | | (0.0460) |
| Leverage | 0.842 | 0.902 | 0.667 | 0.747 | 0.0441 | 0.0789 | 0.0536 | 0.0543 |
| | (0.987) | (0.983) | (1.315) | (1.315) | (0.834) | (0.782) | (1.113) | (1.040) |
| Size | 0.628*** | 0.624*** | 0.583*** | 0.588*** | 0.242*** | 0.186** | 0.194* | 0.144 |
| | (0.0738) | (0.0732) | (0.0981) | (0.0975) | (0.0700) | (0.0657) | (0.0930) | (0.0865) |
| CapIntensity | 0.0346 | 0.0324 | 0.0191 | 0.0174 | 0.0187 | 0.0123 | 0.00462 | 0.000221 |
| | (0.0604) | (0.0601) | (0.0669) | (0.0668) | (0.0508) | (0.0477) | (0.0565) | (0.0528) |
| Growth | -0.769 | -0.771 | -0.569 | -0.564 | -0.663 | -0.706 | -0.745 | -0.834 |
| | (0.733) | (0.729) | (0.978) | (0.976) | (0.617) | (0.579) | (0.826) | (0.771) |
| InnovCapacity | -5.501** | -6.027*** | -5.720* | -6.155** | -2.148 | -2.002 | -2.780 | -2.550 |
| | (1.727) | (1.740) | (2.244) | (2.269) | (1.481) | (1.409) | (1.922) | (1.820) |
| Cash | -0.0431 | -0.0424 | -0.0314 | -0.0313 | -0.0183 | -0.0141 | -0.00943 | -0.00609 |
| | (0.0253) | (0.0252) | (0.0273) | (0.0272) | (0.0214) | (0.0201) | (0.0232) | (0.0216) |
| Constant | -7.439*** | -7.478*** | -7.162*** | -7.278*** | -3.351*** | -2.836*** | -3.039** | -2.541** |
| | (0.799) | (0.793) | (1.061) | (1.055) | (0.755) | (0.709) | (1.001) | (0.933) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | *Panel A: One-period lag (t-1)* | | *Panel B: Two-period lag (t-2)* | | *Panel AI: One-period lag (t-1)* | | *Panel BI: Two-period lag (t-2)* | |
|---|---|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** | **Model (5)** | **Model (6)** | **Model (7)** | **Model (8)** |
| | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** | **EnvPer** |
| Country | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.2564 | 0.2637 | 0.2412 | 0.2421 | 0.4730 | 0.5362 | 0.4584 | 0.5284 |

This table examines the effect of firms' green innovation on their environmental performance. Panel A and Panel AI are lagged by one year while Panel B and Panel BI are lagged by two years. All models are based on lnGHG as a measure for environmental performance All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

## Appendix E - Green Innovation, Environmental and Financial Performance

| | *Panel A: One-period lag (t-1)* | | | *Panel B: Two-period lag (t-2)* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** | **Model (5)** | **Model (6)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| EnvPer | -0.179*** | -0.000292 | -0.0383 | -0.211*** | 0.00145 | -0.0174 |
| | (0.0294) | (0.00155) | (0.0362) | (0.0387) | (0.00190) | (0.0212) |
| GRInnov | 0.0152*** | 0.000433 | 0.0139 | 0.0371*** | 0.00111 | 0.0246 |
| | (0.0291) | (0.00154) | (0.0361) | (0.0438) | (0.00217) | (0.0242) |
| Innov*EnvPer | 0.0399*** | 0.00101* | 0.00836 | 0.0422*** | 0.000861* | 0.00212* |
| | (0.00784) | (0.000417) | (0.00974) | (0.00992) | (0.000494) | (0.00551) |
| Leverage | 1.562** | -0.0984*** | -0.410 | 1.209 | -0.102** | 0.209 |
| | (0.510) | (0.0270) | (0.631) | (0.718) | (0.0352) | (0.392) |
| Size | 0.391*** | 0.00777*** | 0.00874 | 0.442*** | 0.00606* | 0.0244 |
| | (0.0425) | (0.00226) | (0.0527) | (0.0589) | (0.00291) | (0.0325) |
| CapIntensity | -0.111*** | 0.00346* | 0.0112 | -0.0907* | 0.00329 | -0.00265 |
| | (0.0305) | (0.00162) | (0.0379) | (0.0358) | (0.00178) | (0.0198) |
| Growth | -0.138 | 0.0336 | -0.321 | -0.439 | 0.0167 | -0.0859 |
| | (0.380) | (0.0198) | (0.463) | (0.529) | (0.0263) | (0.293) |
| InnovCapacity | 0.465 | 0.00773 | -1.501 | -0.940 | 0.0182 | -0.362 |
| | (0.894) | (0.0470) | (1.098) | (1.211) | (0.0599) | (0.669) |
| Cash | 0.0601*** | -0.000999 | -0.00177 | 0.0517*** | -0.000816 | -0.00152 |
| | (0.0128) | (0.000682) | (0.0159) | (0.0146) | (0.000727) | (0.00811) |
| Constant | -3.605*** | -0.0143 | 0.0626 | -4.168*** | 0.00334 | -0.245 |
| | (0.468) | (0.0248) | (0.580) | (0.650) | (0.0321) | (0.358) |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Country | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |

| | *Panel A: One-period lag (t-1)* | | | *Panel B: Two-period lag (t-2)* | | |
|---|---|---|---|---|---|---|
| | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** | **Model (5)** | **Model (6)** |
| | **Tobin's Q** | **ROA** | **ROE** | **Tobin's Q** | **ROA** | **ROE** |
| Observations | 800 | 800 | 800 | 800 | 800 | 800 |
| R-squared | 0.5831 | 0.1182 | 0.0147 | 0.5785 | 0.0984 | 0.0106 |

This table examines the effect of one- and two-period lagged firms' environmental performance, green innovation, and the interaction between the two on their financial performance. Panel A and B are all based on lnGHG as a measure of environmental performance and citation-weighted count as a proxy for green innovation. All models are estimated with fixed effects. Robust errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.