On the path to net zero: The effect of greenhouse gas emissions and green innovation on corporate investors' financial performance

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ABSTRACT

Against the backdrop of the decarbonization of the world, this paper aims to analyze the impacts of greenhouse gas (GHG) emissions, as a proxy for environmental performance, as well as green innovation on corporate investors' financial performance. The sample consists of 133 U.S. firms with corporate venture capital (CVC) activity between 2002-2019. The findings reveal that both environmental performance and green innovation positively affect corporate investors' financial performance. Moreover, the combined effect of environmental performance and green innovation on financial performance is examined, suggesting a positive relationship. These findings contribute to the ongoing debate on the role of corporations in reaching net zero emissions. The results of this study indicate that corporate investors should have a financial interest to reduce their emissions and drive green innovations.

Palavras-chave:

Capital de risco empresarial

Desempenho ambiental

Desempenho financeiro

Inovação verde

Emissões de gases com efeito de estufa

Contra o pano de fundo da descarbonização do mundo, esta análise visa analisar os impactos das emissões de gases com efeito de estufa (GEE), como um indicador do desempenho ambiental, bem como a inovação verde, no desempenho financeiro dos investidores corporativos. A amostra consiste em 133 empresas americanas com atividade de capital de risco corporativo (CVC) entre 2002-2019. As conclusões revelam que tanto o desempenho ambiental como a inovação verde afetam positivamente o desempenho financeiro dos investidores corporativos. Adicionalmente, o efeito combinado do desempenho ambiental e da inovação verde no desempenho financeiro é examinado, sugerindo uma relação positiva. Estas conclusões contribuem para o debate em curso sobre o papel das empresas no alcance de emissões líquidas zero. Os resultados deste estudo indicam que os investidores empresariais têm um interesse financeiro em reduzir as suas emissões e impulsionar inovações ecológicas.

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1. Introduction

The aggravation of the ongoing climate crisis has dominated political discussions in recent years. Researchers are increasingly warning governments and policymakers to take action in order to limit the devastating effects of rising global surface temperature. The main driver of global warming is the level of GHG emissions in the atmosphere. To counteract this crisis, 196 parties, including the world's leading governments, have agreed on the legally binding Paris Agreement at COP21, on 12 December 2015 (UNFCC, 2015). One of the major outcomes of this agreement is a commitment to reduce GHG emissions to limit global warming "to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UNFCC, 2015). In order to reach this goal, governments, corporations, and individuals are urged to contribute. Accordingly, over the previous years, the importance of sustainable business practices and the reduction of GHG emissions have soared in light of the aggravating climate crisis. Therefore, many scholars have begun to conduct research on measures and effects that shed light on corporate environmental performance.

While a few scholars already considered the relationship between GHG emissions, green innovation, and financial performance in different circumstances, this is the first paper applying and combining these topics in the context of CVC investments. CVC refers to established corporations making venture capital investments, that is direct minority equity investments in privately held entrepreneurial ventures (Wadhwa et al., 2016). Typically, the aim of CVC investments is the acquisition of knowledge and technological innovations (Da Gbadji et al., 2015). The dedicated view on corporate investors is of particular interest for several reasons. In the past, scholars and practitioners agreed that the performance of corporations is mainly dependent on traditional resources such as physical, human, or organizational capital resources. This traditional resource-based view (RBV) of the firm, as originally introduced by Wernerfelt (1984) and Barney (1991), is however no longer sufficient to describe the resources that define firms' performance. As recently suggested by Pereira and Bamel (2021) as well as Battisti et al. (2022), the traditional RBV must be extended by additional factors including social and environmental aspects. Battisti et al. (2022) add that corporate investors, compared to other firms, have an extraordinary ability to acquire such social or ecological aspects through their investments. While many corporate investors face societal pressure from their stakeholders to consider their ecological footprint, they can use investments as a tool to acquire knowledge and technologies, allowing them to significantly improve their environmental performance and reduce GHG emissions (Battisti et al., 2022). Analyzing the effect of green innovation on corporate investors' financial performance, Baierl et al. (2016) show that the innovativeness of corporate investors positively affects their respective financial performance. Similarly, Dushnitsky and Lenox (2005, 2006) are considering the relationship between CVC investments and corporate innovativeness as well as their effect on firm value.

Research on the effect of corporate environmental performance on financial performance has been extensive in recent years. For example, Busch and Hoffmann (2011), Iwata and Okada (2011), as well as Ganda and Milondzo (2018) find positive relationships between environmental and financial performance. Lee et al. (2015) add that green R&D investments aiming at reducing GHG emissions may improve firms' financial outcomes. Similarly, Aggarwal and Dow (2011) as well as Bolton and Kacperczyk (2021) provide evidence that investors are pricing in carbon risk. One major obstacle for firms to improve their environmental performance is related to the costs for reducing GHG emissions. While in countries with low incentives for reducing emissions, for example, costs may outweigh financial benefits (Rokhmawati et al., 2015, 2017), Russo et al. (2021) show that firms with strong environmental performance may indeed benefit from cost reductions and therefore improve their financial performance. Although the effect of environmental performance on financial performance has been covered by many authors, there is no research specifically targeting corporate investors. Therefore, this paper sheds light on the relationship between environmental and financial performance in a sample consisting of corporate investors.

Considering the effect of green innovation on financial performance, research has been intensified in recent years. For instance, authors such as Aguilera-Caracuel and Ortiz-de-Mandojana (2013), Przychodzen and Przychodzen (2015), as well as Scarpellini et al. (2019) all describe the positive relationship between green innovation and financial performance. Going one step further and looking at the relationship between environmental performance and green innovation, Lee and Min (2015) as well as Q. Ma et al. (2021) find that firms with more green innovation have lower GHG emissions. Despite these contributions to the literature, there remain two shortcomings. First, neither the effect of green innovation on financial performance nor the relationship between environmental performance and green innovation has been researched in the specific context of CVC investments. Second, literature has not yet specifically covered the combined effect of GHG emissions and green innovation on the financial performance of firms. There is a gap in the literature demonstrating the relation between corporate investors' innovation and their respective financial performance. This paper takes into consideration sustainability-related measures in modeling environmental and financial performance. By considering GHG emissions and green innovation measures, this study tries to evaluate the impact of sustainable business practices on corporate investors' financial performance. Thus, based on the arguments made above, existing literature has made important contributions that build a strong basis for this paper. The link between GHG emissions, green innovation, and financial performance in the context of corporate investors, however, requires further attention. Accordingly, this paper aims to treat this gap.

In doing so, this paper makes significant contributions to both research and practice. First, to date, this is the first paper to evaluate the effect of green innovation, instead of innovation in general, as well as the effect of GHG emissions on the financial performance of corporate investors. Therefore, the results are based on combined research on corporate investors' financial performance (e.g. Baierl et al., 2016; Battisti et al., 2022; Dushnitsky & Lenox, 2006), on the relationship between GHG emissions or, more generally, environmental performance and corporate financial performance (e.g. Busch & Hoffmann, 2011; Ganda & Milondzo, 2018; Russo et al., 2021), as well as on the impact of green innovation on financial performance (e.g. Aguilera-Caracuel & Ortiz-de-Mandojana, 2013; J. Przychodzen & Przychodzen, 2015; Scarpellini et al., 2019). Second, the empirical results clearly show that environmental performance and green innovation should be considered as part of corporate investors' investment strategies. The evidence therefore adds to the findings of Battisti et al. (2022), who indicate that CVC investments have a positive impact on the investors' environmental and social performance, by showing that enhanced environmental performance and green innovation of corporate investors positively affect financial performance. Third, analyzing the combined effect of GHG emissions and green innovation on corporate investors' financial performance suggests that both reducing GHG emissions and increasing sustainability-related innovation together positively influence financial performance. While Lee and Min (2015) as well as Q. Ma et al. (2021) previously elaborated on the relationship between innovation and carbon emissions, this study confirms their results and additionally proves their effect on corporate financial performance. This demonstrates the relevance of the interrelationship of GHG emissions and green innovation for corporate investors' financial performance.

The remainder of this paper is structured as follows. The literature review is presented in Section 2. Data selection and methodology are described in Section 3. Empirical results as well as their discussion are reported in Section 4. Finally, conclusions are drawn in Section 5, along with their implications for research and practice as well as their limitations.

2. Theoretical background and literature review

As one of the most relevant questions in business research, scholars are aiming to understand the factors influencing the financial performance of firms. To define those factors, researchers are continuously analyzing the different resources and capabilities that companies possess and their impact on performance at a firm level. The notion of the RBV of firms was first described by Wernerfelt (1984) and Barney (1991). In its original form, it analyzes the impact of heterogeneous resources available to firms on their performance over time. The concept of RBV helps to understand the role that a firm's resources have in creating a sustained competitive advantage (Barney, 1991). According to Barney (1991), a firm's resources may therefore be viewed as a tool to achieve its respective strategies and goals. Although the RBV has important implications for understanding the role of a firm's resources on its competitive advantage, Hart (1995) argues that it does not sufficiently consider environmental challenges. Therefore, Hart (1995, 2005) expands the RBV and suggests the natural-resource-based view (NRBV) of the firm. He proposes that the relationship of a firm towards the natural environment affects its competitive advantage.

Hart (1995) presents three interconnected strategies that firms may consider in order to build a sustained competitive advantage, including pollution prevention, product stewardship, and sustainable development. The NRBV demonstrates that firms need to take a long-term approach in accumulating resources and managing capabilities in order to achieve long-term sustainability and ultimately long-term success (Hart, 1995, 2005). Later, Hart and Dowell (2011) review the initial NRBV concept and confirm its relevance in light of economic, societal, and technological developments, linking sustainable strategies with environmental capabilities and competitiveness at a firm level (Hart, 2005; Hart & Dowell, 2011). In addition to the RBV and NRBV, scholars have conducted extensive stakeholder research. Based on the notion of an interconnected relationship between firms and their stakeholders, Freeman and Reed (1983) are the first authors to formulate the stakeholder theory, arguing that firms should create value for both shareholders and all other existing stakeholders. In the following years, scholars have begun to apply the stakeholder theory to a variety of business contexts. For the sake 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, based on the stakeholder theory. Further relevant studies showing the importance of considering the different stakeholders in light of decisions referring to corporate sustainability include the works of Hörisch et al. (2014), Schaltegger et al. (2019), and Freudenreich et al. (2020).

While the traditional RBV view mainly classifies the resources available to firms as either 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). As large corporations are facing increasing pressure from various actors to keep up with innovative and sustainable practices to remain competitive in recent years and as governmental regulations and stakeholder expectations are growing, considerations going beyond purely financial and economic dimensions, such as social and environmental aspects of business, are becoming necessary tools to ensure sustainable long-term financial success (Torugsa et al., 2013). In order to cope with this increasing pressure, Battisti et al. (2022) show that CVC investments may play a crucial role for corporations in acquiring the necessary resources for a sustainable competitive advantage. They suggest that CVC investments may be more efficient compared to the slow process of developing capabilities purely internally.

CVC context is an appropriate setting to test this paper's hypotheses and analyze the assumptions. Dushnitsky and Lenox (2005) as well as Battisti et al. (2022) and Wadhwa et al. (2016) demonstrate that CVC investments serve as an important source of knowledge and innovation for investors. Corporate investors are constantly leveraging their resources in order to create a sustainable competitive advantage. Accordingly, Battisti et al. (2022) take a view on resources and capabilities that have an effect on types of performance other than purely financial, including social and environmental performance. They prove that CVC programs, in addition to improving corporate innovativeness, have the potential to enhance investors' environmental and social performance (Battisti et al., 2022). By acquiring resources and capabilities from their portfolio companies, corporate investors may increase their CSR performance which, in turn, can serve as a driver for a sustainable competitive advantage. The authors, therefore, expand the traditional RBV, claiming that the acquisition of innovation and know-how by corporate investors are tools for achieving CSR objectives (Battisti et al., 2022). That way, CVC investments may be an efficient tool to cope with the initially described economic pressure exerted by governments and stakeholders and can ultimately become part of firms' overall corporate strategies (Battisti et al., 2022).

Changing the perspective away from the resource acquisition by corporate investors towards actual outcomes resulting from CVC investments, Dushnitsky and Lenox (2005) find a statistically significant positive relationship between such investments and patenting outcomes of the investing firms. Therefore, CVC activities are substantially contributing to firms' innovation capabilities. In a later study, Wadhwa et al. (2016) confirm that portfolio diversity and the depth of knowledge in the portfolio affect corporate investors' innovativeness. Chemmanur et al. (2014) take a different approach and study the innovativeness of CVC-backed enterprises. They find that these ventures exhibit higher patenting outcomes in quantity and quality which, in turn, might benefit the respective corporate investor, as Battisti et al. (2022) show. In addition to the effect on corporate innovativeness, Dushnitsky and Lenox (2006) outline that created firm value, considering Tobin's Q, will be even greater and compensate for potentially higher costs if CVC investments are explicitly being pursued for strategic reasons and aiming at adopting novel technologies. Accordingly, Baierl et al. (2016) underline that the innovativeness of corporate investors has a positive effect on their subsequent financial performance.

2.1 Relationship between environmental and financial performance

This study is related to a rapidly growing literature on the relationship between firms' environmental and financial performance. While literature specifically dedicated to venture capital investments with regards to this relationship remains sparse, there is growing evidence in a corporate context, as outlined in the following paragraphs. Furthermore, a few studies have been recently published, for example, in the context of green investments (Shen et al., 2021) or M&A transactions (Bose et al., 2021). The vast majority of studies analyzing the effect of corporate environmental performance on corporate financial performance find a positive relationship. To show this effect, for instance, Busch and Hoffmann (2011) use ROA, ROE, and Tobin's Q while Ganda and Milondzo (2018) make use of ROE, ROI, and ROS. An early study by Iwata and Okada (2011) moreover finds that a reduction in GHG emissions leads to improved financial performance in a mixed sample of firms as well as in a sample of firms specifically operating in clean industries. Some studies go even further and suggest that green R&D investments (Lee et al., 2015) as well as green investment initiatives (Ganda & Milondzo, 2018) that are designed to reduce GHG emissions may improve firms' financial outcomes.

Other related studies investigate the effect of environmental performance on firm value, compared to financial performance, and find that investors seem to ascribe intangible value to a reduction in GHG emissions which, in turn, allows for an increase in firm value (Nishitani & Kokubu, 2012). Scholars furthermore conclude that investors are pricing in carbon risk (Bolton & Kacperczyk, 2021). Put differently, carbon emissions persistently reduce firm value (Aggarwal & Dow, 2011) and the downside effect of high emissions outweighs the positive effect of low emissions (Lee et al., 2015). This penalization by the market is found to be even higher for firms that do not disclose their information (Matsumura et al., 2014). Therefore, firms should have an economic interest in reducing their carbon emissions.

While most studies find positive links, there remain a few contrasting views on the relationship between corporate environmental and financial performance (e.g. Hatakeda et al., 2012; Rokhmawati et al., 2015, 2017; Wang et al., 2014). Misani and Pogutz (2015) conclude that firms with intermediate levels of carbon emissions achieve the highest financial performance, compared to a lower performance attributed to firms with either high or low emissions. The main determinant moderating between a positive and a negative or non-existent relationship is related to firms incurring additional costs or enjoying cost reductions as a consequence of GHG emissions reductions. Russo et al. (2021) find that firms with strong environmental performance may benefit from cost reductions and henceforth improve their financial performance. On the other hand, specific country circumstances such as low economic power, sparse environmental regulations, and low penalties for increasing GHG emissions, mainly in developing countries, may reduce the financial incentives of reducing GHG emissions (Rokhmawati et al., 2015, 2017). Similarly, considering specific industries, such as the paper industry, scholars find a negative relationship between environmental and financial performance (Wagner, 2005; Wagner et al., 2002). Mixed results are also found for further industries, including chemical firms, coal companies, as well as oil and gas firms (Gonenc & Scholtens, 2017).

In addition, scholars have not found consensus yet in defining whether the implications of environmental performance have varying effects on financial outcomes in the short, medium, and long term. Delmas et al. (2015) find a negative effect on the ROA as a short-term performance measure, while Tobin's Q, as a measure capturing both short- and long-term performance, seems to benefit from improved sustainable outcomes. Similarly, Hoang et al. (2020) find that increasing GHG emissions, that is a worse environmental performance, may improve the ROA in the short term while negatively impacting long-term financial performance in terms of long-term capital employed. This is in line with the results of Horváthová (2012), suggesting a negative effect for one-year lagged environmental performance variables which is turning positive for a two-year lag, implying short-term costs and long-term benefits of increased environmental performance. There is, however, contrasting evidence claiming a positive effect of environmental performance on short-term financial performance and a controversial effect in the medium- and long-term (Russo & Pogutz, 2009). Furthermore, it remains debatable whether GHG emissions mitigation has a positive effect on financial performance and firm value (Aggarwal & Dow, 2011; Ganda & Milondzo, 2018).

Overall, considering the positive link discussed in wide parts of the literature in combination with the findings specific to the CVC context, this study aims at confirming a positive effect of corporate investors' environmental performance on their respective financial performance.

H1. *Corporate investors with a better environmental performance show a higher financial performance.*

2.2 Relationship between green innovation and financial performance

Literature on eco-innovation considering green patents as a measure for green innovation is relatively new. In one of the earliest studies using green patents data, Aguilera-Caracuel and Ortiz-de-Mandojana (2013) find that green innovative firms experience a positive relationship between the intensity of their green innovation and their respective financial performance. Similarly, González-Benito et al. (2016) find a positive relationship between corporate innovation activity and financial performance, not differentiating between green and non-green innovation. Earlier, Porter and van der Linde (1995) explain that innovation may offset the costs induced by environmental regulations, reducing the financial burden of environmental improvements. More recently, W. Przychodzen et al. (2020) show that green innovation may positively affect firm financial performance. Rezende et al. (2019) further suggest a positive relationship between time-lagged green innovation intensity, that is the time-lagged proportion of green patents in relation to total patents, and financial performance with no effect in the actual observation year, however. Scarpellini et al. (2019) furthermore show that green patents as well as R&D intensity, as drivers of eco-innovation, positively affect firm performance. These findings confirm the positive effect on firm performance found by Przychodzen and Przychodzen (2015) who observe that eco-innovators exhibit higher ROA and ROE than their counterparts. Similar evidence showing the relevance of eco-innovation in determining firm performance is documented in other studies. Specifically, Marín-Vinuesa et al. (2020) find that the level of green innovation has a positive effect on corporate financial performance, building on earlier findings by Doran and Ryan (2012) who show that green innovation, unlike non-green innovation, positively affects firms' financial performance.

The positive findings discussed above are, however, moderated by some contrasting or ambiguous results. For example, Aguilera-Caracuel and Ortiz-de-Mandojana (2013) cannot find any difference in their results comparing green innovative firms and their non-green innovative counterparts. Additionally, W. Przychodzen et al. (2020) show that too much focus on green innovation, compared to other types of innovation, may even have a negative influence on financial performance. Similarly, Busch and Hoffmann (2011) underline the negative effect of corporate commitment in addressing ecological issues on firms' respective financial performance. Considering different areas of eco-innovation, Horbach et al. (2012) furthermore discuss ambiguous effects on economic performance, depending on the environmental area. Finally, although Marín-Vinuesa et al. (2020) find that the level of green innovation may generally positively affect financial performance, they do not find evidence for a positive relationship between the ownership of green patents and financial performance.

The positive relationship between green innovation and environmental performance, on the other hand, seems obvious. Investments in sustainable business practices and innovation should have a reducing effect on firms' GHG emissions. Lee and Min (2015) make use of green R&D expenditures to prove the negative relationship between green innovation and carbon emissions. Additionally, the authors prove that green R&D has a positive relationship with corporate financial performance, as measured by Tobin's Q. Similarly, Q. Ma et al. (2021) prove the reducing impact of technological innovation and R&D expenses on carbon emissions in China. The effect of green innovation on environmental performance is furthermore developed by Long, Chen, Du, Oh, Han, et al. (2017) as well as Long, Chen, Du, Oh, and Han (2017). They find that the effect of green innovation behavior on environmental performance is even greater than the effect on economic performance.

To place the above discussion in a CVC context, the findings of Battisti et al. (2022), showing that CVC programs may improve corporate innovativeness, environmental, and social performance, as well as the results presented by Baierl et al. (2016), suggesting a positive relationship between the innovativeness and financial performance of corporate investors, are taken into consideration. This serves as a basis to construct hypotheses suggesting a positive impact of corporate investors' green innovation on their respective financial performance as well as a joint positive effect of environmental performance and green innovation on financial performance.

H2. *Corporate investors with more green innovation have a higher financial performance.*

H3. *Corporate investors with both better environmental performance and more green innovation show a higher financial performance.*

3. Data and methodology

3.1 Sample selection

The selected sample comprises longitudinal data on U.S. firms between 2002-2019, based on the Thomson VentureXpert database to construct the main sample of firms that make at least one CVC investment. Financial and accounting data are collected from Standard and Poor's Compustat database. GHG emissions data is retrieved from Refinitiv Eikon. The target period between 2002-2019 is chosen as GHG emissions data is only available on Eikon for firms starting in 2002. To combine the Thomson VentureXpert data with the Compustat and Eikon databases, the names and ticker symbols of the firms are manually checked. If applicable, the ultimate parent firm at the time of the CVC investment is being considered. In a first step, after merging Thomson VentureXpert with Compustat data, a sample of 248 unique firms remains for which financial data is available. In a second step, the sample is being matched with the Eikon database, and only firms for which both financial and environmental data are available are being kept. The final sample comprises 133 corporate investors and 2,394 observations after the removal of missing variables and records that do not disclose the firm's name. Green patent data is furthermore retrieved from the PATSTAT database[1]. In order to match the firms from the sample with firms in PATSTAT, the matching methodology is based on the description by Tarasconi and Menon (2017). For the citation count, citations have been counted by filing year for each patent.

3.1.1 Dependent variables

In this paper, three different measures of financial performance (*FINPER*) are introduced as dependent variables, namely ROA, ROE, and Tobin's Q. ROA and ROE are used as short-term measures with ROA indicating the return on investment with respect to total assets of a firm and ROE with respect to equity. Tobin's Q, as a measure that reflects both short- and long-term financial performance, is the ratio of the firms' market value to their tangible assets' replacement cost, therefore measuring intangible value (Dowell et al., 2000; Konar & Cohen, 2001). Financial performance is used as the dependent variable for testing all three hypotheses.

3.1.2 Independent variables

To test the validity of H1 and H3, environmental performance (*ENVPER*) is assessed by using GHG emissions, that is total CO2 and CO2-equivalent (CO2e) emissions (in tons), following the GHG protocol (Bhatia et al., 2004) for Scope 1 and Scope 2 GHG emissions. In

[1] PATSTAT – EPO patent statistic database – version autumn 2021.

addition to carbon dioxide (CO_2), the GHG emissions data considers methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCS), perfluorinated compound (PFCS), sulfur hexafluoride (SF_6), as well as nitrogen trifluoride (NF_3). According to the GHG protocol, Scope 1 emissions cover all emissions from sources that are directly being owned or controlled by the respective company, such as company-owned vehicles and fuel combustion. Scope 2 emissions, on the other hand, relate to indirect emissions such as emissions from the consumption of purchased energy (electricity, steam, heat). As using absolute GHG emissions would entail significant tail risk, two different measures are used to assess environmental performance, being the natural logarithm of GHG emissions (*lnGHG*) and GHG emissions per unit of revenue, that is GHG emissions intensity (*GHGrev*). Emissions intensity, having GHG emissions in the numerator, is used as the results are being more comparable to *lnGHG*, in contrast to emissions productivity. The ratio of GHG emissions to revenue is commonly being used to assess environmental performance by several scholars (e.g. Bose et al., 2021; Busch & Hoffmann, 2011). Finally, in order to examine the environmental performance of firms, with lower GHG emissions corresponding to higher values for environmental performance, the input variables are multiplied with (-1), following Busch and Hoffmann (2011). This approach is followed as it facilitates the interpretation of all variables used in the empirical models by aligning the positive directions of environmental performance, green innovation, and financial performance.

The second set of independent variables, measuring green innovation, is introduced to test H2 and H3. While early literature widely used R&D expenditures to measure corporate innovativeness, recent literature agrees on using patent-based variables as a tool to adequately measure the innovation output of firms (Chemmanur et al., 2014). Following that approach, two different patent-based measures are considered in order to assess both the quantity and the quality of green innovation. Both green innovation variables are based on the patent application year. First, the number of green patent applications by a firm in each year (*Count*) is introduced to analyze innovation quantity. Second, the number of subsequent citations of these green patents (*Citations*) is used to measure innovation quality. As the citation count is subject to a truncation bias, the variable needs to be adjusted. Patents tend to receive citations over an extended period. Following U.S. patent law, a utility patent is granted for a lifetime of 20 years. Therefore, there is a significant downward bias for more recent patents in the data. Following Hall et al. (2000, 2001, 2005), the citation truncation bias is corrected by estimating the shape of the citation-lag distribution. To further cope with the empirical properties of the variables, it is necessary to take the natural logarithm of the newly introduced variables. Additionally, to avoid losing firm-year observations with zero patents or citations per patent, one is added to the patent as well as citations count before taking the natural logarithm (Chemmanur et al., 2014; S. Ma, 2020). Following this procedure, ln(1+*Count*) is denoted *Count* and ln(1+*Citations*) is denoted *Citations*. As a third variable for green innovation, a citation-weighted patent count (*CitationCount*) is computed, allowing to measure the relationship between *Count* and *Citations*.

3.1.3 Control variables

The set of control variables considered in this paper encompasses six distinct variables. Financial leverage (*LEV*) 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 expenditures to total assets. Revenue growth (*GROWTH*) depicts the year-on-year growth in revenue. Innovation capacity (*RD*) is measuring R&D intensity, therefore calculating the ratio of R&D expenditures to revenue. Finally, CSR performance (*CSR*) is calculated as the average of the social and environmental performance scores reported by Eikon, following the approach taken by Bose et al. (2021). Figure 1 below depicts the three hypotheses which are being tested in this paper.

Figure 1: Research framework (environmental performance, green innovation, and financial performance)

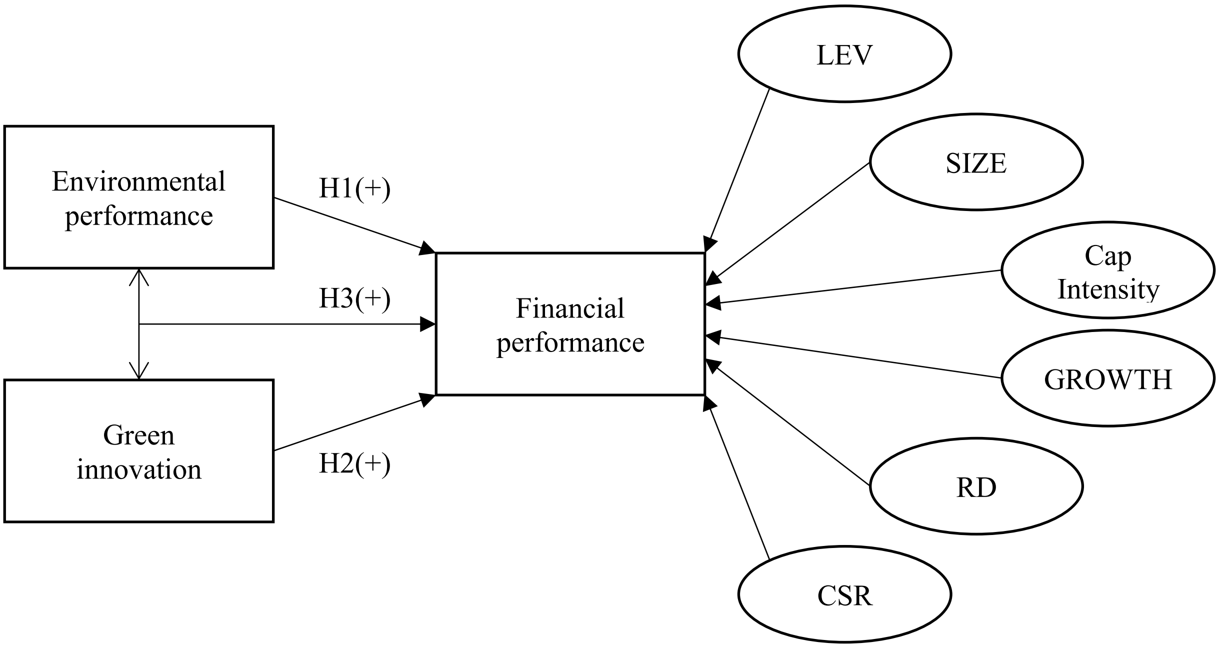

Figure 1 includes the dependent variables (financial performance), independent variables (environmental performance and green innovation), as well as all considered control variables (displayed in ellipses). Hypothesis 1 (H1) posits that corporate investors' environmental performance has a positive effect on their respective financial performance. Hypothesis 2 (H2) suggests a positive relationship between green innovation and financial performance. Finally, hypothesis 3 (H3) asserts that the relationship between environmental performance and green innovation has a positive effect on corporate investors' financial performance.

3.2 Empirical model and variables

To address the effect of GHG emissions on corporate investors' financial performance (H1), equation (1) contains the following parameters:

$$FINPER_{i,t} = \alpha + \beta_1 ENVPER_{i,t} + \beta_2 LEV_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 CapIntensity_{i,t} + \beta_5 GROWTH_{i,t} + \beta_6 RD_{i,t} + \beta_7 CSR_{i,t} + \beta_8 \sum INDUSTRY_i + \beta_9 \sum YEAR_t + \varepsilon_{i,t} \quad (1)$$

where $FINPER_{i,t}$ represents firm i's financial performance, measured as either ROA, ROE, or Tobin's Q. The independent variable $ENVPER_{i,t}$ measures the environmental performance of the firm, building on its GHG emissions. The control variables are leverage (*LEV*), firm size (*SIZE*), capital intensity (*CapIntensity*), revenue growth (*GROWTH*), innovation capacity (*RD*), and CSR performance (*CSR*).

Equation (2) aims to analyze the effect of green innovation on the financial performance of corporate investors (H2):

$$FINPER_{i,t} = \alpha + \beta_1 INNOV_{i,t} + \beta_2 LEV_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 CapIntensity_{i,t} + \beta_5 GROWTH_{i,t} + \beta_6 RD_{i,t} + \beta_7 CSR_{i,t} + \beta_8 \sum INDUSTRY_i + \beta_9 \sum YEAR_t + \varepsilon_{i,t} \quad (2)$$

where $INNOV_{i,t}$ is being introduced as a new variable of interest, measuring green innovation in terms of quantity (*Count*) as well as quality (*Citations*). All control variables remain unchanged when compared to equation (1).

Finally, equations (3.1) and (3.2) are considering the effect of both environmental performance and green innovation on financial performance (H3). First, the variables for environmental performance and green innovation from equations (1) and (2) are simultaneously being applied to analyze the effect of adding one of these variables to either model, either by adding a variable measuring *INNOV* to equation (1) or by adding a variable measuring *ENVPER* to equation (2):

$$FINPER_{i,t} = \alpha + \beta_1 ENVPER_{i,t} + \beta_2 INNOV_{i,t} + \beta_3 LEV_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 CapIntensity_{i,t} + \beta_6 GROWTH_{i,t} + \beta_7 RD_{i,t} + \beta_8 CSR_{i,t} + \beta_9 \sum INDUSTRY_i + \beta_{10} \sum YEAR_t + \varepsilon_{i,t} \quad (3.1)$$

Second, the joint effect of corporate investors' environmental performance and green innovation on their financial performance (H3) is being addressed by adding an interaction variable to equation (3.1). This interaction variable is denoted by *ENVPER*INNOV*, where *ENVPER* and *INNOV* may stand for either of the previously introduced variables for environmental performance and green innovation:

$$FINPER_{i,t} = \alpha + \beta_1 ENVPER_{i,t} + \beta_2 INNOV_{i,t} + \beta_3 ENVPER * INNOV_{i,t} + \beta_4 LEV_{i,t} + \beta_5 SIZE_{i,t} + \beta_6 CapIntensity_{i,t} + \beta_7 GROWTH_{i,t} + \beta_8 RD_{i,t} + \beta_9 CSR_{i,t} + \beta_{10} \sum INDUSTRY_i + \beta_{11} \sum YEAR_t + \varepsilon_{i,t} \quad (3.2)$$

To estimate the empirical models and test the hypotheses, ordinary least squares (OLS) regressions are used as the baseline method while controlling for industry (based on two-digit NAICS codes) and year effects. Given the nature of the variables used in the regression models, fixed effect models are applied. The choice of using fixed effect compared to random effect models was furthermore confirmed based on a Hausman test (Hausman, 1978). For H1 and H2 to be validated, coefficient β_1 needs to be significantly positive, as corporate investors with better environmental performance, that is lower GHG emissions, are expected to generate higher profits (H1) and firms with more green innovation should have better financial performance (H2). Additionally, for H3 to be validated, the coefficient of the interaction term should be positive, as the relationship between environmental performance and green innovation should lead to better financial performance of corporate investors (H3).

4. Empirical results and discussion

4.1 Descriptive statistics

Table 1 outlines the summarized statistics for the underlying research sample. The 133 firms included in the sample have an average (median) ROA of 0.06 (0.05). The values for ROE and Tobin's Q as further financial performance measures are 0.12 (0.05) and 2.20 (1.76), respectively. The observed kurtosis of 710.78 for ROE implies a high likelihood for extreme results. Considering the environmental performance measures, prior to inverting the values, the average (median) natural logarithm of GHG emissions and the average (median) GHG emissions intensity can be observed at 13.61 (13.87) and 257.15 (30.52), respectively. The latter is furthermore characterized by a pronounced likelihood for extreme results with a kurtosis of 686.74 and stands out with a strikingly high positive skewness of 25.68, implying a high positive tail risk. The three measures of green innovation, namely patent count, citation count, and citation-weighted patent count show average (median) values of 2.32 (1.10), 2.64 (1.79), and 1.27 (1.10), respectively. The financial leverage of the sample companies, measured by the ratio of total debt to total assets, is found to be at an average (median) of 0.24 (0.22). The values for firm size, capital intensity, revenue growth, innovation capacity, and CSR performance correspond to 10.09 (10.15), 0.59 (0.62), 0.09 (0.06), 0.11 (0.07), and 54.81 (58.66), respectively. Additionally, for revenue growth, a positive skewness of 37.25 and a remarkably high kurtosis of 1,624.47 can be observed.

Table 1
Summary statistics

	Mean	Median	Std. Dev.	Min	Max	Skewness	Kurtosis
ROA	0.06	0.05	0.09	-1.10	0.77	-2.44	30.00
ROE	0.12	0.05	19.41	-592.71	446.45	-2.15	710.78
Tobin's Q	2.20	1.76	1.43	0.53	16.25	2.92	16.59
lnGHG	13.61	13.87	1.95	2.12	18.88	-0.19	3.65
GHGrev	257.15	30.52	2925.35	0.00	83600.41	25.68	686.74
Count	2.32	1.10	2.66	0.00	10.23	0.79	2.39
Citations	2.64	1.79	2.85	0.00	10.33	0.60	2.04
CitationCount	1.27	1.10	0.53	0.53	4.39	3.31	16.60
LEV	0.24	0.22	0.17	0.00	0.79	0.66	3.06
SIZE	10.09	10.15	1.69	2.77	14.71	-0.19	3.64
CapIntensity	0.59	0.62	0.20	-1.44	1.00	-1.35	8.93
GROWTH	0.09	0.06	0.53	-0.96	23.34	37.25	1624.47
RD	0.11	0.07	0.12	0.00	1.56	3.00	24.12
CSR	54.81	58.66	23.81	1.70	95.71	-0.42	2.14

This table shows the summary statistics for all dependent, independent, and control variables used in the different models. The statistics for the two variables measuring environmental performance, lnGHG and GHGrev, are being shown prior to inverting. Therefore, higher values correspond to higher GHG emissions and worse environmental performance.

Table 2 demonstrates that ROA has positive and statistically significant correlations with ROE, Tobin's Q, and Count, at correlations of 0.52, 0.39, and 0.08, respectively, as well as with CapIntensity and GROWTH. On the other hand, ROA is negatively associated with GHGrev at a correlation of -0.09 and with LEV. ROE is moreover positively related with GROWTH at the 5% significance level while being negatively correlated with lnGHG with a value of -0.08 as well as with LEV and RD. The third financial performance measure, Tobin's Q, is positively related with lnGHG and CitationCount at the 1% significance level with correlations of 0.35 and 0.18, respectively, as well as with CapIntensity, GROWTH, and RD. Tobin's Q is moreover being negatively associated with Count and Citations with correlations of -0.13 and -0.10, respectively, as well as the control variables LEV and SIZE. Considering the environmental performance variables, they are both positively and significantly related with CitationCount with correlations of 0.18 and 0.10, respectively, as well as GROWTH and RD while being negatively linked to Count and Citations at the 1% significance level as well as SIZE. Additionally, lnGHG has a positive correlation with CapIntensity and negative correlations with LEV and CSR. GHGrev is negatively related to LEV. The relationship between lnGHG and GHGrev is found to be positive and significant at 0.56. Finally, Count and

Citations are both negatively correlated with CitationCount at -0.61 and -0.37, respectively, and RD as well as positively related with SIZE. Furthermore, Count has a significant negative relationship with LEV and Citations a positive association with CSR. Count and Citations have a strong positive correlation of 0.92. The third green innovation variable, CitationCount, has positive correlations with both LEV and CSR and a negative correlation with GROWTH.

Table 2
Correlation matrix

	ROA	ROE	Tobin's Q	lnGHG	GHGrev	Count	Citations	Citation Count	LEV	SIZE	Cap Intensity	GROWTH	RD	CSR
ROA	1													
ROE	0.52***	1												
Tobin's Q	0.39***	0.03	1											
lnGHG	-0.06	-0.08*	0.35***	1										
GHGrev	-0.09*	-0.05	0.04	0.56***	1									
Count	0.08*	0.02	-0.13***	-0.40***	-0.23***	1								
Citations	0.07	0.03	-0.10*	-0.40***	-0.22***	0.92***	1							
Citation-Count	-0.03	0.02	0.18***	0.18***	0.10*	-0.61***	-0.37***	1						
LEV	-0.28***	-0.18***	-0.16***	-0.13***	0.08*	-0.10**	0.02	0.24***	1					
SIZE	-0.05	0.05	-0.34***	-0.72***	-0.10**	0.34***	0.42***	-0.04	0.25***	1				
Cap-Intensity	0.24***	0.06	0.17***	0.30***	0.00	-0.01	-0.01	-0.02	-0.18***	-0.29***	1			
GROWTH	0.19***	0.10**	0.23***	0.14***	0.08*	0.01	-0.05	-0.08*	-0.13***	-0.10**	0.12**	1		
RD	-0.01	-0.12**	0.35***	0.62***	0.27***	-0.12**	-0.11**	0.06	-0.09*	-0.40***	0.39***	0.09*	1	
CSR	0.06	0.01	-0.05	-0.34***	-0.01	0.05	0.21***	0.17***	0.18***	0.43***	-0.14***	-0.17***	-0.15***	1

Figures in the table are pairwise correlations, calculated by $\sum_{i=1}^{n}(x_{1i}-\bar{x}_1)(x_{2i}-\bar{x}_2)\,/\sqrt{\sum_{i=1}^{n}(x_{1i}-\bar{x}_1)^2}\,\sqrt{\sum_{i=1}^{n}(x_{2i}-\bar{x}_2)^2}$, where $\bar{x}$ refers to mean value. The correlations for the two variables measuring environmental performance, lnGHG and GHGrev, are being shown after inverting. Therefore, higher values correspond to lower GHG emissions and better environmental performance. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.2 Environmental performance and financial performance

Table 3 presents the estimation results of equation (1). The results demonstrate that environmental performance has a significant positive effect on corporate investors' financial performance. This means that the lower a corporate investor's GHG emissions, the higher is 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 a 6.66 percentage points higher Tobin's Q, on average. This result is statistically significant at a 5% level. This confirms the results of Busch and Hoffmann (2011) who find that carbon intensity is negatively affecting Tobin's Q, as a measure depicting both short- as well as long-term financial performance. Similarly, a negative effect of GHG emissions on ROE is detected. The relationship between lnGHG and ROA is not found to be statistically significant. Using GHGrev as an explanatory variable, a positive and statistically significant result can be observed for all three measures of financial performance, with ROA being significant at a 5% level and ROE as well as Tobin's Q at 10%. This documented positive impact of environmental performance on corporate financial performance (H1) is in line with the previously discussed studies of Busch and Hoffmann (2011), Iwata and Okada (2011), as well as Ganda and Milondzo (2018), amongst others.

Further noteworthy relationships may be observed considering the control variables. First, a strong negative association exists between leverage and both ROA and Tobin's Q, demonstrating that higher leverage and therefore higher financial risk on average imply a lower financial performance for the CVC sample. Second, larger firms in terms of revenue seem to have lower ROA but higher ROE and Tobin's Q. Regarding capital intensity, it is interesting to observe that more capital-intensive firms enjoy better short-term financial performance, as measured by ROA and ROE. No statistically significant effect is found for Tobin's Q as a measure for both short- and long-term financial performance, however. Next, higher revenue growth has a positive and statistically significant impact on both ROA and Tobin's Q. Considering innovation capacity, the sample shows a negative effect on short-term financial performance and a strong positive effect on Tobin's Q, capturing short- and long-term performance. This result was expected as investments in R&D usually pay off more in the long term. Lastly, the CSR score seems to be positively related to corporate investors' financial performance (ROA and Tobin's Q), suggesting that both social and environmental performance positively affect financial performance which is in line with the previous findings of Gregory et al. (2016).

Table 3
Environmental performance and financial performance

	Panel A: lnGHG			*Panel B: GHGrev*		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	0.0011	0.0581*	0.0666**	0.0000**	0.0004*	0.0005*
	(0.0024)	(0.0299)	(0.0337)	(0.0000)	(0.0002)	(0.0003)
LEV	-0.0832***	-0.2200	-0.7860***	-0.0845***	-0.2210	-0.7870***
	(0.0168)	(0.2210)	(0.2490)	(0.0167)	(0.2210)	(0.2490)
SIZE	-0.0087***	0.1310***	-0.3160***	-0.0103***	0.0795**	-0.3750***
	(0.0028)	(0.0381)	(0.0429)	(0.0023)	(0.0317)	(0.0357)
CapIntensity	0.1540***	2.0510***	-0.0898	0.1560***	2.0700***	-0.0682
	(0.0151)	(0.2000)	(0.2250)	(0.0151)	(0.2000)	(0.2260)
GROWTH	0.0330**	0.2420	1.9220***	0.0297*	0.2370	1.9170***
	(0.0159)	(0.2140)	(0.2410)	(0.0159)	(0.2150)	(0.2420)
RD	-0.2240***	-1.2270**	2.3930***	-0.2420***	-0.9810**	2.6790***
	(0.0385)	(0.4890)	(0.5520)	(0.0342)	(0.4370)	(0.4920)
CSR	0.0006***	-0.0007	0.0129***	0.0006***	-0.0013	0.0122***
	(0.0002)	(0.0021)	(0.0024)	(0.0002)	(0.0021)	(0.0024)
Constant	0.0834***	-1.6040***	5.5110***	0.0911***	-1.8160***	5.2660***
	(0.0303)	(0.4000)	(0.4510)	(0.0271)	(0.3620)	(0.4090)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	1,124	984	984	1,124	984	984
R-squared	0.229	0.136	0.434	0.233	0.135	0.433

This table examines the effect of corporate investors' environmental performance on their respective financial performance. Models (1)-(3) make use of the variable lnGHG as a measure for environmental performance. Models (4)-(6) are based on GHGrev. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.3 Green innovation and financial performance

The results of equation (2) are summarized in Table 4. The effects of both the quantity (*Count*) and the quality (*Citations*) of green patents on corporate investors' financial performance are separately assessed. For both measures, similar results are obtained. Increased green innovation on average leads to a better financial performance in terms of ROA and Tobin's Q, in the underlying sample. The effects on ROA and Tobin's Q are positive and statistically significant at the 1% and 5% levels, respectively, therefore suggesting that green innovation pays off for corporate investors. As a consequence, the positive relationship between green innovation and financial performance (H2), as previously shown by Aguilera-Caracuel and Ortiz-de-Mandojana (2013), Przychodzen and Przychodzen (2015), as well as Scarpellini et al. (2019), is confirmed by the findings of this paper as both the short- and long-term financial performance of corporate investors seem to benefit from green innovation. Considering ROE, however, no significant results are observed. Lee and Min (2015) furthermore find a positive effect of green R&D on Tobin's Q in a sample consisting of Japanese manufacturing firms. The authors use green R&D expenditures instead of green patents, however, to measure green innovation.

Furthermore, the results suggest that this effect is decreased with leverage and firm size, as depicted by the negative and significant coefficients for LEV and SIZE. On the contrary, capital intensity, revenue growth, and CSR performance seem to support the positive impact of green innovation on financial performance. Another interesting result is found with respect to R&D expenditures. An increase in such expenses negatively affects ROA and ROE as short-term performance measures but has a positive impact on Tobin's Q. This finding may suggest that R&D expenses pay off mainly in the long term while imposing a financial burden in the short term.

Table 4
Green innovation and financial performance

	Panel A: Count			*Panel B: Citations*		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
INNOV	0.0043***	0.0247	0.0361**	0.0041***	0.0177	0.0373**
	(0.0011)	(0.0206)	(0.0164)	(0.0010)	(0.0191)	(0.0151)
LEV	-0.1130***	-0.1090	-0.9430***	-0.1130***	-0.1100	-0.9570***
	(0.0150)	(0.2990)	(0.2370)	(0.0150)	(0.2990)	(0.2370)
SIZE	-0.0119***	0.0148	-0.3980***	-0.0120***	0.0173	-0.4000***
	(0.0020)	(0.0406)	(0.0321)	(0.0020)	(0.0406)	(0.0321)
CapIntensity	0.1350***	2.0160***	0.4700**	0.1340***	2.0200***	0.4560**
	(0.0138)	(0.2700)	(0.2140)	(0.0138)	(0.2710)	(0.2140)
GROWTH	0.0437***	0.0956	1.8810***	0.0441***	0.0961	1.8850***
	(0.0112)	(0.2160)	(0.1710)	(0.0112)	(0.2160)	(0.1710)
RD	-0.3000***	-0.9270**	1.2310***	-0.3010***	-0.9160**	1.2150***
	(0.0221)	(0.4210)	(0.3330)	(0.0221)	(0.4210)	(0.3330)
CSR	0.0007***	0.0000	0.0179***	0.0007***	0.0001	0.0179***
	(0.0001)	(0.0025)	(0.0020)	(0.0001)	(0.0025)	(0.0020)
Constant	0.0988***	-1.3820***	4.8500***	0.0992***	-1.4030***	4.8700***
	(0.0216)	(0.4280)	(0.3390)	(0.0215)	(0.4290)	(0.3390)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	1,547	1,379	1,379	1,547	1,379	1,379
R-squared	0.280	0.079	0.407	0.281	0.079	0.408

This table examines the effect of corporate investors' green innovation on their respective financial performance. Models (1)-(3) make use of green patent count as a measure for green innovation. Models (4)-(6) are based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.4 Environmental performance, green innovation, and financial performance

After having confirmed both the positive effect of environmental performance on corporate investors' financial performance (H1) as well as the positive impact of green innovation on financial performance (H2), this study will consider the combined effect of environmental performance and green innovation on financial performance.

Table 5 is based on equation (3.1), demonstrating the effect of adding variables measuring both environmental performance and green innovation to the model. For this table, lnGHG is used as a measure of environmental performance. Considering green innovation, two variables are considered to capture green innovation quantity (*Count*) and quality (*Citations*). The results suggest a positive and highly significant relationship between green innovation and ROA at the 1% level, with no significant effect between the environmental performance measure and ROA. ROE, on the other hand, seems to be affected primarily by corporate investors' environmental performance. In this case, no significant impact of green innovation is found. Finally, 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 a clear indicator backing H3 by showing that both independent variables positively affect the financial performance of corporate investors. These results furthermore do not differ between the two considered 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, suggesting positive effects of both environmental performance as well as green innovation on the financial performance of corporate investors.

Table 5
Environmental performance, green innovation, and financial performance

	Panel A: lnGHG					
	Count			Citations		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	0.0012	0.0592**	0.0706**	0.0011	0.0588**	0.0691**
	(0.0023)	(0.0299)	(0.0336)	(0.0023)	(0.0299)	(0.0335)
INNOV	0.0035***	0.0149	0.0527***	0.0033***	0.0139	0.0503***
	(0.0012)	(0.0153)	(0.0172)	(0.0011)	(0.0138)	(0.0155)
LEV	-0.0860***	-0.2340	-0.8380***	-0.0868***	-0.2390	-0.8570***
	(0.0167)	(0.2210)	(0.2480)	(0.0167)	(0.2220)	(0.2490)
SIZE	-0.0108***	0.1250***	-0.3370***	-0.0109***	0.1250***	-0.3400***
	(0.0029)	(0.0386)	(0.0433)	(0.0029)	(0.0387)	(0.0434)
CapIntensity	0.1510***	2.0230***	-0.1880	0.1500***	2.0210***	-0.1990
	(0.0151)	(0.2020)	(0.2270)	(0.0151)	(0.2020)	(0.2270)
GROWTH	0.0332**	0.2390	1.9110***	0.0339**	0.2430	1.9240***
	(0.0159)	(0.2140)	(0.2400)	(0.0159)	(0.2140)	(0.2400)
RD	-0.2330***	-1.2650**	2.2580***	-0.2340***	-1.2660**	2.2530***
	(0.0385)	(0.4910)	(0.5510)	(0.0385)	(0.4910)	(0.5500)
CSR	0.0005***	-0.0009	0.0121***	0.0005***	-0.0009	0.0121***
	(0.0002)	(0.0021)	(0.0024)	(0.0002)	(0.0021)	(0.0024)
Constant	0.1030***	-1.5330***	5.7620***	0.1030***	-1.5350***	5.7630***
	(0.0309)	(0.4070)	(0.4560)	(0.0308)	(0.4060)	(0.4550)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	1,124	984	984	1,124	984	984
R-squared	0.236	0.137	0.439	0.236	0.137	0.440

This table examines the effect of corporate investors' environmental performance and green innovation on their respective financial performance. Models (1)-(6) are all based on lnGHG as a measure for environmental performance. Models (1)-(3) make use of green patent count as a measure for green innovation. Models (4)-(6) are based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Following the previously discussed findings supporting H3, another analysis is performed in order to strengthen the understanding of the nature of this relationship. Table 6 is based on equation (3.2) and differs from Table 5 in that another additional variable is added to the model, namely an interaction variable between environmental performance and green innovation, as denoted by *ENVPER*INNOV*. The results show that the interaction between environmental performance and green innovation has a positive and strongly significant impact on corporate investors' financial performance, measured by Tobin's Q. Considering the isolated effects in this model, an additional positive effect is grounded on green innovation while the isolated effect of environmental performance is found to be negative. Additionally, the analysis reveals a positive effect of the interaction term on firms' ROA, again with a negative effect of the isolated environmental performance measure and no significant effects for the remaining variables. As the citation-weighted count (*CitationCount*) is used as a measure for green innovation, the results suggest that the ratio between patent quality (*Citations*) and quantity

(*Count*) is indeed relevant. A better ratio between Citations and Count seems to entail an improved financial performance.

Table 6
Interaction between environmental performance and green innovation

	Panel A: lnGHG & CitationCount		
	(1)	(2)	(3)
Variables	ROA	ROE	Tobin's Q
ENVPER	-0.0093**	-0.0137	-0.1270*
	(0.0044)	(0.0110)	(0.0673)
INNOV	0.0521	0.1110	2.2160***
	(0.0335)	(0.0824)	(0.5050)
ENVPER*INNOV	0.0045*	0.0078	0.1840***
	(0.0026)	(0.0066)	(0.0403)
LEV	-0.0886***	-0.2520***	-0.9630***
	(0.0183)	(0.0468)	(0.2860)
SIZE	-0.0152***	0.0033	-0.3340***
	(0.0033)	(0.0088)	(0.0536)
CapIntensity	0.1480***	0.0838*	0.1090
	(0.0178)	(0.0476)	(0.2920)
GROWTH	0.0624***	0.1050**	1.3460***
	(0.0167)	(0.0440)	(0.2700)
RD	-0.1930***	-0.3160***	1.0850*
	(0.0430)	(0.1070)	(0.6580)
CSR	0.0007***	-0.0004	0.0117***
	(0.0002)	(0.0005)	(0.0028)
Constant	0.0209	-0.1200	3.6610***
	(0.0599)	(0.1520)	(0.9290)
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
Observations	804	695	695
R-squared	0.264	0.135	0.437

This table examines the effect of corporate investors' environmental performance, green innovation, and the interaction between both on their respective financial performance. Models (1)-(3) are all based on lnGHG as a measure for environmental performance and citation-weighted count as a proxy for green innovation. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5 Additional analyses & robustness checks

4.5.1 Difference between direct and indirect GHG emissions

After having considered total GHG emissions of corporate investors in the main part, it might be of interest to further analyze any potential differences between direct (Scope 1) and indirect (Scope 2) GHG emissions. While the short-term interest of corporations is certainly more focused on reducing and controlling emissions directly emitted by the company, long-term considerations might recognize the relevance of indirect emissions as well, as firms are becoming aware of the importance to reduce their energy consumption and the associated costs of higher energy consumption.

Table 7 shows the results of the regressions using equation (1) and replacing the original *ENVPER* variable by direct and indirect GHG emissions, respectively. Applying this modified research design, no significant results are found for the effect of the environmental performance on ROA. Considering the other two financial performance measures, however, it is interesting to note that a statistically significant positive effect of firms' environmental performance on corporate investors' ROE, using direct GHG emissions, can be observed. This confirms the notion that direct emissions should have an impact on the short-term performance with indirect emissions being less important in the short horizon. Indirect emissions, on the contrary, are found to have a strong negative effect on Tobin's Q, depicting both short- and long-term performance, as showed by the significant positive result for the environmental performance coefficient. This confirms the notion that the entire supply chain should be of interest to shareholders in the long term. Compared to the results presented in Table 3, it seems that total emissions are more meaningful in determining firms' financial performance than direct or indirect emissions in isolation. Nonetheless, both direct and indirect emissions seem to entail a certain degree of explanatory power.

Table 7

Environmental performance and financial performance (direct and indirect emissions)

	Panel A: Direct (Scope 1)			*Panel B: Indirect (Scope 2)*		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	-0.0007	0.0489*	0.0044	-0.0014	0.0375	0.1190***
	(0.0019)	(0.0262)	(0.0282)	(0.0027)	(0.0352)	(0.0374)
LEV	-0.0868***	-0.2520	-0.8590***	-0.0870***	-0.2090	-0.9520***
	(0.0176)	(0.2490)	(0.2680)	(0.0189)	(0.2570)	(0.2720)
SIZE	-0.0097***	0.1400***	-0.3730***	-0.0100***	0.1350***	-0.2810***
	(0.0028)	(0.0402)	(0.0433)	(0.0033)	(0.0456)	(0.0484)
CapIntensity	0.1660***	2.3270***	-0.1620	0.1640***	2.3950***	-0.2540
	(0.0158)	(0.2280)	(0.2460)	(0.0167)	(0.2310)	(0.2450)
GROWTH	0.0232	0.2680	2.1760***	0.0206	0.2740	2.0030***
	(0.0168)	(0.2440)	(0.2630)	(0.0179)	(0.2500)	(0.2650)
RD	-0.2080***	-1.1010**	2.7920***	-0.2010***	-0.8930*	2.4730***
	(0.0380)	(0.5230)	(0.5620)	(0.0407)	(0.5340)	(0.5670)
CSR	0.0006***	0.0005	0.0138***	0.0006***	0.0002	0.0154***
	(0.0002)	(0.0024)	(0.0026)	(0.0002)	(0.0024)	(0.0026)
Constant	0.0611**	-2.1460***	5.1900***	0.0525	-2.2570***	5.7250***
	(0.0298)	(0.4280)	(0.4610)	(0.0334)	(0.4520)	(0.4790)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	975	858	858	958	841	841
R-squared	0.243	0.153	0.444	0.225	0.151	0.453

This table examines the effect of corporate investors' environmental performance on their respective financial performance. Models (1)-(3) make use of Scope 1 emissions as a measure for environmental performance. Models (4)-(6) are based on Scope 2 emissions. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5.2 *Effect of Scope 3 GHG emissions*

While Scope 1 and Scope 2 emissions remain the focus areas to improve for many firms, the reduction of Scope 3 emissions may be of comparable interest to stakeholders and regulators. Scope 3 emissions include indirect emissions related to activities such as employee business travel, waste disposal, contractor-owned vehicles, and outsources activities as well as emissions from the product use by customers and the production of purchased materials (Bhatia et al., 2004).

As presented in Table 8, the results of the analysis using Scope 3 emissions as the measure for environmental performance show a positive and statistically significant effect on ROA. Therefore, firms may benefit from a reduction in their Scope 3 emissions which is consistent with the previous results based on Scope 1 and 2 emissions. Considering ROE and Tobin's Q, however, the analysis does not find significant results. This might be an indicator showing that Scope 3 emissions in isolation have not been sufficiently considered by firms and their stakeholders to have an impact on their financial performance. Nonetheless, the results attribute Scope 3 emissions certain importance in determining corporate financial performance.

Table 8
Environmental performance and financial performance (Scope 3 emissions)

	Panel A: Indirect (Scope 3)		
	(1)	(2)	(3)
Variables	ROA	ROE	Tobin's Q
ENVPER	0.0033**	-0.0086	-0.0165
	(0.0015)	(0.0245)	(0.0244)
LEV	-0.0823***	-0.1070	-1.1340***
	(0.0241)	(0.3930)	(0.3920)
SIZE	-0.0052	0.0998*	-0.4140***
	(0.0033)	(0.0537)	(0.0537)
CapIntensity	0.1500***	3.5790***	-0.6620*
	(0.0218)	(0.3620)	(0.3610)
GROWTH	0.0264	0.3200	2.3510***
	(0.0217)	(0.3380)	(0.3370)
RD	-0.2570***	-0.7290	3.1460***
	(0.0444)	(0.6790)	(0.6780)
CSR	0.0006**	0.0009	0.0149***
	(0.0002)	(0.0039)	(0.0039)
Constant	0.0759**	-3.3320***	5.5640***
	(0.0382)	(0.6030)	(0.6030)
Year FE	YES	YES	YES
Industry FE	YES	YES	YES
Observations	648	562	562
R-squared	0.220	0.193	0.459

This table examines the effect of corporate investors' environmental performance on their respective financial performance. Models (1)-(3) are based on Scope 3 emissions as a measure for environmental performance. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5.3 Effect of lagged performance variables on financial performance

This section aims at replicating all three previously analyzed hypotheses with lagged performance variables. In a first step, the effect of lagged environmental performance on financial performance is examined. Next, the green innovation variables are being lagged in order to investigate their effect on corporate investors' financial performance. Last, these lagged variables are combined in the interaction term previously introduced in Table 6.

As the effect of a firm's environmental performance on its financial performance might only be reflected with a delay, it must be of interest to evaluate the impact of previous years' environmental performance on current financial performance. Therefore, Table 9 shows the results for one- as well as two-year lagged environmental performance variables. The results demonstrate the positive relationship between lagged environmental performance and financial performance. Considering lnGHG, a positive 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 positive and significant relationship is found with regards to Tobin's Q, as a measure for both short- and long-term performance. Similar results are found with regards to GHGrev as an environmental performance variable, with positive and significant results for ROA and ROE in the one-period lag case as well as for all three variables in the two-period scenario.

Table 9
Lagged environmental performance and financial performance

	Panel A: One-period lag (t-1)						*Panel B: Two-period lag (t-2)*					
	lnGHG			GHGrev			lnGHG			GHGrev		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	0.0014	0.0651**	0.0553	0.0001**	0.0007**	0.0004	0.0019	0.0562	0.0684*	0.0001**	0.0006*	0.0006*
	(0.0025)	(0.0328)	(0.0346)	(0.0000)	(0.0003)	(0.0003)	(0.0025)	(0.0355)	(0.0358)	(0.0000)	(0.0003)	(0.0003)
LEV	-0.0868***	-0.2390	-0.8870***	-0.0889***	-0.2570	-0.8940***	-0.0787***	-0.2080	-0.9410***	-0.0814***	-0.2310	-0.9650***
	(0.0174)	(0.2420)	(0.2560)	(0.0174)	(0.2430)	(0.2560)	(0.0182)	(0.2650)	(0.2670)	(0.0182)	(0.2650)	(0.2680)
SIZE	-0.0089***	0.1300***	-0.3010***	-0.0111***	0.0679*	-0.3490***	-0.0092***	0.1230***	-0.3290***	-0.0117***	0.0703*	-0.3910***
	(0.0029)	(0.0413)	(0.0436)	(0.0024)	(0.0353)	(0.0372)	(0.0029)	(0.0442)	(0.0447)	(0.0025)	(0.0377)	(0.0381)
CapIntensity	0.1570***	2.1740***	-0.2180	0.1600***	2.2080***	-0.1950	0.1470***	2.2610***	-0.3360	0.1510***	2.3010***	-0.2910
	(0.0154)	(0.2160)	(0.2280)	(0.0154)	(0.2160)	(0.2280)	(0.0159)	(0.2350)	(0.2370)	(0.0159)	(0.2350)	(0.2370)
GROWTH	0.0273	0.2160	1.8540***	0.0292*	0.2840	1.9110***	0.0316*	0.2040	2.1330***	0.0340*	0.2800	2.2250***
	(0.0167)	(0.2370)	(0.2500)	(0.0165)	(0.2350)	(0.2480)	(0.0180)	(0.2720)	(0.2740)	(0.0177)	(0.2670)	(0.2700)
RD	-0.2320***	-1.4510**	3.1980***	-0.2600***	-1.3450**	3.4050***	-0.2510***	-1.3620**	2.6040***	-0.2750***	-1.2890**	2.7610***
	(0.0422)	(0.5660)	(0.5970)	(0.0393)	(0.5300)	(0.5600)	(0.0420)	(0.5900)	(0.5960)	(0.0389)	(0.5490)	(0.5540)
CSR	0.0005***	-0.0007	0.0133***	0.0004**	-0.0014	0.0126***	0.0004*	-0.0004	0.0159***	0.0003*	-0.0010	0.0152***
	(0.0002)	(0.0024)	(0.0025)	(0.0002)	(0.0024)	(0.0025)	(0.0002)	(0.0027)	(0.0027)	(0.0002)	(0.0026)	(0.0026)
Constant	0.0994***	-1.5390***	5.1820***	0.1100***	-1.7090***	4.9760***	0.1210***	-1.6780***	5.5910***	0.1300***	-1.8270***	5.3750***
	(0.0321)	(0.4450)	(0.4700)	(0.0289)	(0.4070)	(0.4290)	(0.0333)	(0.4820)	(0.4870)	(0.0297)	(0.4370)	(0.4410)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,031	901	901	1,031	901	901	947	823	823	946	823	823
R-squared	0.235	0.144	0.439	0.239	0.145	0.438	0.234	0.145	0.444	0.238	0.146	0.444

This table examines the effect of one- and two-period lagged corporate investors' environmental performance on their respective financial performance. Models (1)-(6) are using one-period lagged environmental performance measures with models (1)-(3) making use of the variable lnGHG as a measure for environmental performance and models (4)-(6) being based on GHGrev. Models (7)-(12) are using two-period lagged environmental performance measures with models (7)-(9) making use of the variable lnGHG as a measure for environmental performance and models (10)-(12) being based on GHGrev. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Similar to the previously discussed effect of lagged environmental performance on financial performance, the effect of lagged green innovation on financial performance is of interest as new firm innovations might only be reflected in the financial performance with a time lag. Appendix B replicates the results shown in Table 4, considering both one-period and two-period lagged green innovation variables. The findings are similar to the previously discussed results. One additional outcome, however, is that the effect of green innovation on Tobin's Q as a financial performance measure loses its significance in the two-year lag case. Therefore, green innovation seems to have a greater impact on corporate investors' financial performance in the shorter term.

The lagged results for the regressions shown in Table 5 can be found in Appendix C. More interestingly, replicating the results previously shown in Table 6 with a time lag indicates the joint effect of lagged environmental performance and green innovation measures on corporate investors' financial performance. Table 10 below makes use of lnGHG as an environmental performance indicator as well as CitationCount as a measure for green innovation to show the joint effect on financial performance. Similar to the results presented in Table 6, this analysis finds a positive and highly significant (1%) effect of the interaction variable (*ENVPER*INNOV)* on Tobin's Q. Again, the isolated effects of INNOV and ENVPER are highly significant with a positive impact of INNOV and a negative association between ENVPER and Tobin's Q. These findings provide further evidence supporting H3.

Table 10
Lagged environmental performance, green innovation, and interaction

	Panel A: lnGHG & CitationCount					
	One-period lag (t-1)			Two-period lag (t-2)		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	-0.0028	-0.0052	-0.3230***	-0.0034	-0.0000	-0.3130***
	(0.0055)	(0.0150)	(0.0902)	(0.0061)	(0.0161)	(0.0988)
INNOV	-0.0074	0.0642	4.2920***	0.0224	0.0630	4.4960***
	(0.0499)	(0.1350)	(0.8100)	(0.0570)	(0.1500)	(0.9210)
ENVPER*INNOV	0.0006	0.0040	0.3480***	0.0020	0.0055	0.3620***
	(0.0039)	(0.0109)	(0.0654)	(0.0045)	(0.0121)	(0.0743)
LEV	-0.0913***	-0.2740***	-1.0700***	-0.0805***	-0.2270***	-0.9860***
	(0.0181)	(0.0488)	(0.2930)	(0.0186)	(0.0503)	(0.3090)
SIZE	-0.0137***	0.0048	-0.3260***	-0.0152***	0.0090	-0.3770***
	(0.0033)	(0.0093)	(0.0558)	(0.0033)	(0.0095)	(0.0583)
CapIntensity	0.1480***	0.0785	-0.1280	0.1330***	0.0660	-0.3620
	(0.0176)	(0.0498)	(0.2990)	(0.0178)	(0.0507)	(0.3110)
GROWTH	0.0539***	0.0978**	1.4110***	0.0621***	0.0900*	1.6520***
	(0.0171)	(0.0474)	(0.2840)	(0.0184)	(0.0517)	(0.3170)
RD	-0.2020***	-0.3400***	1.6360**	-0.2450***	-0.4100***	1.0210
	(0.0453)	(0.1200)	(0.7190)	(0.0435)	(0.1150)	(0.7060)
CSR	0.0006***	-0.0005	0.0130***	0.0005***	-0.0006	0.0159***
	(0.0002)	(0.0005)	(0.0029)	(0.0002)	(0.0005)	(0.0032)
Constant	0.1120	-0.0045	1.0400	0.1210	0.0629	1.6720
	(0.0773)	(0.2090)	(1.2540)	(0.0839)	(0.2240)	(1.3730)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	754	651	651	705	608	608
R-squared	0.266	0.136	0.451	0.264	0.140	0.472

This table examines the effect of one- and two-period lagged corporate investors' environmental performance, green innovation, and interaction between both on their respective financial performance. Models (1)-(6) are all based on lnGHG as a measure for environmental performance and citation-weighted count as a proxy for green innovation. Models (1)-(3) are using one-period lagged measures while models (4)-(6) are using two-period lagged variables. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5.4 Robustness over time

While all previous analyses were performed over the entire sample period, differences between earlier and later years might reasonably be expected, as the importance of GHG emissions has dramatically increased in recent years. Therefore, the following tables separately consider the results of the three hypotheses for the periods 2002-2010 as well as 2011-2019.

First, Table 11 breaks equation (1) into the two separate periods. For the earlier period, only the effect of firms' environmental performance on Tobin's Q can be confirmed. For ROA and ROE, no statistically significant results are obtained. Therefore, short-term financial performance seems to be relatively unaffected by firms' environmental performance whereas their combined short- and long-term performance, as measured by Tobin's Q, significantly depends on GHG emissions in this period. For the period between 2011-2019, positive and significant relationships are found for all three financial performance measures (ROA, ROE, and Tobin's Q) with regards to GHG emissions intensity. Considering lnGHG, the only statistically significant result exists with regards to ROE. Overall, it seems that the impact of corporate environmental on financial performance has increased over time, primarily with regards to short-term performance measures.

Table 11
Different time periods (environmental performance)

	Panel A: Period 2002-2010						*Panel B: Period 2011-2019*					
	lnGHG			GHGrev			lnGHG			GHGrev		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	-0.0005	-0.0005	0.1220***	0.0000	0.0001	0.0005**	0.0020	0.1010**	0.0506	0.0001***	0.0011**	0.0012***
	(0.0043)	(0.0134)	(0.0456)	(0.0000)	(0.0001)	(0.0003)	(0.0028)	(0.0446)	(0.0447)	(0.0000)	(0.0004)	(0.0004)
LEV	-0.1370***	-0.5120***	-0.8920***	-0.1400***	-0.5190***	-0.8920***	-0.0610***	-0.2130	-0.9170***	-0.0643***	-0.2260	-0.9510***
	(0.0309)	(0.0963)	(0.3270)	(0.0310)	(0.0964)	(0.3290)	(0.0201)	(0.3390)	(0.3400)	(0.0199)	(0.3390)	(0.3390)
SIZE	-0.0036	0.0124	-0.0900	-0.0035	0.0122	-0.1860***	-0.0089***	0.1920***	-0.4060***	-0.0127***	0.0885*	-0.4740***
	(0.0054)	(0.0173)	(0.0589)	(0.0044)	(0.0143)	(0.0488)	(0.0033)	(0.0559)	(0.0560)	(0.0027)	(0.0474)	(0.0473)
CapIntensity	0.1970***	0.2240**	1.2660***	0.1970***	0.2240**	1.3780***	0.1490***	2.7250***	-0.4860*	0.1540***	2.7630***	-0.4420
	(0.0321)	(0.1030)	(0.3510)	(0.0319)	(0.1030)	(0.3510)	(0.0168)	(0.2820)	(0.2830)	(0.0167)	(0.2820)	(0.2820)
GROWTH	0.0513**	0.1530*	0.4220	0.0471*	0.1420	0.4110	0.0092	0.3110	2.7140***	0.0051	0.3130	2.6850***
	(0.0253)	(0.0857)	(0.2910)	(0.0254)	(0.0863)	(0.2950)	(0.0207)	(0.3370)	(0.3380)	(0.0205)	(0.3370)	(0.3360)
RD	-0.2860***	-0.5980***	0.0788	-0.3050***	-0.6370***	0.6710	-0.1920***	-1.4700**	2.7710***	-0.2450***	-1.3290*	2.4200***
	(0.0688)	(0.2150)	(0.7290)	(0.0623)	(0.1950)	(0.6650)	(0.0461)	(0.7370)	(0.7390)	(0.0419)	(0.6820)	(0.6810)
CSR	0.0007**	-0.0009	0.0043	0.0007**	-0.0009	0.0027	0.0005**	-0.0010	0.0186***	0.0004**	-0.0019	0.0182***
	(0.0003)	(0.0008)	(0.0028)	(0.0003)	(0.0008)	(0.0028)	(0.0002)	(0.0034)	(0.0034)	(0.0002)	(0.0034)	(0.0034)
Constant	-0.0049	-0.0494	3.9260***	0.0064	-0.0267	3.2500***	0.0998***	-2.0400***	6.0870***	0.1260***	-2.2070***	6.2390***
	(0.0594)	(0.1860)	(0.6300)	(0.0512)	(0.1620)	(0.5520)	(0.0352)	(0.5890)	(0.5910)	(0.0321)	(0.5500)	(0.5490)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	406	348	348	406	348	348	717	636	636	717	636	636
R-squared	0.318	0.228	0.414	0.319	0.229	0.408	0.203	0.170	0.481	0.218	0.172	0.486

This table examines the effect of corporate investors' environmental performance on their respective financial performance, divided into two periods. Models (1)-(6) are based on the period between 2002-2010 with models (1)-(3) making use of the variable lnGHG as a measure for environmental performance and models (4)-(6) being based on GHGrev. Models (7)-(12) consider the period from 2011-2019 with models (7)-(9) making use of the variable lnGHG as a measure for environmental performance and models (10)-(12) being based on GHGrev. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Moving towards H2, the results in Appendix D confirm the findings from Table 4 for the period between 2002-2010. Green innovation positively affects both ROA and Tobin's Q with no significant effect on ROE. Considering the later period between 2011-2019, however, the only positive and significant result is found between Citations and ROA. These findings suggest that the effect of green innovation on corporate investors' financial performance became more relevant in recent years.

Having evaluated the time-robustness of H1 and H2, Appendix E breaks down the results of Table 5 into the two different periods to analyze the robustness of H3. Considering environmental performance, the previously discussed positive and significant effect on ROE is confirmed for the period from 2011-2019 while the positive impact on Tobin's Q can be observed for the period between 2002-2019. Furthermore, Appendix E presents positive and significant results for the effect of green innovation on all three financial performance variables in the earlier period. In comparison, the baseline results for the entire sample did not show significant results for ROE. In the latter period, however, a positive and significant result is only found with relation to Tobin's Q. Overall, there seems to be a certain extent of variation in the results over the years. The overall positive relationship between environmental performance, green innovation, and financial performance, however, is confirmed across the varying periods.

As previously described in Table 6, the interaction between environmental performance and green innovation has relevant implications for the evaluation of their effect on financial performance. Table 12 below summarizes this effect for the two different periods and confirms the positive effect of the interaction term between environmental performance and green innovation on the financial performance of corporate investors. This effect, however, is only found during the period between 2011-2019. While Table 6 indicated an effect on ROA and Tobin's Q, Table 12 shows positive and significant results for both ROE and Tobin's Q but not for ROA. These results demonstrate that the relevance of environmental performance and green innovation has increased over time and positively affects corporate investors' financial performance.

Table 12
Different time periods (environmental performance, green innovation, and interaction)

	Panel A: lnGHG & CitationCount					
	Period: 2002-2010			Period: 2011-2019		
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	0.0318	0.0378	0.6370**	-0.0150***	-0.0157**	-0.2410***
	(0.0263)	(0.0924)	(0.3130)	(0.0051)	(0.0064)	(0.0907)
INNOV	-0.3900	-0.5710	-5.1530	0.0477	0.1040**	2.2020***
	(0.3130)	(1.0830)	(3.6740)	(0.0338)	(0.0422)	(0.5980)
ENVPER*INNOV	-0.0292	-0.0456	-0.4510	0.0042	0.0078**	0.1860***
	(0.0250)	(0.0884)	(0.3000)	(0.0027)	(0.0034)	(0.0476)
LEV	-0.1220***	-0.5950***	-0.6440*	-0.0685***	-0.0132	-1.1120***
	(0.0316)	(0.1070)	(0.3620)	(0.0224)	(0.0289)	(0.4100)
SIZE	-0.0104*	0.0049	-0.1270*	-0.0173***	0.0093*	-0.5170***
	(0.0057)	(0.0200)	(0.0679)	(0.0040)	(0.0053)	(0.0754)
CapIntensity	0.1870***	0.1460	1.3180***	0.1220***	0.0393	-0.4740
	(0.0344)	(0.1230)	(0.4160)	(0.0200)	(0.0269)	(0.3820)
GROWTH	0.0456*	0.1570*	0.2110	0.0827***	0.0453	2.3300***
	(0.0250)	(0.0926)	(0.3140)	(0.0227)	(0.0282)	(0.4000)
RD	-0.3410***	-0.5940**	-0.5290	-0.0481	-0.0819	1.8350*
	(0.0689)	(0.2350)	(0.7970)	(0.0544)	(0.0670)	(0.9500)
CSR	0.0009***	-0.0010	0.0038	0.0004*	-0.0003	0.0164***
	(0.0003)	(0.0010)	(0.0034)	(0.0002)	(0.0003)	(0.0040)
Constant	0.5060	0.5840	10.4400**	-0.0151	-0.2540***	4.1540***
	(0.3460)	(1.1900)	(4.0370)	(0.0673)	(0.0864)	(1.2250)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	323	271	271	480	423	423
R-squared	0.356	0.227	0.454	0.227	0.130	0.482

This table examines the effect of corporate investors' environmental performance, green innovation, and interaction between both on their respective financial performance, divided into two periods. Models (1)-(6) are all based on lnGHG as a measure for environmental performance and citation-weighted count as a proxy for green innovation. Models (1)-(3) consider the period between 2002-2010 while models (4)-(6) consider the period from 2011-2019. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

4.5.5 Relationship between green innovation and environmental performance

While all previously presented analyses considered the effects of either environmental performance, green innovation, or both on financial performance, the direct relationship between the different environmental performance and green innovation measures might be of interest as well. The results presented in Table 13 indicate that both the green patent count as well as green patent citations positively affect GHGrev as an environmental performance measure. No impact is found with respect to lnGHG. Considering the citation-weighted count, a positive and statistically significant result is only found regarding lnGHG. Overall, these results add to the previous findings by Lee and Min (2015), suggesting a positive relationship between environmental performance and green innovation.

Table 13
Green innovation and environmental performance

	Panel A: Count		*Panel B: Citations*		*Panel C: CitationCount*	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	lnGHG	GHGrev	lnGHG	GHGrev	lnGHG	GHGrev
INNOV	-0.0063	3.6430*	-0.0002	3.7480**	0.2430**	7.8740
	(0.0149)	(1.9210)	(0.0136)	(1.7530)	(0.0992)	(9.4710)
LEV	0.0494	28.8900	0.0445	27.6900	-0.2410	42.1300*
	(0.2170)	(28.0000)	(0.2170)	(28.0100)	(0.2390)	(22.8700)
SIZE	-0.7130***	17.7800***	-0.7170***	17.5000***	-0.6780***	15.7100***
	(0.0307)	(3.9650)	(0.0307)	(3.9610)	(0.0353)	(3.3700)
CapIntensity	-0.0457	-49.1200*	-0.0524	-50.0600**	-0.1400	-70.2500***
	(0.1950)	(25.2300)	(0.1950)	(25.2300)	(0.2310)	(22.0600)
GROWTH	0.6170***	98.6600***	0.6170***	99.4000***	0.6720***	48.1500**
	(0.2050)	(26.4700)	(0.2050)	(26.4600)	(0.2170)	(20.7600)
RD	9.0700***	656.1000***	9.0560***	654.0000***	8.6590***	528.4000***
	(0.4160)	(53.7600)	(0.4170)	(53.7800)	(0.4700)	(44.8500)
CSR	-0.0080***	0.3930	-0.0081***	0.3890	-0.0129***	-0.1190
	(0.0021)	(0.2690)	(0.0021)	(0.2690)	(0.0023)	(0.2170)
Constant	-6.4450***	-343.0000***	-6.4110***	-341.2000***	-6.7420***	-256.5000***
	(0.3500)	(45.2000)	(0.3490)	(45.1000)	(0.4600)	(43.9700)
Year FE	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Observations	1,124	1,124	1,124	1,124	804	804
R-squared	0.764	0.298	0.764	0.299	0.770	0.292

This table examines the effect of corporate investors' green innovation on their respective environmental performance. Models (1)-(2) make use of green patent count as a measure for green innovation, models (3)-(4) are based on green patent citations, and models (5-6) use citation-weighted count as a proxy for green innovation. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

5. Conclusions

This paper examines the effect of GHG emissions and green innovation on the financial performance of corporate investors and demonstrates that both better environmental performance and more green innovation positively affect corporate investors' financial performance. To date, it is the first paper considering the effect of GHG emissions as well as green innovation in a CVC context. The study is using the data of U.S. corporate investors between 2002-2019. It is building on existing research from three different fields including literature on CVC performance, on the relationship between environmental and financial performance, as well as on the impact of green innovation on financial performance. Following existing literature, GHG emissions are used as a proxy to measure corporate environmental performance and green patent data, including patent count and citations, is applied to indicate green innovation performance.

First, the impact of GHG emissions on financial performance is analyzed. The results show that environmental performance has a positive effect on corporate investors' financial performance. Firms with lower GHG emissions on average have a better short- (ROA, ROE, and Tobin's Q) and long-term (Tobin's Q) financial performance. These results prove robust to the type of GHG emissions, namely Scope 1, Scope 2, and Scope 3 emissions. Better results, however, are found with regards to total GHG emissions (sum of Scope 1 and Scope 2 emissions), compared to the individual measures. As the effect of GHG emissions may only be reflected in firm financial performance with a time delay, lagged environmental performance measures are further introduced. It appears that the relationship between environmental and financial performance similarly exists for both one- and two-year lagged variables. Additionally, this paper finds evidence that this effect is stronger for more recent years, comparing the period between 2002-2010 to the years from 2011-2019. Therefore, firms should consider their emissions as part of their overall corporate strategy to increase profitability. As costs remain one of the major constraints for many firms to adopt carbon-reducing measures, governments and policymakers must provide the necessary incentives for firms to reduce their carbon emissions. In the specific case of corporate investors, societal changes may be an additional driver for this effect, as stakeholders increasingly demand performance factors other than purely financial results. This mind shift will certainly continue to impact corporations, as the entire society is continuously increasing its awareness of the need for ecological and social change.

Second, this paper evaluates the impact of green innovation on corporate investors' financial performance. The results show that firms with more green innovation, in terms of both quantity (patent count) and quality (patent citations) on average have a better financial performance. These findings, however, are only confirmed for ROA and Tobin's Q as financial performance measures. With regards to ROE, no significant results are obtained. The results are furthermore found to be robust over time and can be confirmed using one- and two-period lagged green innovation variables. Additionally, a positive relationship between environmental performance and green innovation is found. Therefore, firms with more green innovation seem to have lower GHG emissions. These findings suggest that green innovation may be a tool for corporations to generate a significant and sustainable competitive advantage. Considering sustainability as part of firms' innovation strategy may help firms to cope with the increasing pressure exercised by their stakeholders and the overall society to reduce carbon emissions. Green innovation is undoubtedly one of the key instruments for reducing GHG emissions. Therefore, further investments into new green technologies are necessary and should accordingly be supported by national governments and policymakers.

Finally, this study combines both previous analyses by investigating the joint effect of environmental performance and green innovation on the financial performance of U.S.

corporate investors. The results indicate that the interplay of the two independent variables positively affects corporate financial performance in the sample. As a consequence, there is no way around considering GHG emissions and green innovation as part of corporate investors' overall strategies. Even for corporate investors that are not being convinced by the positive effects of sustainable business practices on our planet and society, neglecting the necessity to reduce carbon emissions and to drive green innovation may further impact their financial performance. The potential positive financial effects discussed in this paper may provide an incentive for such firms to adapt their strategies.

Based on the aforementioned results, this paper entails important implications for research and practice. It builds a strong foundation for further studies to analyze either the isolated or the combined effects of GHG emissions and green innovation on the financial performance of corporate investors. Simultaneously, it illustrates the necessity for corporate investors to include ecological considerations into their overall strategies. As previous studies show, CVC investments allow investors to acquire the necessary resources for a sustainable competitive advantage (Battisti et al., 2022). Governments and policymakers must provide incentives for companies to reduce their emissions and to drive green innovation while creating the necessary framework to support CVC investments. Although regulations and incentives already exist in many developed countries, problems remain in certain less developed countries and markets (Rokhmawati et al., 2015, 2017).

While this paper contributes significantly to existing literature related to CVC activities, it has some limitations. First, the sample used in this paper is exclusively comprised of corporate investors. Future studies could compare the results obtained for corporate investors with individual venture capitalists or corporations without investment activity. This would allow extrapolating the effect of CVC investments. Additionally, this study is limited to U.S. firms and could be expanded to other countries. It would be of particular interest to consider the impact of carbon policies of different countries on the results of this paper. Another effect of considering different countries would be an increase in sample size which might further improve the robustness of the results, as this paper is based on a rather narrow sample due to data availability. Finally, another limitation is related to the variables measuring green innovation, mainly because of variations between the actual innovation date, the patent application date, and the grant date. Although adjustments are made to reduce potential biases in the patent citations variable, the estimated citation-lag distribution might not perfectly represent the actual distribution of green patent citations over their lifetime. Similarly, a truncation bias might exist regarding the patent count variable which could be further investigated in a subsequent study.

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Appendix A

Variable descriptions

Panel A: Dependent and independent variables		
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
INNOV	Green innovation	
Count	Green patent count	The natural logarithm of one plus the green patent count
Citations	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		
LEV	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
RD	Innovation capacity	The ratio of R&D expenditures to revenue
CSR	CSR performance	The average of the social and environmental performance scores reported by the Refinitiv Eikon database

Appendix B

Lagged green innovation and financial performance

	Panel A: One-period lag (t-1)						*Panel B: Two-period lag (t-2)*					
	Count			Citations			Count			Citations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
INNOV	0.0038***	0.0133	0.0322*	0.0037***	0.0126	0.0360**	0.0038***	0.0153	0.0206	0.0039***	0.0149	0.0257
	(0.0011)	(0.0114)	(0.0165)	(0.0010)	(0.0107)	(0.0154)	(0.0011)	(0.0118)	(0.0165)	(0.0010)	(0.0112)	(0.0156)
LEV	-0.1110***	-0.2060	-0.8320***	-0.1120***	-0.2100	-0.8480***	-0.1110***	-0.2290	-0.7760***	-0.1120***	-0.2330	-0.7880***
	(0.0152)	(0.1660)	(0.2400)	(0.0152)	(0.1670)	(0.2400)	(0.0157)	(0.1730)	(0.2420)	(0.0157)	(0.1730)	(0.2420)
SIZE	-0.0122***	0.0647***	-0.4390***	-0.0123***	0.0646***	-0.4420***	-0.0134***	0.0649***	-0.4190***	-0.0135***	0.0648***	-0.4220***
	(0.0021)	(0.0234)	(0.0338)	(0.0021)	(0.0234)	(0.0338)	(0.0022)	(0.0249)	(0.0349)	(0.0022)	(0.0249)	(0.0348)
CapIntensity	0.1390***	1.5070***	0.4630**	0.1390***	1.5050***	0.4480**	0.1440***	1.5480***	0.3340	0.1430***	1.5460***	0.3230
	(0.0139)	(0.1500)	(0.2160)	(0.0139)	(0.1500)	(0.2160)	(0.0142)	(0.1550)	(0.2170)	(0.0142)	(0.1550)	(0.2170)
GROWTH	0.0336***	0.0546	1.9360***	0.0338***	0.0551	1.9400***	0.0366***	0.0701	2.0240***	0.0367***	0.0702	2.0270***
	(0.0115)	(0.1220)	(0.1760)	(0.0115)	(0.1220)	(0.1760)	(0.0122)	(0.1290)	(0.1810)	(0.0121)	(0.1290)	(0.1810)
RD	-0.2800***	-0.4800**	1.0960***	-0.2810***	-0.4820**	1.0730***	-0.3050***	-0.5300*	1.7970***	-0.3070***	-0.5340*	1.7680***
	(0.0229)	(0.2400)	(0.3470)	(0.0229)	(0.2400)	(0.3470)	(0.0261)	(0.2790)	(0.3910)	(0.0261)	(0.2790)	(0.3910)
CSR	0.0008***	-0.0015	0.0192***	0.0008***	-0.0015	0.0192***	0.0008***	-0.0016	0.0197***	0.0008***	-0.0016	0.0196***
	(0.0001)	(0.0014)	(0.0020)	(0.0001)	(0.0014)	(0.0020)	(0.0001)	(0.0015)	(0.0021)	(0.0001)	(0.0015)	(0.0021)
Constant	0.0972***	-1.4330***	5.1590***	0.0973***	-1.4320***	5.1860***	0.1060***	-1.4450***	4.9220***	0.1070***	-1.4450***	4.9510***
	(0.0223)	(0.2440)	(0.3530)	(0.0223)	(0.2440)	(0.3520)	(0.0234)	(0.2600)	(0.3630)	(0.0233)	(0.2590)	(0.3630)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,479	1,317	1,317	1,479	1,317	1,317	1,414	1,258	1,258	1,414	1,258	1,258
R-squared	0.267	0.104	0.417	0.268	0.104	0.418	0.266	0.107	0.424	0.267	0.107	0.425

This table examines the effect of one- and two-period lagged corporate investors' green innovation on their respective financial performance. Models (1)-(6) are using one-period lagged green innovation measures with models (1)-(3) making use of green patent count as a measure for green innovation and models (4)-(6) being based on green patent citations. Models (7)-(12) are using two-period lagged green innovation measures with models (7)-(9) making use of green patent count as a measure for green innovation and models (10)-(12) being based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix C

Lagged environmental performance, green innovation, and financial performance

	Panel A: lnGHG											
	One-period lag (t-1)						Two-period lag (t-2)					
	Count			Citations			Count			Citations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin’s Q	ROA	ROE	Tobin’s Q	ROA	ROE	Tobin’s Q	ROA	ROE	Tobin’s Q
ENVPER	0.0015	0.0663**	0.0592*	0.0014	0.0658**	0.0579*	0.0018	0.0568	0.0702**	0.0017	0.0564	0.0691*
	(0.0024)	(0.0329)	(0.0345)	(0.0024)	(0.0329)	(0.0344)	(0.0025)	(0.0355)	(0.0357)	(0.0025)	(0.0355)	(0.0356)
INNOV	0.0037***	0.0151	0.0533***	0.0034***	0.0137	0.0554***	0.0035***	0.0166	0.0472***	0.0033***	0.0151	0.0521***
	(0.0012)	(0.0164)	(0.0172)	(0.0011)	(0.0151)	(0.0158)	(0.0012)	(0.0176)	(0.0177)	(0.0011)	(0.0164)	(0.0165)
LEV	-0.0915***	-0.2610	-0.9630***	-0.0924***	-0.2650	-0.9920***	-0.0836***	-0.2340	-1.0140***	-0.0844***	-0.2370	-1.0410***
	(0.0174)	(0.2430)	(0.2550)	(0.0174)	(0.2440)	(0.2560)	(0.0182)	(0.2660)	(0.2680)	(0.0182)	(0.2670)	(0.2680)
SIZE	-0.0112***	0.1230***	-0.3240***	-0.0113***	0.1230***	-0.3270***	-0.0115***	0.1160***	-0.3500***	-0.0115***	0.1160***	-0.3530***
	(0.0030)	(0.0419)	(0.0440)	(0.0030)	(0.0419)	(0.0439)	(0.0030)	(0.0449)	(0.0452)	(0.0030)	(0.0449)	(0.0451)
CapIntensity	0.1530***	2.1450***	-0.3210	0.1530***	2.1440***	-0.3400	0.1440***	2.2310***	-0.4230*	0.1440***	2.2310***	-0.4410*
	(0.0153)	(0.2180)	(0.2290)	(0.0154)	(0.2180)	(0.2290)	(0.0158)	(0.2370)	(0.2380)	(0.0158)	(0.2370)	(0.2380)
GROWTH	0.0275*	0.2120	1.8410***	0.0275*	0.2130	1.8410***	0.0317*	0.1970	2.1130***	0.0313*	0.1960	2.1050***
	(0.0166)	(0.2370)	(0.2490)	(0.0166)	(0.2370)	(0.2480)	(0.0180)	(0.2720)	(0.2730)	(0.0180)	(0.2720)	(0.2730)
RD	-0.2400***	-1.4850***	3.0770***	-0.2400***	-1.4810***	3.0740***	-0.2560***	-1.3910**	2.5210***	-0.2560***	-1.3890**	2.5140***
	(0.0421)	(0.5680)	(0.5960)	(0.0421)	(0.5670)	(0.5940)	(0.0419)	(0.5910)	(0.5950)	(0.0419)	(0.5910)	(0.5930)
CSR	0.0004**	-0.0010	0.0123***	0.0004**	-0.0010	0.0122***	0.0003	-0.0008	0.0149***	0.0003	-0.0008	0.0147***
	(0.0002)	(0.0024)	(0.0025)	(0.0002)	(0.0024)	(0.0025)	(0.0002)	(0.0027)	(0.0027)	(0.0002)	(0.0027)	(0.0027)
Constant	0.1220***	-1.4610***	5.4550***	0.1200***	-1.4680***	5.4680***	0.1410***	-1.5980***	5.8200***	0.1400***	-1.6070***	5.8370***
	(0.0328)	(0.4530)	(0.4760)	(0.0327)	(0.4520)	(0.4740)	(0.0339)	(0.4900)	(0.4920)	(0.0337)	(0.4880)	(0.4900)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,031	901	901	1,031	901	901	947	823	823	947	823	823
R-squared	0.242	0.145	0.445	0.242	0.145	0.447	0.241	0.146	0.449	0.241	0.146	0.451

This table examines the effect of one- and two-period lagged corporate investors' environmental performance and green innovation on their respective financial performance. Models (1)-(12) are all based on lnGHG as a measure for environmental performance. Models (1)-(6) are using one-period lagged green innovation measures with models (1)-(3) making use of green patent count as a measure for green innovation and models (4)-(6) being based on green patent citations. Models (7)-(12) are using two-period lagged green innovation measures with models (7)-(9) making use of green patent count as a measure for green innovation and models (10)-(12) being based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix D

Different time periods (green innovation and financial performance)

	Panel A: Period 2002-2010						*Panel B: Period 2011-2019*					
	Count			Citations			Count			Citations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
INNOV	0.0063***	0.0191	0.0428*	0.0061***	0.0154	0.0387*	0.0022	0.0232	0.0319	0.0020*	0.0175	0.0324
	(0.0015)	(0.0343)	(0.0222)	(0.0015)	(0.0345)	(0.0224)	(0.0014)	(0.0227)	(0.0237)	(0.0012)	(0.0189)	(0.0198)
LEV	-0.2000***	-0.2020	-1.8360***	-0.2000***	-0.1950	-1.8270***	-0.0661***	-0.1420	-0.5410*	-0.0667***	-0.1500	-0.5560*
	(0.0249)	(0.5770)	(0.3730)	(0.0249)	(0.5770)	(0.3740)	(0.0181)	(0.2860)	(0.2990)	(0.0181)	(0.2870)	(0.2990)
SIZE	-0.0078**	-0.0262	-0.2790***	-0.0076**	-0.0239	-0.2760***	-0.0114***	0.0959**	-0.4630***	-0.0115***	0.0964**	-0.4660***
	(0.0032)	(0.0733)	(0.0475)	(0.0032)	(0.0733)	(0.0475)	(0.0025)	(0.0416)	(0.0434)	(0.0025)	(0.0417)	(0.0434)
CapIntensity	0.1610***	1.7670***	1.7260***	0.1610***	1.7720***	1.7310***	0.1350***	2.3080***	-0.3410	0.1340***	2.3100***	-0.3540
	(0.0242)	(0.5510)	(0.3570)	(0.0242)	(0.5510)	(0.3570)	(0.0159)	(0.2490)	(0.2600)	(0.0159)	(0.2490)	(0.2600)
GROWTH	0.0474***	-0.0114	1.2580***	0.0471***	-0.0124	1.2560***	0.0190	0.3370	2.8280***	0.0196	0.3410	2.8400***
	(0.0142)	(0.3230)	(0.2090)	(0.0142)	(0.3230)	(0.2090)	(0.0190)	(0.2880)	(0.3010)	(0.0190)	(0.2890)	(0.3010)
RD	-0.3910***	-1.1730*	0.1090	-0.3900***	-1.1640*	0.1200	-0.1690***	-0.4190	2.7230***	-0.1710***	-0.4270	2.6740***
	(0.0302)	(0.6630)	(0.4290)	(0.0303)	(0.6630)	(0.4290)	(0.0325)	(0.5040)	(0.5270)	(0.0327)	(0.5070)	(0.5290)
CSR	0.0007***	0.0010	0.0121***	0.0007***	0.0010	0.0121***	0.0006***	-0.0032	0.0250***	0.0006***	-0.0031	0.0249***
	(0.0002)	(0.0042)	(0.0027)	(0.0002)	(0.0042)	(0.0027)	(0.0002)	(0.0028)	(0.0029)	(0.0002)	(0.0028)	(0.0029)
Constant	0.0570*	-0.8630	3.5130***	0.0553	-0.8800	3.4920***	0.0861***	-2.1620***	5.2320***	0.0869***	-2.1710***	5.2640***
	(0.0344)	(0.7880)	(0.5100)	(0.0344)	(0.7880)	(0.5100)	(0.0277)	(0.4430)	(0.4630)	(0.0277)	(0.4440)	(0.4630)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	727	653	653	727	653	653	820	726	726	820	726	726
R-squared	0.384	0.078	0.415	0.383	0.078	0.414	0.224	0.146	0.474	0.225	0.145	0.475

This table examines the effect of corporate investors' green innovation on their respective financial performance, divided into two periods. Models (1)-(6) are based on the period between 2002-2010 with models (1)-(3) making use of green patent count as a measure for green innovation and models (4)-(6) being based on green patent citations. Models (7)-(12) consider the period from 2011-2019 with models (7)-(9) making use of green patent count as a measure for green innovation and models (10)-(12) being based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Appendix E

Different time periods (environmental performance, green innovation, and financial performance)

	Panel A: lnGHG											
	Period: 2002-2010						Period: 2011-2019					
	Count			Citations			Count			Citations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q	ROA	ROE	Tobin's Q
ENVPER	0.0006	0.0041	0.1430***	0.0005	0.0039	0.1420***	0.0019	0.1010**	0.0497	0.0018	0.1000**	0.0480
	(0.0043)	(0.0135)	(0.0456)	(0.0043)	(0.0135)	(0.0456)	(0.0028)	(0.0446)	(0.0446)	(0.0028)	(0.0446)	(0.0446)
INNOV	0.0056***	0.0130**	0.0591***	0.0054***	0.0128**	0.0573***	0.0022	0.0228	0.0508**	0.0021	0.0170	0.0492**
	(0.0019)	(0.0059)	(0.0198)	(0.0019)	(0.0058)	(0.0197)	(0.0015)	(0.0253)	(0.0253)	(0.0013)	(0.0212)	(0.0211)
LEV	-0.1490***	-0.5450***	-1.0450***	-0.1480***	-0.5440***	-1.0370***	-0.0615***	-0.2240	-0.9400***	-0.0623***	-0.2310	-0.9670***
	(0.0308)	(0.0969)	(0.3270)	(0.0308)	(0.0969)	(0.3270)	(0.0201)	(0.3400)	(0.3390)	(0.0201)	(0.3400)	(0.3400)
SIZE	-0.0074	0.0075	-0.1130*	-0.0073	0.0077	-0.1110*	-0.0101***	0.1830***	-0.4260***	-0.0103***	0.1830***	-0.4310***
	(0.0055)	(0.0174)	(0.0587)	(0.0055)	(0.0174)	(0.0587)	(0.0034)	(0.0567)	(0.0567)	(0.0034)	(0.0569)	(0.0568)
CapIntensity	0.1850***	0.1800*	1.0680***	0.1860***	0.1810*	1.0750***	0.1460***	2.6870***	-0.5710**	0.1460***	2.6900***	-0.5870**
	(0.0320)	(0.1050)	(0.3540)	(0.0320)	(0.1050)	(0.3540)	(0.0168)	(0.2850)	(0.2850)	(0.0168)	(0.2850)	(0.2850)
GROWTH	0.0523**	0.1460*	0.3920	0.0520**	0.1460*	0.3920	0.0093	0.3120	2.7150***	0.0100	0.3180	2.7330***
	(0.0250)	(0.0852)	(0.2880)	(0.0250)	(0.0853)	(0.2880)	(0.0207)	(0.3380)	(0.3370)	(0.0207)	(0.3380)	(0.3370)
RD	-0.3030***	-0.6550***	-0.1800	-0.3010***	-0.6510***	-0.1590	-0.1970***	-1.5030**	2.6980***	-0.1980***	-1.5050**	2.6700***
	(0.0684)	(0.2150)	(0.7250)	(0.0684)	(0.2150)	(0.7250)	(0.0462)	(0.7380)	(0.7380)	(0.0462)	(0.7390)	(0.7370)
CSR	0.0007**	-0.0008	0.0043	0.0007**	-0.0008	0.0044	0.0004*	-0.0016	0.0174***	0.0004*	-0.0014	0.0173***
	(0.0003)	(0.0008)	(0.0028)	(0.0003)	(0.0008)	(0.0028)	(0.0002)	(0.0035)	(0.0035)	(0.0002)	(0.0035)	(0.0035)
Constant	0.0378	0.0511	4.3810***	0.0351	0.0458	4.3530***	0.1120***	-1.9460***	6.2970***	0.1120***	-1.9620***	6.3130***
	(0.0604)	(0.1900)	(0.6410)	(0.0603)	(0.1900)	(0.6400)	(0.0360)	(0.5990)	(0.5980)	(0.0359)	(0.5980)	(0.5960)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	406	348	348	406	348	348	717	636	636	717	636	636
R-squared	0.334	0.240	0.429	0.333	0.239	0.429	0.206	0.171	0.485	0.206	0.171	0.486

This table examines the effect of corporate investors' environmental performance and green innovation on their respective financial performance, divided into two periods. Models (1)-(12) are all based on lnGHG as a measure for environmental performance. Models (1)-(6) consider the period between 2002-2010 with models (1)-(3) making use of green patent count as a measure for green innovation and models (4)-(6) being based on green patent citations. Models (7)-(12) consider the period from 2011-2019 with models (7)-(9) making use of green patent count as a measure for green innovation and models (10)-(12) being based on green patent citations. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.