Business Strategy and the Environment

WILEY | Business Strategy and the Environment

RESEARCH ARTICLE OPEN ACCESS

International Evidence on How Investors Value Environmental Innovation: Non-Pecuniary Investor Preferences or Risk Mitigation?

Ellen Pei-yi Yu[1] | Bac Van Luu[2] | Dominic H. Chai[3,4] | Alessandra Tanda[5,6]

[1]Birkbeck Business School, Birkbeck, University of London, London, UK | [2]Russell Investments, London, UK | [3]College of Business Administration, Loyola Marymount University, Los Angeles, California, USA | [4]Centre for Business Research, University of Cambridge, Cambridge, UK | [5]Department of Economics and Management, University of Pavia, Pavia, Italy | [6]Department of Economics, University of Insubria, Varese, Italy

Correspondence: Dominic H. Chai (dominic.chai@lmu.edu)

Received: 9 October 2025 | **Revised:** 1 June 2026 | **Accepted:** 11 June 2026

Keywords: environment | environmental innovation | investor expectations | non-pecuniary preferences | risk mitigation | sustainability

ABSTRACT

We study how environmental innovation shapes investor expectations. We propose two mechanisms through which sustained improvements in environmental innovation may influence these expectations: non-pecuniary investor preferences and risk mitigation. Using an international sample, we find that long-term improvements in environmental innovation materially influence investor expectations, as reflected in a lower ex-ante cost of equity and higher market valuation. Our evidence further highlights the moderating role of intra-industry R&D dispersion, which captures firms' risk of falling behind their industry peers technologically. We show that investors do not reward environmental innovation unconditionally; they value sustained improvements in environmental innovation more when firms operate in industries with higher R&D dispersion because they perceive that such improvements will likely lower risks of technological lag and transition-related vulnerability. Overall, our findings suggest that sustained improvements in environmental innovation shape investor expectations primarily through the risk mitigation mechanism rather than through the non-pecuniary investor preference channel.

JEL Classification: G3, G15, L2, O3, Q55

1 | Introduction

A company's environmental innovation activities can contribute to addressing environmental challenges and aligning with long-term sustainability objectives. Working towards the global net-zero target by 2050 (e.g., IPCC 2018), many companies are increasing investment in environmental innovation in response to stricter regulations worldwide (e.g., IMF 2023). If investors value these efforts, it is likely that capital will flow to companies that lead in environmental innovation and away from those that lag.

Following the prior literature, we define environmental innovation as a company's ability to reduce environmental risks and address environmental challenges through the development of environmentally beneficial products, processes and technologies (e.g., Angelo et al. 2012; European Commission 2012; Zaman et al. 2023). This definition differentiates environmental innovation from broader environmental performance and sustainability disclosure. Environmental performance reflects current environmental outcomes, while sustainability disclosure concerns the communication of environmental information.

Importantly, compared with broader sustainability characteristics, environmental innovation exhibits several features that complicate investor evaluation. Innovation activities often face high failure rates at early stages and typically require a long time to yield results (e.g., Acharya et al. 2013; Derrien et al. 2023). At the same time, capital markets are slow to recognise the value of intangible assets, including environmental innovation (e.g., Chan et al. 2001; Edmans 2012). These features make it difficult for investors to assess the true value of environmental innovation in the short run. Building on these insights, we pose a central question: how do investors perceive environmental innovation, and through which mechanisms do these perceptions operate?

Most prior studies tend to treat environmental innovation as a single construct and do not distinguish the mechanisms through which investors assess such innovation. An exception is Iqbal et al. (2022), who show that organisational capital strengthens the positive association between environmental innovation and firm value among US-listed firms. In their study, environmental innovation is measured through product and process innovation. While their study focuses on the moderating role of organisational capital, we focus on two mechanisms through which environmental innovation may shape investor expectations: risk mitigation mechanism and non-pecuniary preferences. Under the non-pecuniary preference mechanism, investors may value environmental innovation because it aligns with sustainability preferences or institutional mandates, independently of its direct impact on firm risk. Under the risk mitigation mechanism, sustained environmental innovation reduces firms' exposure to environmental, regulatory and technological risks, leading investors to require lower risk premia and lower financing costs (higher market valuations).

We also highlight the moderating role of intra-industry R&D dispersion, which captures heterogeneity in firms' R&D intensity within the same industry. In industries characterised by large dispersion in R&D intensity, firms are more unevenly positioned relative to the technological frontier. In such industries, sustained improvements in environmental innovation are more likely to be interpreted by investors as reducing the financial risk of technological lag and transition-related vulnerability. Therefore, we argue that the risk mitigation effect of sustained improvements in environmental innovation is stronger in industries with greater intra-industry R&D dispersion.

To examine these mechanisms, we analyse an international sample of 1464 companies from the MSCI All Country World Index covering 29 high-income and 12 non-high-income economies. To align with our definition, we measure a firm's capacity for environmental innovation using the Refinitiv Environmental Innovation Score, which aggregates more than 40 company-level indicators, including environmental R&D investment, green product development and environmentally beneficial technologies. Importantly, this is a performance-oriented measure of environmental innovation rather than a disclosure score. Our measure encompasses environmental innovation activities that may not be reflected in patent applications but are economically meaningful for investors (e.g., Nadeem et al. 2020; Iqbal et al. 2022; Zaman et al. 2023).

To capture investor expectations, we employ two forward-looking measures widely used in the finance literature: the ex-ante cost of equity and Tobin's Q (e.g., Aggarwal and Dow 2011; Breuer et al. 2018; El Ghoul et al. 2018; Yu et al. 2018). Companies seeking to maximise value aim to reduce equity financing costs (by lowering the ex-ante cost of equity) while enhancing market valuation (by increasing Tobin's Q).

Our empirical specification allows us to disentangle the relative contributions of the two proposed mechanisms. We propose that the non-pecuniary preference mechanism operates primarily through the direct effect of environmental innovation, whereas the risk mitigation mechanism operates through both the direct and interaction effects. This distinction matters because if investor responses are primarily preference-based, the valuation effect of environmental innovation should not systematically depend on intra-industry R&D dispersion. By contrast, if the mechanism operates through risk mitigation, the valuation effect should be stronger precisely where firms face a greater risk of falling behind the technological frontier. This interaction effect is grounded in models of competition and innovation developed by Aghion et al. (2005) and Acemoglu et al. (2006), which suggest that firms better positioned relative to the technological frontier face lower risks of displacement and competitive erosion. Empirically, the direct effect of sustained environmental innovation improvements is associated with higher financing costs and has no significant effect on Tobin's Q. By contrast, the interaction with intra-industry R&D dispersion significantly lowers financing costs and increases market valuations. Taken together, the combined effects imply lower financing costs (a 1.082% decline in the cost of equity) and higher market valuations (a 2.45% increase in Tobin's Q), particularly in industries with high dispersion of R&D investment where the risk of falling behind competitors is greater. The magnitudes are economically meaningful and comparable to those reported in the broader ESG and cost-of-capital literature, including Chava (2014), Breuer et al. (2018) and El Ghoul et al. (2018).

Our study contributes to the literature in two ways. First, we contribute to the sustainable finance literature by clarifying the mechanisms through which investors interpret environmental innovation, distinguishing between risk mitigation and non-pecuniary preference channels. Second, we help reconcile the mixed empirical evidence in prior ESG research by showing that the financial relevance of environmental innovation is conditional on competitive industry structure: investors value environmental innovation primarily when it mitigates competitive technological risk. More broadly, our findings also speak to the policy debate on sustainability reporting. If environmental innovation is financially material to investors, especially when firms face greater competitive technological risk, then reporting frameworks should facilitate more comparable and decision-useful, firm-level information on environmental innovation across countries and industries.

2 | Theoretical Framework, Hypothesis Development and Measurement

In this section, we synthesise the literature that informs our theoretical framework and empirical design. We start by defining environmental innovation and discussing its distinctive features, which underpin our theoretical arguments and subsequent empirical analyses. From the investor's perspective, we then develop two mechanisms through which environmental innovation may influence investor expectations: non-pecuniary investor preferences and risk mitigation. Building on these mechanisms, we derive two testable hypotheses. Lastly, we discuss the measurement of environmental innovation, drawing on prior literature and data-provider documentation across countries.

2.1 | Environmental Innovation: Definition and Distinctive Features

Following the sustainability and innovation literature (e.g., Angelo et al. 2012; European Commission 2012; Zaman et al. 2023), we define environmental innovation as a company's ability to reduce environmental risks and address environmental challenges through the development of environmentally beneficial products, processes and technologies. A company with stronger environmental innovation demonstrates a greater capacity to develop new green products, generate revenue from environmentally friendly products, invest in environmental R&D relative to its peers and implement innovative environmental technologies.

This definition differentiates environmental innovation from broader environmental performance and sustainability disclosure. Environmental performance reflects current environmental outcomes, while sustainability disclosure concerns the communication of environmental information. By contrast, environmental innovation captures the firm's substantive innovation activities and capabilities directed toward environmental improvement.

We argue that environmental innovation encounters challenges similar to those associated with general innovation activity. Prior research broadly recognises that a company's innovation takes time and that markets are also slow to recognise its intangible value. A rich prior literature documents that a company's innovation activities can take several years to yield results due to the likelihood of failures at the early stage (e.g., Acharya et al. 2013; Francis et al. 2011; Tian and Wang 2014). The likelihood of early-stage failures arises because a company's innovation often involves adopting untested approaches or new technologies. Derrien et al. (2023) echo a similar view that innovation outcomes are relatively infrequent at the one-year horizon, so they propose measuring a company's innovation performance over 5 years.

Related literature also shows that markets are slow to price intangible assets. Investors find it difficult to gather material information, while managers face the challenge of assigning credible values to these intangible assets (e.g., Chan et al. 2001; Leendertse et al. 2021). Among these studies, Edmans (2012) documents that it takes markets four to 5 years to fully incorporate intangible assets. These features are especially relevant for environmental innovation, whose effects often materialise gradually through improved technologies, cleaner production processes and new green products.

We incorporate the distinctive features of environmental innovation into the development of our two testable hypotheses. Our empirical analysis focuses on companies' long-term improvements in environmental innovation, given the substantial lag between the initiation of environmental innovation and its realisation, as well as the long time required for markets to recognise its value.

2.2 | Prior Literature on How Investors Perceive and Price Sustainability-Related Information

The prior literature documents that investors' portfolio decisions are shaped not only by conventional risk–return considerations but also by non-pecuniary preferences, including social norms, personal beliefs and values. Using US data, Hong and Kacperczyk (2009) examine publicly listed "sin" stocks in the alcohol, tobacco and gaming industries and show that social norms can affect market valuation. A related strand of literature focuses more directly on sustainability and ESG information. Using a natural experiment in the US mutual fund market, Hartzmark and Sussman (2019) find that investors respond to sustainability ratings, consistent with the view that sustainability may be valued partly for non-pecuniary reasons. Baker et al. (2022) provide related revealed-preference evidence, showing that investors are willing to pay about 20 basis points more per year for an ESG index fund than for an otherwise similar non-ESG fund.

Survey-based studies also show that sustainability-related investment decisions reflect both financial and non-financial motives. Based on a survey of institutional investors, Krueger et al. (2020) conclude that investors view climate risks as financially material. Using survey data linked to Vanguard retail investors' portfolio holdings, Giglio et al. (2025) report that some investors may value ESG because they expect superior financial outcomes, while others may invest for ethical, identity-based or impact-related reasons.

Environmental innovation may therefore be interpreted by investors in different ways. Some investors may view sustained improvements in environmental innovation as costly or uncertain, particularly because innovation activities often involve lengthy development cycles and high failure risks. Others may view such improvements as evidence that the firm is better prepared for future regulation, changing demand for environmentally friendly products and transition-related risks. Still others may value environmental innovation because it aligns with their non-pecuniary sustainability preferences.

Building on this literature, we develop two mechanisms through which environmental innovation may shape investor expectations: non-pecuniary investor preferences and risk mitigation. The former focuses on investors' preferences for sustainability-related attributes, while the latter focuses on whether environmental innovation reduces firms' exposure to future risks. We now describe these two mechanisms in greater detail and develop our testable hypotheses.

2.3 | Non-Pecuniary Investor Preference Mechanism

The first mechanism is the non-pecuniary investor preference mechanism. Investors motivated by non-pecuniary sustainability preferences may prioritise environmental innovation over and above its financial reward and risk implications. Under the non-pecuniary investor preference mechanism, investors value firms' long-term improvements in environmental innovation because such advances align with their sustainability preferences, personal beliefs or institutional mandates, independently of any direct effect on firm risk.

This mechanism is rooted in a growing literature which argues that investment decisions are not explained by conventional risk–return considerations alone (e.g., Cui et al. 2019; Urbain 2014). For example, Pástor et al. (2021) formalise the conditions under which sustainable investing can arise in equilibrium when investors have taste-based preferences for sustainability characteristics. Hartzmark and Sussman (2019) show that fund flows respond strongly to sustainability rankings. Under this view, environmental innovation can affect firm value by attracting investors who place positive value on environmental alignment as a non-pecuniary attribute. If this is the case, valuation effects operate through investors' preferences rather than through perceived changes in firm risk or cash flows.

However, some investors view sustainability activities negatively. For example, climate change scepticism may be linked to political conservatism (e.g., Rutjens et al. 2018; Rutjens et al. 2022). Likewise, sceptical investors may perceive CSR as diverting scarce resources away from core business operations, thereby harming financial performance (e.g., Barnea and Rubin 2010). Some scholars suggest that managers may use corporate social responsibility (CSR) initiatives to align with their own social preferences at the expense of shareholders (e.g., Richardson and Welker 2001).

The non-pecuniary investor preference mechanism does not necessarily predict a uniformly positive market response. Rather, investor valuation depends on whether the dominant investor clientele assigns positive or negative non-financial value to environmental innovation. The mechanism is therefore demand-based: environmental innovation may attract investors who place positive non-financial value on environmental alignment. Other investors may view environmental innovation as costly, politically contentious or a diversion from core business operations.

If the dominant investor clientele places positive non-financial value on sustained improvements in environmental innovation because these improvements align with their non-pecuniary sustainability preferences, the firm's ex-ante cost of equity will decline and its Tobin's Q will increase. The opposite may occur if the dominant investor clientele assigns negative non-financial value to such improvements.

If the dominant investor clientele places a positive value on firms' long-term improvements in environmental innovation because of non-pecuniary preferences, they should lower the cost of equity and raise Tobin's Q through the direct effect of the key explanatory variable. Accordingly, we propose the following hypothesis:

Hypothesis 1. *If the dominant investor clientele values sustained improvements in environmental innovation because such improvements align with its non-pecuniary sustainability preferences, the firm's ex-ante cost of equity will decline and its Tobin's Q will increase. The opposite effect occurs if the dominant investor clientele views such improvements as inconsistent with its non-pecuniary preferences.*

2.4 | Risk Mitigation Mechanism: Direct Effect and Interaction Effect

The second mechanism is risk mitigation. Based on our definition of environmental innovation, this mechanism suggests that investors value sustained improvements in environmental innovation because they reduce firms' exposure to future risks. Such risks include stricter environmental regulations, future environmental liabilities, technological obsolescence, shifting customer demand for green products and broader environmental transition-related risks. Companies with sustained improvements in environmental innovation may therefore be better positioned to adapt to the environmental transition. As a result, investors may require lower risk premia and assign higher valuations to these firms.

We argue that the risk mitigation mechanism operates through two related channels: direct effect and interaction effect. First, sustained improvements in environmental innovation may have a direct risk-reducing effect if investors view such improvements as evidence that firms are better prepared for environmental challenges. Second, the risk mitigation effect is stronger in industries with higher R&D dispersion, where firms face a greater risk of falling behind technologically advanced peers. We therefore distinguish between the direct effect of environmental innovation and its interaction effect with intra-industry R&D dispersion.

2.4.1 | Risk Mitigation Mechanism: Direct Effect

The direct effect of the risk mitigation mechanism is rooted in the idea that environmental innovation can reduce firms' exposure to transition-related risks. Firms with stronger environmental innovation capabilities may be less vulnerable to environmental regulation, technological obsolescence and competitive displacement (e.g., Benkraiem et al. 2023; Flammer 2013, 2015; Leendertse et al. 2021). Prior research also suggests that companies actively engaged in climate mitigation efforts are more effective in mitigating regulatory, physical and financial risks (e.g., Boiral et al. 2012; Lemma et al. 2021). Investors may therefore view these firms as less risky, require lower risk premia and assign higher market valuations.

This risk-based interpretation is particularly relevant in the current regulatory environment. National and regional legal frameworks increasingly expose firms to legal and financial consequences when they fail to fulfil environmental responsibilities. For instance, France's 2017 corporate duty of vigilance law requires French companies with more than 5000 employees to manage environmental risks and human rights issues (Business and Human Rights Resource Centre, n.d.). Non-compliant firms may face court orders to fulfil their vigilance obligations and may incur civil liabilities. Such developments suggest that environmental innovation may reduce financial risk by improving firms' preparedness for stricter environmental governance.

The direct effect of risk mitigation arises when investors perceive sustained improvements in environmental innovation as risk-reducing. Such improvements should be associated with a lower ex-ante cost of equity and a higher Tobin's Q.

2.4.2 | Risk Mitigation Mechanism: Interaction Effect Through the Moderating Role of Intra-Industry R&D Dispersion

We argue that the risk mitigation mechanism may operate not only through the direct effect of sustained improvement in environmental innovation, but also through its interaction effect with intra-industry R&D dispersion.

We use intra-industry R&D dispersion to capture the extent to which firms face the risk of falling behind their industry peers technologically. When R&D dispersion is high, firms are more unevenly positioned relative to the technological frontier. In such industries, sustained improvements in environmental innovation are more likely to be interpreted by investors as reducing the financial risk from technological lag and transition-related vulnerability. Accordingly, the risk-mitigation effect of environmental innovation should be stronger in industries with greater intra-industry R&D dispersion.

This argument is grounded in the models of competition and innovation, which suggest firms better positioned relative to the technological frontier face lower risks of displacement and competitive erosion (Aghion et al. 2005; Acemoglu et al. 2006). The innovation literature also suggests that firms are affected not only by their own R&D investment but also by the R&D investment of other firms in the same industry (e.g., Chen et al. 2013; Nguyen and Kecskés 2020). Building on this insight, we argue that intra-industry dispersion of R&D intensity helps identify the circumstances under which environmental innovation is particularly relevant for investors' risk assessments.

We view intra-industry R&D dispersion as a measure of the heterogeneity in firms' innovative positioning within an industry. When intra-industry R&D dispersion is low, firms invest in innovation at relatively similar levels, and the risk of technological lag is less pronounced. By contrast, when intra-industry R&D dispersion is high, some firms invest heavily in innovation while others invest much less. This creates greater asymmetry in technological position and increases the risk that lagging firms will face technological obsolescence, competitive erosion and displacement by more innovative peers.

In industries with high R&D dispersion, sustained improvements in environmental innovation should therefore be relevant to investors' risk appraisals. Firms that improve their environmental innovation capabilities in these settings can reduce the financial risks of falling behind competitors in environmentally relevant technologies, products and processes. Investors should therefore view environmental innovation as more valuable when it helps firms protect their competitive position and reduce future financial risk arising from environmental challenges.

To capture the moderating role of intra-industry R&D dispersion, we employ the coefficient of variation, a normalised measure of dispersion calculated as the ratio of the standard deviation to the mean (e.g., Hibbs and Locking 2000; Barron and Waddell 2003). If firms within an industry invest similar proportions of sales or assets in R&D, the industry has relatively low R&D dispersion. Conversely, if a few firms invest heavily in R&D while others invest much less, intra-industry R&D dispersion is high. We therefore interpret intra-industry R&D dispersion as capturing competitive technological risk exposure.

Accordingly, we propose the following Hypotheses 2a and 2b:

Hypothesis 2a. *Risk mitigation mechanism: direct effect*

If investors perceive sustained improvements in environmental innovation as reducing firms' risk exposure to regulatory, technological and transition-related risks, such improvements will be associated with a lower ex-ante cost of equity and a higher Tobin's Q.

Hypothesis 2b. *Risk mitigation mechanism: interaction effect*

This risk mitigation effect of sustained improvements in environmental innovation will be stronger in industries with higher intra-industry R&D dispersion, where firms face greater risk of falling technologically behind industry peers.

Empirically, Hypotheses 2a and 2b predict two related effects. First, if investors sustain improvements in environmental innovation unconditionally, the direct effect should be associated with a lower cost of equity and higher market valuation. Second, if investors value sustained improvements in environmental innovation because it mitigates competitive technological risk, the interaction between sustained improvements in environmental innovation and intra-industry R&D dispersion should be negatively associated with the ex-ante cost of equity and positively associated with Tobin's Q. This interaction effect allows us to test whether environmental innovation is especially valued in industries where it helps reduce the risk of falling behind technologically.

Lastly, Figure 1 visualises our theoretical framework, which links long-term improvements in environmental innovation to forward-looking investor expectations and illustrates the development of our two hypotheses.

2.5 | Measurement of Environmental Innovation

As discussed in Section 2.1, we define environmental innovation as the firm's ability to address environmental challenges through the development of environmentally beneficial products, processes and technologies. This definition implies that environmental innovation is broader than patenting activity, as not all environmental innovations result in patent applications and patenting practices vary across countries and industries (e.g., Archibugi and Planta 1996; Leippold and Yu 2026). Moreover, our empirical measure should capture firm-level environmental innovation activities in a way that is equivalent across countries and industries.

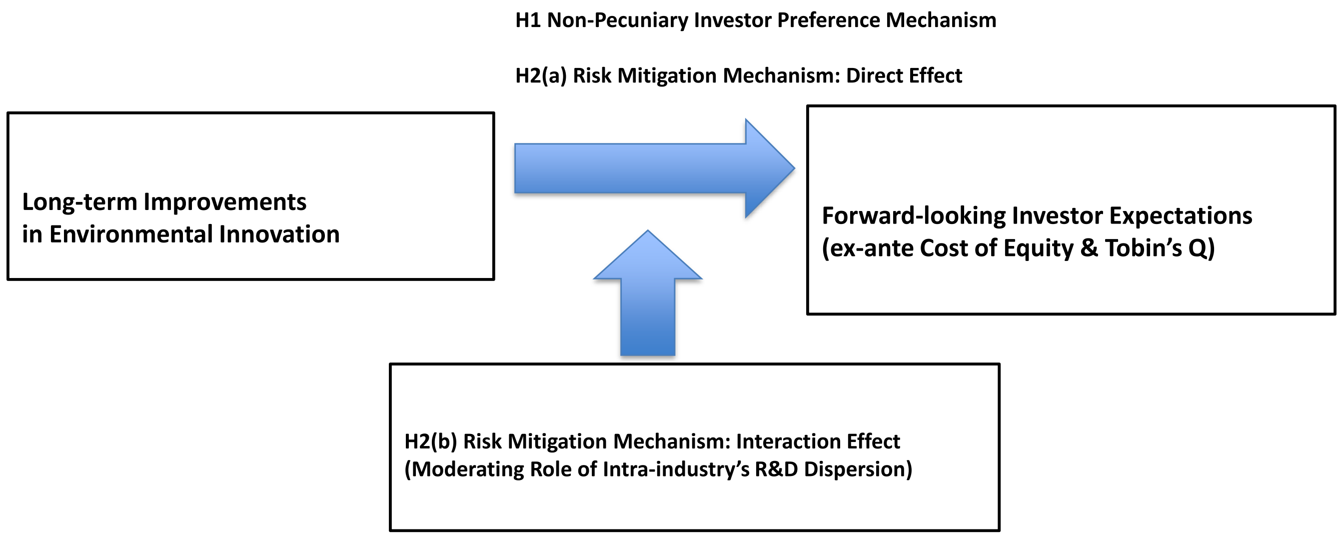

FIGURE 1 | Proposed Theoretical Framework and Hypotheses Development.

2.5.1 | Limitations of Patent-Based Measures

Our study focuses on environmental innovation rather than general innovation. Therefore, total patents or total R&D expenditure would not be appropriate measures as they capture general inventive activity regardless of environmental relevance.

Patent-based measures require thorough interpretation in cross-country research. Patent data can be affected by patent office procedures, patent families, patent classifications, citations, patent quality and patent value, which complicates their use as equivalent measures of innovation across countries (Canadian Intellectual Property Office 2024; Rajaiya 2023; Intellectual Property Office 2015). Patent-based indicators may also reflect differences in national patent systems, filing incentives, legal traditions, enforcement quality and patentability rather than firms' underlying environmental innovation capabilities (Corrocher and Solito 2017; Dosi et al. 2023; Rajaiya 2023). Prior research further shows that firms' motivation to patent varies substantially across countries, sectors, firms and technologies, limiting the comparability of patent-based indicators in international settings (Archibugi and Planta 1996; Cohen et al. 2000; Corrocher and Solito 2017).

International technical guidance also supports this caution. Guidance from the World Intellectual Property Organisation (WIPO) on patent information emphasises that patent data should be interpreted judiciously, as no single data source provides complete coverage of patent or technology information. Patent database coverage may vary across countries, dates and search facilities (WIPO 2020). In a similar vein, the OECD Patent Statistics Manual explains that patent indicators need to be compiled and interpreted carefully to minimise statistical noise and bias, especially when used for cross-country and cross-sector comparisons (OECD 2009).

The concerns over patents are particularly relevant to our global sample, where patent systems and incentives differ across countries and industries. Many economically meaningful environmental innovation activities do not result in patent applications. These activities include environmental R&D, process improvements, renewable energy adoption, responsible product use, cleaner production methods and green product development. Other recent studies also highlight the limitations of relying on patent-based measures. For example, Leippold and Yu (2026) argue that broader measures of green innovation are meaningfully related to firm value because they capture aspects that are not reflected in patents. A broader view of environmental innovation aligns with prior research that views it as a product-, process- and technology-oriented concept rather than as patenting activity alone (Angelo et al. 2012; European Commission 2012; Oltra et al. 2010; Rave et al. 2011; Nadeem et al. 2020; Iqbal et al. 2022; Zaman et al. 2023).

Much of the existing literature using green patents as proxies for environmental innovation is based on more constrained empirical settings, such as single-country or single-sector contexts (e.g., Fabrizi et al. 2018; Dosi et al. 2023; Reyes-Rodriguez and Ulhøi 2022). Recent studies examining how markets value green patents also tend to focus on specific institutional or sectoral settings. For example, Tian et al. (2023) examine green patent stocks among heavily polluting firms in China's A-share market, while Faria et al. (2022) study green technologies in the oil industry. These studies make important contributions, but their more focused settings differ from our international multi-sector research design.

While green patents are valuable indicators of patentable environmental inventions, they are less suitable as the sole proxy for environmental innovation in an international multi-sector setting. Our study examines 1464 firms across 41 economies and 10 sectors. This setting requires a measure of environmental innovation that is equivalent across countries and industries.

2.5.2 | Refinitiv Environmental Innovation Score

Rather than use green patents as a proxy, we use the Refinitiv Environmental Innovation Score as our measure of environmental innovation. This score aggregates more than 40 company-level indicators, including environmental R&D investment, green product development and environmentally beneficial technologies (e.g., Zaman et al. 2023). It is therefore closely aligned with our theoretical definition of environmental innovation because it captures a broader set of firm-level environmental innovation activities than patent-based measures.

The use of Refinitiv's Environmental Innovation Score should not be interpreted as a rejection of green patents as a useful measure. Rather, it reflects the suitability of this measure for our research question and empirical setting. Given the international scope of our study, we require a measure that is comparable across countries, sectors and firms. We examine whether investors value sustained improvements in firms' broader environmental innovation capabilities across 41 economies and 10 sectors. For this purpose, Refinitiv's Environmental Innovation Score provides a broader, more comparable and theoretically appropriate measure.

By using this measure in an empirical setting designed to distinguish between non-pecuniary investor preferences and risk mitigation mechanisms, our study elucidates how investors incorporate environmental innovation into capital allocation decisions in an international context.

3 | Research Design and Data

We construct our sample using a multi-stage screening process. We begin with companies included in the MSCI All Country World Index, which represents approximately 85% of global listed equity opportunities. Our dataset combines information from three primary data sources: Refinitiv ESG, Refinitiv I/B/E/S and Bloomberg. The primary sample spans 2013–2021, while the environmental innovation dataset extends further back to 2007–2021.

Following the innovation literature, we recognise that innovation requires time to yield measurable outcomes and that capital markets are typically slow to incorporate the value of intangible assets. Therefore, we establish our environmental innovation dataset with a longer sample period, allowing us to observe the lagged impact of sustained, long-term improvements in environmental innovation on investor expectations. To ensure comparability and reliability, we restrict our sample to cross-listed companies. This choice serves two purposes. First, it excludes companies from segmented markets, which is important since our model incorporates market risk factors (e.g., Beta). Second, cross-listed companies are subject to more stringent disclosure requirements across multiple jurisdictions, thereby enhancing the availability, reliability and comparability of data on environmental R&D and related environmental innovation activities, an essential prerequisite for monitoring long-term environmental innovation. Applying these criteria results in a final sample of 1464 companies covering 2013–2021. The sample includes companies from 29 high-income and 12 non-high-income economies.[1]

3.1 | The Measurement of Environmental Innovation at the Company Level

We measure firm-level environmental innovation using the Environmental Innovation Score by Refinitiv. Our choice is guided by our theoretical definition of environmental innovation and by the international scope of our empirical study.

Our definition is consistent with prior research that conceptualises environmental innovation as a broad product-, process- and technology-oriented construct rather than as patenting activity alone (Angelo et al. 2012; European Commission 2012; Iqbal et al. 2022; Nadeem et al. 2020; Oltra et al. 2010; Rave et al. 2011; Zaman et al. 2023). In this study, environmental innovation refers to a firm's capability to develop and implement environmentally beneficial products, processes and technologies. Refinitiv's Environmental Innovation Score is well aligned with this definition because it captures multiple dimensions of environmentally oriented innovation, including environmental R&D investment, green product development, renewable energy adoption, responsible product use, cleaner production methods and other environmentally beneficial technologies.

More specifically, Refinitiv's Environmental Innovation Score is a performance-oriented measure that aggregates more than 40 firm-level indicators related to environmental innovation activities. We therefore interpret long-term changes in this score as capturing broad changes in environmental innovation capability and outcomes, rather than merely changes in ESG reporting.

Moreover, the score captures a broader set of environmental innovation inputs and outputs than patent-based measures alone. As discussed in Section 2.5, green patents are useful indicators of patentable environmental inventions but are less suitable as the sole proxy for environmental innovation in our international multi-sector setting. Patent-based measures may be affected by cross-country differences in patent systems, filing incentives, enforcement regimes, database coverage and sector-specific patentability. In addition, many economically meaningful environmental innovation activities, such as process improvements, renewable energy adoption, responsible product use, cleaner production methods and environmental R&D, may enhance a firm's environmental innovation capability without resulting in patent applications. Refinitiv's Environmental Innovation Score therefore provides a broader and more comparable measure for our sample of firms across 41 economies and 10 sectors.

Importantly, Refinitiv's Environmental Innovation Score also helps distinguish environmental innovation from general environmental performance, sustainability disclosure and standard R&D activity. Environmental performance may capture outcomes such as emissions reduction or resource efficiency. Sustainability disclosure reflects the magnitude and quality of reporting practices. Standard R&D encapsulates general innovation investment that may or may not be environmentally relevant. By contrast, Refinitiv's Environmental Innovation Score is specifically designed to capture environmentally oriented innovation activities, including environmental R&D, green product development and environmentally beneficial technologies. As such, it reflects innovation activities, outcomes and capabilities rather than merely the volume of sustainability reporting. This makes it well-suited to our research question, which examines how investors value sustained improvements in firms' broader environmental innovation capability.

Our study focuses on the influence of a company's long-term improvement in its environmental innovation. For each of our sample companies' environmental innovation performance at each data point, we use Refinitiv's Environmental Innovation Score $(InnovE_{i,t})$, representing a company's environmental innovation performance at Year t. Our key explanatory variable is the long-term improvement in environmental innovation, measured as the change in $(InnovE)$ between *Year* $(t-1)$ *and Year* $(t-5)$. A positive value indicates a sustained improvement in a firm's environmental innovation over this period. Focusing on long-term changes rather than levels allows us to capture sustained improvements in innovation capability and ensure that short-term fluctuations or disclosure adjustments do not drive the results.

3.2 | Overview of Environmental Innovation Scores Across Sectors Over Time

Appendix A presents our sample companies by Global Industry Classification Standard (GICS) sectors and geographical regions. We exclude the financial sector, as banking and financial regulations may influence the relationship between environmental innovation and financial performance (e.g., Eccles et al. 2014; Asad et al. 2023).

Appendix A shows substantial sectoral variation in environmental innovation scores over the 2007–2021 period. Among the 10 GICS sectors included in our sample, Health (13.70) and Energy (20.63) had the lowest average environmental innovation scores, while Utilities (45.88) and Communication Services (42.89) had the highest. Despite their lower scores, the Energy and Health sectors ranked among the top three sectors in annual improvement rates in environmental innovation alongside the Real Estate sector.

These patterns support our focus on changes rather than levels, as sectors with initially low environmental innovation scores may exhibit substantial improvement over time. This is central to our empirical design, which examines how sustained improvements in environmental innovation shape investor expectations.

4 | Model Specification

We incorporate the distinctive features of environmental innovation into our model specification. Our primary focus is on the long-term changes in a company's environmental innovation. This long-horizon specification is consistent with our argument that environmental innovation typically takes time to materialise and that capital markets are also slow to recognise the value of intangible assets.

Our model specification accounts for the lagged effect of a company's long-term improvements in environmental innovation on investor expectations, measured by the ex-ante cost of equity and Tobin's Q. Consistent with prior studies using international datasets, we control for firm-, country- and sector-specific differences in our primary model specification to ensure the robustness of our results (e.g., Bolton and Kacperczyk 2021; Bolton et al. 2025; Nadeem et al. 2020). The model is defined in Equation (1), which examines how investors perceive long-term changes in a company's environmental innovation.

$$\begin{aligned}\text{Investor expectations}_{it} = \alpha &+ b_1 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} \\ &+ b_2 * (\text{Intra}-\text{industry R\&D disperse})_{i,t-1} \\ &+ b_3 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} \\ &* (\text{Intra}-\text{industry R\&D disperse})_{i,t-1} \\ &+ \sum b_4 * \text{Control at the firm level}_{i,t-1} \\ &+ \sum b_5 * \text{Control at the country level}_{k,t-1} \\ &+ \sum w_n * \text{Industry}_n + \sum \tau_m \text{Year}_m + \varepsilon_{ikt}\end{aligned} \tag{1}$$

In this study, we measure investor expectations, $(Investor\ expectations_{it})$ using two proxies: a company's ex-ante cost of equity and Tobin's Q. Both serve as the dependent variable in our primary Equation (1). The variable of $Investor\ expectations_{it}$ denotes the investor expectations of our sample company i in year t.

Consistent with the prior research (e.g., Pinto 2020; Yu et al. 2021), we estimate a company's ex-ante cost of equity using a forward earnings-price ratio $\left(\frac{forcasted\ EPS_1}{P_0}\right)$, while we estimate Tobin's Q as the ratio of a company's market value to the replacement cost of its assets. Equity analysts' forecasted EPS_1 information for $Year_{t+1}$ is obtained from the Refinitiv I/B/E/S database. This forward-looking measure is widely used by investment professionals to gauge the cost of equity because it incorporates anticipated earnings and growth potential, thereby capturing how investors perceive a company's future prospects and their associated risk expectations. In line with the literature, we avoid using ex-post realised returns, as they do not accurately reflect investors' forward-looking perceptions (e.g., Fama and French 1997; El Ghoul et al. 2018).

As an alternative proxy, we employ Tobin's Q, defined as the ratio of a firm's market value to the replacement cost of its assets. A higher Tobin's Q suggests that investors expect the company's future growth opportunities, profitability or intangible assets (e.g., environmental innovation) to generate returns exceeding the book value of existing assets. Therefore, Tobin's Q also reflects investors' forward-looking perceptions, as it embeds not only current fundamentals but also expectations of future value creation. Prior literature widely uses Tobin's Q as a proxy for investor expectations and market valuation (e.g., Aggarwal and Dow 2011; Iqbal et al. 2020; Iqbal et al. 2022). Taken together, these two proxies provide complementary perspectives on investor expectations.

The three key explanatory variables in our primary Equation (1) are as follows:

a. $(InnovE_{t-1} - InnovE_{t-5})_{i,t-1}$, a company's long-term change in environmental innovation proxied by the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$;
b. $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, the intra-industry dispersion of R&D intensity; and

c. $\left(InnovE_{t-1} - InnovE_{t-5}\right)_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.

To account for company- and country-level differences that may influence investor expectations, we include a set of control variables commonly used in previous research in Equation (1). At the company level, we control for leverage, company size, R&D intensity, board structure (including board size and independence), institutional ownership, liquidity (measured by the current ratio), sales growth and market risk measures (such as Beta and volatility). These variables capture variations in capital structure, innovation capacity, governance, ownership concentration, operational performance and risk exposure, all of which are known to influence companies' ex-ante cost of equity and Tobin's Q (e.g., Aggarwal and Dow 2011; Breuer et al. 2018; Iqbal et al. 2022). At the country level, we include a dummy variable for high-income economies, following the World Bank classification, and the natural logarithm of GDP per capita (Purchasing Power Parity adjusted) from the IMF World Economic Outlook database, in line with prior international studies (e.g., Bolton and Kacperczyk 2021). These controls help isolate the effect of long-term environmental innovation improvements from other firm fundamentals, governance characteristics, risk factors and macroeconomic conditions that could also influence investor expectations.

To mitigate concerns about reverse causality, we use $Investor\ expectations_{it}$ in Year t as the dependent variable with lagged values of the main independent variables. Appendix B provides detailed definitions and data sources for all variables. To further ensure robustness, we control for sector- and country-level heterogeneity. To account for industry-level heterogeneity, we include GICS sector fixed effects through the use of sector dummy variables (e.g., Bolton and Kacperczyk 2021). Outliers are mitigated through winsorisation.

4.1 | Linking the Theoretical Framework to the Model Specification

Equation (1) is designed to map directly onto the two mechanisms developed in Section 2: non-pecuniary investor preferences and risk mitigation. Here, we explain how the direct effect of environmental innovation and its interaction with intra-industry R&D dispersion allow us to empirically distinguish between these mechanisms.

Under the non-pecuniary investor preference mechanism, investors value sustained improvements in environmental innovation because such improvements align with their sustainability preferences, personal values or institutional mandates, independently of any direct effect on firm risk. Empirically, this mechanism is captured by the direct effect of $\Delta InnovE_{i,t-1}$. If the dominant investor clientele assigns positive non-financial value to environmental innovation, sustained improvements in environmental innovation are associated with a lower ex-ante cost of equity and a higher Tobin's Q. Conversely, if the dominant investor clientele views environmental innovation negatively, the direct effect is associated with higher financing costs or lower valuation.

This direct effect is important because it captures investors' response to environmental innovation, which is not conditional on the competitive structure of the industry. In other words, if investors value environmental innovation primarily because it aligns with their non-pecuniary sustainability preferences, the valuation effect should appear through the coefficient on $\Delta InnovE_{i,t-1}$, rather than depending systematically on intra-industry R&D dispersion. Put differently, there is no clear theoretical reason to expect this preference-based mechanism to vary systematically with the intra-industry dispersion.

Under the risk mitigation mechanism, investors value sustained improvements in environmental innovation because these improvements reduce firms' exposure to future risks. These risks may include stricter environmental regulations, future environmental liabilities, technological obsolescence, shifting customer demand for green products and broader transition-related risks. Firms that make sustained improvements in environmental innovation may therefore be better able to adapt to the transition towards a low-carbon economy. As a result, investors may require lower risk premia and assign higher valuations to these firms.

The risk mitigation mechanism operates through both the direct effect and the interaction effect. If investors perceive environmental innovation as unconditionally risk-reducing, the direct effect of $\Delta InnovE_{i,t-1}$ should be associated with lower ex-ante cost of equity and higher Tobin's Q. However, our theoretical framework further suggests that the risk mitigation value of environmental innovation should be stronger in industries where firms face greater risk of falling behind technologically. We capture this conditional risk with the intra-industry R&D dispersion variable.

Intra-industry R&D dispersion reflects the extent to which innovation intensity varies across firms within the same industry. Our argument is grounded in models of competition and innovation, which suggest that firms better positioned relative to the technological frontier face lower risks of displacement and competitive erosion (Aghion et al. 2005; Acemoglu et al. 2006). Moreover, the innovation literature shows that firms are affected not only by their own R&D investment but also by other firms' R&D investment in the same industry (e.g., Chen et al. 2013; Nguyen and Kecskés 2020). When R&D dispersion is high, firms are more unevenly positioned relative to the technological frontier. In such industries, sustained improvements in environmental innovation are more likely to be interpreted by investors as reducing the risk of technological lag, competitive erosion and transition-related vulnerability. Therefore, the interaction term $\Delta InnovE_{i,t-1} \times R\&DDispersion_{i,t-1}$ captures the moderating role of intra-industry dispersion and tests whether environmental innovation becomes more financially relevant when competitive technological risk is greater.

Accordingly, we interpret the coefficients in Equation (1) as follows. A negative coefficient on $\Delta InnovE_{i,t-1}$ in the ex-ante cost of equity regression or a positive coefficient in the Tobin's Q regression, suggests that investors value sustained improvements in environmental innovation directly. This pattern would be consistent with either positive non-pecuniary investor preferences or an unconditional risk mitigation effect. By contrast, a negative coefficient on the interaction term in the ex-ante cost of equity regression and a positive coefficient in the Tobin's Q regression indicate that investors place greater value on environmental innovation when firms operate in industries with higher R&D dispersion. This pattern would provide stronger support for the risk mitigation mechanism because it suggests that environmental innovation is valued when it helps lessen competitive technological risk.

This empirical mapping enables us to link the theoretical framework to the model specification. The direct effect captures investor responses to environmental innovation that are not conditional on industry-level technological dispersion, while the interaction effect captures the extent to which environmental innovation becomes financially material in settings where firms face a greater competitive technological risk of falling behind their industry peers.

5 | Empirical Results

Table 1 reports the descriptive statistics and Pearson correlations for the key variables. The median environmental innovation score among our sample companies is 33.33, while the average is slightly higher at 36.16, with a maximum score of 100. For our key variable, the long-term improvement in environmental innovation ($\Delta\, Long\ term_{InnovE}$), the average value is 5.86, while the median is 0. The first quartile is −1.08, and the third quartile reaches 65. These statistics indicate that half of our observations experienced zero improvement or deterioration in environmental innovation. In contrast, a substantial number of observations showed significant improvement, as reflected by the high third-quartile value (with scores for the third quartile at 65). All pairwise correlations are below 0.7, thereby alleviating concerns about multicollinearity (Asad et al. 2023). Panel B of Table 1 reports the mean and standard deviation of the key variables.

To examine how investors perceive the moderating role of the intra-industry dispersion of R&D intensity, we incorporate this variable into our model specification. We argue that, in industries with higher variation in R&D intensity, investors view long-term improvements in a company's environmental innovation as risk-reducing, which may translate into a lower cost of equity and a higher Tobin's Q.

High intra-industry dispersion of R&D indicates that a few companies invest heavily in R&D while others within the same sector invest far less, whereas low intra-industry dispersion of R&D reflects a more even distribution of R&D intensity across companies in the sector. Table 2 presents the average environmental innovation scores (***InnovE***), which capture how each GICS sector has performed in developing environmentally beneficial innovations over the primary sample period 2013–2021. Table 2 shows that the Utilities sector has a low intra-industry dispersion of R&D intensity but exhibits the highest average environmental innovation scores among all sectors (0.79 and 45.88). In contrast, the Energy and Health Care sectors have substantial intra-industry dispersion in R&D intensity (1.23 and 1.50, respectively), yet they have the lowest average environmental innovation scores (20.63 and 13.70, respectively). These sectoral patterns suggest that average environmental innovation performance and intra-industry R&D dispersion capture different dimensions of firms' innovation environments. We therefore argue that the investor response depends not only on firms' environmental innovation performance, but also on whether such innovation occurs in industries where the risk of falling behind technologically advanced peers is greater.

TABLE 1 | Descriptive statistics.

Panel A: Descriptive statistics and correlation matrix, 2013–2021

Variable	Mean	S.D.	1	2	3	4	5	6	7	8
1. $\Delta\, Long\ term_{InnovE}$	5.86	24.16	1.00							
2. InnovE	36.16	33.58	0.35	1.00						
3. $Intra\text{-}industry\ R\&D\ Disperse_{t-1}$	1.25	1.09	0.03	−0.05	1.00					
2. LEV	28.06	16.48	0.02	0.01	0.02	1.00				
3. CUR	1.74	1.89	0.01	−0.06	0.04	−0.29	1.00			
4. BOARD	10.72	2.93	−0.04	0.17	0.02	0.09	−0.11	1.00		
5. InstInv	65.42	28.50	−0.03	−0.09	−0.02	0.06	0.08	−0.07	1.00	
6. IndBoard	61.71	25.38	−0.04	−0.06	−0.02	0.19	−0.06	−0.11	0.43	1.00

Panel B: Mean and standard deviation for our key variables, 2013–2021

Variable	Mean	Standard deviation (S.D.)
Ex-ante cost of equity	0.0697	0.0439
Tobin's Q	2.0350	1.6818
Main term: $\Delta\, Long\ term_{InnovE}$	5.8618	24.1617
Interaction term: $(\Delta\, Long\ term_{InnovE}) * (Intra\text{-}industry\ R\&D\ Disperse_{t-1})$	8.9702	45.4985

Note: We define all the key explanatory variables in Appendix B. In this study, we winsorise variables if appropriate.

TABLE 2 | Intra-industry R&D dispersion, 2013–2021.

	GICS sector	Intra-industry R&D dispersion	The average environmental innovation score (*InnovE*)
1	Real Estate	2.87	34.60
2	Consumer Discretionary	1.89	31.63
3	Health Care	1.50	13.70
4	Energy (top 3 GHG intensity sector)	1.23	20.63
5	Materials (top 3 GHG intensity sector)	1.14	37.89
6	Communication Services	1.10	42.89
7	Consumer Staples	0.81	37.61
8	Utilities (top 3 GHG intensity sector)	0.79	45.88
9	Information Technology	0.74	34.50
10	Industrials	0.74	39.22

Source: Calculated by the authors.

5.1 | Main Regression Results

We now turn to the analysis of our main regressions and their implications for our hypotheses. To quantify investor expectations, we use two proxies: the ex-ante cost of equity and Tobin's Q, both of which are widely adopted measures of forward-looking investor perceptions (e.g., Aggarwal and Dow 2011; El Ghoul et al. 2018).

5.1.1 | Ex-Ante Cost of Equity

Using Equation (1), we examine how a long-term change in a company's environmental innovation may influence its ex-ante cost of equity by shaping investors' perceptions. Table 3 reports the regression results.

Our key independent variable is the lagged long-term improvement in environmental innovation $\left(\Delta Long\ term_{InnovE}\right)_{t-1}$, which may affect the ex-ante cost of equity $(ex-ante\ cost\ \ of\ equity)_t$ through two ways: (i) first, through its direct effect of $\left(\Delta Long\ term_{InnovE}\right)_{t-1}$ and (ii) second, through its interaction with the intra-industry dispersion of R&D intensity, expressed as $\left(\Delta Long\ term_{InnovE}\right)_{t-1}{}^{*}(Intra-industry\ \ R\&D\ Disperse)_{t-1}$.

The moderating variable, intra-industry R&D dispersion, captures technological heterogeneity within industries. The results in Table 3 show that the direct effect, the lagged sustained improvement in environmental innovation $\left(\Delta Long\ term_{InnovE}\right)_{t-1}$, is consistently positively and significantly associated with its ex-ante cost of equity at the 5% level. We interpret this coefficient cautiously because our model includes an interaction term. In the presence of an interaction term, the main effect does not represent a uniform average effect of environmental innovation across all industry settings. Rather, it captures the effect when intra-industry R&D dispersion is zero. Accordingly, we do not interpret this coefficient as evidence that environmental innovation generally raises financing costs. Instead, it suggests that when considered in isolation, environmental innovation may be perceived as costly or uncertain, which is consistent with the long development periods and failure risks associated with innovation activity.

By contrast, the interaction term in Table 3 is consistently negative across all model specifications and is statistically significantly associated with a company's ex-ante cost of equity at the 5% level. These results lend empirical support to Hypothesis 2b. In an industry with high dispersion of R&D intensity, investors perceive long-term improvements in a company's environmental innovation as risk-reducing, contributing to a lower ex-ante cost of equity. The effect of sustained improvement in environmental innovation on the cost of equity becomes more favourable as intra-industry R&D dispersion increases. In industries with high R&D dispersion, firms are more unevenly positioned relative to the technological frontier, and the risk of technological lag and transition-related vulnerability is more salient. Under these conditions, sustained improvements in environmental innovation are more likely to be viewed as risk-reducing by investors.

If the results were mostly driven by non-pecuniary investor preferences, we would not expect the interaction effect to be systematically significant. Instead, the favourable effect appears specifically in industries where sustained improvement in environmental innovation is more likely to reduce competitive technological risk. These empirical results are consistent with our proposed risk mitigation mechanism.

The economically relevant interpretation lies in the combined effect of environmental innovation and its interaction with intra-industry R&D dispersion. Because the Environmental Innovation Score is an aggregate index, we do not interpret the coefficients in terms of a one-point score movement. Instead, our discussion of economic magnitude focuses on sustained multi-year changes and standard-deviation shifts in the key explanatory variables.

We illustrate the economic significance of these findings using Model 1 in Table 3. A one-standard-deviation increase in

TABLE 3 | Regression results examining the effect of lagged long-term changes in environmental innovation $\left(\Delta Long\ term_{InnovE}\right)_{t-1}$ on the ex-ante cost of equity $(ex-ante\ cost\ \ of\ equity)_t$.

Dependent variable $(ex-ante\ cost\ \ of\ equity)_t$				
Variables	**Model (1)**	**Model (2)**	**Model (3)**	**Model (3)**
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}$	7.14E-05** (3.54E-05)	6.84E-05** (3.55E-05)	7.08E-05** (3.55E-05)	7.12E-05** (3.54E-05)
$(Intra\text{-}industry\ R\&D\ Disperse)_{t-1}$	−0.0018 (0.0012)	−0.0018 (0.0012)	−0.0017 (0.0012)	−0.0018 (0.0012)
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}$ $*(Intra-industry\ \ R\&D\ Disperse)_{t-1}$	−5.45E-05** (2.68E-05)	−5.35E-05** (2.68E-05)	−5.50E-05** (2.69E-05)	−5.58E-05** (2.68E-05)
Lev_{t-1}	0.0092*** (0.0032)	0.0096*** (0.0032)	0.0093*** (0.0032)	0.0089*** (0.0032)
$\log(Size)_{t-1}$	−0.0018*** (0.0005)	−0.0014*** (0.0005)	−0.0017*** (0.0005)	−0.0018*** (0.0005)
RDI_{t-1}	−0.0442*** (0.0081)	−0.0447*** (0.0082)	−0.0448*** (0.0081)	−0.0442*** (0.0081)
$(Board)_{t-1}$	0.0011*** (0.0002)	0.0010*** (0.0002)	0.0011*** (0.0002)	0.0011*** (0.0002)
$(IndBoard)_{t-1}$	0.0011 (0.0021)	−0.0007 (0.0021)	0.0009 (0.0021)	−0.0005 (0.0024)
$(InstInV)_{t-1}$	−0.0001*** (2.26E-05)	−9.96E-05*** (2.23E-05)	−0.0001*** (2.25E-05)	−0.0001*** (2.27E-05)
$(Cur)_{t-1}$	−0.0027*** (0.0004)	−0.0026*** (0.0004)	−0.0027*** (0.0004)	−0.0027*** (0.0004)
$(SG)_{t-1}$	0.0001*** (3.69E-05)		0.0001*** (3.68E-05)	0.0001*** (3.69E-05)
$(Sigma)_t$	0.0004*** (7.37E-05)	0.0004*** (7.58E-05)	0.0004*** (7.38E-05)	0.0004*** (7.43E-05)
$(Beta)_t$	6.67E-05 (6.17E-05)			6.42E-05 (6.18E-05)
Dummy for a high-income economy				−0.0072* (0.0040)
$\log(GDPPC)_{t-1}$	−0.0071*** (0.0013)	−0.0071*** (0.0013)	−0.0071*** (0.0013)	−0.0022 (0.0027)
Constant	0.1540*** (0.0153)	0.1555*** (0.0153)	0.1542*** (0.0153)	0.1540*** (0.0153)
Period fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Firm number	1464	1464	1464	1464
Adjusted R^2	0.1336	0.1280	0.1312	0.1340

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample consists of 1464 companies from the MSCI All World Index, covering the period from 2013 to 2021. Definitions of all variables and their corresponding data sources are provided in Appendix B. The table presents regression coefficients with standard deviations shown in parentheses. We employ a panel fixed effect model specification, incorporating various country-level and firm-level controls, along with industry dummies. Standard errors are clustered at the firm level. The dependent variable is a company's ex-ante cost of equity in Year t. The three key independent variables are:
(a) $\left(InnovE_{t-1}-InnovE_{t-5}\right)_{i,t-1}$, which captures a company's long-term change in environmental innovation, measured as the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$;.
(b) $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, as the intra-industry dispersion of R&D intensity; and
(c) $\left(InnovE_{t-1}-InnovE_{t-5}\right)_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.
We examine the Hypotheses using our primary model, Equation (1).

$$
\begin{aligned}
\text{ex}-\text{ante cost of equity}_{\text{it}} = {} & \alpha + b_1 * \left(\text{InnovE}_{t-1} - \text{InnovE}_{t-5}\right)_{i,t-1} + b_2 * (\text{Intra}-\text{industry R\&D disperse})_{i,t-1} \\
& + b_3 * \left(\text{InnovE}_{t-1} - \text{InnovE}_{t-5}\right)_{i,t-1} * (\text{R\&D disperse})_{i,t-1} + \sum b_4 * \text{Control at the firm level}_{i,t-1} \\
& + \sum b_5 * \text{Control at the country level}_{k,t-1} + \sum w_n * \text{Industry}_n + \sum \tau_m \text{Year}_m + \varepsilon_{ikt}
\end{aligned}
$$

sustained environmental innovation improvement is associated with a 2.476% increase in the ex-ante cost of equity through the direct effect. However, a one-standard-deviation increase in the interaction term is associated with a 3.558% reduction in the ex-ante cost of equity. The combined effect is a net reduction of approximately 1.082% relative to the mean ex-ante cost of equity (2.476%–3.558% = −1.082%).[2] This calculation shows that the financing-cost benefit of environmental innovation arises primarily when environmental innovation occurs in industries with high intra-industry R&D dispersion. The negative interaction effect therefore offsets the positive direct effect and leads to an overall reduction in the ex-ante cost of equity.

In economic terms, a 1.082% reduction in the cost of equity is not trivial. It is of a similar order of magnitude to the financing-cost effects reported in the broader ESG literature. For example, Breuer et al. (2018) show that stronger CSR performance is associated with roughly a 1% reduction in the mean cost of equity.

Our own estimates indicate that sustained environmental innovation can be financially material when it mitigates the risk of falling behind technologically advanced industry peers.

Overall, the results in Table 3 indicate that environmental innovation is not unconditionally rewarded by investors. Our evidence underscores the essential moderating role of intra-industry R&D dispersion: investors assign greater value to environmental innovation improvements in industries with higher R&D dispersion. This finding supports that the effect of sustained environmental innovation operates primarily through the risk mitigation mechanism. In low-R&D-dispersion industries, sustained environmental innovation may be viewed as costly or uncertain. In high-R&D-dispersion industries, however, it appears to lower investors' perceived risk by helping firms to keep up technologically. This conditional pattern supports our risk mitigation mechanism: investors value environmental innovation most when it reduces exposure to competitive technological risk.

5.1.2 | Tobin's Q

As reported in Table 4, the direct effect of sustained improvements in environmental innovation (main term) is not statistically significant for Tobin's Q across all models. In contrast, the interaction with intra-industry R&D dispersion is consistently positive and significant for Tobin's Q, indicating that market valuations increase when such improvements occur in industries with greater R&D dispersion.

To illustrate the economic magnitude, we use Model 1 in Table 4. Since the main term is not statistically significant, the effect arises entirely from the interaction term. Taking the one-standard-deviation increase in the interaction term (45.4985; Panel B, Table 1) and multiplying it by its coefficient (0.0011) yields 0.05. Dividing this by the mean of Tobin's Q (2.035) implies an increase of approximately 2.45%. Similar to our previous discussion of the ex-ante cost of equity, this effect is economically meaningful and suggests that sustained environmental improvements in environmental innovation can increase firm value in industries where intra-industry R&D dispersion is high.

Together with the results for the ex-ante cost of equity, a consistent pattern emerges. Using two proxies for investor expectations, we find that the direct effect of sustained environmental innovation improvements is associated with higher financing costs but has no significant influence on market valuation. However, the interaction with intra-industry R&D dispersion is consistently negative and significant for financing costs and consistently positive and significant for market valuation. These findings support Hypothesis 2b, which predicts that the risk mitigation effect of sustained improvements in environmental innovation will be stronger in industries with higher intra-industry R&D dispersion, where firms face a greater risk of falling technologically behind industry peers.

Our evidence helps distinguish the two proposed mechanisms. According to our model specification (see Equation 1), the non-pecuniary preference mechanism is expected to operate through the main term, whereas the risk mitigation mechanism may operate through both the main and interaction terms. The interaction effect works through the moderating role of intra-industry R&D dispersion: in industries with greater R&D dispersion, investors perceive companies as facing a higher competitive technological risk of falling behind their peers.

When considered alongside our empirical results for the ex-ante cost of equity, a consistent pattern emerges (see Tables 3 and 4). Using two proxies for investor expectations, we find that the direct effect (main term) of sustained improvements in environmental innovation is associated with higher financing costs (measured by ex-ante cost of equity) but has no influence on market valuations (measured by Tobin's Q). However, the interaction with intra-industry R&D dispersion is consistently negative and significant for financing costs (Table 3) and consistently positive and significant for market valuations (Table 4). These findings support Hypothesis 2b: investors interpret sustained improvements in a company's environmental innovation as reducing the risk of falling behind peers in industries with higher R&D dispersion.

To conclude, these results suggest that the risk mitigation mechanism is at work when environmental innovation reduces firms' exposure to competitive technological risk, which is captured by the interaction with intra-industry R&D dispersion. Since the favourable effects arise mainly through the interaction term, our results are more consistent with the risk mitigation mechanism than with a purely preference-based interpretation.

5.2 | Summary of Findings

Taken together, the results indicate that environmental innovation is not rewarded unconditionally by investors. The direct effect of sustained improvements in environmental innovation does not consistently reduce financing costs or increase market valuation. Instead, the favourable effects arise mainly through the interaction with intra-industry R&D dispersion. Specifically, sustained improvements in environmental innovation are associated with lower ex-ante cost of equity and higher Tobin's Q when firms operate in industries with greater intra-industry R&D dispersion.

The conditional pattern is more consistent with the risk-mitigation mechanism than with a purely non-pecuniary investor preference mechanism. This interpretation also helps explain why prior ESG and environmental innovation studies have reported mixed findings: the capital-market benefit of environmental innovation may depend on whether such sustained improvements are perceived as financially material and risk-reducing.

6 | Robustness Checks

This section presents additional analyses to assess the robustness of our results. First, we substitute our primary measure of a company's long-term improvement in environmental innovation with an alternative specification. Second, we conduct supplementary tests to address potential endogeneity concerns (Wooldridge 2013), focusing on three sources of bias: (a) omitted variable bias, (b) unobserved shocks and (c) bidirectional causality.

TABLE 4 | Regression results examining the effect of lagged long-term changes in environmental innovation $(\Delta Long\ term_{InnovE})_{t-1}$ on $(Tobin's\ Q)_t$.

Dependent variable $(Tobin's\ Q)_t$			
Variables	**Model (1)**	**Model (2)**	**Model (3)**
$(\Delta Long\ term_{InnovE})_{t-1}$	−0.0001 (0.0009)	−9.23E-05 (0.0009)	−0.0002 (0.0009)
$(Intra\text{-}industry\ R\&D\ Disperse)_{t-1}$	−0.0022 (0.0216)	−0.0030 (0.0219)	−0.0045 (0.0222)
$(\Delta Long\ term_{InnovE})_{t-1} * (Intra-industry\ \ R\&D\ Disperse)_{t-1}$	0.0011* (0.0006)	0.0011* (0.0006)	0.0013** (0.0006)
Lev_{t-1}	0.0221 (0.1392)	0.0245 (0.1388)	0.0097 (0.1386)
$\log(Size)_{t-1}$	0.2792*** (0.0192)	0.2782*** (0.0189)	0.2891*** (0.0193)
RDI_{t-1}	3.8670*** (0.5034)	3.8681*** (0.5026)	3.9550*** (0.5087)
$(Board)_{t-1}$	−0.0815*** (0.0061)	−0.0810*** (0.0061)	−0.0841*** (0.0061)
$(IndBoard)_{t-1}$	0.6777*** (0.0855)	0.6744*** (0.0852)	0.6469*** (0.0848)
$(InstInV)_{t-1}$	0.0028*** (0.0007)	0.0028*** (0.0007)	0.0033*** (0.0007)
$(Cur)_{t-1}$	0.1048*** (0.0184)	0.1052*** (0.0184)	0.1019*** (0.0187)
$(SG)_{t-1}$	0.0073*** (0.0010)	0.0073*** (0.0010)	
$(Sigma)_t$	−0.0050** (0.0021)	−0.0048** (0.0020)	−0.0054*** (0.0020)
$(Beta)_t$	0.0024 (0.0042)		
$\log(GDPPC)_{t-1}$	−0.0932** (0.0438)	−0.0936** (0.0438)	−0.1250*** (0.0430)
Constant	0.5798 (0.5243)	0.5861 (0.5222)	0.8889* (0.5115)
Period fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm number	1464	1464	1464
Adjusted R^2	0.2328	0.2328	0.2269

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample consists of 1464 companies from the MSCI All World Index, covering the period from 2013 to 2021. Definitions of all variables and their corresponding data sources are provided in Appendix B. The table presents regression coefficients with standard deviations shown in parentheses. We employ a panel fixed effect model specification, incorporating various country-level and firm-level controls, along with industry dummies. Standard errors are clustered at the firm level. As a robustness check, we replace a company's ex-ante cost of equity with Tobin's Q as an alternative proxy for investor expectations. The dependent variable is a company's Tobin's Q in Year t. The three key independent variables are:
(a) $(InnovE_{t-1} - InnovE_{t-5})_{i,t-1}$, which captures a company's long-term change in environmental innovation, measured as the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$;
(b) $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, as the intra-industry dispersion of R&D intensity; and
(c) $(InnovE_{t-1} - InnovE_{t-5})_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.
We examine the Hypotheses using our primary model, Equation (1), by introducing Tobin's Q as an alternative proxy for investor expectations.

$$\begin{aligned}\text{Tobin's } Q_{it} = {} & \alpha + b_1 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} + b_2 * (\text{Intra}-\text{industry R\&D disperse})_{i,t-1} \\ & + b_3 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} * (\text{R\&D disperse})_{i,t-1} + \sum b_4 * \text{Control at the firm level}_{i,t-1} \\ & + \sum b_5 * \text{Control at the country level}_{k,t-1} + \sum w_n * \text{Industry}_n + \sum \tau_m \text{Year}_m + \varepsilon_{ikt}\end{aligned}$$

6.1 | Alternative Measure for Long-Term Improvement in Environmental Innovation

Using our primary model specification (Equation 1), we examine how the lagged long-term change in environmental innovation, $(\Delta Long\ term_{InnovE})_{t-1}$, affects the ex-ante cost of equity $(ex-ante\ cost\ of\ equity)_t$ at the Year t. In our primary analysis reported in Table 3, the long-term change in environmental innovation is measured as the difference in a company's Environmental Innovation Score ($InnovE$) between Year $(t-1)$ *and* Year$(t-5)$. A positive value of $(\Delta Long\ term_{InnovE})$ thus reflects a favourable long-term improvement in environmental innovation.

To validate the robustness of our findings, we employ an alternative measure of long-term change. Instead of measuring the absolute difference, we construct a relative change measure $\frac{(InnovE1+100)}{(InnovE5+100)}$ as an alternative indicator.

This alternative indicator captures the relative improvement in a company's Environmental Innovation Score over the same period. A value greater than one indicates an improvement relative to the earlier score, whereas a value below one indicates a relative decline. The addition of 100 ensures that zero values in the denominator do not create distortions. Regression results reported in Appendix C corroborate our earlier findings, confirming the robustness and consistency of the results reported in Table 3.

6.2 | Addressing Potential Endogeneity

To further strengthen the validity of our findings, we conduct additional tests to mitigate potential endogeneity concerns (Wooldridge 2013). Specifically, we address three sources of bias: (a) omitted variable bias, (b) unobserved shocks and (c) bidirectional causality.

6.2.1 | Omitted Variable Bias

First, to reduce the risk of omitted variable bias, we augment our primary specification with additional company- and country-level controls to ensure that unobserved heterogeneity is not driving the results. In the additional regression models reported in Appendix D, we introduce one company-level factor (insider ownership) and two country-level factors (Transparency International Corruption Perceptions Index and Social Progress Index).[3] Following the prior literature (Wooldridge 2013), these variables are included separately as additional controls for corporate governance quality at the company level and institutional quality at the country level. The results, presented in Appendix D, confirm that our earlier findings reported in Table 3 remain robust.

6.2.2 | Unobserved Shocks

Second, to account for unobserved shocks that may simultaneously influence both environmental innovation and investor expectations, we conduct robustness checks that incorporate a major global climate-policy event. Specifically, we re-estimate our model specification (Equation 1), including a dummy variable indicating whether a country had ratified the Paris Agreement. We select the Paris Agreement because it represents a major international climate-policy shock that may affect both firms' incentives to improve environmental innovation and investors' assessment of climate-related risks. This approach is also consistent with recent studies, such as Kruse et al. (2024), which use the Paris Agreement as a natural experiment to examine how financial markets respond to green opportunities.

In our study, the Paris Agreement dummy takes the value of 1 for the period after a country's ratification date and 0 otherwise. Ratification of the Paris Agreement represents a significant global policy commitment to climate mitigation, serving as a plausible structural break that may influence companies' incentives for environmental innovation and investor expectations. Ratification data are obtained from the United Nations Treaty Collection (United Nations Treaty Collection, n.d.). The findings, reported in Appendix E, remain consistent with those in Table 3, suggesting that unobserved shocks do not materially affect the documented relationship.

6.2.3 | Bidirectional Causality

Finally, we address potential concerns regarding bidirectional causality. To investigate this issue, we conduct Durbin–Wu–Hausman tests within an instrumental-variable framework. Prior to implementing the 2SLS estimator, the purpose of these tests is to assess whether the potentially endogenous variables can be treated as exogenous.

Following prior studies (e.g., Breuer et al. 2018; El Ghoul et al. 2018; Iqbal et al. 2022; Nadeem et al. 2020), we use these four instrumental variables related to our key explanatory variable: (i) the industry average of long-term change in environmental innovation, (ii) the industry median of long-term change in environmental innovation, (iii) the difference in *InnovE* between Year $(t-2)$ *and* Year$(t-6)$ and (iv) the difference in *InnovE* between Year $(t-3)$ *and* Year$(t-6)$.

Industry-level measures capture broader sectoral innovation trends that are strongly correlated with company-level environmental innovation decisions. Similarly, lagged differences in environmental innovation (*InnovE*) reflect historical changes in environmental innovation capacity that shape current company-level innovation but are temporally distant enough to avoid direct effects on contemporaneous financing costs and market valuations.

We recognise that industry-level instruments may be correlated with broader sector-wide valuation trends or policy shocks. Therefore, we interpret the instrumental-variable analysis cautiously and use it as a supplementary diagnostic exercise rather than as the primary basis for causal identification. Our main empirical design uses lagged explanatory variables, long-horizon changes in environmental innovation, extensive controls and additional robustness tests for omitted variables and unobserved shocks, including the ratification of the Paris Agreement as a global climate-policy event.

To assess instrument relevance, we evaluate instrument strength using the first-stage F-statistic, which exceeds the conventional Stock and Yogo (2005) threshold of 10, indicating that the instruments are relevant and unlikely to be weak. The Durbin–Wu–Hausman test yields p-values of 0.68 for the main term and 0.64 for the interaction term, both well above the 5% significance level (see Appendix F). Accordingly, we fail to reject the null hypothesis of exogeneity and find no statistical evidence that endogeneity materially biases our results. While this does not eliminate all endogeneity concerns, it suggests that endogeneity is unlikely to materially bias our main findings.

Taken together, the research design, robustness tests for omitted variables and policy shocks and Durbin–Wu–Hausman tests provide reassurance that bidirectional causality is unlikely to be the primary driver of our findings. Nevertheless, we interpret these results cautiously and acknowledge that, as with all observational research, endogeneity concerns cannot be completely eliminated.

7 | Conclusion

We examine how investors value firms' sustained improvements in environmental innovation in the context of mounting global pressure for companies to contribute to long-term sustainability and the net-zero transition. Environmental innovation may be perceived either as a costly and uncertain endeavour or as a strategic response to potential risks associated with the environmental transition. To shed light on these contrasting interpretations, we distinguish between two mechanisms: risk mitigation and non-pecuniary investor preferences.

Using an international sample of 1464 firms across 41 economies and 10 sectors, we study the relationship between long-term improvements in environmental innovation and two forward-looking measures of investor expectations: ex-ante cost of equity and Tobin's Q. We measure environmental innovation using Refinitiv's Environmental Innovation Score, which captures a broad range of environmental innovation inputs and outputs. This measure enables us to study environmental innovation as a broad capability set rather than focusing only on green patents. It also helps distinguish environmental innovation from general environmental disclosure and standard R&D activity.

At the centre of our study is the distinction between non-pecuniary investor preferences and risk mitigation. We do not rule out the possibility that some investors may value sustainability for reasons beyond expected financial returns. However, our results suggest that non-pecuniary preferences alone do not generate an unconditional valuation premium for environmental innovation. Instead, the favourable valuation effects arise mostly when environmental innovation helps firms reduce the risk of competitive technological lag. Specifically, sustained improvements in environmental innovation are associated with lower ex-ante cost of equity and higher Tobin's Q when firms operate in industries with greater intra-industry R&D dispersion. This suggests that investors value environmental innovation most when it reduces firms' exposure to competitive technological risk.

Our findings have practical implications for companies and investors. For companies, they suggest that environmental innovation should be treated as a strategic capability rather than a generic sustainability activity, especially in industries where R&D dispersion is high and the risk of technological lag looms large. In such settings, sustained investment in environmental innovation may be related to lower financing costs and higher market valuations. For investors, the findings underline the importance of evaluating environmental innovation in relation to intra-industry R&D dispersion, which reflects industry structure, technological competition and the risk of falling behind industry peers.

The results also have implications for policymakers and standard setters. Data on environmental innovation can help investors assess firms' preparedness for transition-related and competitive risks. In this context, our findings connect to the broader transition towards more standardised sustainability reporting frameworks, including ISSB-, CSRD- and TCFD-related developments. More comparable firm-level metrics of environmental innovation across countries and industries can help capital markets distinguish substantive environmental innovation from broader sustainability claims and support more efficient capital allocation towards the low-carbon transition.

In future research, scholars could extend this study by exploring how policy incentives or regulatory environments shape managers' pursuit of sustained improvements in environmental innovation.

Author Contributions

Ellen Pei-yi Yu: conceptualization, investigation, writing – original draft, methodology, validation, visualization, writing – review and editing, software, formal analysis, project administration, data curation, supervision, resources. **Bac Van Luu:** conceptualization, investigation, writing – original draft, methodology, validation, visualization, writing – review and editing, software, formal analysis, data curation, resources. **Dominic H. Chai:** conceptualization, investigation, writing – original draft, methodology, validation, visualization, writing – review and editing, software, formal analysis, data curation, resources. **Alessandra Tanda:** writing – review and editing, data curation, methodology, validation, conceptualization, investigation, writing – original draft.

Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

[1] According to the World Bank's definition of a high-income economy, our final sample comprises 12 non-high-income economies and 29 high-income economies. The 12 non-high-income economies included are Thailand, South Africa, Russia, the Philippines, Mexico, Malaysia, Indonesia, India, China, Colombia, Jordan and Brazil. The 29 high-income economies in our study are the United States, Switzerland, Sweden, Spain, South Korea, Singapore, Portugal, Poland, Norway, New Zealand, the Netherlands, Taiwan, Luxembourg, Japan, Italy, Israel, Ireland, Hungary (since 2014), Hong Kong, Germany, France, Finland, Denmark, Chile, Canada, the United Kingdom, Belgium, Austria and Australia.

[2] Using the same Model (1) in Table 3 as an example, we observe that a one standard deviation increase in a firm's long-term change in environmental innovation increases a company's ex-ante cost of equity by 2.476%. This is calculated as follows: the one standard deviation of (Δ $Long\ term_{InnovE}$) is 24.16168 (See Table 1, Panel B), and multiplying this by its coefficient (0.0000714) yields an effect of 0.001725. Given the mean of the ex-ante cost of equity for our sample companies is 0.069685. This translates to an increase of 0.001725/0.069685, which equals 0.02476 or 2.476%. This represents an economically significant effect.

Similarly, we compute the economic significance of the interaction term in our primary model. Again using Model (1) in Table 3, we find that a one standard deviation increase in the interaction term reduces a company's ex-ante cost of equity by 3.558%. In this case, the one standard deviation of the interaction term is 45.49853, and multiplying this by its coefficient (−0.0000545) yields −0.00247966. Dividing this by the mean ex-ante cost of equity (0.00247966/0.069685) results in a decrease of approximately 3.558%. This reduction is also economically significant.

The combined effect of the single term and the interaction term results in an overall reduction in a company's ex-ante cost of equity. The final overall economic effect is −1.082% (2.476% minus 3.558%).

[3] Insider ownership, defined as the proportion of shares held by company executives, directors and affiliated parties, captures the alignment of managerial and shareholder interests. This variable, sourced from Bloomberg, has been widely used as a measure of corporate governance quality (e.g., La Porta et al. 1999). The International Transparency Index, obtained from Transparency International, reflects the perceived level of corruption in a country's public sector. Higher scores indicate lower corruption and, by extension, stronger institutional integrity, transparency and regulatory enforcement (Transparency International 2023). Countries with greater transparency are more likely to provide more regulatory frameworks to reduce information asymmetries between companies and investors and consequently enhance investor confidence. The Social Progress Index,

provided by the Social Progress Imperative (2023), measures a broad set of social and environmental outcomes beyond economic indicators. It encompasses dimensions such as access to basic human needs (e.g., healthcare and education), foundations of well-being (e.g., access to information) and opportunities (e.g., personal rights and inclusiveness). Higher scores indicate a more supportive societal environment for sustainable business practices.

References

Acemoglu, D., P. Aghion, and F. Zilibotti. 2006. "Distance to Frontier, Selection, and Economic Growth." *Journal of the European Economic Association* 4, no. 1: 37–74. https://doi.org/10.1162/jeea.2006.4.1.37.

Acharya, V., R. Baghai-Wadji, and K. Subramanian. 2013. "Labor Laws and Innovation." *Journal of Law and Economics* 56, no. 4: 997–1037. https://doi.org/10.1086/674106.

Aggarwal, R., and S. Dow. 2011. "Corporate Governance and Business Strategies for Climate Change and Environmental Mitigation." *European Journal of Finance* 18, no. 3–4: 311–331. https://doi.org/10.1080/1351847X.2011.579745.

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: An Inverted-U Relationship." *Quarterly Journal of Economics* 120, no. 2: 701–728. https://doi.org/10.1093/qje/120.2.701.

Angelo, F. D., C. J. C. Jabbour, and S. V. Galina. 2012. "Environmental Innovation: In Search of a Meaning." *World Journal of Entrepreneurship, Management and Sustainable Development* 8, no. 2/3: 113–121.

Archibugi, D., and M. Planta. 1996. "Measuring Technological Change Through Patents and Innovation Surveys." *Technovation* 16, no. 9: 451–468. https://doi.org/10.1016/0166-4972(96)00031-4.

Asad, S., J. C. Hennig, J. Oehmichen, M. Wolff, and V. Haas. 2023. "From Attention to Action: How Board Environmental Expertise Influences Corporate Environmental Performance." *Strategic Organization* 23: 259–284. https://doi.org/10.1177/14761270231197995.

Baker, M., M. L. Egan, and S. K. Sarkar. 2022. "How Do Investors Value ESG? NBER Working Paper No. 30708." https://doi.org/10.3386/w30708.

Barnea, A., and A. Rubin. 2010. "Corporate Social Responsibility as a Conflict Between Shareholders." *Journal of Business Ethics* 97: 71–86.

Barron, J., and G. Waddell. 2003. "Executive Rank, Pay and Project Selection." *Journal of Financial Economics* 67: 305–349.

Benkraiem, R., E. Dubocage, and Y. Lelong. 2023. "Payment for Environmental Services to Reduce Deforestation: Do the Positive Effects Last?" *Ecological Economics* 210: 107840. https://doi.org/10.1016/j.ecolecon.2023.107840.

Boiral, O., J.-F. Henri, and D. Talbot. 2012. "Modeling the Impacts of Corporate Commitment on Climate Change." *Business Strategy and the Environment* 21, no. 8: 495–516.

Bolton, P., and M. Kacperczyk. 2021. "Do Investors Care About Carbon Risk?" *Journal of Financial Economics* 142, no. 2: 517–549.

Bolton, P., A. Lam, and M. Muûls. 2025. "Do Carbon Prices Affect Stock Prices?" *Journal of Financial Research* 49: 631–665. https://doi.org/10.1111/jfir.12472.

Breuer, W., T. Mueller, D. Rosenbach, and A. Salzmann. 2018. "Corporate Social Responsibility, Investor Protection, and Cost of Equity: A Cross-Country Comparison." *Journal of Banking & Finance* 96: 34–55.

Business & Human Rights Resource Centre. n.d. "France's Duty of Vigilance Law." Accessed October 9, 2025 from https://www.business-humanrights.org/en/big-issues/corporate-legal-accountability/frances-duty-of-vigilance-law/.

Canadian Intellectual Property Office. 2024. "IP Canada Report 2023: Appendix B." Government of Canada.

Chan, L., J. Lakonishok, and T. Sougiannis. 2001. "The Stock Market Valuation of Research and Development Expenditures." *Journal of Finance* 56: 2431–2456. https://doi.org/10.1111/0022-1082.00411.

Chava, S. 2014. "Environmental Externalities and Cost of Capital." *Management Science* 60, no. 9: 2223–2247. https://doi.org/10.1287/mnsc.2013.1863.

Chen, S. S., Y. S. Chen, W. L. Liang, and Y. Wang. 2013. "R&D Spillover Effects and Firm Performance Following R&D Increases." *Journal of Financial and Quantitative Analysis* 48, no. 5: 1607–1634.

Cohen, W. M., R. R. Nelson, and J. P. Walsh. 2000. "Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not)." NBER Working Paper No. 7552. https://doi.org/10.3386/w7552.

Corrocher, N., and I. Solito. 2017. "How Do Firms Capture Value From Environmental Innovations? An Empirical Analysis on European SMEs." *Industry and Innovation* 24, no. 5: 569–585. https://doi.org/10.1080/13662716.2017.1302792.

Cui, J., H. Jo, and M. G. Velasquez. 2019. "Christian Religiosity and Corporate Community Involvement." *Business Ethics Quarterly* 29, no. 1: 85–125. https://doi.org/10.1017/bsq.2018.13.

Derrien, F., A. Kecskés, and P. A. Nguyen. 2023. "Labor Force Demographics and Corporate Innovation." *Review of Financial Studies* 36, no. 7: 2797–2838.

Dosi, G., L. Marengo, J. Staccioli, and M. E. Virgillito. 2023. "Big Pharma and Monopoly Capitalism: A Long-Term View." *Structural Change and Economic Dynamics* 65: 15–35. https://doi.org/10.1016/j.strueco.2023.01.004.

Eccles, R. G., I. Ioannou, and G. Serafeim. 2014. "The Impact of Corporate Sustainability on Organizational Processes and Performance." *Management Science* 60, no. 11: 2835–2857.

Edmans, A. 2012. "The Link Between Job Satisfaction and Firm Value, With Implications for Corporate Social Responsibility." *Academy of Management Perspectives* 26: 1–19. https://doi.org/10.5465/amp.2012.0046.

El Ghoul, S., O. Guedhami, H. Kim, and K. Park. 2018. "Corporate Environmental Responsibility and the Cost of Capital: International Evidence." *Journal of Business Ethics* 149: 335–361.

European Commission. 2012. "Eco-Innovation – The Key to Europe's Future Competitiveness." Publications Office of the European Union.

Fabrizi, A., G. Guarini, and V. Meliciani. 2018. "Green Patents, Regulatory Policies and Research Network Policies." *Research Policy* 47: 1018–1031. https://doi.org/10.1016/j.respol.2018.03.005.

Fama, E., and K. French. 1997. "Industry Costs of Equity." *Journal of Financial Economics* 43: 153–193.

Faria, J. R., G. Tindall, and S. Terjesen. 2022. "The Green Tobin's q: Theory and Evidence." *Energy Economics* 110: 106033.

Flammer, C. 2013. "Corporate Social Responsibility and Shareholder Reaction: The Environmental Awareness of Investors." *Academy of Management Journal* 56, no. 3: 758–781.

Flammer, C. 2015. "Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach." *Management Science* 61, no. 11: 2549–2568.

Francis, B., I. Hasan, and Z. Sharma. 2011. "Do Incentives Create Innovation? Evidence From CEO Compensation Contracts." Bank of Finland Research, Discussion Paper 17.

Giglio, S., M. Maggiori, J. Stroebel, Z. Tan, S. Utkus, and X. Xu. 2025. "Four Facts About ESG Beliefs and Investor Portfolios." *Journal of Financial Economics* 164: 103984. https://doi.org/10.1016/j.jfineco.2024.103984.

Hartzmark, S. M., and A. B. Sussman. 2019. "Do Investors Value Sustainability? A Natural Experiment Examining Ranking and Fund Flows." *Journal of Finance* 74, no. 6: 2789–2837.

Hibbs, D. A., Jr., and H. Locking. 2000. "Wage Dispersion and Productive Efficiency: Evidence for Sweden." *Journal of Labor Economics* 18, no. 4: 755–782.

Hong, H., and M. Kacperczyk. 2009. "The Price of Sin: The Effects of Social Norms on Markets." *Journal of Financial Economics* 93, no. 1: 15–36.

Intellectual Property Office. 2015. *The Patent Guide: A Handbook for Analyzing and Interpreting Patent Data*. 2nd ed. GOV.UK. https://www.gov.uk/government/publications/the-patent-guide/the-patent-guide-a-handbook-for-analysing-and-interpreting-patent-data.

International Monetary Fund. 2023. "World Needs More Policy Ambition, Private Funds, and Innovation to Meet Climate Goals." https://www.ifrs.org/sustainability/knowledge-hub/introduction-to-issb-and-ifrs-sustainability-disclosure-standards/.

IPCC -Intergovernmental Panel on Climate Change. 2018. "Global Warming of 1.5°C." An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways.

Iqbal, U., C. Gan, and M. Nadeem. 2020. "Economic Policy Uncertainty and Firm Performance." *Applied Economics Letters* 27, no. 10: 765–770. https://doi.org/10.1080/13504851.2019.1645272.

Iqbal, U., M. Nadeem, A. A. Gull, and U. N. Kayani. 2022. "Environmental Innovation and Firm Value: The Moderating Role of Organizational Capital." *Journal of Environmental Management* 316: 115253. https://doi.org/10.1016/j.jenvman.2022.115253.

Krueger, P., Z. Sautner, and L. T. Starks. 2020. "The Importance of Climate Risks for Institutional Investors." *Review of Financial Studies* 33, no. 3: 1067–1111. https://doi.org/10.1093/rfs/hhz137.

Kruse, T., M. Mohnen, and M. Sato. 2024. "Do Financial Markets Respond to Green Opportunities?" *Journal of the Association of Environmental and Resource Economists* 11, no. 3: 549–576. https://doi.org/10.1086/727370.

La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. W. Vishny. 1999. "Corporate Ownership Around the World." *Journal of Finance* 54, no. 2: 471–517. https://doi.org/10.1111/0022-1082.00115.

Leendertse, J., N. W. M. Heijl, E. Botha, and F. A. J. van Oorsouw. 2021. "The Sustainable Start-Up Paradox: Predicting the Business Performance of Sustainable Ventures." *Business Strategy and the Environment* 30, no. 5: 2726–2739. https://doi.org/10.1002/bse.2667.

Leippold, M., and T. Yu. 2026. "Firm-Level Green Innovation Beyond Patents." *Review of Finance* 30, no. 2: 423–458. https://doi.org/10.1093/rof/rfaf058.

Lemma, T. T., A. Lulseged, and M. Tavakolifar. 2021. "Corporate Commitment to Climate Change Action, Carbon Risk Exposure, and a Firm's Debt Financing Policy." *Business Strategy and the Environment* 30, no. 5: 3919–3936. https://doi.org/10.1002/bse.2849.

Nadeem, M., S. Bahadar, A. A. Gull, and U. Iqbal. 2020. "Are Women Eco-Friendly? Board Gender Diversity and Environmental Innovation." *Business Strategy and the Environment* 29, no. 8: 3146–3161. https://doi.org/10.1002/bse.2563.

Nguyen, P. A., and A. Kecskés. 2020. "Do Technology Spillovers Affect the Corporate Information Environment?" *Journal of Corporate Finance* 62: 101581.

OECD. 2009. *OECD Patent Statistics Manual*. OECD Publishing. https://doi.org/10.1787/9789264056442-en.

Oltra, V., R. Kemp, and F. P. de Vries. 2010. "Patents as a Measure for Eco-Innovation." *International Journal of Environmental Technology and Management* 13, no. 2: 130–148. https://doi.org/10.1504/IJETM.2010.034303.

Pástor, L., R. F. Stambaugh, and L. A. Taylor. 2021. "Sustainable Investing in Equilibrium." *Journal of Financial Economics* 142, no. 2: 550–571. https://doi.org/10.1016/j.jfineco.2020.12.011.

Pinto, J. E. 2020. *Equity Asset Valuation (CFA Institute Investment Series)*. Fourth ed. 470. Wiley.

Rajaiya, H. 2023. "Innovation Success and Capital Structure." *Journal of Corporate Finance* 79: 102345. https://doi.org/10.1016/j.jcorpfin.2022.102345.

Rave, T., F. Goetzke, and M. Larch. 2011. "The Determinants of Environmental Innovations and Patenting: Germany Reconsidered." Ifo Working Paper no. 97. Ifo Institute.

Reyes-Rodriguez, J. F., and J. P. Ulhøi. 2022. "Justifying Environmental Sustainability in Small- and Medium-Sized Enterprises: An Analysis of Complementary Assets in the Printing Industry." *Business Strategy and the Environment* 31, no. 1: 59–75. https://doi.org/10.1002/bse.2874.

Richardson, A. J., and M. Welker. 2001. "Social Disclosure, Financial Disclosure and the Cost of Equity Capital." *Accounting, Organizations and Society* 26: 597–616.

Rutjens, B. T., S. J. Heine, R. M. Sutton, and F. van Harreveld. 2018. "Attitudes Toward Science." In *Advances in Experimental Social Psychology*, edited by J. M. Olson, vol. 57, 125–165. Academic Press.

Rutjens, B. T., N. Sengupta, R. V. Der Lee, et al. 2022. "Science Skepticism Across 24 Countries." *Social Psychological and Personality Science* 13, no. 1: 102–117.

Social Progress Imperative. 2023. "Social Progress Index 2023." Accessed from https://www.socialprogress.org.

Stock, J. H., and M. Yogo. 2005. "Testing for Weak Instruments in Linear IV Regression." In *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, edited by D. W. K. Andrews and J. H. Stock, 80–108. Cambridge University Press.

Tian, J., X. Li, Q. a. Wang, and H. Yang. 2023. "Green Innovation and the Stock Market Value of Heavily Polluting Firms." *Business Strategy and the Environment* 32, no. 7: 4938–4953. https://doi.org/10.1002/bse.3401.

Tian, X., and T. Wang. 2014. "Tolerance for Failure and Corporate Innovation." *Review of Financial Studies* 27, no. 1: 211–255.

Transparency International. 2023. "Corruption Perceptions Index 2023." Accessed from https://www.transparency.org.

United Nations Treaty Collection. n.d. "Paris Agreement, Paris. 12 December 2015." Chapter XXVII 7.d. Accessed May 31, 2026. United Nations. Accessed from https://treaties.un.org.

Urbain, O. Ed. 2014. "A Forum for Peace: Daisaku Ikeda's Proposals to the UN." Toda Institute for Global Peace and Policy Research.

Wooldridge, J. M. 2013. *Introductory Econometrics: A Modern Approach*. 5th ed. South-Western Cengage Learning.

World Intellectual Property Organization. 2020. "WIPO Guide to Using Patent Information." WIPO. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-rn2021-1e-en-wipo-guide-to-using-patent-information.pdf.

Yu, E. P., C. Q. Guo, and B. V. Luu. 2018. "The Relevance of Personal Characteristics and Gender Diversity for (Eco-)Innovation Activities at the Firm-Level: Results From a Linked Employer–Employee Database in Germany." *Business Strategy and the Environment* 27, no. 7: 987–1004. https://doi.org/10.1002/bse.2042.

Yu, E. P., A. Tanda, B. V. Luu, and D. H. Chai. 2021. "Environmental Transparency and Investors' Risk Perception: Cross-Country Evidence on Multinational Corporations' Sustainability Practices and Cost of Equity." *Business Strategy and the Environment* 30, no. 8: 3975–4000.

Zaman, R., K. Asaei, M. Nadeem, I. Malik, and M. Arif. 2023. "Board Demographic, Structural Diversity, and Eco-Innovation: International Evidence." *Corporate Governance: An International Review* 32: 374–390. https://doi.org/10.1111/corg.12545.

Appendix A: Overview of a Company's Environmental Score (*InnovE*), 2007-2021

GICS sector	Sector representation by number of companies	The average environmental innovation score (*InnovE*) within the same sector	The average annual improvement rate on the average environmental score
Consumer discretionary	264	31.63	5.44%
Consumer staples	143	37.61	4.50%
Energy	110	20.63	11.26%
Health care	134	13.70	16.03%
Industrials	268	39.22	5.14%
Information technology	159	34.50	4.66%
Materials	136	37.89	5.24%
Real estate	95	34.60	34.08%
Communication services	57	42.89	3.91%
Utilities	98	45.88	5.39%

Note: This Appendix presents the distribution of our sample companies' average environmental innovation scores within sectors and each sector's average annual improvement rate. In this study, we have 1464 sample companies. Since innovation takes time to produce results, our innovation dataset has a more extended sample period than our primary dataset. The sample period for our innovation dataset is from 2007 to 2021. Geographical distribution of our sample companies: Germany(62), Canada(50), Norway(8), New Zealand(5), Netherlands(10), Mexico(12), Malaysia(3), Luxembourg(4), Jordan(1), Japan(207), Italy(10), Israel(4), Ireland(5), Indonesia(21), India(3), Hong Kong(62), United States(506), Thailand(23), Taiwan(6), Switzerland(25), Sweden(21), Spain(14), South Korea(6), South Africa(32), Singapore(18), Russia(8), Portugal(3), Poland(11), Philippines(15), France(53), Finland(11), Denmark(15), Colombia(3), Chile(6), China(80), UK(63), Brazil(37), Belgium(7), Austria(3) and Australia(43).
Source: Calculated by the authors.

Appendix B: Key Variable Definitions and Data Sources

Variable	Definition	Source
Key explanatory variables		
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}$	A company's long-term change in environmental innovation is measured as the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$.	The data on the variable of $\Delta\ Long\ term_{InnovE}$ is based on the authors' calculation. The annual environmental innovation data at the company level is from the Refinitive ESG database.
Intra-industry $R\&D\ Disperse_{t-1}$	To capture intra-industry dispersion in R&D intensity, we use the coefficient of variation—a standardised measure of dispersion defined as the ratio of the standard deviation to the mean. A low coefficient indicates that companies within an industry invest a similar portion of their sales or assets in R&D, suggesting a small variation in R&D intensity across the industry.	Authors' calculation. The original R&D intensity data at the company level is from the Refinitive ESG database and Bloomberg.
Joint effect $\left(\Delta Long\ term_{InnovE}\right)_{t-1}{}^{*}$ $(Intra-industry\ \ R\&D\ Disperse)_{t-1}$	$\left(\Delta Long\ term_{InnovE}\right)_{t-1}{}^{*}\ (Intra-industry\ \ R\&D\ Disperse)_{t-1}$	Authors' calculation
Explained variable: $Investor\ expectations_{it}$		
$(ex-ante\ cost\ of\ equity)_{it}$	Estimated using the forward earnings–price ratio $\left(\frac{forcasted\ EPS_1}{P_0}\right)$.	Refinitiv I/B/E/S (equity analysts' forecasted EPS_1 information for $(Year_{t+1})$; cshare prices).
$\left(Tobin's\ Q\right)_{it}$	Ratio of a company's market value to the replacement cost of its assets.	Bloomberg
Company characteristics		
Lev_{t-1}	Leverage is measured as a company's total debt divided by its total assets.	Bloomberg
$\log(Size)_{t-1}$	The company size is defined as the natural logarithm of its market capitalisation, denominated in US dollars.	Bloomberg
RDI_{t-1}	Research and development (R&D) intensity if estimated as a company's R&D expense divided by its total sales.	Bloomberg/the Refinitive ESG database.
$(Board)_{t-1}$	The number of directors on the supervisory board	Bloomberg
$(IndBoard)_{t-1}$	The percentage of a company's total board seats occupied by independent directors	Bloomberg
$(InstInV)_{t-1}$	The percentage of freely traded shares held by institutional investors	Bloomberg
$(Cur)_{t-1}$	The current ratio is calculated by dividing a company's current assets by its current liabilities.	Bloomberg
$(SG)_{t-1}$	A company's sales growth is defined as the year-over-year change in sales.	Bloomberg
$(Beta)_t$	Beta is calculated as the share price volatility relative to the volatility in the MSCI World All-Country Index, which serves as a proxy for the market portfolio.	Bloomberg
$(Sigma)_t$	Sigma is estimated as the annualised standard deviation of a company's daily equity returns over the past 260 trading days.	Bloomberg
Country characteristics		
Dummy for high-income economy	Based on the World Bank's classification, high-income economies are coded as $D=1$ and non-high-income economies as $D=0$.	World Bank
$\log(GDPPC)_{t-1}$	Using the purchasing power parity (PPP) exchange rate, we convert this country-level variable into US dollars.	IMF World Economic Outlook database

Appendix C: Robustness Check Using an Alternative Measure of (Δ *Long term*$_{InnovE}$). Regression Results: A Lagged Long-Term Change in a Company's Environmental Innovation $\left(\Delta Long\ term_{InnovE}\right)_{t-1}$ and Its Ex-Ante Cost of Equity $(ex-ante\ cost\ \ of\ equity)_t$

Dependent variable: $(ex-ante\ cost\ \ of\ equity)_t$	**Model (1)**	**Model (2)**	**Model (3)**	**Model (4)**
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}$ [Alternative indicator]	0.0081* (0.0043)	0.0080* (0.0043)	0.0081* (0.0042)	0.0081* (0.0043)
$Intra\text{-}industry\ R\&D\ Disperse_{t-1}$	0.0038 (0.0038)	0.0038 (0.0038)	0.0036 (0.0037)	0.0039 (0.0038)
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}{}^{*}$ $\left(Intra-industry\ R\&D\ Disperse_{t-1}\right)$	−0.0056* (0.0030)	−0.0056* (0.0030)	−0.0053* (0.0029)	−0.0057* (0.0030)
Lev_{t-1}	0.0092*** (0.0032)	0.0092*** (0.0032)	0.0089*** (0.0031)	0.0089*** (0.0032)
$\log(Size)_{t-1}$	−0.0018*** (0.0005)	−0.0017*** (0.0005)	−0.0014*** (0.0005)	−0.0018*** (0.0005)
RDI_{t-1}	−0.0442*** (0.0081)	−0.0447*** (0.0081)	−0.0437*** (0.0081)	−0.0442*** (0.0081)
$(Board)_{t-1}$	0.0011*** (0.0002)	0.0011*** (0.0002)	0.0011*** (0.0002)	0.0011*** (0.0002)
$(IndBoard)_{t-1}$	0.0012 (0.0021)	0.0009 (0.0021)		−0.0005 (0.0024)
$(InstInV)_{t-1}$	−0.0001*** (2.26E-05)	−0.0001*** (2.25E-05)	−0.0001*** (2.07E-05)	−0.0001*** (2.27E-05)
$(Cur)_{t-1}$	−0.0026*** (0.0004)	−0.0027*** (0.0004)	−0.0026*** (0.0004)	−0.0027*** (0.0004)
$(SG)_{t-1}$	0.0001*** (3.69E-05)	0.0001*** (3.68E-05)	0.0001*** (3.64E-05)	0.0001*** (3.69E-05)
$(Beta)_t$	6.76E-05 (6.18E-05)			6.51E-05 (6.18E-05)
$(Sigma)_t$	0.0004*** (7.37E-05)	0.0004*** (7.38E-05)	0.0004*** (7.26E-05)	0.0004*** (7.43E-05)
Dummy for high-income economy				−0.0072* (0.0040)
$\log(GDPPC)_{t-1}$	−0.0071*** (0.0013)	−0.0071*** (0.0013)	−0.0068*** (0.0013)	−0.0022 (0.0027)
Constant	0.1458*** (0.0160)	0.1461*** (0.0160)	0.1401*** (0.0157)	0.1011*** (0.0262)
Period fixed effect	Yes	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes	Yes
Firm number	1464	1464	1464	1464
Adjusted R^2	0.1336	0.1311	0.1319	0.1340

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample consists of 1464 companies from the MSCI All World Index, covering the period from 2013 to 2021. Definitions of all variables and their corresponding data sources are provided in Appendix B. The table presents regression coefficients with standard deviations shown in parentheses. We employ a panel fixed effect model specification, incorporating various country-level and firm-level controls, along with industry dummies. Standard errors are clustered at the firm level. The dependent variable is a company's ex-ante cost of equity in Year t.
For robustness, we replace our key variable $\left(InnovE_{t-1} - InnovE_{t-5}\right)$, which captures a company's long-term change in environmental innovation, with an alternative measurement: $\frac{(InnovE_{t-1}+100)}{(InnovE_{t-5}+100)}$. We replaced our primary measure of long-term improvement in environmental innovation (the key explanatory variable) with an alternative specification that uses relative rather than absolute change. The addition of 100 prevents issues associated with zero values in the denominator. Overall, the results remain consistent, reinforcing the robustness of our findings.
In these supplementary analyses, the three key independent variables in our model specification are:
(a) $\left(\frac{(InnovE_{t-1}+100)}{(InnovE_{t-5}+100)}\right)_{i,t-1}$, as a company's long-term change in environmental innovation;
(b) $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, as the intra-industry dispersion of R&D intensity; and
(c) $\left(\frac{(InnovE_{t-1}+100)}{(InnovE_{t-5}+100)}\right)_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.
Using an alternative measure of a company's long-term change in environmental innovation, we examine the Hypotheses using our primary model, Equation (1).

$$\begin{aligned}\text{ex}-\text{ante cost of equity}_{\text{it}} = {} & \alpha + b_1 * \left(\frac{(\text{InnovE}_{t-1}+100)}{(\text{InnovE}_{t-5}+100)}\right)_{i,t-1} + b_2 * (\text{Intra}-\text{industry R\&D disperse})_{i,t-1} \\ & + b_3 * \left(\frac{(\text{InnovE}_{t-1}+100)}{(\text{InnovE}_{t-5}+100)}\right)_{i,t-1} * (\text{R\&D disperse})_{i,t-1} + \sum b_4 * \text{Control at the firm level}_{i,t-1} \\ & + \sum b_5 * \text{Control at the country level}_{k,t-1} + \sum w_n * \text{Industry}_n + \sum \tau_m \text{Year}_m + \varepsilon_{ikt}\end{aligned}$$

Appendix D: Robustness—Addressing Potential Endogeneity From Omitted Variable Bias

Ex-ante cost of equity $(ex-ante\ cost\ \ of\ equity)_t$	**Model (1)**	**Model (2)**	**Model (3)**
$(\Delta Long\ term_{InnovE})_{t-1}$	7.05E-05* (4.15E-05)	7.26E-05* (4.21E-05)	7.25E-05* (4.12E-05)
$(Intra\text{-}industry\ R\&D\ Disperse)_{t-1}$	−0.0018 (0.0011)	−0.0021* (0.0012)	−0.0018 (0.0012)
$(\Delta Long\ term_{InnovE})_{t-1}{}^{*}$ $(Intra-industry\ \ R\&D\ Disperse)_{t-1}$	−5.52E-05* (2.89E-05)	−6.97E-05** (3.33E-05)	−5.50E-05* (2.89E-05)
Lev_{t-1}	0.0083 (0.0058)	0.0054 (0.0056)	0.0095* (0.0057)
$\log(Size)_{t-1}$	−0.0018* (0.0010)	−0.0016 (0.0010)	−0.0017* (0.0010)
RDI_{t-1}	−0.0440*** (0.0143)	−0.0377*** (0.0141)	−0.0377*** (0.0141)
$(Board)_{t-1}$	0.0010*** (0.0004)	0.0013*** (0.0004)	0.0011*** (0.0004)
$(IndBoard)_{t-1}$	0.0002 (0.0042)	0.0011 (0.0043)	0.0011 (0.0041)
$(InstInV)_{t-1}$	−0.0001** (4.44E-05)	−9.02E-05** (4.41E-05)	−0.0001** (4.40E-05)
$(Cur)_{t-1}$	−0.0027*** (0.0006)	−0.0029*** (0.0007)	−0.0027*** (0.0006)
$(SG)_{t-1}$	0.0001*** (4.25E-05)	7.14E-05 (4.52E-05)	0.0001*** (4.15E-05)
$(Beta)_t$	6.55E-05 (6.39E-05)	−5.78E-06 (6.22E-05)	6.74E-05 (6.41E-05)
$(Sigma)_t$	0.0004*** (0.0001)	0.0003*** (0.0001)	0.0004*** (0.0001)
$\log(GDPPC)_{t-1}$	−0.0037 (0.0044)	−0.0004 (0.0046)	−0.0071*** (0.0026)
International transparency index	−0.0001 (0.0001)		
Social progress index		−0.0006** (0.0003)	
Insider ownership			−0.0001 (0.0002)
Constant	0.1298*** (0.0382)	0.1339*** (0.0313)	0.1543*** (0.0297)
Period fixed effect	Yes	Yes	Yes
Industry fixed effect	Yes	Yes	Yes
Firm number	1168	1112	1168
Adjusted R^2	0.1339	0.1286	0.1339

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample consists of 1464 companies from the MSCI All World Index, covering the period from 2013 to 2021. Definitions of all variables and their corresponding data sources are provided in Appendix B. The table presents regression coefficients with standard deviations shown in parentheses. We employ a panel fixed effect model specification, incorporating various country-level and firm-level controls, along with industry dummies. Standard errors are clustered at the firm level. The dependent variable is a company's ex-ante cost of equity in Year t. The three key independent variables are.
(a) $(InnovE_{t-1} - InnovE_{t-5})_{i,t-1}$, which captures a company's long-term change in environmental innovation, measured as the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$;.
(b) $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, as the intra-industry dispersion of R&D intensity; and
(c) $(InnovE_{t-1} - InnovE_{t-5})_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.
We re-examine the Hypotheses using our primary model, Equation (1), by introducing three new independent variables: one company-level factor (insider ownership) and two country-level factors (the International Transparency Index and the Social Progress Index). These three variables are included separately as additional controls for corporate governance quality at the company level and institutional quality at the country level.

$$\begin{aligned}\text{ex-ante cost of equity}_{it} &= \alpha + b_1 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} + b_2 * (\text{Intra-industry R\&D disperse})_{i,t-1} \\ &+ b_3 * (\text{InnovE}_{t-1} - \text{InnovE}_{t-5})_{i,t-1} * (\text{R\&D disperse})_{i,t-1} + \sum b_4 * \text{Control at the firm level}_{i,t-1} \\ &+ \sum b_5 * \text{Control at the country level}_{k,t-1} + \sum w_n * \text{Industry}_n + \sum \tau_m \text{Year}_m + \varepsilon_{ikt}\end{aligned}$$

Appendix E: Robustness—Addressing Potential Endogeneity From Unobserved Shocks

	Ex-ante cost of equity $(ex-ante\ cost\ \ of\ equity)_t$
	Model 1
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}$	7.16E-05* (4.14E-05)
$(Intra\text{-}industry\ R\&D\ Disperse)_{t-1}$	−0.0018 (0.0012)
$\left(\Delta Long\ term_{InnovE}\right)_{t-1}{}^{*}\,(Intra-industry\ \ R\&D\ Disperse)_{t-1}$	−5.44E-05* (2.90E-05)
Lev_{t-1}	0.0095* (0.0057)
$\log(Size)_{t-1}$	−0.0018* (0.0010)
RDI_{t-1}	−0.0443*** (0.0143)
$(Board)_{t-1}$	0.0011*** (0.0004)
$(IndBoard)_{t-1}$	0.0014 (0.0042)
$(InstInV)_{t-1}$	−0.0001** (4.46E-05)
$(Cur)_{t-1}$	−0.0027*** (0.0006)
$(SG)_{t-1}$	0.0001*** (4.22E-05)
$(Beta)_t$	6.68E-05 (6.44E-05)
$(Sigma)_t$	0.0004*** (0.0001)
$\log(GDPPC)_{t-1}$	−0.0068*** (0.0026)
Paris Climate Agreement	0.0010 (0.0024)
Constant	0.1503*** (0.0305)
Period Fixed Effect	Yes
Industry Fixed Effect	Yes
Firm number	1168
Adjusted R^2	0.1335

Note: *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. The sample consists of 1464 companies from the MSCI All World Index, covering the period from 2013 to 2021. Definitions of all variables and their corresponding data sources are provided in Appendix B. The table presents regression coefficients with standard deviations shown in parentheses. We employ a panel fixed effect model specification, incorporating various country-level and firm-level controls, along with industry dummies. Standard errors are clustered at the firm level. The dependent variable is a company's ex-ante cost of equity in Year t. The three key independent variables are.

(a) $\left(InnovE_{t-1} - InnovE_{t-5}\right)_{i,t-1}$, which captures a company's long-term change in environmental innovation, measured as the difference between its Environmental Innovation Score of $Year_{t-1}$ and its score in $Year_{t-5}$.

(b) $(Intra-industry\ R\&D\ disperse)_{i,t-1}$, as the intra-industry dispersion of R&D intensity; and

(c) $\left(InnovE_{t-1} - InnovE_{t-5}\right)_{i,t-1} * (Intra-industry\ R\&D\ disperse)_{i,t-1}$, the interaction term as the moderating role of intra-industry R&D dispersion through the joint effect.

We re-estimate our model specification (Equation 1), including a dummy variable indicating whether a country is a signatory to the Paris Agreement. The variable takes the value of 1 for the period after a country's ratification date and 0 otherwise. Ratification of the Paris Agreement represents a significant global policy commitment to climate mitigation, serving as a plausible structural break that may influence companies' incentives for environmental innovation and investor expectations.

$$
\begin{aligned}
\mathrm{ex-ante\ cost\ of\ equity}_{it} = {} & \alpha + b_1 * \left(\mathrm{InnovE}_{t-1} - \mathrm{InnovE}_{t-5}\right)_{i,t-1} + b_2 * (\mathrm{Intra-industry\ R\&D\ disperse})_{i,t-1} \\
& + b_3 * \left(\mathrm{InnovE}_{t-1} - \mathrm{InnovE}_{t-5}\right)_{i,t-1} * (\mathrm{R\&D\ disperse})_{i,t-1} + \sum b_4 * \mathrm{Control\ at\ the\ firm\ level}_{i,t-1} \\
& + \sum b_5 * \mathrm{Control\ at\ the\ country\ level}_{k,t-1} + \sum w_n * \mathrm{Industry}_n + \sum \tau_m \mathrm{Year}_m + \varepsilon_{ikt}
\end{aligned}
$$

Appendix F: Durbin–Wu–Hausman Test for Endogeneity

Test	Variable	T statistic	*p*	Conclusion
Durbin–Wu–Hausman test	Long-term improvements in environmental innovation (main term)	−0.4016	0.6881	Fail to reject the null hypothesis of exogeneity
Durbin–Wu–Hausman test	Interaction with intra-industry R&D dispersion (interaction term)	0.4607	0.6451	Fail to reject the null hypothesis of exogeneity

Note: This table reports the results of the Durbin–Wu–Hausman test of endogeneity. The null hypothesis (H_0) is that the specified variables are exogenous. Since the *p*-values are greater than 0.05, we fail to reject the null hypothesis of exogeneity. Our results provide no statistical evidence that endogeneity materially biases the main term or the interaction term.